BANARAS HINDU UNIVERSITY

B.Sc.(Hons.) Courses

Effective from 2024 under NEP

Offered by

Faculty of Science

Course content: B.Sc. (Hons.)

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* MD - **Multidisciplinary Courses**
* SEC- **Skill Enhancement Courses**
* VAC- **Value Added Course**

BANARAS HINDU UNIVERSITY

Department of Botany

Faculty of Science

SYLLABI

B.Sc. (Hons.) Programme

In

Botany

DEPARTMENT OF BOTANY
BANARAS HINDU UNIVERSITY, VARANASI-221005
Syllabus
NEP Course Structure for Four Year Undergraduate BotanyProgram

	Paper/Course	Credit	Name of paper
Semester I (20 Credits)	**Introductory/Foundation Level Course**		
	BOTMJ11	3	Cryptogams
	BOTMJ12	1	Lab Work Based on Paper BOTMJ11
	BOTMN11	3	Cryptogams
	BOTMN12	1	Lab Work Based on Paper BOTMN11
	BOTMD11	2	Elements of Ecology
	BOTMD12	1	Lab Work Based on Paper BOTMD11
	AE1	2	Offered by Institute/University
	BOTSE11	2	Waste Management
	BOTSE12	1	Lab Work Based on Paper BOTSE11
	VA1	2	Offered by Institute/University
	VA2	2	Offered by Institute/University
Total		**20 Credits**	

	Paper/Course	Credit	Name of paper
Semester II (20 Credits)	**Introductory/Foundation Level Course**		
	BOTMJ21	3	General Microbiology
	BOTMJ22	1	Lab Work Based on Paper BOTMJ21
	BOTMN21	3	General Microbiology
	BOTMN22	1	Lab Work Based on PaperBOTMN21
	BOTMD21	2	Herbal Medicine
	BOTMD22	1	Lab Work Based on Paper BOTMD21
	AE2	2	Offered by Institute/University
	BOTSE21	2	Preservation and Management of Microbial Resource
	BOTSE22	1	Lab Work Based on Paper BOTSE21
	VA3	2	Offered by Institute/University
	VA4	2	Offered by Institute/University
Total		**20 Credits**	

	Paper/Course	Credit	Name of paper
Semester III (20 Credits)	**Intermediate Level Course**		
	BOTMJ31	3	Cytology and Genetics
	BOTMJ32	1	Lab Work Based on Paper BOTMJ31
	BOTMJ33	3	Plant Anatomy and Embryology
	BOTMJ34	1	Lab Work Based on Paper BOTMJ33
	BOTMV31	3	Mushroom Cultivation
	BOTMV32	1	Lab Work Based on Paper BOTMV31
	BOTMD31	2	Industrial Microbiology
	BOTMD32	1	Lab Work Based on Paper BOTMD31
	AE3	2	Offered by Institute/University
	BOTSE31	2	Ethnobotany
	BOTSE32	1	Lab Work Based on Paper BOTSE31
Total-		**20 Credits**	

	Paper/Course	Credit	Name of paper
Semester IV (20 Credits)	**Intermediate Level Course**		
	BOTMJ41 BOTMJ42	3 1	Angiosperm Taxonomy Lab Work Based on PaperBOTMJ41
	BOTMJ43 BOTMJ44	3 1	Gymnosperm and Paleobotany Lab Work Based on PaperBOTMJ43
	BOTMJ45 BOTMJ46	3 1	Plant Ecology Lab Work Based on PaperBOTMJ45
	BOTMJ47 BOTMJ48	1 1	Microbial Resource Lab Work Based on PaperBOTMJ47
	BOTMN41/BOTMN43/ BOTMN45 BOTMN42/ BOTMN44/ BOTMN46	3 1	*Students may opt for any of the following: BOTMN41/BOTMN43/BOTMN45 Lab Work Based on PaperBOTMN41/BOTMN43/BOTMN45
	AE4	2	Offered by Institute/University
	Total	**20 Credits**	

	Paper/Course	Credit	Name of paper
Semester V (20 Credits)	**High Level Course**		
	BOTMJ51 BOTMJ52	3 1	Plant Physiology Lab Work Based on Paper BOTMJ51
	BOTMJ53 BOTMJ54	3 1	Plant Pathology Lab Work Based on Paper BOTMJ53
	BOTMJ55 BOTMJ56	3 1	Recombinant DNA Technology Lab Work Based on Paper BOTMJ55
	BOTMJ57 BOTMJ58	1 1	Plant and Microbial Techniques Lab Work Based on PaperBOTMJ57
	BOTMV51 BOTMV52	3 1	Herbarium Preparation and Preservation Lab Work Based on Paper BOTMV51
	BOTIN51	2	Internship
	Total	**Credits**	
	Paper/Course	**Credit**	**Name of paper**
Semester VI (20 Credits)	**High Level Course**		
	BOTMJ61 BOTMJ62	3 1	Comparative Cryptogams Lab Work Based on Paper BOTMJ61
	BOTMJ63 BOTMJ64	3 1	Comparative Phanerogams Lab Work Based on Paper BOTMJ63
	BOTMJ65 BOTMJ66	3 1	Biodiversity and Biostatistics Lab Work Based on Paper BOTMJ65
	BOTMJ67 BOTMJ68	3 1	Cytogenetics and Evolutionary Processes Lab Work Based on Paper BOTMJ67
	BOTMV61 BOTMV62	3 1	Plant Micropropagation Lab Work Based on Paper BOTMV61
	Total	**20 Credits**	

Honours without Research

	Paper/Course	Credit	Name of paper
Semester VII (20 Credits) B.Sc. (Hons.) without Research	**Advance Level Course**		
	BOTMJ71	3	Plant Biochemistry and Molecular Biology
	BOTMJ72	1	Lab Work Based on Paper BOTMJ71
	BOTMJ73	3	Plant Biotechnology and Genetic Engineering
	BOTMJ74	1	Lab Work Based on Paper BOTMJ73
	BOTMJ75	2	Field Excursion
	BOTMJ76	3	Photoecophysiology
	BOTMJ77	1	Lab Work Based on Paper BOTMJ76
	BOTMJ78	2	Research Methodology
	BOTMN71/BOTMN73/BOTMN76	3	*Students may opt for any of the following: BOTMN71/BOTMN73/ BOTMN76
	BOTMN72/BOTMN74/ BOTMN77	1	Lab Work Based on Paper BOTMN71/ BOTMN73/BOTMN76
	Total	**20 Credits**	

	Paper/Course	Credit	Name of paper
Semester VIII (20 Credits) B.Sc. (Hons.) without Research	**Advance Level Course**		
	BOTMJ81	3	Microbiology
	BOTMJ82	1	Lab Work Based on Paper BOTMJ81
	BOTMJ83	3	Stress Biology
	BOTMJ84	1	Lab Work Based on Paper BOTMJ83
	BOTMJ85	3	Ecology,Pollution and Toxicology
	BOTMJ86	1	Lab Work Based on Paper BOTMJ85
	BOTMJ87	3	Plant Diseases and Protection
	BOTMJ88	1	Lab Work Based on Paper BOTMJ87
	BOTMN81/BOTMN83/BOTMN85/ BOTMN87	3	*Students may opt for any of the following: BOTMN81/BOTMN83/BOTMN85/BOTMN 87
	BOTMN82/BOTMN84/BOTMN86/ BOTMN88	1	Lab work based on paper BOTMN81/BOTMN83/BOTMN85/BOTMN 87
	Total	**20 Credits**	

Honours with Research

	Paper/Course	Credit	Name of paper
Semester VII (20 Credits) B.Sc. (Hons.) with Research	**Advance Level Course**		
	BOTMJ71R	3	Plant Biochemistry and Molecular Biology
	BOTMJ72R	1	Lab Work Based on Paper BOTMJ71R
	BOTMJ73R	3	Plant Biotechnology and Genetic Engineering
	BOTMJ74R	1	Lab Work Based on Paper BOTMJ73R
	BOTMJ75R	3	Ecosystem Dynamics
	BOTMJ76R	1	Lab Work Based on Paper BOTMJ75R
	BOTMJ77R	2	Field Excursion
	BOTMJ78R	2	Research Methodology
	BOTMN71R/BOTMN73R/BOTMN75R	3	*Students may opt for any of the following: BOTMN71R/BOTMN73R/BOTMN75R
	BOTMN72R/BOTMN74R/BOTMN76R	1	Lab work based on paper BOTMN71R/BOTMN73R/BOTMN75R
	Total	**20 Credits**	

	Paper/Course	Credit	Name of paper
Semester VIII (20 Credits) B.Sc. (Hons.) with Research	**Advance Level Course**		
	BOTDS81R	12	Dissertation/Project
	BOTMJ82R	3	Aquatic Ecology
	BOTMJ83R	1	Lab Work Based on PaperBOTMJ82R
	BOTMN84R	3	Aquatic Ecology
	BOTMN85R	1	Lab Work Based on Paper BOTMN84R
	Total:	**20 Credits**	

BANARAS HINDU UNIVERSITY
(Detailed Syllabus of different Courses under NEP 2020)

Department of Botany, Institute of Science

Faculty of Science, BHU

SEMESTER: I

Course Title	**BOTMJ11 : Cryptogams**
Category of Course[1]	**Major**/ Minor / Minor (Vocational) / SEC / AEC / VAC / MD/Internship/Dissertation
Credits[2]**& Hour of Teaching**	

	Theory	Practical	Cumulative
Credits	3	1	4
Hours of Teaching	**45**	**30**	**75**

Course Objectives	The course on cryptogams aims to provide students with a comprehensive understanding of the general characteristics, classification, and life cycles of various cryptogamic groups. It covers detailed studies of representative genera from algae, fungi, bryophytes, and pteridophytes, exploring their structure, reproduction, and ecological significance. Through this course, students will gain foundational knowledge essential for further studies in plant sciences and biodiversity.

Units	**Course Content**	**Hours of Teaching:45 h**
I	General characteristics and classification of cryptogams	5.0 h
II	Structure, reproduction and life cycles of representative genera of algae: • Chlorophyceae: *Volvox*, *Oedogonium* • Xanthophyceae: *Vaucheria* • Phaeophyceae: *Ectocarpus* • Rhodophyceae: *Polysiphonia* • Cyanophyceae: *Nostoc*, *Scytonema*	12.0 h
III	Structure, reproduction and life cycles of representative genera of fungi: • Mastigomycotina:*Albugo* • Zygomycotina: *Rhizopus* • Ascomycotina: *Peziza* • Basidiomycotina: *Agaricus* • Deuteromycotina: *Cercospora*, *Alternaria*	12.0 h
IV	Structure, reproduction and life cycles of representative genera of Bryophytes: • Hepaticopsida: *Marchantia* • Anthocerotopsida: *Anthoceros* • Bryopsida: *Funaria*	8.0 h
V	Structure, reproduction and life cycles of representative genera of Pteridophytes: • Lycophyta: *Selaginella* • Sphenophyta: *Equisetum* • Filicophyta: *Pteris*	8.0 h

Texts/ References	1. F.E. Fritsch (1935, reprinted in 1979). Structure and Reproduction of the Algae. Vol I.Vikash Publishing House Pvt. Ltd, New Delhi 2. F.E. Fritsch (1945, reprinted in 1979). Structure and Reproduction of the Algae. Vol I.Vikash Publishing House Pvt. Ltd, New Delhi

[1] SEC – Skill Enhancement Course; AEC – Ability Enhancement Course; VAC – Value Added Course; MD – Multidisciplinary Course

[2] 1 Credit (Theory) = 15 Hours; 1 Credit (Practical) = 30 Hours

3. Morris I (1967) Introduction to Algae, Hutchinson University Library, London.
4. Lee RE (2018) Phycology, Fifth Edition. Cambridge University Press, New Delhi.
5. Smith GM (1972) Cryptogamic Botany Vol I and II, Tata McGraw Hill Publishing Co Ltd, New Delhi.
6. Alexopolous CJ, Mims CW, Blackwell M (2007 Reprinted in 2013) Introductory Mycology 4th edition,Wiley, India, New Delhi..
7. Parihar NS (1973) An Introduction to Embryophyta, Vol I (Bryophyta) and Vol II (Pteridophyta), Central Book Department, Allahabad.
8. Rashid A (2011, reprinted in 2019) An Introduction to Pteridophyta 2nd edition, Vikas Publishing House Pvt Ltd, Noida.
9. Gangulee HC, Kar AK (2015) College Botany VolII(Algae, Fungi, Brophyta, Pteridophyta), New Central Book Agency, Kolkata.
10. Kumar HD (2007) Introductory Phycology, 2nd edition, Affiliated East-West Press Pvt. Ltd., New Delhi
11. Dubey HC (2017) An Introduction to Fungi, 3rd edition, Vikash Publication House Pvt Ltd, Noida.
12. Bold HC, Wynne MJ (1985) Introduction to the Algae, 2nd edition, Prentice-Hall Inc, New Jersey.
13. L.E. Graham, J.M. Graham (1009) Algae, 2nd Edition, Benjamin Cummings.
14. J. Weber and RW Weber (2007, reprinted in 1016). Introduction to Fungi. Cambridge, New Delhi.

Learning Outcomes	By the end of this course on cryptogams, students will understand and classify various groups of cryptogams, describe the structure, reproduction, and life cycles of key genera in algae, fungi, bryophytes, and pteridophytes, and identify their ecological roles and evolutionary significance. This foundational knowledge will enable students to apply their understanding of cryptogams to broader studies in plant sciences and biodiversity.

Course Title	**BOTMJ12 : Lab Work Based on Paper BOTMJ11**

Units	**Practicals**	**Hours of Teaching:30 h**
I	General instructions for staining, slide preparation, and microscopic observation	6.0 h
II	Observation of morphological and reproductive structure of following Algae: *Volvox* *Oedogonium* *Vaucheria* *Ectocarpus* *Polysiphonia* *Nostoc* *Scytonema*	6.0 h
III	Observation of morphological and reproductive structure of following Fungi: *Albugo* *Rhizopus* *Peziza* *Agaricus* *Cercospora* *Alternaria*	6.0 h
IV	Observation of morphological and reproductive structure of following Bryophytes: *Marchantia* *Anthoceros* *Funaria*	6.0 h
V	Observation of morphological and reproductive structure of following Pteridophytes: *Selaginella* *Equisetum* *Pteris*	6.0 h

Course Title	**BOTMN11: Cryptogams**
Category of Course[3]	Major / **Minor** / Minor (Vocational) / SEC / AEC / VAC / MD/Internship/Dissertation
Credits[4]**& Hour of Teaching**	

	Theory	Practical	Cumulative
Credits	3	1	4
Hour of Teaching	45	30	75

Course Objectives	This course aims to provide students with a comprehensive understanding of cryptogams by exploring their general characteristics, classification, and life cycles. Covering key genera in algae, fungi, bryophytes, and pteridophytes, students will study the structure and reproduction of these organisms. By the end of the course, students will gain a foundational knowledge essential for further studies in plant sciences, ecology, and biodiversity, enabling them to appreciate the ecological and evolutionary significance of these diverse groups.

Units	**Course Content**	**Hours of Teaching:45 h**
I	General characteristics and classification of cryptogams	5.0 h
II	Structure, reproduction and life cycles of representative genera of algae: • Chlorophyceae: *Volvox*, *Oedogonium* • Xanthophyceae: *Vaucheria* • Phaeophyceae: *Ectocarpus* • Rhodophyceae: *Polysiphonia* • Cyanophyceae: *Nostoc*, *Scytonema*	12.0 h
III	Structure, reproduction and life cycles of representative genera of fungi: • Mastigomycotina:*Albugo* • Zygomycotina: *Rhizopus* • Ascomycotina: *Peziza* • Basidiomycotina: *Agaricus* • Deuteromycotina: *Cercospora* , *Alternaria*	12.0 h
IV	Structure, reproduction and life cycles of representative genera of Bryophytes: • Hepaticopsida: *Marchantia* • Anthocerotopsida: *Anthoceros* • Bryopsida: *Funaria*	8.0 h
V	Structure, reproduction and life cycles of representative genera of Pteridophytes: • Lycophyta: *Selaginella* • Sphenophyta: *Equisetum* • Filicophyta: *Pteris*	8.0 h

Texts / References

1 F.E. Fritsch (1935, reprinted in 1979). Structure and Reproduction of the Algae. Vol I.Vikash Publishing House Pvt. Ltd, New Delhi

2 F.E. Fritsch (1945, reprinted in 1979). Structure and Reproduction of the Algae. Vol I.Vikash Publishing House Pvt. Ltd, New Delhi

3 Morris I (1967) Introduction to Algae, Hutchinson University Library, London.

4 Lee RE (2018) Phycology, Fifth Edition. Cambridge University Press, New Delhi.

5 Smith GM (1972) Cryptogamic Botany Vol I and II, Tata McGraw Hill Publishing Co Ltd, New Delhi.

6 Alexopolous CJ, Mims CW, Blackwell M (2007 Reprinted in 2013) Introductory Mycology 4th edition,Wiley, India, New Delhi..

[3] SEC – Skill Enhancement Course; AEC – Ability Enhancement Course; VAC – Value Added Course; MD – Multidisciplinary Course

[4] 1 Credit (Theory) = 15 Hours; 1 Credit (Practical) = 30 Hours

	7 Parihar NS (1973) An Introduction to Embryophyta, Vol I (Bryophyta) and Vol II (Pteridophyta), Central Book Department, Allahabad. 8 Rashid A (2011, reprinted in 2019) An Introduction to Pteridophyta 2nd edition, Vikas Publishing House Pvt Ltd, Noida. 9 Gangulee HC, Kar AK (2015) College Botany VolII(Algae, Fungi, Brophyta, Pteridophyta), New Central Book Agency, Kolkata. 10 Kumar HD (2007) Introductory Phycology, 2nd edition, Affiliated East-West Press Pvt. Ltd., New Delhi 11 Dubey HC (2017) An Introduction to Fungi, 3rd edition, Vikash Publication House Pvt Ltd, Noida. 12 Bold HC, Wynne MJ (1985) Introduction to the Algae, 2nd edition, Prentice-Hall Inc, New Jersey. 13 L.E. Graham, J.M. Graham (1009) Algae, 2nd Edition, Benjamin Cummings. 14 J. Weber and RW Weber (2007, reprinted in 1016). Introduction to Fungi. Cambridge, New Delhi.
Learning Outcomes	By the end of this course on cryptogams, students will be able to classify and describe the general characteristics, structure, reproduction, and life cycles of key genera in algae, fungi, bryophytes, and pteridophytes. They will gain an understanding of the ecological roles and evolutionary significance of these groups, providing a strong foundation for further studies in plant sciences and biodiversity. This knowledge will enable students to appreciate the diversity and complexity of cryptogamic organisms and their importance in various ecosystems.

Course Title	**BOTMN12: Lab Work Based on Paper BOTMN11**

Units	**Practicals**	**Hours of Teaching:30 h**
I	General instructions for staining, slide preparation, and microscopic observation	6.0 h
II	Observation of morphological and reproductive structure of following Algae: *Volvox* *Oedogonium* *Vaucheria* *Ectocarpus* *Polysiphonia* *Nostoc* *Scytonema*	6.0 h
III	Observation of morphological and reproductive structure of following Fungi: *Albugo* *Rhizopus* *Peziza* *Agaricus* *Cercospora* *Alternaria*	6.0 h
IV	Observation of morphological and reproductive structure of following Bryophytes: *Marchantia* *Anthoceros* *Funaria*	6.0 h
V	Observation of morphological and reproductive structure of following Pteridophytes: *Selaginella* *Equisetum* *Pteris*	6.0 h

Course Title	**BOTMD11 : Elements of Ecology**
Category of Course	Major / Minor / Minor (Vocational) / SEC / AEC / VAC / **MD**/Internship/Dissertation

Credits& Hour of Teaching

	Theory	Practical	Cumulative
Credits	2	1	3
Hour of Teaching	30	30	60

Course Objectives

This course aims to provide students with a foundational understanding of ecology by exploring key concepts such as types of population interactions, ecosystem components, types and functions, and the significance of biodiversity. Additionally, the course will examine ecological adaptations in hydrophytes and xerophytes. By the end of the course, students will gain essential knowledge for further ecological studies and an appreciation of the complexity and interdependence of life within various ecosystems.

Units	Course Content	Hours of Teaching:30 h
I	Introduction to ecology	4.0 h
II	Types of population interactions	4.0 h
III	Ecosystem: Components, types and function	8.0 h
IV	Significance ofbiodiversity	7.0 h
V	Ecological adaptation: Hydrophytes and xerophytes	7.0 h

Texts/ References

1. Odum EP, Barrett GW (2005) Fundamentals of Ecology, Thomson Ed. Brooks/Cole, Cengage Learning India Pvt. Ltd, New Delhi.
2. Odum EP (1983) Basic Ecology Ed. Saunders College Pub, New York.
3. Smith TM, Smith RL (2008) Elements of Ecology, 7th edition, Benjamin- Cummings New York.
4. Miller GT (2004) Essentials of Ecology, 3rd edition, Brooks, Cole, New York.
5. Smith RL (2001) Ecology and Field Biology, Benjamin Cummings, New York.
6. Vallero D (2014) Fundamentals of Air Pollution, 3rd edition, Academic Press, Elsevier, Burlington.
7. Klassen C, Watkins JB (2010) Essentials of Toxicolgy, 2nd edition, McGraw- Hill Companies, New York.
8. Singh JS, Singh SP, Gupta SR (2014) Ecology Environmental Science and Conservation, S Chand & Co, New Delhi.
9. Mueller-Dombois D and Ellenberg H (1974) Aims and Methods of Vegetation Ecology. Wiley & Sons., NY, USA

Learning Outcomes

By the end of this course, students will be able to understand and explain the fundamentals of ecology, including types of population interactions, ecosystem components and functions, and the significance of biodiversity. They will also be able to identify and describe ecological adaptations in hydrophytes and xerophytes. This knowledge will provide a solid foundation for further ecological studies and foster an appreciation for the complexity and interdependence of organisms within various ecosystems.

Course Title	**BOTMD12 : Lab Work Based on Paper BOTMD11**

Units	Practicals	Hours of Teaching:30 h
I	Soil properties analysis: • soil texture • pH • Carbonate and nitrate content	10.0 h
II	Demonstration of instruments involved in measurement of abiotic factors	10.0 h
III	Ecological study of plant adaptations in response to: • Hydrophytes • Xerophytes	10.0 h

Course Title	AE1: Offered by Institute/University (2 Credits)
Category of Course[5]	Major / Minor / Minor (Vocational) / SEC / **AEC** / VAC / MD/Internship/Dissertation

Course Title	BOTSE11: Waste Management			
Category of Course[6]	Major / Minor / Minor (Vocational) / **SEC** / AEC / VAC / MD/Internship/Dissertation			
Credits[7]& Hour of Teaching		Theory	Practical	Cumulative
	Credits	2	1	3
	Hour of Teaching	30	30	60
Course Objectives	The course on waste management aims to provide students with a comprehensive understanding of the principles and practices for handling solid and liquid wastes. It covers the characteristics, segregation, and management of different types of wastes, along with effective treatment and disposal methods. Students will also learn about the environmental and health impacts of wastes and the relevant rules and regulations governing waste management. By the end of the course, students will be equipped with the knowledge and skills necessary to implement sustainable waste management practices and ensure compliance with legal standards.			

Units	Course Content	Hours of Teaching: 30 h
I	Introduction to solid and liquid wastes Electronic and Medical Wastes	5.0 h
II	Solid wastes: Electronic and Medical Wastes, Characteristics, segregation and management	9.0 h
III	Liquid wastes: Characteristics and management	9.0 h
IV	Waste management: Rules and regulations	7.0 h

Texts/ References	1. Singh JS, Singh SP and Gupta SR. 2014. Ecology, Environmental Science and Conservation. S. Chand & Company Pvt. Ltd., New Delhi 2. Hassan A. 2022. Introduction to waste management: a text book. Wiley publishers 3. Linda G. 2021. Waste management practices in developing countries (Eds). MDPI
Learning Outcomes	Upon completing this course, students will be able to identify and classify different types of solid and liquid wastes, implement effective segregation and management techniques, and understand their environmental and health impacts. They will be skilled in applying appropriate treatment and disposal methods while ensuring regulatory compliance. Additionally, students will develop sustainable waste management strategies, navigate relevant rules and regulations, and address waste management challenges with innovative solutions that prioritize environmental protection and public health.

Course Title	BOTSE12: Lab Work Based on Paper BOTSE11

Units	Practicals	Hours of Teaching:30 h
I	Collection of solid wastes	6.0 h
II	Segregation of solid wastes	6.0 h
III	Visit to solid waste treatment plants	6.0 h
IV	Visit to wastewater treatment plants	6.0 h
V	Water quality analysis	6.0 h

[5] SEC – Skill Enhancement Course; AEC – Ability Enhancement Course; VAC – Value Added Course; MD – Multidisciplinary Course

[6] SEC – Skill Enhancement Course; AEC – Ability Enhancement Course; VAC – Value Added Course; MD – Multidisciplinary Course

[7] 1 Credit (Theory) = 15 Hours; 1 Credit (Practical) = 30 Hours

Course Title	**VA1: Offered by Institute/University(2 Credits)**
Category of Course[8]	Major / Minor / Minor (Vocational) / SEC / AEC / **VAC** -1/ MD/Internship/Dissertation

Course Title	**VA2: Offered by Institute/University(2 Credits)**
Category of Course[9]	Major / Minor / Minor (Vocational) / SEC / AEC / **VAC** -2/ MD/Internship/Dissertation

SEMESTER: II

Course Title	**BOTMJ21: General Microbiology**
Category of Course[10]	**Major** / Minor / Minor (Vocational) / SEC / AEC / VAC / MD/Internship/Dissertation

Credits[11] **& Hour of Teaching**

	Theory	Practical	Cumulative
Credits	3	1	4
Hour of Teaching	45	30	75

Course Objectives

This course aims to provide students with a comprehensive understanding of microbiology, covering its history, scope, and the role of microbes in extreme environments. It explores the ecological, morphological, physiological, biochemical, and molecular criteria for bacterial classification, and details the structure of bacterial cells and bacteriophages. Additionally, the course examines genetic recombination in bacteria, the role of microorganisms in carbon and nitrogen cycling, antibiotic production, alcohol and beverage production, xenobiotic degradation, and their impact on human health. Through this course, students will gain essential knowledge for advanced studies and applications in microbiology and related fields.

Units	Course Content	Hours of Teaching:45 h
I	• History and scope of microbiology • Microbes in extreme environment	8.0 h
II	• Position of microorganisms in the living world; Ecological, morphological, physiological, biochemical and molecular criteria for the classification of bacteria (scheme not required)	7.0 h
III	• Structure of a bacterial cell: flagella, cell envelope, cell membrane, chromosome, plasmid and endospore • Structure of bacteriophages T4 and Lambda; Lysogenic and lytic cycle	8.0 h
IV	• A brief account of genetic recombination in bacteria (transformation, conjugation and transduction) • Role of microorganisms in carbon and nitrogen cycling	10.0 h
V	• Microorganisms and their role in the production of antibiotics • Role of microbes in alcohol and beverages production • Microbes in xenobiotic degradation • Microorganisms and human health	12.0 h

[8] SEC – Skill Enhancement Course; AEC – Ability Enhancement Course; VAC – Value Added Course; MD – Multidisciplinary Course

[9] SEC – Skill Enhancement Course; AEC – Ability Enhancement Course; VAC – Value Added Course; MD – Multidisciplinary Course

[10] SEC – Skill Enhancement Course; AEC – Ability Enhancement Course; VAC – Value Added Course; MD – Multidisciplinary Course

[11] 1 Credit (Theory) = 15 Hours; 1 Credit (Practical) = 30 Hours

Texts/ References	1. Willey J, Sandman K, Wood D (2020) Prescott's Microbiology, 11th edition, McGraw-Hill, New York. 2. Madigan MT, Bender KS, Buckley DH, Sattley WM, Stahl DA (2020) Brock Biology of Microorganism, 16th edition, Pearson Education, London, United Kingdom 3. Stanier RY, Ingraham JL, Wheelis ML, Painter PR (1987) General Microbiology, 5th edition, MacMillan Press Ltd, New Jersey. 4. Dubey RC, Maheshwari DK (2014) A Textbook of Microbiology, Revised edition, S Chand and Company Ltd, New Delhi
Learning Outcomes	By the end of this course, students will be able to understand the history and scope of microbiology, describe the role of microbes in extreme environments, and classify bacteria based on ecological, morphological, physiological, biochemical, and molecular criteria. They will be able to explain the structure of bacterial cells and bacteriophages, understand genetic recombination in bacteria, and describe the roles of microorganisms in carbon and nitrogen cycling, antibiotic production, alcohol and beverage production, xenobiotic degradation, and human health. This knowledge will prepare students for advanced studies and practical applications in microbiology.

Course Title	**BOTMJ22: Lab Work Based on Paper BOTMJ21**	
Units	**Practicals**	**Hours of Teaching:30 h**
I	• Study of free-living nitrogen fixing cyanobacteria (*Nostoc*, *Anabaena* and *Aulosira*)	6.0 h
II	• Study of symbiotic nitrogen fixers in *Cycas* and *Azolla* plants	6.0 h
III	• Calibration of microscope using ocular and stage micrometers, and the measurement of dimensions of microbial cells	6.0 h
IV	• Study of cyanobacterial blooms • Gram's staining of bacteria	6.0 h
V	• Demonstration of equipment's (autoclave, laminar flow, thermal cycler, spectrophotometer and bacteriological incubators)	6.0 h

Course Title	**BOTMN21: General Microbiology**			
Category of Course[12]	Major / **Minor**/ Minor (Vocational) / SEC / AEC / VAC / MD/Internship/Dissertation			
Credits[13]& Hour of Teaching		Theory	Practical	Cumulative
	Credits	3	1	4
	Hour of Teaching	45	30	75
Course Objectives	This course aims to provide students with a thorough understanding of microbiology by covering its history, scope, and the role of microbes in extreme environments. It includes an exploration of microbial classification, the structure of bacterial cells and bacteriophages, and genetic recombination processes. The course also examines the impact of microorganisms on carbon and nitrogen cycling, their roles in antibiotic production, alcohol and beverage production, xenobiotic degradation, and human health. By the end, students will be well-equipped for advanced studies and practical applications in microbiology.			
Units	**Course Content**			**Hours of Teaching:45 h**
I	• History and scope of microbiology • Microbes in extreme environment			8.0 h
II	• Position of microorganisms in the living world; Ecological, morphological, physiological, biochemical and molecular criteria for			7.0 h

[12] SEC – Skill Enhancement Course; AEC – Ability Enhancement Course; VAC – Value Added Course; MD – Multidisciplinary Course

[13] 1 Credit (Theory) = 15 Hours; 1 Credit (Practical) = 30 Hours

	the classification of bacteria (scheme not required)	
III	• Structure of a bacterial cell: flagella, cell envelope, cell membrane, chromosome, plasmid and endospore • Structure of bacteriophages T4 and Lambda; Lysogenic and lytic cycle	8.0 h
IV	• A brief account of genetic recombination in bacteria (transformation, conjugation and transduction) • Role of microorganisms in carbon and nitrogen cycling	10.0 h
V	• Microorganisms and their role in the production of antibiotics • Role of microbes in alcohol and beverages production • Microbes in xenobiotic degradation • Microorganisms and human health	12.0 h

Texts/ References	1. Willey J, Sandman K, Wood D (2020) Prescott's Microbiology, 11th edition, McGraw-Hill, New York. 2. Madigan MT, Bender KS, Buckley DH, Sattley WM, Stahl DA (2020) Brock Biology of Microorganism, 16th edition, Pearson Education, London, United Kingdom 3. Stanier RY, Ingraham JL, Wheelis ML, Painter PR (1987) General Microbiology, 5th edition, MacMillan Press Ltd, New Jersey. 4. Dubey RC, Maheshwari DK (2014) A Textbook of Microbiology, Revised edition, S Chand and Company Ltd, New Delhi
Learning Outcomes	Upon completion of this course, students will be able to describe the history and scope of microbiology, classify microorganisms based on various criteria, and explain the structure and function of bacterial cells and bacteriophages. They will understand genetic recombination in bacteria, and the roles of microorganisms in carbon and nitrogen cycling, antibiotic production, alcohol and beverage production, xenobiotic degradation, and human health. This knowledge will enable students to apply microbiological concepts to practical and research contexts effectively.

Course Title	**BOTMN22: Lab Work Based on Paper BOTMN21**	
Units	**Practicals**	**Hours of Teaching:30 h**
I	• Study of free-living nitrogen fixing cyanobacteria (*Nostoc*, *Anabaena* and *Aulosira*)	6.0 h
II	• Study of symbiotic nitrogen fixers in *Cycas* and *Azolla* plants	6.0 h
III	• Calibration of microscope using ocular and stage micrometers, and the measurement of dimensions of microbial cells	6.0 h
IV	• Study of cyanobacterial blooms • Gram's staining of bacteria	6.0 h
V	• Demonstration of equipments (autoclave, laminar flow, thermal cycler, spectrophotometer and bacteriological incubators)	6.0 h

Course Title	**BOTMD21: Herbal Medicine**
Category of Course[14]	Major / Minor/ Minor (Vocational) / SEC / AEC / VAC / **MD**/Internship/Dissertation

Credits[15]**& Hour of Teaching**

	Theory	Practical	Cumulative
Credits	2	1	3
Hour of Teaching	30	30	60

Course Objectives

This course aims to provide students with a comprehensive understanding of herbal medicine, including its fundamentals and integration into complementary, alternative, and integrative medicine. Students will learn about the standardization of herbal drugs through pharmacognostical and organoleptic studies, and techniques for analyzing herbal drugs using chromatographic methods. The course will cover the commercial cultivation, diagnostic features, bioactive molecules, and therapeutic values of various medicinal plants. Additionally, students will explore herbs' therapeutic actions, conservation efforts, bioprospection, and protection of traditional medicinal knowledge. By the end, students will be equipped to critically evaluate and apply herbal medicine in various contexts.

Units	Course Content	Hour of Teaching:30 h
I	• Fundamentals of herbal medicine:MateriaMedica- an introduction to herbal medicine; herbal medicine an integral part of complementary, alternative and integrative medicine	4.0 h
II	• Standardization of herbal drugs:Pharmacognostical and organoleptic study of the herbal medicines; Factors affecting the quality of herbs ingredients, adulterations of herbal drugs, deterioration of herbal drugs, substitution of herbs, counterfeiting of herbal medicine	6.0 h
III	• Analysis of herbal drugs: Chromatographic analysis of herbal drugs using TLC, High-Performance Thin-Layer Chromatography (HPTLC), HPLC	5.0 h
IV	• Commercial cultivation, diagnostic features, bioactive molecules and therapeutic values of some common medicinal plants: Giloy, Brahmi, Safed Musli, Aola, Kalmegh, Satavari, Bel, Sarpgandha, Ashwagandha, Aloe, Tulsi, Neem	7.0 h
V	• Herbs and drug action: Neuro-promontory drugs, Cardiovascular drugs, Nutraceuticals and medicinal foods; anti-inflammatory drugs and anticancer drugs • Conservation of medicinal plants • Bioprospection, biopiracy and protection of traditional medicinal knowledge	8.0 h

Texts/ References

1. SC Mandal (2011). Herbal Drugs, New Central Book Agency, New Delhi.
2. ND Prajapati, S.S. Purohit, Arun K. Sharma andTarun Kumar (2006). A Hand Book of Medicinal Plants: A Complete Source Book, Agrobios (India), Jodhpur.
3. SG Joshi (2018). Medicinal Plants,Oxford& IBH Publishing.
4. JB (2019). Herbal Medicine: Simple and Effective Natural Remedies to Heal Common Ailments,Novelty Publishing LLC
5. AK (2014). Fundamentals of Herbal Medicine: Science of Nutrition, Human Anatomy and Body Systems, Chaukhambha Orientalia.
6. PC Trivedi (2009). Indian Medicinal Plants. Aavishkar Publishers & Distributors.
7. SK Bhattacharjee (2019). Hand Book of Aromatic Plants. 3rd Edition; Pointer Publishers.
8. LD Kapoor (2005). Handbook of Ayurvedic Medicinal Plants.
9. MP Singh et al. (2003). Indigenous Medicinal Plants Social Forestry &Tribals. Daya Publishing House.
10. VV Sivarajan & I Balachandran (1994). Ayurvedic Drugs and their Plant Sources, Oxford&

[14] SEC – Skill Enhancement Course; AEC – Ability Enhancement Course; VAC – Value Added Course; MD – Multidisciplinary Course

[15] 1 Credit (Theory) = 15 Hours; 1 Credit (Practical) = 30 Hours

	IBH. 11. HW Youngken (2018). A Text Book of Pharmacognosy, Palala Press.
Learning Outcomes	Upon completing this course, students will be able to understand the fundamentals of herbal medicine and its role in integrative health practices. They will be proficient in the standardization and analysis of herbal drugs, using techniques like TLC, HPTLC, and HPLC. Students will gain knowledge about the commercial cultivation, diagnostic features, and therapeutic values of key medicinal plants. Additionally, they will be able to assess herbs' therapeutic actions, understand issues related to conservation, bioprospection, and protection of traditional medicinal knowledge, and apply this understanding to practical and research contexts in herbal medicine.

Course Title	**BOTMD22: Lab Work Based on Paper BOTMD21**	
Units	**Practicals**	**Hours of Teaching:30 h**
I	• Identification and medicinal value of locally available medicinal plants	10.0 h
II	• Locally available crude herbal raw materials and its histo- anatomical analysis	10.0 h
III	• Methods of extraction of drugs from crud herbal raw materials: Maceration, Decoction, and Hot continuous extraction (Soxhlet)	10.0 h

Course Title	**AE2: Offered by Institute/University (2 Credits)**
Category of Course[16]	Major / Minor / Minor (Vocational) / SEC / **AEC-2**/ VAC / MD/Internship/Dissertation

Course Title	**BOTSE21: Preservation and Management of Microbial Resource**			
Category of Course[17]	Major / Minor / Minor (Vocational) / **SEC** / AEC / VAC / MD/Internship/Dissertation			
Credits[18]**& Hour of Teaching**		Theory	Practical	Cumulative
	Credits	2	1	3
	Hour of Teaching	30	30	60
Course Objectives	This course provides an overview of the principles and practices involved in the preservation and management of microbial resources. It covers the importance of microbial diversity, various preservation techniques, microbial culture collections, and the legal and ethical aspects of microbial resource management. Students will gain practical knowledge and skills necessary for handling, preserving, and managing microbial resources in research and industrial settings.			

Units	**Course Content**	**Hours of Teaching:30 h**
I	Introduction to Microbial Resources Types of microorganisms, their roles in the environment, and importance in various industries, Ecological, industrial, and biotechnological importance of preserving microbial diversity, Definition, examples, and the concept of microbial genetic resources.	6.0 h
II	Techniques for Preserving Microbial Cultures Refrigeration, storage on agar slants, and sub-culturing, Cryopreservation,	6.0 h

[16] SEC – Skill Enhancement Course; AEC – Ability Enhancement Course; VAC – Value Added Course; MD – Multidisciplinary Course

[17] SEC – Skill Enhancement Course; AEC – Ability Enhancement Course; VAC – Value Added Course; MD – Multidisciplinary Course

[18] 1 Credit (Theory) = 15 Hours; 1 Credit (Practical) = 30 Hours

	lyophilization (freeze-drying), and storage in liquid nitrogen, Factors affecting the stability and viability of preserved cultures.	
III	Microbial Culture Collections Standards and protocols for maintaining microbial collections, Examples of major culture collections (e.g., ATCC, DSMZ) and their significance in research and industry, Importance of accurate documentation and information systems in managing culture collections.	6.0 h
IV	Legal and Ethical Considerations Patents, copyrights, and trademarks related to microbial resources, Guidelines for the safe handling and transport of microbial cultures, Access and benefit-sharing, biopiracy, and compliance with the Nagoya Protocol.	6.0 h
V	Microbial Resource Management Real-world examples of microbial resource management in research and industry, Management and preservation of microbial cultures, including creating a mini-culture collection.	6.0 h

Texts/ References	1. Atlas, R.M. (2010). Handbook of Microbiological Media. CRC Press. 2. Smith, D., & Onions, A.H.S. (1994). The Preservation and Maintenance of Living Fungi. CAB International. 3. Sneath, P.H.A., & Holt, J.G. (2001). Bergey's Manual of Systematic Bacteriology. Springer.
Learning Outcomes	This course content provides a structured approach to understanding and managing microbial resources, equipping students with both theoretical knowledge and practical skills essential for careers in microbiology and related fields.

Course Title	**BOTSE22: Lab Work Based on PaperBOTSE21**	
Units	**Practicals**	**Hours of Teaching:30 h**
I	Isolation and Culturing of Microorganisms, Techniques for isolating microorganisms from soil, water, and air samples	10.0 h
II	Preservation of Microorganisms by freezing with glycerol. Preparation of cryoprotectants, Freezing and storage techniques for bacteria, fungi and algae	10.0 h
III	Lyophilization (Freeze-Drying) methods for preservation	5.0 h
IV	Examination of successful microbial resource management project	5.0 h

Course Title	**VA3: Offered by Institute/University(2 Credits)**
Category of Course[19]	Major / Minor / Minor (Vocational) / SEC / AEC / **VAC-3**/ MD/Internship/Dissertation

Course Title	**VA4: Offered by Institute/University(2 Credits)**
Category of Course[20]	Major / Minor / Minor (Vocational) / SEC / AEC / **VAC-4**/ MD/Internship/Dissertation

[19] SEC – Skill Enhancement Course; AEC – Ability Enhancement Course; VAC – Value Added Course; MD – Multidisciplinary Course

[20] SEC – Skill Enhancement Course; AEC – Ability Enhancement Course; VAC – Value Added Course; MD – Multidisciplinary Course

SEMESTER: III

Course Title	**BOTMJ31: Cytology and Genetics**
Category of Course[21]	**Major** / Minor / Minor (Vocational) / SEC / AEC / VAC / MD/Internship/Dissertation
Credits[22] **& Hour of Teaching**	

	Theory	Practical	Cumulative
Credits	3	1	4
Hour of Teaching	45	30	75

Course Objectives	This course aims to provide a comprehensive understanding of cytology and genetics. It covers the fundamentals of cell biology, including cell structure, organelles, and the ultrastructure of the nucleus. Students will study cell division processes, including mitosis and meiosis, and explore basic and advanced genetic principles, such as Mendelian genetics, gene interactions, and linkage. The course also addresses genetic mapping, extra-nuclear inheritance, and sex determination mechanisms. By the end, students will be equipped with a solid foundation in cytological and genetic concepts applicable to both research and practical applications.

Units	**Course Content**	**Hours of Teaching:45 h**
I	• Introduction to cell: Cell as the basic unit of life, cell theory, prokaryotic and eukaryotic cell, differences between plant and animal cell • Structural organization and function of intracellular organelles • Cell wall: primary and secondary structure, middle lamella, plasmodesmata, apoplast and symplast and their functions • Cell membrane: chemical composition, membrane models, function • Cytoskeleton: microtubules, microfilaments and intermediate filaments, structure and their functions. • Endomembrane system: endoplasmic reticulum, Golgi apparatus, lysosomes, peroxisomes, vacuoles	10.0 h
II	• Other organelles: mitochondria, chloroplast and ribosomes • Ultrastructure of nucleus: nuclear envelope, NPC, nucleolus, chromatin and chromosomes, DNA packaging, euchromatin and heterochromatin, special types of chromosomes- polytene chromosomes, lamp brush chromosomes, B chromosomes	10.0 h
III	• Cell division: Cell cycle, mitosis and meiosis, control and regulation of cell cycle, significance of meiosis	5.0 h
IV	• Basic Principles of Genetics: Pre-Mendalian concepts of Genetics, Mendel's experiments, law of segregation and law of independent assortment • Neo Mendelism: Intergenic and intragenic gene interactions, incomplete dominance and Co-dominance, lethal alleles, epistasis, complementary gene, supplementary gene, inhibitory gene, duplicate gene, multiple allelism	6.0 h
V	• Linkage, Crossing over and Genetic mapping: Chromosomal theory of inheritance, Linkage and crossing over, Cytological basis of crossing over, crossing over and linkage map • Intragenic mapping and modern concept of gene • Extra-Nuclear Inheritance: Chloroplast and mitochondrial genomes, chloroplast inheritance and variegation in Four O'clock plant, mitochondrial inheritance in *Neurospora* and petites in yeast, maternal effect; shell coiling in Snails and Kappa particles in	14.0 h

[21] SEC – Skill Enhancement Course; AEC – Ability Enhancement Course; VAC – Value Added Course; MD – Multidisciplinary Course

[22] 1 Credit (Theory) = 15 Hours; 1 Credit (Practical) = 30 Hours

	Paramecium • Sex determination: Basis of sex determination, sex determination in plants, chromosome theory of sex determination, sex linked characters	

Texts/ References	1. Gardner, E.J., Simmons, M.J., Snustad, D.P. (1991). Principles of Genetics, 8th edition. New Delhi, Delhi: John Wiley & sons. 2. Griffiths, A.J.F., Doebley,J., Peichel, C, Wassarman D (2020). Introduction to Genetic Analysis, 12th edition. New York, NY: W.H. Freeman and Co. 3. Clark MS, Wall WJ (1996) Chromosomes: The Complex Code, Chapman & Hall, London. 4. Alberts B, Bray D, Lewis J, Ralf M, Roberts K, Watson JD (1999) Molecular Biology of the Cell, Garland Publishing Inc, New York.. 5. Campbell, N.A., Reece J.B., Urry L.A., Cain M.L., Wasserman S.A., Minorsky P.V., Jackson, R.B. (2020). Biology. San Francisco, SF: Pearson Benjamin Cummings. 6. Russell, P. J. (2010). Genetics- A Molecular Approach. 3rd Edition. Benjamin Cummings. 7. Snustad, D.P., Simmons, M.J. (2016). Principles of Genetics, 7th Edition. New Delhi, Delhi: John Wiley & sons. 8. Hartl, D.L., Ruvolo, M. (2019). Genetics: Analysis of Genes and Genomes, 9th edition, Jones and Bartlett Learning. 9. Singh, B. D. (2023). Fundamentals of Genetics, 6th edition. MedTech. 10. De Robertis EDP, De Robertis EMF (2006) Cell and Molecular Biology, 8th edition, 11. Cooper GM (2019) The Cell: A Molecular Approach, 8th edition, Sinauer Oxford University Press, New York. 12. Alberts, Heald, Johnson, Morgan, Raff, Roberts, Walter Molecular Biology of the Cell, 7th edition, W.W. Norton & Company. 13. Gerald Karp (2019). Cell and Molecular Biology, 9th edition, Wiley 14. Harvey Lodish, Arnold Berk, Chris A. Kaiser, et al., (2016) Molecular Cell Biology, 8th edition, WH Freeman.
Learning Outcomes	Upon completing this course, students will be able to understand cell structure and function, including organelles and the nucleus, and explain cell division processes such as mitosis and meiosis. They will grasp fundamental and advanced genetic principles, including Mendelian genetics, gene interactions, linkage, and genetic mapping. Students will also be familiar with extra-nuclear inheritance, sex determination mechanisms, and their applications in various organisms. This knowledge will provide a strong foundation for further studies and research in cytology and genetics.

Course Title	**BOTMJ32: Lab Work Based on Paper BOTMJ31**

Units	**Practicals**	**Hours of Teaching:30 h**
I	• Acquaintance with cytochemical techniques: fixative and stains • Study of prokaryotic (cyanobacteria) and eukaryotic cells (onion peel)	6.0 h
II	• Mitosis in root tip of onion	6.0 h
III	• Meiosis in flower bud of onion	6.0 h
IV	• Demonstration of Mendel's law using Chi-square test (Monohybrid and Dihybrid Crosses)	6.0 h
V	• Study of epistasis using Chi-square test • Demonstration and construction of linkage map using suitable data	6.0 h

Course Title	**BOTMJ33: Plant Anatomy and Embryology**
Category of Course[23]	**Major**/ Minor / Minor (Vocational) / SEC / AEC / VAC / MD/Internship/Dissertation
Credits[24]**& Hour of Teaching**	

	Theory	Practical	Cumulative
Credits	3	1	4

[23] SEC – Skill Enhancement Course; AEC – Ability Enhancement Course; VAC – Value Added Course; MD – Multidisciplinary Course

	Hour of Teaching	45	30	75

Course Objectives	This course aims to provide students with an in-depth understanding of plant anatomy and embryology. It covers tissue classification, shoot apex organization, and the structural differences between dicot and monocot leaves and stems. Students will study cambium function, secondary growth, and anatomical anomalies in stems and roots. The course also includes detailed exploration of flower structure, reproductive processes, and gametogenesis. Additionally, students will learn about pollination, fertilization, endosperm development, and embryogeny in dicots and monocots. By the end of the course, students will gain comprehensive knowledge of plant structure and development crucial for advanced botanical studies.

Units	**Course Content**	**Hours of Teaching:45 h**
I	• Classification of tissues: simple and complex Organization of shoot apex: Apical cell theory, Histogen theory, Tunica Corpus theory	9.0 h
II	• Structure of dicot and monocot leaf, Kranz anatomy • Structure of dicot and monocot stem • Structure, function and seasonal activity of cambium; secondary growth in root and stem	10.0 h
III	• Anatomy of stem and root with special reference to plants showing anomalies: *Nyctanthes, Bignonia, Strychnos, Boerhaavia, Dracaena*; Root-*Tinospora*	6.0 h
IV	• Flower structure and reproduction • Microsporangium and microsporogenesis • Megasporangium and megasporogenesis • Male gametophyte	10.0 h
V	• Female gametophyte • Pollination and fertilization • Endosperm (different modes of development) • Embryogeny (development of typical dicot and monocot embryo)	10.0 h

Texts/ References	1. Dickson, W.C. (2000) Integrative Plant Anatomy. Harcourt Academic Press, USA. 2. Fahn, A. (1974) Plant Anatomy. Pergmon Press, USA. 3. Mauseth, J. D. (1988) Plant Anatomy. The Benjammin/ Cummings Publisher, USA. 4. Esau, K. (1977). Anatomy of Seed Plants. John Wiley and Sons, Inc., Delhi. 5. Pandey BP (2007) Angiosperms- Taxonomy, Embryology and Anatomy, S Chand and Co, New Delhi. 6. Tayal MS (1994) Plant Anatomy, Rastogi Publications, Meerut. 7. Bhojwani SS, Bhatnagar SP and Dantu PK (2015) The Embryology of Angiosperms, 6th Edition, Vikas Publishing House Pvt Ltd, Noida. 8. Johri, BM (2011) Embryology of Angiosperms, Springer Berlin Heidelberg.
Learning Outcomes	Upon completing this course, students will be able to identify and classify plant tissues, understand shoot apex organization theories, and describe the structural differences between dicot and monocot leaves and stems. They will also be able to explain cambium function, secondary growth, and anatomical anomalies in stems and roots. Students will gain knowledge of flower structure, reproductive processes, gametogenesis, and the development of endosperm and embryos in dicots and monocots. This comprehensive understanding will enable students to apply anatomical and embryological concepts to advanced botanical research and practical applications.

[24] 1 Credit (Theory) = 15 Hours; 1 Credit (Practical) = 30 Hours

Course Title	BOTMJ34: Lab Work Based on Paper BOTMJ33

Units	Practicals	Hours of Teaching:30 h
I	• T.S. of stems:*Nyctanthes, Bignonia, Strychnos, Boerhaavia* and *Dracaena*	15.0 h
II	• T.S of *Tinospora* root	5.0 h
III	• T.S of dicot leaf and monocot leaf	5.0 h
IV	• Adaptive Anatomy of xerophytes and hydrophytes	5.0 h

Course Title	BOTMV31: Mushroom Cultivation			
Category of Course[25]	Major/ Minor / **Minor (Vocational-1)**/ SEC / AEC /VAC / MD/Internship/Dissertation			
Credits[26]& Hour of Teaching		Theory	Practical	Cumulative
	Credits	3	1	4
	Hour of Teaching	45	30	75
Course Objectives	This course aims to provide students with a comprehensive understanding of mushroom cultivation, including identification of edible and medicinal species, and various cultivation methods such as substrate preparation, spawning, casing, and outdoor techniques. It covers environmental factors affecting cultivation, common diseases and pests along with their control strategies, and best practices for harvesting, handling, packaging, and storage. Additionally, students will explore the economic and nutritional importance of mushrooms. By the end of the course, students will be equipped with practical knowledge and skills for successful mushroom cultivation and management.			

Units	Course Content	Hours of Teaching:45 h
I	• Introduction to Mushroom Cultivation	7.0 h
II	• Mushroom Identification: Edible and medicinal mushroom species	8.0 h
III	• Cultivation Methods: Substrate preparation, spawning, casing and outdoor cultivation methods	8.0 h
IV	• Environmental Factors affecting mushroom cultivation • Common diseases and pests affecting mushroom cultivation and its control strategies	12.0 h
V	• Harvesting, handling, packaging, and storage of mushrooms • Economic and nutritional importance of mushrooms	10.0 h

Texts/ References	1. Mushroom Cultivation and Its Use in Rural Development by J. H. Wasson. 2. The Mushroom Cultivator: A Practical Guide to Growing Mushrooms at Home by PaulStamets and J. S. Chilton. 3. Mushroom Biology: Concise Basics and Current Developments by Philip G. Miles and Shu-Ting Chang. 4. Scientific Paper: "Cultivation of Edible Mushrooms by Authors: M. M. R. Khan, M. A. Kabir, and M. A. Hannan. 5. Website: Mushroom Expert - Mushroom Cultivation (http://www.mushroomexpert.com/) 6. Description: This website offers a wealth of information on mushroom cultivation, including tutorials, tips, and troubleshooting guides
Learning Outcomes	Upon completing this course, students will be able to identify edible and medicinal mushrooms and understand various cultivation methods, including substrate preparation, spawning, and casing. They will gain knowledge of environmental factors affecting mushroom growth, and strategies for managing diseases and pests. Students will also learn effective techniques for harvesting, handling, packaging, and storing mushrooms. Additionally, they will understand the economic and nutritional significance of mushrooms, preparing them to apply their knowledge in both practical cultivation and the broader context of mushroom production and management.

[25] SEC – Skill Enhancement Course; AEC – Ability Enhancement Course; VAC – Value Added Course; MD – Multidisciplinary Course

[26] 1 Credit (Theory) = 15 Hours; 1 Credit (Practical) = 30 Hours

Course Title	BOTMV32: Lab Work Based on Paper BOTMV31

Units	Practicals	Hours of Teaching: 30 h
I	• Hands-on lab sessions on substrate preparation	10.0 h
II	• Spawning and casing layer application	10.0 h
III	• Field visits and case Studies	10.0 h

Course Title	BOTMD31: Industrial Microbiology
Category of Course[27]	Major / Minor / Minor (Vocational) / SEC / AEC /VAC / MD/Internship/Dissertation
Credits[28]& Hour of Teaching	See table below
Course Objectives	This course aims to provide students with a comprehensive understanding of industrial microbiology, including its definition, scope, and historical development. Students will explore the role of microorganisms in industrial processes, microbial growth and physiology, and the applications of microbial biotechnology in agriculture, environment, pharmaceuticals, and energy. The course covers food and beverage microbiology, including fermentation processes and biotechnological advancements, as well as the role of microbes in food spoilage, enzyme production, and biofuels. Additionally, students will study pharmaceutical microbiology, focusing on biopharmaceutical production, microbial contamination, sterilization, and regulatory compliance.

	Theory	Practical	Cumulative
Credits	2	1	3
Hour of Teaching	30	30	30

Units	Course Content	Hours of Teaching:30 h
I	• Introduction to Industrial Microbiology:Definition and scope of industrial microbiology, historical development and milestones, microorganisms and their role in industrial processes, importance of industrial microbiology in the modern world • Microbial Growth and Physiology:Microbial cell structure and function, growth phases and factors influencing microbial growth, measurement of microbial growth, microbial metabolism and energy production	6.0 h
II	• Microbial Biotechnology:Microbial biotechnology in the context of agriculture, environment, pharmaceuticals and energy - An Overview. Industrial applications of genetic engineering for production of biopharmaceuticals and industrial enzymes; synthetic biology and its industrial implications	6.0 h
III	• Food and Beverage Microbiology:Microorganisms as source of food such as single cell protein, curd, yogurt, bakery products and mushrooms; biotechnological advancements in the food industry, fermentation processes, basic design of a fermenter and production of alcohol, vinegar, organic acids and amino acids	6.0 h
IV	• Microbes in spoilage of foods and food products: Cereals, vegetables, pickles, fish and dairy products, food safety, quality control and food preservation • Microbes as source of enzyme and energy:Microbial production of industria enzymes, amylase, cellulase, protease, lipase**,** microbes as a source of bioplastic and biofuels (ethanol, methane and biogas	6.0 h

[27] SEC – Skill Enhancement Course; AEC – Ability Enhancement Course; VAC – Value Added Course; MD – Multidisciplinary Course

[28] 1 Credit (Theory) = 15 Hours; 1 Credit (Practical) = 30 Hours

V	• Pharmaceutical microbiology:Biopharmaceutical production of vaccines, antibiotics, interferons; microbial contamination in pharmaceuticals, sterilization techniques and aseptic processing, quality control and regulatory considerations • Safety and Regulations:Biosafety in industrial microbiology, ethical considerations in microbiology, regulatory guidelines and its compliance	6.0 h
Texts/ References	1. Prescott's Microbiology by Joanne M. Willey, Linda Sherwood, and Christopher J. Woolverton. 2. Industrial Microbiology: An Introduction by Michael J. Waites, Neil L. Morgan, and John S. Rockey. 3. Industrial Microbiology by L. E. Casida Jr. 4. Principles of Fermentation Technology by Whittaker and Stanbury.	
Learning Outcomes	Upon completing this course, students will understand the scope and significance of industrial microbiology, including the role of microorganisms in various industrial processes. They will be able to describe microbial growth and physiology, and apply microbial biotechnology to agriculture, environment, pharmaceuticals, and energy. Students will gain insights into food and beverage microbiology, fermentation processes, and microbial contributions to enzyme production and biofuels. They will also be knowledgeable about pharmaceutical microbiology, focusing on biopharmaceuticals, contamination control, sterilization, and regulatory guidelines. This knowledge will prepare students for practical applications and advancements in industrial microbiology.	

Course Title	**BOTMD32: Lab Work Based on Paper BOTMD31**	
Units	**Practicals**	**Hours of Teaching:30 h**
I	• Study of growth behaviour of bacteria and determination of generation time (g) • Enumeration of bacteria from environmental sample using serial dilution method	6.0 h
II	• Qualitative detection of microorganisms producing amylase, cellulose, protease and lipase	6.0 h
III	• Qualitative detection of microorganisms which ferment carbohydrates	6.0 h
IV	• Testing antibiotic sensitivity of microorganisms (Disc diffusion method)	6.0 h
V	• Methylene blue reduction test to assess quality of milk samples	6.0 h

Course Title	**AE3: Offered by Institute/University (2 Credits)**
Category of Course[29]	Major / Minor / Minor (Vocational) / SEC / **AEC-3** / VAC / MD/Internship/Dissertation

[29] SEC – Skill Enhancement Course; AEC – Ability Enhancement Course; VAC – Value Added Course; MD – Multidisciplinary Course

Course Title	BOTSE31: Ethnobotany
Category of Course[30]	Major / Minor / Minor (Vocational) / **SEC** / AEC / VAC / MD/Internship/Dissertation

Credits[31] & Hour of Teaching

	Theory	Practical	Cumulative
Credits	2	1	3
Hour of Teaching	30	30	60

Course Objectives

The course aims to provide a comprehensive understanding of ethnobotany by exploring its history, scope, and methodologies. Students will learn about traditional literature, data collection techniques, and the importance of ethnobotanical flora in conservation strategies. The course will cover medico-ethnobotany, focusing on the preparation and uses of traditional medicines, and will delve into the traditional knowledge of plants like Ocimum and Withania. Additionally, students will examine the role of ethnic practices in biodiversity conservation and the relevance of ethnobotany in contemporary research and sustainable development.

Units	Course Content	Hours of Teaching:30 h
I	• History and scope of ethnobotany • Ethnobotanical studies: Traditional literature and other sources, tools and techniques (Sampling of informants, data collection, interviews & group discussion, data analysis)	6.0 h
II	• Importance of ethnobotanical flora and its conservation strategies • Medico-ethnobotany: ethnomedicine preparation, their uses	6.0 h
III	• Traditional knowledge of some plants of ethnobotanical importance: *Ocimum*, *Withania*, *Andrographis*, *Terminalia*, *Phyllanthus*, *Eclipta*, *Artemesia*, *Moringa* • Role of ethnic practices in biodiversity conservation: ethnic groups, religious practices, sacred place, sacred groves, community protocols	6.0 h
IV	• Ethnobotany and its relevance in contemporary research • Importance of ethnobotanical flora and its conservation strategies	6.0 h
V	• Traditional Herbal Medicine • Role of Ethnobotany in sustainable development	6.0 h

Texts/ References

1. Maheshwari JK (2019) Ethnobotany and medicinal plants of Indian subcontinent, Scientific publishers, Jodhpur, India.
2. Martinez JL, Munoz- Acevedo A& Rai M (2018) Ethnobotany: application of medicinal plants, CRC Press.
3. Jordan JA, Minnis PE, Eliseus WJ (2014) Plains apache ethnobotany, University of Oklahoma Press.
4. Young KJ & Hopkins WG (2006) Ethnobotany, Facts on File.

Learning Outcomes

Upon completion of this course, students will have a deep understanding of ethnobotany, including its history, methodologies, and practical applications. They will be proficient in ethnobotanical study techniques such as data collection and analysis, and recognize the significance of ethnobotanical flora for conservation. Students will gain insights into medico-ethnobotany, including traditional medicinal practices and plant uses. They will also appreciate the role of ethnic practices in preserving biodiversity and understand the relevance of ethnobotany in contemporary research and sustainable development. This knowledge will equip them to contribute effectively to ethnobotanical and conservation efforts.

[30] SEC – Skill Enhancement Course; AEC – Ability Enhancement Course; VAC – Value Added Course; MD – Multidisciplinary Course

[31] 1 Credit (Theory) = 15 Hours; 1 Credit (Practical) = 30 Hours

Course Title	BOTSE32: Lab Work Based on Paper BOTSE31	
Units	**Practicals**	**Hours of Teaching:30 h**
I	• Preparation of herbarium of 10 ethnobotanical plants	10.0 h
II	• Local visit to identify the plants used in traditional medicine	10.0 h
III	• People-plant interaction: Collection of data about traditional uses of local plants from common people	10.0 h

SEMESTER: IV

Course Title	**BOTMJ41: Angiosperm Taxonomy**
Category of Course[32]	**Major** / Minor / Minor (Vocational) / SEC / AEC /VAC / MD/Internship/Dissertation
Credits[33]**& Hour of Teaching**	Theory: Credits 3, Hour of Teaching 45 — Practical: 1, 30 — Cumulative: 4, 75
Course Objectives	This course aims to provide students with a thorough understanding of angiosperm taxonomy and classification. It covers principles and systems of plant classification, including Bentham and Hooker's and Hutchinson's systems. Students will learn about the distinguishing characteristics and economic importance of various dicot and monocot families. The course also explores botanical nomenclature, numerical taxonomy, and the role of embryology and chemotaxonomy in plant classification. Additionally, students will gain insights into molecular approaches and the APG system of classification. By the end of the course, students will be equipped to apply these concepts to the study and classification of angiosperms.

Units	**Course Content**	**Hours of Teaching:45 h**
I	• Systematics: Principles, outline, merits and demerits of classification; Bentham and Hooker's system, Hutchinson system	8.0 h
II	• Distinguishing characteristics of the following families and their economic importance: a. *Dicots: Ranunculaceae, Papaveraceae, Myrtaceae, Apiaceae, Cucurbitaceae, Rubiaceae, Apocynaceae, Asclepiadaceae, Solanaceae, Acanthaceae, Lamiaceae, Euphorbiaceae, Asteraceae* b. *Monocots: Zingeberaceae,Poaceae, Cyperaceae*	20.0 h
III	• Botanical nomenclature: International code of nomenclature; principles: rules and recommendations; priority; typification; rules of effective and valid publications; retention and choice of names • Numerical Taxonomy: characters and attributes, OTUs, coding, cluster analysis, merits and demerits	8.0 h
IV	• Embryology in relation to taxonomy • Chemotaxonomy: Role of phytochemicals (non-protein amino acids, alkaloids, betalins, cynogenicglucosides) andtechniques in chemotaxonomy	6.0 h
V	• Basic idea on molecular approaches to angiosperm taxonomy; APG system of classification	3.0 h

[32] SEC – Skill Enhancement Course; AEC – Ability Enhancement Course; VAC – Value Added Course; MD – Multidisciplinary Course

[33] 1 Credit (Theory) = 15 Hours; 1 Credit (Practical) = 30 Hours

Texts/ References	1. Singh V, Jain DK (2012) Taxonomy of Angiosperms, 2nd edition, Rastogi Publication, Meerut. 2. Pandey BP (2007) Angiosperms- Taxonomy, Embryology and Anatomy, S Chand and Co, New Delhi. 3. Chopra GL (1984) Angiosperms: Systematic and Life Cycle, Pradeep Publications, Jalandhar. 4. Singh G (1999) Plant Systematics: Theory and Practices, Oxford and IBH Publishing Co, New Delhi. 5. Judd WS, Christopher S, Campbell, Kellogg AE, Stevens PF (1999) Plant Systematics: A Phylogenetic Approach, Sinauer Associates Inc Publishers, Sunderland, Massachusetts. 6. Simpson MG (2006) Plant Systematics, Elsevier Academic Press,Amsterdam. 7. Verma BK (2011) Introduction to Taxonomy of Angiosperms, PHI Learning, New Delhi.
Learning Outcomes	Upon completing this course, students will be able to understand and apply principles of plant systematics, including various classification systems like Bentham and Hooker's and Hutchinson's. They will be proficient in identifying and describing the characteristics and economic importance of major dicot and monocot families. Students will grasp the principles of botanical nomenclature, numerical taxonomy, and the role of embryology and chemotaxonomy in plant classification. Additionally, they will have an overview of molecular approaches and the APG classification system. This knowledge will enable students to effectively study, classify, and apply taxonomy to angiosperms.

Course Title	**BOTMJ42: Lab Work Based on Paper BOTMJ41**	
Units	**Practicals**	**Hours of Teaching:30 h**
I	• Taxonomic description of plants of the following families: *Ranunculaceae, Papaveraceae, Myrtaceae, Apiaceae, Cucurbitaceae, Rubiaceae, Apocynaceae, Asclepiadaceae, Solanaceae, Acanthaceae, Lamiaceae, Euphorbiaceae,Asteraceae, Zingeberaceae,Poaceae, Cyperaceae*	20.0 h
II	• Plant collection: submission of at least 25 herbarium sheets	10.0 h

Course Title	**BOTMJ43: Gymnosperm and Paleobotany**
Category of Course[34]	**Major** / Minor / Minor (Vocational) / SEC / AEC /VAC / MD/Internship/Dissertation

Credits[35] **& Hour of Teaching**

	Theory	Practical	Cumulative
Credits	3	1	4
Hour of Teaching	45	30	75

Course Objectives	This course aims to provide students with a comprehensive understanding of gymnosperms and paleobotany. It covers the characteristic features and classification of gymnosperms, including detailed accounts of Progymnospermopsida, Pteridospermales, and Glossopteridales. Students will study the morphology, anatomy, and reproduction of key gymnosperms such as Cycas, Pinus, and Ephedra. The course also introduces paleobotany, including the geological timescale, evolutionary trends, and the origin of plant groups. Additionally, students will learn about fossils, their types, the process of fossilization, and their significance in understanding plant evolution.

Units	**Course Content**	**Hours of Teaching: 45 h**
I	Characteristic features and classification of Gymnosperms General accounts of Progymnospermopsida and Pteridospermales (*Lyginopteris*plant; *Sphenopteris* leaf, *Lygonopteris*stem, *Crossotheca* male organ *and Lagenostoma* female organ)	6.0 h

[34] SEC – Skill Enhancement Course; AEC – Ability Enhancement Course; VAC – Value Added Course; MD – Multidisciplinary Course

[35] 1 Credit (Theory) = 15 Hours; 1 Credit (Practical) = 30 Hours

II	Glossopteridales: General account of Glossopteris plant (*Vertebraria* root, *Araucarioxilon* trunk, *Glossopteris* leaf, *Glossotheca*male organ, *Dictyopteridium* female organ)	7.0 h
III	Morphology, anatomy and reproduction of *Cycas, Pinus* and *Ephedra*	16.0 h
IV	• An elementary knowledge of Paleobotany: Geological timescale • Evolutionary trends; origin and evolution of different plant groups	8.0 h
V	Fossils, Types of fossils, Process of fossilization, Importance of fossils	8.0 h

Texts/ References	1. Sporne, K.R. (1967) Morphology of Gymnosperms, BI Publication, New Delhi. 2. Bhatnagar, S.P and Moitra, A. (1996) Gymnosperms, New Age International Pvt Ltd Publishers, New Delhi. 3. Arnold, C. A. (1947) An Introduction to Palaeobotany. Mc Graw Hill Publ. Co. 4. Andrews, H. N. (1967) Studies in Palaeobotany. Wiley, New York. 5. Stewart, W. N. and Rothwell, G.W. (1993) Palaeobotany and Evolution of Plants. CambridgeUniversity Press. 6. Taylor, T. N., Taylor, E. L. and Krings, M. (2009) Palaeobotany, the biology and evolution offossil plants. Elsevier Inc. 7. Beck, C. B. (1988) Origin and evolution of gymnosperms. Columbia University Press. 8. Chamberlain, C. J. (1934) Gymnsoperms – structure and evolution. Chicago Univ. Press.
Learning Outcomes	Upon completing this course, students will be able to identify and classify gymnosperms, including Progymnospermopsida, Pteridospermales, and Glossopteridales. They will understand the morphology, anatomy, and reproduction of key gymnosperms like Cycas, Pinus, and Ephedra. Students will gain foundational knowledge in paleobotany, including the geological timescale, evolutionary trends, and the origin of plant groups. They will also be able to describe fossil types, the fossilization process, and the significance of fossils in studying plant evolution. This comprehensive understanding will equip students to apply paleobotanical concepts to the study of plant history and evolution.

Course Title	**BOTMJ44: Lab Work Based on Paper BOTMJ43**	
Units	**Practicals**	**Hours of Teaching: 30 h**
I	• *Cycas* - General morphology of vegetative and reproductive structures, anatomy (coralloid root,leaflet, rachis, permanent slides), and reproduction (megasporophyll, male cone, section ofmicrosporophyll, permanent slides of ovule and microsporophyll)	10.0 h
II	• *Pinus* - General morphology of vegetative and reproductive structures, anatomy (T.S of shoots,needle, permanent slides), reproduction (male cone, female cone, sections of megasporophyll and microsporophyll, permanent slides)	10.0 h
III	• *Ephedra* - General morphology of vegetative and reproductive structures, anatomy (stem, reproductive structures)	10.0 h

Course Title	**BOTMJ45: Plant Ecology**
Category of Course[36]	**Major**/ Minor / Minor (Vocational) / SEC / AEC /VAC / MD/Internship/Dissertation

Credits[37] **& Hour of Teaching**

	Theory	Practical	Cumulative
Credits	3	1	4
Hour of Teaching	45	30	75

Course Objectives

This course aims to provide students with a foundational understanding of plant ecology. It covers the abiotic and biotic components of the environment, including interactions among plants, animals, and microorganisms. Students will learn about plant adaptations to water, light, and temperature, and explore population dynamics and community ecology, focusing on analytical and synthetic characters. The course also includes ecosystem ecology, covering ecosystem structure, function, and biogeochemical cycles. Additionally, students will study ecological succession, including its processes, mechanisms, and patterns such as hydrosere and xerosere. This comprehensive knowledge will enable students to analyze and interpret ecological interactions and processes in plant communities.

Units	Course Content	Hours of Teaching:45 h
I	• Introduction to ecology • Abiotic environment: Atmosphere, temperature, water, light and soil (structure and soil profile)	8.0 h
II	• Biotic environment: Interactions among plants, animals and man; interactions among plants growing in a community; interactions among plants and microorganisms	8.0 h
III	• Plant adaptations in response to water availability, light and temperature • Population: Concepts, attributes and dynamics	9.0 h
IV	• Community Ecology: Analytical and synthetic characters (Frequency, density, cover, IVI, life forms, biological spectrum, phenology, sociability)	8.0 h
V	• Ecosystem Ecology: Ecosystem structure (abiotic and biotic components, food chain, food web, ecological pyramids); ecosystem function (models of energy flow), biogeochemical cycles (carbon, nitrogen, and phosphorus) • Ecological succession: General process, mechanisms and patterns (Hydrosere and Xerosere)	12.0 h

Texts/ References

1. Odum EP, Barrett GW (2005) Fundamentals of Ecology, Thomson Ed. Brooks/Cole, Cengage Learning India Pvt. Ltd, New Delhi.
2. Odum EP (1983) Basic Ecology Ed. Saunders College Pub, New York.
3. Smith TM, Smith RL (2008) Elements of Ecology, 7th edition, Benjamin- Cummings New York.
4. Miller GT (2004) Essentials of Ecology, 3rd edition, Brooks, Cole, New York.
5. Smith RL (2001) Ecology and Field Biology, Benjamin Cummings, New York.
6. Vallero D (2014) Fundamentals of Air Pollution, 3rd edition, Academic Press, Elsevier, Burlington.
7. Klassen C, Watkins JB (2010) Essentials of Toxicolgy, 2nd edition, McGraw- Hill Companies, New York.
8. Singh JS, Singh SP, Gupta SR (2014) Ecology Environmental Science and Conservation, S Chand & Co, New Delhi.
9. Mueller-Dombois D, Ellenberg H (1974), Aims and Methods of Vegetation Ecology. Wiley & Sons., NY, USA

Learning

Upon completing this course, students will be equipped to analyze and interpret the complex

[36] SEC – Skill Enhancement Course; AEC – Ability Enhancement Course; VAC – Value Added Course; MD – Multidisciplinary Course

[37] 1 Credit (Theory) = 15 Hours; 1 Credit (Practical) = 30 Hours

Outcomes	interactions within plant ecology. They will understand the influence of abiotic factors like atmosphere, temperature, water, light, and soil structure on plant life. Students will gain insights into biotic interactions among plants, animals, and microorganisms, and how plants adapt to environmental variables such as water availability, light, and temperature. They will be able to describe population dynamics, community ecology metrics, and ecosystem functions, including energy flow and biogeochemical cycles. Additionally, students will grasp the processes and patterns of ecological succession, enabling them to assess and manage plant communities effectively.

Course Title	**BOTMJ46: Lab Work Based on Paper BOTMJ45**	
Units	**Practicals**	**Hours of Teaching:30 h**
I	• To study soil properties by spot tests: texture, pH, CO_3^{--}, NO_3^-, base deficiency and reductivity	6.0 h
II	• Demonstration of the working and use of the instruments for measuring the environmental factors: *Temperature: Ordinary Thermometer, Maximum-Minimum Thermometer.* *Moisture: Rain Gauge, Psychrometer* *Wind velocity: Anemometer* *Light intensity: Lux meter*	6.0 h
III	• Determination of minimal size of sample lot by species-area curve • Charting of vegetation to find out coverage	6.0 h
IV	• Study of community structure by quadrat method with respect to following: *Density* *Frequency*	6.0 h
V	• Study of following ecological adaptations: *Hydrophytes: Nymphaea leaf, Hydrilla stem* *Xerophytes: Nerium leaf, Muehlenbekia, Casuarina* *Epiphytes: Vanda* *Parasites: Cuscuta with host*	6.0 h

Course Title	**BOTMJ47: Microbial Resource**
Category of Course[38]	**Major**/ Minor / Minor (Vocational) / SEC / AEC /VAC / MD/Internship/Dissertation
Credits[39]**& Hour of Teaching**	Theory: Credits 1, Hour of Teaching 15 | Practical: 1, 30 | Cumulative: 2, 45
Course Objectives	This course aims to provide students with an in-depth understanding of microbial resources and their applications for human welfare. It covers the role of microbes in food production, including fermented foods, probiotics, and single-cell proteins, as well as their use in the production of enzymes, amino acids, and biofuels. Students will explore the medical applications of microbes, such as antibiotic production and resistance. The course also addresses microbial contributions to crop improvement, waste management through composting, and bioremediation. By the end of the course, students will be equipped to apply microbial knowledge to various industries and environmental solutions.

[38] SEC – Skill Enhancement Course; AEC – Ability Enhancement Course; VAC – Value Added Course; MD – Multidisciplinary Course

[39] 1 Credit (Theory) = 15 Hours; 1 Credit (Practical) = 30 Hours

Units	Course Content	Hours of Teaching:15 h
I	• Introduction to microbial world applications for human welfare • Microbes as edible foods: Microorganism involved in fermented foods production-fermented milk, Probiotics, Cheese production, Production of alcoholic beverages; Single Cell Protein (SCP): microorganisms used, raw material used as substrate, condition for growth and production; nutritive value and uses of SCP; Baker's yeast: Production and mold cultures; Edible mushroom and nutritional value	2.0 h
II	• Microbes in industries: Microorganism involved in the production of enzymes, amino acids, organic acids, biopolymers and biofuel; biotransformation	3.0 h
III	• Microbes as medical products: Microorganism as a source of antibiotics, mode of action of antibiotics and microbial resistance against antibiotics	3.0 h
IV	• Crop improvement using microbes: Nitrogen fixing microorganisms (Cyanobacteria and Bactria), biological nitrogen fixation, bio pesticides, phosphate solubilizing bacteria, mycorrhiza, plant growth promoting rhizobacteria (PGPR)	3.0 h
V	• Microbes in composting of solid wastes: Waste water treatment, anaerobic digestion, methane production • Bioremediation and microbes: Process and organisms involved, Constraints and priorities of bioremediation, microbial degradation of hydrocarbons, microbial leaching of ores and metals, biotransformation of xenobiotics, biodegradable plastics and super bug	4.0 h

Texts/ References	1. Dubey RC, Maheshwari DK (2022). A Textbook of Microbiology. S Chand and Company Ltd, New Delhi. 2. Madigan MT, Martinko JM, Bender KS, Buckley DH, Stahl DA (2014) Brock Biology of Microorganism, 14th edition, Benjamin Cummings, New York. 3. Stanier RY, Ingraham JL, Wheelis ML, Painter PR (1987) General Microbiology, 5th edition, MacMillan, New Jersey. 4. Talaro KP, Chess B (2011) Foundation in Microbiology, 8th edition, MacGraw-Hill, New York 5. Willey JM, Sherwood L, Woolverton CJ (2013) Prescott's Microbiology, 9th edition, McGraw-Hill, New York. 6. PD Sharma (2017). Microbiology. Rastogi Publications, Meerut 7. Dubey RC, Maheshwari DK (2012) A Textbook of Microbiology, Revised edition, S Chand and Company Ltd, New Delhi.
Learning Outcomes	Upon completing this course, students will be able to identify and apply microbial resources for human welfare across various sectors. They will understand the role of microbes in food production, including fermented products and single-cell proteins, and their applications in industry for enzyme and biofuel production. Students will grasp the use of microbes in medicine, focusing on antibiotics and resistance. They will also learn how microbes contribute to crop improvement and environmental management, including composting, bioremediation, and waste treatment. This knowledge will enable students to leverage microbial technologies for sustainable and innovative solutions in multiple fields.

Course Title	BOTMJ48: Lab Work Based on Paper BOTMJ47	
Units	**Practicals**	**Hours of Teaching: 30 h**
I	• Study of free living nitrogen fixing cyanobacteria: *Nostoc*, *Anabaena*, *Aulosira*	6.0 h
II	• Study of symbiotic nitrogen fixers in *Cycas* and *Azolla*	6.0 h
III	• Study and enumeration of soil bacteria/microflora using MPN • Methylene blue reduction test of milk	6.0 h
IV	• Demonstration of certain metabolic activates: *Fermentation of carbohydrates* *Catalase activity*	6.0 h
V	• Determination of minimum inhibitory concentrations of antibiotics and toxins	6.0 h

Course Title	BOTMN41: Angiosperm Taxonomy			
Category of Course[40]	Major / **Minor**/ Minor (Vocational) / SEC / AEC /VAC / MD/Internship/Dissertation			
Credits[41]**& Hour of Teaching**		Theory	Practical	Cumulative
	Credits	3	1	4
	Hour of Teaching	45	30	75
Course Objectives	This course aims to provide students with a thorough understanding of angiosperm taxonomy and classification. It covers principles and systems of plant classification, including Bentham and Hooker's and Hutchinson's systems. Students will learn about the distinguishing characteristics and economic importance of various dicot and monocot families. The course also explores botanical nomenclature, numerical taxonomy, and the role of embryology and chemotaxonomy in plant classification. Additionally, students will gain insights into molecular approaches and the APG system of classification. By the end of the course, students will be equipped to apply these concepts to the study and classification of angiosperms.			

Units	**Course Content**	**Hours of Teaching:45 h**
I	• Systematics: Principles, outline, merits and demerits of classification; Bentham and Hooker's system, Hutchinson system	8.0 h
II	• Distinguishing characteristics of the following families and their economic importance: *a. Dicots: Ranunculaceae, Papaveraceae, Myrtaceae, Apiaceae, Cucurbitaceae, Rubiaceae, Apocynaceae, Asclepiadaceae, Solanaceae, Acanthaceae, Lamiaceae, Euphorbiaceae, Asteraceae* *b. Monocots: Zingeberaceae,Poaceae, Cyperaceae*	20.0 h
III	• Botanical nomenclature: International code of nomenclature; principles: rules and recommendations; priority; typification; rules of effective and valid publications; retention and choice of names • Numerical Taxonomy: characters and attributes, OTUs, coding, cluster analysis, merits and demerits	8.0 h
IV	• Embryology in relation to taxonomy • Chemotaxonomy: Role of phytochemicals (non-protein amino acids, alkaloids, betalins, cynogenicglucosides) andtechniques in chemotaxonomy	6.0 h
V	• Basic idea on molecular approaches to angiosperm taxonomy; APG system of classification	3.0 h

[40] SEC – Skill Enhancement Course; AEC – Ability Enhancement Course; VAC – Value Added Course; MD – Multidisciplinary Course

[41] 1 Credit (Theory) = 15 Hours; 1 Credit (Practical) = 30 Hours

Texts/ References	1. Singh V, Jain DK (2012) Taxonomy of Angiosperms, 2nd edition, Rastogi Publication, Meerut. 2. Pandey BP (2007) Angiosperms- Taxonomy, Embryology and Anatomy, S Chand and Co, New Delhi. 3. Chopra GL (1984) Angiosperms: Systematic and Life Cycle, Pradeep Publications, Jalandhar. 4. Singh G (1999) Plant Systematics: Theory and Practices, Oxford and IBH Publishing Co, New Delhi. 5. Judd WS, Christopher S, Campbell, Kellogg AE, Stevens PF (1999) Plant Systematics: A Phylogenetic Approach, Sinauer Associates Inc Publishers, Sunderland, Massachusetts. 6. Simpson MG (2006) Plant Systematics, Elsevier Academic Press,Amsterdam. 7. Verma BK (2011) Introduction to Taxonomy of Angiosperms, PHI Learning, New Delhi.
Learning Outcomes	Upon completing this course, students will be able to understand and apply principles of plant systematics, including various classification systems like Bentham and Hooker's and Hutchinson's. They will be proficient in identifying and describing the characteristics and economic importance of major dicot and monocot families. Students will grasp the principles of botanical nomenclature, numerical taxonomy, and the role of embryology and chemotaxonomy in plant classification. Additionally, they will have an overview of molecular approaches and the APG classification system. This knowledge will enable students to effectively study, classify, and apply taxonomy to angiosperms.
Course Title	**BOTMN42: Lab Work Based on Paper BOTMN41**

Units	**Practicals**	**Hours of Teaching:30 h**
I	• Taxonomic description of plants of the following families: *Ranunculaceae, Papaveraceae, Myrtaceae, Apiaceae, Cucurbitaceae, Rubiaceae, Apocynaceae, Asclepiadaceae, Solanaceae, Acanthaceae, Lamiaceae, Euphorbiaceae,Asteraceae, Zingeberaceae,Poaceae, Cyperaceae*	20.0 h
II	• Plant collection: submission of at least 25 herbarium sheets	10.0 h

Course Title	**BOTMN43: Gymnosperm and Paleobotany**
Category of Course[42]	Major / **Minor**/ Minor (Vocational) / SEC / AEC /VAC / MD/Internship/Dissertation

Credits[43]& Hour of Teaching

	Theory	Practical	Cumulative
Credits	3	1	4
Hour of Teaching	45	30	75

Course Objectives	This course aims to provide students with a comprehensive understanding of gymnosperms and paleobotany. It covers the characteristic features and classification of gymnosperms, including detailed accounts of Progymnospermopsida, Pteridospermales, and Glossopteridales. Students will study the morphology, anatomy, and reproduction of key gymnosperms such as Cycas, Pinus, and Ephedra. The course also introduces paleobotany, including the geological timescale, evolutionary trends, and the origin of plant groups. Additionally, students will learn about fossils, their types, the process of fossilization, and their significance in understanding plant evolution.

Units	**Course Content**	**Hours of Teaching: 45 h**
I	• Characteristic features and classification of Gymnosperms • General accounts of Progymnospermopsida and Pteridospermales (*Lyginopteris*plant;*Sphenopteris* leaf, *Lygonopteris*stem, *Crossotheca* male organ *and Lagenostoma* female organ)	6.0 h

[42] SEC – Skill Enhancement Course; AEC – Ability Enhancement Course; VAC – Value Added Course; MD – Multidisciplinary Course

[43] 1 Credit (Theory) = 15 Hours; 1 Credit (Practical) = 30 Hours

II	• Glossopteridales: General account of Glossopteris plant (*Vertebraria* root, *Araucarioxilon* trunk, *Glossopteris* leaf, *Glossotheca*male organ, *Dictyopteridium* female organ)	7.0 h
III	• Morphology, anatomy and reproduction of *Cycas*, *Pinus* and *Ephedra*	16.0 h
IV	• An elementary knowledge of Paleobotany: Geological timescale • Evolutionary trends; origin and evolution of different plant groups	8.0 h
V	• Fossils, Types of fossils, Process of fossilization, Importance of fossils	8.0 h

Texts/ References	1. Sporne, K.R. (1967) Morphology of Gymnosperms, BI Publication, New Delhi. 2. Bhatnagar, S.P and Moitra, A. (1996) Gymnosperms, New Age International Pvt Ltd Publishers, New Delhi. 3. Arnold, C. A. (1947) An Introduction to Palaeobotany. Mc Graw Hill Publ. Co. 4. Andrews, H. N. (1967) Studies in Palaeobotany. Wiley, New York. 5. Stewart, W. N. and Rothwell, G.W. (1993) Palaeobotany and Evolution of Plants. CambridgeUniversity Press. 6. Taylor, T. N., Taylor, E. L. and Krings, M. (2009) Palaeobotany, the biology and evolution offossil plants. Elsevier Inc. 7. Beck, C. B. (1988) Origin and evolution of gymnosperms. Columbia University Press. 8. Chamberlain, C. J. (1934) Gymnsoperms – structure and evolution. Chicago Univ. Press.
Learning Outcomes	Upon completing this course, students will be able to identify and classify gymnosperms, including Progymnospermopsida, Pteridospermales, and Glossopteridales. They will understand the morphology, anatomy, and reproduction of key gymnosperms like Cycas, Pinus, and Ephedra. Students will gain foundational knowledge in paleobotany, including the geological timescale, evolutionary trends, and the origin of plant groups. They will also be able to describe fossil types, the fossilization process, and the significance of fossils in studying plant evolution. This comprehensive understanding will equip students to apply paleobotanical concepts to the study of plant history and evolution.

Course Title	**BOTMN44: Lab Work Based on Paper BOTMN43**

Units	**Practicals**	**Hours of Teaching: 30 h**
I	• *Cycas* - General morphology of vegetative and reproductive structures, anatomy (coralloid root,leaflet, rachis, permanent slides), and reproduction (megasporophyll, male cone, section ofmicrosporophyll, permanent slides of ovule and microsporophyll)	10.0 h
II	• *Pinus* - General morphology of vegetative and reproductive structures, anatomy (T.S of shoots,needle, permanent slides), reproduction (male cone, female cone, sections of megasporophyll and microsporophyll, permanent slides)	10.0 h
III	• *Ephedra* - General morphology of vegetative and reproductive structures, anatomy (stem, reproductive structures)	10.0 h

Course Title	**BOTMN45: Plant Ecology**
Category of Course[44]	Major / **Minor** / Minor (Vocational) / SEC / AEC /VAC / MD/Internship/Dissertation
Credits[45]**& Hour of Teaching**	

	Theory	Practical	Cumulative
Credits	3	1	4
Hour of Teaching	45	30	75

Course Objectives	This course aims to provide students with a foundational understanding of plant ecology. It covers the abiotic and biotic components of the environment, including interactions among plants, animals, and microorganisms. Students will learn about plant adaptations to water, light, and temperature, and explore population dynamics and community ecology, focusing on analytical and synthetic characters. The course also includes ecosystem ecology, covering ecosystem structure, function, and biogeochemical cycles. Additionally, students will study ecological succession, including its processes, mechanisms, and patterns such as hydrosere and xerosere. This comprehensive knowledge will enable students to analyze and interpret ecological interactions and processes in plant communities.

Units	**Course Content**	**Hours of Teaching:45 h**
I	• Introduction to ecology • Abiotic environment: Atmosphere, temperature, water, light and soil (structure and soil profile)	8.0 h
II	• Biotic environment: Interactions among plants, animals and man; interactions among plants growing in a community; interactions among plants and microorganisms	8.0 h
III	• Plant adaptations in response to water availability, light and temperature • Population: Concepts, attributes and dynamics	9.0 h
IV	• Community Ecology: Analytical and synthetic characters (Frequency, density, cover, IVI, life forms, biological spectrum, phenology, sociability)	8.0 h
V	• Ecosystem Ecology: Ecosystem structure (abiotic and biotic components, food chain, food web, ecological pyramids); ecosystem function (models of energy flow), biogeochemical cycles (carbon, nitrogen, and phosphorus) • Ecological succession: General process, mechanisms and patterns (Hydrosere and Xerosere)	12.0 h

Texts/ References	1. Odum EP, Barrett GW (2005) Fundamentals of Ecology, Thomson Ed. Brooks/Cole, Cengage Learning India Pvt. Ltd, New Delhi. 2. Odum EP (1983) Basic Ecology Ed. Saunders College Pub, New York. 3. Smith TM, Smith RL (2008) Elements of Ecology, 7th edition, Benjamin- Cummings New York. 4. Miller GT (2004) Essentials of Ecology, 3rd edition, Brooks, Cole, New York. 5. Smith RL (2001) Ecology and Field Biology, Benjamin Cummings, New York. 6. Vallero D (2014) Fundamentals of Air Pollution, 3rd edition, Academic Press, Elsevier, Burlington. 7. Klassen C, Watkins JB (2010) Essentials of Toxicolgy, 2nd edition, McGraw- Hill Companies, New York. 8. Singh JS, Singh SP, Gupta SR (2014) Ecology Environmental Science and Conservation, S Chand & Co, New Delhi. 9. Mueller-Dombois D, Ellenberg H (1974), Aims and Methods of Vegetation Ecology. Wiley & Sons., NY, USA
Learning Outcomes	Upon completing this course, students will be equipped to analyze and interpret the complex interactions within plant ecology. They will understand the influence of abiotic factors like

[44] SEC – Skill Enhancement Course; AEC – Ability Enhancement Course; VAC – Value Added Course; MD – Multidisciplinary Course

[45] 1 Credit (Theory) = 15 Hours; 1 Credit (Practical) = 30 Hours

	atmosphere, temperature, water, light, and soil structure on plant life. Students will gain insights into biotic interactions among plants, animals, and microorganisms, and how plants adapt to environmental variables such as water availability, light, and temperature. They will be able to describe population dynamics, community ecology metrics, and ecosystem functions, including energy flow and biogeochemical cycles. Additionally, students will grasp the processes and patterns of ecological succession, enabling them to assess and manage plant communities effectively.

Course Title	**BOTMN46: Lab Work Based on Paper BOTMN45**	
Units	**Practicals**	**Hours of Teaching: 30 h**
I	• To study soil properties by spot tests: texture, pH, CO_3^{--}, NO_3^-, base deficiency and reductivity	6.0 h
II	• Demonstration of the working and use of the instruments for measuring the environmental factors: *Temperature: Ordinary Thermometer, Maximum-Minimum Thermometer* *Moisture: Rain Gauge, Psychrometer* *Wind velocity: Anemometer* *Light intensity: Lux meter*	6.0 h
III	• Determination of minimal size of sample lot by species-area curve • Charting of vegetation to find out coverage	6.0 h
IV	• Study of community structure by quadrat method with respect to following: *Density* *Frequency*	6.0 h
V	• Study of following ecological adaptations: *Hydrophytes: Nymphaea leaf, Hydrilla stem* *Xerophytes: Nerium leaf, Muehlenbekia, Casuarina* *Epiphytes: Vanda* *Parasites: Cuscuta with host*	6.0 h

Course Title	**AE4: Offered by Institute/University (2 Credits)**
Category of Course[46]	Major / Minor / Minor (Vocational) / SEC / **AEC-4**/ VAC / MD/Internship/Dissertation

[46] SEC – Skill Enhancement Course; AEC – Ability Enhancement Course; VAC – Value Added Course; MD – Multidisciplinary Course

SEMESTER-V

Course Title	BOTMJ51: Plant Physiology
Category of Course[47]	**Major**/ Minor / Minor (Vocational) / SEC / AEC /VAC / MD/Internship/Dissertation

Credits[48] & Hour of Teaching	Theory	Practical	Cumulative
Credits	3	1	4
Hour of Teaching	45	30	75

Course Objectives	This course objective is to provide students with a detailed understanding of key aspects of plant physiology, including water relations, transport mechanisms, and nutrient translocation. Students will explore the processes of phloem transport, transpiration, and photosynthesis, including various pathways and factors affecting these processes. The course also covers respiration, plant photoreceptors, and plant growth regulation, emphasizing hormones and growth regulators. By integrating these concepts, students will gain a comprehensive understanding of plant physiological processes, enabling them to analyze and apply physiological principles to enhance plant growth and development in various agricultural and research contexts.

Units	Course Content	Hours of Teaching:45 h
I	• Plant Water Relations: Permeability, osmosis, water potential • Transport of Water, Solutes and Translocation: Uptake, transport and translocation of water, ions, solutes from soil, passive and active transports	7.0 h
II	• Phloem transport; composition of photo-assimilates translocated by phloem, mechanism of phloem transport, phloem loading and unloading • Transpiration: foliar transpiration, guttation, plant anti-transpirants, factors affecting transpiration, significance of transpiration	8.0 h
III	• Photosynthesis:Light harvesting complexes, absorption and action spectrum, light reaction, dark reaction, photorespiration, Hatch-Slack Pathway, CAM Pathway, comparison of C3, C4 and CAM plants, factors affecting photosynthesis	8.0 h
IV	• Respiration: Glycolysis, oxidative decarboxylation of pyruvate to acetyl CoA, citric acid cycle (Krebs Cycle), regulation of respiratory pathways, respiratory quotient • Plant photoreceptors: Phytochromes, cryptochromes, photoperiodism	12.0 h
V	• Plant growth regulation: Plant hormones and plant growth regulators, auxins, gibberellins, cytokinins, abscisic acid, ethylene, polyamines, salicylic acid, nitric oxide, jasmonates, brassinosteroids • Fruit ripening: Plant senescence, programmed cell death	10.0 h

Texts/ References

1. Buchanan BB, Gruisemm W, Jones RL (2015) Biochemistry and Molecular Biology of Plants, 2nd edition, Wiley Blackwell, New Jersey.
2. Hopkins WG, Huner NPA (2009) Introduction to Plant Physiology, 4th edition, Wiley International edition, John Wiley & Sons, New York.
3. Taiz L, Zeiger E, Moller IM, Murph A (2015) Plant Physiology and Development, 6th edition, Sinurer Associates Inc Publishers, Sunderland, Massachusetts.
4. Frank B. Salisbury and Cleon W. Ross (1985) Plant Physiology Wadsworth Publishing Company, Belmont, California.
5. Robert M. Devlin (3rd edition) (1975) Plant Physiology Van Nostrand Reinhold Company,

[47] SEC – Skill Enhancement Course; AEC – Ability Enhancement Course; VAC – Value Added Course; MD – Multidisciplinary Course

[48] 1 Credit (Theory) = 15 Hours; 1 Credit (Practical) = 30 Hours

	New York. 6. Walter Larcher (4th edition) (2003) Physiological Plant Ecology: Ecophysiology and Stress Physiology of Functional Groups Springer Verlag, Berlin. 7. Hans Mohr and Peter Schopfer (2010) Plant Physiology Springer Verlag, Berlin. 8. Edwin Oxlade (2007) Plant Physiology: The Structure of Plants Explained Glmp Ltd, Abergele, United Kingdom. 9. Kochhar SL and Gujral SK (2020) Plant Physiology: Theory and Applications, Second Edition, Springer
Learning Outcomes	Upon completing this course, students will be able to analyze and explain plant water relations, transport mechanisms, and nutrient translocation. They will understand the processes of phloem transport, transpiration, and photosynthesis, including different pathways like C3, C4, and CAM. Students will also grasp the principles of respiration, the role of plant photoreceptors, and the impact of plant hormones on growth regulation. This knowledge will enable them to assess plant physiological processes critically and apply this understanding to optimize plant growth, development, and productivity in agricultural and research settings.

Course Title	**BOTMJ52: Lab Work Based on Paper BOTMJ51**	
Units	**Practicals**	**Hours of Teaching:30 h**
I	• Measurement of osmotic concentration of cell sap by plasmolytic method (*Tradescantia* leaf epidermal peel/ potato tuber cylinders) • Effect of temperature, organic solvent and salt on permeability of cells membrane of beet root (*Beta vulgaris*)	6.0 h
II	• Determination of the rate of transpiration by varying environmental factors • Determination of the rate of photosynthesis in terms of oxygen evolution of an aquatic plant (*Hydrilla*): with varying light intensity, wavelengths of light and CO_2 concentrations	6.0 h
III	• Extraction, separation and study of the properties of photosynthetic pigments by paper chromatography	6.0 h
IV	• Isolation of chloroplasts and demonstration of photoreduction of dye [2,6-dichloro-phenol indophenols (DCPIP)	6.0 h
V	• Determination of RQ of different plant tissues (pipette manometer method) • Fruit ripening experiment: ethephon treatment of climacteric and non- climacteric fruits and their observation	6.0 h

Course Title	**BOTMJ53: Plant Pathology**
Category of Course[49]	**Major**/ Minor / Minor (Vocational) / SEC / AEC /VAC / MD/Internship/Dissertation

Credits[50] **& Hour of Teaching**

	Theory	Practical	Cumulative
Credits	3	1	4
Hour of Teaching	45	30	75

Course Objectives

This course aims to provide a comprehensive understanding of plant pathology, including the historical development and fundamental concepts of plant diseases. Students will learn about various plant pathogens—viruses, bacteria, fungi, and nematodes—along with their characteristics, disease symptoms, and infection cycles. The course covers plant defense mechanisms, disease management strategies including traditional, biological, and chemical methods, and integrated disease management approaches. Students will also explore recent trends and molecular tools for disease diagnosis, equipping them to analyze, manage, and mitigate plant diseases effectively in agricultural and research contexts.

Units	Course Content	Hours of Teaching:45 h
I	• Introduction to Plant Pathology and Historicaldevelopments • Plant Pathogens: Viruses, Bacteria, Fungi and Nematodes; Characteristics, disease symptoms, mode of infection and disease cycle	10.0 h
II	• Plant defense mechanisms: Structural, biochemical and molecular mechanism	10.0 h
III	• Disease symptoms, cycle and management of Virus (TMV), bacteria (Citrus canker), fungi (Late blight of potato, Powdery mildew of pea, wilt of Arhar and smut of wheat)	7.0 h
IV	• Disease Management Strategies: Traditional, biological and chemical methods of disease control, integrated disease management (IDM), engineering approaches and resistant varieties	10.0 h
V	• Recent Trends and molecular tools in disease diagnosis	8.0 h

Texts/ References

1. Madigan MT, Martinko JM, Dunlap PV, Clark DP (2011) Brock Biology of Microorganisms, 13th edition, Pearson Education Inc, New Jersey.
2. Talaro KP, Chess B (2011) Foundation in Microbiology, 8th edition, McGraw-Hill, New York.
3. Agrios GN (2005) Plant Pathology, 5th edition, Academic Press, London.
4. Lucas John A (1998) Plant Pathology and Plant Pathogens, Wiley-Blackwell, CRC Press, New York.
5. Willey JM, Sherwood L, Woolverton CJ (2013) Prescott's Microbiology, 9the edition, McGraw-Hill, New York.
6. Dubey RC, Maheshwari Dk (2012) A Textbook of Microbiology, Revised edition, S Chand and Company Ltd, New Delhi.
7. Singh RS (2009) Plant Diseases, 9th edition, Oxford and IBH Pub Co Pvt Ltd, New Delhi.
8. PD Sharma (2020) Microbiology and Plant Pathology 4th Ed, Rastogi Publications.
9. Kumar S, Behera L, Yadav AS & Sonakar VK (2022). Biotech Laboratory Manual On Plant Pathology Biochemical and Molecular Techniques, Biotech Publisher.
10. Anne Marte Tronsmo, David B. Collinge, Annika Djurle, Lisa Munk, Jonathan Yuen, Arne Tronsmo (2020). Plant pathology and plant diseases, CABI Publication.

Learning Outcomes

Upon completing this course, students will be able to identify and classify plant pathogens including viruses, bacteria, fungi, and nematodes, and understand their modes of infection and disease cycles. They will gain insights into plant defense mechanisms and be able to diagnose and manage plant diseases using traditional, biological, and chemical methods. Students will also be

[49] SEC – Skill Enhancement Course; AEC – Ability Enhancement Course; VAC – Value Added Course; MD – Multidisciplinary Course

[50] 1 Credit (Theory) = 15 Hours; 1 Credit (Practical) = 30 Hours

	equipped to apply integrated disease management strategies and utilize recent molecular tools for disease diagnosis. Overall, they will be prepared to address plant pathology challenges effectively in agricultural and research settings.

Course Title	**BOTMJ54: Lab Work Based on Paper BOTMJ53**	
Units	**Practicals**	**Hours of Teaching:30 h**
I	• Study of the following plant pathogens: *Sclerospora graminicola* *Peronospora parasiticia* *Erysiphe polygoni* *Uromyces pisi* *Melampsora lini* *Ustilago* *Tolyposporium penicillariae* *Fusarium oxysporum*	24.0 h
II	• Symptoms of bacterial blight	2.0 h
III	• Symptoms of mosaic	2.0 h
IV	• Little leaf of brinjal	2.0 h

<table>
<tr><td>Course Title</td><td colspan="2">BOTMJ55: Recombinant DNA Technology</td></tr>
<tr><td>Category of Course[51]</td><td colspan="2">Major / Minor / Minor (Vocational) / SEC / AEC /VAC / MD/Internship/Dissertation</td></tr>
<tr><td>Credits[52]& Hour of Teaching</td><td colspan="2"><table>
<tr><td></td><td>Theory</td><td>Practical</td><td>Cumulative</td></tr>
<tr><td>Credits</td><td>3</td><td>1</td><td>4</td></tr>
<tr><td>Hour of Teaching</td><td>45</td><td>30</td><td>75</td></tr>
</table></td></tr>
<tr><td>Course Objectives</td><td colspan="2">This course aims to provide comprehensive knowledge in recombinant DNA technology, covering the isolation, analysis, and modification of nucleic acids. Students will learn to utilize DNA modifying enzymes and various molecular tools for gene manipulation, including the CRISPR-Cas system. They will gain practical skills in transgenic plant production, vector construction, and the generation of genomic and cDNA libraries. The course also emphasizes the selection and screening of recombinants and the engineering of vectors for gene expression in different systems. Ultimately, students will be equipped to apply these techniques in research and biotechnology applications.</td></tr>
<tr><td>Units</td><td>Course Content</td><td>Hours of Teaching:45 h</td></tr>
<tr><td>I</td><td>• Isolation of DNA (genomic and plasmid) and RNA, qualitative and quantitative analyses of nucleic acids, labeling of nucleic acids, reverse-transcription
• DNA modifying enzymes: Endonucleases, exonucleases, ligase, types and nomenclature of restriction enzymes, isoschizomers and neoschizomers, polymerases, Klenow fragment, phosphatase, transcriptase, transferase, topoisomerase, telomerase, in vitro translation</td><td>10.0 h</td></tr>
<tr><td>II</td><td>• Transgenic plant production, principle of Agrobacterium mediated gene transfer, Ti and Ri plasmids, CRISPR-Cas system, genetically modified crops and their importance</td><td>6.0 h</td></tr>
<tr><td>III</td><td>• Plasmid vectors, cloning and expression vectors, construction of genomic and cDNA libraries, joining of DNA fragments to vectors, restriction digestion, dephosphorylation, cohesive and blunt end ligation, adaptors, linkers, transformation, transduction, conjugation, electroporation</td><td>10.0 h</td></tr>
<tr><td>IV</td><td>• Selection, screening and analysis of recombinants, antibiotics and their resistance cassettes, colony PCR, restriction fragments length polymorphism, RAPD</td><td>10.0 h</td></tr>
<tr><td>V</td><td>• Basic components of vector and its engineering, shuttle vector, gene expression in bacteria, yeast, insects and mammalian cells, codon optimization, promoters, reporter genes, gene silencing, targeted and random mutagenesis
• Biosafety regulations</td><td>9.0 h</td></tr>
</table>

[51] SEC – Skill Enhancement Course; AEC – Ability Enhancement Course; VAC – Value Added Course; MD – Multidisciplinary Course

[52] 1 Credit (Theory) = 15 Hours; 1 Credit (Practical) = 30 Hours

Texts/ References	• Brown, T. A. (2013, 2020). Gene Cloning and DNA Analysis: An Introduction. John Wiley & Sons. • Primrose, S. B., & Twyman, R. (2001, 2006). Principles of Gene Manipulation and Genomics. John Wiley & Sons. • Michael Goldberg, Janice Fischer, Leroy Hood, Leland Hartwell, Charles (Chip) Aquadro, Lee Silver and Ann E. Reynolds (2023) Genetics: From Genes to Genomes. McGraw Hill. • Cox MM, Nelson DL (2021) Lehninger Principle of Biochemistry, 8th edition, MacMillan, Worth Publishers, London. • Devlin TM (2011) Textbook of Biochemistry, 7th edition, John Wiley & Sons, Inc, New York. • Dubey RC (2013) A Text Book of Biotechnology 4th edition, S Chand & Co Ltd, New Delhi. • Wilson K, Walker J (2018) Principle & Techniques of Biochemistry and Molecular Biology, 8th edition, Cambridge University Press, Cambridge. **Suggested Websites** https://www.google.co.in/books/edition/Applications_of_Recombinant_DNA_Technolo/zf3EDwAAQBAJ?hl=en&gbpv=1&dq=recombinant%20dna%20technology&pg=PR1&printsec=frontcover https://academic.oup.com/aob/article/105/7/1141/148741 https://dx.doi.org/10.1016/B978-0-12-800180-6.00001-3 https://doi:10.1016/j.molp.2016.05.004 https://doi.org/10.1093/jn/130.5.1081 https://academic.oup.com/jxb/article/68/10/2463/2967464
Learning Outcomes	By the end of this course, students will be proficient in isolating and analyzing nucleic acids, using DNA modifying enzymes, and applying molecular tools such as CRISPR-Cas for gene editing. They will understand the principles and techniques of transgenic plant production, vector construction, and library construction. Students will be able to perform cloning, transformation, and screening of recombinants, and will gain practical experience with vector engineering for gene expression in various systems. Additionally, they will be equipped to apply these skills in biotechnology and genetic research.

Course Title	**BOTMJ56: Lab Work Based on Paper BOTMJ55**	
Units	**Practicals**	**Hours of Teaching:30 h**
I	• Extraction of genomic DNA • Qualitative and quantitative analyses of extracted genomic DNA	6.0 h
II	• Extraction of plasmid DNA	6.0 h
III	• Qualitative and quantitative analyses of extracted plasmid DNA	6.0 h
IV	• Restriction digestion of plasmid DNA	6.0 h
V	• Transformation and selection of plasmid DNA in *E. coli*	6.0 h

Course Title	BOTMJ57: Plant and Microbial Techniques
Category of Course[53]	**Major**/ Minor / Minor (Vocational) / SEC / AEC /VAC / MD/Internship/Dissertation

Credits[54]& Hour of Teaching	Theory	Practical	Cumulative
Credits	1	1	2
Hour of Teaching	15	30	45

Course Objectives	This course aims to equip students with essential research methodology skills, covering the entire research process from problem formulation to data collection, analysis, and reporting. It focuses on ethical research practices, effective literature review, diverse data collection methods, and the use of statistical and qualitative analysis tools. The course also enhances students' abilities to present and publish their research findings.

Units	Course Content	Hours of Teaching:15 h
I	• Principles of light-, bright- and dark-field microscopy, fluorescence and phase-contrast microscopy • Basics of scanning and transmission electron microscopy	3.5 h
II	• Spectrophotometry: UV-Visible, fluorescence and nanodrop spectrophotometer • Principles of centrifugation, sedimentation and equilibrium, factors affecting sedimentation velocity, gradient centrifugation, ultracentrifugation	3.5 h
III	• Chromatography techniques: TLC, HPLC, GC, mass spectrometry • Electrophoresis: agarose gel electrophoresis, SDS-PAGE and 2-D gel electrophoresis	3.0 h
IV	• PCR, site directed mutagenesis, microarray and RNA sequencing • DNA sequencing: dideoxy nucleotide and automated sequencing methods	2.5 h
V	• Basic concept of plant cell and tissue culture, microbial culture and cryopreservation • Bioinformatics tools and their applications: BLAST, multiple sequence alignment	2.5 h

Texts/ References

1. Dubey RC (2013) A Text Book of Biotechnology, 4th edition, S Chand & Co Ltd, New Delhi.
2. Green MR, Sambrook J (2000) Molecular Cloning: A Laboratory Manual, 4th edition, Cold Spring Harbor Laboratory Press, Cold Spring Harbor.
3. Bhojwani SS, Razdan MK (1996) Plant Tissue Culture: Theory and Practice, Elsevier, Amsterdam.
4. Baxevanis AD, Ouellette BFF (2005) Bioinformatics: A practical guide to the analysis of genes and proteins, 3rd edition, John Wiley and Sons, New Jersey.
5. Simpson MG (2010) Plant Systematics, 2nd edition, Elsevier Academic Press, Amsterdam.
6. Singh G (2012) Plant Systematics-Theory and Practice, 3rd edition, Oxford and IBH Publishing Co, New Delhi.
7. Karp G (2010) Cell Biology, 6th edition, John Wiley and Sons, New Jersey.
8. Dubey RC, Maheshwari DK (2016) A Text Book of Microbiology, S Chand & Co Ltd, New Delhi.
9. Brown TA (2007) Gemones-3, 3rd edition, Garland Sci Publishing, New York.
10. Willey JM, Sherwood LM, Woolverton CJ (2014) Prescott's Microbiology, 9th edition, MacGraw Hill International, New York.

Suggested Websites

https://bio-protocol.org/en

https://conductscience.com/microbiology-techniques/

Learning Outcomes	Upon completing this course, students will be able to effectively utilize advanced microscopy techniques, spectrophotometry, and centrifugation methods for analyzing plant and microbial samples. They will

[53] SEC – Skill Enhancement Course; AEC – Ability Enhancement Course; VAC – Value Added Course; MD – Multidisciplinary Course

[54] 1 Credit (Theory) = 15 Hours; 1 Credit (Practical) = 30 Hours

	demonstrate proficiency in chromatography, electrophoresis, PCR, and DNA sequencing techniques. Students will gain hands-on experience in plant cell and tissue culture, microbial culture, and cryopreservation. Additionally, they will be adept at using bioinformatics tools for sequence analysis, including BLAST and multiple sequence alignment. This knowledge will enable them to conduct sophisticated research and solve complex problems in plant and microbial sciences.

Course Title	**BOTMJ58: Lab Work Based on Paper BOTMJ57**	
Units	**Practicals**	**Hours of Teaching: 30 h**
I	• Analysis of DNA and RNA samples by spectrophotometer	6.0 h
II	• Demonstration of PCR and Gel Documentation system	6.0 h
III	• Analysis of samples by fluorescence spectrophotometer	6.0 h
IV	• Study of different biological samples by microscopic techniques	6.0 h
V	• Nucleic acids and protein sequence analysis using bioinformatics tools	6.0 h

Course Title	**BOTMV51: Herbarium Preparation and Preservation**			
Category of Course[55]	Major / Minor / **Minor (Vocational-2)**/ SEC / AEC /VAC / MD/Internship/Dissertation			
Credits[56]**& Hour of Teaching**		Theory	Practical	Cumulative
	Credits	3	1	4
	Hour of Teaching	45	30	75
Course Objectives	The objective of this course is to provide students with comprehensive knowledge and practical skills in herbarium preparation and preservation. Students will learn the history, objectives, and functions of herbaria, including important global and Indian examples. They will gain expertise in techniques for collecting, pressing, drying, mounting, and labeling plant specimens, as well as preserving and maintaining herbarium materials. The course will also cover the collection and preservation of algae, lichens, fungi, bryophytes, pteridophytes, gymnosperms, and angiosperms. Additionally, students will explore botanical nomenclature and the principles of virtual herbaria and digitalization.			

Units	**Course Content**	**Hours of Teaching:45 h**
I	• Introduction to herbarium: History of herbarium, objectives of herbarium • Role of herbarium in teaching and research, types of herbaria, functions of herbarium • Important herbaria of the world and India	10.0 h
II	• Herbarium techniques:Collection of the specimen (plants) • Pressingand drying of the specimen, Herbarium pests, Poisoning of specimens or protection of plants from insects or pests, Mounting, stitching, and labelling of specimen, Storage of herbarium sheets	9.0 h
III	• Maintenance of herbaria:Fumigation, heating, chemical treatment, handling of specimens, challenges in maintenance • Collection, identification, and preservation of different types of algae and lichens • Collection, identification, and preservation of fungi	9.0 h

[55] SEC – Skill Enhancement Course; AEC – Ability Enhancement Course; VAC – Value Added Course; MD – Multidisciplinary Course

[56] 1 Credit (Theory) = 15 Hours; 1 Credit (Practical) = 30 Hours

	• Collection, identification, and preservation of bryophytes • Collection, identification, and preservation of pteridophtes	
IV	• Collection, identification, and preservation of gymnosperms • Collection, identification, and preservation of angiosperms • Botanical Nomenclature: Binomial nomenclature, Taxonomical hierarchy, Concept of ICN, Principles and rules of ICN, Ranks, and names, Typification, and principle of priority	9.0 h
V	• Virtual herbarium: Goal of virtual herbarium, importance, Techniques used, Herbarium based databases, Specimens imaging, and Digitalization	8 h

Texts/ References	1. Forman, Leonard, and Diane M. Bridson (2013). The Herbarium Handbook. Kew: Royal Botanic Gardens. ISBN-10: 1900347431. 2. Metsger, D A, and S C. Byers (1999). Managing the Modern Herbarium: An Interdisciplinary Approach. Society for Preservation. ISBN-10: 0963547623 3. Taxonomic Literature II (TL-2) https://www.sil.si.edu/DigitalCollections/tl-2/ 4. Turland, N. J., et al. (eds.) 2018: International Code of Nomenclature for algae, fungi, and plants (Shenzhen Code) adopted by the Nineteenth International Botanical Congress Shenzhen, China, July 2017. Regnum Vegetabile 159. Print and Web. DOI https://doi.org/10.12705/Code.2018 5. Ainsworth, G., Kirk, P., et al. Ainsworth &Bisby's Dictionary of the Fungi (10th ed.), 2008. Wallingford, CT: CABI. ISBN-13: 978 0 85199 826 8 6. https://www.floridamuseum.ufl.edu/herbarium/methods/vouchers/ 7. https://www.herbsociety.org/file_download/inline/2c81731f-ecd5-4f5d-a142-666830a89ed2 8. https://bsi.gov.in/uploads/userfiles/file/Training/Manual_Herbarium%20Technique.pdf
Learning Outcomes	Upon completing this course, students will gain a comprehensive understanding of herbarium practices, including the historical development, objectives, and types of herbaria and their significance in research and education. They will be skilled in the techniques for collecting, pressing, drying, mounting, and labeling plant specimens, as well as implementing effective preservation methods and addressing maintenance challenges. Students will learn to collect and preserve a variety of plant groups, such as algae, lichens, fungi, bryophytes, pteridophytes, gymnosperms, and angiosperms. Additionally, they will acquire knowledge of botanical nomenclature principles and the International Code of Nomenclature, and be proficient in using virtual herbarium techniques and digital tools for specimen imaging and database management.

Course Title	**BOTMV52: Lab Work Based on Paper BOTMV51**	
Units	**Practicals**	**Hours of Teaching: 30 h**
I	• Local field visit to study and identify the local flora and vegetation • Collection, and preservation of algal and lichens samples • Demonstration of herbarium techniques • Collection, and preservation of fungal samples	10.0 h
II	• Collection, and preservation of bryophytes samples • Collection, and preservation of pteridophyte samples • Collection, and preservation of bryophytes samples • Collection, and preservation of pteridophyte samples	10.0 h
III	• Collection, and preservation of gymnosperm samples • Collection, and preservation of angiosperm samples	10.0 h

Course Title	BOTIN51 (2 Credits)
Category of Course[57]	Major / Minor / Minor (Vocational) / SEC / AEC-4/ VAC / MD/**Internship**/Dissertation

SEMESTER-VI

Course Title	BOTMJ61: Comparative Cryptogams
Category of Course[58]	**Major**/ Minor / Minor (Vocational) / SEC / AEC /VAC / MD/Internship/Dissertation
Credits[59]& Hour of Teaching	

	Theory	Practical	Cumulative
Credits	3	1	4
Hour of Teaching	45	30	75

Course Objectives	This course aims to provide a thorough understanding of comparative cryptogams, focusing on algae, fungi, bryophytes, and pteridophytes. Students will explore the classification systems and general characteristics of major algal classes, including pigmentation, storage products, thallus organization, and reproductive strategies. They will study fungal classifications, structures, reproductive cycles, and evolutionary trends. Additionally, the course covers the classification and life histories of bryophytes and pteridophytes, including specific genera and evolutionary aspects of sporophytes and stelar evolution. By the end, students will gain insights into the diversity, evolutionary adaptations, and ecological significance of these non-flowering plants.

Units	Course Content	Hours of Teaching: 45 h
I	• Classification (Fritsch's system) and general characteristics of major classes • Pigmentation and storage products • Thallus organization and evolutionary tendencies	8.0 h
II	• Reproduction and life history types with reference to Chlorophyceae, Phaeophyceae, Rhodophyceae and Cyanophyceae	8.0 h
III	• General features of fungi and their classification (Ainsworth's system) • Structure, reproduction and life cycles of representative classes of fungi	9.0 h
IV	• Types of fungal spores and mode of their liberation • Evolutionary trends in fungi	7.0 h
V	• Classification of Bryophyta and Pteridophyta • Life histories of bryophytes with reference to *Cyathodium, Notothylus, Sphagnum* • General account of evolution of sporophyta • Life history of *Psilotum*and*Marsilea*General account on stelar evolution in Pteridophyta	13.0 h

Texts/	1. Fritsch FE (1935) The Structure and Reproduction of the Algae, Vol I, Cambridge University Press, Cambridge.

[57] SEC – Skill Enhancement Course; AEC – Ability Enhancement Course; VAC – Value Added Course; MD – Multidisciplinary Course

[58] SEC – Skill Enhancement Course; AEC – Ability Enhancement Course; VAC – Value Added Course; MD – Multidisciplinary Course

[59] 1 Credit (Theory) = 15 Hours; 1 Credit (Practical) = 30 Hours

References	2. Fritsch FE (1945) The Structure and Reproduction of the Algae, Vol II, Cambridge University Press, Cambridge. 3. Morris I (1967) Introduction to Algae, Hutchinson University Library, London. 4. Smith GM (1972) Cryptogamic Botany Vol I and II, Tata McGraw Hill Publishing Co Ltd, New Delhi. 5. Dixon PS (1973) Biology of the Rhodophyta, Oliver & Boyd, UK 6. Singh V, Pande PC, Jain DK (2010) A Text Book of Botany (Algae, Fungi, Brophyta, Pteridophyta), Pub Rastogi Publication, Meerut. 7. Bold HC, Wynne MJ (1985) Introduction to the Algae, 2nd edition, Prentice-Hall Inc, New Jersey. 8. South GR, Whittick A (1998) Introduction to Phycology, Blackwell Scientific Publication, London. 9. Gangulee HC, Kar AK (2011) College Botany Vol II (Algae, Fungi, Brophyta, Pteridophyta), New Central Book Agency, Kolkata. 10. Lee RE (2018) Phycology, 5th edition, Cambridge University Press, Cambridge. 11. Sambamurty AVSS (2019) A text Book of Algae, Dreamtech Press 9389447178 12. Sharma OP (2017) Algae, McGraw Hill Education 978-0070681941 13. Dubey HC (2012) An Introduction to Fungi: 4th Edition. Scientific Publishers. 14. Watkinson SC, Boddy L and Money N (2015) The Fungi, Third Edition. Academic Press, Elsevier. 15. Petersen JH (2013) The Kingdom of Fungi, Princeton University Press, USA. 16. Kavanagh K. (2018) Fungi Biology and Applications,Third Edition. John Wiley 17. Aneja KR (2015) An Introduction to Mycology. New Age International Private Limited. New Delhi. 18. Sharma OP (2017) Bryophytea, McGraw Hill Education 2017 978-1259062872 19. Alam A (2019) Text Book of Bryophyta, Dreamtech Press 978-9389307221 20. Rashid A (2015). An Introduction to Bryophyta. 1st edition, Vikas Publishing House Pvt. Ltd., New Delhi. 21. Parihar NS (1996). Biology and Morphology of Pteridophytes. Central book Depot. Allahabad. 22. Sambamurthy AVSS (2020) A Textbook of Bryophytes, Pteridophytes, Gymnosperms and Paleobotany. Dreamtech Press India Pvt Ltd. Delhi 23. Rashid A (2011) An Introduction to Pteridopyta, 2nd edition, (Reprint), Vikas Publishing House Pvt Ltd, Noida. 24. Rashid A. (2013) An Introduction to Pteridophyta: Diversity, Development, Differentiation, Second edition. VikasPublishing House PVT LMT, Noida, India. 25. Vashishta PC,Sinha AK, Kumar K (2021) Botany for degree students-Pteridophyta. Vikas Publishing House Pvt. Ltd., Ghaziabad. **Suggested Websites** 1. https://www.algaebase.org/ 2. https://www.psaalgae.org/ 3. http://www.cyanodb.cz/ 4. http://bryophytes.plant.siu.edu/
Learning Outcomes	Upon completing this course, students will gain a comprehensive understanding of comparative cryptogams, including algae, fungi, bryophytes, and pteridophytes. They will be able to classify and describe major algal classes, including their pigmentation, storage products, thallus organization, and reproductive mechanisms. Students will learn about fungal classifications, structures, reproductive cycles, and evolutionary trends. They will also acquire knowledge of the classification and life histories of bryophytes and pteridophytes, including specific genera and evolutionary developments in sporophytes and stelar structures. This course will enhance their understanding of the diversity, adaptations, and ecological roles of these non-flowering plants.

Course Title	BOTMJ62: Lab Work Based on Paper BOTMJ61

Units	Practicals	Hours of Teaching:30 h
I	Study of the following genera of Algae: *Pandorina, Eudorina, Scenedesmus, Hydrodictyon, Ulva, Pithophora, Coleochaete, Oedocladium, Cosmarium, Codium, Bryopsis, Padina, Batrachospermum, Gloeotrichia, Aulosira*	10.0 h
II	Study of the following genera of Fungi: *Saccharomyces,Synchytrium, Protomyces, Peronospora,Phyllactinia, Puccinia, Ustilago, Helminthosporium, Alternaria*	10.0 h
III	Study of the following genera of Bryophyta: *Cyathodium, Notothylus, Sphagnum*	5.0 h
IV	Pteridophyta: *Psilotum, Marsilea*	5.0 h

Course Title	BOTMJ63: Comparative Phanerogams
Category of Course[60]	**Major** / Minor / Minor (Vocational) / SEC / AEC /VAC / MD/Internship/Dissertation

Credits[61]& Hour of Teaching		Theory	Practical	Cumulative
	Credits	3	1	4
	Hour of Teaching	45	30	75

Course Objectives	This course aims to provide a comprehensive understanding of phanerogams by exploring the classification, morphology, anatomy, and reproductive strategies of gymnosperms and angiosperms. Students will delve into the phylogenetic trends and world distribution of gymnosperms, including Cycadales, Ginkgoales, Coniferales, and Gnetales. They will also examine the classification and distinguishing characteristics of key angiosperm families, along with their economic importance. The course will integrate numerical taxonomy and molecular approaches, including Hutchinson's classification system and the Angiosperm Phylogeny Group (APG) system, to provide insights into the evolutionary relationships and phylogenetic developments within these plant groups.

Units	Course Content	Hours of Teaching: 45 h
I	• Classification of Gymnosperm (K R Sporne) and general account of morphology, anatomy and reproduction of the following: *Cycadales (Zamia), Ginkgoales (Ginkgo), Coniferales (Biota) and Gnetales (Gnetum)*	14.0 h
II	• General account of *Williamsonia* and *Pentaxyl* • Phylogenetic trends in Gymnosperms • World distribution of living Gymnosperms	8.0 h
III	• Classification of Angiosperms (Hutchinson's) and general account of numerical taxonomy	7.0 h
IV	• Distinguishing characters of the following families and their economic importance: *Mangoliaceae, Rutaceae, Combretaceae, Asteraceae, Convolvulaceae, Scrophulariaceae, Verbenaceae, Polygonaceae, Euphorbiaceae, Zingiberaceae, Liliaceae and Cyperaceae*	12.0 h

[60] SEC – Skill Enhancement Course; AEC – Ability Enhancement Course; VAC – Value Added Course; MD – Multidisciplinary Course

[61] 1 Credit (Theory) = 15 Hours; 1 Credit (Practical) = 30 Hours

V	• Molecular approach to taxonomy and Angiosperm phylogeny group (APG)	4.0 h

Texts/ References	1. Sporne KR (1967) Morphology of Gymnosperms, BI Publication, New Delhi. 2. Singh V, Jain DK (2012) Taxonomy of Angiosperms, 2nd edition, Rastogi Publication, Meerut. 3. Bhojwani SS, Bhatnagar SP (2009) Embryology of Angiosperms, Vikash Publishing House, New Delhi. 4. Singh Gurucharan (1999) Plant Systematics- Theory and Practices, Oxfordand IBH Publishing Co, New Delhi. 5. Judd WS, Christopher S, Campbell, Kellogg, AE, Stevens, PF (1999) Plant Systematics: A Phylogenetic Approach, Sinauer Associates Inc Publishers, Sunderland. 6. Simpson MG (2006) Plant Systematics, Elsevier Academic Press, Amsterdam. 7. Bhojwani SS, Bhatnagar SP and Dantu PK (2015) The Embryology of Angiosperms, 6th Edition, Vikas Publishing House Pvt Ltd, Noida. 8. Johri, BM (2011) Embryology of Angiosperms, Springer Berlin Heidelberg. 9. Bhatnagar, S.P and Moitra, A. (1996) Gymnosperms, New Age International Pvt. Ltd. Publishers, New Delhi. 10. Beck, C. B. (1988) Origin and evolution of gymnosperms. Columbia University Press. Chamberlain, C. J. (1934) Gymnsoperms – structure and evolution. Chicago Univ. Press
Learning Outcomes	Upon completing this course, students will be proficient in classifying and understanding the morphology, anatomy, and reproductive strategies of both gymnosperms and angiosperms. They will be able to analyze and compare the evolutionary trends and global distribution of gymnosperms, including Cycadales, Ginkgoales, Coniferales, and Gnetales. Students will also gain expertise in the classification and economic significance of key angiosperm families, and apply numerical taxonomy and molecular techniques, including Hutchinson's classification and the Angiosperm Phylogeny Group (APG) system, to elucidate the phylogenetic relationships within these plant groups.

Course Title	**BOTMJ64: Lab Work Based on Paper BOTMJ63**	
Units	**Practicals**	**Hours of Teaching:30 h**
I	• Study of morphology, anatomy and reproductive structure of *Zamia*, *Biota*,*Ginkgo* and*Gnetum*	10.0 h
II	• Study of fossils, *viz.*, *Williamsonia* (*Bucklandia*, *Ptilophyllum*) and *Pentaxylon*	10.0 h
III	• Taxonomic description of plant families: *Rutaceae, Combretaceae, Asteraceae, Convolvulaceae, Scrophulariaceae,Verbenaceae, Polygonaceae, Euphorbiaceae, Liliaceae, Cyperaceae*	5.0 h
IV	• Plant collection: Identification, preservation and submission of at least 25 herbarium sheets	5.0 h

Course Title	**BOTMJ65: Biodiversity and Biostatistics**			
Category of Course[62]	**Major** / Minor / Minor (Vocational) / SEC / AEC /VAC / MD/Internship/Dissertation			
Credits[63]**& Hour of Teaching**		Theory	Practical	Cumulative
	Credits	3	1	4
	Hour of Teaching	45	30	75

[62] SEC – Skill Enhancement Course; AEC – Ability Enhancement Course; VAC – Value Added Course; MD – Multidisciplinary Course

[63] 1 Credit (Theory) = 15 Hours; 1 Credit (Practical) = 30 Hours

Course Objectives	This course aims to provide students with a comprehensive understanding of biodiversity and biostatistics. Students will explore various levels of biodiversity—genetic, species, and ecosystem—and examine its distribution, ecosystem functions, and services. They will learn about the threats to biodiversity and strategies for its conservation. In the biostatistics section, students will gain skills in sampling methods, experimental design, and statistical analyses, including central tendency, correlation, regression, and analysis of variance. The course will also introduce multivariate methods and statistical software for data analysis, equipping students with essential tools for research and conservation efforts.

Units	Course Content	Hours of Teaching:45 h
I	• Introduction to biodiversity • Levels of biodiversity: Genetic, species and ecosystem	10.0 h
II	• Biodiversity and ecosystem functions: Concepts and Hypotheses • Biodiversity and ecosystem services: Provisioning, regulatory, supporting and cultural	5.0 h
III	• Threats to biodiversity: Causes of biodiversity loss, species extinction, vulnerability of species to extinction, IUCN threat categories, Red data book • Strategies for biodiversity conservation: Principles of biodiversity conservation, *in-situ* and *ex-situ* conservation strategies	8.0 h
IV	• Sampling methods and experimental design • Concepts of central tendency, normal distribution and variability • Contingency tables and chi-square test • Comparison of means: t-test, multiple range tests	10.0 h
V	• Correlation and regression analyses • Analysis of variance: One-way • Introduction to multivariate methods: Parametric and non-parametric ordination, statistical packages for data analyses	12.0 h

Texts/ References	1. Heywood VH and Watson RT. 1995. Global Biodiversity Assessment. UNEP, Cambridge University Press. 2. Singh JS, Singh SP and Gupta SR. 2014. Ecology, Environmental Science and Resource Conservation. S. Chand & Company Pvt. Ltd. New Delhi 3. Magurran, A.E. 2004. Measuring Biological Diversity. Blackwell Publishing, Oxford 4. Snedecor GW and Cochran WG. 1989. Statistical Methods. 8th Edition, Iowa State University Press, Ames. 5. Infan AK and Khanum A. 2020. Fundamentals of Biostatistics. Ukaa Publications, Hyderabad.
Learning Outcomes	Upon completing this course, students will have a thorough understanding of biodiversity at genetic, species, and ecosystem levels, including its distribution, functions, and services. They will be equipped to analyze biodiversity threats and implement conservation strategies. Additionally, students will acquire practical skills in biostatistics, including sampling methods, experimental design, and statistical analyses such as central tendency, correlation, regression, and variance. They will also be familiar with multivariate methods and statistical software, enabling them to effectively analyze and interpret complex ecological and biodiversity data for research and conservation applications.

Course Title	BOTMJ66: Lab Work Based on Paper BOTMJ65

Units	Practicals	Hours of Teaching:30 h
I	• Analysis of species-area relations • Analysis of herbaceous species richness in protected and unprotected grasslands	6.0 h
II	• Analysis of herbaceous species evenness in protected and unprotected grasslands • To assess alpha diversity of protected and unprotected grasslands	6.0 h
III	• To assess beta diversity in protected and unprotected grasslands • To analyze gamma diversity across grassland communities • To estimate mean, standard deviation, standard error and variance	6.0 h
IV	• To estimate chi-square test for association analysis • To estimate t-test for differentiating the means • Determination of one way analysis of variance	6.0 h
V	• To establish correlation between variables • To establish regression equation between variables	6.0 h

Course Title	BOTMJ67: Cytogenetics and Evolutionary Processes
Category of Course[64]	**Major** / Minor / Minor (Vocational) / SEC / AEC /VAC / MD/Internship/Dissertation

Credits[65]& Hour of Teaching		Theory	Practical	Cumulative
	Credits	3	1	4
	Hour of Teaching	45	30	75

Course Objectives	The objective of this course is to provide a comprehensive understanding of cytogenetics and evolutionary processes by exploring chromosome structure, karyotyping, and chromosomal rearrangements. Students will learn about chromosome manipulation techniques, the impact of numerical chromosomal variations, and the principles of mutagenesis. The course will cover chromatin remodeling and epigenetics, emphasizing their roles in gene regulation and evolutionary biology. Additionally, students will delve into quantitative genetics, focusing on inheritance patterns and QTL analysis, and study population and evolutionary genetics, including gene pool dynamics, Hardy-Weinberg equilibrium, and speciation processes.

Units	Course Content	Hours of Teaching:45 h
I	• Chromosome structure and karyotype:Physical, chemical, and molecular organization of chromosomes; Classical and modern concepts**,** Karyotype symmetry and asymmetry, Karyotype classification and estimation, Karyotype evolutionary factors and trends in natural plant population	5.0 h
II	• Banding techniques and chromosome manipulations:Classical banding techniques, The International System for Human Cytogenomic Nomenclature (ISCN), chromosome linearization and differentiation of selected gymnosperms and angiosperms, Genomic level or whole genome manipulations, Chromosome level (addition and substitution) manipulations, applications	7.0 h
III	• Threats to biodiversity: Causes of biodiversity loss, speChromosome rearrangements: Meiotic configuration and genetic consequences of	11.0 h

[64] SEC – Skill Enhancement Course; AEC – Ability Enhancement Course; VAC – Value Added Course; MD – Multidisciplinary Course

[65] 1 Credit (Theory) = 15 Hours; 1 Credit (Practical) = 30 Hours

	deletion, duplication, inversion, and translocation. Permanent translocation heterozygote (PTH) • Source and consequences of numerical variation in chromosomes: Monosomic, nullisomic, trisomics; autopolyploids, allopolyploids,Status of allopolyploids in plant evolution • cies extinction, vulnerability of species to extinction, IUCN threat categories, Red data book • Strategies for biodiversity conservation: Principles of biodiversity conservation, *in-situ* and *ex-situ* conservation strategies	
IV	• Mutagens and mutagenesis:Basic concepts of mutation, Mutation types, Molecular basis of mutations, Chemical mutagens (Base analogs, deaminating, hydroxylating, alkylating, and intercalating agents), and Physical mutagens (Ionising and Non-ionising radiations) • Chromatin remodelling and epigenetics: Concept and scope of epigenetics, Components of chromatin remodelling complexes, Assembly and disassembly of nucleosome, DNA methylation and histone modifications, Techniques for studying epigenetics mechanisms, and the biological significance of epigenetics: genomic imprinting, paramutation, and silencing	12.0 h
V	• Quantitative genetics:Concept of quantitative inheritance, genes, and environment, the multiple factor hypothesis, partitioning the phenotypic variance, Broad-Sense Heritability, Narrow-Sense Heritability, quantitative trait loci, and QTL analysis • Population and evolutionary genetics:Population, gene pool, allele frequency, Hardy-Weinberg principle (Allele frequencies and genotype frequencies), selection, mutation, migration, genetic drift, linkage disequilibrium, and speciation	10.0 h

Texts/ References	1. Stebbins GL (1971) Chromosome Evolution in Higher Plants, Edward Arnold LTD, London 2. Swanson CP, Mertz TF, Young WJ (1982) Cytogenetics: The Chromosomes in Division, Inheritance, and Evolution, 2nd edition, Englewood Cliff, Prentice-Hall, New Jersey. 3. Clark MS, Wall WJ (1996) Chromosomes: The Complex Code, Chapman & Hall, London. 4. Sharma AK, Sharma A (1985) Advances in Chromosome and Cell Genetics, Oxford & IBH Publishing Co, Kolkata. 5. Krebs JE, Lewin B, Goldstein ES (2011) Genes X, Sudburry, Masschusetts. 6. Brooker RJ (2011) Genetics: Analysis and Principles, 4th edition, McGraw-Hill Education, New Delhi. 7. De Robertis EMF (2011) Cell and Molecular Biology, 8th edition, Lippincott Williams & Wilkins, New York. 8. Singh BD (2014) Genetics, Kalyani Publishers, Kolkata. 9. Alberts B (2014) Molecular Biology of the Cell, 6th edition, Garland Science Pub, New York. 10. David CA, et al., (2007) Epigenetics, 2nd edition, Cold Spring Harbor Laboratory Press, New York. 11. Spillane C, McKeown PC (2014) Plant Epigenetics and Epigenomics: Methods and Protocol, Springer Publisher, London
Learning Outcomes	Upon completing this course, students will be proficient in analyzing chromosome structure and karyotype, understanding chromosomal rearrangements and manipulations. They will gain insight into numerical chromosomal variations and their evolutionary implications, and become familiar with mutagenesis, chromatin remodeling, and epigenetics. The course will enable students to grasp quantitative genetics concepts, such as inheritance patterns and QTL analysis, and apply these principles to real-world genetic studies. Additionally, students will understand population genetics dynamics, including gene pool, allele frequencies, and evolutionary processes like selection, mutation, and speciation.

Course Title	BOTMJ68: Lab Work Based on Paper BOTMJ67

Units	Practicals	Hours of Teaching: 30 h
I	• Preparation of metaphase squashes and karyotype analysis in *Allium*, *Vicia*, and *Aloe* • Karyotype analysis using microphotographs of metaphase squashes and preparation of ideograms of suitable plant materials	6.0 h
II	• To study the effects of Colchicine: a) C-mitosis, b) polyploidy	6.0 h
III	• To study the permanent translocation heterozygote in suitable plant material	6.0 h
IV	• Study of; a) mitotic index and b) mitotic phase index	6.0 h
V	• Demonstration of QTL mapping • Demonstration of Hardy-Weinberg equilibrium using available data	6.0 h

Course Title	BOTMV61: Plant Micropropagation
Category of Course[66]	Major / Minor / **Minor (Vocational-3)**/ SEC / AEC /VAC/ MD/Internship/Dissertation

Credits[67] & Hour of Teaching

	Theory	Practical	Cumulative
Credits	3	1	4
Hour of Teaching	45	30	75

Course Objectives

This course aims to provide students with a comprehensive understanding of plant micropropagation techniques. Students will learn the historical development, principles, and laboratory organization for in vitro plant culture. They will master media preparation, aseptic techniques, and explant handling. The course covers cellular totipotency, micropropagation stages, and various methods such as meristem culture, organogenesis, and somatic embryogenesis. Students will also address common problems, including contamination and somaclonal variations, and explore advanced topics like haploid plant production and industrial applications. By the end, students will be equipped to apply these techniques in both research and commercial settings.

Units	Course Content	Hours of Teaching:45 h
I	• Introduction to *In vitro*plant micropropagation: Historical perspectives, principles of plant tissue culture, Laboratory organization • Media preparation: Constituents, Types of media, Steps of media preparation, Precaution	9.0 h
II	• Maintenance of aseptic conditions, Explant selection and preparation, Surface sterilization • Cellular totipotency and differentiation: Concept of cellular totipotency and differentiation, role of plant growth regulators	9.0 h
III	• Stages of micropropagation: Preparatory, Culture initiation, Multiplication, Plantlet formation, Hardening and acclimatization • Types of micropropagation: Meristem culture, Organogenesis and Somatic embryogenesis	9.0 h

[66] SEC – Skill Enhancement Course; AEC – Ability Enhancement Course; VAC – Value Added Course; MD – Multidisciplinary Course

[67] 1 Credit (Theory) = 15 Hours; 1 Credit (Practical) = 30 Hours

IV	• Problems associated with micropropagation: Contamination, recalcitrance, vitrification, off types, high costs, somaclonal variations • Haploid plant production: parasexual hybridization significance of Androgensis and Gynogenesis, In-vitro fertilization	9.0 h
V	• Industrial and other applications of micropropagation: Production of disease-free plants, Suspension cultures, Hairy root cultures.Use of bioreactorsfor commercial production of bioactive compounds	9.0 h
Texts/ References	1. Bhojwani SS & Dantu PK (2013) Plant Tissue Culture: An Introductory Text, Springer. 2. Park S (2021) Plant Tissue Culture: Techniques and Experiments, Fourth Edition, Academic Press, Elsevier. 3. Razdan MK (2003) Introduction to Plant Tissue Culture, Science Publishers, USA.	
Learning Outcomes	Upon completing this course, students will have developed a thorough understanding of plant micropropagation techniques and their applications. They will be proficient in media preparation, aseptic techniques, and explant handling. Students will grasp the concepts of cellular totipotency and differentiation, and be able to navigate the stages of micropropagation, including meristem culture, organogenesis, and somatic embryogenesis. They will also identify and address common issues such as contamination and somaclonal variations. Additionally, students will be knowledgeable about haploid plant production and the industrial applications of micropropagation, including the use of bioreactors for bioactive compound production.	

Course Title	**BOTMV62: Lab Work Based on Paper BOTMV61**	
Units	**Practicals**	**Hours of Teaching: 30 h**
I	• Stock preparation of Murashige and Skoog Medium	5.0 h
II	• Media preparation	5.0 h
III	• Explant preparation and surface sterilization	10.0 h
IV	• To initiate culture by inoculating explants in different combinations of auxins and cytokinins	10.0 h

Honours without Research Degree

SEMESTER-VII

Course Title	**BOTMJ71: Plant Biochemistry and Molecular Biology**			
Category of Course	**Major**/ Minor / Minor (Vocational) / SEC / AEC /VAC/ MD/Internship/Dissertation			
Credits& Hour of Teaching		Theory	Practical	Cumulative
	Credits	3	1	4
	Hour of Teaching	45	30	75
Course Objectives	The course objective is to provide students with a comprehensive understanding of plant biochemistry and molecular biology. Students will learn the biosynthesis of key carbon compounds, including sucrose, starch, and cellulose, and delve into sulfur and phosphorus metabolism, including ATP synthesis. They will gain insight into nitrogen metabolism, including the biochemistry of nitrogen fixation and nitrate reduction. The course will cover the structure and replication of DNA, RNA transcription and processing, and protein synthesis and modification. Additionally, students will explore enzyme mechanisms and molecular tools and techniques such as electrophoresis and cloning vectors.			

Units	**Course Content**	**Hours of Teaching:45 h**
I	• Biosynthesis of carbon compounds: sucrose, starch, cellulose • Sulphur and phosphorus metabolism: Activation and assimilation of sulphur, energy-rich phosphorus compounds; ATP synthesis	10.0 h

II	• Nitrogen metabolism: components, types and substrate of enzyme nitrogenase, biochemistry of nitrogen fixation; Nitrate metabolism: Uptake and reduction into ammonia, ammonia assimilation	8.0 h
III	• DNA: Structure and properties of different forms of DNA, DNA replication in prokaryotes and eukaryotes, DNA damage and repair	8.0 h
IV	• RNA:Structure and properties of different forms of RNA, transcription in prokaryotes and eukaryotes, mRNA processing-5' cap formation-3'end processing and polyadenylation, splicing, nuclear export of mRNA	6.0 h
V	• Protein: Basic aspects of protein conformation, translation in prokaryotes and eukaryotes (activation of amino acids, initiation, elongation, termination and release of peptides), post-translational modification of proteins • Enzymes: Mechanism of enzyme action, coenzymes, allosteric enzyme, isozymes • Molecular tools and techniques: Basic principles of electrophoresis and blotting, cloning vectors, molecular cloning of nucleic acid fragments	13.0 h

Texts/References	1. Berg JM et al. (2018) Biochemistry, 8th edition, WH Freeman & Company, New York. 2. Cox MM, Nelson DL (2021) Lehninger Principle of Biochemistry, 8th edition MacMillan, Worth Publishers,London. 3. Devlin TM (2011) Textbook of Biochemistry, 7th edition, John Wiley & Sons, Inc, New York. 4. Voet D, Voet JG and Pratt CW (2018) Biochemistry, 5th Edition, John Wiley & Sons, Inc, New York. 5. Zubay GL (1998) Biochemistry, 4th edition, Wm C Brown Publishers, Dubuque, Iowa. 6. Dubey RC (2013) A Text Book of Biotechnology 4th edition, S Chand & Co Ltd, New Delhi. 7. Wilson K, Walker J (2018) Principle & Techniques of Biochemistry and Molecular Biology, 8th edition, Cambridge University Press, Cambridge. 8. Bowsher C & Tobin A (2021) Plant Biochemistry, 2nd Edition, Taylor & Francis Inc, CRC press. 9. Arthur M. Lesk (2016) Introduction to Protein Science Architecture Function and Genomics, Oxford University press, London **Suggested websites** https://academic.oup.com/aob/article/105/7/1141/148741 https://dx.doi.org/10.1016/B978-0-12-800180-6.00001-3 https://doi:10.1016/j.molp.2016.05.004 https://doi.org/10.1093/jn/130.5.1081 https://academic.oup.com/jxb/article/68/10/2463/2967464 https://epgp.inflibnet.ac.in/Home/ViewSubject?catid=2 https://epgp.inflibnet.ac.in/epgpdata/uploads/epgp_content/food_technology/food_chemistry/16. protein_ structure_and_denaturation/et/40_et_m16.pdf https://www.youtube.com/watch?v=MODnIkQvyz0 https://www.youtube.com/watch?v=AeVDoDp3llI
Learning Outcomes	Upon completion of this course, students will be able to understand and describe the biosynthesis of essential carbon compounds like sucrose, starch, and cellulose, and elucidate sulfur and phosphorus metabolism, including ATP synthesis. They will gain insights into nitrogen metabolism, focusing on nitrogen fixation and nitrate reduction. Students will be proficient in explaining DNA structure, replication, and repair, RNA transcription, processing, and translation, and protein synthesis and post-translational modifications. Additionally, they will be familiar with enzyme mechanisms and molecular techniques such as electrophoresis and molecular cloning, enabling practical applications in plant biochemistry and molecular biology.

Course Title	BOTMJ72: Lab Work Based on Paper BOTMJ71

Units	Practicals	Hours of Teaching:30 h
I	• Chromatographic separation and comparative analysis of photosynthetic pigments in plants • Chromatographic separation of amino acids	6.0 h
II	• Preparation of standard graph and estimation of DNA by diphenylamine test • Preparation of standard graph and estimation of RNA by Orcinol test	6.0 h
III	• Preparation of standard graph and estimation of protein by Bradford method • Study on the effects of light/dark on the nitrate reductase enzyme	6.0 h
IV	• To study the time dependent activity of urease enzyme. • Study on the effects of different concentrations of urea on urease activity	6.0 h
V	• Determination of different concentrations of urease enzyme on its activity • Preparation of standard graph and estimation of carbohydrates by anthrone reagent method • Demonstration of electrophoretic and blotting instruments	6.0 h

Course Title	BOTMJ73: Plant Biotechnology and Genetic Engineering			
Category of Course[68]	Major/ Minor / Minor (Vocational) / SEC / AEC /VAC/ MD/Internship/Dissertation			
Credits[69]& Hour of Teaching		Theory	Practical	Cumulative
	Credits	3	1	4
	Hour of Teaching	45	30	75
Course Objectives	This course aims to provide a comprehensive understanding of plant biotechnology and genetic engineering, covering historical developments, model plants, and applications. Students will learn about recombinant DNA technology, including vectors, restriction enzymes, and genomic libraries. They will explore plant cell, tissue, and organ culture techniques, including totipotency, media preparation, and regeneration protocols. The course will cover plant transformation techniques, including both indirect and direct methods. Students will examine transgenic plants and their applications, gene expression regulation, and advanced gene editing technologies like ZFNs, TALENs, and CRISPR/Cas systems, addressing their applications, limitations, and ethical considerations.			

Units	Course Content	Hours of Teaching: 45 h
I	• Plant Biotechnology: Introduction, History, Model plants, Scope and applications • Recombinant DNA technology: Vectors, restriction enzymes, molecular probes, genomic and cDNA libraries	8.0 h
II	• Plant Cell, Tissue and Organ Culture *(a) History, concept of totipotency, nutritional requirements of culture, mediapreparation, aseptic condition, applications and limitations* *(b) Regeneration Protocols: Single Cell Culture, Organogenesis and Somatic Embryogenesis, Factors and significance* *(c) Protoplast Culture and Fusion: Protoplast isolation and culture, Protoplast fusion, methods and factors, Applications*	8.0 h
III	• Techniques for plant transformation	8.0 h

[68] SEC – Skill Enhancement Course; AEC – Ability Enhancement Course; VAC – Value Added Course; MD – Multidisciplinary Course

[69] 1 Credit (Theory) = 15 Hours; 1 Credit (Practical) = 30 Hours

	(a) Indirect gene transfer methods (Agrobacterium tumefaciens, and Agrobacterium rhizogenes mediated transfer) *(b) Direct Gene transfer methods (electroporation, particle bombardment, microinjection, PEG, silicon carbide)*	
IV	• Transgenic plants, some genetically modified plants (Flavr Savr tomato, Bt brinjal, Bt corn, Bt cotton, Golden rice, virus resistant plants, pest resistant plants) and molecular forming, applications and limitations (ethical and environmental issues)	9.0 h
V	• Gene expression and its regulation in plants: Transcription factors and cis-regulatory elements (CREs), epigenetic mechanisms of transcriptional regulation, translational control, programmed DNA rearrangements. • Gene editing and its applications: Zinc-finger nucleases (ZFNs), transcription • activator-like effector nucleases (TALENs), CRISPR/Cas systems	12.0 h

Texts/ References	1. Bhojwani SS & Dantu PK (2013) Plant Tissue Culture: An Introductory Text, Springer. 2. Park S (2021) Plant Tissue Culture: Techniques and Experiments, Fourth Edition, Academic Press, Elsevier. 3. Razdan MK (2003) Introduction to Plant Tissue Culture, Science Publishers, USA 4. Slater A, Scott NW and Fowler MR (2008) Plant biotechnology: the genetic manipulation of plants, second edition, Oxford University Press. 5. Sahni S, Prasad BD and Kumar P (2017) Plant Biotechnology: Transgenics, Stress 6. Management and Biosafety Issues, CRC Press.
Learning Outcomes	Upon completing this course, students will be proficient in plant biotechnology and genetic engineering techniques. They will understand the historical development and applications of plant biotechnology, including recombinant DNA technology and plant cell culture methods. Students will gain expertise in various plant transformation techniques, both indirect and direct, and be familiar with the production and use of transgenic plants. They will also learn about gene expression regulation and advanced gene editing technologies, such as ZFNs, TALENs, and CRISPR/Cas systems. Additionally, students will address the applications, limitations, and ethical considerations of these biotechnological advances.

Course Title	**BOTMJ74: Lab Work Based on Paper BOTMJ73**	
Units	**Practicals**	**Hours of Teaching:30 h**
I	• Medium preparation of Murashige and Skoog • Surface sterilization and inoculation of nodal explants on MS medium	6.0 h
II	• To raise suspension culture by using friable calli	6.0 h
III	• To initiate hairy root culture	6.0 h
IV	• Floral dip method of plant transformation (*Arabidopsis thaliana*) and screening for gene transfer (plasmid isolation & transformation, screening through PCR and agarose gel electrophoresis)	6.0 h
V	• Synthetic seed preparation	6.0 h

Course Title	BOTMJ75: Field Excursion			
Category of Course[70]	Major/ Minor / Minor (Vocational) / SEC / AEC /VAC/ MD/Internship/Dissertation			
Credits[71]& Hour of Teaching		Theory	Practical	Cumulative
	Credits	2		2
	Hour of Teaching	30		30
Course Objectives	Field excursions will provide immersive, hands-on learning experiences that bridge theoretical knowledge and real-world applications. These trips are designed to enhance students' understanding of ecological, geological, botanical, and environmental concepts through direct observation and interaction with natural habitats. By engaging in fieldwork, students develop essential skills in data collection, species identification, and environmental assessment, fostering critical thinking and problem-solving abilities. Field excursions also promote teamwork, collaboration, and effective communication, as students often work in groups to conduct research and share findings. Moreover, these experiences help students appreciate the complexity and interconnectedness of natural systems, encouraging a deeper commitment to environmental conservation and sustainability. Ultimately, field excursions enrich the educational journey by making abstract concepts tangible and inspiring a lasting passion for scientific inquiry and exploration.			
Learning Outcomes	Field excursions for BSc students offer hands-on learning experiences, enhancing their understanding of ecological systems, plant identification, and data collection methods. These trips provide practical insights into theoretical concepts, foster observational and analytical skills, and encourage environmental awareness. By interacting directly with nature, students gain a deeper appreciation for biodiversity and conservation. Additionally, fieldwork promotes teamwork, critical thinking, and problem-solving abilities, preparing students for advanced research and professional careers in biological sciences.			

Course Title	BOTMJ76: Photoecophysiology			
Category of Course[72]	Major/ Minor / Minor (Vocational) / SEC / AEC /VAC/ MD/Internship/Dissertation			
Credits[73]& Hour of Teaching		Theory	Practical	Cumulative
	Credits	3	1	4
	Hour of Teaching	45	30	75
Course Objectives	This course aims to provide a comprehensive understanding of photoecophysiology, focusing on light-regulated growth and development in cyanobacteria and plants. Students will explore the roles of photoreceptors, light quality, and light signaling in plant and microbial adaptation. Key topics include molecular mechanisms of photodamage and protection, light harvesting processes, and carbon concentrating mechanisms. Through this course, students will gain insights into how light influences physiological processes, signal transduction, and adaptation strategies in diverse photosynthetic organisms.			

Units	Course Content	Hours of Teaching: 45 h
I	• Light-regulated growth and development in cyanobacteria: Phytochrome-related photosensor and light perception, Photomorphogenesis, Complementary chromatic acclimation, Light quality and quantity dependent changes in light-harvesting complex, Signal transduction, Photoregulation of morphology	9.5 h

[70] SEC – Skill Enhancement Course; AEC – Ability Enhancement Course; VAC – Value Added Course; MD – Multidisciplinary Course

[71] 1 Credit (Theory) = 15 Hours; 1 Credit (Practical) = 30 Hours

[72] SEC – Skill Enhancement Course; AEC – Ability Enhancement Course; VAC – Value Added Course; MD – Multidisciplinary Course

[73] 1 Credit (Theory) = 15 Hours; 1 Credit (Practical) = 30 Hours

II	• Molecular mechanisms of photodamage and photoprotection: Photo-induced damage to microbes; genetical, biochemical and molecular aspects of mycosporine-like amino acids (MAAs) and scytonemin production, ecological and economical implications	9.5 h
III	• Light-regulated plant growth and development: Photoreceptors and light perception, Physiological responses, Photomorphogenesis, Circadian clock, Signal transduction, Seed germination, Hypocotyl elongation	6.5 h
IV	• Light signalling dynamics in plants: Phytochromes, Cryptochromes, PIFs, Phototropins, UV resistance locus8 (UVR8), HY5, COP1, SUMOylation, Chloroplast movement • Light harvesting in plants and cyanobacteria: Photosynthetic pigments and phycobilisomes, State transition, photochemical quenching (PQ), non-photochemical quenching (NPQ), photoinhibition, orange carotenoid protein (OCP), xanthophyll cycle, principle of PAM fluorometry	13.0 h
V	• Carbon concentrating mechanisms (CCM) in plants and cyanobacteria: Photorespiration, Components of CCM, Pyrenoids, Carboxysome, RuBISCO, Carbonic anhydrase	6.5 h

Texts/References	1. Ruban, A., Foyer, C., & Murchie, E. (Eds.). (2022). Photosynthesis in Action: Harvesting Light, Generating Electrons, Fixing Carbon. Academic Press. 2. Taiz L, Zeiger E (2015) Plant Physiology and Development, 7th edition, Sinauer Associates Inc. Publishers, Sunderland. 3. Hopkins WG, Hunter NPA (2011) Introduction to Plant Physiology, Wiley International edition, John Wiley & Sons, New Jersey. 4. Buchanan B, GruissemW, Jones RL (2002) Biochemistry and Molecular Biology of Plants, American Society of Plant Biologists, Rockville. 5. Devlin R.M. (1983) Plant Physiology, Cengage Learning Inc., London. 6. Salisbury F.B., Ross C.W. (2004) Plant Physiology, Wadsworth, California
Learning Outcomes	Upon completing this course, students will have a thorough understanding of the principles and mechanisms underlying light-regulated growth and development in cyanobacteria and plants. They will be able to explain the roles of various photoreceptors and light signaling pathways in photomorphogenesis and adaptation. Students will gain insights into the molecular mechanisms of photodamage and photoprotection, including the production of protective compounds. They will also understand light harvesting processes, including the functions of photosynthetic pigments and carbon concentrating mechanisms. Overall, students will be equipped to analyze and interpret the effects of light on plant and microbial physiology.

Course Title	**BOTMJ77: Lab Work Based on Paper BOTMJ76**

Units	**Practicals**	**Hours of Teaching:30 h**
I	• Effects of light and dark on seed germination • Hypocotyl length measurements in light and dark grown seedlings	6.0 h
II	• Photosynthetic pigments analysis in light and dark grown seedlings • Growth measurement of cyanobacteria under white light, blue light, red light and UVR	6.0 h
III	• Extraction and quantification of photosynthetic pigments from cyanobacteria grown under different light conditions	6.0 h
IV	• Extraction and spectrophotometric analysis of mycosporine-like amino acids in cyanobacteria	6.0 h
V	• Extraction and spectrophotometric analysis of scytonemin in cyanobacteria	6.0 h

Course Title	BOTMJ78: Research Methodology
Category of Course[74]	Major/ Minor / Minor (Vocational) / SEC / AEC /VAC / MD/Internship/Dissertation

Credits[75]& Hour of Teaching

	Theory	Practical	Cumulative
Credits	2	0	2
Hour of Teaching	30	0	30

Course Objectives

This course aims to equip students with essential research methodology skills, covering the entire research process from problem formulation to data collection, analysis, and reporting. It focuses on ethical research practices, effective literature review, diverse data collection methods, and the use of statistical and qualitative analysis tools. The course also enhances students' abilities to present and publish their research findings.

Units	Course Content	Hours of Teaching:30 h
I	Introduction to Research Methodology Understanding research, its significance, and different types of research, Steps involved in the research process, Ethical considerations and plagiarism, Identifying and defining research problems, Types of research designs	6.0 h
II	Literature Review Role and significance of literature review in research, Identifying and accessing various sources of literature. Methods for effective literature review, Importance and methods of citation and referencing	4.0 h
III	Data Collection Methods Techniques for collecting primary data (surveys, interviews, observations, experiments), Utilizing secondary data sources, understanding different sampling techniques (random, stratified, cluster), Designing and using questionnaires, interview guides, and other tools, Reliability and validity in data collection	7.0 h
IV	Data Analysis and Interpretation Statistical methods for analysing quantitative data, Techniques for analysing qualitative data, Introduction to statistical software (SPSS, R) and qualitative analysis tools, making sense of data and drawing conclusions, Effective ways to present data using tables, graphs, and charts	7.0 h
V	Research Reporting and Presentation Structure and components of a research report (introduction, methodology, results, discussion, conclusion), Guidelines for writing a thesis or dissertation, writing research papers and articles for journals, Techniques for presenting research findings orally and visually, Understanding the publication process and choosing appropriate journals	6.0 h

Texts/References

1. Research Methodology: Methods and Techniques" by C.R. Kothari and Gaurav Garg
2. Research Methods for Business Students" by Mark Saunders, Philip Lewis, and Adrian Thornhill
3. The Craft of Research" by Wayne C. Booth, Gregory G. Colomb, and Joseph M. Williams
4. Research Design: Qualitative, Quantitative, and Mixed Methods Approaches" by John W. Creswell and J. David Creswell
5. Qualitative Inquiry and Research Design: Choosing Among Five Approaches" by John W. Creswell and Cheryl N. Poth
6. Research Methods: The Essential Knowledge Base" by William M. Trochim and James P. Donnelly
7. Research Methods in Education" by Louis Cohen, Lawrence Manion, and Keith Morrison
8. Practical Research: Planning and Design" by Paul D. Leedy and Jeanne Ellis Ormrod

[74] SEC – Skill Enhancement Course; AEC – Ability Enhancement Course; VAC – Value Added Course; MD – Multidisciplinary Course

[75] 1 Credit (Theory) = 15 Hours; 1 Credit (Practical) = 30 Hours

	9. Introduction to Research Methods: A Hands-On Approach" by Bora Pajo **Suggested Websites** https://bio-protocol.org/en https://conductscience.com/microbiology-techniques
Learning Outcomes	By the end of this course, students will proficiently design, conduct, and analyze research, adhering to ethical standards. They will be adept at literature review, data collection, and using analytical tools, enabling them to write structured research reports and present their findings effectively.

Course Title	**BOTMN71: Plant Biochemistry and Molecular Biology**
Category of Course	Major / **Minor**/ Minor (Vocational) / SEC / AEC /VAC/ MD/Internship/Dissertation
Credits & Hour of Teaching	

	Theory	Practical	Cumulative
Credits	3	1	4
Hour of Teaching	45	30	75

Course Objectives	The course objective is to provide students with a comprehensive understanding of plant biochemistry and molecular biology. Students will learn the biosynthesis of key carbon compounds, including sucrose, starch, and cellulose, and delve into sulfur and phosphorus metabolism, including ATP synthesis. They will gain insight into nitrogen metabolism, including the biochemistry of nitrogen fixation and nitrate reduction. The course will cover the structure and replication of DNA, RNA transcription and processing, and protein synthesis and modification. Additionally, students will explore enzyme mechanisms and molecular tools and techniques such as electrophoresis and cloning vectors.

Units	**Course Content**	**Hours of Teaching:45 h**
I	• Biosynthesis of carbon compounds: sucrose, starch, cellulose • Sulphur and phosphorus metabolism: Activation and assimilation of sulphur, energy-rich phosphorus compounds; ATP synthesis	10.0 h
II	• Nitrogen metabolism: components, types and substrate of enzyme nitrogenase, biochemistry of nitrogen fixation; Nitrate metabolism: Uptake and reduction into ammonia, ammonia assimilation	8.0 h
III	• DNA: Structure and properties of different forms of DNA, DNA replication in prokaryotes and eukaryotes, DNA damage and repair	8.0 h
IV	• RNA:Structure and properties of different forms of RNA, transcription in prokaryotes and eukaryotes, mRNA processing-5' cap formation-3'end processing and polyadenylation, splicing, nuclear export of mRNA	6.0 h
V	• Protein: Basic aspects of protein conformation, translation in prokaryotes and eukaryotes (activation of amino acids, initiation, elongation, termination and release of peptides), post-translational modification of proteins • Enzymes: Mechanism of enzyme action, coenzymes, allosteric enzyme, isozymes • Molecular tools and techniques: Basic principles of electrophoresis and blotting, cloning vectors, molecular cloning of nucleic acid fragments	13.0 h

Texts/References	1. Berg JM et al. (2018) Biochemistry, 8th edition, WH Freeman & Company, New York. 2. Cox MM, Nelson DL (2021) Lehninger Principle of Biochemistry, 8th edition MacMillan, Worth Publishers,London. 3. Devlin TM (2011) Textbook of Biochemistry, 7th edition, John Wiley & Sons, Inc, New York. 4. Voet D, Voet JG and Pratt CW (2018) Biochemistry, 5th Edition, John Wiley & Sons, Inc, New York. 5. Zubay GL (1998) Biochemistry, 4th edition, Wm C Brown Publishers, Dubuque, Iowa. 6. Dubey RC (2013) A Text Book of Biotechnology 4th edition, S Chand & Co Ltd, New Delhi. 7. Wilson K, Walker J (2018) Principle & Techniques of Biochemistry and Molecular Biology, 8th edition, Cambridge University Press, Cambridge. 8. Bowsher C & Tobin A (2021) Plant Biochemistry, 2nd Edition, Taylor & Francis Inc, CRC press. 9. Arthur M. Lesk (2016) Introduction to Protein Science Architecture Function and Genomics, Oxford University press, London **Suggested websites** https://academic.oup.com/aob/article/105/7/1141/148741 https://dx.doi.org/10.1016/B978-0-12-800180-6.00001-3 https://doi:10.1016/j.molp.2016.05.004 https://doi.org/10.1093/jn/130.5.1081 https://academic.oup.com/jxb/article/68/10/2463/2967464 https://epgp.inflibnet.ac.in/Home/ViewSubject?catid=2 https://epgp.inflibnet.ac.in/epgpdata/uploads/epgp_content/food_technology/food_chemistry/16. protein_ structure_and_denaturation/et/40_et_m16.pdf https://www.youtube.com/watch?v=MODnIkQvyz0 https://www.youtube.com/watch?v=AeVDoDp3llI
Learning Outcomes	Upon completion of this course, students will be able to understand and describe the biosynthesis of essential carbon compounds like sucrose, starch, and cellulose, and elucidate sulfur and phosphorus metabolism, including ATP synthesis. They will gain insights into nitrogen metabolism, focusing on nitrogen fixation and nitrate reduction. Students will be proficient in explaining DNA structure, replication, and repair, RNA transcription, processing, and translation, and protein synthesis and post-translational modifications. Additionally, they will be familiar with enzyme mechanisms and molecular techniques such as electrophoresis and molecular cloning, enabling practical applications in plant biochemistry and molecular biology.

Course Title	**BOTMN72: Lab Work Based on Paper BOTMN71**	
Units	**Practicals**	**Hours of Teaching:30 h**
I	• Chromatographic separation and comparative analysis of photosynthetic pigments in plants • Chromatographic separation of amino acids	6.0 h
II	• Preparation of standard graph and estimation of DNA by diphenylamine test • Preparation of standard graph and estimation of RNA by Orcinol test	6.0 h
III	• Preparation of standard graph and estimation of protein by Bradford method • Study on the effects of light/dark on the nitrate reductase enzyme	6.0 h
IV	• To study the time dependent activity of urease enzyme • Study on the effects of different concentrations of urea on urease activity	6.0 h
V	• Determination of different concentrations of urease enzyme on its activity • Preparation of standard graph and estimation of carbohydrates by anthrone reagent method • Demonstration of electrophoretic and blotting instruments	6.0 h

Course Title	BOTMN73: Plant Biotechnology and Genetic Engineering
Category of Course[76]	Major / **Minor**/ Minor (Vocational) / SEC / AEC /VAC/ MD/Internship/Dissertation

Credits[77]& Hour of Teaching

	Theory	Practical	Cumulative
Credits	3	1	4
Hour of Teaching	45	30	75

Course Objectives

This course aims to provide a comprehensive understanding of plant biotechnology and genetic engineering, covering historical developments, model plants, and applications. Students will learn about recombinant DNA technology, including vectors, restriction enzymes, and genomic libraries. They will explore plant cell, tissue, and organ culture techniques, including totipotency, media preparation, and regeneration protocols. The course will cover plant transformation techniques, including both indirect and direct methods. Students will examine transgenic plants and their applications, gene expression regulation, and advanced gene editing technologies like ZFNs, TALENs, and CRISPR/Cas systems, addressing their applications, limitations, and ethical considerations.

Units	Course Content	Hours of Teaching:45 h
I	• Plant Biotechnology: Introduction, History, Model plants, Scope and applications • Recombinant DNA technology: Vectors, restriction enzymes, molecular probes, genomic and cDNA libraries	8.0 h
II	• Plant Cell, Tissue and Organ Culture (a) History, concept of totipotency, nutritional requirements of culture, mediapreparation, aseptic condition, applications and limitations (b) Regeneration Protocols: Single Cell Culture, Organogenesis and Somatic embryogenesis, Factors and significance (c) Protoplast Culture and Fusion: Protoplast isolation and culture, Protoplast fusion, methods and factors, applications	8.0 h
III	• Techniques for plant transformation *(a) Indirect gene transfer methods (Agrobacterium tumefaciens, and Agrobacterium rhizogenes mediated transfer)* *(b) Direct Gene transfer methods (electroporation, particle bombardment, microinjection, PEG, silicon carbide)*	8.0 h
IV	• Transgenic plants, some genetically modified plants (Flavr Savr tomato, Bt brinjal, Bt corn, Bt cotton, Golden rice, virus resistant plants, pest resistant plants) and molecular forming, applications and limitations (ethical and environmental issues)	9.0 h
V	• Gene expression and its regulation in plants: Transcription factors and cis-regulatory elements (CREs), epigenetic mechanisms of transcriptional regulation, translational control, programmed DNA rearrangements. • Gene editing and its applications: Zinc-finger nucleases (ZFNs), transcription • activator-like effector nucleases (TALENs), CRISPR/Cas systems	12.0 h

Texts/References

1. Bhojwani SS & Dantu PK (2013) Plant Tissue Culture: An Introductory Text, Springer.
2. Park S (2021) Plant Tissue Culture: Techniques and Experiments, Fourth Edition, Academic Press, Elsevier.
3. Razdan MK (2003) Introduction to Plant Tissue Culture, Science Publishers, USA
4. Slater A, Scott NW and Fowler MR (2008) Plant biotechnology: the genetic manipulation of plants, second edition, Oxford University Press.
5. Sahni S, Prasad BD and Kumar P (2017) Plant Biotechnology: Transgenics, Stress
6. Management and Biosafety Issues, CRC Press.

[76] SEC – Skill Enhancement Course; AEC – Ability Enhancement Course; VAC – Value Added Course; MD – Multidisciplinary Course

[77] 1 Credit (Theory) = 15 Hours; 1 Credit (Practical) = 30 Hours

Learning Outcomes	Upon completing this course, students will be proficient in plant biotechnology and genetic engineering techniques. They will understand the historical development and applications of plant biotechnology, including recombinant DNA technology and plant cell culture methods. Students will gain expertise in various plant transformation techniques, both indirect and direct, and be familiar with the production and use of transgenic plants. They will also learn about gene expression regulation and advanced gene editing technologies, such as ZFNs, TALENs, and CRISPR/Cas systems. Additionally, students will address the applications, limitations, and ethical considerations of these biotechnological advances.

Course Title	**BOTMN74: Lab Work Based on Paper BOTMN73**

Units	**Practicals**	**Hours of Teaching: 30 h**
I	• Medium preparation of Murashige and Skoog • Surface sterilization and inoculation of nodal explants on MS medium 6 h	6.0 h
II	• To raise suspension culture by using friable calli	6.0 h
III	• To initiate hairy root culture	6.0 h
IV	• Floral dip method of plant transformation (*Arabidopsis thaliana*) and screening for gene transfer (plasmid isolation & transformation, screening through PCR and agarose gel electrophoresis)	6.0 h
V	• Synthetic seed preparation	6.0 h

Course Title	**BOTMN76: Photoecophysiology**
Category of Course[78]	Major/ **Minor** / Minor (Vocational) / SEC / AEC /VAC/ MD/Internship/Dissertation

Credits[79]**& Hour of Teaching**

	Theory	Practical	Cumulative
Credits	3	1	4
Hour of Teaching	45	30	75

Course Objectives

This course aims to provide a comprehensive understanding of photoecophysiology, focusing on light-regulated growth and development in cyanobacteria and plants. Students will explore the roles of photoreceptors, light quality, and light signaling in plant and microbial adaptation. Key topics include molecular mechanisms of photodamage and protection, light harvesting processes, and carbon concentrating mechanisms. Through this course, students will gain insights into how light influences physiological processes, signal transduction, and adaptation strategies in diverse photosynthetic organisms.

Units	**Course Content**	**Hours of Teaching: 45 h**
I	• Light-regulated growth and development in cyanobacteria: Phytochrome-related photosensor and light perception, Photomorphogenesis, Complementary chromatic acclimation, Light quality and quantity dependent changes in light-harvesting complex, Signal transduction, Photoregulation of morphology	9.5 h
II	• Molecular mechanisms of photodamage and photoprotection: Photo-induced damage to microbes; genetical, biochemical and molecular aspects of mycosporine-like amino acids (MAAs) and scytonemin	9.5 h

[78] SEC – Skill Enhancement Course; AEC – Ability Enhancement Course; VAC – Value Added Course; MD – Multidisciplinary Course

[79] 1 Credit (Theory) = 15 Hours; 1 Credit (Practical) = 30 Hours

	production, ecological and economical implications	
III	• Light-regulated plant growth and development: Photoreceptors and light perception, Physiological responses, Photomorphogenesis, Circadian clock, Signal transduction, Seed germination, Hypocotyl elongation	6.5 h
IV	• Light signalling dynamics in plants: Phytochromes, Cryptochromes, PIFs, Phototropins, UV resistance locus8 (UVR8), HY5, COP1, SUMOylation, Chloroplast movement • Light harvesting in plants and cyanobacteria: Photosynthetic pigments and phycobilisomes, State transition, photochemical quenching (PQ), non-photochemical quenching (NPQ), photoinhibition, orange carotenoid protein (OCP), xanthophyll cycle, principle of PAM fluorometry	13.0 h
V	• Carbon concentrating mechanisms (CCM) in plants and cyanobacteria: Photorespiration, Components of CCM, Pyrenoids, Carboxysome, RuBISCO, Carbonic anhydrase	6.5 h

Texts/References	1. Ruban, A., Foyer, C., & Murchie, E. (Eds.). (2022). Photosynthesis in Action: Harvesting Light, Generating Electrons, Fixing Carbon. Academic Press. 2. Taiz L, Zeiger E (2015) Plant Physiology and Development, 7th edition, Sinauer Associates Inc. Publishers, Sunderland. 3. Hopkins WG, Hunter NPA (2011) Introduction to Plant Physiology, Wiley International edition, John Wiley & Sons, New Jersey. 4. Buchanan B, GruissemW, Jones RL (2002) Biochemistry and Molecular Biology of Plants, American Society of Plant Biologists, Rockville. 5. Devlin R.M. (1983) Plant Physiology, Cengage Learning Inc., London. 6. Salisbury F.B., Ross C.W. (2004) Plant Physiology, Wadsworth, California
Learning Outcomes	Upon completing this course, students will have a thorough understanding of the principles and mechanisms underlying light-regulated growth and development in cyanobacteria and plants. They will be able to explain the roles of various photoreceptors and light signaling pathways in photomorphogenesis and adaptation. Students will gain insights into the molecular mechanisms of photodamage and photoprotection, including the production of protective compounds. They will also understand light harvesting processes, including the functions of photosynthetic pigments and carbon concentrating mechanisms. Overall, students will be equipped to analyze and interpret the effects of light on plant and microbial physiology.

Course Title	**BOTMN77: Lab Work Based on Paper BOTMN76**

Units	**Practicals**	**Hours of Teaching:30 h**
I	• Effects of light and dark on seed germination • Hypocotyl length measurements in light and dark grown seedlings	6.0 h
II	• Photosynthetic pigments analysis in light and dark grown seedlings • Growth measurement of cyanobacteria under white light, blue light, red light and UVR	6.0 h
III	• Extraction and quantification of photosynthetic pigments from cyanobacteria grown under different light conditions	6.0 h
IV	• Extraction and spectrophotometric analysis of mycosporine-like amino acids in cyanobacteria	6.0 h
V	• Extraction and spectrophotometric analysis of scytonemin in cyanobacteria	6.0 h

SEMESTER-VIII

Course Title	**BOTMJ81: Microbiology**
Category of Course[80]	**Major**/ Minor / Minor (Vocational) / SEC / AEC /VAC/ MD/Internship/Dissertation
Credits[81]**& Hour of Teaching**	

	Theory	Practical	Cumulative
Credits	3	1	4
Hour of Teaching	45	30	75

Course Objectives	This course aims to provide a comprehensive understanding of microbiology, covering the fundamentals of Archaea and Bacteria, including key genera such as Halobacteria and Agrobacterium. Students will explore microbial growth, nutrition, and energy metabolism, and delve into the structure and lifecycle of various viruses. The course will examine modes of genetic exchange, operon regulation, and quorum sensing. Additionally, students will gain insights into the applications of microbes in antibiotics production, bioremediation, and fermentation technology. The course will also address nitrogen fixation processes and Rhizobium-legume interactions, emphasizing their impact on soil fertility and agricultural productivity.

Units	**Course Content**	**Hours of Teaching:45 h**
I	• Introduction to Archaea and Bacteria: A general account of *Halobacteria, Thermoplasma, Agrobacterium* • Growth and nutrition: Growth kinetics, Batch and continuous cultures, Nutritional classification of microorganisms, Assimilation of Sulfur and phosphate	10.0 h
II	• Energy Metabolism: Autotrophs and heterotrophs, hydrogen bacteria, purple non-sulphur bacteria and cyanobacteria • A detailed account of different types of viruses; structure of bacteriophages, LPP1, TMV and retroviruses. Lytic cycle in T4 phages and its regulation; lysogeny and its regulation in lambda phage; a brief account of viroids and prions	11.0 h
III	• Modes of genetic exchange in microbes: Transformation, Transduction, Conjugation, Evolutionary Significance • Repression and activation of Lac operon	7.0 h
IV	• Quorum sensing: Role of Quorum sensing in bioluminescence and virulence • Role of Microbes in preparation of antibiotics, secondary metabolites, bioremediation and soil fertility	8.0 h
V	• Fermentation technology for production of lactic acid and acetic acid • Nitrogen fixation by free-living and symbiotic microorganisms, Rhizobium-legume interaction, genetics of nodulation	9.0 h

Texts/References	1. Michael T. Madigan, Kelly S. Bender, Daniel H. Buckley, W. Matthew Sattley and David A. Stahl (2019). Brock Biology of Microorganisms, 15th edition (Global Edition, 15/E) 2. Stanier RY, Ingraham JL, Wheelis ML, Painter RR (1992). General Microbiology, 5th edition, MacMillan, Hampshire & London. 3. Talaro KP, Chess B (2011). Foundation in Microbiology, 8th edition, MacGraw-Hill, New York. 4. Dubey, R.C. and Maheshwari, D. K. (1999, reprint 2016). A text book of Microbiology(1stEdn), S. Chand & company, Pvt. Ltd., New Delhi, India

[80] SEC – Skill Enhancement Course; AEC – Ability Enhancement Course; VAC – Value Added Course; MD – Multidisciplinary Course

[81] 1 Credit (Theory) = 15 Hours; 1 Credit (Practical) = 30 Hours

	5. Frobisher, Hinsdill, Crabtree and Goodheart (1974). Fundamentals of Microbiology. Saunders' International Students Edition. Toppan Company Ltd. Singapore 6. Joanne M. Willey, Linda M. Sherwood, C.J. Woolverton (2017). Prescott's Microbiology. 10th Edition. McGraw Hills. International Edition. Singapore. 7. Michael J. Pelczer JR, ECS Chan and NoelR. Krieg (1986, reprint 2011). Microbiology, Vth Edition, Tata McGraw Hills, India
Learning Outcomes	Upon completing this course, students will be equipped with a thorough understanding of microbial diversity, including Archaea, Bacteria, and various viruses. They will grasp key concepts in microbial growth, nutrition, and energy metabolism, and will be familiar with microbial genetic exchange and operon regulation. Students will understand the role of quorum sensing in microbial behavior and its applications in bioluminescence and virulence. They will also acquire practical knowledge in microbial applications, such as antibiotics production, bioremediation, and fermentation technologies, and will comprehend the processes and significance of nitrogen fixation and Rhizobium-legume interactions in soil fertility.

Course Title	**BOTMJ82: Lab Work Based on Paper BOTMJ81**	
Units	**Practicals**	**Hours of Teaching:30 h**
I	• Staining of microorganisms and endospore • Preparation of culture medium, sterilization and cultivation of bacteria	5.0 h
II	• Study of growth of unicellular microorganism by turbidometric method • Methylene blue reduction test of milk	10.0 h
III	• Demonstration of certain metabolic activities: *Fermentation of carbohydrates, Catalase activity*	5.0 h
IV	• Determination of minimum inhibitory concentrations and LC_{50} of antibiotics.	5.0 h
V	• Determination of beta-galactosidase activity for degradation of ONPG in *E. coli* grown in different combination of sugar	5.0 h

Course Title	**BOTMJ83: Stress Biology**			
Category of Course[82]	**Major**/ Minor / Minor (Vocational) / SEC / AEC /VAC/ MD/Internship/Dissertation			
Credits[83] **& Hour of Teaching**		Theory	Practical	Cumulative
	Credits	3	1	4
	Hour of Teaching	45	30	75
Course Objectives	This course aims to provide a comprehensive understanding of stress biology in extremophiles, cyanobacteria, and plants. Students will explore the molecular phylogenetics of these organisms, mechanisms of reactive oxygen species (ROS) generation and control, and the impact of abiotic stresses such as drought, salinity, and temperature. Emphasis will be placed on the photosynthetic system's adaptations, functional genomics, proteomics, and metabolomics related to stress responses. Additionally, the course covers gene mining for stress tolerance and the application of green chemistry for biofuel and bioactive compound production using photosynthetic organisms.			

[82] SEC – Skill Enhancement Course; AEC – Ability Enhancement Course; VAC – Value Added Course; MD – Multidisciplinary Course

[83] 1 Credit (Theory) = 15 Hours; 1 Credit (Practical) = 30 Hours

Units	Course Content	Hours of Teaching: 45 h
I	• Distribution of extremophiles, cyanobacteria and plants across environmental gradients, molecular phylogenetic analysis • Reactive oxygen species (ROS), generation, impacts on nucleic acid, proteins, lipids and its molecular control and anti-oxidant processe	11.0 h
II	• Abiotic stress tolerance and signaling: Drought, salinity, ultraviolet radiation, light, temperatures, desiccation and heavy metals, HSPs	9.0 h
III	• Photosynthetic system: light harvesting complex, chlorophyll, phycobiliproteins, carotenoids and light harvesting proteins (LHCs), genetic regulation and adjustments during abiotic stresses.	9.0 h
IV	• Functional genomics, proteomics and metabolomics of cyanobacteria and plants with reference to stress responsive gene/proteins	5.5 h
V	• Gene mining from cyanobacterial and plant model system for the development of stress tolerant crops • Green chemistry using photosynthetic organisms for production of biofuels and bioactive compounds	10.5 h

Texts/References	1. Bryant DA (1995) The Molecular Biology of Cyanobacteria, Kluwer Academic Publisher, Berlin. 2. WhittonBA**,** Potts M (2000) Ecology of Cyanobacteria - Their diversity in Time and Space, Kluwer Academic Publishers, Berlin. 3. Walters, Dale, Adrian Newton, and Gary Lyon. Induced resistance for plant defence. Blackwell, 2007. 4. Burdon, Roy H. *Genes and the Environment*. CRC Press, 1999. 5. Buchanan, Bob B., Wilhelm Gruissem, and Russell L. Jones, eds. Biochemistry and molecular biology of plants. John wiley & sons, 2015. 6. Lazar, Thomas. "Taiz, L. and Zeiger, E. Plant physiology. 3rd edn." (2003): 750-751. 7. Salisbury, F. B., and Ross, C. W. (1992). Plant Physiology, Wadsworth Pub. *Com., Inc., Belmont, California-USA*.
Learning Outcomes	Upon completing this course, students will gain a comprehensive understanding of stress biology in extremophiles, cyanobacteria, and plants. They will be proficient in analyzing reactive oxygen species (ROS) and their impact on cellular macromolecules, mastering mechanisms of abiotic stress tolerance, and understanding the adaptations of photosynthetic systems under stress. Students will also be skilled in utilizing functional genomics, proteomics, and metabolomics to investigate stress responses, apply gene mining for developing stress-tolerant crops, and leverage green chemistry for biofuel and bioactive compound production.

Course Title	**BOTMJ84: Lab Work Based on Paper BOTMJ83**

Units	Practicals	Hours of Teaching:30 h
I	• Demonstration of CYANOBASE, Phytozome, Tair, and retrieving of gene sequences for multiple sequence alignment for candidate gene for making phylogenetic tree using (MEGA 5.0, CLUSTAL X etc) • Determination of LC_{50} doses of selected abiotic stresses in cyanoacterium *Anabaena* sp PCC 7120 and *Arabidopsis thaliana*	10.0 h
II	• Determination of lipid per-oxidation and hydrogen peroxide content in stressed and non-stressed photosynthetic organisms • SDS-PAGE profiling of controlled and selected abiotic stress exposed model photosynthetic organisms in order to monitor stressed induced proteins	5.0 h
III	• DNA isolation, primer designing and PCR amplification of 16S and 18S rDNA sequences from photosynthetic organisms	5.0 h
IV	• Lipid assay from stressed and non-stressed photosynthetic organisms	5.0 h

V	• Study of fluorescence spectra of control and stressed model cyanobacterium and plant using PAM fluorometry	5.0 h

Course Title	**BOTMJ85: Ecology, Environmental Pollution and Toxicology**			
Category of Course[84]	**Major**/ Minor / Minor (Vocational) / SEC / AEC /VAC/ MD/Internship/Dissertation			
Credits[85]**& Hour of Teaching**		Theory	Practical	Cumulative
	Credits	3	1	4
	Hour of Teaching	45	30	75
Course Objectives	The course aims to provide a comprehensive understanding of ecological principles, environmental pollution, and toxicology. Students will explore population dynamics, community structures, ecosystem functions, and ecological succession. They will analyze the sources and impacts of water, air, and soil pollution on ecosystems, and gain insights into ecotoxicology, including toxicity types, dose-response relationships, and biomagnification. This course equips students with the knowledge to assess environmental challenges and develop strategies for mitigating pollution and its effects on ecological systems.			

Units	Course Content	Hours of Teaching: 45 h
I	• Population: Patterns of population dispersion, population growth, *r* and *k*-selection strategies, population regulation, mechanisms of differentiation • Community: Continuum and discreet community concepts, community characteristics and their analyses, species diversity and indices, concept of ecological niche	10.5 h
II	• Ecosystem: Concept, components and organization; primary productivity and its measurement; energy flow • Ecological succession: Mechanisms; individualistic and holistic models of succession; trends of succession, concept of climax	9.5 h
III	• Water Pollution: Sources and kinds, impact of pollution on aquatic ecosystems, eutrophication	7.5 h
IV	• Air Pollution: Sources and kinds, impact of air pollutants (SO_2, NO_2 and particulate) on plants and ecosystems • Soil Pollution: Sources and kinds, impact of heavy metals and pesticides on plants and ecosystems	9.0 h
V	• Ecotoxicology: Concept of toxicity, types of toxicants, dose-response relationship, chronic and acute toxicity, indices of toxicity, factors affecting toxicity; biomagnification	8.5 h

Texts/References

1. Klassen C, Watkins JB (2010) Essentials of Toxicolgy, 2nd edition, McGraw- Hill Companies, New York.
2. Singh JS, Singh SP, Gupta SR (2014) Ecology Environmental Science and Conservation, S Chand & Co, New Delhi.
3. Begon, M., Townsend, C. R. 2021) Ecology: From Individuals to Ecosystems. United Kingdom: Wiley.
4. Bradshaw RHW and Sykes MT. 2014. Ecosystem Dynamics: From the Past to the Future. United Kingdom: Wiley.
5. Molles Jr MC and Laursen A. 2020. Ecology: Concepts & Applications Author(s): 5th Canadian Edition McGraw-Hill
6. Mueller-Dombois D and Ellenberg 1974. Aims and Methods of Vegetation Ecology. John Wiley & Sons. New York
7. Odum Eugene Pleasants 1967. Fundamentals of Ecology. United States: Saunders.

[84] SEC – Skill Enhancement Course; AEC – Ability Enhancement Course; VAC – Value Added Course; MD – Multidisciplinary Course

[85] 1 Credit (Theory) = 15 Hours; 1 Credit (Practical) = 30 Hours

	8. Raffaelli DG, Frid CLJ, 2010. Ecosystem Ecology: A New Synthesis. Cambridge University Press
Learning Outcomes	Upon completing this course, students will be able to understand and analyze various ecological concepts, including population dynamics, community structures, and ecosystem functions. They will gain insights into ecological succession and primary productivity. Students will also be proficient in identifying sources and impacts of water, air, and soil pollution, and assessing their effects on ecosystems. Additionally, they will acquire knowledge in ecotoxicology, including the types of toxicants, dose-response relationships, and the concept of biomagnification. This comprehensive understanding will enable students to address environmental challenges and contribute to pollution mitigation and ecological conservation efforts.

Course Title	**BOTMJ86: Lab Work Based on Paper BOTMJ85**	
Units	**Practicals**	**Hours of Teaching: 30 h**
I	• Determination of the minimal size of sample plot for vegetation analysis by species-area curve method	6.0 h
II	• Study of frequency of herbaceous species in grassland and to compare the frequency distribution with Raunkiaer's Standard Frequency Diagram. • Estimation of the density and abundance of species in protected and grazed grasslands	6.0 h
III	• Estimation of Importance Value Index (IVI) for grassland species on the basis of frequency, density and biomass • Determination of water holding capacity of polluted soil samples	6.0 h
IV	• Determination of foliar dust deposition in samples collected from different sites exposed to air pollution • Assessment of leaf area injury in foliar samples collected from sites exposed to air pollution	6.0 h
V	• Measurement of the dissolved oxygen content of different water samples • Estimation of the total alkalinity of different water samples	6.0 h

Course Title	**BOTMJ87: Plant Diseases and Protection**			
Category of Course[86]	**Major**/ Minor / Minor (Vocational) / SEC / AEC /VAC/ MD/Internship/Dissertation			
Credits[87]& Hour of Teaching		Theory	Practical	Cumulative
	Credits	3	1	4
	Hour of Teaching	45	30	75
Course Objectives	The objective of this course is to provide students with a comprehensive understanding of plant diseases, including historical epidemics, physiology of parasitism, and the role of effectors and elicitors in disease development. Students will learn about factors influencing disease progression and study specific diseases such as green ear disease and rust. The course will cover the molecular mechanisms of plant immunity, pathogen virulence, and modern engineering techniques for disease resistance, including RNA interference and gene editing. Additionally, students will gain insights into epidemiology, disease management strategies, and the importance of biosecurity and intellectual property in plant protection.			

[86] SEC – Skill Enhancement Course; AEC – Ability Enhancement Course; VAC – Value Added Course; MD – Multidisciplinary Course

[87] 1 Credit (Theory) = 15 Hours; 1 Credit (Practical) = 30 Hours

Units	Course Content	Hours of Teaching: 45 h
I	• Historical account of major plant disease epidemics • Physiology of Parasitism and role of effectors in host-pathogen interaction and disease development • Role of elicitor (enzyme, toxin, growth regulator, and polysaccharides) in plant disease development	10.5 h
II	• Factors regulating disease development and disease cycle of following diseases: Green ear disease of bajara, downey mildew of cucurbits, rust of linseed, smut of bajara , wilt of Arhar, root knot nematodes, viral/viriods disease, little leaf of brinjal	15.0 h
III	• Molecular basis of plant Immunity and pathogen virulence: Effector-triggered immunity (ETI), Pattern-triggered immunity (PTI), and pathogen-associated molecular patterns (PAMPs)	10.5 h
IV	• Engineering for disease resistance: RNA interferences, *Agrobacterium* mediated plant transformation, gene editing	4.5 h
V	• Epidemiology, disease spread and management: Biosecurity, Intellectual property rights (IPR) and Intellectual Property Management (IPM)	4.5 h

Texts/References	1. Agrios GN (2005) Plant Pathology (Vth edition) Academic Press, Burlington. 2. Dickinson CM (2003) Molecular Plant Pathology, Bios Scientific Publisher, Oxford. 3. Robert N, Trigiano, Windham MT, Windham AS (2003) Plant Pathology: Concepts and Laboratory Exercises, CRC Press, Boca Raton, USA. 4. Singh RS (2008) Plant Diseases, Oxford and IBH Publishing Co Pvt Ltd, New Delhi. 5. Singh RS (2008) Principles of Plant Pathology, Oxford and IBH Publishing Co Pvt Ltd, New Delhi. 6. Dhingra OD, James B, Sinclair (1995) Basic Plant Pathology Methods, CRC Publication, Boca Raton, USA. 7. PD Sharma (2020) Microbiology and Plant Pathology 4th Ed, Rastogi Publications. 8. R Maheshwary (2016) Fungi: Experimental Methods In Biology, Second Edition. CRC Press. 9. Anne Marte Tronsmo, David B. Collinge, Annika Djurle, Lisa Munk, Jonathan Yuen, Arne Tronsmo (2020). Plant pathology and plant diseases, CABI Publication.
Learning Outcomes	Upon completing this course, students will understand the historical and physiological aspects of plant diseases, including the role of effectors and elicitors in disease development. They will gain knowledge of disease-specific factors and cycles for various plant diseases and grasp the molecular mechanisms underlying plant immunity and pathogen virulence. Students will also learn about advanced techniques for engineering disease resistance, such as RNA interference and gene editing. Furthermore, they will be equipped with insights into epidemiology, disease management strategies, biosecurity, and intellectual property rights related to plant protection.

Course Title	**BOTMJ88: Lab Work Based on Paper BOTMJ87**

Units	Practicals	Hours of Teaching:30 h
I	• Study of symptoms and cause of following plant diseases, namely wart of potato, downy mildew of cucurbits, wart of sesame, stem gall on coriander, linseed rust, tikka disease of groundnut, red rot of sugarcane, bacterial blight of rice, yellow vein mosaic of bhindi, and other local diseases on crops	10.0 h
II	• Preparation of media and slants for isolation of pathogens	5.0 h
III	• *In-vitro* Isolation of pathogenic fungi • Identification of pathogenic organism of local disease using Koch's postulates	5.0 h
IV	• To Study synergism/antagonism between pathogen in culture medium	5.0 h
V	• Symptoms of bacterial blight, mosaic and little leaf of brinjal	5.0 h

Course Title	**BOTMN81: Microbiology**
Category of Course[88]	Major/ **Minor** / Minor (Vocational) / SEC / AEC /VAC/ MD/Internship/Dissertation
Credits[89]**& Hour of Teaching**	

	Theory	Practical	Cumulative
Credits	3	1	4
Hour of Teaching	45	30	75

Course Objectives	This course aims to provide a comprehensive understanding of microbiology, covering the fundamentals of Archaea and Bacteria, including key genera such as Halobacteria and Agrobacterium. Students will explore microbial growth, nutrition, and energy metabolism, and delve into the structure and lifecycle of various viruses. The course will examine modes of genetic exchange, operon regulation, and quorum sensing. Additionally, students will gain insights into the applications of microbes in antibiotics production, bioremediation, and fermentation technology. The course will also address nitrogen fixation processes and Rhizobium-legume interactions, emphasizing their impact on soil fertility and agricultural productivity.

Units	**Course Content**	**Hours of Teaching:45 h**
I	• Introduction to Archaea and Bacteria: A general account of *Halobacteria*, *Thermoplasma*, *Agrobacterium* • Growth and nutrition: Growth kinetics, Batch and continuous cultures, Nutritional classification of microorganisms, Assimilation of Sulfur and phosphate	10.0 h
II	• Energy Metabolism: Autotrophs and heterotrophs, hydrogen bacteria, purple non-sulphur bacteria and cyanobacteria • A detailed account of different types of viruses; structure of bacteriophages, LPP1, TMV and retroviruses. Lytic cycle in T4 phages and its regulation; lysogeny and its regulation in lambda phage; a brief account of viroids and prions	11.0 h
III	• Modes of genetic exchange in microbes: Transformation, Transduction, Conjugation, Evolutionary Significance • Repression and activation of Lac operon	7.0 h
IV	• Quorum sensing: Role of Quorum sensing in bioluminescence and virulence • Role of Microbes in preparation of antibiotics, secondary metabolites, bioremediation and soil fertility	8.0 h
V	• Fermentation technology for production of lactic acid and acetic acid • Nitrogen fixation by free-living and symbiotic microorganisms, Rhizobium-legume interaction, genetics of nodulation	9.0 h

Texts/References	1. Michael T. Madigan, Kelly S. Bender, Daniel H. Buckley, W. Matthew Sattleyand David A. Stahl (2019). Brock Biology of Microorganisms, 15th edition (Global Edition, 15/E). 2. Stanier RY, Ingraham JL, Wheelis ML, Painter RR (1992). General Microbiology, 5th edition, MacMillan, Hampshire & London. 3. Talaro KP, Chess B (2011). Foundation in Microbiology, 8th edition, MacGraw-Hill, New York. 4. Dubey, R.C. and Maheshwari, D. K. (1999, reprint 2016). A text book of Microbiology(1stEdn), S. Chand & company, Pvt. Ltd., New Delhi, India **5.** Frobisher, Hinsdill, Crabtree and Goodheart (1974). Fundamentals of Microbiology. Saunders' International Students Edition. Toppan Company Ltd. Singapore **6.** Joanne M. Willey, Linda M. Sherwood, C.J. Woolverton (2017). Prescott's Microbiology. 10thEdition. McGraw Hills. International Edition. Singapore.

[88] SEC – Skill Enhancement Course; AEC – Ability Enhancement Course; VAC – Value Added Course; MD – Multidisciplinary Course

[89] 1 Credit (Theory) = 15 Hours; 1 Credit (Practical) = 30 Hours

	7. Michael J. Pelczer JR, ECS Chan and NoelR. Krieg (1986, reprint 2011). Microbiology, Vth Edition, Tata McGraw Hills, India
Learning Outcomes	Upon completing this course, students will be equipped with a thorough understanding of microbial diversity, including Archaea, Bacteria, and various viruses. They will grasp key concepts in microbial growth, nutrition, and energy metabolism, and will be familiar with microbial genetic exchange and operon regulation. Students will understand the role of quorum sensing in microbial behavior and its applications in bioluminescence and virulence. They will also acquire practical knowledge in microbial applications, such as antibiotics production, bioremediation, and fermentation technologies, and will comprehend the processes and significance of nitrogen fixation and Rhizobium-legume interactions in soil fertility.

Course Title	**BOTMN82: Lab Work Based on Paper BOTMN81**	
Units	**Practicals**	**Hours of Teaching:30 h**
I	• Staining of microorganisms and endospore • Preparation of culture medium, sterilization and cultivation of bacteria	5.0 h
II	• Study of growth of unicellular microorganism by turbidometric method • Methylene blue reduction test of milk	1.0.0 h
III	• Demonstration of certain metabolic activities: *Fermentation of carbohydrates, Catalase activity*	5.0 h
IV	• Determination of minimum inhibitory concentrations and LC_{50} of antibiotics	5.0 h
V	• Determination of beta-galactosidase activity for degradation of ONPG in *E. coli* grown in different combination of sugar	5.0 h

Course Title	**BOTMN83: Stress Biology**
Category of Course[90]	Major/ **Minor**/ Minor (Vocational) / SEC / AEC /VAC/ MD/Internship/Dissertation

Credits[91]& Hour of Teaching

	Theory	Practical	Cumulative
Credits	3	1	4
Hour of Teaching	45	30	75

Course Objectives

This course aims to provide a comprehensive understanding of stress biology in extremophiles, cyanobacteria, and plants. Students will explore the molecular phylogenetics of these organisms, mechanisms of reactive oxygen species (ROS) generation and control, and the impact of abiotic stresses such as drought, salinity, and temperature. Emphasis will be placed on the photosynthetic system's adaptations, functional genomics, proteomics, and metabolomics related to stress responses. Additionally, the course covers gene mining for stress tolerance and the application of green chemistry for biofuel and bioactive compound production using photosynthetic organisms.

Units	**Course Content**	**Hours of Teaching:45 h**
I	• Distribution of extremophiles, cyanobacteria and plants across environmental gradients, molecular phylogenetic analysis • Reactive oxygen species (ROS), generation, impacts on nucleic acid, proteins, lipids and its molecular control and anti-oxidant processes	11.0 h
II	• Abiotic stress tolerance and signaling: Drought, salinity, ultraviolet radiation, light, temperatures, desiccation and heavy metals	9.0 h
III	• Photosynthetic system: light harvesting complex, chlorophyll, phycobiliproteins, carotenoids and light harvesting proteins (LHCs), genetic regulation and adjustments during abiotic stresses	9.0 h
IV	• Functional genomics, proteomics and metabolomics of cyanobacteria and plants with reference to stress responsive gene/proteins	5.5 h
V	• Gene mining from cyanobacterial and plant model system for the development of stress tolerant crops • Green chemistry using photosynthetic organisms for production of biofuels and bioactive compounds	10.5 h

Texts/References

1. Bryant DA (1995) The Molecular Biology of Cyanobacteria, Kluwer Academic Publisher, Berlin.
2. WhittonBA**,** Potts M (2000) Ecology of Cyanobacteria - Their diversity in Time and Space, Kluwer Academic Publishers, Berlin.
3. Walters, Dale, Adrian Newton, and Gary Lyon. Induced resistance for plant defence. Blackwell, 2007.
4. Burdon, Roy H. *Genes and the Environment*. CRC Press, 1999.
5. Buchanan, Bob B., Wilhelm Gruissem, and Russell L. Jones, eds. Biochemistry and molecular biology of plants. John wiley & sons, 2015.
6. Lazar, Thomas. "Taiz, L. and Zeiger, E. Plant physiology. 3rd edn." (2003): 750-751.
7. Salisbury, F. B., and Ross, C. W. (1992). Plant Physiology, Wadsworth Pub. *Com., Inc., Belmont, California-USA.*

Learning Outcomes

Upon completing this course, students will gain a comprehensive understanding of stress biology in extremophiles, cyanobacteria, and plants. They will be proficient in analyzing reactive oxygen species (ROS) and their impact on cellular macromolecules, mastering mechanisms of abiotic stress tolerance, and understanding the adaptations of photosynthetic systems under stress. Students will also be skilled in utilizing functional genomics, proteomics, and metabolomics to investigate stress responses, apply gene mining for developing stress-tolerant crops, and leverage green chemistry for biofuel and bioactive compound production.

[90] SEC – Skill Enhancement Course; AEC – Ability Enhancement Course; VAC – Value Added Course; MD – Multidisciplinary Course

[91] 1 Credit (Theory) = 15 Hours; 1 Credit (Practical) = 30 Hours

Course Title	BOTMN84: Lab Work Based on Paper BOTMN83	
Units	**Practicals**	**Hours of Teaching:30 h**
I	• Demonstration of CYANOBASE, Phytozome, Tair, and retrieving of gene sequences for multiple sequence alignment for candidate gene for making phylogenetic tree using (MEGA 5.0, CLUSTAL X etc) • Determination of LC_{50} doses of selected abiotic stresses in cyanoacterium *Anabaena* sp PCC 7120 and *Arabidopsis thaliana*	10.0 h
II	• Determination of lipid per-oxidation and hydrogen peroxide content in stressed and non-stressed photosynthetic organisms • SDS-PAGE profiling of controlled and selected abiotic stress exposed model photosynthetic organisms in order to monitor stressed induced proteins	5.0 h
III	• DNA isolation, primer designing and PCR amplification of 16S and 18S rDNA sequences from photosynthetic organisms	5.0 h
IV	• Lipid assay from stressed and non-stressed photosynthetic organisms	5.0 h
V	• Study of fluorescence spectra of control and stressed model cyanobacterium and plant using PAM fluorometry	5.0 h

Course Title	**BOTMN85: Ecology,Pollution and Toxicology**			
Category of Course[92]	Major/ **Minor**/ Minor (Vocational) / SEC / AEC /VAC/ MD/Internship/Dissertation			
Credits[93]**& Hour of Teaching**		Theory	Practical	Cumulative
	Credits	3	1	4
	Hour of Teaching	45	30	75
Course Objectives	The course aims to provide a comprehensive understanding of ecological principles, environmental pollution, and toxicology. Students will explore population dynamics, community structures, ecosystem functions, and ecological succession. They will analyze the sources and impacts of water, air, and soil pollution on ecosystems, and gain insights into ecotoxicology, including toxicity types, dose-response relationships, and biomagnification. This course equips students with the knowledge to assess environmental challenges and develop strategies for mitigating pollution and its effects on ecological systems.			

Units	**Course Content**	**Hours of Teaching:45 h**
I	• Population: Patterns of population dispersion, population growth, *r* and *k*-selection strategies, population regulation, mechanisms of differentiation • Community: Continuum and discreet community concepts, community characteristics and their analyses, species diversity and indices, concept of ecological niche	10.5 h
II	• Ecosystem: Concept, components and organization; primary productivity and its measurement; energy flow • Ecological succession: Mechanisms; individualistic and holistic models	9.5 h

[92] SEC – Skill Enhancement Course; AEC – Ability Enhancement Course; VAC – Value Added Course; MD – Multidisciplinary Course

[93] 1 Credit (Theory) = 15 Hours; 1 Credit (Practical) = 30 Hours

	of succession; trends of succession, concept of climax	
III	• Water Pollution: Sources and kinds, impact of pollution on aquatic ecosystems, eutrophication	7.5 h
IV	• Air Pollution: Sources and kinds, impact of air pollutants (SO_2, NO_2 and particulate) on plants and ecosystems • Soil Pollution: Sources and kinds, impact of heavy metals and pesticides on plants and ecosystems	9.0 h
V	• Ecotoxicology: Concept of toxicity, types of toxicants, dose-response relationship, chronic and acute toxicity, indices of toxicity, factors affecting toxicity; biomagnification	8.5 h

Texts/References	1. Klassen C, Watkins JB (2010) Essentials of Toxicolgy, 2nd edition, McGraw- Hill Companies, New York. 2. Singh JS, Singh SP, Gupta SR (2014) Ecology Environmental Science and Conservation, S Chand & Co, New Delhi. 3. Begon, M., Townsend, C. R. 2021) Ecology: From Individuals to Ecosystems. United Kingdom: Wiley. 4. Bradshaw RHW and Sykes MT. 2014. Ecosystem Dynamics: From the Past to the Future. United Kingdom: Wiley. 5. Molles Jr MC and Laursen A. 2020. Ecology: Concepts & Applications Author(s): 5th Canadian Edition McGraw-Hill 6. Mueller-Dombois D and Ellenberg 1974. Aims and Methods of Vegetation Ecology. John Wiley & Sons. New York 7. Odum Eugene Pleasants 1967. Fundamentals of Ecology. United States: Saunders. 8. Raffaelli DG, Frid CLJ, 2010. Ecosystem Ecology: A New Synthesis. Cambridge University Press
Learning Outcomes	Upon completing this course, students will be able to understand and analyze various ecological concepts, including population dynamics, community structures, and ecosystem functions. They will gain insights into ecological succession and primary productivity. Students will also be proficient in identifying sources and impacts of water, air, and soil pollution, and assessing their effects on ecosystems. Additionally, they will acquire knowledge in ecotoxicology, including the types of toxicants, dose-response relationships, and the concept of biomagnification. This comprehensive understanding will enable students to address environmental challenges and contribute to pollution mitigation and ecological conservation efforts.

Course Title	**BOTMN86: Lab Work Based on Paper BOTMN85**	
Units	**Practicals**	**Hours of Teaching: 30 h**
I	• Determination of the minimal size of sample plot for vegetation analysis by species-area curve method	6.0 h
II	• Study of frequency of herbaceous species in grassland and to compare the frequency distribution with Raunkiaer's Standard Frequency Diagram • Estimation of the density and abundance of species in protected and grazed grasslands	6.0 h
III	• Estimation of Importance Value Index (IVI) for grassland species on the basis of frequency, density and biomass • Determination of water holding capacity of polluted soil samples	6.0 h
IV	• Determination of foliar dust deposition in samples collected from different sites exposed to air pollution • Assessment of leaf area injury in foliar samples collected from sites exposed to air pollution	6.0 h

V	• Measurement of the dissolved oxygen content of different water samples • Estimation of the total alkalinity of different water samples	6.0 h

Course Title	**BOTMN87: Plant Diseases and Protection**			
Category of Course[94]	Major/ **Minor** / Minor (Vocational) / SEC / AEC /VAC/ MD/Internship/Dissertation			
Credits[95]**& Hour of Teaching**		Theory	Practical	Cumulative
	Credits	3	1	4
	Hour of Teaching	45	30	75
Course Objectives	The objective of this course is to provide students with a comprehensive understanding of plant diseases, including historical epidemics, physiology of parasitism, and the role of effectors and elicitors in disease development. Students will learn about factors influencing disease progression and study specific diseases such as green ear disease and rust. The course will cover the molecular mechanisms of plant immunity, pathogen virulence, and modern engineering techniques for disease resistance, including RNA interference and gene editing. Additionally, students will gain insights into epidemiology, disease management strategies, and the importance of biosecurity and intellectual property in plant protection.			

Units	**Course Content**	**Hours of Teaching:45 h**
I	• Historical account of major plant disease epidemics • Physiology of Parasitism and role of effectors in host-pathogen interaction and disease development • Role of elicitor (enzyme, toxin, growth regulator, and polysaccharides) in plant disease development	10.5 h
II	• Factors regulating disease development and disease cycle of following diseases: Green ear disease of bajara, downey mildew of cucurbits, rust of linseed, smut of bajara , wilt of Arhar, root knot nematodes, viral/viriods disease, little leaf of brinjal	15.0 h
III	• Molecular basis of plant Immunity and pathogen virulence: Effector-triggered immunity (ETI), Pattern-triggered immunity (PTI), and pathogen-associated molecular patterns (PAMPs)	10.5 h
IV	• Engineering for disease resistance: RNA interferences, *Agrobacterium* mediated plant transformation, gene editing,	4.5 h
V	• Epidemiology, disease spread and management: Biosecurity, Intellectual property rights (IPR) andIntellectual Property Management (IPM)	4.5 h

Texts/References

1. Agrios GN (2005) Plant Pathology (Vth edition) Academic Press, Burlington.
2. Dickinson CM (2003) Molecular Plant Pathology, Bios Scientific Publisher, Oxford.
3. Robert N, Trigiano, Windham MT, Windham AS (2003) Plant Pathology: Concepts and Laboratory Exercises, CRC Press, Boca Raton, USA.
4. Singh RS (2008) Plant Diseases, Oxford and IBH Publishing Co Pvt Ltd, New Delhi.
5. Singh RS (2008) Principles of Plant Pathology, Oxford and IBH Publishing Co Pvt Ltd, New Delhi.
6. Dhingra OD, James B, Sinclair (1995) Basic Plant Pathology Methods, CRC Publication, Boca Raton, USA.
7. PD Sharma (2020) Microbiology and Plant Pathology 4th Ed, Rastogi Publications.
8. R Maheshwary (2016) Fungi: Experimental Methods In Biology, Second Edition. CRC Press.

[94] SEC – Skill Enhancement Course; AEC – Ability Enhancement Course; VAC – Value Added Course; MD – Multidisciplinary Course

[95] 1 Credit (Theory) = 15 Hours; 1 Credit (Practical) = 30 Hours

	9. Anne Marte Tronsmo, David B. Collinge, Annika Djurle, Lisa Munk, Jonathan Yuen, Arne Tronsmo (2020). Plant pathology and plant diseases, CABI Publication.
Learning Outcomes	Upon completing this course, students will understand the historical and physiological aspects of plant diseases, including the role of effectors and elicitors in disease development. They will gain knowledge of disease-specific factors and cycles for various plant diseases and grasp the molecular mechanisms underlying plant immunity and pathogen virulence. Students will also learn about advanced techniques for engineering disease resistance, such as RNA interference and gene editing. Furthermore, they will be equipped with insights into epidemiology, disease management strategies, biosecurity, and intellectual property rights related to plant protection.

Course Title	**BOTMN88: Lab Work Based on Paper BOTMN87**	
Units	**Practicals**	**Hours of Teaching:30 h**
I	• Study of symptoms and cause of following plant diseases, namely wart of potato, downy mildew of cucurbits, wart of sesame, stem gall on coriander, linseed rust, tikka disease of groundnut, red rot of sugarcane, bacterial blight of rice, yellow vein mosaic of bhindi, and other local diseases on crops	10.0 h
II	• Preparation of media and slants for isolation of pathogens	5.0 h
III	• *In-vitro* Isolation of pathogenic fungi. • Identification of pathogenic organism of local disease using Koch's postulates	5.0 h
IV	• To Study synergism /antagonism between pathogen in culture medium	5.0 h
V	• Symptoms of bacterial blight, mosaic and little leaf of brinjal	5.0 h

Honours with Research Degree

SEMESTER-VII

Course Title	**BOTMJ71R: Plant Biochemistry and Molecular Biology**			
Category of Course[96]	**Major**/ Minor / Minor (Vocational) / SEC / AEC /VAC/ MD/Internship/Dissertation			
Credits[97]**& Hour of Teaching**		Theory	Practical	Cumulative
	Credits	3	1	4
	Hour of Teaching	45	30	75
Course Objectives	The course objective is to provide students with a comprehensive understanding of plant biochemistry and molecular biology. Students will learn the biosynthesis of key carbon compounds, including sucrose, starch, and cellulose, and delve into sulfur and phosphorus metabolism, including ATP synthesis. They will gain insight into nitrogen metabolism, including the biochemistry of nitrogen fixation and nitrate reduction. The course will cover the structure and replication of DNA, RNA transcription and processing, and protein synthesis and modification. Additionally, students will explore enzyme mechanisms and molecular tools and techniques such as electrophoresis and cloning vectors.			

[96] SEC – Skill Enhancement Course; AEC – Ability Enhancement Course; VAC – Value Added Course; MD – Multidisciplinary Course

[97] 1 Credit (Theory) = 15 Hours; 1 Credit (Practical) = 30 Hours

Units	Course Content	Hours of Teaching:45 h
I	• Biosynthesis of carbon compounds: sucrose, starch, cellulose • Sulphur and phosphorus metabolism: Activation and assimilation of sulphur, energy-rich phosphorus compounds; ATP synthesis	8.0 h
II	• Nitrogen metabolism: components, types and substrate of enzyme nitrogenase, biochemistry of nitrogen fixation; Nitrate metabolism: Uptake and reduction into ammonia, ammonia assimilation	8.0 h
III	• DNA: Structure and properties of different forms of DNA, DNA replication in prokaryotes and eukaryotes, DNA damage and repair	8.0 h
IV	• RNA:Structure and properties of different forms of RNA, transcription in prokaryotes and eukaryotes, mRNA processing-5' cap formation-3'end processing and polyadenylation, splicing, nuclear export of mRNA	8.0 h
V	• Protein: Basic aspects of protein conformation, translation in prokaryotes and eukaryotes (activation of amino acids, initiation, elongation, termination and release of peptides), post-translational modification of proteins • Enzymes: Mechanism of enzyme action, coenzymes, allosteric enzyme, isozymes • Molecular tools and techniques: Basic principles of electrophoresis and blotting, cloning vectors, molecular cloning of nucleic acid fragments	13.0 h

Texts/References	1. Berg JM et al. (2018) Biochemistry, 8th edition, WH Freeman & Company, New York. 2. Cox MM, Nelson DL (2021) Lehninger Principle of Biochemistry, 8th edition MacMillan, Worth Publishers,London. 3. Devlin TM (2011) Textbook of Biochemistry, 7th edition, John Wiley & Sons, Inc, New York. 4. Voet D, Voet JG and Pratt CW (2018) Biochemistry, 5th Edition, John Wiley & Sons, Inc, New York. 5. Zubay GL (1998) Biochemistry, 4th edition, Wm C Brown Publishers, Dubuque, Iowa. 6. Dubey RC (2013) A Text Book of Biotechnology 4th edition, S Chand & Co Ltd, New Delhi. 7. Wilson K, Walker J (2018) Principle & Techniques of Biochemistry and Molecular Biology, 8th edition, Cambridge University Press, Cambridge. 8. Bowsher C & Tobin A (2021) Plant Biochemistry, 2nd Edition, Taylor & Francis Inc, CRC press. 9. Arthur M. Lesk (2016) Introduction to Protein Science Architecture Function and Genomics,Oxford University press, London **Suggested websites** https://academic.oup.com/aob/article/105/7/1141/148741 https://dx.doi.org/10.1016/B978-0-12-800180-6.00001-3 https://doi:10.1016/j.molp.2016.05.004 https://doi.org/10.1093/jn/130.5.1081 https://academic.oup.com/jxb/article/68/10/2463/2967464 https://epgp.inflibnet.ac.in/Home/ViewSubject?catid=2 https://epgp.inflibnet.ac.in/epgpdata/uploads/epgp_content/food_technology/food_chemistry/16.protein_ structure_and_denaturation/et/40_et_m16.pdf https://www.youtube.com/watch?v=MODnIkQvyz0 https://www.youtube.com/watch?v=AeVDoDp3llI
Learning Outcomes	Upon completion of this course, students will be able to understand and describe the biosynthesis of essential carbon compounds like sucrose, starch, and cellulose, and elucidate sulfur and phosphorus metabolism, including ATP synthesis. They will gain insights into nitrogen metabolism, focusing on nitrogen fixation and nitrate reduction. Students will be proficient in explaining DNA structure, replication, and repair, RNA transcription, processing, and translation, and protein synthesis and post-translational modifications. Additionally, they will be familiar with enzyme mechanisms and molecular techniques such as electrophoresis and molecular cloning, enabling practical applications in plant biochemistry and molecular biology.

Course Title	BOTMJ72R: Lab Work Based on Paper BOTMJ71R

Units	Practicals	Hours of Teaching:30 h
I	• Chromatographic separation and comparative analysis of photosynthetic pigments in plants • Chromatographic separation of amino acids	6.0 h
II	• Preparation of standard graph and estimation of DNA by diphenylamine test • Preparation of standard graph and estimation of RNA by Orcinol test	6.0 h
III	• Preparation of standard graph and estimation of protein by Bradford method • Study on the effects of light/dark on the nitrate reductase enzyme	6.0 h
IV	• To study the time dependent activity of urease enzyme. • Study on the effects of different concentrations of urea on urease activity	6.0 h
V	• Determination of different concentrations of urease enzyme on its activity • Preparation of standard graph and estimation of carbohydrates by anthrone reagent method • Demonstration of electrophoretic and blotting instruments	6.0 h

Course Title	BOTMJ73R: Plant Biotechnology and Genetic Engineering
Category of Course[98]	**Major**/ Minor / Minor (Vocational) / SEC / AEC /VAC/ MD/Internship/Dissertation

Credits[99]& Hour of Teaching	Theory	Practical	Cumulative
Credits	3	1	4
Hour of Teaching	45	30	75

Course Objectives	This course aims to provide a comprehensive understanding of plant biotechnology and genetic engineering, covering historical developments, model plants, and applications. Students will learn about recombinant DNA technology, including vectors, restriction enzymes, and genomic libraries. They will explore plant cell, tissue, and organ culture techniques, including totipotency, media preparation, and regeneration protocols. The course will cover plant transformation techniques, including both indirect and direct methods. Students will examine transgenic plants and their applications, gene expression regulation, and advanced gene editing technologies like ZFNs, TALENs, and CRISPR/Cas systems, addressing their applications, limitations, and ethical considerations.

Units	Course Content	Hours of Teaching: 45 h
I	• Plant Biotechnology: Introduction, History, Model plants, Scope and applications • Recombinant DNA technology: Vectors, restriction enzymes, molecular probes, genomic and cDNA libraries	8.5 h
II	• Plant Cell, Tissue and Organ Culture *(a) History, concept of totipotency, nutritional requirements of culture, mediapreparation, aseptic condition, applications and limitations* *(b) Regeneration Protocols: Single Cell Culture, Organogenesis and Somatic embryogenesis, factors and significance*	8.5 h

[98] SEC – Skill Enhancement Course; AEC – Ability Enhancement Course; VAC – Value Added Course; MD – Multidisciplinary Course

[99] 1 Credit (Theory) = 15 Hours; 1 Credit (Practical) = 30 Hours

	(c) Protoplast Culture and Fusion: Protoplast isolation and culture, Protoplastfusion, methods and factors, applications	
III	• Techniques for plant transformation *(a) Indirect gene transfer methods (Agrobacterium tumefaciens, and Agrobacterium rhizogenes mediated transfer)* *(b)Direct Gene transfer methods (electroporation, particle bombardment, microinjection, PEG, silicon carbide)*	8.0 h
IV	• Transgenic plants, some genetically modified plants (Flavr Savr tomato, Bt brinjal, Bt corn, Bt cotton, Golden rice, virus resistant plants, pest resistant plants) and molecular forming, applications and limitations (ethical and environmental issues)	8.0 h
V	• Gene expression and its regulation in plants: Transcription factors and cis-regulatory elements (CREs), epigenetic mechanisms of transcriptional regulation, translational control, programmed DNA rearrangements. • Gene editing and its applications: Zinc-finger nucleases (ZFNs), transcription activator-like effector nucleases (TALENs), CRISPR/Cas systems	12.0 h

Texts/ References	1. Bhojwani SS & Dantu PK (2013) Plant Tissue Culture: An Introductory Text, Springer. 2. Park S (2021) Plant Tissue Culture: Techniques and Experiments, Fourth Edition, Academic Press, Elsevier. 3. Razdan MK (2003) Introduction to Plant Tissue Culture, Science Publishers, USA 4. Slater A, Scott NW and Fowler MR (2008) Plant biotechnology: the genetic manipulation of plants, second edition, Oxford University Press. 5. Sahni S, Prasad BD and Kumar P (2017) Plant Biotechnology: Transgenics, Stress 6. Management and Biosafety Issues, CRC Press.
Learning Outcomes	Upon completing this course, students will be proficient in plant biotechnology and genetic engineering techniques. They will understand the historical development and applications of plant biotechnology, including recombinant DNA technology and plant cell culture methods. Students will gain expertise in various plant transformation techniques, both indirect and direct, and be familiar with the production and use of transgenic plants. They will also learn about gene expression regulation and advanced gene editing technologies, such as ZFNs, TALENs, and CRISPR/Cas systems. Additionally, students will address the applications, limitations, and ethical considerations of these biotechnological advances.

Course Title	**BOTMJ74R: Lab Work Based on paper BOTMJ73R**

Units	**Practicals**	**Hours of Teaching:30 h**
I	• Medium preparation of Murashige and Skoog • Surface sterilization and inoculation of nodal explants on MS medium	6.0 h
II	• To raise suspension culture by using friable calli	6.0 h
III	• To initiate hairy root culture	6.0 h
IV	• Floral dip method of plant transformation (*Arabidopsis thaliana*) and screening for gene transfer (plasmid isolation & transformation, screening through PCR and agarose gel electrophoresis)	6.0 h
V	• Synthetic seed preparation	6.0 h

Course Title	**BOTMJ75R: Ecosystem Dynamics**
Category of Course[100]	**Major**/ Minor / Minor (Vocational) / SEC / AEC /VAC/ MD/Internship/Dissertation

Credits[101] **& Hour of Teaching**

	Theory	Practical	Cumulative
Credits	3	1	4
Hour of Teaching	45	30	75

Course Objectives

This course aims to provide students with a comprehensive understanding of ecosystem dynamics, including the organization and development of communities, mechanisms of ecological succession, and the evolution of ecosystems. Students will explore energy flow models, primary productivity, and nutrient cycling within ecosystems. The course covers ecosystem stability, complexity, and sustainability, and examines the interactions between human activities and ecosystem dynamics. By integrating theoretical concepts and practical applications, students will develop insights into maintaining and managing ecosystem health and functionality.

Units	Course Content	Hours of Teaching:45 h
I	• Introduction: Introduction to ecosystem dynamics • Community organization: Holistic, Reductionist, continuum concepts and related theories, Synthetic approach	9.0 h
II	• Ecosystem development: Mechanism and concepts of ecological succession, pattern of ecosystem attributes along successional stages, Concept and models of succession	9.5 h
III	• Ecosystem processes: Energy flow models, Net primary productivity, functional metabolic ratio, ecological efficiencies, decomposition, herbivory and carnivory	9.5 h
IV	• Nutrient dynamics: Nutrient cycling and models, nutrient import, export and retention, nutrient use efficiency, nutrient resorption and retranslocation, nutrient conserving adaptation in oligotrophic soils	9.5 h
V	• Ecosystem stability, complexity and sustainability • Man and ecosystem dynamics	7.5 h

Texts/ References

1. Begon, M., Townsend, C. R. 2021) Ecology: From Individuals to Ecosystems. United Kingdom: Wiley.
2. Bradshaw RHW and Sykes MT. 2014. Ecosystem Dynamics: From the Past to the Future. United Kingdom: Wiley.
3. Molles Jr MC and Laursen A. 2020. Ecology: Concepts and Applications Author(s): 5th Canadian Edition McGraw-Hill
4. Mueller-Dombois D and Ellenberg 1974. Aims and Methods of Vegetation Ecology. John Wiley & Sons. New York
5. Odum Eugene Pleasants 1967. Fundamentals of Ecology. United States: Saunders.
6. Raffaelli DG, Frid CLJ, 2010. Ecosystem Ecology: A New Synthesis. Cambridge University Press
7. Singh JS, Singh SP and Gupta SR. 2014. Ecology, Environmental Science and Conservation. S. Chand & Company Pvt. Ltd., New Delhi

Learning Outcomes

Upon completing this course, students will be able to understand and analyze ecosystem dynamics, including community organization, ecological succession, and ecosystem development. They will gain insights into energy flow models, nutrient cycling, and ecosystem processes such as decomposition and herbivory. Students will also learn to evaluate ecosystem stability, complexity, and sustainability, and understand the impact of human activities on ecosystems. Through this knowledge, they will be equipped to apply concepts in managing and conserving ecosystems effectively.

[100] SEC – Skill Enhancement Course; AEC – Ability Enhancement Course; VAC – Value Added Course; MD – Multidisciplinary Course

[101] 1 Credit (Theory) = 15 Hours; 1 Credit (Practical) = 30 Hours

Course Title	BOTMJ76R: Lab work based on paper BOTMJ75R	
Units	**Practicals**	**Hours of Teaching: 30 h**
I	• Estimation of herbaceous species biomass • Analysis of species composition (based on IVI)	10.0 h
II	• Quantification of dominance	5.0 h
III	• Estimation of soil carbon	5.0 h
IV	• Estimation of total nitrogen	5.0 h
V	• Estimation of Chlorophyll content	5.0 h

Course Title	**BOTMJ77R: Field Excursion**			
Category of Course[102]	**Major**/ Minor / Minor (Vocational) / SEC / AEC /VAC/ MD/Internship/Dissertation			
Credits[103]& Hour of Teaching		Theory	Practical	Cumulative
	Credits	2		2
	Hour of Teaching	30		30
Course Objectives	Field excursions will provide immersive, hands-on learning experiences that bridge theoretical knowledge and real-world applications. These trips are designed to enhance students' understanding of ecological, geological, botanical, and environmental concepts through direct observation and interaction with natural habitats. By engaging in fieldwork, students develop essential skills in data collection, species identification, and environmental assessment, fostering critical thinking and problem-solving abilities. Field excursions also promote teamwork, collaboration, and effective communication, as students often work in groups to conduct research and share findings. Moreover, these experiences help students appreciate the complexity and interconnectedness of natural systems, encouraging a deeper commitment to environmental conservation and sustainability. Ultimately, field excursions enrich the educational journey by making abstract concepts tangible and inspiring a lasting passion for scientific inquiry and exploration.			
Learning Outcomes	Field excursions for BSc students offer hands-on learning experiences, enhancing their understanding of ecological systems, plant identification, and data collection methods. These trips provide practical insights into theoretical concepts, foster observational and analytical skills, and encourage environmental awareness. By interacting directly with nature, students gain a deeper appreciation for biodiversity and conservation. Additionally, fieldwork promotes teamwork, critical thinking, and problem-solving abilities, preparing students for advanced research and professional careers in biological sciences.			

[102] SEC – Skill Enhancement Course; AEC – Ability Enhancement Course; VAC – Value Added Course; MD – Multidisciplinary Course

[103] 1 Credit (Theory) = 15 Hours; 1 Credit (Practical) = 30 Hours

Course Title	**BOTMJ78R: Research Methodology**
Category of Course[104]	**Major**/ Minor / Minor (Vocational) / SEC / AEC /VAC / MD/Internship/Dissertation
Credits[105]& Hour of Teaching	

	Theory	Practical	Cumulative
Credits	2	0	2
Hour of Teaching	30	0	30

Course Objectives	This course aims to equip students with essential research methodology skills, covering the entire research process from problem formulation to data collection, analysis, and reporting. It focuses on ethical research practices, effective literature review, diverse data collection methods, and the use of statistical and qualitative analysis tools. The course also enhances students' abilities to present and publish their research findings.

Units	**Course Content**	**Hours of Teaching:30 h**
I	Introduction to Research Methodology Understanding research, its significance, and different types of research, Steps involved in the research process, Ethical considerations and plagiarism, Identifying and defining research problems, Types of research designs	6.0 h
II	Literature Review Role and significance of literature review in research, Identifying and accessing various sources of literature. Methods for effective literature review, Importance and methods of citation and referencing	6.0 h
III	Data Collection Methods Techniques for collecting primary data (surveys, interviews, observations, experiments), Utilizing secondary data sources, understanding different sampling techniques (random, stratified, cluster), Designing and using questionnaires, interview guides, and other tools, Reliability and validity in data collection	6.0 h
IV	Data Analysis and Interpretation Statistical methods for analysing quantitative data, Techniques for analysing qualitative data, Introduction to statistical software (SPSS, R) and qualitative analysis tools, making sense of data and drawing conclusions, Effective ways to present data using tables, graphs, and charts	6.0 h
V	Research Reporting and Presentation Structure and components of a research report (introduction, methodology, results, discussion, conclusion), Guidelines for writing a thesis or dissertation, writing research papers and articles for journals, Techniques for presenting research findings orally and visually, Understanding the publication process and choosing appropriate journals	6.0 h

Texts/ References	1. Research Methodology: Methods and Techniques" by C.R. Kothari and Gaurav Garg 2. Research Methods for Business Students" by Mark Saunders, Philip Lewis, and Adrian Thornhill 3. The Craft of Research" by Wayne C. Booth, Gregory G. Colomb, and Joseph M. Williams 4. Research Design: Qualitative, Quantitative, and Mixed Methods Approaches" by John W.

[104] SEC – Skill Enhancement Course; AEC – Ability Enhancement Course; VAC – Value Added Course; MD – Multidisciplinary Course

[105] 1 Credit (Theory) = 15 Hours; 1 Credit (Practical) = 30 Hours

	Creswell and J. David Creswell 5. Qualitative Inquiry and Research Design: Choosing Among Five Approaches" by John W. Creswell and Cheryl N. Poth 6. Research Methods: The Essential Knowledge Base" by William M. Trochim and James P. Donnelly 7. Research Methods in Education" by Louis Cohen, Lawrence Manion, and Keith Morrison 8. Practical Research: Planning and Design" by Paul D. Leedy and Jeanne Ellis Ormrod 9. Introduction to Research Methods: A Hands-On Approach" by Bora Pajo **Suggested Websites** https://bio-protocol.org/en https://conductscience.com/microbiology-techniques
Learning Outcomes	By the end of this course, students will proficiently design, conduct, and analyze research, adhering to ethical standards. They will be adept at literature review, data collection, and using analytical tools, enabling them to write structured research reports and present their findings effectively.

Course Title	**BOTMN71R: Plant Biochemistry and Molecular Biology**
Category of Course[106]	Major/ **Minor** / Minor (Vocational) / SEC / AEC /VAC/ MD/Internship/Dissertation
Credits[107]& Hour of Teaching	
Course Objectives	The course objective is to provide students with a comprehensive understanding of plant biochemistry and molecular biology. Students will learn the biosynthesis of key carbon compounds, including sucrose, starch, and cellulose, and delve into sulfur and phosphorus metabolism, including ATP synthesis. They will gain insight into nitrogen metabolism, including the biochemistry of nitrogen fixation and nitrate reduction. The course will cover the structure and replication of DNA, RNA transcription and processing, and protein synthesis and modification. Additionally, students will explore enzyme mechanisms and molecular tools and techniques such as electrophoresis and cloning vectors.

	Theory	Practical	Cumulative
Credits	3	1	4
Hour of Teaching	45	30	75

Units	Course Content	Hours of Teaching: 45 h
I	Biosynthesis of carbon compounds: sucrose, starch, cellulose Sulphur and phosphorus metabolism: Activation and assimilation of sulphur, energy-rich phosphorus compounds; ATP synthesis	8.0 h
II	Nitrogen metabolism: components, types and substrate of enzyme nitrogenase, biochemistry of nitrogen fixation; Nitrate metabolism: Uptake and reduction into ammonia, ammonia assimilation	8.0 h
III	DNA: Structure and properties of different forms of DNA, DNA replication in prokaryotes and eukaryotes, DNA damage and repair	8.0 h
IV	RNA:Structure and properties of different forms of RNA, transcription in prokaryotes and eukaryotes, mRNA processing-5' cap formation- 3'end processing and polyadenylation, splicing, nuclear export of mRNA	8.0 h
V	Protein: Basic aspects of protein conformation, translation in prokaryotes and eukaryotes (activation of amino acids,	13.0 h

[106] SEC – Skill Enhancement Course; AEC – Ability Enhancement Course; VAC – Value Added Course; MD – Multidisciplinary Course

[107] 1 Credit (Theory) = 15 Hours; 1 Credit (Practical) = 30 Hours

	initiation, elongation, termination and release of peptides), post-translational modification of proteins Enzymes: Mechanism of enzyme action, coenzymes, allosteric enzyme, isozymes Molecular tools and techniques: Basic principles of electrophoresis and blotting, cloning vectors, molecular cloning of nucleic acid fragments	
Texts/ References	Cox MM, Nelson DL (2021) Lehninger Principle of Biochemistry, 8th edition MacMillan, Worth Publishers,London. Devlin TM (2011) Textbook of Biochemistry, 7th edition, John Wiley & Sons, Inc, New York. Voet D, Voet JG and Pratt CW (2018) Biochemistry, 5th Edition, John Wiley & Sons, Inc, New York. Zubay GL (1998) Biochemistry, 4th edition, Wm C Brown Publishers, Dubuque, Iowa. Dubey RC (2013) A Text Book of Biotechnology 4th edition, S Chand & Co Ltd, New Delhi. Wilson K, Walker J (2018) Principle & Techniques of Biochemistry and Molecular Biology, 8th edition, Cambridge University Press, Cambridge. Bowsher C & Tobin A (2021) Plant Biochemistry, 2nd Edition, Taylor & Francis Inc, CRC press. Arthur M. Lesk (2016) Introduction to Protein Science Architecture Function and Genomics, Oxford University press, London. Berg JM et al. (2018) Biochemistry, 8th edition, WH Freeman & Company, New York. **Suggested websites** https://academic.oup.com/aob/article/105/7/1141/148741 https://dx.doi.org/10.1016/B978-0-12-800180-6.00001-3 https://doi:10.1016/j.molp.2016.05.004 https://doi.org/10.1093/jn/130.5.1081 https://academic.oup.com/jxb/article/68/10/2463/2967464 https://epgp.inflibnet.ac.in/Home/ViewSubject?catid=2 https://epgp.inflibnet.ac.in/epgpdata/uploads/epgp_content/food_technology/food_chemistry/16.protein_ structure_and_denaturation/et/40_et_m16.pdf https://www.youtube.com/watch?v=MODnIkQvyz0 https://www.youtube.com/watch?v=AeVDoDp3llI	
Learning Outcomes	Upon completion of this course, students will be able to understand and describe the biosynthesis of essential carbon compounds like sucrose, starch, and cellulose, and elucidate sulfur and phosphorus metabolism, including ATP synthesis. They will gain insights into nitrogen metabolism, focusing on nitrogen fixation and nitrate reduction. Students will be proficient in explaining DNA structure, replication, and repair, RNA transcription, processing, and translation, and protein synthesis and post-translational modifications. Additionally, they will be familiar with enzyme mechanisms and molecular techniques such as electrophoresis and molecular cloning, enabling practical applications in plant biochemistry and molecular biology.	

Course Title	**BOTMN72R: Lab Work Based on Paper BOTMN71R**	
Units	**Practicals**	**Hours of Teaching:30 h**
I	• Chromatographic separation and comparative analysis of photosynthetic pigments in plants • Chromatographic separation of amino acids	6.0 h
II	• Preparation of standard graph and estimation of DNA by diphenylamine test • Preparation of standard graph and estimation of RNA by Orcinol test	6.0 h
III	• Preparation of standard graph and estimation of protein by Bradford method • Study on the effects of light/dark on the nitrate reductase enzyme	6.0 h
IV	• To study the time dependent activity of urease enzyme • Study on the effects of different concentrations of urea on urease activity	6.0 h

V	• Determination of different concentrations of urease enzyme on its activity • Preparation of standard graph and estimation of carbohydrates by anthrone reagent method • Demonstration of electrophoretic and blotting instruments	6.0 h

Course Title	**BOTMN73R: Plant Biotechnology and Genetic Engineering**			
Category of Course[108]	Major/**Minor** / Minor (Vocational) / SEC / AEC /VAC/ MD/Internship/Dissertation			
Credits[109]**& Hour of Teaching**		Theory	Practical	Cumulative
	Credits	3	1	4
	Hour of Teaching	45	30	75
Course Objectives	This course aims to provide a comprehensive understanding of plant biotechnology and genetic engineering, covering historical developments, model plants, and applications. Students will learn about recombinant DNA technology, including vectors, restriction enzymes, and genomic libraries. They will explore plant cell, tissue, and organ culture techniques, including totipotency, media preparation, and regeneration protocols. The course will cover plant transformation techniques, including both indirect and direct methods. Students will examine transgenic plants and their applications, gene expression regulation, and advanced gene editing technologies like ZFNs, TALENs, and CRISPR/Cas systems, addressing their applications, limitations, and ethical considerations.			

Units	**Course Content**	**Hours of Teaching:45 h**
I	• Plant Biotechnology: Introduction, History, Model plants, Scope and applications • Recombinant DNA technology: Vectors, restriction enzymes, molecular probes, genomic and cDNA libraries	8.5 h
II	• Plant Cell, Tissue and Organ Culture *(a) History, concept of totipotency, nutritional requirementsof culture, mediapreparation, aseptic condition, applications and limitations* *(b) Regeneration Protocols: Single Cell Culture, Organogenesis and SomaticEmbryogenesis, Factors and significance* *(c) Protoplast Culture and Fusion: Protoplast isolation and culture, Protoplastfusion, methods and factors, applications*	8.5 h
III	• Techniques for plant transformation *(a) Indirect gene transfer methods (Agrobacterium tumefaciens, and Agrobacterium rhizogenes mediated transfer)* *(b) Direct Gene transfer methods (electroporation, particle bombardment, microinjection, PEG, silicon carbide)*	8.0 h
IV	• Transgenic plants, some genetically modified plants (Flavr Savr tomato, Bt brinjal, Bt corn, Bt cotton, Golden rice, virus resistant plants, pest resistant plants) and molecular forming, applications and limitations (ethical and environmental issues)	8.0 h
V	• Gene expression and its regulation in plants: Transcription factors and cis-regulatory elements (CREs), epigenetic mechanisms of transcriptional regulation, translational control, programmed DNA rearrangements • Gene editing and its applications: Zinc-finger nucleases (ZFNs), transcription activator-like effector nucleases (TALENs), CRISPR/Cas systems	12.0 h

[108] SEC – Skill Enhancement Course; AEC – Ability Enhancement Course; VAC – Value Added Course; MD – Multidisciplinary Course

[109] 1 Credit (Theory) = 15 Hours; 1 Credit (Practical) = 30 Hours

Texts/References	1. Bhojwani SS & Dantu PK (2013) Plant Tissue Culture: An Introductory Text, Springer. 2. Park S (2021) Plant Tissue Culture: Techniques and Experiments, Fourth Edition, Academic Press, Elsevier. 3. Razdan MK (2003) Introduction to Plant Tissue Culture, Science Publishers, USA 4. Slater A, Scott NW and Fowler MR (2008) Plant biotechnology: the genetic manipulation of plants, second edition, Oxford University Press. 5. Sahni S, Prasad BD and Kumar P (2017) Plant Biotechnology: Transgenics, Stress 6. Management and Biosafety Issues, CRC Press.
Learning Outcomes	Upon completing this course, students will be proficient in plant biotechnology and genetic engineering techniques. They will understand the historical development and applications of plant biotechnology, including recombinant DNA technology and plant cell culture methods. Students will gain expertise in various plant transformation techniques, both indirect and direct, and be familiar with the production and use of transgenic plants. They will also learn about gene expression regulation and advanced gene editing technologies, such as ZFNs, TALENs, and CRISPR/Cas systems. Additionally, students will address the applications, limitations, and ethical considerations of these biotechnological advances.

Course Title	**BOTMN74R: Lab Work Based on Paper BOTMN73R**	
Units	**Practicals**	**Hours of Teaching:30 h**
I	• Medium preparation of Murashige and Skoog • Surface sterilization and inoculation of nodal explants on MS medium	6.0 h
II	• To raise suspension culture by using friable calli.	6.0 h
III	• To initiate hairy root culture	6.0 h
IV	• Floral dip method of plant transformation (*Arabidopsis thaliana*) and screening for gene transfer (plasmid isolation & transformation, screening through PCR and agarose gel electrophoresis)	6.0 h
V	• Synthetic seed preparation	6.0 h

Course Title	**BOTMN75R: Ecosystem Dynamics**			
Category of Course[110]	Major/ **Minor**/ Minor (Vocational) / SEC / AEC /VAC/ MD/Internship/Dissertation			
Credits[111]**& Hour of Teaching**		Theory	Practical	Cumulative
	Credits	3	1	4
	Hour of Teaching	45	30	75
Course Objectives	This course aims to provide students with a comprehensive understanding of ecosystem dynamics, including the organization and development of communities, mechanisms of ecological succession, and the evolution of ecosystems. Students will explore energy flow models, primary productivity, and nutrient cycling within ecosystems. The course covers ecosystem stability, complexity, and sustainability, and examines the interactions between human activities and ecosystem dynamics. By integrating theoretical concepts and practical applications, students will develop insights into maintaining and managing ecosystem health and functionality.			

[110] SEC – Skill Enhancement Course; AEC – Ability Enhancement Course; VAC – Value Added Course; MD – Multidisciplinary Course

[111] 1 Credit (Theory) = 15 Hours; 1 Credit (Practical) = 30 Hours

Units	Course Content	Hours of Teaching:45 h
I	• Introduction: Introduction to ecosystem dynamics. • Community organization: Holistic, Reductionist, continuum concepts and related theories, Synthetic approach	9.0 h
II	• Ecosystem development: Mechanism and concepts of ecological succession, pattern of ecosystem attributes along successional stages, Evolution of ecosystem	9.5 h
III	• Ecosystem processes: Energy flow models, Net primary productivity, functional metabolic ratio, ecological efficiencies, decomposition, herbivory and carnivory	9.5 h
IV	• Nutrient dynamics: Nutrient cycling and models, nutrient import, export and retention, nutrient use efficiency, nutrient resorption and retranslocation, nutrient conserving adaptation in oligotrophic soils	9.5 h
V	• Ecosystem stability, complexity and sustainability • Man and ecosystem dynamics	7.5 h

Texts/ References	1. Begon, M., Townsend, C. R. 2021) Ecology: From Individuals to Ecosystems. United Kingdom: Wiley. 2. Bradshaw RHW and Sykes MT. 2014. Ecosystem Dynamics: From the Past to the Future. United Kingdom: Wiley. 3. Molles Jr MC and Laursen A. 2020. Ecology: Concepts and Applications Author(s): 5th Canadian Edition McGraw-Hill 4. Mueller-Dombois D and Ellenberg 1974. Aims and Methods of Vegetation Ecology. John Wiley & Sons. New York 5. Odum Eugene Pleasants 1967. Fundamentals of Ecology. United States: Saunders. 6. Raffaelli DG, Frid CLJ, 2010. Ecosystem Ecology: A New Synthesis. Cambridge University Press 7. Singh JS, Singh SP and Gupta SR. 2014. Ecology, Environmental Science and Conservation. S. Chand & Company Pvt. Ltd., New Delhi
Learning Outcomes	Upon completing this course, students will be able to understand and analyze ecosystem dynamics, including community organization, ecological succession, and ecosystem development. They will gain insights into energy flow models, nutrient cycling, and ecosystem processes such as decomposition and herbivory. Students will also learn to evaluate ecosystem stability, complexity, and sustainability, and understand the impact of human activities on ecosystems. Through this knowledge, they will be equipped to apply concepts in managing and conserving ecosystems effectively.

Course Title	**BOTMN76R: Lab Work Based on Paper BOTMN75R**

Units	Practicals	Hours of Teaching: 30 h
I	• Estimation of herbaceous species biomass • Analysis of species composition (based on IVI)	10.0 h
II	• Quantification of dominance	5.0 h
III	• Estimation of soil carbon	5.0 h
IV	• Estimation of total nitrogen	5.0 h
V	• Estimation of Chlorophyll content	5.0 h

SEMESTER-VIII

Course Title	BOTDS81R: Dissertation			
Category of Course[112]	Major / Minor / Minor (Vocational) / SEC / AEC /VAC/ MD/Internship/**Dissertation**			
Credits[113]& Hour of Teaching		Theory	Practical	Cumulative
	Credits			12

Course Title	BOTMJ82R: Aquatic Ecology			
Category of Course[114]	**Major**/ Minor / Minor (Vocational) / SEC / AEC /VAC/ MD/Internship/Dissertation			
Credits[115]& Hour of Teaching		Theory	Practical	Cumulative
	Credits	3	1	4
	Hour of Teaching	45	30	75
Course Objectives	This course aims to provide a comprehensive understanding of aquatic ecosystems, including hydrological cycles, primary productivity, and food web dynamics. Students will explore the characteristics and ecological processes of lakes, rivers, estuaries, and oceans, focusing on topics such as thermal stratification, eutrophication, and nutrient limitations. The course will also cover the diversity of aquatic organisms, including phytoplankton, zooplankton, and benthic communities, and address the ecological significance and conservation of coral reefs and other marine biota. Through this course, students will develop skills to analyze and manage aquatic environments effectively.			

Units	Course Content	Hours of Teaching:45 h
I	• Hydrological cycle; Watershed hydrology • Aquatic primary productivity and its measurement	10.0 h
II	• Aquatic food webs; trophic cascade • Lakes: General characteristics, ecological zonation in lakes, thermal stratification, water circulation	11.0 h
III	• Diversity of phytoplankton and zooplankton, concept of nutrient limitation • General account of benthic and periphytic communities	8.0 h
IV	• Eutrophication: Causes and consequences, indices of eutrophy, control of eutrophication • Rivers: Characteristics of lotic systems; River continuum concept	7.0 h
V	• Estuaries: General account of estuaries, types and significance • Oceans: Ecological zonation in marine environment, marine biota, coral reefs	9.0 h

Texts/ References	
	1. Singh JS, Singh SP, Gupta SR (2014) Ecology Environmental Science and Conservation, S Chand & Co, New Delhi. 2. Barnes RSK and Mann KH 1991. Fundamentals of aquatic ecology. Wiley and Blackwell. 3. Doods WK. and Whiles MR, Freshwater Ecology, 3rd Edition Concepts and Environmental

[112] SEC – Skill Enhancement Course; AEC – Ability Enhancement Course; VAC – Value Added Course; MD – Multidisciplinary Course

[113] 1 Credit (Theory) = 15 Hours; 1 Credit (Practical) = 30 Hours

[114] SEC – Skill Enhancement Course; AEC – Ability Enhancement Course; VAC – Value Added Course; MD – Multidisciplinary Course

[115] 1 Credit (Theory) = 15 Hours; 1 Credit (Practical) = 30 Hours

	Applications of Limnology. Elesiever. 4. Polunin NVC 2010. Aquatic ecosystems, Cambridge university press.
Learning Outcomes	Upon completion of this course, students will be able to analyze and interpret the dynamics of aquatic ecosystems, including the hydrological cycle, primary productivity, and trophic interactions. They will understand the ecological characteristics of lakes, rivers, estuaries, and oceans, with insights into thermal stratification, nutrient limitations, and eutrophication. Students will gain knowledge about the diversity of aquatic organisms, including phytoplankton, zooplankton, and benthic communities. They will also be equipped to assess and address environmental issues related to aquatic systems, such as eutrophication and conservation of marine habitats like coral reefs.

Course Title	**BOTMJ83R: Lab Work Based on Paper BOTMJ82R**	
Units	**Practicals**	**Hours of Teaching:30 h**
I	• To determine the pH of given water samples • To estimate free CO_2 in given water samples	6.0 h
II	• To estimate the chloride concentration in given water samples • To determine the total hardness of the water samples	6.0 h
III	• To measure the dissolve oxygen (DO) in water samples • To estimate the nitrate concentration in water samples	6.0 h
IV	• To estimate the phosphate concentration in given water samples • To measure the biological oxygen demand (BOD) in given water samples	6.0 h
V	• To estimate the primary productivity in given water samples	6.0 h

Course Title	**BOTMN84R: Aquatic Ecology**			
Category of Course[116]	Major/ **Minor** / Minor (Vocational) / SEC / AEC /VAC/ MD/Internship/Dissertation			
Credits[117]**& Hour of Teaching**		Theory	Practical	Cumulative
	Credits	3	1	4
	Hour of Teaching	45	30	75
Course Objectives	This course aims to provide a comprehensive understanding of aquatic ecosystems, including hydrological cycles, primary productivity, and food web dynamics. Students will explore the characteristics and ecological processes of lakes, rivers, estuaries, and oceans, focusing on topics such as thermal stratification, eutrophication, and nutrient limitations. The course will also cover the diversity of aquatic organisms, including phytoplankton, zooplankton, and benthic communities, and address the ecological significance and conservation of coral reefs and other marine biota. Through this course, students will develop skills to analyze and manage aquatic environments effectively.			
Units	**Course Content**			**Hours of Teaching:45 h**
I	• Hydrological cycle; Watershed hydrology • Aquatic primary productivity and its measurement			10.0 h
II	• Aquatic food webs; trophic cascade • Lakes: General characteristics, ecological zonation inlakes, thermal stratification, water circulation			11.0 h

[116] SEC – Skill Enhancement Course; AEC – Ability Enhancement Course; VAC – Value Added Course; MD – Multidisciplinary Course

[117] 1 Credit (Theory) = 15 Hours; 1 Credit (Practical) = 30 Hours

III	• Diversity of phytoplankton and zooplankton, concept of nutrient limitation • General account of benthic and periphytic communities	8.0 h
IV	• Eutrophication: Causes and consequences, indices of eutrophy, control of eutrophication • Rivers: Characteristics of lotic systems; River continuum concept.	7.0 h
V	• Estuaries: General account of estuaries, types and significance • Oceans: Ecological zonation in marine environment, marine biota, coral reefs	9.0 h

Texts/ References	1. Singh JS, Singh SP, Gupta SR (2014) Ecology Environmental Science and Conservation, S Chand & Co, New Delhi. 2. Barnes RSK and Mann KH 1991. Fundamentals of aquatic ecology. Wiley and Blackwell. 3. *Doods WK. and Whiles MR, Freshwater Ecology, 3rd Edition Concepts and Environmental Applications of Limnology. Elesiever.* 4. Polunin NVC 2010. Aquatic ecosystems, Cambridge university press.
Learning Outcomes	Upon completion of this course, students will be able to analyze and interpret the dynamics of aquatic ecosystems, including the hydrological cycle, primary productivity, and trophic interactions. They will understand the ecological characteristics of lakes, rivers, estuaries, and oceans, with insights into thermal stratification, nutrient limitations, and eutrophication. Students will gain knowledge about the diversity of aquatic organisms, including phytoplankton, zooplankton, and benthic communities. They will also be equipped to assess and address environmental issues related to aquatic systems, such as eutrophication and conservation of marine habitats like coral reefs.

Course Title	**BOTMN85R: Lab Work Based on Paper BOTMN84R**

Units	**Practicals**	**Hours of Teaching:30 h**
I	• To determine the pH of given water samples • To estimate free CO_2 in given water samples	6.0 h
II	• To estimate the chloride concentration in given water samples • To determine the total hardness of the water samples	6.0 h
III	• To measure the dissolve oxygen (DO) in water samples • To estimate the nitrate concentration in water samples	6.0 h
IV	• To estimate the phosphate concentration in given water samples • To measure the biological oxygen demand (BOD) in given water samples	6.0 h
V	• To estimate the primary productivity in given water samples	6.0 h

BANARAS HINDU UNIVERSITY

Department of Biochemistry

Faculty of Science

SYLLABI

B.Sc. Programme

In

Biochemistry

Multidisciplinary Courses:

BIOMD11: Introductory Bioinformatics

Course Content	Hr. of Teaching
Biomolecules (carbohydrates, proteins, lipids and nucleic acids) their role as constitution of human body and health diet	5
Structures and functions of carbohydrates, proteins, lipids and nucleic acids. Physiological functions of these biomolecules.	15
Dietary requirements for the balanced nutrition and the essential nutrients required by human body. Disease caused due to the deficiency of various nutrients.	15
Energy requirement of human body and their storage forms.	5
Healthy eating and change in the quality of food due to presence/ absence of a biomolecule. Protein-calorie malnutrition disorders- Kwashiorkor and Marasmus. High quality and Low quality proteins, Vitamin deficiency diseases.	5

BIOMD21: Immunity and Human Diseases

Course Content	Hr. of Teaching
History and scope of immunology, biological threats (parasites, bacteria, virus, fungi etc.) and their recognition by immune system	05
General features of Cells, Tissues, and organs of the human immune system, types of immunity (innate vs adaptive and active vs passive immunity), Fundamentals of cellular and humoral immunity	15
Effector molecules of immune system. Mechanisms and production of cytokines and antibodies and their role in elimination of potential biological threats Antigenicity vs Immunogenicity, Immunology of organ transplantation	10
Basic biology of Filariasis, Tuberculosis, Malaria, Leishmaniasis and Cancer diseases prevalent in the Indian subcontinent	10
Vaccines: Types and mechanism of protection Serology: Basics of immunological Techniques like agglutination, precipitation, ELISA, Widal and VDRL tests.	05

Skill Enhancement Course:

BIOSE31: Basic Tools and Techniques for Biological Research

Course Content	Hr. of Teaching
Spectrophotometry: Theory and applications in quality determination and quantification of biomolecules	05
Chromatography: Types and their applications in biochemical/biological research	10
Basics of Centrifugation (sedimentation), Preparative and analytical centrifugation techniques, and their applicability in determining purity/conformation/molecular weights of biomolecules	10
Microscopes and their uses in biological research	10
Biomolecular techniques and their applications	10

(SEMESTER-I)

Course Title	**Introductory Bioinformatics**
Category of Course[118]/ Course Code	Multidisciplinary (MD)/ **BIOMD11**
Credits[119]& Hour of Teaching	

	Theory	Practical	Cumulative
Credits	3	-	3
Hour of Teaching (Total)	45	-	45

Course Objectives (not more than 100 words)	1. To familiarize UG students with components of human nutrition and various biomolecules which are responsible for diverse physiological functions. 2. To provide comprehensive knowledge of carbohydrates, proteins, lipids, nucleic acids and vitamins, their essential features, storage forms and physiological functions in our body. 3. To provide information about various types of deficiency of food nutrients and the diseases caused due to their deficiency. 4. To make them understand the dietary energy, calorie requirement and expenditure in the body. Imbalance in dietary energy and its role in metabolic disorders. 5. To provide knowledge about the quality of food and how the quality of food changes with the presence or absence of different biomolecules. Also to apprise students about healthy eating.
Course Content	The course content be divided into minimum 3 Units to maximum 5 units along with defined hour of teaching for each unit.

Units	**Course Content**	**Hr. of Teaching**
I	Biomolecules (carbohydrates, proteins, lipids and nucleic acids), their role as constitution of human body and health diet	5
II	Structures and functions of carbohydrates, proteins, lipids and nucleic acids. Physiological functions of these biomolecules.	15
III	Dietary requirements for the balanced nutrition and the essential nutrients required by human body. Disease caused due to the deficiency of various nutrients.	15
IV	Energy requirement of human body and their storage forms.	5
V	Healthy eating and change in the quality of food due to presence/ absence of a biomolecule. Protein-calorie malnutrition disorders- Kwashiorkor and Marasmus. High quality and Low quality proteins, Vitamin deficiency diseases.	5

Texts / References	1. Fundamentals of Biochemistry 5th Edition: By Donald Voet, Judith G. Voet, Charlotte W. Pratt 2. Lehninger Principles of Biochemistry 7th Edition: By David L. Nelson, Michael Cox 3. Deep Nutrition: Why Your Genes Need Traditional Food: By Catherine Shanahan M.D., Luke Shanahan
Learning Outcomes (not more than 100 words)	The student will comprehend knowledge on basics of Biomolecules like carbohydrates, proteins, nucleic acids, lipids, vitamins and minerals. They will understand the dietary requirements of human body to sustain and live healthy life. Student's knowledge about deficiency diseases will lead to the good health by supplementing those nutrients in their diet

[118] SEC – Skill Enhancement Course; AEC – Ability Enhancement Course; VAC – Value Added Course; MD – Multidisciplinary Course

[119] 1 Credit (Theory) = 15 Hours; 1 Credit (Practical) = 30 Hours

(SEMESTER-II)

Course Title	**Immunity and Human diseases**
Category of Course[120]/ Course Code	Multidisciplinary (MD)/ **BIOMD11**

Credits[121]& Hour of Teaching	Theory	Practical	Cumulative
Credits	3	-	3
Hour of Teaching (Total)	45	-	45

Course Objectives (not more than 100 words)	1. To acquaint students to immune defense mechanisms of the human body against potential threats, a glimpse of immunology history and threat elimination. 2. To provide knowledge about the essential features of cells, tissues, organs and their functioning. 3. To disseminate knowledge about vaccines and their functioning. 4. To orient students toward common diseases prevailing in the region locally and at the pan India level. 5. To provide knowledge on the methods of detection of pathogens in diseased individuals.
Course Content	The course content will be divided into minimum of 3 units to maximum 5 units along with defined hours of teaching for each unit.

Units	Course Content	Hr. of Teaching
I	History and scope of immunology, biological threats (parasites, bacteria, virus, fungi etc.) and their recognition by immune system	05
II	General features of Cells, Tissues, and organs of the human immune system, types of immunity (innate vs adaptive and active vs passive immunity), Fundamentals of cellular and humoral immunity	15
III	Effector molecules of immune system Mechanisms and production of cytokines and antibodies and their role in elimination of potential biological threats Antigenicity vs Immunogenicity, Immunology of organ transplantation	10
IV	Basic biology of Filariasis, Tuberculosis, Malaria, Leishmaniasis and Cancer diseases prevalent in the Indian subcontinent	10
V	Vaccines: Types and mechanism of protection Serology: Basics of immunological Techniques like agglutination, precipitation, ELISA, Widal and VDRL tests.	05

Texts / References	1) Roitt's Essential Immunology: By Peter J. Delves, Seamus J. Martin, Dennis R. Burton, Ivan M. Roitt 2) Introduction to Immunology: By John W. Kimball 3) Immunology: By D.M. Weir, John Stewart 4) Kuby Immunology: By Jenni Punt, Sharon Stranford, Patricia Jones, Judith A Owen 5) SCHAUM'S OUTLINE OF IMMUNOLOGY / 1ST, EDITION: By George Pinchuk
Learning Outcomes (not more than 100 words)	The student will comprehend knowledge on basics of human immune system, its mechanisms, and role in maintaining healthy status of human being. Students will also gain knowledge on effector mechanisms of our immune system, potential diseases and their burden in the region along with their diagnostic and prevention approaches. They will also learn about vaccines and various tools/ techniques that are used to diagnose immunological diseases.

[120] SEC – Skill Enhancement Course; AEC – Ability Enhancement Course; VAC – Value Added Course; MD – Multidisciplinary Course

[121] 1 Credit (Theory) = 15 Hours; 1 Credit (Practical) = 30 Hours

(SEMESTER-III)

Course Title	**Basics Tools and Techniques for Biological Research**
Category of Course[122]/ Course Code	Skill Enhancement/ **BIOSE31**
Credits[123]& Hour of Teaching	

	Theory	Practical	Cumulative
Credits	3	-	3
Hour of Teaching (Total)	45	-	45

Course Objectives (not more than 100 words)	For any scientific exploration, fundamental knowledge of research tools and techniques is essential. This course is developed to acquaint UG students about basic techniques that are used in various fields of biochemistry research. This course would provide knowledge on tools used in qualitative and quantitative measurements/estimations of biomolecules like proteins, nucleic acids, fats &lipids, carbohydrates etc. This course will also offer UG students to learns various techniques used in isolation, separation, purification etc of an analyte mixed in heterogeneous solution. The students will also learn about some DNA/RNA manipulation techniques that are important in context to cloning and producing transgenic cells and animals.
Course Content	The course content be divided into minimum 3 Units to maximum 5 units along with defined hour of teaching for each unit.

Units	**Course Content**	**Hr. of Teaching**
I	Spectrophotometry: Theory and applications in quality determination and quantification of biomolecules	05
II	Chromatography: Types and their applications in biochemical/biological research	10
III	Basics of Centrifugation (sedimentation), Preparative and analytical centrifugation techniques, and their applicability in determining purity/conformation/molecular weights of biomolecules	10
IV	Microscopes and their uses in biological research	10
V	Biomolecular techniques and their applications	10

Texts / References	1. Principles and Techniques of practical Biochemistry. Eds. Keith Wilson and John Walker 2. Techniques in Molecular Biology: by J.M. Walker, W. Gaastra 3. An introduction to spectroscopy for Biochemistry. Ed. Brown S.N., Academic press. 4. Physical Biochemistry: Principles and Applications by David Sheehan 5. Analytical Biochemistry, Holmes and Hazel peck, Longman. 6. An introduction to practical biochemistry. David T. Plummer, Tata MacGrew-Hill. 7. Biophysical chemistry, Edshall& Wyman, Academic press Vol II & I. 8. Biochemical calculations Seigel, IH, 2nd Edit, John Wiley &sons Inc.
	The student will comprehend knowledge on various tools and techniques that are used to study physical and chemical properties of biomolecules. This course is designed to facilitate learning on separation, and quantification of bio-analytes. Also, by learning the microscopy tools, students will be acquainted with invisible world of mircro-organisms, cells and intracellular dynamics. Students will also gain knowledge on some modern tools/techniques of DNA and gene manipulation.

[122] SEC – Skill Enhancement Course; AEC – Ability Enhancement Course; VAC – Value Added Course; MD – Multidisciplinary Course

[123] 1 Credit (Theory) = 15 Hours; 1 Credit (Practical) = 30 Hours

BANARAS HINDU UNIVERSITY

Department of Biotechnology

Faculty of Science

SYLLABI

B.Sc. Programme

In

Biotechnology

BANARAS HINDU UNIVERSITY
(Detailed Syllabus of different Courses under NEP 2020)

Department of School of Biotechnology
Faculty of Science
MD – **Multidisciplinary Course**; Course Name: **Techniques of Biotechnology (to be offered in 3rd Semester)**

Course Title	**Techniques of Biotechnology (Course code- BTCMD31)**
Category of Course[124]	~~Major~~ /~~**Minor**~~/ ~~Minor (Vocational) / SEC / AEC / VAC~~ / **MD**/~~Internship/Dissertation~~ (Tick any one of the above)

Credits[125]& Hour of Teaching	Theory	Practical	Cumulative
Credits	3	0	3
Hour of Teaching (Total)	45	0	45

Course Objectives (not more than 100 words)	The objective of this course is to introduce the students to the field of Biotechnology. The emphasis will be given to experimental techniques employed in various areas of Biotechnology such as Genetic engineering, Immunology, Animal cell culture, Plant Biotechnology, Protein Chemistry, Microbial Biotechnology, and Bioinformatics. The course will be helpful for the students in understanding and applying the core concepts of Biotechnology in their project and higher studies. Further, it will prepare and sensitize the students to the scope for research, in increasing the skilled scientific manpower with an understanding of research, industrials applications, and scientific ethics.
Course Content	The course content be divided into minimum 3 Units to maximum 5 units along with defined hour of teaching for each unit.

Units	**Course Content**	**Hr. of Teaching**
I	**Genome Biology & Basics of Bioinformatics Techniques:** Basics of genomic techniques, Human genome project, discussion on some representative genomics techniques. Introduction to Bioinformatics, Biological databases, Significance of Bioinformatics.	14
II	**Immunological Techniques & Animal Cell Culture:** Basics of Immunology, discussion on some representative techniques. Basics of animal cell culture techniques.	12
III	**Techniques in Plant Biotechnology:** Culture media, establishment and maintenance of Cultures, Totipotency	7
IV	**Introduction to Protein Chemistry** and Basic Techniques involved.	5
V	**Techniques in Microbial Biotechnology:** Isolation, purification, cultivation and preservation of microbes, identification based on molecular methods.	7

Texts / References	1. Keith Wilson and & John Walker : Principles and Techniques of Biochemistry and Molecular Biology , Cambridge, UK. 2. David W Mount : Bioinformatics : Sequence and Genome analysis , CSHL Press, New York 3. Lesk, Arthur M: Introduction to Bioinformatics: Oxford University press, Oxford. 4. S. B. Primrose, Richard M. Twyman, R. W. Old, Principles of Gene Manipulation and Genomics, Blackwell Science (Asia Pvt Ltd). 5. Bhojwani and Razdan, Tissue Culture, Elsevier, Amsterdam. 6. J Sambrook & EF Fritsch, Molecular Cloning: A laboratory manual, Cold Spring Harbor Laboratory press, U.S.A. 7. Freshney, R.I : Culture of Animal cells , Wiley Publications , New York. 8.Edi. Jhon R.W. Masters : Animal cell culture- practical approach , Oxford University press, Oxford

[124] SEC – Skill Enhancement Course; AEC – Ability Enhancement Course; VAC – Value Added Course; MD – Multidisciplinary Course

[125] 1 Credit (Theory) = 15 Hours; 1 Credit (Practical) = 30 Hours

Learning Outcomes (not more than 100 words)	1. Describe the principles of gene expression and regulation in prokaryotic and eukaryotic cells. 2. Acquiring theoretical knowledge in the techniques, tools, application and safety measures of genetic engineering. 3. The basic and general concept of Immunology and Animal cell culture, basic Understanding of various Immunology and Animal cell culture techniques. 4. Acquainted with principles, technical requirement, scientific, and commercial applications in Plant Biotechnology, 5. To study the basic techniques in Protein Biochemistry. 6. To study the methods of Isolation, cultivation, preservation, of microorganisms. 7. To get acquainted to the basic knowledge of Bioinformatics and its application in research.

BANARAS HINDU UNIVERSITY

Department of Chemistry

Faculty of Science

SYLLABI

B.Sc. (Hons.) Programme

In

Chemistry

Framework of Syllabi for UG according to NEP

Semester	Number of Credits (for Major Course Only)		
	Theory (1 credit- 1 hr/week)	Practicals (1 credit= 2hr/week)	Total
Certificate			
I	**3 Credits**	1	4
II	**3 Credits**	1	4
Diploma			
III	Inorganic-I, Organic-I, Physical-I- **2 Credits each**	2	8
IV	Inorganic-II, Organic-II, Physical-II, **3 Credits each** Techniques in Chemistry-**1 Credit**	4	14
B.Sc.			
V	Analytical-I, Inorganic-III- **2 Credits** Organic-III, Physical-III- **3 Credits**	2+2+2	16
VI	Analytical-II, Inorganic-IV- **3 Credits** Organic-IV, Physical-IV- **2 Credits**	2+2+2	16
B.Sc. (Hons.)			
VII (without Research)	Analytical-III, Inorganic-V, Organic-V, Physical-V Materials Chemistry- **2 Credits**	2+2+2	16
VII (with Research)	Analytical-III, Inorganic-V, Organic-V, Physical-V Materials Chemistry- **2 Credits**	2+2+2	
VIII (without Research)	Analytical-IV, Inorganic-VI, Organic-VI, Physical-VI Advanced Spectroscopy- **2 Credits each**	2+2+2	16
VIII (with Research)	Advanced Spectroscopy and any one of the following courses: Analytical-IV, Inorganic-VI, Organic-VI, Physical-VI **- 2 Credits each**	12 **(project)**	16

CHEMJ11: Basic Concepts of Chemistry-I	
Objectives: To understand the wave nature of matter and its implications.To study the classification of elements and their properties. To study the states of matter; behavior of ideal and real gases, liquids, and the structures of solids.To understand the laws of thermodynamics.	
1.**Atomic Structure:** Wave-particle duality, Heisenberg uncertainty principle, Schrodinger wave equation, Eigen values and Eigen functions, significance of Ψ and Ψ^2 Radial and angular wave functions, Multi-electron system: Concept of Effective Nuclear Charge (Slater's rules).	**5**
2. Atomic properties and their periodic trends: A brief introduction to the modern periodic table (Block wise). Atomic size (Covalent, Ionic and van der Waal's radii; Lanthanide contraction), Electron loss, and electron gain enthalpies. Inert pair effect. Electronegativity (Pauling, Mulliken, Allred Rochow'smethods of determination): As a criterion of bond type. Lattice energy and its determination: a) Born-Haber cycle b) Born Lande equation c) Comparison of experimental and theoretical values. Solvation/Hydration energy (Solubility of ionic solids in water). Covalency in ionic compounds (Fajan's rules). Redox reaction, Standardelectrode potential and its determination. Electrochemical series and its applications Latimer and Frost diagrams; specific illustrative examples.	**10**
3. Gaseous State: Kinetic theory of gases and ideal gas laws, Maxwell distribution of speed, Equipartition of Energy collisions in a gas: collision number, collision diameter and mean free path, behaviour of real gases: van der Waals equation and its applicability, the critical state: critical constants, law of corresponding states.	**10**
4. Liquid State: Surface tension, capillary action, measurement of surface tension, viscosity of liquids andits measurement, temperature effect on surface tension and viscosity	**4**
5. Solid State: Crystal lattices, space lattice, unit cell, crystal systems, law of rational indices, Millerindices, Bragg's equation, crystal structure of NaCl, graphite and diamond	**4**
6. Chemical Thermodynamics and its Applications: First law of Thermodynamics, Thermodynamic quantities (w, q, ΔU and ΔH) for isothermal and adiabatic reversible expansion of ideal gases, Kirchoff's relations, Joule effect, Joule-Thomson effect, Joule-Thomson coefficient of real (van der Waals) gases. Second Law of Thermodynamics, Carnot cycle, concept of entropy and its physical significance, entropy changes for an ideal gas, entropy changes at constant pressure and volume, entropy change in spontaneous processes, free energy and maximum work functions, conditions for spontaneous changes and equilibrium, Gibbs-Helmholtz equation, Maxwell relations. Statement of third law of Thermodynamics.	**12**
Outcomes: Students are expected to be able to understand the wave-particle duality, quantumnumbers, and screening effect of electrons and its consequences. Students will be able to understand the basis of classification in the Modern Periodic Tableand also will be able to explain the properties of various elements. The students will be able to understand the properties of solids, liquids, real and idealgases. The students will learn various laws of thermodynamics.	
Suggested Books:	
1. Basic Inorganic Chemistry, F. A Cotton, G. Wilkinson, and Paul L. Gaus, 3rdEdition (Indian Adaptation 2021), Wiley. 2. Concise Inorganic Chemistry, J. D. Lee, 5th Edition (1996), Chapman & Hall,London. 3. Principle of Physical Chemistry, B. R. Puri, L. R. Sharma and M. S. Pathania,Vishal Publishing Co., New Delhi. 4. Physical Chemistry, P. C. Rakshit, 5th Edition (1988), 4th Reprint (1997), SaratBook House, Calcutta. 5. Physical Chemistry, P. W. Atkins, 8th Ed., Oxford University Press, New York. 6. Textbook of Physical Chemistry, K.L. Kapoor, vol. 1, Macmillan India Ltd, NewDelhi. 7. Physical Chemistry, G. W. Castellan, 3rd Ed (1983), Addison-Wesley Publishing Company, Massachusetts.	

CHEMJ12: Lab Work-I	
1. Redox titrations: (a) Redox Titrimetric Estimations Based on Iodometry (b) Redox Titrimetric Estimations with standard $K_2Cr_2O_7$ solution	
2. (a) Determination of Surface Tension of liquids. (b) Determination of Viscosity Coefficients of liquids.	
or	
Inorganic/Organic Chemistry Laboratory: 1. Preparation of molecular models using wire and beads to study (a) Various hybridization geometries (b) Isomerism 2. Identification of Metal ions by borax bead test 3. Preparation of some simple and double salts. 4. Study of displacement of ions in aqueous solutions (e.g. Cu^{2+} by Zn) 5. Preparation of m-dinitrobenzene from nitrobenzene 6. Preparation of acetanilide from aniline	
Note: Experiments may be added/ modified subject to availability of facilities.	
CHEMJ21: Basic Concepts of Chemistry-II	
Objectives: To understand the nature of chemical bonds and its various types using different approaches. To impart knowledge of general reactions mechanisms, preparation and reactivity patterns of alkyl halides, alcohols, ethers, and active methylene compounds.	
1. Chemical Bonding: i) A comparative account of the Valence Bond (VB) and Molecular Orbital (MO) approach of H2 molecule. Molecular orbital treatment of Homonuclear diatomic molecules of elements of first and second period and Heteronuclear (CO, NO) diatomic molecules. Illustration of HOMO and LUMO. ii) Concept of Hybridization, Bent's Rule, VSEPR theory applied to the compounds of s and p block elements. iii) An introduction to multi-center bonding with illustrative examples of Li-alkyls and diborane. iv) Concept of multiple bonding (p□□p□ and p□-d□) with illustrative examples of BF3, P4O10, (Me3Si)3N and SiF4	6
2. Ionic Bonding: A brief introduction to Crystal Packing, Radius Ratio rule, and its exceptions Structures of a few representative crystal types (Rock salt, Zinc blende, Wurtzite, Rutile, Brookite and Anatase).	5
3. Metallic Bonding: Theories of bonding in metal: Valence Bond, Free electron, and Band theories	2
4.Weak Interactions: Brief introduction to Hydrogen bonding and other weak interactions: Effects on physical and chemical properties.	2
5. Electronic and Field Effect: Electronic (electromeric, inductive, resonance, mesomeric effect, and hyperconjugation) and steric effects on the acidity/basicity of organic molecules.	4
6. Stereochemistry: Fischer, Saw-horse and Newman projection formulae. Chirality-optical activity, enantiomerism and diasteroisomerism involving one and two chiral centers. Configuration: D/L, erythrose/threose, R/S nomenclatures; geometrical isomerism - E/Z nomenclatures. Conformations of n-butane.	5
7. Hydrocarbons: **i.** Alkenes: Addition reactions (electrophilic and free radical), hydration, hydroxylation, hydroboration, epoxidation, ozonolysis and polymerization. Addition reactions of conjugated dienes and Diels–Alder reaction. ii. Alkynes: Reduction, electrophilic addition, acidity and metal acetylides.	6
8. Alkyl Halides: Nucleophilic substitution: SN1, SN2 and SNi, Eliminations reactions: E1, E2, and E1cB mechanisms. Elimination versus substitution reactions. Preparation and synthetic applications of Grignard reagents.	6
9. Alcohols and Ethers: Preparation and reactions of primary, secondary, and tertiary alcohols and ethers.	4
10. Active methylene compounds: Preparation and synthetic applications of ethyl acetoacetate and diethyl malonate. **(L)**	5

Outcome: The students will be able to understand the principles of various types of chemical bonding.	
They will understand the chemistry of hydrocarbons and their derivatives. The students will learn the mechanisms of substitution and elimination reactions.	
Suggested Books: 1. Basic Inorganic Chemistry, F. A Cotton, G. Wilkinson, and Paul L. Gaus, 3rd Edition (Indian Adaptation 2021), Wiley. 2. Concise Inorganic Chemistry, J. D. Lee, 5th Edition (1996), Chapman & Hall,London. 3. Organic Chemistry, I. L. Finar, [Vol. I, 6th Edition (1973), Reprinted in 1980 &Vol. II, 5th Edition (1975), Reprinted in 1996], ELBS and Longman Ltd., New Delhi. 4. Organic Chemistry", 9th Edition, L. G. Wade, J. W. Simek& M. S. Singh, PearsonIndia Education Services Pvt. Ltd. 2020 (ISBN 978-93-893-4267-3). 5. Organic Chemistry, R. T. Morrison and R. N. Boyd, 6th Edition (1992), Prentice-Hall of India (P) Ltd., New Delhi. 6. Organic Chemistry, Paula Y. Bruice, 2nd Edition, (1998) Prentice-Hall, International Edition.	

CHEMJ22: Lab Work-II	
1. Redox titrations: (a) Redox Titrimetric Estimations Based on Iodometry (b) Redox Titrimetric Estimations with standard $K_2Cr_2O_7$ solution	
2. (a) Determination of Surface Tension of liquids. (b) Determination of Viscosity Coefficients of liquids.	
or	
Inorganic/Organic Chemistry Laboratory: 1. Preparation of molecular models using wire and beads to study (a) Various hybridization geometries (b) Isomerism 2. Identification of Metal ions by borax bead test 3. Preparation of some simple and double salts. 4. Study of displacement of ions in aqueous solutions (e.g. Cu^{2+} by Zn) 5. Preparation of m-dinitrobenzene from nitrobenzene 6. Preparation of acetanilide from aniline	
Note: Experiments may be added/ modified subject to availability of facilities.	

CHEMJ31: Inorganic Chemistry-I	
Objectives: To study the preparation and chemical nature of some important class of compounds ofmain group elements. To study industrially relevant inorganic molecules and materials.	
1. Chemistry of main group elements with special references of the following Flame colorations of alkali and alkaline earth metals. Complexes of alkali and alkaline earth metals (the idea of complexation, examples having inorganic, organic chelating ligands, crowns, electrides, and crypts.). Difference between the first and the other members of the group [Be and other elements, B and other elements]. Metalloids. Allotropes (of C, N, P,O, and S) Hydrides, Halides, Hydroxides, Oxo-acids and their salts, and Oxide With special emphasis on (i) Relevant structures (ii) Acidity and Basicity (iii) Redox behaviour (iv) Stabilities (v) Classification and typical examples, and (vi) General methods of preparation of the afore mentioned genres.	18
2. Industrial Chemistry: Silicates with examples of practical utilities (Zeolites. Application in Molecular sieves) Glass, Ceramics, Refractories, Cement, Fertilizers(Nitrogenous and Phosphate fertilizers)	12
Outcomes: The students will understand the structure and properties of some S and p blockelements. The students will learn how some industrially important compounds are prepared and how they are important commercially.	
Suggested Books: 1. Basic Inorganic Chemistry, F. A Cotton, G. Wilkinson, and Paul L. Gaus, 3rdEdition (Indian Adaptation 2021), Wiley. 2. Concise Inorganic Chemistry, J. D. Lee, 5th Edition (1996), Chapman & Hall,London. 3. Inorganic Chemistry, Gary Wulfsberg, Iva Student Edition, Reprinted 2014	

CHEMJ32: Organic chemistry-I	
Objectives: To impart a comprehensive understanding of the chemistry involving carbonyl compounds, ylides, aromaticity, their reactivity patterns, and notable reactions in organicchemistry.	
1. Chemistry of Carbonyl compounds: Preparations and reactions - addition and condensation reactions, Cannizzaro, Perkin, Aldol, Benzoin, Haloform, Mannich, and Baylis-Hillman reaction. Important reactions of acids, HVZ reaction, relative reactivity of acid chlorides, acid anhydrides, amides, and esters.	**8**
2. Chemistry of Phosphorous and Sulphur Ylides: Preparation and Reactions. Wittig reaction, Arbuzov rearrangement, Horner-Woodsworth Emons Modification	**5**
3. Aromaticity: A general concept of aromaticity antiaromaticity and homoaromaticity. Molecular orbital picture of benzene.Benzenoid and non-benzenoid systems, alternant and nonalternant hydrocarbons.	**7**
4. Aromatic Electrophilic Substitution: Mechanism of nitration, halogenation, sulphonation, and Friedel-Crafts (alkylation andacylation) reactions. Effects of substituents on *ortho/para* ratio, orientation and reactivity.	**6**
5. Preparation and Reactions of Phenols.	**4**
Outcomes: The students will be able to (a) Understand reaction conditions, products formation and mechanisms of somenamed reactions. (b) Understand about applications of phosphorous and sulphur ylides. (c) Relate and distinguish various forms of aromaticity and their characteristics. (d) comprehend the reactivity tendencies towards electrophilic aromatic substitutionreactions and (e) Learn about the basic chemistry of phenols.	

Suggested Books: 1. Organic Chemistry, I. L. Finar, Vol. I, 5th Edition (1975), Reprinted in 1996,ELBS and Longman Ltd., New Delhi. 2. Advanced Organic Chemistry-Reactions and Mechanisms 2e"– M. S. Singh & K.Raghuvanshi, Pearson Education Pvt. Ltd. 3. Organic Chemistry", R. T. Morrison and R. N. Boyd, 6th Edition (1992),Prentice- Hall of India (P) Ltd., New Delhi. 4. A Guide Book to Mechanism in Organic Chemistry, Peter Sykes, 6th Edition(1997), Orient Longman Ltd., New Delhi. 5. Advanced Organic Chemistry: Reactions, Mechanisms, and Structure, JerryMarch J. Wiley and Sons. 6. Modern Methods of Organic Synthesis, W. Carruthers and I. Coldham,Cambridge University Press, 2004. 7. J. Clayden, N. Greeves, S. Warren, and P. Wothers, Organic Chemistry, OxfordUniversity Press, 2014	

CHEMJ33: Physical Chemistry-I	
Objectives: To impart the knowledge of electrochemisty and electrochemical cells. They will also learn about various types of equilibria.	
1. Electrochemistry: Arrhenius theory of electrolytic dissociation; Conductance ofelectrolytes in solution; Ionic conductance, transference number, Determination of transport number by moving boundary method. Kohlrausch's law of independent migration of ions, ion conductance and ionic mobility,applications of conductance measurements, conductometric titrations.	**6**
2. Chemical Cells and Electromotive Force: Types of Electrodes and electrode reactions, Electrode potential, Standard Electrode potentials, Electrochemical cells, EMF and chemical cell reactions. Free energy, enthalpy and entropy changes of cell reactions; Concentration cells with and without liquid junction, liquid junction potential, salt bridges, applications of EMF measurements.Glass electrode and determination of pH of a solution. Potentiometric titrations: acid-base and redox. Buffer Solutions, Acid-base Indicators	**10**
3. Phase Equilibria: Thermodynamics of phase transition, Clapeyron-Clausius equation,phase rule, phase diagrams of one-component (water) and two components (phenol-waterand Pb-Ag) systems, distribution law, application to cases for dissociation andassociation, determination of equilibrium constant ($KI + I_2 = KI_3$).	**8**
4. Chemical Kinetics: Rate laws for zero, first, and second and Pseudo first-order reactions, steady state approximation, temperature dependence of rates of chemical reactions, Collision theory, qualitative concepts of transition state theory.	**6**
Outcomes: The students will be able to understand the theories of electrochemistry; mobilities of ions and ionic conductance in solution. They will learn about the working principles of electrochemical cells. The students will be able to understand theories of chemical kinetics and phase equilibria.	
Suggested Books: 1. Physical Chemistry, P. C. Rakshit, 5th Edition (1988), 4th Reprint (1997), SaratBook House, Calcutta. 2. Textbook of Physical Chemistry, K.L. Kapoor, vol. 3rd (2005), Macmillan IndiaLtd, New Delhi. 3. Physical Chemistry, I. Levine, Tata McGraw Hill, 5th Edn., 2007. 4. Physical Chemistry, P. W. Atkins, 8th Ed., Oxford University Press, New York 5.Principle of Physical Chemistry, B. R. Puri, L. R. Sharma, M. S. Pathania, Vishal Publishing Co., New Delhi. 5. Principals of Electrochemistry, D.R. Crow, Taylor & Francis, 4the Ed. 1994 6. Chemical Kinetics, K. J. Laidler, Pearson India, 3rd Ed.	

CHEMJ34: Qualitative Analysis and Thermochemistry	
1(a) Systematic semimicroanalysis of inorganic salts Mixtures containing 2 cations and 2 anions	
1(b). Qualitative analysis of simple organic compounds:Preliminary Test Element detection Functional group Test Melting point measurement	
2. Thermochemistry: Determination of water equivalent of a calorimeter and the enthalpy of neutralization ofhydrochloric acid with sodium hydroxide. Determination of enthalpy of ionization of ethanoic acid. Determination of integral enthalpy of solution of salts	

CHEMJ41: Inorganic Chemistry-II	
Objectives: To understand the various theories of acids and bases Tostudy a representative non-aqueous solvent. To study the descriptive chemistry of transition metals, lanthanides and actinides.	
1. Acids and Bases: Brønsted–Lowry, Lux-Flood and Solvent system concepts of acidsand bases, leveling effect, Lewis concept of acids and bases and factors affecting their strength, HSAB theory applications: Characteristics of hard-soft acids and bases and borderline cases. Prediction of the feasibility of reactions and stability of compounds, bonding preferences, occurrence of metals as ores in nature, and symbiosis. Super-acids and frustrated acid-base pairs.	**9**
2. Non-aqueous Solvent: Significance of a solvent towards chemical reactions and limitations of water as a solvent. Classification and solvent physical properties for being an effective reaction medium, viz. melting and boiling points, heat of fusion and vaporization, dielectric constant, dipole moment, and viscosity. Liquid NH_3 as a nonaqueous solvent, chemical reactions, and alkali metal solutions in liquid NH_3. A briefintroduction to solvent-free, ionic liquid, and green synthesis.	**6**
3. Transition Metal Chemistry: Characteristics of *d*-block elements with special reference to 3*d* transition series (electronic configuration, oxidation state, color, spinonly magnetic moment, complex formation, and catalytic properties.	**8**
4. Coordination compounds: Molecular addition compounds: double salts and coordination compounds. Definition of ligand, denticity. Werner's theory, nomenclatureof coordination complexes. Sidgwick's EAN concept and Valence Bond Theory, outer/inner orbital complexes. Geometrical isomerism of coordination compounds with coordination nos. 4 and 6 (Ma_6, Ma_5b, Ma_4b_2, Ma_3b_3, $M(aa)_3$, $M(aa)_2b_2$ type). Optical isomerism.	**12**
5. Lanthanides: Separation of Lanthanide elements (Various methods in brief). Comparative study of lanthanide elements with respect to electronic configuration, atomic and ionic radii, oxidation state, lanthanide contraction, and complex formation tendency.	**5**
6. Actinides: Occurrence and preparation of actinide elements. Special reference/methodto the enrichment of Uranium. Comparative study of actinide elements with respect to electronic configuration, atomic and ionic radii, oxidation states, compounds, and complex formation tendency.	**5**
Outcomes: The students will learn the theories that explain various types of acid-base behaviour.They will learn the importance of non-aqueous solvents and their applications. The students will be able to understand the bonding in coordination compounds includingthe characteristics of transition metals, lanthanides, and actinides.	
Suggested Books: 1. Inorganic Chemistry, J. E. Huheey, E.A. Keiter and R.L. Keiter, 4th Edition (2006), Addison Wesley Publishing Co, NY. 2. Basic Inorganic Chemistry, F. A Cotton, G. Wilkinson, and Paul L. Gaus, 3rd Edition (1995), John Wiley & Sons, New York. 3. Concise Inorganic Chemistry, J. D. Lee, 5th Edition (1996), Chapman & Hall, London. 4. Inorganic Chemistry, Gary L. Miessler and Donald A. Tarr, 3rd Edition (2008), Pearson, India Education Service Pvt Ltd.	

CHEMJ42: Organic Chemistry-II	
Objectives: To make the students aware of the chemistry of various classes of organic compounds	
1. Nitrogen containing compounds: Preparation and reactions of nitrobenzene and aniline. Preparation and synthetic applications of Diazonium salts.	**5**
2. Heterocyclic Compounds: Nomenclature of heterocyclic compounds, synthesis andreactions of furan, pyrrole, thiophene, pyridine, indole and quinoline. **3.** Polynuclear Hydrocarbons: Chemistry of naphthalene and anthracene.	**13**
3. Colour and Constitution: Synthesis of malachite green, fluorescein, Indigotin.	**5**
4. Alicyclic compounds: Cycloalkanes, general synthesis, Bayer's strain theory. Cyclohexane:chair and boat conformations, conformation of mono substituted and disubstituted cyclohexanes.	**6**
5. Protection and Deprotection of Functional Groups: protection of NH group, OH group, diols, carbonyl groups, carboxyl groups, double bonds and triple bonds.	**8**
6. Carbohydrates: Characteristic reactions of aldoses and ketoses. Glucose-structure (Open and Cyclic), Mutarotation, anomeric effect, iminosugar and sialic acids. Sucrose, starch and cellulose(Structural aspects only), glycosylation reactions.	**8**
Outcomes: The students will be able to understand a. The fundamental chemistry of diazonium salts, heterocyclic compounds, dyes, alicyclic compounds and carbohydrates. b. Pros and cons of protection and deprotection strategies in organic transformations. Suggested Books: 1. Organic Chemistry", R. T. Morrison and R. N. Boyd, 6th Edition (1992), Prentice-Hall of India (P) Ltd., New Delhi. 2. Organic Chemistry", 9th Edition, L. G. Wade, J. W. Simek& M. S. Singh, Pearson India Education Services Pvt. Ltd. 2020 (ISBN 978-93-893-4267-3) 3. Organic Chemistry, I. L. Finar, [Vol. I, 6th Edition (1973), Reprinted in 1980 & Vol. II, 5th Edition (1975), Reprinted in1996], ELBS and Longman Ltd., New Delhi. 4. Organic Chemistry, J. Clayden, N. Greeves, S. Warren, and E. Wothers, (2001) Oxford Univ. Press, Oxford. 5. Carbohydrates in drug discovery and development, V. K. Tiwari, Elsevier Inc. 2020. 6. Advanced Organic Chemistry: Reactions, Mechanisms, and Structure, Jerry March J. Wiley and Sons. 7. Heterocyclic Chemistry, Thomas L. Gilchrist; Edition, 5; Publisher, World Publishing Corporation, 1997; ISBN, 7506233983 8. P. G. M. Wuts and T. W. Greene, Greene; Protective Groups in Organic Synthesis, 4th Edition, 2006.	

CHEMJ43: Physical Chemistry-II	
Objectives: To impart knowledge on the application of classical thermodynamics on solution, surface and photochemistry and nuclear chemistry	
1. Thermodynamics of Solutions: Partial molal quantities, chemical potential of a mixture of ideal gases, Gibbs-Duhem equation, chemical potential of real gases and fugacity, activity and activity coefficient, variation of fugacity with temperature and pressure, Lewis-Randall rule, thermodynamic functions of mixing (ΔG_{mix}, ΔS_{mix}, ΔV_{mix}, ΔH_{mix}), ideal solutions and their characteristic properties, Duhem-Margules equation and its applications, Henry and Raoult's laws, thermodynamics of colligative properties, relative lowering of vapour pressure, freezing point depression, elevation of boiling point and osmotic pressure, van't Hoff equation, measurement of osmotic pressure and determination of molecular weight of macromolecules.	**15**

2. Surface and Photochemistry: Langmuir adsorption isotherm, Multi-layer adsorption-BET equation (no derivation) and its application to surface area measurements; Gibbs Adsorption isotherm, surface reactions: kinetics of unimolecular surface reactions, inhibition and activation energy, nature of surface. Enzyme kinetics (Michaelis-Menten equation), Photochemical reactions: quantum efficiency, reasons for low and high quantum efficiency, kinetics of photochemical reactions: decomposition of HI, H_2-Br_2 reaction, photostationary state: dimerisation of anthracene, Stern-Volmer relation.	**15**
3. Nuclear Chemistry: Radioactivity: general characteristics of radioactive decay kinetics, artificial radioactivity, detection and measurement of radioactivity: GM counter. Nuclear Reactions: Types of nuclear reactions, conservation of linear momentum and mass- energy in nuclear reactions, nuclear reaction cross section. Compound nucleus theory and its experimental verification. Radio chemistry: Probing by isotopes, preparation of radioisotopes, radiochemical principles in use of tracers, some typical applications: chemical, physicochemical and analytical applications, age determination. Radiation Chemistry: Interaction ofnuclear radiations with matter- charged particle, neutrons and gamma rays. Radiolysis of water and aqueous solutions, radiation dosimetry.	**15**
Outcomes: After the completion of the course, the students should be able to 1. Apply the concept of chemical potential to explain the Gibbs free energy change due to mixing and calculate partial molar quantities. 2. Understand the concept of fugacity, activity, ideal and nonideal solution. 3. Explain the thermodynamic basis of colligative properties and applications 4. Learn about surface phenomenon, adsorption isotherms, BET Equation, the laws of absorption of light energy by molecules and the subsequent photochemical reactions 5. Understand the basics of nuclear chemistry	
Suggested Books: 1. Physical Chemistry, P. C. Rakshit, 5th Edition (1988), Sarat Book House, Calcutta. 2. Textbook of Physical Chemistry, K.L. Kapoor, vol. 5th (2005), Macmillan India Ltd, New Delhi. 3. Essentials of Nuclear Chemistry, H.J. Arnikar, 4th Edition (2003), New Age International Publishers, New Delhi. 4. Physical Chemistry, I. Levine, 5th Ed., (2007), Tata McGraw Hill New Delhi. 5. Physical Chemistry, P. W. Atkins, 8th Ed., Oxford University Press, New York.	

CHEMJ44: Techniques in Chemistry	
Objectives: To introduce basic concepts about stoichiometry, acid-base equilibria, and separationmethods.	
1. Introduction to Separation and Instrumental Methods Distillation, Crystallization, Precipitation, Extraction, Chromatography, Introductoryideas of UV-visible spectroscopy, Infrared Spectroscopy, and NMR Spectroscopy.	**8**
2. General Introduction to Analysis, and Stoichiometric Calculations Qualitative and quantitative analysis, primary standard, secondary standard, preparation of standard solutions, molarity, normality, molality, weight/weight percentage,weight/volume percentage, and ppm.	**4**
3. Concepts of Acid-Base Equilibria and Titrations General concepts of acids and bases, strength of conjugate acid/base pair, acid-base equilibria in water, pH calculations for strong acids and strong bases, concepts of acid base titration, complexometric titration, redox titration, and precipitation titration, indicators**.**	**3**
Outcomes: The student will understand about qualitative and quantitative analysis, titrations, and instrumentations on the separation techniques.	
Suggested Books: 1. Daniel C. Harris, Quantitative Chemical Analysis, 9th Edition (2015), W. H. Freeman and Company, New York. 2. Basic Concepts of Analytical Chemistry', S.M. Khopkar, 2nd edition (1998), New Age International Publications, New Delhi. 3. Analytical Chemistry, G.D. Christian, (2001) John Willey & sons, New York 4. Fundamentals of Analytical Chemistry, D.A. Skoog, D. M. West, F. James, Cengage Learning India, 10th Ed. 2022	

CHEMJ45: Physical Chemistry Lab Work	
1. Complexometric titrations with EDTA: Mg^{2+}, Zn^{2+} estimation. 2. Determination of the hardness of water. 3. Kinetics study of acid catalysed hydrolysis of methyl acetate. 4. Determination of pH of a given buffer by colour matching method. 5. Determination of Critical Solution Temperature (CST) of Phenol-Water system. 6. Effect of impurity on Critical Solution Temperature of Phenol-Water system	
Note: Experiments may be added/ modified subject to availability of facilities.	

CHEMJ46: Organic, Inorganic Chemistry Lab Work	
A. Preparation of organic compounds: 1. Acetanilide from aniline 2. p-Bromo acetanilide from acetanilide 3. Phthalic anhydride from phthalic acid 4. Preparation of phenyl–azo–β-naphthol (an Azo dye). 5. Preparation of aniline yellow (p-amino-azobenzene). 6. Preparation of Schiff base (Salicylaldehyde and aniline)	
B. Preparation of Some Inorganic complexes (Including those using the prepared Schiffbase as ligand) Purification by recrystallization of the compounds.	
C. Preparation of standard solutions (both primary and secondary) of a particular normality/ molarity.	
D. Application of Separation and Purification Techniques.	
Note: Experiments may be added/ modified subject to availability of facilities.	

CHEMJ51: Analytical Chemistry-I	
Objectives: To learn the basics of chemical analysis, the use of statistical methods, and gravimetricanalysis	
1. Statistical Evaluation: Chemical analysis, Classification of analytical methods, Stepsin a quantitative analysis, Quantitative range, Determinate and indeterminate errors, Normal error curve, Accuracy and Precision, Relative error, Relative standard deviation,Methods for minimizing errors, Criteria for rejection of observation, Significant figures and computation rules, Error propagation.	**8**
2. Recent trends for chemical analysis: Method selection, method validation, sample preparation, Analytical validation of results, LOD and LOQ, Good lab practice, Good manufacturing practice.	**7**
3. Precipitation: Desirable properties of gravimetric precipitates, Formation of gravimetric precipitates, Conditions for quantitative precipitations, Contamination in precipitates, Method for removal of impurities in precipitates, Steps involved in quantitative precipitation, Organic precipitants (oxine, dithizone, α-nitroso-(naphthol,cupferon, dimethyl glyoxime) in chemical analysis.	**15**
Outcomes: The student will understand about the recent developments in chemical analysis,including gravimetric analysis	
Suggested Books: 1. Modern Methods of Chemical Analysis', R.L. Pecscock, L.D. Shields, T. Cairns,and I.C. Mc William, 2nd Edition (1976), John Willey, New York. 2. Basic Concepts of Analytical Chemistry', S.M. Khopkar, 2nd edition (1998), NewAge International Publications, New Delhi. 3. Analytical Chemistry', G.D. Christian, (2001) John Willey & sons, New York 4. Environmental Chemistry', A.K. De, 3rd edition (1994), Willey Eastern, NewDelhi.	

CHEMJ52: Inorganic Chemistry-III	
Objectives: To teach the theories of metal-ligand bonding, their drawbacks and applications To impart the knowledge of electronic spectra of transition metal complexes.To impart the knowledge of reactivities of transition metal complexes	
1. 1. Theories of Metal-Ligand bonding: Crystal-field theory and crystal-field splitting in octahedral, tetrahedral, and square planar complexes. Jahn-Teller distortion. Factors affecting the crystal-field splitting, Spinel, Inverse spinel, OSSE, Spectrochemical and Nephelauxetic series.Concept of Metal-ligand orbital overlap: ligand field theory, molecular orbital theory withreferenceto octahedral 3d transition metal complexes (without-bonding, and with bonding).	**14**
2. Electronic Spectra of Transition Metal Complexes: Types of electronic transitions;static and dynamic electronic transitions, selection rules for d-d transitions, spectroscopic ground states. Explanation of electronic spectra on the basis of Orgel energy level diagrams for d^1-d^{10}) states.Charge transfer spectra; electronic spectra of octahedral and tetrahedral Co(II) and Ni(II) complexes and calculation of ligand-field parameters.	**10**
3. Thermodynamic and Kinetic aspects of Metal Complexes: A brief outline of thermodynamic and kinetic stabilities of metal complexes and factors affecting their stability. Substitution reactions of square-planar complexes, Trans effect.	**6**
Outcomes: The student will be able to understand the nature of metal-ligand bonding in transition metal complexes. They will be able to explain the electronic spectra of the transition metal complexes and also their reactivity.	
Suggested Books: 1. "Concise Inorganic Chemistry", J. D. Lee, 5th Edition (1996), Chapman & Hall,London. 2. "Inorganic Chemistry", J.E. Huheey, E.A. Keiter and R.L. Keiter. , 4th Edition (2006), Addison Wesley Publishing Co, NY. 3. "Basic Inorganic Chemistry", F. A Cotton, G. Wilkinson, and Paul L. Gaus, 3rd Edition (1995), John Wiley & Sons, New York. 4. "Inorganic Chemistry", A. G. Sharpe, 3rd International Student Edition (1999),ELBS / Longman, U.K. 5. "Inorganic Chemistry", D. F. Shriver and P. W. Atkins, 3rd Edition (1999),ELBS, London.	

CHEMJ53: Organic Chemistry-III	
Objectives: To impart knowledge of stereochemistry, reactive intermediates, isotope effect,photo chemistry, and notable reactions in organic chemistry.	
1. Stereochemistry: Symmetry elements, symmetry operations, racemates, racemization, resolution (chemical and enzymatic), pro-chirality, concept of homotopic and heterotopic, pro-stereoisomerism with suitable examples of one and two chiral centers. Asymmetric induction, Cram's rule: Addition of nucleophile to carbonyl function. Aldol reaction (achiral-achiral). Regioselective, chemoselective, stereospecific and stereoselective reactions. Estimation of optical purity (ee and de). Axial chirality (e. g., allenes, biphenyls and spiranes).	**10**
2. Reactive intermediates: Generation, stability and reactivity of carbocations,carbanions, free-radicals, carbenes, and nitrenes.	**8**
3. Isotope effect: Isotopic substitution in a molecule, primary and secondary kinetic isotope effects, solvent isotopic effect and their importance in mechanistic studies.	**5**
4. Name reactions: Michael addition, Mitsunobu reaction, Birch reduction, WagnerMeerwein, Baeyer-Villiger oxidation, Robinson annulation, Pinacol-pinacolone rearrangement, Wolff rearrangement, dienone-phenol rearrangement, benzidine rearrangement, Favorskii rearrangement. Hofmann, Curtius, & Schmidt rearrangements,Click chemistry.	**12**
5. Photochemistry: Principles of photochemistry, Energy (inter and intramolecular) transfer, Photosensitisation, Singlet and Triplet state photochemical reactions of 1,3butadiene, cis-trans isomerism, Inter and intramolecular cycloaddition reactions, Di- πmethane rearrangement. Photochemical reaction of carbonyl compounds: Photo reduction, Norrish type-I cleavage of acyclic and cyclic compounds, Norrish type-II cleavage. Photocyclo-addition reaction: Paterno-Buchi reaction. Photo-Fries rearrangement.	**10**

Outcomes:

The students will be able to understand the

1. Basic chemistry of stereochemistry, reactive intermediates, and isotope effect inorganic molecules.
2. Reaction conditions, product formation, and mechanisms of specific rearrangementreactions commonly employed in organic synthesis.
3. Reactions involving photochemical process for organic molecules.

Suggested Books:

1. Organic Chemistry, I. L. Finar, Vol. I, 5th Edition (1975), Reprinted in 1996, ELBSand Longman Ltd., New Delhi.
2. Advanced Organic Chemistry-Reactions and Mechanisms 2e"–M. S. Singh & K.Raghuvanshi, Pearson Education Pvt. Ltd., 2021.
3. Advanced Organic Chemistry: Reactions, Mechanisms, and Structure, Jerry MarchJ. Wiley and Sons
4. Stereochemistry of Organic Compounds, D. Nasipuri, 2nd Edition (1994), WileyEastern Ltd., New Delhi
5. Stereochemistry of Organic Compounds, E. L. Eliel, S. H. Wilen and Mander,(2004) Wiley Interscience, New York.
6. Organic Chemistry, J. Clayden, N. Greeves, S. Warren, and E. Wothers, (2001)Oxford Univ. Press, Oxford.
7. Reactive Intermediates in Organic Chemistry-Structure, Mechanisms, and Reactions, M. S. Singh Wiley-VCH, Germany, (2014)

CHEMJ54: Physical Chemistry-III

Objectives:

To make students understand the limitations of classical mechanics and the necessity of quantum chemistry, introduce them with postulates of quantum chemistry and apply thesame to derive equations for various models and hydrogen atoms. Understand the basis of molecular spectroscopy and its applications.

1. Elementary Quantum Mechanics: quantum mechanical operators, Hamiltonian operator, Schrödinger wave equation and its importance, Eigen functions, Eigen values, physical interpretation of the wave function, orthogonality of wave functions, Heisenberg's uncertainty principle, the particle in a one-dimensional box problem and its solutions, particle in a three dimensional box, degeneracy, rigid rotor and harmonic oscillator.

2. Molecular Symmetry: Symmetry elements and operations. Point groups. Matrix representation of symmetry elements and point groups, matrices of C3v and C4v point groups, Structure of character tables, determination of symmetry species for translations and rotations.

3. Molecular Spectroscopy: Region of electromagnetic spectrum, Interaction of electromagnetic radiation with molecules and various types of spectra, signal to noise ratio and resolving power, width and intensity of spectral transitions, Born Oppenheimer approximation, pure rotational spectra, diatomic rigid rotor molecules, effect of isotope substitution, vibrational and vibration- rotational spectra of diatomic molecules, harmonic oscillator-rigid rotor approximation, anharmonicity effect, normal modes of vibration, infrared spectra of linear and bent AB2 molecules, Franck-Condon principle, electronic spectra of diatomic molecules, vibrational structure. Nuclear Magnetic Resonance Spectroscopy: Introduction, chemical shifts, spin-spin splitting, relaxation times

Outcomes:

After the completion of the course, the students should be able to

1. Learn about the limitations of classical mechanics and how quantum mechanicscan be used to solve problems with atomic and molecular systems.
2. Gain knowledge of quantum mechanics, quantization, and probability distribution,the uncertainty principle, and spectroscopy & use of quantization.
3. Understand how to interpret distinct spectra and how they might be used to reveal structures.

Suggested Books:

1. Physical Chemistry, P. Atkins and J. De Paul, 8th Edition (2006), InternationalStudent Edition, Oxford University Press.
2. Physical Chemistry - A Molecular Approach, D. A. Mc Quarrie and J. D. Simon,Viva Books, New Delhi, 2004.
3. Symmetry and Spectroscopy of Molecules, K. Veera Reddy, Paperback, New AgeInternational Private Limited, 2007.
4. Fundamentals of Molecular Spectroscopy, C. N. Banwell, 4th Edn. (2017),Paperback, McGraw Hill Education (India) Private Limited, New Delhi.
5. Introduction to Molecular Spectroscopy, G.M. Barrow, Paperback, McGraw Hill,2018.
6. Introductory Quantum Chemistry, A. K. Chandra, 4th Edn. (2017), McGraw HillEducation (India) Private Limited.
7. Chemical Applications of Group Theory, Cotton, F. A., Wiley India, 3rd Ed. 2017
8. Basic Organometallic Chemistry, B.D. Gupta and A.J. Elias, Universities Press, 2nd Ed. 2013

CHEMJ55: Physical Chemistry Lab Work	
1. Composition determination of an unknown binary liquid mixture from surfacetension-composition curve. 2. Composition determination of an unknown binary liquid mixture from viscosity composition curve. 3. Conductometric titration of strong acid against strong alkali. 4. Conductometric titration of weak acid against strong alkali. 5. Potentiometric titration of strong acid against strong alkali. 6. Study the kinetics of the catalytic decomposition of H_2O_2 by chemical method. 7. Verify Lambert-Beer's law and determine the concentration of an unknown$CuSO_4$/ $KMnO_4$/ $K_2Cr_2O_7$ solution.	
Note: Experiments may be added/ modified subject to availability of facilities.	

CHEMJ56: Systematic Organic Analysis	
Systematic identification of organic compounds and derivatization	
Note: Experiments may be added/ modified subject to availability of facilities.	

CHEMJ61: Analytical Chemistry-II	
Objectives: To gain knowledge on advanced separation techniques, analytical reagents, and UV-Vis molecular absorbance spectroscopy	
1. Solvent Extraction and Chromatography: Distribution law, Single extraction, Multiple extraction, Craig concept of counter-current distribution, Important solvent systems: chelate extraction, synergic extraction, extraction by solvation, ion-pair extraction, Basics and classification of chromatographic methods, paper chromatography, adsorption chromatography, and ion-exchange chromatography.	**15**
2. Analytical Reagents: Theoretical and practical aspects of the use of EDTA, cerate, iodate, bromate, chloramine-T, Karl Fischer and Malaprade (periodate) reagents inchemical analysis.	**15**
3. Spectrophotometry: Beer's law and application, Nomenclature and units, General instrumentations for spectrophotometry, Spectrophotometric determinations of one component (iron, chromium, and manganese) and two components (overlapping and non- overlapping) systems, Spectrophotometric determination of dissociation constants of indicator, Photometric errors.	**15**
Outcomes: The students will understand the widely used techniques like, chromatography, analytical reagents and spectrophotometry.	

Suggested Books: 1. Principles of Instrumental Analysis, D.A. Skoog, F.J.Holler and T.A. Nieman, , 5th edition (l998), Horcourt Brace & Company, Florida. 2. Analytical Chemistry, G.D. Christian, (2001) John Willey & sons, New York. 3. Instrumental Methods of Analysis', H.H. Willard, L.L. Merritt, and J.A.Dean, 6th Edition (l986), CBS Publishers & Distributors, Shahdara, Delhi. 4. Modem Methods of Chemical Analysis, R.L. Pecscock, L.D. Shields, T .Cairns, and I.C. Mc William, 2nd Edition (l976), John Willey, New York.	

CHEMJ62: Inorganic Chemistry-IV	
Objectives: To provide standard guidance to students about the magnetic properties of transition metal chemistry and their anomalies. To give a comparative approach among the chemistry of metals belonging to 3rd, 4th and 5th transition series of elements and their uses.To train students about the organometallic synthesis using industrially important metals.To educate the students about some functional inorganic materials.	
1. Magnetic Properties of Transition Metal Complexes: Types of magnetic behavior, methods of determining magnetic susceptibility, *L-S* and *J-J* coupling, orbital contribution to magnetic moments. Correlation of magnetic moment data and stereochemistry of Co(II) and Ni(II) complexes; anomalous magnetic moments.	**10**
2. Chemistry of Second and Third Transition Series: A general comparative treatment of 4d and 5d elements with their 3d analogs in respect of ionic radii, oxidation states, complex formation tendency, magnetic behavior, and electronic spectral properties.	**8**
3. Organometallic Chemistry: Definition, nomenclature, and classification of organometallic compounds. Preparation, properties, bonding, and applications of alkyls and aryls of Li, Al, Sn, and Ti. Preparation, structure, and properties. Bonding in metal carbonyls, variants of CO bridging, vibrational spectra of metal Carbonyls. A brief account of metal-ethylenic complexes. Concept of catalyst designing. Homogeneous hydrogenation (Wilkinson's catalyst) Heterogeneous (Ziegler-Natta catalyst) catalyst, a brief introduction to catalytic cycle.	**17**
4. Functional materials: Structural and applicative aspects in brief: Diamond,Graphite, Graphene, CNT, Graphyne, Quantum dots, Fullerene (C60). Intercalation compounds and Clathrates. Soft Materials	**10**
Outcomes: **Students shall be able to** 1. Learn the magnetic properties of transition metals and related compounds as well as their anomalous behavior. 2. Significantly understand the concept of metal-to-carbon bonding and its applications. 3. Understand the need and importance of functional materials as well as their synthesis and properties.	
Suggested Books: 1. Concise Inorganic Chemistry, J. D. Lee, 5th Edition (1996), Chapman & Hall, London. 2. Inorganic Chemistry, J. E. Huheey, E.A. Keiter and R.L.Keiter, 4th Edition (2006), Addison Wesley Publishing Co, NY. 3. Basic Inorganic Chemistry, F.A. Cotton, G. Wilkinson, and Paul L. Gaus, 3rd Edition (1995), John Wiley & Sons, New York. 4. Inorganic Chemistry A. G. Sharpe, 3rd International Student Edition (1999), ELBS/Longman, U.K. 5. Elements of Magneto chemistry, R.L. Dutta and A. Shyamal, (1993) Affiliated EastWest Press Ltd 6. Organometallic Chemistry, R. C. Mehrotra and A. Singh 7. Modern Inorganic Chemistry, William Jolly, Tata McGraw Hill 2nd Ed.	

CHEMJ63: Organic Chemistry-IV	
Objectives: To impart knowledge of amino acids, proteins, polymers, terpenes, vitamins, andhormones.	
1. Amino acids and Peptides: Amino acids - preparations, physical properties, dipolar nature, isoelectric point, chemical reactions, and configuration. Peptides: peptide linkage, peptide synthesis and structure of poly peptides, C and N terminal amino acid determination. Proteins: General characteristics and	**10**

secondary structure.	
2. Polymers: Types of polymers and polymerization process: Addition (radical, ionic), step growth (condensation), and stereo-controlled (coordination) polymerization mechanisms. Synthesis and uses of following polymers: (i) Plastics: PVC, PE, and Teflon, (ii) Specialty polymers: Conducting & electroluminescent (Organic light emitting diodes), Liquid crystals (iii) Natural and synthetic rubber (iv) Fibers: Rayon, Polyester, Polyamides (v) Foaming agent and plasticizers (vi) Biodegradable polymers.	**8**
3. Terpenes: Occurrence, isolation and classification. Isoprene rule of terpenes. Structure and synthesis of Citral, α–terpinol, and camphor.	**7**
4. Vitamin and hormones: Chemical constitution and synthesis of vitamin A, vitamin C and thyroxin.	**5**
Outcomes: **The students will be able to understand** 1. The structure and characteristics of amino acids, peptides, proteins and carbohydrates. 2. the structure elucidation for some natural prodcuts isolated from terpenes and alkaloids. 3. the fundamental concepts of polymer synthesis and its various properties.	
Suggested Books: 1. Organic Chemistry, I. L. Finar, Vol. I, 5th Edition (1975) Reprinted in 1996, ELBS and Longman Ltd, New Delhi. 2. Organic Chemistry, I. L. Finar, Vol. II, 5th Edition (1975) Reprinted in 1996, ELBS and Longman Ltd, New Delhi. 3. Organic Polymer Chemistry, K. J. Saunders, 2nd Edition (1988), Chapman & Hall, London. 4. Introduction to Synthetic Polymers, Ian M. Campbell, 2nd Edition (2000), Oxford University Press, USA. 5. Principles of Polymer Science, P. Bahadur and N. V. Sastry, (2002) Narosa, New Delhi.	

CHEMJ64: Physical Chemistry-IV	
Objectives: To impart knowledge on different type of interaction in electrolytic solution and Debye Huckel theory, statistical concept of thermodynamics and kinetics of relatively complex reactions.	
1. Electrochemistry: Theory of strong electrolytes: qualitative idea of Debye-Hückel theory of ion-ion interactions, Debye-Hückel limiting law for activity coefficient of ions in electrolyte solution (derivation not required), its modification for concentrated solutions, Debye-Hückel-Onsager (D-H-O) theory of electrolytic conductance: qualitative idea of electrophoretic and relaxation effects, D-H-O equation for conductance of electrolyte solutions. Effect of high frequency and high field on conductance.	**7**
2. Advanced Chemical Kinetics: Kinetics of complex reactions (reversible, simultaneous, and consecutive), chain reactions; dynamic chain (Hydrogen-Bromine reaction, decomposition of ethane), branched-chain (Hydrogen-Oxygen reaction), oscillatory reactions (Belousov-Zhabotinskii reaction), experimental techniques for fast reactions (stopped-flow, temperature- jump and flash photolysis).	**8**
3. Molecular Statistics: The Boltzmann distribution, Maxwell-Boltzmann distribution law for the distribution of molecular energies, partition functions, thermodynamic quantities from partition functions, Sackur-Tetrode equation for molar entropy of monatomic gases, rotational and vibrational partition functions, calculation of Gibbs free energy changes and equilibrium constant in terms of partition functions.	**15**
Outcomes: After the completion of the course, the students should be able to 1. Describe the activity coefficients of electrolyte solution as a function of concentration. 2. Understand ionic atmosphere and the dependence of conductance on concentration 3. Demonstrate the relation between microscopic and macroscopic properties of matter. 4. Understand the kinetics and rate equation of some restively complex reactions	
Suggested Books: 1. Modern Electrochemistry, vol. 2 A & B, J.O'M. Bockris and A. K. N. Reddy, Plenum Press, New York. 2. Chemical Kinetics, K. J. Laidler, Harper & Row, New York. 3. Physical Chemistry, P. Atkins and J. De Paul, 8th Edition (2006), International Student Edition, Oxford University Press.	

CHEMJ65: Physical Chemistry Lab Work	
1. Order of reaction of I_2 / Acetone / H^+. 2. Study of the kinetics of acid-catalyzed hydrolysis of sugar by chemical method. 3. Conductometric titration of KCl with $AgNO_3$. 4. Conductometric titration of a mixture of weak and strong acids. 5. Distribution coefficient of acetic acid between *n*-butanol and water solvents. 6. Potentiometric titration of a redox system (ferrous ammonium sulfate with $K_2Cr_2O_7$). 7. Determination of relative strengths of two acids by studying the kinetics of acid- catalyzed ester hydrolysis. 8. Determination of relative strengths of two $FeCl_3$ solutions by studying thekinetics of $FeCl_3$ - catalysed H_2O_2 decomposition gasometrically. 9. Determination isosbestic point and indicator constant	

CHEMJ66: Quantitative Inorganic Analysis	
Quantitative estimation of Metal ions by Gravimetric method(Fe^{3+}, Ba^{2+}, Ni^{2+}, Co^{2+}, Hg^{2+}) Separation and identification of metal ions by paper chromatography	

CHEMJ67: Organic Chemistry Lab Work	
Preparation of derivatives: 1. Preparation of SBT from thiourea 2. Preparation of Phthalimide from phthalic anhydride 3. Preparation of dibenzylidene acetone from benzaldehyde 4. Preparation of hippuric acid from glycine 5. Preparation of benzyl from benzoin 6. Preparation of Benzilic acid from benzyl	

CHEMJ71:Analytical Chemistry-III	
Objectives: To introduce conceptual knowledge on advanced statistical methods, chemicalequilibria, and stoichiometry.	
1. Analytical chemometrics: Propagation of measurement uncertainties (inaccuracy and imprecision).Useful statistical test: test of significance, the F test, the student 't' test, the chi-test, the correlation coefficient, confidence limit of the mean, comparison of two standard values, comparison of standard deviation with average deviation, comparison of mean with true values, significant figures, regression analysis (least square method for linear and non-linear plots), statistics of sampling and detection limit evaluation. Chemometrics for modeling and parameter estimation, factor analysis, resolution and pattern recognition.	**15**
2. Treatment of Equilibria: Solvents and solutions, general treatment of equilibria in aqueous medium involving monoprotic weak acid and weak base, and salts of weak acids and weak bases. Activity and concentration, Effect of electrolytes on chemical equilibria,Calculation of pH, Constructing titration curves from charge balance and mass balance equations, Acid-base titrations and theory of pH indicators, Complexation equilibria and complexometric titrations, Redox equilibria and redox titration, Theory of redox indicators, Precipitation reaction and precipitation titrations and theory of adsorption indicators.	**8**
3. Spectrophotometric Determination of Stoichiometry of Complexes: **7** Job's method of continuous variation, mole ratio and slope ratio analysis, Advantages andlimitations, typical examples.	**7**

Outcomes: The students will establish knowledge on chemometrics, theory of various titrations, andstoichiometric calculations using instrumental techniques.	
Suggested Books: 1. R. L. Pecsok, L. D. Shields, T. Cairns and L.C. Mc William, Modern Methods ofChemical Analysis, 2nd Edition (1976), John Wiley, New York. 2. G. D. Christian, Analytical Chemistry, 5th Edition (1994), John Wiley & Sons, NewYork. 3. D. A. Skoog, D.M. West, F.J. Holler, S.R. Crouch, Analytical Chemistry - AnIntroduction, 7th Edition (2000), Saunders College Publishing, Philadelphia, London. 4. J. H. Kennedy, Analytical Chemistry: Principles, 2nd Edition (1990), SaundersHolt, London.	

CHEMJ72: Inorganic Chemistry-V	
Objectives: 1. **To train students about the illustration of symmetry in complexes and the fundamentals of character tables; and Orgel diagrams of metal complexes.** 2. **To teach the biological perspectives of important metal ions.**	
1. Symmetry-based concepts of energy level diagrams of metal complexes: Symmetry elements and operations, determination of point group of a molecule, Group representations, Features of specific character tables in reference to Orgel diagrams, Symmetry-based concepts of Orgel energy level diagrams of metal complexes. Introduction to Tanabe-Sugano diagrams (d2 configuration)	15
2. Bioinorganic chemistry: Metal ions in biological processes. Biological role of iron. Oxygen transport with reference to hemoglobin and myoglobin. Synthetic model complexes for oxygen transport. Cytochromes and iron-sulfur proteins: Electron Transfer reactions. Photosystems, Role of metalloenzymes. Biological role of alkali metal ions, and their transport with special reference to Na+/K+ ATPase. Vitamin B12. Nitrogen Fixation.	15
Outcomes: **Students shall be able to** 1. Learn the importance of symmetry-based concepts in the field of coordination chemistry. **2.** Develop an interdisciplinary approach to metal chemistry with the biological world.	
Suggested Books: 1. Physical Methods in Inorganic Chemistry, R. S. Drago, International Edn. (1971), Affiliated East-West Press, New Delhi. 2. Chemical Applications of Group Theory, F. A. Cotton 3. Inorganic Chemistry, J.E. Huheey, E.A. Keiter and R.L. Keiter, 4th Edn. (1993), Addison-Wesley Pub. Co., New York. 4. Bioinorganic Chemistry, I. Bertini, H. B. Gray, S. J. Lippard, J.S. Valentine, Viva Books, P. Ltd. New Delhi, South Asian Ed., 1998 (Reprint 2004). 5. Principles of Bioinorganic Chemistry, S. J. Lippard, J. M. Berg, University Science Books, California 1994. 6. Bioinorganic Chemistry: Inorganic Elements in the Chemistry of Life, W. Kaim, B. Schwederski, John Wiley & Sons, England, 2004.	

CHEMJ73: Organic Chemistry-V	
Objectives: To impart knowledge of mechanistic aspects of the reactivity of C=X (X = C, N, O, S)multiple bonds, and aromatic nucleophilic substitution reactions.	
1. Nucleophilic Substitution and addition reactions: Mechanism and Stereochemistry of SN1, SN2, SN*i*& SN2' reactions. The effect of substrate structure, nucleophile, leaving group, temperature, and reaction medium. Phase transfer catalysis (Basic concept);epoxidation of unsaturated ketone, nucleophilic addition to C=X bond, solid-liquid phase transfer catalysis.	**10**
2. Elimination reactions: The E1, E2 and E1cB mechanisms, Orientation of the double bond. Hofmann versus Saytzeff elimination, Pyrolytic syn-elimination, Competition between substitution and elimination reactions. Stereoselective olefination reactions: Peterson, Julia and Petasis. Olefin metathesis (RCM) using Ru catalysis.	**10**
3. Neighbouring Group Participation: Evidences of N.G.P.; the phenonium ion, participation by π and σ bonds. Classical versus non-classical carbonium ions.	**4**
4. Aromatic nucleophilic substitution (SNAr): Benzyne Mechanism, Reactivity and effect of leaving group. Chichibabin reaction, von Richter rearrangement, Sommelet– Hauser rearrangement, and Smile rearrangement	**6**
Outcomes: The students will be able to understand 1. The mechanistic details of substitution and elimination reactions. 2. Reaction conditions for the formation of different ion intermediates. 3. Mechanistic aspects of some reaction intermediates. 4. Advantages and disadvantages of protection and deprotection approaches in organic syntheses.	
Suggested Books: 1. Clayden, Greeves, Warren and Wothers, Organic Chemistry, Oxford University Press, 2001. 2. Organic Chemistry", 9th Edition, L. G. Wade, J. W. Simek& M. S. Singh, Pearson India Education Services Pvt. Ltd. 2020 (ISBN 978-93-893-4267-3). 3. M. B. Smith & Jerry March, March's Advanced Organic Chemistry, 5th Edition (2001), John Wiley & Sons, New York. 4. Peter Sykes, A Guide book to Mechanism in Organic Chemistry, 6th Edition (1997), Orient Longman Ltd., New Delhi. 5. S. M. Mukherjee and S. P. Singh, Reaction Mechanism in Organic Chemistry, 1st Edition (1990), Macmillan India Ltd., New Delhi. 6. G. S. Zweifel and M. H. Nantz, Modern Organic Synthesis, (2007), Freeman and Company, New York.	

CHEM74: Physical Chemistry-V	
Objectives: To impart basic knowledge on energy levels in atom and molecules, atomic term symbols, and chemical bonding.	
1. Atomic structure: The Hydrogen atom, atomic orbitals, variation theorem, Secular determinant, He-atom, electron spin, Slater determinant, antisymmetry rule, and Pauli's exclusion principle, many-electron atoms: SCF method,atomic term symbols	**15**
2. Molecular structure: Born-Oppenheimer approximation, molecular orbital treatment for H_2^+ MO treatment of homo- and heteronuclear diatomic molecules, electronic terms of diatomic molecules, VB approach, comparison of the MO and VB theories, Hückel MO treatment of simple and conjugated polyenes .	**15**

Outcomes: After the completion of the course, the students should be able to 1. Gain a preliminary notion about the quantum mechanical model of the atom andthe shape of s, p, d, and f-orbitals. 2. Explain the idea of spin quantum number, Slater determinant, antisymmetry ruleand Pauli's exclusion principle and atomic term symbols term symbol. 3. Explain different energy level in molecule and rationalize the qualitative idea of bonding between atoms that generates molecules.	
Suggested Books: 1. Molecular Quantum Mechanics, P. W. Atkins and R. S. Friedman, 3rd edition(1997), Oxford University Press. Oxford. 2. Quantum Chemistry, I. N. Levine, 5th edition (2000), Pearson Educ., Inc., NewDelhi. 3. Introductory Quantum Chemistry, A. K. Chandra, 4thEdn. (2017), McGraw HillEducation (India) Private Limited. 4. Quantum Chemistry, D. A. McQuarrie, Viva Books Private Limited, New Delhi,2007.	

CHEMJ75: Material Chemistry	
Objectives: To impart knowledge on new materials and their classifications.	
1. Introduction: Materials and their classification, inorganic and organic materials.	**4**
2. Inorganic materials: Design and synthesis of inorganic materials, requirements and constraints, combination properties of composites, solid state reactions for synthesis of inorganic materials: ceramic methods, precursor method and sol-gel synthesis, physical and chemical vapour depositions; carbides, nitrides, structural and functional ceramics, intermetallics; ceramic superconductors, magnetic ceram	**10**
3. **Organic materials:** Molecular electronics: molecular materials for electronics and molecular scale electronics: Molecular properties, molecular arrangement. and molecular interactions, piezoelectric and pyroelectric organic materials; molecular magnets based on transition metal complexes and organic ferromagnets, organic nonlinear optical materials: photochromic organic materials and their classes; conducting polymers: polyacetylene, polypyrrole, polyaniline, and polythiophene; conductive change transfer materials: TTFTCNQ, metal–dithiolate systems, fullerenes. Langmuir Blodgett films, molecular electronic logic, and architectures.	**10**
4. **Nanomaterials:** Fundamentals of nanoscience: definition, nano versus bulk, quantum confinement: nanoscale in 1D, 2D, and 3D with examples, synthesis of nanomaterials: top-down and bottom-up approaches, size and shape-dependent optical properties of semiconducting (CdSe) and plasmonic metal nanoparticles, nanoclusters, and nanowires,nanoparticles, concept of magnetic nanoparticles, applications of nanomaterials.	**6**
Outcomes: The students will be able to clarify the concepts of molecular electronics.	
Suggested Books: 1. Inorganic Chemistry of Materials, P.J. Vander Put, Plenum Press, New York, 1998. 2. An Introduction to Molecular Electronics, M. C. Petty, M. R. Bryce and D. Bloor, Editors Edward Arnold, London 1995. 3. An Introduction to Nanomaterials and Nanoscience, A. K. Das, Mahua Das, CBS publishers and distributors Pvt Ltd (2019). 4. Characterization Techniques for Nanomaterials, I. Munaweera, M. L. Chamalki Madhusha, 7th Ed., CRC Press (2023).	

CHEMJ76: Physical Chemistry Lab Work	
1. Study of the kinetics of inversion of cane sugar catalysed by acid polarimetrically. 2. Verification of Debye-Hückel-Onsager equation $\Lambda = \Lambda 0 - S\,C^{1/2}$ for stronguni-univalent electrolyte. 3. Energy of activation of acid catalyzed hydrolysis of methyl acetate. 4. To study the effect of ionic strength on the reaction between $S_2O_8^{2-}$ and I^- ions. 5. Conductometric titration of a triple mixture (HCl+NH_4Cl+KCl) with (i) NaOHand (ii) $AgNO_3$. 6. Verification of the Nernst law of electrode potential. 7. Potentiometric titration of a polybasic acid.	

Note: Experiments may be added/ modified subject to availability of facilities.	
CHEMJ77: Inorganic Chemistry Lab Work	
1. Quantitative estimation of metal ions (two) by gravimetric/ titrimetric/ spectrophotometric methods 2. Study of symmetry elements and point groups using models	
Note: Experiments may be added/ modified subject to availability of facilities.	
Outcomes: Students shall be able to 1. Learn the difference between thermodynamic and kinetic approach in the formation of inorganic complexes. 2. Learn the ability for interpretation of IR, Raman, UV-vis, NMR and Mass spectral data.	
Suggested Books: 1. F. Basalo and R. G. Pearson, Mechanism of Inorganic Reactions, 2nd Edn (1967), Wiley Eastern Ltd., New Delhi. 2. D. F. Shriver and P. W. Atkins, Inorganic Chemistry, 3rd Edn. (1999), ELBS, London. 3. F. A. Cotton and G. Wilkinson, Advanced Inorganic Chemistry, 6th Edn. (1999), John Wiley & Sons, New York. 4. D.N. Sathyanarayana, Electronic Absorption Spectroscopy and Related Techniques, Universities Press (India) Ltd., Hyderabad (2001). 5. Keith F. Purcell and John C. Kotz, Inorganic Chemistry, W. B. Sauders Com. (1987), Hong Kong. 6. Martin L. Tobe and John Burgess, Inorganic Reaction Mechanisms, Longmans 1st Edn. (1999). 7. D. Banerjea, M.K.Bharty, Mechanisms of Reactions of Metal Complexes in Solution, RSC, 2022.	

CHEMJ78: Organic Chemistry Lab Work	
Separation of Organic mixture and their identification	
Note: Experiments may be added/ modified subject to availability of facilities.	

CHEMJ81:Analytical Chemistry-IV	
Objectives: To impart knowledge on electrochemical methods, separation methods and thermalanalysis.	
1. Electrochemical methods: Origin of polargraphy, Current-voltage relationship, Theory of polarographic waves (DC and sampled DC (tast) polarograms), Instrumentation, Ilkovic equation, Qualitative and quantitative applications.	**8**
2. Separation Methods: Principle of chromatography, Classifications of chromatography, Techniques of planar and column chromatography, Gas chromatography, High-performance liquid chromatography .	**15**
3. Thermal Analysis: Theory, methodology and applications of thermogravimetric analysis (TGA), Differential Thermal Analysis (DTA), and Differential scanning calorimetry (DSC). Principles, techniques and applications of thermometric titration methods.	**7**
Outcomes: The student will have deep understanding on the various analytical methods like polarography, column chromatography, TGA, DTA, and DSC.	
Suggested Books: 1. D.A. Skoog, *Principles of Instrumental Analysis*, 5th Edition (1998), Saunders College Publishing, Philadelphia, London. 2. G.W. Ewing, *Instrumental Methods of Chemical Analysis*, 5th Edition (1978), McGraw Hill Books Co., New York. 3. R.L. Pecsok, L. D. Shields, T. Cairns and L.C. Mc William, *Modern Methods of Chemical Analysis*, 2nd Edition (1976), John Wiley, New York. 4. J.H. Kennedy, *Analytical Chemistry: Principles*, 2nd Edition (1990), Saunders Holt, London.	

CHEMJ82: Inorganic Chemistry-VI	
Objectives: 1. To gain the concept of thermodynamic and kinetic stability of coordination complexes and inorganic substitution reactions to obtain complexes with selective stereo specificity. 2. To train the students about the characterization of inorganic compounds with the help of IR NMR, UV-vis and Mass spectral techniques.	
1. Kinetics and Mechanism of Substitution Reactions: Nature of substitution reactions; prediction of reactivity of octahedral, tetrahedral and square-planar complexes in terms ofcrystal field activation energy and structure preference energy; rates of reactions; acid hydrolysis, base hydrolysis and anation reactions.	**10**
2. Electron Transfer Reactions: Mechanism and rate laws; various types of electrontransfer reactions, Marcus-Husch theory, correlation between thermal and optical electron transfer reactions; identification of intervalence transfer bands in solution.	**10**
3. Characterization of Inorganic Compounds: Vibrational, NMR, Uv-vis, and Mass spectroscopic techniques	**10**
Outcomes: **Students shall be able to** 1. Learn the difference between thermodynamic and kinetic approach in theformation of inorganic complexes. 2. Learn the ability for interpretation of IR, Raman, UV-vis, NMR and Mass spectral data.	
Suggested Books: 1. F. Basalo and R. G. Pearson, *Mechanism of Inorganic Reactions*, 2nd Edn (1967),Wiley Eastern Ltd., New Delhi. 2. D. F. Shriver and P. W. Atkins, *Inorganic Chemistry*, 3rd Edn. (1999), ELBS,London. 3 F. A. Cotton and G. Wilkinson *Advanced Inorganic Chemistry*, 6th Edn. (1999), John Wiley & Sons, New York. 4. D.N. Sathyanarayana, *Electronic Absorption Spectroscopy and RelatedTechniques*, UniversitiesPress (India) Ltd., Hyderabad (2001). Keith F. Purcell and John C. Kotz, *Inorganic Chemistry*, W. B. Sauders Com.(1987), Hong Kong. 5. Martin L. Tobe and John Burgess, *Inorganic Reaction Mechanisms*, Longmans1st Edn. (1999). 6. D. Banerjea, M.K.Bharty, Mechanisms of Reactions of Metal Complexes inSolution, RSC,2022	

CHEMJ83: Organic Chemistry-VI	
Objectives: The mechanistic aspects of asymmetric synthesis, pericyclic reactions, and the formationof carbon-carbon bonds in contemporary organic synthesis.	
1. Asymmetric Synthesis: Enolization (Lithium and Boron enolate), Stereoselective Aldol condensation reaction (chiral enolate& achiral aldehyde and achiral enolate and chiral aldehyde). The chiral pool, chiral auxiliaries, chiral catalysts and reagents, and enantiomeric excess.	**8**
2. Pericyclic Reactions: Woodward-Hoffmann rules and molecular orbitals; Electrocylic reactions; Cycloaddition reactions, 1,3-Dipolar cycloaddition and cheletropic reactions; Sigmatropic rearrangements; Group transfer reactions: Ene reactions.	**8**
3. Modern organic synthesis: Retrosynthesis, Umpolung, Domino reactions andfunctional group interconversion.	**6**
4. Formation of Carbon-Carbon Bonds *via* Organometallic reagents: Organozinc, Organocopper, and Organoborane reagents, Palladium catalyzed coupling reactions(Heck, Sonogashira, and Suzuki).	**8**
Outcomes: The students will be able to understand 1. the mechanistic details of asymmetric synthesis of some bioactive molecules. 2. C-C Bond formation employing pericyclic reactions and organometallic reagents. 3. mechanistic aspects some functional group interconversion.	
Suggested Books: 1. Clayden, Greeves, Warren and Wothers, Organic Chemistry, Oxford University Press, 2001. 2. Advanced Organic Chemistry-Reactions and Mechanisms 2e"–Maya Shankar Singh & Keshav Raghuvanshi, Pearson Education Pvt. Ltd., 2021 (ISBN 978-93-544- 9078-1)	

3.	M.B. Smith & Jerry March, March's Advanced Organic Chemistry, 5th Edition (2001), John Wiley & Sons, New York.	
4.	G. S. Zweifel and M. H. Nantz, Modern Organic Synthesis, (2007), Freeman and Company, New York.	
5.	S. Kumar, V. Kumar, and S. P. Singh, Pericyclic Reaction; A Mechanistic and Problem-Solving Approach, 1st Edition (2015), Elsevier Inc.	
6.	T. H. Lowry and K. S. Richardson, Mechanism and Theory in Organic Chemistry, 3rd Edition (1998), Addison – Wesley Longman Inc. (IS Edition).	
7.	I. Fleming, Pericyclic Reactions, Oxford University Press, Oxford (1999).	
8.	W. Carruthers an Iain Coldham Modern Methods of Organic Synthesis Cambridge University Press	
9.	Charles H. Depuy and Orville L Chapman, Molecular reactions and photochemistry, New Delhi: Prentice Hall of India, 1988.	

CHEMJ84:Physical Chemistry-VI	
Objectives: To impart knowledge on different advanced electrochemistry topics (like electrochemical double layer, electrode kinetics and cyclic voltammetry), basic conceptsof polymer chemistry and micelles and colloids.	
1. Advanced Electrochemistry: Metal/Electrolyte interface: OHP and IHP, potential profile across double layer region, potential difference across electrified interface; structure of the double layer: Helmholtz- Perrin, Gouy-Chapman, and Stern models. Butler-Volmer equation under near equilibrium and non-equilibrium conditions, exchange current density, Tafel plot, polarizable and non-polarizable interfaces. Semiconductor (SC)/electrolyte interface: Creation of space charge region, capacity ofspace-charge, Mott-Schottky plots for n-type and p-type semiconductors, determinationof flat-band potential and donor/acceptor densities, application of SC/electrolyte interfacein solar cells, Fuel Cell, Battery.Cyclic voltammetry (CV) technique basics and applications.	**15**
2. Polymer Chemistry: Introduction, Classification of Polymers & Intermolecular forces of Polymers. Different types of molecular weight of polymer, polydispersity Index, Determination of molecular weight of polymers. Thermodynamic Aspects of Polymerization. Mechanism of Living Radical Polymerizations: Nitroxide mediated polymerization (NMP), Metal-catalyzed Living Radical Polymerization, Reversible Addition-Fragmentation Chain Transfer (RAFT) Radical Polymerization. Coordination polymerization, Ring-opening polymerization. Thermal and mechanical properties of polymers: Glass transition temperature, melting temperature, Rheological properties, industrial polymers.	**8**
3. Micelles and Colloids: Surface active agents and their classification, micellization, hydrophobic interaction, critical miceller concentration (cmc), factors affecting cmc of surfactants, thermodynamics of micellization, phase separation and mass action models, reverse micelles, solubilization. Stability and properties of colloids. Zeta potential, Stern double layer, Tyndall effect.	**7**
Outcomes: After the completion of the course, the students should be able to Explain the origin of electrical double layer, different models describing double layer and electrical double layer capacitance and their applications. 1. Understand the kinetics of electrode reaction, exchange current density, overpotential, transference coefficient, Tafel plot. 2. Know definition of polymer, molecular weight, different type of polymerization techniques with emphasis of radical polymerization, their kinetics, thermal and mechanical properties of polymer. 3. Understand the fundamentals of micelles and colloids, CMC, stability and properties of colloids, Zeta potential, Stern double layer, Tyndall effect.	
Suggested Books: 1. Modern Electrochemistry, Vol. 2 A & B, J.O'M. Bockris and A. K. N. Reddy,Plenum Press, New York. 2. F. W. Billmayer, Jr., Text Book of Polymer Science, 3rd Edition (1984), Willey Interscience, New York. 3. Fundamentals of Polymerization, B. M. Mandal, Illustrated edition (2012), World Scientific; Singapore. 4. Micelles: Theoretical and Applied Aspects, Y. Moroi, Plenum Press, New York	

CHEMJ85: Advanced Spectroscopy	
Objectives: The course aims to provide the knowledge on basic fundamentals of various spectroscopic techniques like UV-Vis, IR, NMR, Raman, Fluorescence, Electron Paramagnetic Resonance spectroscopy, Mass spectrometry and Lasers.	
1. UV-Vis spectroscopy: π-π^* and n-π^* electronic transitions, effects of substituents,conjugation and chain length (on λ_{max} & amp; ε_{max}) of conjugated polyenes and polyones, Woodward- Feiser rules for calculating λ_{max}.	**3**
2. IR spectroscopy: Molecular vibrations and IR absorption, the functional groups and fingerprint regions, the effect of bond orders on C-C, C-O, C-N bands; ring size and electronic effects. H-bonding and dilution effect.	**4**
3. NMR spectroscopy: The chemical shifts, diamagnetic shielding, anisotropic effect, 1 H- 1 H spin-spin splitting, and coupling constant, Interpretation of NMR spectra (1H & 13C NMR).	**4**
4. Mass spectrometry: Basics, mass spectra of straight and branched chain alkanes, molecular ion, base and isotope peaks, fragmentation pattern of alkyl halides, ethers,alcohols and ketones, Mc Lafferty rearrangement.	**2**
5. Identification of simple organic molecules using spectral data (UV-Vis, IR, NMR,and Mass).	**2**
6. Raman spectroscopy: Rayleigh Scattering, Raman scattering effect, classical treatment of Raman scattering, rotational Raman transitions and rotation-vibrational Raman transitions.	**3**
7. Fluorescence spectroscopy: Instrumentation, fluorophores, solvent and environmental effect on fluorescence, quenching of fluorescence, fluorescence anisotropy, time-resolved fluorescence spectroscopy (TCSPC).	**4**
8. Lasers: laser action, characteristics, pulsed lasers, non-linear effects, harmonic generation, examples of lasers: He-Ne, Nd-YAG. Single molecule spectroscopy: Principle, instrumentation and application.	**4**
9. Electron Paramagnetic Resonance Spectroscopy: Introduction to electron spin resonance, Hyperfine splitting, Factors affecting hyperfine splitting, EPR of hydrogen,organic radicals in solution.	**4**
Outcomes: After completion of the course, the student should be able to 1. Explain the principles of UV-Vis, IR, NMR, Raman, Electron Paramagnetic Resonance spectroscopy and interpret the spectral data for simple molecular system. 2. Understand the basic instrumentation of fluorimeter and some advance topics on fluorescence spectroscopy like solvent polarity effect on fluorescence, mode of interaction between fluorophores and quenchers, fluorescence anisotropy and fluorescence lifetime and its measurement. 3. Explore the theories Mass spectrometry to realize the spectra and characterize simple/complex organic molecules. 4. Understand basic principle of EPR and analyse the EPR spectra of systems having unpaired electrons. 5. Understand LASER and basics of single molecule spectroscopy and their application.	
Suggested Books: 1. Principles of Fluorescence Spectroscopy, Joseph R. Lakowicz, 2006, Springer. 2. Modern Spectroscopy, J. M. Hollas, 4th Edn., (2004), John Wiley & Sons, Inc, New York. 3. Atkin's Physical Chemistry by Peter Atkins and Julio de Paula, W. H. Freeman& Co. 4. Fundamentals of Molecular Spectroscopy, C. N. Banwell, 4th Edn. (2017),Paperback, McGraw Hill Education (India) Private Limited, New Delhi. 5. Physical methods in Inorganic Chemistry by Russell S. Drago (Affiliated East- West Press Pvt. New Delhi). 6. lntroduction to Magnetic Resonance by A. Carrington and A. D. McLachlan.(Chapman & Hall. London)	

CHEMJ86: Physical Chemistry Lab Work	
1. Determination of the rate constant for the decomposition of bezene diazonium chloride by gasometric method. 2. Degree of hydrolysis of urea-hydrochloride by kinetics method. 3. Conductometric study of the kinetics of saponification of ethyl acetate. 4. Determination of Critical Micelle Concentration (CMC) of a Surfactant byconductometry. 5. Electrochemical Impedance study of metal/solution interface. 6. Cyclic Voltammetry of the $[Fe(CN)6]^{3-}$/$[Fe(CN)6]^{4-}$ system. 7. Analysis of halide mixture by differential potentiometry. 8. Fluorescence quenching of organic fluorophores. 9. FRET for suitable donor – acceptor pair. 10. Determination of molecular weight by viscometry: Polyacrylamide-aq.$NaNO_2$solution/Polyvinyl pyrolidone in water. 11. Analysis of the given (i) vibrational-rotational, (ii) FTIR, and (iii) NMR spectraof a Compound	
Note: Experiments may be added/ modified subject to availability of facilities.	

CHEMJ87: Inorganic Chemistry Lab Work	
1. Synthesis of some coordination complexes (Including those involving morethan one step). 2. Conductivity and spectroscopic studies of the complexes	
Note: Experiments may be added/ modified subject to availability of facilities.	

CHEMJ88: Organic Chemistry Lab Work	
Two-step synthesis of organic compounds: 1. Preparation of m-nitroaniline from nitrobenzene 2. Preparation of anthranilic acid from phthalic anhydride. 3. Preparation of 2-phenylindole from phenylhydrazine. 4. Preparation of methyl red dye 5. Preparation of thioxazole	
Note: Experiments may be added/ modified subject to availability of facilities.	

Semester- VII (Honours with Research)

CHEMJ7R1:Analytical Chemistry-III	
Objectives: To introduce conceptual knowledge on advanced statistical methods, chemicalequilibria, and stoichiometry.	
1. Analytical chemometrics: Propagation of measurement uncertainties (inaccuracy and imprecision).Useful statistical test: test of significance, the F test, the student 't' test, the chi-test, the correlation coefficient, confidence limit of the mean, comparison of two standard values, comparison of standard deviation with average deviation, comparison of mean with true values, significant figures, regression analysis (least square method for linear and non-linear plots), statistics of sampling and detection limit evaluation. Chemometrics for modeling and parameter estimation, factor analysis, resolution and pattern recognition.	**15**
2. Treatment of Equilibria: Solvents and solutions, general treatment of equilibria in aqueous medium involving monoprotic weak acid and weak base, and salts of weak acids and weak bases. Activity and concentration, Effect of electrolytes on chemical equilibria,Calculation of pH, Constructing titration curves from charge balance and mass balance equations, Acid-base titrations and theory of pH indicators, Complexation equilibria and complexometric titrations, Redox equilibria and redox titration, Theory of redox indicators, Precipitation reaction and precipitation titrations and theory of adsorption indicators.	**8**
3. Spectrophotometric Determination of Stoichiometry of Complexes: **7** Job's method of continuous variation, mole ratio and slope ratio analysis, Advantages andlimitations, typical examples.	**7**
Outcomes: The students will establish knowledge on chemometrics, theory of various titrations, and stoichiometric calculations using instrumental techniques.	
Suggested Books: 1. R. L. Pecsok, L. D. Shields, T. Cairns and L.C. Mc William, Modern Methods of Chemical Analysis, 2nd Edition (1976), John Wiley, New York. 2. G. D. Christian, Analytical Chemistry, 5th Edition (1994), John Wiley & Sons, NewYork. 3. D. A. Skoog, D.M. West, F.J. Holler, S.R. Crouch, Analytical Chemistry - An Introduction, 7th Edition (2000), Saunders College Publishing, Philadelphia, London. 4. J. H. Kennedy, Analytical Chemistry: Principles, 2nd Edition (1990), SaundersHolt, London.	

CHEMJ7R2: Inorganic Chemistry-V	
Objectives: 1. To train students about the illustration of symmetry in complexes and the fundamentals of character tables; and Orgel diagrams of metal complexes. 2. To teach the biological perspectives of important metal ions.	
1. Symmetry-based concepts of energy level diagrams of metal complexes: Symmetry elements and operations, determination of point group of a molecule, Group representations, Features of specific character tables in reference to Orgel diagrams, Symmetry-based concepts of Orgel energy level diagrams of metal complexes. Introduction to Tanabe-Sugano diagrams (d2 configuration)	15
2. Bioinorganic chemistry: Metal ions in biological processes. Biological role of iron. Oxygen transport with reference to hemoglobin and myoglobin. Synthetic model complexes for oxygen transport. Cytochromes and iron-sulfur proteins: Electron Transfer reactions. Photosystems, Role of metalloenzymes. Biological role of alkali metal ions, and their transport with special reference to Na+/K+ ATPase. Vitamin B12. Nitrogen Fixation.	15
Outcomes: Students shall be able to 1. Learn the importance of symmetry-based concepts in the field of coordination chemistry. 2. Develop an interdisciplinary approach to metal chemistry with the biological world.	
Suggested Books: 1. Physical Methods in Inorganic Chemistry, R. S. Drago, International Edn. (1971), Affiliated East-West Press, New Delhi. 2. Chemical Applications of Group Theory, F. A. Cotton 3. Inorganic Chemistry, J.E. Huheey, E.A. Keiter and R.L. Keiter, 4th Edn. (1993), Addison-	

	Wesley Pub. Co., New York. 4. Bioinorganic Chemistry, I. Bertini, H. B. Gray, S. J. Lippard, J.S. Valentine, Viva Books, P. Ltd. New Delhi, South Asian Ed., 1998 (Reprint 2004). 5. Principles of Bioinorganic Chemistry, S. J. Lippard, J. M. Berg, University Science Books, California 1994. 6. Bioinorganic Chemistry: Inorganic Elements in the Chemistry of Life, W. Kaim, B. Schwederski, John Wiley & Sons, England, 2004.	

CHEMJ7R3: Organic Chemistry-V	
Objectives: To impart knowledge of mechanistic aspects of the reactivity of C=X (X = C, N, O, S)multiple bonds and aromatic nucleophilic substitution reactions.	
1. Nucleophilic Substitution and addition reactions: Mechanism and Stereochemistry of SN1, SN2, SN*i*& SN2' reactions. The effect of substrate structure, nucleophile, leaving group, temperature, and reaction medium. Phase transfer catalysis (Basic concept); epoxidation of unsaturated ketone, nucleophilic addition to C=X bond, solid-liquid phase transfer catalysis.	**10**
2. Elimination reactions: The E1, E2 and E1cB mechanisms, Orientation of the doublebond. Hofmann versus Saytzeff elimination, Pyrolytic syn-elimination, Competitionbetween substitution and elimination reactions. Stereoselective olefination reactions: Peterson, Julia and Petasis. Olefin metathesis (RCM) using Ru catalysis.	**10**
3. Neighbouring Group Participation: Evidences of N.G.P.; the phenonium ion,participation by π and σ bonds. Classical versus non-classical carbonium ions.	**4**
4. Aromatic nucleophilic substitution (SNAr): Benzyne Mechanism, Reactivity and effect of leaving group. Chichibabin reaction, von Richter rearrangement, Sommelet–Hauser rearrangement, and Smile rearrangement	**6**
Outcomes: The students will be able to understand 1. The mechanistic details of substitution and elimination reactions. 2. Reaction conditions for the formation of different ion intermediates. 3. Mechanistic aspects of some reaction intermediates. 4. Advantages and disadvantages of protection and deprotection approaches in organic syntheses.	
Suggested Books: 1. Clayden, Greeves, Warren and Wothers, Organic Chemistry, Oxford University Press, 2001. 2. Organic Chemistry", 9th Edition, L. G. Wade, J. W. Simek& M. S. Singh, Pearson India Education Services Pvt. Ltd. 2020 (ISBN 978-93-893-4267-3). 3. M. B. Smith & Jerry March, March's Advanced Organic Chemistry, 5th Edition (2001), John Wiley & Sons, New York. 4. Peter Sykes, A Guide book to Mechanism in Organic Chemistry, 6th Edition (1997), Orient Longman Ltd., New Delhi. 5. S. M. Mukherjee and S. P. Singh, Reaction Mechanism in Organic Chemistry, 1st Edition (1990), Macmillan India Ltd., New Delhi. 6. G. S. Zweifel and M. H. Nantz, Modern Organic Synthesis, (2007), Freeman and Company, New York.	

CHEMJ7R4: Physical Chemistry-V	
Objectives: To impart basic knowledge on energy levels in atom and molecules, atomic term symbols, and chemical bonding.	
1. Atomic structure: The Hydrogen atom, atomic orbitals, variation theorem, Secular determinant, He-atom, electron spin, Slater determinant, anti symmetry rule, and Pauli's exclusion principle, many-electron atoms: SCF method, atomic term symbols	**15**

2. Molecular structure: Born-Oppenheimer approximation, molecular orbital treatment for H_2^+ MO treatment of homo- and heteronuclear diatomic molecules, electronic terms of diatomic molecules, VB approach, comparison of the MO and VB theories, Hückel MO treatment of simple and conjugated polyenes .	**15**
Outcomes: After the completion of the course, the students should be able to 1. Gain a preliminary notion about the quantum mechanical model of the atom and the shape of s, p, d, and f-orbitals. 2. Explain the idea of spin quantum number, Slater determinant, anti symmetry rule and Pauli's exclusion principle and atomic term symbols term symbol. 3. Explain different energy level in molecule and rationalize the qualitative idea of bonding between atoms that generates molecules**.**	
Suggested Books: 1. Molecular Quantum Mechanics, P. W. Atkins and R. S. Friedman, 3rd edition (1997), Oxford University Press. Oxford. 2. Quantum Chemistry, I. N. Levine, 5th edition (2000), Pearson Educ., Inc., New Delhi. 3. Introductory Quantum Chemistry, A. K. Chandra, 4thEdn. (2017), McGraw Hill Education (India) Private Limited. 4. Quantum Chemistry, D. A. Mc Quarrie, Viva Books Private Limited, New Delhi,2007.	
CHEMJ7R5: Material Chemistry	
Objectives: To impart knowledge on new materials and their classifications.	
1. Introduction: Materials and their classification, inorganic and organic materials.	**4**
2. **Inorganic materials:** Design and synthesis of inorganic materials, requirements and constraints, combination properties of composites, solid state reactions for synthesis of inorganic materials: ceramic methods, precursor method and sol-gel synthesis, physical and chemical vapour depositions; carbides, nitrides, structural and functional ceramics, intermetallics; ceramic superconductors, magnetic ceramics. .	**10**
3. **Organic materials:** Molecular electronics: molecular materials for electronics and molecular scale electronics: Molecular properties, molecular arrangement. and molecular interactions, piezoelectric and pyroelectric organic materials; molecular magnets based on transition metal complexes and organic ferromagnets, organic nonlinear optical materials: photochromic organic materials and their classes; conducting polymers: polyacetylene, polypyrrole, polyaniline, and polythiophene; conductive change transfer materials: TTFTCNQ, metal–dithiolate systems, fullerenes. LangmuirBlodgett films, molecular electronic logic, and architectures.	**10**
4. **Nanomaterials:** Fundamentals of nanoscience: definition, nano versus bulk, quantum confinement: nanoscale in 1D, 2D, and 3D with examples, synthesis of nanomaterials: top-down and bottom-up approaches, size and shape-dependent optical properties of semiconducting (CdSe) and plasmonic metal nanoparticles, nanoclusters, and nanowires,nanoparticles, concept of magnetic nanoparticles, applications of nanomaterials.	**6**
Outcomes: The students will be able to clarify the concepts of molecular electronics.	
Suggested Books: 1. Inorganic Chemistry of Materials, P.J. Vander Put, Plenum Press, New York, 1998. 2. An Introduction to Molecular Electronics, M. C. Petty, M. R. Bryce and D. Bloor, Editors Edward Arnold, London 1995. 3. An Introduction to Nanomaterials and Nanoscience, A. K. Das, Mahua Das, CBS publishers and distributors Pvt Ltd (2019). 4. Characterization Techniques for Nanomaterials, I. Munaweera, M. L. Chamalki Madhusha, 7th Ed., CRC Press (2023).	

CHEMJ7R6: Physical Chemistry Lab Work	
1. Study of the kinetics of inversion of cane sugar catalysed by acidpolarimetrically. 2. Verification of Debye-Hückel-Onsager equation $\Lambda = \Lambda_0 - S\,C^{1/2}$ for strong uni-univalent electrolyte. 3. Energy of activation of acid catalyzed hydrolysis of methyl acetate. 4. To study the effect of ionic strength on the reaction between $S_2O_8^{2-}$ and I^- ions. 5. Conductometric titration of a triple mixture (HCl+NH_4Cl+KCl) with (i) NaOHand (ii) $AgNO_3$. 6. Verification of the Nernst law of electrode potential. 7. Potentiometric titration of a polybasic acid.	
Note: Experiments may be added/ modified subject to availability of facilities.	

CHEMJ7R7: Inorganic Chemistry Lab Work	
1. Quantitative estimation of metal ions (two) by gravimetric/ titrimetric/spectrophotometric methods 2. Study of symmetry elements and point groups using models	
Note: Experiments may be added/ modified subject to availability of facilities.	

CHEMJ7R8: Organic Chemistry Lab Work	
Separation of Organic mixture and their identification	
Note: Experiments may be added/ modified subject to availability of facilities.	

Semester-VIII (Total Credits 16; L-4, P-12)

The students will opt any one paper out of the four papers

CHEMJ8R1: Analytical

Chemistry-IV

CHEMJ8R2: Inorganic

Chemistry-VI

CHEMJ8R3: Organic

Chemistry-VI

CHEMJ8R4: Physical

Chemistry-VI

The course CHEMJ8R5: Advanced Spectroscopy **is compulsory**

CHEMJ8R1:Analytical Chemistry-IV	
Objectives: To impart knowledge on electrochemical methods, separation methods and thermalanalysis.	
1. Electrochemical methods: Origin of polargraphy, Current-voltage relationship, Theory of polarographic waves (DC and sampled DC (tast) polarograms), Instrumentation, Ilkovic equation, Qualitative and quantitative applications.	**8**
2. Separation Methods: Principle of chromatography, Classifications of chromatography, Techniques of planar and column chromatography,Gas chromatography, High-performance liquid chromatography	**15**
3. Thermal Analysis: Theory, methodology and applications of thermogravimetric analysis (TGA), Differential Thermal Analysis (DTA), and Differential scanning calorimetry (DSC). Principles, techniques and applications of thermometric titration methods.	**7**
Outcomes: The student will have deep understanding on the various analytical methods likepolarography, column chromatography, TGA, DTA, and DSC.	
Suggested Books: 1. D.A. Skoog, *Principles of Instrumental Analysis*, 5th Edition (1998), SaundersCollege Publishing, Philadelphia, London. 2. G.W. Ewing, *Instrumental Methods of Chemical Analysis*, 5th Edition (1978),McGraw Hill Books Co., New York. 3. R.L. Pecsok, L. D. Shields, T. Cairns and L.C. Mc William, *Modern Methods ofChemical Analysis*, 2nd Edition (1976), John Wiley, New York. 4. J.H. Kennedy, *Analytical Chemistry: Principles*, 2nd Edition (1990), Saunders Holt, London.	

CHEMJ8R2: Inorganic Chemistry-VI	
Objectives: 1. To gain the concept of thermodynamic and kinetic stability of coordination complexes and inorganic substitution reactions to obtain complexes with selective stereospecificity. 2. To train the students about the characterization of inorganic compounds with the help of IR, NMR, UV-vis and Mass spectral techniques.	
1. Kinetics and Mechanism of Substitution Reactions: Nature of substitution reactions; prediction of reactivity of octahedral, tetrahedral and square-planar complexes in terms of crystal field activation energy and structure preference energy; rates of reactions; acid hydrolysis, base hydrolysis and anation reactions.	**10**
2. Electron Transfer Reactions: Mechanism and rate laws; various types of electron transfer reactions, Marcus-Husch theory, correlation between thermal and optical electrontransfer reactions; identification of inter valence transfer bands in solution.	**10**
3. Characterization of Inorganic Compounds: Vibrational, NMR, Uv-vis, and Mass spectroscopic techniques	**10**
Outcomes: **Students shall be able to** 1. Learn the difference between thermodynamic and kinetic approach in theformation of inorganic complexes. 2. Learn the ability for interpretation of IR, Raman, UV-vis, NMR and Mass spectral data.	
Suggested Books: 1. F. Basalo and R. G. Pearson, Mechanism of Inorganic Reactions, 2nd Edn (1967), Wiley Eastern Ltd., New Delhi. 2. D. F. Shriver and P. W. Atkins, Inorganic Chemistry, 3rd Edn. (1999), ELBS, London. 3. F. A. Cotton and G. Wilkinson, Advanced Inorganic Chemistry, 6th Edn. (1999), John Wiley & Sons, New York. 4. D.N. Sathyanarayana, Electronic Absorption Spectroscopy and Related Techniques, Universities Press (India) Ltd., Hyderabad (2001). 5. Keith F. Purcell and John C. Kotz, Inorganic Chemistry, W. B. Sauders Com. (1987), Hong Kong. 6. Martin L. Tobe and John Burgess, Inorganic Reaction Mechanisms, Longmans 1st Edn.(1999). 7 .J. Singh, M.D. Pandey and J. Singh, Spectroscopy of Inorganic Compounds, New Age International, 2nd Ed, 2024.	

CHEMJ8R3: Organic Chemistry-VI	
Objectives: The mechanistic aspects of asymmetric synthesis, pericyclic reactions, and the formationof carbon-carbon bonds in contemporary organic synthesis.	
1. Asymmetric Synthesis: Enolization (Lithium and Boron enolate), Stereo selective Aldol condensation reaction (chiral enolate & achiral aldehyde and achiral enolate and chiral aldehyde). The chiral pool, chiral auxiliaries, chiral catalysts and reagents, and enantiomeric excess.	**8**
2. Pericyclic Reactions: Woodward-Hoffmann rules and molecular orbitals; Electrocylic reactions; Cycloaddition reactions, 1,3-Dipolar cycloaddition and cheletropic reactions; Sigmatropic rearrangements; Group transfer reactions: Ene reactions.	**8**
3. Modern organic synthesis: Retrosynthesis, Umpolung, Domino reactions and functional group interconversion.	**6**
4. Formation of Carbon-Carbon Bonds *via* Organometallic reagents: Organozinc,Organocopper, and Organoborane reagents, Palladium catalyzed coupling reactions(Heck, Sonogashira, and Suzuki).	**8**
Outcomes: **The students will be able to understand** 1. The mechanistic details of asymmetric synthesis of some bioactive molecules. 2. C-C Bond formation employing pericyclic reactions and organometallic reagents. **3.** Mechanistic aspects some functional group interconversion.	
Suggested Books: 1. Clayden, Greeves, Warren and Wothers, Organic Chemistry, Oxford University Press, 2001. 2. Advanced Organic Chemistry-Reactions and Mechanisms 2e"–Maya Shankar Singh & Keshav Raghuvanshi, Pearson Education Pvt. Ltd., 2021 (ISBN 978-93-544- 9078-1) 3. M.B. Smith & Jerry March, March's Advanced Organic Chemistry, 5th Edition (2001), John Wiley & Sons, New York. 4. G. S. Zweifel and M. H. Nantz, Modern Organic Synthesis, (2007), Freeman and Company, New York. 5. S. Kumar, V. Kumar, and S. P. Singh, Pericyclic Reaction; A Mechanistic and Problem-Solving Approach, 1st Edition (2015), Elsevier Inc. 6. T. H. Lowry and K. S. Richardson, Mechanism and Theory in Organic Chemistry, 3rd Edition (1998), Addison – Wesley Longman Inc. (IS Edition). 7. I. Fleming, Pericyclic Reactions, Oxford University Press, Oxford (1999). 8. W. Carruthers an Iain Coldham Modern Methods of Organic Synthesis Cambridge University Press 9. Charles H. Depuy and Orville L Chapman, Molecular reactions and photochemistry, New Delhi: Prentice Hall of India, 1988.	

CHEMJ8R4: Physical Chemistry-VI	
Objectives:	
1. Advanced Electrochemistry: Metal/Electrolyte interface: OHP and IHP, potential profile across double layer region, potential difference across electrified interface; structure of the double layer: Helmholtz- Perrin, Gouy-Chapman, and Stern models. Butler-Volmer equation under near equilibrium and non-equilibrium conditions, exchange current density, Tafel plot, polarizable and non-polarizable interfaces. Semiconductor (SC)/electrolyte interface: Creation of space charge region, capacity ofspace-charge, Mott-Schottky plots for n-type and p-type semiconductors, determinationof flat-band potential and donor/acceptor densities, application of SC/electrolyte interfacein solar cells, Fuel Cell, Battery.Cyclic voltammetry (CV) technique basics and applications.	**15**
2. Polymer Chemistry: Introduction, Classification of Polymers & Intermolecular forces of Polymers. Different types of molecular weight of polymer, polydispersity Index, Determination of molecular weight of polymers. Thermodynamic Aspects of Polymerization. Mechanism of Living Radical Polymerizations: Nitroxide mediated polymerization (NMP), Metal-catalyzed Living Radical Polymerization, Reversible Addition-Fragmentation Chain Transfer (RAFT) Radical Polymerization. Coordination polymerization, Ring-opening polymerization. Thermal and mechanical properties of polymers: Glass transition temperature, melting temperature, Rheological properties,industrial polymers.	**8**

3. Micelles and Colloids: Surface active agents and their classification, micellization, hydrophobic interaction, critical miceller concentration (cmc), factors affecting cmc of surfactants, thermodynamics of micellization, phase separation and mass action models, reverse micelles, solubilization. Stability and properties of colloids. Zeta potential, Sterndouble layer, Tyndal effect.	**7**
Outcomes:	
Suggested Books: 1. Modern Electrochemistry, Vol. 2 A & B, J.O'M. Bockris and A. K. N. Reddy,Plenum Press, New York. 2. F. W. Billmayer, Jr., Text Book of Polymer Science, 3rd Edition (1984), Willey Interscience, New York. 3. Fundamentals of Polymerization, B. M. Mandal, Illustrated edition (2012), World Scientific; Singapore. 4. Micelles: Theoretical and Applied Aspects, Y. Moroi, Plenum Press, New York	

CHEMJ8R5: Advanced Spectroscopy	
Objectives:	
1. UV-Vis spectroscopy: π-π* and n-π* electronic transitions, effects of substituents, conjugation and chain length (on λ_{max} & amp; ε_{max}) of conjugated polyenes and polyones, Woodward- Feiser rules for calculating λ_{max}.	**3**
2. **IR spectroscopy:** Molecular vibrations and IR absorption, the functional groups and fingerprint regions, the effect of bond orders on C-C, C-O, C-N bands; ring size andelectronic effects. H-bonding and dilution effect.	**4**
3. **NMR spectroscopy:** The chemical shifts, diamagnetic shielding, anisotropic effect, 1H- 1 H spin-spin splitting, and coupling constant, Interpretation of NMR spectra (^{1}H & amp; ^{13}C NMR).	**4**
4. Mass spectrometry: Basics, mass spectra of straight and branched chain alkanes, molecular ion, base and isotope peaks, fragmentation pattern of alkyl halides, ethers,alcohols and ketones, Mc Lafferty rearrangement.	**2**
5. Identification of simple organic molecules using spectral data (UV-Vis, IR, NMR,and Mass).	**2**
6. Raman spectroscopy: Rayleigh Scattering, Raman scattering effect, classicaltreatment of Raman scattering, rotational Raman transitions and rotation-vibrational Raman transitions.	**3**
7. Fluorescence spectroscopy: Instrumentation, fluorophores, solvent and environmental effect on fluorescence, quenching of fluorescence, fluorescence anisotropy, time-resolvedfluorescence spectroscopy (TCSPC).	**4**
8. Lasers: laser action, characteristics, pulsed lasers, non-linear effects, harmonicgeneration, examples of lasers: He-Ne, Nd-YAG. Single molecule spectroscopy: Principle, instrumentation and application.	**4**
9. Electron Paramagnetic Resonance Spectroscopy: Introduction to electron spinresonance, Hyperfine splitting, Factors affecting hyperfine splitting, EPR of hydrogen, organic radicals in solution.	**4**
Outcomes:	
Suggested Books: 1. Principles of Fluorescence Spectroscopy, Joseph R. Lakowicz, 2006, Springer. 2. Modern Spectroscopy, J. M. Hollas, 4th Edn., (2004), John Wiley & Sons,Inc, New York. 3. Atkin's Physical Chemistry by Peter Atkins and Julio de Paula, W. H. Freeman&Co. 4. Fundamentals of Molecular Spectroscopy, C. N. Banwell, 4th Edn. (2017),Paperback, McGraw Hill Education (India) Private Limited, New Delhi. 5. Physical methods in Inorganic Chemistry by Russell S. Drago (Affiliated East-West Press Pvt. New Delhi). 6. lntroduction to Magnetic Resonance by A. Carrington and A. D. McLachlan.(Chapman & Hall. London)	

CHEMN11: Basic Concepts of Chemistry-I	
Objectives: To understand the wave nature of matter and its implications.To study the classification of elements and their properties.To study the states of matter; behavior of ideal and real gases, liquids, and the structures of solids. To understand the laws of thermodynamics.	
1.**Atomic Structure:** Wave-particle duality, Heisenberg uncertainty principle, Schrodinger wave equation, Eigenvalues and Eigenfunctions, significance of Ψ and Ψ^2 Radial and angular wave functions, Multi-electron system: Concept of Effective Nuclear Charge (Slater's rules).	**5**
2. Atomic properties and their periodic trends: A brief introduction to the modern periodic table (Block wise).Atomic size (Covalent, Ionic and van der Waal's radii; Lanthanide contraction), Electron loss, and electron gain enthalpies. Inert pair effect. Electronegativity (Pauling, Mulliken, Allred Rochow's methods of determination): As a criterion of bond type. Lattice energy and its determination: a) Born-Haber cycle b) Born Lande equation c) Comparison of experimental and theoretical values. Solvation/Hydration energy (Solubility of ionic solids in water). Covalency in ionic compounds (Fajan's rules). Redox reaction, Standardelectrode potential and its determination. Electrochemical series and its applications Latimer and Frost diagrams; specific illustrative examples.	**10**
3. Gaseous State: Kinetic theory of gases and ideal gas laws, Maxwell distribution of speed, Equipartition of Energy collisions in a gas: collision number, collision diameter and mean free path, behaviour of real gases: van der Waals equation and its applicability, the critical state: critical constants, law of corresponding states.	**10**
4. Liquid State: Surface tension, capillary action, measurement of surface tension, viscosity of liquids andits measurement, temperature effect on surface tension and viscosity	**4**
5. Solid State: Crystal lattices, space lattice, unit cell, crystal systems, law of rational indices, Millerindices, Bragg's equation, crystal structure of NaCl, graphite and diamond	**4**
6. Chemical Thermodynamics and its Applications: First law of Thermodynamics, Thermodynamic quantities (w, q, ΔU and ΔH) for isothermal and adiabatic reversible expansion of ideal gases, Kirchoff's relations, Joule effect, Joule-Thomson effect, Joule-Thomson coefficient of real (van der Waals) gases.	**12**
Second Law of Thermodynamics, Carnot cycle, concept of entropy and its physical significance, entropy changes for an ideal gas, entropy changes at constant pressure and volume, entropy change in spontaneous processes, free energy and maximum work functions, conditions for spontaneous changes and equilibrium, Gibbs-Helmholtz equation, Maxwell relations. Statement of third law of Thermodynamics.	
Outcomes: Students are expected to be able to understand the wave-particle duality, quantumnumbers, and screening effect of electrons and its consequences.Students will be able to understand the basis of classification in the Modern Periodic Tableand also will be able to explain the properties of various elements. The students will be able to understand the properties of solids, liquids, real and ideal gases. The students will learn various laws of thermodynamics.	
Suggested Books: 1. Basic Inorganic Chemistry, F. A Cotton, G. Wilkinson, and Paul L. Gaus, 3rdEdition (Indian Adaptation 2021), Wiley. 2. Concise Inorganic Chemistry, J. D. Lee, 5th Edition (1996), Chapman & Hall,London. 3. Principle of Physical Chemistry, B. R. Puri, L. R. Sharma and M. S. Pathania,Vishal Publishing Co., New Delhi. 4. Physical Chemistry, P. C. Rakshit, 5th Edition (1988), 4th Reprint (1997), SaratBook House, Calcutta. 5. Physical Chemistry, P. W. Atkins, 8th Ed., Oxford University Press, New York. 6. Textbook of Physical Chemistry, K.L. Kapoor, vol. 1, Macmillan India Ltd, NewDelhi. 7. Physical Chemistry, G. W. Castellan, 3rd Ed (1983), Addison-Wesley PublishingCompany, Massachusetts.	

CHEMN12: Lab Work-I	
1. Redox titrations: (a) Redox Titrimetric Estimations Based on Iodometry (b) Redox Titrimetric Estimations with standard $K_2Cr_2O_7$ solution	
2. (a) Determination of Surface Tension of liquids. (b) Determination of Viscosity Coefficients of liquids.	
OR	
Inorganic/Organic Chemistry Laboratory: 1. Preparation of molecular models using wire and beads to study (a) Various hybridization geometries (b) Isomerism 2. Identification of Metal ions by borax bead test 3. Preparation of some simple and double salts. 4. Study of displacement of ions in aqueous solutions (e.g. Cu^{2+} by Zn) 5. Preparation of m-dinitrobenzene from nitrobenzene 6. Preparation of acetanilide from aniline	
Note: Experiments may be added/ modified subject to availability of facilities.	

CHEMN21: Basic Concepts of Chemistry-II	
Objectives: To understand the nature of chemical bonds and its various types using different approaches.To impart knowledge of general reactions mechanisms, preparation and reactivitypatterns of alkyl halides, alcohols, ethers, and active methylene compounds.	
1. Chemical Bonding: i) A comparative account of the Valence Bond (VB) and Molecular Orbital (MO) approach of H2 molecule. Molecular orbital treatment of Homonuclear diatomic molecules of elements of first and second period and Heteronuclear (CO, NO) diatomic molecules. Illustration of HOMO and LUMO. ii) Concept of Hybridization, Bent's Rule, VSEPR theory applied to the compounds of s and p block elements. iii) An introduction to multi-center bonding with illustrative examples of Li-alkyls and diborane. iv) Concept of multiple bonding (p□-p□ and p□□d□) with illustrative examples of BF3, P4O10, (Me3Si)3N and SiF4	6
2. Ionic Bonding: A brief introduction to Crystal Packing, Radius Ratio rule, and its exceptions Structures of a few representative crystal types (Rock salt, Zinc blende, Wurtzite, Rutile, Brookite and Anatase).	5
3. Metallic Bonding: Theories of bonding in metal: Valence Bond, Free electron, and Band theories	2
4.Weak Interactions: Brief introduction to Hydrogen bonding and other weak interactions: Effects on physical and chemical properties.	2
5. Electronic and Field Effect: Electronic (electromeric, inductive, resonance, mesomeric effect, and hyperconjugation) and steric effects on the acidity/basicity and reactivity of organic molecules.	
6. Stereochemistry: Fischer, Saw-horse and Newman projection formulae. Chirality-optical activity, enantiomerism and diasteroisomerism involving one and two chiral centers. Configuration: D/L, erythrose/threose, R/S nomenclatures; geometrical isomerism - E/Z nomenclatures. Conformations of n-butane.	6
7. Hydrocarbons: i. Alkenes: Addition reactions (electrophilic and free radical), hydration, hydroxylation, hydroboration, epoxidation, ozonolysis and polymerization. Addition reactions of conjugated dienes and Diels–Alder reaction. ii. Alkynes: Reduction, electrophilic addition, acidity and metal acetylides.	4
8. Alkyl Halides: **Nucleophilic substitution:** SN1, SN2 and SNi, Eliminations reactions: E1, E2, and E1cB mechanisms. Elimination versus substitution reactions. Preparation and synthetic applications of Grignard reagents.	
9. Alcohols and Ethers: Preparation and reactions of primary, secondary, and tertiary alcohols and ethers.	4

10. Active methylene compounds: Preparation and synthetic applications of ethyl acetoacetate and diethyl malonate. (L)	5
Outcomes: The students will be able to understand how various types of chemical bonds are formed. Students are expected to be able to predict an organic compound's behavior. Students will be able to identify the mechanism of a specific chemical reaction. The goal of the unit is to provide an understanding of practically all facets of general organic chemistry and to provide a strong foundation in this area.The course aims to give a solid foundation of Alkyl/Aryl Halides, Alcohols, Phenols and Nitrogen-containing compounds and a grasp of nearly all its components.	
Suggested Books: 1. Basic Inorganic Chemistry, F. A Cotton, G. Wilkinson, and Paul L. Gaus, 3rd Edition (Indian Adaptation 2021), Wiley. 2. Concise Inorganic Chemistry, J. D. Lee, 5th Edition (1996), Chapman & Hall, London. 3. A Guide Book to Mechanism in Organic Chemistry, Peter Sykes, 6th Edition (1997), Orient Longman Ltd., New Delhi. 4. Stereochemistry of Organic Compounds, D. Nasipuri, 2nd Edition (1994), Wiley Eastern Ltd., New Delhi 5. Organic Chemistry, I. L. Finar, [Vol. I, 6th Edition (1973), Reprinted in 1980 & Vol. II, 5th Edition (1975), Reprinted in 1996], ELBS and Longman Ltd., New Delhi. 6. Organic Chemistry", 9th Edition, L. G. Wade, J. W. Simek & M. S. Singh, Pearson India Education Services Pvt. Ltd. 2020 (ISBN 978-93-893-4267-3). 7. Organic Chemistry, R. T. Morrison and R. N. Boyd, 6th Edition (1992), Prentice- Hall of India (P) Ltd., New Delhi. 8. Organic Chemistry, Paula Y. Bruice, 2nd Edition, (1998) Prentice-Hall, International Edition.	

CHEMN22: Lab Work-II	
1. Redox titrations: (a) Redox Titrimetric Estimations Based on Iodometry (b) Redox Titrimetric Estimations with standard $K_2Cr_2O_7$ solution	
2. (a) Determination of Surface Tension of liquids. (b) Determination of Viscosity Coefficients of liquids.	
OR	
Inorganic/Organic Chemistry Laboratory: 1. Preparation of molecular models using wire and beads to study (a) Various hybridization geometries (b) Isomerism 2. Identification of Metal ions by borax bead test 3. Preparation of some simple and double salts. 4. Study of displacement of ions in aqueous solutions (e.g. Cu^{2+} by Zn) 5. Preparation of m-dinitrobenzene from nitrobenzene 6. Preparation of acetanilide from aniline	
Note: Experiments may be added/ modified subject to availability of facilities.	

CHEMV31: Industrial Chemistry -I	
Objectives: To provide a comprehensive introduction to the science, formulation, production, andapplications of cosmetics, soaps, and detergents.	
1. Introduction to Cosmetics, Soaps, and Detergents: Definition and classification of cosmetics, soaps, and detergents, Historical developmentand cultural significance, Regulatory framework and quality standards	4
2. Cosmetics: Types of cosmetics (skincare, makeup, haircare, etc.), Cosmetic ingredients and their functions (emollients, emulsifiers, preservatives, etc.), Formulation and manufacturing processes, Packaging and labelling requirements.	8
3. Soaps: Saponification process and soap chemistry, Types of soaps (bar, liquid, transparent, etc.),Specialty soaps (medicated, herbal, etc.), Soap additives and fragrances.	8
4. Detergents: Types of detergents (household, industrial, personal care, etc.), Surfactants and their role in detergency, Formulation and production processes, Environmental considerations andbiodegradability.	8
5. Safety, Regulation and Consumer Awareness: Safety considerations in cosmetic and detergent production, Regulatory agencies and compliance requirements, Consumer awareness and product labelling.	2
Outcome: Students will gain practical knowledge about the ingredients, manufacturing processes, and quality control procedures involved in the production of these essential personal care products.	
Books Recommended: 1. Introduction to Cosmetic Formulation and Technology by Gabriella Baki, Kenneth S. Alexander 2. Soap Manufacturing Technology by Luis Spitz 3. Harry's Cosmeticology by Meyer R. Rosen, Richard L. Gabriele 4. Cosmetic and Toiletry Formulations by Ernest W. Flick 5. Handbook of Detergents, Part F: Production" by Uri Zoller 6. Soap Technology for the 1990s by H. P. Stevens 7. Detergent Science: A Primer on the Properties and Performance of Everyday Detergents" by Michael S. Showell 8. Handbook of Detergents, Part A: Properties by Uri Zoller **9.** Cosmetic Safety Assessment: A Guide for Cosmetic Scientists, Regulators, Toxicologists and Dermatologists" by P. Elsner, H. I. Maibach	

CHEMV32: Industrial Chemistry Lab Work –I	
Preparation of Soaps, Detergents, and various types of cosmetics.	

CHEMN41: Physical Chemistry-II

Objectives:

To impart knowledge on the application of classical thermodynamics on solution, surfaceand photochemistry and nuclear chemistry

1. Thermodynamics of Solutions: Partial molal quantities, chemical potential of a mixture of ideal gases, Gibbs-Duhem equation, chemical potential of real gases and fugacity, activity and activity coefficient, variation of fugacity with temperature and pressure, Lewis-Randall rule, thermodynamic functions of mixing (ΔG_{mix}, ΔS_{mix}, ΔV_{mix}, ΔH_{mix}), ideal solutions and their characteristic properties, Duhem-Margules equation and its applications, Henry and Raoult's laws, thermodynamics of colligative properties, relative lowering of vapour pressure, freezing point depression, elevation of boiling point and osmotic pressure, van't Hoff equation, measurement of osmotic pressure and determination of molecular weight of macromolecules.

2. Surface and Photochemistry: Langmuir adsorption isotherm, Multi-layer adsorption- BET equation (no derivation) and its application to surface area measurements; Gibbs Adsorption isotherm, surface reactions: kinetics of unimolecular surface reactions, inhibition and activation energy, nature of surface. Enzyme kinetics (Michaelis-Menten equation),Photochemical reactions: quantum efficiency, reasons for low and high quantum efficiency, kinetics of photochemical reactions: decomposition of HI, H_2-Br_2 reaction, photostationary state: dimerisation of anthracene, Stern-Volmer relation.

3. Nuclear Chemistry: Radioactivity: general characteristics of radioactive decay kinetics, artificial radioactivity, detection and measurement of radioactivity: GM counter.

Nuclear Reactions: Types of nuclear reactions, conservation of linear momentum and mass- energy in nuclear reactions, nuclear reaction cross section. Compound nucleus theory and its experimental verification.

Radio chemistry: Probing by isotopes, preparation of radioisotopes, radiochemical principles in use of tracers, some typical applications: chemical, physicochemical and analytical applications, age determination.

Radiation Chemistry: Interaction ofnuclear radiations with matter- charged particle, neutrons and gamma rays. Radiolysis of water and aqueous solutions, radiation dosimetry.

Outcomes:

After the completion of the course, the students should be able to

1. Apply the concept of chemical potential to explain the Gibbs free energy change dueto mixing and calculate partial molar quantities.
2. Understand the concept of fugacity, activity, ideal and nonideal solution.
3. Explain the thermodynamic basis of colligative properties and applications
4. Learn about surface phenomenon, adsorption isotherms, BET Equation, the laws of absorption of light energy by molecules and the subsequent photochemical reactions
5. Understand the basics of nuclear chemistry

Suggested Books:

1. Physical Chemistry, P. C. Rakshit, 5th Edition (1988), Sarat Book House, Calcutta.
2. Textbook of Physical Chemistry, K.L. Kapoor, vol. 5th (2005), Macmillan India Ltd, New Delhi.
3. Essentials of Nuclear Chemistry, H.J. Arnikar, 4th Edition (2003), New Age International Publishers, New Delhi.
4. Physical Chemistry, I. Levine, 5th Ed., (2007), Tata McGraw Hill New Delhi.
5. Physical Chemistry, P. W. Atkins, 8th Ed., Oxford University Press, New York.

CHEMN42: Techniques in Chemistry	
Objectives: To introduce basic concepts about stoichiometry, acid-base equilibria, and separationmethods.	
1. Introduction to Separation and Instrumental Methods Distillation, Crystallization, Precipitation, Extraction, Chromatography, Introductoryideas of UV-visible spectroscopy, Infrared Spectroscopy, and NMR Spectroscopy.	**8**
2. General Introduction to Analysis, and Stoichiometric Calculations Qualitative and quantitative analysis, primary standard, secondary standard, preparation of standard solutions, molarity, normality, molality, weight/weight percentage, weight/volume percentage, and ppm.	**4**
3. Concepts of Acid-Base Equilibria and Titrations General concepts of acids and bases, strength of conjugate acid/base pair, acid-base equilibria in water, pH calculations for strong acids and strong bases, concepts of acid basetitration, complexometric titration, redox titration, and precipitation titration, indicators.	**3**
Outcomes: The student will understand about qualitative and quantitative analysis, titrations, andinstrumentations on the separation techniques.	
Suggested Books: 1. Daniel C. Harris, *Quantitative Chemical Analysis*, 9th Edition (2015), W. H.Freeman and Company, New York. 2. *Basic Concepts of Analytical Chemistry'*, S.M. Khopkar, 2nd edition (1998), NewAge International Publications, New Delhi. 3. *Analytical Chemistry*, G.D. Christian, (2001) John Willey & sons, New York	

CHEMV51: Food Adulteration & Detection	
Objectives: To provide students with a comprehensive understanding of food adulteration, its detectionmethods, and the principles of food quality assessment.	
1. Introduction to Food Adulteration: Definition and types of food adulteration, Historical perspective and global prevalence, Impact of food adulteration on public health and economy.	2
2. Common Adulterants in Food: Adulteration in staple foods (e.g., grains, pulses), Adulteration in dairy products, Adulteration in edible oils and fats, Adulteration in spices and condiments.	6
3. Methods of Food Adulteration Detection: Chemical methods (e.g., spectroscopy, chromatography), Physical methods (e.g., microscopy, texture analysis), Biological methods (e.g., DNA-based techniques).	12
4. Quality Assessment Parameters: Sensory evaluation, Nutritional analysis, Microbiological quality, Physical and chemical attributes.	4
5. Food Safety Regulations and Standards: International and national regulatory bodies (e.g., FDA, FSSAI), Food safety standards (e.g., ISO, HACCP), Compliance and enforcement mechanisms.	4
6. Case Studies and Real-world Applications: Notable incidents of food adulteration, Success stories in quality assurance and adulteration prevention.	2
Outcome: Students will learn about various types of food adulteration, its impact on public health, and techniques to ensure food safety and quality. The course will also cover relevant regulatory frameworks and standards**.**	
Books Recommended: 1. Food Adulteration and Quality Control by S. Suzumura, J. Yoshimura, and T. Kuwata 2. Food Adulteration and Analysis by Yashwant Pathak and Taylor Wallace 3. Food Analysis by S. S. Nielsen 4. Food Quality Assurance: Principles and Practices by Inteaz Alli	

CHEMV52: Food Adulteration & Detection Lab work	
Qualitative/quantitative analysis of food samples for moisture content, carbohydrates, proteins, fats, ash etc.Characterization of various adulterants. Identificationof adulterants in real samples	

CHEMV61: Industrial Chemistry -II	
Objectives: To provide a comprehensive introduction to the science and technology of pigments, dyes,and paints.	
1. Introduction to Pigments, Dyes, and Paints: Definition, Historical development and classification and their significance. Chemicalstructures and properties.	3
2. Pigments: Inorganic vs. Organic pigments, Pigment synthesis and manufacturing processes, Colorimetry and color spaces, Applications in paints, plastics, printing inks, and more.	8
3. Dyes: Classification of dyes (acid, basic, direct, etc.), Dyeing processes (fiber, yarn, fabric, etc.), Dye synthesis and application techniques, Environmental considerations and regulations.	8
4. Paints: Types of paints (emulsion, enamel, lacquer, etc.), Formulation and composition of paints, Paint application methods (brushing, spraying, etc.), Surface preparation and finishing techniques.	6
5. Environmental impacts and sustainability: Environmental considerations in pigment, dye, and paint production, Waste management and pollution control, Green alternatives and sustainable practices.	5
Outcome: Students will gain a thorough understanding of the properties, synthesis, applications, and environmental impact of these important materials. Practical laboratory work will complement theoretical knowledge, enabling students to apply principles learned in lectures.	
Books Recommended: 1. Introduction to Pigments by E. Reinhold, R. M. Christie 2. Pigment Compendium; A Dictionary and Optical Microscopy of Historical Pigments" by Nicholas Eastaugh, Valentine Walsh, Tracey Chaplin, Ruth Siddall 3. The Chemistry of Synthetic Dyes by K. Venkataraman 4. Paint and Surface Coatings: Theory and Practice" by R. Lambourne, T. A. Strivens 5. Environmental Impact of Textile Dyeing" by Subramanian Senthilkannan Muthu	

CHEMV62: Industrial Chemistry Lab work -II	
Isolation of Pigments from plantsSynthesis of Dyes Preparation of a few Paint samples	

CHEMN71: **Analytical Chemistry-III**	
Objectives: To introduce conceptual knowledge of advanced statistical methods, chemicalequilibria, and stoichiometry.	
1.Analytical chemometrics: Propagation of measurement uncertainties (inaccuracy and imprecision).Useful statistical test: test of significance, the F test, the student 't' test, the chi-test, the correlation coefficient, confidence limit of the mean, comparison of two standard values, comparison of standard deviation with average deviation, comparison of mean with true values, significant figures, regression analysis (least square method for linear and non-linear plots), statistics of sampling and detection limit evaluation. Chemometrics for modeling and parameter estimation, factor analysis, resolution and pattern recognition.	**15**
2. Treatment of Equilibria: Solvents and solutions, general treatment of equilibria in aqueous medium involving monoprotic weak acid and weak base, and salts of weak acids and weak bases. Activity and concentration, Effect of electrolytes on chemical equilibria, Calculation of pH, Constructing titration curves from charge balance and mass balance equations, Acid-base titrations and theory of pH indicators, Complexation equilibria and complexometric titrations, Redox equilibria and redox titration, Theory of redox indicators, Precipitation reaction and precipitation titrations and theory of adsorption indicators.	**8**
3.Spectrophotometric Determination of Stoichiometry of Complexes: 7 Job's method of continuous variation, mole ratio and slope ratio analysis, Advantagesand limitations, typical examples.	**7**
Outcomes: The students will establish knowledge on chemometrics, theory of various titrations, and stoichiometric calculations using instrumental techniques.	
Suggested Books: 1. R. L. Pecsok, L. D. Shields, T. Cairns and L.C. Mc William, Modern Methods ofChemical Analysis, 2nd Edition (1976), John Wiley, New York. 2. G. D. Christian, Analytical Chemistry, 5th Edition (1994), John Wiley & Sons,New York. 3. D. A. Skoog, D.M. West, F.J. Holler, S.R. Crouch, Analytical Chemistry - AnIntroduction, 7th Edition (2000), Saunders College Publishing, Philadelphia, London. 4. J. H. Kennedy, Analytical Chemistry: Principles, 2nd Edition (1990), SaundersHolt, London.	

CHEMN72: Inorganic Chemistry-V	
Objectives: 1. To train students about the illustration of symmetry in complexes and the fundamentals of character tables; and Orgel diagrams of metal complexes. 2. To teach the biological perspectives of important metal ions.	
1. Symmetry-based concepts of energy level diagrams of metal complexes: Symmetry elements and operations, determination of point group of a molecule, Group representations, Features of specific character tables in reference to Orgel diagrams, Symmetry-based concepts of Orgel energy level diagrams of metal complexes. Introduction to Tanabe-Sugano diagrams (d2 configuration)	15
2. Bioinorganic chemistry: Metal ions in biological processes. Biological role of iron. Oxygen transport with reference to hemoglobin and myoglobin. Synthetic model complexes for oxygen transport. Cytochromes and iron-sulfur proteins: Electron Transfer reactions. Photosystems, Role of metalloenzymes. Biological role of alkali metal ions, and their transport with special reference to Na+/K+ ATPase. Vitamin B12. Nitrogen Fixation.	15
Outcomes: **Students shall be able to** 1. Learn the importance of symmetry-based concepts in the field of coordination chemistry. 2. Develop an interdisciplinary approach to metal chemistry with the biological world.	
Suggested Books: 1. Physical Methods in Inorganic Chemistry, R. S. Drago, International Edn. (1971), Affiliated East-West Press, New Delhi. 2. Chemical Applications of Group Theory, F. A. Cotton 3. Inorganic Chemistry, J.E. Huheey, E.A. Keiter and R.L. Keiter, 4th Edn. (1993), Addison-Wesley Pub. Co., New York. 4. Bioinorganic Chemistry, I. Bertini, H. B. Gray, S. J. Lippard, J.S. Valentine, Viva Books, P. Ltd. New Delhi, South Asian Ed., 1998 (Reprint 2004). 5. Principles of Bioinorganic Chemistry, S. J. Lippard, J. M. Berg, University Science **Books,**	

California 1994. 6. Bioinorganic Chemistry: Inorganic Elements in the Chemistry of Life, W. Kaim, B. Schwederski, John Wiley & Sons, England, 2004.	
CHEMN81: Organic Chemistry-VI	
Objectives: The mechanistic aspects of asymmetric synthesis, pericyclic reactions, and the formation of carbon-carbon bonds in contemporary organic synthesis.	
1. Asymmetric Synthesis: Enolization (Lithium and Boron enolate), Stereoselective Aldol condensation reaction (chiral enolate& achiral aldehyde and achiral enolate and chiral aldehyde). The chiral pool, chiral auxiliaries, chiral catalysts and reagents, and enantiomeric excess.	
2. Pericyclic Reactions: Woodward-Hoffmann rules and molecular orbitals; Electrocylic reactions; Cycloaddition reactions, 1,3-Dipolar cycloaddition and cheletropic reactions; Sigmatropic rearrangements; Group transfer reactions: Ene reactions.	
3. Modern organic synthesis: Retrosynthesis, Umpolung, Domino reactions and functional group interconversion.	
4. Formation of Carbon-Carbon Bonds via Organometallic reagents: Organozinc, Organocopper, and Organoborane reagents, Palladium catalyzed coupling reactions (Heck, Sonogashira, and Suzuki).	
Outcomes: The students will be able to understand 1. The mechanistic details of asymmetric synthesis of some bioactive molecules. 2. C-C Bond formation employing pericyclic reactions and organometallic reagents. **3.** Mechanistic aspects some functional group interconversion.	
Suggested Books: 1. Clayden, Greeves, Warren and Wothers, Organic Chemistry, Oxford University Press, 2001. 2. Advanced Organic Chemistry-Reactions and Mechanisms 2e"–Maya Shankar Singh & Keshav Raghuvanshi, Pearson Education Pvt. Ltd., 2021 (ISBN 978-93-544- 9078-1) 3. M.B. Smith & Jerry March, March's Advanced Organic Chemistry, 5th Edition (2001), John Wiley & Sons, New York. 4. G. S. Zweifel and M. H. Nantz, Modern Organic Synthesis, (2007), Freeman and Company, New York. 5. S. Kumar, V. Kumar, and S. P. Singh, Pericyclic Reaction; A Mechanistic and Problem-Solving Approach, 1st Edition (2015), Elsevier Inc. 6. T. H. Lowry and K. S. Richardson, Mechanism and Theory in Organic Chemistry, 3rd Edition (1998), Addison – Wesley Longman Inc. (IS Edition). 7. I. Fleming, Pericyclic Reactions, Oxford University Press, Oxford (1999). 8. W. Carruthers an Iain Coldham Modern Methods of Organic Synthesis Cambridge University Press 9. Charles H. Depuy and Orville L Chapman, Molecular reactions and photochemistry, New Delhi: Prentice Hall of India, 1988.	

CHEMN82: Phys. Chem-VI	
Objectives: To impart knowledge on different advanced electrochemistry topics (like electrochemical double layer, electrode kinetics and cyclic voltammetry), basic conceptsof polymer chemistry and micelles and colloids.	
1. Advanced Electrochemistry: Metal/Electrolyte interface: OHP and IHP, potential profile across double layer region, potential difference across electrified interface; structure of the double layer: Helmholtz- Perrin, Gouy-Chapman, and Stern models. Butler-Volmer equation under near equilibrium and non-equilibrium conditions, exchange current density, Tafel plot, polarizable and non-polarizable interfaces. Semiconductor (SC)/electrolyte interface: Creation of space charge region, capacity of space-charge, Mott-Schottky plots for n-type and p-type semiconductors, determination of flat-band potential and donor/acceptor densities, application of SC/electrolyte interfacein solar cells, Fuel Cell, Battery. Cyclic voltammetry (CV) technique basics and applications.	**15**

2. Polymer Chemistry: Introduction, Classification of Polymers & Intermolecular forces of Polymers. Different types of molecular weight of polymer, polydispersity Index, Determination of molecular weight of polymers. Thermodynamic Aspects of Polymerization. Mechanism of Living Radical Polymerizations: Nitroxide mediated polymerization (NMP), Metal-catalyzed Living Radical Polymerization, Reversible Addition-Fragmentation Chain Transfer (RAFT) Radical Polymerization. Coordination polymerization, Ring-opening polymerization. Thermal and mechanical properties of polymers: Glass transition temperature, melting temperature, Rheological properties, industrial polymers.	**8**
3. Micelles and Colloids: Surface active agents and their classification, micellization, hydrophobic interaction, critical miceller concentration (cmc), factors affecting cmc of surfactants, thermodynamics of micellization, phase separation and mass action models, reverse micelles, solubilization. Stability and properties of colloids. Zeta potential, Sterndouble layer, Tyndall effect.	**7**
Outcomes: After the completion of the course, the students should be able to explain the origin of electrical double layer, different models describing doublelayer and electrical double layer capacitance and their applications. 1. Understand the kinetics of electrode reaction, exchange current density,over potential, transference coefficient, Tafel plot. 2. Know definition of polymer, molecular weight, different type of polymerizationtechniques with emphasis of radical polymerization, their kinetics, thermal and mechanical properties of polymer. 3. Understand the fundamentals of micelles and colloids, CMC, stability and properties ofcolloids, Zeta potential, Stern double layer, Tyndall effect. ***Suggested Books:*** 1. *Modern Electrochemistry*, Vol. 2 A & B, J.O'M. Bockris and A. K. N.Reddy,Plenum Press, New York. 2. F. W. Billmayer, Jr., Text Book of Polymer Science, 3rd Edition (1984),WilleyInterscience, New York. 3. Fundamentals of Polymerization, B. M. Mandal, Illustrated edition (2012), WorldScientific; Singapore. 4. Micelles: Theoretical and Applied Aspects, Y. Moroi, Plenum Press, New York	

CHEMN7R1 (Anal. Chem-III), CHEMN7R2 (Inorg. Chem-V), CHEMN8R1 (Org. Chem- VI) AND CHEMN8R2 (Phys. Chem-VI) ARE NOT MENTIONED IN THE ABOVE LIST

CHEMN7R1: **Analytical Chemistry-III**	
Objectives: To introduce conceptual knowledge of advanced statistical methods, chemical equilibria,and stoichiometry.	
1. **Analytical chemometrics:** Propagation of measurement uncertainties (inaccuracy and imprecision).Useful statistical test: test of significance, the F test, the student 't' test, the chi-test, the correlation coefficient, confidence limit of the mean, comparison of two standard values, comparison of standard deviation with average deviation, comparison of mean with true values, significant figures, regression analysis (least square method for linear and non-linear plots), statistics of sampling and detection limit evaluation. Chemometrics for modeling and parameter estimation, factor analysis, resolution and pattern recognition.	15
2. **Treatment of Equilibria:** Solvents and solutions, general treatment of equilibria in aqueous medium involving, Effect of electrolytes on chemical equilibria, Calculation of pH, Constructing titration curves from charge balance and mass balance equations, Acid-base titrations and theory of pH indicators, Complexation equilibria and complexometric titrations, Redox equilibria and redox titration, Theory of redox indicators, Precipitation reaction and precipitation titrations and theory of adsorption indicators.	8
3. **Spectrophotometric Determination of Stoichiometry of Complexes:** 7Job's method of continuous variation, mole ratio and slope ratio analysis, Advantages and limitations, typical examples.	7
Outcomes: The students will establish knowledge on chemometrics, theory of various titrations, and stoichiometric calculations using instrumental techniques.	
Suggested Books: 1. R. L. Pecsok, L. D. Shields, T. Cairns and L.C. Mc William, Modern Methods of Chemical Analysis, 2nd Edition (1976), John Wiley, New York.	

2.	G. D. Christian, Analytical Chemistry, 5th Edition (1994), John Wiley & Sons, New York.	
3.	D. A. Skoog, D.M. West, F.J. Holler, S.R. Crouch, Analytical Chemistry - An Introduction, 7th Edition (2000), Saunders College Publishing, Philadelphia, London.	
4.	J. H. Kennedy, Analytical Chemistry: Principles, 2nd Edition (1990), Saunders Holt, London.	

CHEMN7R2: Inorganic Chemistry-V	
Objectives: 1. To train students about the illustration of symmetry in complexes and thefundamentals of character tables; and Orgel diagrams of metal complexes. 2. To teach the biological perspectives of important metal ions.	
1. **Symmetry-based concepts of energy level diagrams of metal complexes:** Symmetry elements and operations, determination of point group of a molecule, Group representations, Features of specific character tables in reference to Orgel diagrams, Symmetry-based concepts of Orgel energy level diagrams of metal complexes. Introduction to Tanabe-Sugano diagrams (d2 configuration)	**15**
2. **Bioinorganic chemistry:** Metal ions in biological processes. Biological role of iron. Oxygen transport with reference to hemoglobin and myoglobin. Synthetic model complexes for oxygen transport. Cytochromes and iron-sulfur proteins: Electron Transfer reactions. Photosystems, Role of metalloenzymes. Biological role of alkali metal ions, and their transport with special reference to Na+/K+ ATPase. Vitamin B12. Nitrogen Fixation.	**15**
Outcomes: Students shall be able to 1. Learn the importance of symmetry-based concepts in the field of coordination chemistry. 2. Develop an interdisciplinary approach to metal chemistry with the biological world.	
Suggested Books: 1. Physical Methods in Inorganic Chemistry, R. S. Drago, International Edn. (1971), Affiliated East-West Press, New Delhi. 2. Chemical Applications of Group Theory, F. A. Cotton 3. Inorganic Chemistry, J.E. Huheey, E.A. Keiter and R.L. Keiter, 4th Edn. (1993), Addison-Wesley Pub. Co., New York. 4. Bioinorganic Chemistry, I. Bertini, H. B. Gray, S. J. Lippard, J.S. Valentine, Viva Books, P. Ltd. New Delhi, South Asian Ed., 1998 (Reprint 2004). 5. Principles of Bioinorganic Chemistry, S. J. Lippard, J. M. Berg, University Science Books, California 1994. 6. Bioinorganic Chemistry: Inorganic Elements in the Chemistry of Life, W. Kaim, B.Schwederski, John Wiley & Sons, England, 2004.	

CHEMN8R1: Organic Chemistry-VI	
Objectives: The mechanistic aspects of asymmetric synthesis, pericyclic reactions, and the formationof carbon-carbon bonds in contemporary organic synthesis.	
1. Asymmetric Synthesis: Enolization (Lithium and Boron enolate), Stereoselective Aldol condensation reaction (chiral enolate& achiral aldehyde and achiral enolate and chiral aldehyde). The chiral pool, chiral auxiliaries, chiral catalysts and reagents, and enantiomeric excess.	
2. Pericyclic Reactions: Woodward-Hoffmann rules and molecular orbitals; Electrocylic reactions; Cycloaddition reactions, 1,3-Dipolar cycloaddition and cheletropic reactions; Sigmatropic rearrangements; Group transfer reactions: Ene reactions.	
3. Modern organic synthesis: Retrosynthesis, Umpolung, Domino reactions and functional group interconversion.	
4. Formation of Carbon-Carbon Bonds via Organometallic reagents: Organozinc, Organocopper, and Organoborane reagents, Palladium catalyzed coupling reactions (Heck, Sonogashira, and Suzuki).	
Outcomes: The students will be able to understand 1. the mechanistic details of asymmetric synthesis of some bioactive molecules. 2. C-C Bond formation employing pericyclic reactions and organometallic reagents.mechanistic aspects some functional group interconversion.	

Suggested Books: 1. Clayden, Greeves, Warren and Wothers, Organic Chemistry, Oxford University Press, 2001. 2. Advanced Organic Chemistry-Reactions and Mechanisms 2e"–Maya Shankar Singh & Keshav Raghuvanshi, Pearson Education Pvt. Ltd., 2021 (ISBN 978-93-544- 9078-1) 3. M.B. Smith & Jerry March, March's Advanced Organic Chemistry, 5th Edition (2001), John Wiley & Sons, New York. 4. G. S. Zweifel and M. H. Nantz, Modern Organic Synthesis, (2007), Freeman and Company, New York. 5. S. Kumar, V. Kumar, and S. P. Singh, Pericyclic Reaction; A Mechanistic and Problem-Solving Approach, 1st Edition (2015), Elsevier Inc. 6. T. H. Lowry and K. S. Richardson, Mechanism and Theory in Organic Chemistry, 3rd Edition (1998), Addison – Wesley Longman Inc. (IS Edition). 7. I. Fleming, Pericyclic Reactions, Oxford University Press, Oxford (1999). 8. W. Carruthers an Iain Coldham Modern Methods of Organic Synthesis Cambridge University Press 9. Charles H. Depuy and Orville L Chapman, Molecular reactions and photochemistry, New Delhi: Prentice Hall of India, 1988.	

CHEMN8R2: Phys. Chem-VI	
Objectives: To impart knowledge on different advanced electrochemistry topics (like electrochemical double layer, electrode kinetics and cyclic voltammetry), basic conceptsof polymer chemistry and micelles and colloids.	
1. Advanced Electrochemistry: Metal/Electrolyte interface: OHP and IHP, potential profile across double layer region, potential difference across electrified interface; structure of the double layer: Helmholtz- Perrin, Gouy-Chapman, and Stern models. Butler-Volmer equation under near equilibrium and non-equilibrium conditions, exchange current density, Tafel plot, polarizable and non-polarizable interfaces. Semiconductor (SC)/electrolyte interface: Creation of space charge region, capacity of space-charge, Mott-Schottky plots for n-type and p-type semiconductors, determination of flat-band potential and donor/acceptor densities, application of SC/electrolyte interfacein solar cells, Fuel Cell, Battery. Cyclic voltammetry (CV) technique basics and applications.	**15**
2. Polymer Chemistry: Introduction, Classification of Polymers & Intermolecular forces of Polymers. Different types of molecular weight of polymer, polydispersity Index, Determination of molecular weight of polymers. Thermodynamic Aspects of Polymerization. Mechanism of Living Radical Polymerizations: Nitroxide mediated polymerization (NMP), Metal-catalyzed Living Radical Polymerization, Reversible Addition-Fragmentation Chain Transfer (RAFT) Radical Polymerization. Coordination polymerization, Ring-opening polymerization. Thermal and mechanical properties of polymers: Glass transition temperature, melting temperature, Rheological properties, industrial polymers.	**8**
3. Micelles and Colloids: Surface active agents and their classification, micellization, hydrophobic interaction, critical miceller concentration (cmc), factors affecting cmc of surfactants, thermodynamics of micellization, phase separation and mass action models, reverse micelles, solubilization. Stability and properties of colloids. Zeta potential, Stern double layer, Tyndall effect**.**	**7**
Outcomes: After the completion of the course, the students should be able to 1. Explain the origin of electrical double layer, different models describing double layer and electrical double layer capacitance and their applications. 2. Understand the kinetics of electrode reaction, exchange current density, overpotential, transference coefficient, Tafel plot. 3. Know definition of polymer, molecular weight, different type of polymerization techniques with emphasis of radical polymerization, their kinetics, thermal and mechanical properties of polymer. 4. Understand the fundamentals of micelles and colloids, CMC, stability and properties of colloids, Zeta potential, Stern double layer, Tyndall effect.	
Suggested Books: 1. Modern Electrochemistry, Vol. 2 A & B, J.O'M. Bockris and A. K. N. Reddy,Plenum Press, New York. 2. F. W. Bill mayer, Jr., Text Book of Polymer Science, 3rd Edition (1984), Willey Inter science, New York.	

3.	Fundamentals of Polymerization, B. M. Mandal, Illustrated edition (2012), World Scientific; Singapore.	
4.	Micelles: Theoretical and Applied Aspects, Y. Moroi, Plenum Press, New York	

CHESE11: Quality Control in Chemical Analysis	
Objectives: To train the students with the quality control practices being adopted in the chemical and pharmaceutical industries. The course includes the principles related to statistical handling of data; quality control principles applicable in the laboratories as well as quality management systems including those laid down by the International Standard Organization (ISO).	
1. **Statistical Quality Control Techniques:** Statistical treatment of data, Control charts, Performance Evaluation uncertainties in measurement, Validation of analytical methods, Elements of quality Assurance, Principles of Good Laboratory Practices, Good manufacturing Practices in Drugs and Pharmaceutical Industries, Accreditation of QC laboratories, Tools and Mechanisms ICH Guidelines on Drug substances and Products.	25
2. Quality Management and Standards: Quality Management System(QMS), Quality management concepts and principles: ISO 9001:2000 QMS, Case studies on ISO 9001: 2000 in chemical industries. ISO 14000 Series of Standards. Total Quality Management (TQM) in Chemical Industry. Six Sigma Approach to Quality: Applying Six Sigma to chemical Industries.	20
Outcome: The students will be able to learn the quality control practices and also to apply them.	
Books Recommended: 1. Douglas M. Considine, Handbook of applied instrumentation, McGraw-Hill. 2. George T. Austin, Shreve's Chemical Process Industries, McGraw-Hill. 3. Willing, S.W., & Stoker, Good Manufacturing Practices for Pharmaceuticals,Marcel Dekker, New York. 4. Guarino, R.A., New Drug Approval Process, Marcel Dekker, New York.	

CHESE21: Instrumentation in Chemical Industry	
Objectives: To develop the skills of Chemical Analysis using sophisticated modern equipments to the students Using sophisticated Instruments in Chemical analysis and Characterization. This will enable them to understand the functioning of the equipment and their proper handling for qualitative and quantitative analysis of molecules and materials.	
1. **Thermoanalytical methods:** Thermoanalytical methods: thermogravimetry, factors affecting thermogravimetric curves, derivative thermogravimetry (DTG), thermobalance. Applications of thermogravimetry, differential thermal analysis (DTA), factors affecting DTA curves, instrumentation, and application of DTA. Differential scanning calorimetry (DSC), theory, instrumentation, applications of DSC, thermometric titrations, and principal classification.	15
2. Electrochemical Analysis: Potentiometry – fundamentals, reference electrodes (hydrogen, calomel, silver, and silver chloride electrode).Indicator and ion selective electrode, instrumentation and measurement of cell and emf-conductance and conductometric titrations.	15
3. Structure Analysis: Diffraction Techniques**:** Elementary theory (Neutron. Electron and X-ray diffraction), instrumentation, and applications of X-ray methods (emission, absorption, diffraction, and fluorescence methods). Spectroscopic Techniques: Atomic absorption, Spectroscopy, Atomic emission spectrometry, UV-visible molecular absorption spectrometry, Molecular luminescence spectroscopy (fluorescence, phosphorescence, chemiluminescence).	15
Outcome: The students will learn the theoretical background as well as practical handling of sophisticated instruments used for chemical analysis.	

Books Recommended: 1. H. Willard, L. Merrit, J.A. Dean & F.A. Settle, Instrumental Method of Analysis, 7th Ed. CBS (2006). 2. G. D. Christian, Analytical Chemistry, 5th Ed., John Wiley & Sons, New York (2004). **3.** D.A. Skoog, D.M. West, F.J. Holler, S.R. Crouch, Analytical Chemistry: An introduction, 7th Ed., Saunders College Publishing, Philadelphia, London (2003).	

CHESE31: Synthetic Methodologies	
Objectives: To stay abreast with the present-day chemical synthetic methods and strategies. Synthesisis one of the core topics of chemistry which requires knowledge and skill to handle air/moisture-sensitive compounds. At the same time, there are techniques to use non- aqueous solvents such as liquid ammonia at low temperatures.	
1. **Purification and drying of solvents:** Water and common non-aqueous solvents. Distillation (including fractional distillation and distillation under low pressure). Removal of hazardous impurities from solvents. Drying of non-aqueous solvents.	8
2. Synthesis: Preparation of sodium solution in liquid ammonia and its application. Synthesis andApplications of Grignard Reagent	15
3. Click Chemistry: Regioselectivity in Click Chemistry, CuAAC, RuAAC, Bioorthogonal Chemistry, Organocatalyzed Click, Sufex, Thiol-ene Click, and Their Applications.	15
4. Reduction using metal hydrides	7
Outcome: The students will learn the recent advances including some conventional (but tricky) methods of synthesis. They will be able to handle and perform reactions under an inert atmosphere.	
Books Recommended: 1. Practical Organic Chemistry, A.I. Vogel 2. Click Chemistry, V.K. Tiwari, M. K. Jaisawal, S. Rajkhowa, S.K. Singh, Springer, Singapore, 2024 3. IL Finar Vol. 1 4. E. S. Gould	

CHEMD11: Basic Principles of Chemistry and Its Applications in Daily Life	
Objectives: Chemistry is the central science. By studying chemistry one can find answers of many questions that arise to an inquisitive mind. This course is to be offered to students who are curiousand interested to know the realities of the world in terms of atoms, molecules, materials and their chemical reactions. Further, some light will also be thrown on the chemistry of some materials thatwe come across in our everyday life.	
1. Basic Principles of Chemistry: Atoms, molecules, and their electronic structures. Types of Chemical bonding. Basic concept of Hybridization. Energetics of bond formation, Types of intermolecular/intramolecular forces, and molecular association for the formation of materials.	10
2. Chemical Reactions: Thermodynamic basis of chemical changes. Enthalpy, entropy, andfree energy change during a chemical reaction. Types of Chemical Reactions. The conceptof oxidation number, Reducing and oxidizing agents.	10
3. Applications of Chemistry in daily life : a) Dyes and pigments: General idea about the chemistry of dyes, Classification of dyes, Origin of the colors in the dyes and pigments, and application in garment and printing industries. b) Polymers: Natural and synthetic polymers, synthesis, properties, and applications. (Examples: polyester, rubber, nylon, bakelite, etc). Introduction to biopolymers. Application of synthetic polymers in surgical treatments and transplantations. c) Food and beverage industry: use of preservatives, food adulteration, flavor enhancers, artificial sweetening agents, and antioxidants. d) Fragrance: Basic principles, types of fragrances, and their applications. e) Cleansing agents: Soaps, detergents, Surfactants, and underlying chemistry of cleansing agents.	25

4. Reduction using metal hydrides	
Outcome: The learners of this course will find answers to several fundamental questions about molecules, materials and their chemical reactivity. They will also gain knowledge about several substances, such as polymers, pigment & dyes, fragrance, cleansing agents etc. that are commonlyused in our daily life.	
Books Recommended: 1. Basic Inorganic Chemistry, F. A Cotton, G. Wilkinson, and Paul L. Gaus, 3rd Edition (1995), John Wiley & Sons, New York. 2. Concise Inorganic Chemistry, J. D. Lee, 5th Edition (1996), Chapman & Hall, London. 3. Principle of Physical Chemistry, B. R. Puri, L. R. Sharma and M. S. Pathania, Vishal Publishing Co., New Delhi. 4. Physical Chemistry, P. W. Atkins, 8th Ed., Oxford University Press, New York. 5. Textbook of Physical Chemistry, K.L. Kapoor, vol. 1, Macmillan India Ltd, New Delhi. 6. Hall, A.J. (Eighth Edition) The Standard Hand Book of Textiles Buttor Worth. London. 7. Clark, W. An Introduction to Textile Printing , Buttor Worth, London, 3rd Edition, 1971. 8. The Chemistry and Application of Dyes - D. R. Waring and G. Hallas, Springer, 1990. 9. Introduction to polymer chemistry, R. Seymour, Wiley –Interscience (1981) 10. Darrell D. Ebbing and Mark S. Wrighton, 5th Edition 1998, A.I.T.B.S. Publishers & Distributors (Regd.) J-5/6 Krishna Nagar, Delhi-110051 (INDIA) 11. Pearson D; "Chemical Analysis of Food", Chemical Publ. Co. New York, 1971. 12. Fragrance chemistry: The Science of the sense of smell, edited by Ernst T. Theimer, Rumson, New Jersey, Academic Press, 1982, New York London.	

CHEMD21: Energy & Metallurgy	
Objectives: Chemistry is the central science. By studying chemistry one can find answers of many questions that arise to an inquisitive mind. This course is to be offered to the students who are curious and interested to know realities of the world in terms of energy and its utilization. Howsolar energy is used by the plants and how we can manage various energy sources. Further, somelight will also be shed on the importance of metals and chemistry of metal extraction.	
1. Photosynthesis: Introduction- a key process for life on earth, Light reaction, Dark reaction, Factors affecting photosynthesis, Photorespiration, artificial photosynthesis. **2. Energy Sources and storage:** Introduction to renewable (green) and non-renewable sources of energy. Requirement and consumption of energy in India. Worldwide potential of these sources.	8
Understanding (i) Definition (ii) source (iii) advantages/disadvantages (iv) environmental aspects (v) future scope/sustainability along with specific attributes of each of the following types: **Non-Renewable:** a) Thermal-Oil, natural gas, and coal Oil - Origin, composition, specification, and characteristics of petroleum products Natural gas - Classification (natural and synthetic gas), Natural gas reserves - India and World Coal: Coal reserves- India and World, Origin, composition, Action of heat on coal, Coal derived chemicals Nuclear energy - Radioactivity, Different types of radiation, Nuclear fission, Basic components of Nuclear power reactor. **Renewable:** a) Solar energy - Importance, storage, applications (solar cooker, solar weather heater, solar greenhouses, solar cell, absorption air conditioning) b) Biomass energy - biomass conversion, biogas generation (types of plants needed, plant wastes, materials), Utilisation of biogas, energy farming (biomass production for energy) c) FuelCell Li-ion battery	27
3. Metals and Metallurgy: Role of metals in our life with special mention of Iron and Copper, Recovery of Iron and copper from its ores, Stainless Steel, corrosion of metals, and its prevention.	10
Outcome: The modern life is highly dependent on availability of energy. With limited resources of fossil fuels need for alternative sources have become evident. The students will be able to learnthe present senario about the conventional energy sources, their limitations and problems. The students will be made aware of the alternative sources of energy which have already been part of our life to some extent and are going to be very important in coming years.	
1. G.W. Vanloon, S.J. Duffer, Environmental Chemistry- A Global Perspective, OxfordUniversity Press (2000). 2. A.K. De, Environmental Chemistry, 4th Edition (2000), New Age International Private Ltd.,New Delhi. 3. Non-conventional energy sources - G.D. Rai - Khanna Publishers, New Delhi	

4. Godfrey Boyle, “Renewable Energy, Power for a sustainable future”, 2004, Oxford UniversityPress, in association with The Open University.
5. Vladimir Strezov, Hossain Md. Anawar, Renewable Energy Systems From Biomass:Efficiency, Innovation and Sustainability, 1st Edition.
6. S.P. Sharma & Chander Mohan, “Fuels & Combustion”, Tata McGraw Hill PublishingCo.Ltd.,1984
7. Sarkar S. (2010); Fuels and Combustion, Third Edition, CRC Press
8. “Photosynthesis” - J. J. Eaton-Rye, B. C. Tripathy, T. D. Sharkey , Springer, 2012.
9. Colin Baird, Environmental Chemistry, W.H. Freeman and Company, New York (1995).

CHEMD31: Environmental Chemistry	
Objectives: Sustainable development is one of the most important challenges to the human civilization today. Indiscriminate use of natural resources, such as fossil fuels has polluted not onlythe air, soil and water bodies near to us but also has damaged the outer atmosphere. This course will throw light on various aspects of environmental chemistry, Pollution and its causes and also potential remedies with an idea of sustainable development.	
1. Introduction: Concept and scope of environmental chemistry, Pollution versus contamination, Receptor, Sink, and pathways of a pollutant. Terminology (DO, BOD, COD, TLV) used in environmental analysis and their estimation.	7
2. Environmental Segments: Atmosphere- Regions of atmosphere, Carbon Footprint, Greenhouse effect, and Global warming, ozone hole. Hydrosphere- Microorganisms in aquatic chemical reactions, eutrophication versus oligotrophication. Lithosphere- Soil profile, soil properties, organic and inorganic components of soil, micro- andmacro-nutrients Biosphere.	22
3. Natural cycles of the environment: Hydrological cycle, oxygen cycle, nitrogen cycle, phosphate cycle, and sulfur cycle.	6
4. Pollution: Sources of air pollution, Auto exhaust emission, and its prevention. Air quality parameters, ELNino phenomenon, Water pollution, Acid rains, Waste–water treatment: domestic and industrial effluents. Water quality parameters. Recent environmental concerns in the national and global context.	10
Outcome: After studying this course the students will be able to understand the various causes of pollution, how these can be minimized. How can scientific and industrial development go ahead without disturbing the natural balance so that not only human beings but also other flora and faunacan survive on this earth?	
Text Books: 1. Environmental Chemistry A.K. De, 3rd edition (1994), Willey Eastern, New Delhi. 2. Collin Baird, Environmental Chemistry, 4th edition (2000), New age international Private Ltd.,New Delhi. 3. G. W. Vanloon, S. J. Duffer, Environmental Chemistry – A Global Perspective, Oxford University Press (2000).	

BANARAS HINDU UNIVERSITY

Department of Computer Science

Faculty of Science

SYLLABI

B.Sc. (Hons.) Programme

In

Computer Science

Banaras Hindu University
B.Sc. (four Years) Computer Science Course Curriculum as per NEP-2020

I Semester

* *Pre-requisite: Computer Science/Information Technology/Mathematics at 10+2 level*

Code	Title	T	P	C	Course Category
CSCMJ11	Introduction to Programming using C	3	1	4	Major/Minor
CSCSE11	Web Designing*	2	1	3	SEC-1
	From outside the Department	-	-	4	Minor
	From outside the Department	-	-	3	MDC-1
	From outside the Department	-	-	4	VAC-1
	From outside the Department	-	-	2	AEC-1
Total Credits				**20**	
CSCMD11	Fundamentals of Computing	3	0	3	MDC-1

II Semester

Code	Course Title	T	P	C	Course Category
CSCMJ21	Data Structures and Algorithms	3	1	4	Major/Minor
CSCSE21	Mobile Application Development*	2	1	3	SEC-2
	From outside the Department	-	-	4	Minor
	From outside the Department	-	-	3	MDC-2
	From outside the Department	-	-	2	VAC-2
	From outside the Department	-	-	2	VAC-3
	From outside the Department	-	-	2	AEC-2
Total Credits				**20**	
CSCMD21	Introduction to Information Technology	3	0	3	MDC-2

* *Pre-requisite: Computer Science/Information Technology/Mathematics at 10+2 level*

III Semester

Code	Course Title	T	P	C	Course Category
CSCMJ31	Digital Logic and Circuit Design	3	1	4	Major
CSCMJ33	Object Oriented Programming	3	1	4	Major
CSCSE31	Python Programming*	2	1	3	SEC-3
	From outside the Department	-	-	2	AEC-3
	From outside the Department	-	-	4	Minor (VOC-1)
	From outside the Department	-	-	3	MDC-3
Total Credits				**20**	
CSCMV31	IT Tools and Applications	3	1	4	Minor (VOC-1)
CSCMD31	Introduction to Cyber Security	3	0	3	MDC-3

* *Pre-requisite: Computer Science/Information Technology/Mathematics at 10+2 level*

IV Semester

Code	Course Title	T	P	C	Course Category
CSCMJ41	Mathematics for Computer Science	3	0	3	Major
CSCMJ42	Database Management System	3	1	4	Major
CSCMJ44	Computer Organization	3	0	3	Major
CSCMJ45	Numerical Computing	3	1	4	Major/Minor
	From other Departments	-	-	4	Minor
	From other Departments	-	-	2	AEC-4
Total Credits				**20**	

V Semester

Code	Course Title	T	P	C	Course Category
CSCMJ51	Operating System Concepts	3	1	4	Major
CSCMJ53	Design and Analysis of Algorithms	3	1	4	Major
CSCMJ55	Theory of Computation	4	0	4	Major
CSCMJ56	Swayam Course *The course must be selected with dept approval.*	-	-	2	Major
CSCIN51	Internship	-	-	2	Internship
	From other Departments	-	-	4	Minor(VOC-2)
Total Credits				**20**	
CSCMV51	Introduction to Multimedia	3	1	4	Minor(VOC-2)

VI Semester

Code	Course Title	T	P	C	Course Category
CSCMJ61	Software Engineering	4	0	4	Major
CSCMJ62	Compiler Design	3	1	4	Major
CSCMJ64	Computer Networks	3	1	4	Major
CSCMJ66	Artificial Intelligence	3	1	4	Major
	From other Departments	-	-	4	Minor(VOC-3)
Total Credits				**20**	
CSCMV61	Data Analysis and Visualization	3	1	4	Minor(VOC-3)

VII Semester (Honours/Research)

Code	Course Title	T	P	C	Course Category
CSCMJ71	Machine Learning	3	1	4	Major/Minor
CSCMJ73	Research Methodology	2	0	2	Major
Electives (Any Two)					
CSCMJ75	Operations Research	3	1	8	Major
CSCMJ76	Cloud Computing	3	1		
CSCMJ77	Soft Computing	3	1		
CSCMJ78	Network Security and Cryptography	3	1		
CSCMJ79	Heuristics & Metaheuristics	3	1		
CSCMJ7R8	Knowledge & Data Discovery	3	1		
CSCMJ7R9	Distributed Systems	3	1		
CSCMJ7R10	Parallel Computing	3	1		
CSCMJ7R11	Image Processing	3	1		
CSCMJ7R12	Swayam Course *The course must be selected with dept approval.*	-	-	2	Major
	From other departments	-	-	4	Minor
Total Credits				**20**	

VIII Semester

Code	Course Title	T	P	C	Course Category
CSCMJ81	Deep Learning	3	1	4	Major/Minor
Electives (Any two)					
CSCMJ82	Internet of Things	3	1	8	Major
CSCMJ83	Blockchain Technology	3	1		
CSCMJ84	Information Retrieval	3	1		
CSCMJ85	Statistical Pattern Recognition	3	1		
CSCMJ86	Image Analysis and Computer Vision	3	1		
CSCMJ87	Natural Language Processing	3	1		
CSCMJ88	Data Compression	3	1		
CSCMJ89	Mobile Adhoc Networks	3	1		
CSCMJ810	Big Data Analytics	3	1		
CSCMJ811	Quantum Computing	3	1		
CSCMJ812	Swayam Course *The course must be selected with dept approval.*	-	-	4	*Major*
	From other departments	-	-	4	Minor
	Total Credits			**20**	

VIII Semester (Research)

Code	Course Title	T	P	C	Course Category
CSCMJ8R1	Deep Learning	3	1	4	Major/Minor
CSCDS8R1	Project/Dissertation	-	-	12	
	From other departments	-	-	4	Minor
	Total Credits			**20**	
The students from Computer Science Major may have choice to choose any one of the following in place CSCMJ8R1					
CSCMJ8R2	Internet of Things	3	1	4	Major
CSCMJ8R3	Block chain Technology	3	1		
CSCMJ8R4	Information Retrieval	3	1		
CSCMJ8R5	Statistical Pattern Recognition	3	1		
CSCMJ8R6	Image Analysis and Computer Vision	3	1		
CSCMJ8R7	Natural Language Processing	3	1		
CSCMJ8R8	Data Compression	3	1		
CSCMJ8R9	Mobile Adhoc Networks	3	1		
CSCMJ8R10	Big Data Analytics	3	1		
CSCMJ8R11	Quantum Computing	3	1		

T→*stands for number of lecture hours per week*

P→*stands for number of Practical hours per week*

C→*stands for Total credit per week*

Semester-I

CSCMJ11	Introduction to Programming using C	Theory	Practical	Cumulative
		3	1	4
Major/Minor		45	30	75

Course Objectives

- The course aims to provide exposure to problem-solving through programming.
- It aims to train the student to the basic concepts of the C-programming language.
- Students will learn to develop simple algorithms and flow charts to solve a problem.
- Students will be able to develop logics which will help them to create programs, applications in C.
- By learning the basic programming constructs they can easily switch over to any other language in future.
- This course involves a lab component which is designed to give the student hands-on experience with the concepts.

Syllabus

Units	Course Content	Hr. of Teaching
I	Introduction to Programming, Program Concept, Characteristics of Programming, Stages in Program Development, Algorithms, Flowcharts, Types of Programming Methodologies, Introduction to C Programming Basic Program Structure in C, Variables and Assignments, Input and Output, Selection and Repetition Statements.	15
II	User defined functions, Standard library functions, Passing values between functions, Calling convention: Call by value and Call by reference, Recursive functions. Introduction to Arrays, Declaration and Referring Arrays, Arrays in Memory, Initializing Arrays. Arrays in Functions, Multi-Dimensional Arrays.	10
III	Introduction to String, Declaration and Initialization, Reading and Writing Strings, Arrays of Strings, String and Function, Standard String Library Functions. Basics of Pointers, Pointers and One-dimensional Arrays, Pointer Arithmetic, Pointers as Function Arguments, Pointers and Strings, Pointers and two-dimensional arrays, Arrays of Pointers, Storage Classes.	10
IV	Basics of Structures, Structures and Functions, Arrays of Structures, Pointers to Structures, Unions, Preprocessor, File Inclusion, Macro, Conditional Compilation, Dynamic Memory Allocation, Command Line Arguments, File Handling.	10

Texts / References Books

1. Kernighan, B.W. and Ritchie, D.M., The C Programming Language, PHI.
2. Kanetkar, Y., Let Us C, BPB Publications.
3. Balagurusamy,E., Programming in ANSI C, McGraw-Hill.

Learning Outcomes

After the completion of this course the students will be able to:

- Apply problem-solving knowledge and skills to write small, well-documented, effective C programs.
- Choose the right data representation formats based on the requirements of the problem.
- Able to write simple programs in the corresponding programming language to solve a task, given the constraints on the inputs.
- Able to manually trace through a program to identify logical errors;
- Able to differentiate between logical errors, syntax errors, and run-time errors.
- Able to write code following good programming style (clear comments, naming convention, indentation, etc.)

CSCSE11	Web Designing	Theory	Practical	Cumulative
		2	1	3
SEC		30	30	60

Course Objectives

- Learn to create visually appealing and user-friendly websites using HTML, CSS, and JavaScript, focusing on design principles, layout techniques, and responsive design.
- Develop skills in integrating advanced features and frameworks, such as interactive elements and backend integration, to build functional and dynamic web applications.

Syllabus

Units	Course Content	Hr. of Teaching
I	HTML: Overview, Basic Tags, Elements, Attributes, Formatting, Phrase Tags, Meta Tags, Comments, Images, Tables, Lists, Text Links, Image Links, Email Links, Frames, Iframes, Blocks, Backgrounds, Colors, Fonts, Forms, Embed Multimedia, Marquees, Style Sheet, Layouts.	8
II	CSS: Overview, Syntax, Inclusion, Measurement Units, Colors, Background, Fonts, Text, Images, Links, Tables, Borders, Margins, Lists, Paddings, Cursors, Outlines, Dimension, Scrollbars, Visibility, Positioning, Layers, Filters, Media, Printing, Layouts, Validations	8
III	JAVASCRIPT: Overview, Syntax, Enabling, Placement, Variables, Operators, If-Else, Switch-Case, While Loop, For Loop, For-in Loop, Loop Control, Functions, Events, Cookies, Page Redirect, Dialog Box, Void Keyword, Page Printing, Objects, Number, Boolean, String, Arrays, Date, Math, Errors and Exceptions, Form Validation, Animation, Multimedia	7
IV	PHP: Introducing PHP, Using Variables and Operators, Controlling Program Flow, Working with Arrays, Using Functions and Classes, Working with Files and Directories, Working with Databases and SQL, Working with XML, Working with Cookies, Sessions, and Headers, Handling Errors, Securing PHP, Extending PHP.	7

Texts / References Books

1. Powell, T. A. ,HTML & CSS: The Complete Reference.
2. Goodman, D., Morrison, M., Novitski, P., Rayl, T. G., JavaScript Bible.
3. Vaswani, V., PHP: A Beginner's Guide.

Learning Outcomes

- Create visually appealing and responsive web pages using HTML, CSS, and JavaScript, ensuring optimal user experience across various devices and screen sizes.
- Utilize design principles and best practices to develop intuitive layouts, navigation, and user interfaces that enhance usability and accessibility.
- Implement interactive features and advanced web technologies, such as front-end frameworks and APIs, to build dynamic and functional web applications.

CSCMD11	Fundamentals of Computing	Theory	Practical	Cumulative
		3	0	3
MD		45	0	45

Course Objectives

- Core Concepts Mastery: Introduce students to the fundamental principles and concepts of computing, including algorithms, data structures, and software design.
- Programming Proficiency: Develop basic programming skills and logical thinking through hands-on experience with a programming language.
- Computational Thinking: Foster computational thinking to solve problems systematically and efficiently.
- Software Development Insight: Provide an understanding of the software development lifecycle and best practices in software engineering.
- Ethical and Social Awareness: Instill awareness of the ethical, social, and professional issues related to computing.

Syllabus

Units	Course Content	Hr. of Teaching
I	Introduction to Computers: Characteristics of Computers, Evolution of Computing, Introduction to Computer Hardware/Software, Binary Number Systems, Types of Computer Software.	10
II	Problem Solving Techniques using Computers: Algorithm, Flow Charts, Pseudo code, Introduction to Low-Level, Assembly and High-Level Languages.	10
III	Introduction to Operating System: Concept, Functions, Types, Single-user/Multi-user operating system, Architectural differences Introduction to Memory: Memory Hierarchy and Management, Cache Memory, Primary Memory, Secondary Memory.	15
IV	Introduction to Computer Networks, Internet, World Wide Web: Basic of Computer networks; LAN, WAN; Concept of Internet; Applications of Internet; connecting to internet; What is ISP; Knowing the Internet; World Wide Web; Web Browsing software, Search Engines; Understanding URL; Domain name; IP Address.	10

Texts / References Books

1. Balagurusamy, E., Computing Fundamentals & C programming, TMH.
2. Godse, A. P., Godse, D. A. ,Fundamental of Computing and Programming (Technical Publications).

Learning Outcomes

- Conceptual Understanding: Students will comprehend core computing concepts such as algorithms, data structures, and programming paradigms.
- Programming Skills: Students will be able to write, debug, and maintain simple programs in a programming language.
- Problem-Solving Ability: Students will apply computational thinking and algorithmic approaches to solve problems.
- Software Development Knowledge: Students will understand the stages of software development and the importance of testing and documentation.
- Ethical Awareness: Students will demonstrate an understanding of the ethical and societal impacts of computing technologies and practices.

Semester–II

CSCMJ21	Data Structures and Algorithms	Theory	Practical	Cumulative
		3	1	4
Major/Minor		45	30	75

Course Objectives

- Understanding Fundamental Concepts: Grasp the key principles of data structures and their importance in computer science.
- Implementation Skills: Learn to implement various data structures such as arrays, linked lists, stacks, queues, trees, and graphs.
- Algorithm Efficiency: Analyze the efficiency of data structures and algorithms using Big O notation.
- Problem-Solving Techniques: Develop problem-solving skills through the application of data structures in various algorithmic challenges.
- Real-World Applications: Explore the practical applications of data structures in software development and system design.

Syllabus

Units	Course Content	Hr. of Teaching
I	Defining a Data Structure: Types of Data Structures. Linear Structures: Array, List, Stack, Queue, Applications of arrays, lists, stacks and queues.	13
II	Non-Linear Data Structures: Tree, Tree Traversals, Binary Tree, Applications of Trees, Binary Search Tree, Graph, Shortest Path, Spanning Tree, Hashing and Collision Resolution Techniques.	12
III	Introduction to Algorithm Analysis and Design: Time Complexity Analysis, Asymptotic Notations, Introduction to Design Techniques such as Greedy, Divide and Conquer, Dynamic Programming, Backtracking, Branch and Bound.	10
IV	Searching and Sorting: Linear Search, Binary Search, Bubble Sort, Selection Sort, Insertion Sort and Quick Sort.	10

Texts / References Books

1. Horowitz,E. , Sahani, S., Anderson-Freed, S., Fundamentals of Data Structures in C, Universities Press.
2. Tennenbaum, A. M., Langsam, Y. and Augenstein, M. J., Data Structures using C, PHI.
3. Knuth, D. E. ,The Art of Computer Programming (Volume I), Pearson.
4. Cormen, T. H. et al., Introduction to Algorithms, PHI.

Learning Outcomes

- Proficient in Data Structures: Ability to choose and implement the appropriate data structure for a given problem.
- Enhanced Coding Skills: Improved coding proficiency through hands-on programming assignments.
- Analytical Skills: Enhanced ability to analyze algorithm performance and optimize solutions.
- Foundation for Advanced Topics: Establish a solid foundation for further studies in algorithms, databases, and software engineering.

CSCSE21	Mobile Application Development	Theory	Practical	Cumulative
		2	1	3
SEC		30	30	60

Course Objectives

- Foundational Knowledge: Understand mobile development principles, platforms, and user experience design.
- Technical Proficiency: Gain hands-on experience with key programming languages and frameworks for Android.
- App Integration: Learn to integrate mobile applications with backend services and APIs, focusing on data management.
- Testing and Deployment: Develop skills in testing, debugging, and deploying apps to app stores, along with understanding current trends in mobile technology.

Syllabus

Units	Course Content	Hr. of Teaching
I	Introduction to Android: The Android Platform, Android SDK, Eclipse Installation, Android Installation, Building you First Android application, Understanding Anatomy of Android Application, Android Manifest file	8
II	Android Application Design Essentials: Anatomy of an Android applications, Android terminologies, Application Context, Activities, Services, Intents, Receiving and Broadcasting Intents, Android Manifest File and its common settings, Using Intent Filter, Permissions.	8
III	Android User Interface Design Essentials: User Interface Screen elements, Designing User Interfaces with Layouts, Drawing and Working with Animation. Testing Android applications, Publishing Android Application, Using Android preferences, Managing Application resources in a hierarchy, working with different types of resources.	7
IV	Using Common Android APIs: Using Android Data and Storage APIs, Managing data using Sqlite, Sharing Data between Applications with Content Providers, Using Android Networking APIs, Using Android Web APIs, Using Android Telephony APIs, Deploying Android Application to the World.	7

Texts / References Books

1. Darcey, L. and Conder, S., Android Wireless Application Development, Pearson Education, 2nd ed. (2011).
2. Meier, R., Professional Android 2 Application Development, Wiley India Pvt Ltd.
3. Murphy, M. L., Beginning Android, Wiley India Pvt Ltd.
4. Burd, B., Android Application Development All in one for Dummies, Edition: I.

Learning Outcomes

After successful completion of this course, the students will be able to:

- Understand about the mobile application market and web services for various mobile devices.
- Understand about the various Mobile Information Design, design Tools, Mobile Platforms and Mobile Web Option.
- Design the User interface with various features of Android SDK like displaying pictures, menus etc.
- Utilize the messaging, networking and location based service in Android application
- Create, Debug and build the apps.

CSCMD21	Introduction to Information Technology	Theory	Practical	Cumulative
		3	0	3
MD		45	0	45

Course Objectives

- Fundamentals Understanding: Provide students with a solid foundation in the basic concepts and principles of information technology, including hardware, software, and networking.
- Technological Literacy: Develop technological literacy by familiarizing students with current IT tools and practices.
- Problem-Solving Skills: Enhance problem-solving skills by teaching students how to apply IT solutions to real-world problems.
- Digital Citizenship: Promote responsible digital citizenship by educating students about ethical and legal issues related to IT.
- Practical Skills: Equip students with practical skills in using software applications, such as word processing, spreadsheets, and databases.

Syllabus

Units	Course Content	Hr. of Teaching
I	Introduction to Computers: Introduction, Definition, Characteristics of computer, Evolution of Computer, Capabilities and limitations of computer. Basic Computer Organization: Role of input-output devices in a computer system. Input Units: Keyboard, Terminals and its types. Pointing Devices, Scanners and its types, Voice Recognition Systems, Vision Input System, Touch Screen, and Output Units: Monitors and its types. Printers: Impact Printers and its types. Non Impact Printers and its types, Plotters, types of plotters, Sound cards, Speakers.	10
II	Storage Fundamentals: Primary Vs Secondary Storage, Data storage & retrieval methods. Primary Storage: RAM, ROM, PROM, EPROM, EEPROM. Secondary Storage: Magnetic Tapes, Magnetic Disks. Cartridge tape, hard disks, Floppy disks Optical Disks, Compact Disks, Zip Drive, Flash Drives. Software (S/W): Software and its needs, Types of S/W. System Software: Operating System, Utility Programs Programming Language: Machine Language, Assembly Language, High Level Language their advantages & disadvantages. Application S/W and its types: Word Processing, Spread Sheets Presentation, Graphics, DBMS S/W.	10
III	Operating System: Functions, Measuring System Performance, Assemblers, Compilers and Interpreters. Batch Processing, Multiprogramming, Multi Tasking, Multiprocessing, Time Sharing, DOS, Windows, Unix/Linux. Data Communication: Communication Process, Data Transmission speed, Communication Types (modes), Data Transmission Medias, Modem and its working, characteristics, Types of Networks, LAN Topologies, Computer Protocols, Concepts relating to networking.	15
IV	Business Data Processing: Introduction, data storage hierarchy, Method of organizing data, File Types, File Organization, File Utilities.Computer Arithmetic: Binary, Binary Arithmetic, Number System: Positional & Non Positional, Binary, Octal, Decimal, Hexadecimal, Converting from one number system to another, Converting from one number system to another , Converting from one number system to another.	10

Texts / References Books

1. Rajaraman, V., Fundamentals of Computers, PHI.
2. Fox, R., Information Technology, Chapman and Hall/CRC.
3. Sinha, P. K., & Sinha, P., Computer fundamentals. BPB publications.

Learning Outcomes

- Knowledge Acquisition: Students will understand the fundamental components and functions of computer systems and networks.
- Skill Development: Students will be able to effectively use common software applications for personal, academic, and professional tasks.
- Analytical Ability: Students will be able to analyze and solve basic IT-related problems.
- Ethical Awareness: Students will demonstrate awareness of ethical, privacy, and security issues in IT.
- Career Readiness: Students will be prepared for further studies or entry-level positions in IT fields, equipped with a foundational understanding of technology's role in various industries.

Semester III

CSCMJ31	Digital Logic and Circuit Design	Theory	Practical	Cumulative
		3	1	4
Major		45	30	75

Course Objectives

- To provide a foundational understanding of digital logic and Circuit design.
- To learn number systems, Boolean algebra, logic gates, and Boolean function simplification using Karnaugh maps and the tabulation method.
- To design and analyze combinational circuits, such as adders, subtractors, encoders, and multiplexers.
- To design and analyze sequential circuits like flip-flops, counters, and shift registers.

Syllabus

Units	Course Content	Hr. of Teaching
I	Number System: Weighted and Unweighted Codes, Binary, Octal, and Hexadecimal numbers; Fixed and Floating Point Number Representations, number base conversion, Complements, Binary Arithmetic: Addition, Subtraction, Multiplication and Division, BCD Code.	10
II	Boolean algebra and Logic Gates: Introduction to Boolean algebra, laws of Boolean algebra, logic gates, universal logic gates, POS and SOP notations, Canonical logic forms. Simplification of Boolean Functions: Laws of Boolean algebra and K-Maps, Tabulation Method.	12
III	Combinational Circuits: Design Procedure of Combinational Circuits, Adders, Subtractors, Code Converters, Magnitude Comparator, Encoder, Decoder, Multiplexer, Demultiplexer, ROM.	12
IV	Sequential Circuits: Flip-Flops: SR, D, JK, T, Master/Slave F/F, Edge-trigerred F/F, Excitation Tables; Registers, Counters: synchronous and asynchronous, Design of Counters, Shift Registers, RAM.	11

Texts / References Books

1. Mano, M. M. Digital logic and computer design. PHI.
2. Mano, M. M., &Kime, C. R..Logic and computer design fundamentals. Pearson.
3. Malvino, A., & Leach, D. Digital principles and applications. McGraw-Hill.
4. Bartee, T. C. Digital computer fundamentals. McGraw-Hill.

Learning Outcomes

After completion of this course the students will be able to:

- Gain proficiency in understanding and converting between number systems such as binary, octal, and hexadecimal, and performing binary arithmetic operations.
- Master the principles of Boolean algebra and logic gates, and simplify Boolean functions using Karnaugh maps and the tabulation method.
- Develop skills in designing and analyzing combinational circuits, including adders, subtractors, encoders, decoders, multiplexers, etc.
- Understand and design sequential circuits, including various types of flip-flops, counters, and shift registers.
- Acquire competencies essential for creating efficient digital systems, crucial for developing modern electronics, computers, and embedded systems used in various practical applications in today's technology-driven world.

CSCMJ44	Object Oriented Programming	Theory	Practical	Cumulative
		3	1	4
Major		45	30	75

Course Objectives

- OOP Principles: Introduce the fundamental principles of object-oriented programming (OOP) and how they are implemented in Java.
- Java Syntax and Semantics: Teach students the syntax and semantics of the Java programming language.
- Design and Implementation: Develop skills in designing and implementing robust, reusable, and maintainable software using Java.
- Problem-Solving with OOP: Enhance problem-solving abilities by applying OOP concepts to real-world scenarios.
- Software Development Practices: Instill best practices in software development, including debugging, testing, and documentation.

Syllabus

Units	Course Content	Hr. of Teaching
I	Object Oriented Concepts: Objects and Classes, Bottom up approach, OO design principles, OO Design and Modeling.	8
II	Basic OO language Constructs: Primitive Data Types and Operations, Selection Statements, Loops, Arrays, Strings, Objects and Classes, Inheritance and method overriding, Polymorphism.	15
III	Java Language Fundamentals: Object Design: constructors, instance variables, methods. Memory models, scope, streams and I/O programming, Inner classes, Interfaces and packages, Exception Handling, Multithreading.	15
IV	Advanced Concepts: Creating GUIs and Displaying Data, Event Driven Programming. Frameworks: The framework concept, Frameworks in the Java API: Collections Framework, Graphics Framework.	7

Texts / References Books

1. Wu, C. T. An introduction to object oriented programming with JAVA. McGraw Hill.
2. Balagurusamy, E. Programming with Java. TMH.
3. Eckel, B. Thinking in Java. Pearson.
4. Schildt, H. Java: The complete reference. McGraw Hill Education.
5. Deitel, H., & Deitel, P. Java 9 for programmers. Pearson

Learning Outcomes

- Understanding OOP: Students will understand and apply the core concepts of object-oriented programming, such as classes, objects, inheritance, polymorphism, and encapsulation.
- Java Proficiency: Students will be proficient in writing, compiling, and executing Java programs.
- Design Skills: Students will be able to design and develop object-oriented software solutions for complex problems.
- Code Quality: Students will produce code that is modular, well-documented, and adheres to industry standards.
- Project Experience: Students will complete projects that demonstrate their ability to apply Java and OOP concepts to build functional applications.

CSCSE31	Python Programming	Theory	Practical	Cumulative
		2	1	3
SEC		30	30	60

Course Objectives

- Master Python syntax, data structures, functions, and object-oriented programming to write, debug, and optimize code effectively.
- Solve real-world problems by using Python for tasks like data analysis, file manipulation, and automation, leveraging libraries and frameworks.

Syllabus

Units	Course Content	Hr. of Teaching
I	Introduction to Computers and Programming: Introduction, Hardware and Software, How Computers Store Data, How a Program Works, Python Installation, Input, Processing, and Output: Displaying Output with the print Function, Comments, Variables, Reading Input from the Keyboard, Performing Calculations, More About Data Output.	8
II	Decision Structures and Boolean Logic: The if Statement, The if-else Statement, Comparing Strings, Nested Decision Structures and the if-elif-else Statement, Logical Operators, Boolean Variables. Repetition Structures: Introduction to Repetition Structures, The while Loop: A Condition-Controlled Loop, The for Loop: A Count-Controlled Loop, Calculating a Running Total, Sentinels, Input Validation Loops, Nested Loops	8
III	Functions: Introduction to Functions, Defining and Calling a Void Function, Designing a Program to Use Functions, Local Variables, Passing Arguments to Functions, Global Variables and Global Constants, Introduction to Value-Returning Functions: Generating Random Numbers, Writing Your Own Value-Returning Functions, Recursion, The math Module, Storing Functions in Modules Lists and Tuples: Sequences, Introduction to Lists, List Slicing, Finding Items in Lists with the in Operator, List Methods and Useful Built-in Functions, Copying Lists, Processing Lists, Two-Dimensional Lists, Tuples, Plotting List Data with the matplotlib Package.	7
IV	More About Strings:Basic String Operations, String Slicing, Testing, Searching, and Manipulating Strings. Dictionaries and Sets: Dictionaries, Sets, Serializing Objects. Files and Exceptions: Introduction to File Input and Output, Using Loops to Process Files, Processing Records, Exceptions Object-Oriented Programming:Procedural and Object-Oriented Programming, Classes, Working with Instances, Techniques for Designing Classes, Introduction to Inheritance, Polymorphism.	7

Texts / References Books

1. Gaddis, T. Starting out with Python.
2. Dierbach, C.Introduction to computer science using Python.
3. Chun, W. J. Core Python programming

Learning Outcomes

- Develop basic programs using fundamental structures.
- Create programs using various collection data types.
- Apply appropriate Python control flow structure.
- Implement user defined python functions.
- Understand the objected oriented concepts of Python.

CSCMV31	IT TOOLS AND APPLICATIONS	Theory	Practical	Cumulative
		3	1	4
Voc		45	30	75

Course Objectives

- Fundamental Understanding: Acquire a solid foundation in essential IT tools and applications used in various business environments.
- Tool Proficiency: Develop practical skills in widely-used software applications, including productivity suites, project management tools, and collaboration platforms.
- Problem-Solving Skills: Enhance critical thinking and problem-solving abilities by applying IT tools to real-world scenarios and case studies.
- Technology Integration: Understand how to integrate different IT tools and applications to improve efficiency and streamline workflows in organizational settings.

Syllabus

Units	Course Content	Hr. of Teaching
I	**Word Processing** Word processing concepts: saving, closing, Opening an existing document, Selecting text, Editing text, Finding and replacing text, printing documents, Creating and Printing Merged Documents, Character and Paragraph Formatting, Page Design and Layout. Editing and Profiling Tools: Checking and correcting spellings, Handling Graphics, Creating Tables and Charts, Document Templates and Wizards. Applications in different domains.	12
II	**Spreadsheet Package** Spreadsheet Concepts, Creating, Saving and Editing a Workbook, Inserting, Deleting Work Sheets, entering data in a cell / formula Copying and Moving from selected cells, handling operators in Formulae, Functions: Mathematical, Logical, statistical, text, financial, Date and Time functions, Using Function Wizard. Formatting a Worksheet: Formatting Cells – changing data alignment, changing date, number, character or currency format, changing font, adding borders and colors, Printing worksheets, Charts and Graphs – Creating, Previewing, Modifying Charts. Integrating word processor, spread sheets, web pages. Applications in different domains.	14
III	**Presentation Package** Creating, Opening and Saving Presentations, Creating the Look of Your Presentation, Working in Different Views, Working with Slides, Adding and Formatting Text, Formatting Paragraphs, Checking Spelling and Correcting Typing Mistakes, Making Notes Pages and Handouts, Drawing and Working with Objects, Adding Clip Art and other pictures, Designing Slide Shows, Running and Controlling a Slide Show, Printing Presentations. Applications in different domains.	10
IV	**Data Base Operations** Data Manipulation-Concept: Database, Relational Database, Integrity. Operations: Creating, dropping, manipulating table structure. Manipulation of Data: Query, Data Entry Form, Reports. Applications in different domains.	9

Texts / References Books

1. Sinha P.K., and Sinha P., "Foundations of Computing", BPB Publication.
2. Sagman S, "MS Office for Windows XP", Pearson Education.
3. ITL Educational Society, "Introduction to IT", Pearson Education.
4. Miller M, "Absolute Beginners Guide to Computer Basics", Pearson Education.

Learning Outcomes

At the end of the course the students will be able to:

- Acquire the foundation level knowledge required to understand computer and its operations.
- Understand to use the packages of word processing, spread sheet and presentation in detail.
- Understand the issues related to IT and IT applications.

CSCMD31	Introduction to Cyber Security	Theory	Practical	Cumulative
		3	0	3
MD		45	0	45

Course Objectives

- To prepare students with the technical knowledge and skills needed to protect and defend computer systems and networks.
- To develop graduates that can plan, implement, and monitor cyber security mechanisms to help ensure the protection of information technology assets.
- To develop graduates that can identify, analyze, and remediate computer security breaches.

Syllabus

Units	Course Content	Hr. of Teaching
I	Introduction History of Internet, Cyber Crime, Information Security, Computer Ethics and Security Policies, Guidelines to choose web browsers, Securing web browser, Antiviruses, Email security, Guidelines for setting up a Secure password, Two-steps authentication ,Password Manager, Wi-Fi Security.	15
II	Social media, Smart Phone and basic Windows security: Guidelines for social media security, best practices for safer Social, Introduction to mobile phones, Smartphone Security, Android Security, IOS Security, Basic Security for Windows User Account Password, etc	10
III	Cyber Security Initiatives in India and online Banking Security: IT Security Act, Cyber Security Initiatives in India, Cyber Security Exercise, Cyber Security Incident Handling.	10
IV	Cyber Security Assurance, Online Banking Security, Mobile Banking Security, Security of Debit and Credit Card , UPI Security, Security of Micro ATMs, e-wallet Security Guidelines, Security Guidelines for Point of Sales(POS).	10

Texts / References Books

1. Cryptography and Network Security Principles and Practice, William Stallings, Pearson.
2. Computer Security Fundamentals, by William (Chuck) Easttom II, Pearson.

Learning Outcomes

- Understand what is cyber security
- Understand various aspects of Internet Security.
- Know the cyber security initiatives taken by the Government
- Know how to do online transactions in a secured way

Semester –IV

CSCMJ41	Mathematics For Computer Science	Theory	Practical	Cumulative
		3	0	3
Major		45	0	45

Course Objectives

- To use sets for solving applied problems, and use the properties of set operations algebraically. Work with relations and investigate their properties. Investigate functions as relations and their properties.
- To learn about partial ordering , lattice theory, and theoretical foundation of Boolean algebra.
- To introduce concepts of mathematical logic – prepositional and predicate - for analyzing propositions and proving theorems.
- To learn rule of inference in propositional and predicate framework of logic.
- To learn basics concept of probability.
- To introduce basic concepts of graphs, types of graphs and its application to solve real life problem.

Syllabus

Units	Course Content	Hr. of Teaching
I	Set, set operations, relation, matrix and graph representation of relation, Properties of relation, and Partial order relations. Hasse diagram, lattice, and Boolean algebra. Number theoretic function, and recursion.	10
II	Propositional calculus / statement calculus – statement, logic connective, statement formula and truth table, well formed formula, tautology, contradiction, substitution instance, equivalence of formula, duality law, tautological implication, functionally complete set of connectives, satisfiability, decision problem, normal forms. Theory of inference for propositional calculus. Predicate calculus: Limitation of propositional calculus, statement representation using predicate and quantifier.	15
III	Probability: Sample Space and Events, Axioms of Probability, Conditional Probability. Random Variables and Expectations: Random variables, Jointly Distributed Random variables, Expectation, Variance, Co-variance, Probability Distributions. Parameter Estimation-Maximum Likelihood Estimates; Regression Analysis; Applications, Markov Process, Poisson Process.	10
IV	Basic Concepts of Graphs and Trees, Adjacency and Incidence Matrices, Planar Graphs, Graph Coloring, Eulerian and Hamiltonian graphs, Applications of Graph Theoretic Concepts to Computer Science.	10

Texts / References Books

1. J. P. Trembley and R. P. Manohar, Discrete Mathematical Structures with Applications to Computer Science, McGraw Hill.
2. K. Rosen, Discrete Mathematics, Tata McGraw Hill.
3. Irwin Miller, Maryless Miller, Mathematical Statics with Applications, PHI.
4. Oliver C. Ibe, Fundamentals of Applied Probability and Random Processes, Academic Press, 2014
5. Jay Devore, Probability and Statistics for Engineering and the Sciences, Cengage Learning India, 202**2.**

Learning Outcomes

After successful completion of this course, students will be able to:

- Understand sets and perform operations and algebra on sets.
- Determine properties of relations identify equivalence and partial order relations, sketch relations, functions and determine their properties; understand the theoretical foundation of Boolean algebra.
- Analyze logical propositions via truth tables, able express proposition in different standard form. Use inference rules to solve different reasoning problems.
- Learn basic concepts of probability and statistics, and able to use parameter estimation and regression for real life problem.
- Define graphs, digraphs and trees, and identify their main properties. Learn to model the problem using and their solution.

CSCMJ42	Database Management System	Theory	Practical	Cumulative
		3	1	4
Major		45	30	75

Course Objectives

- Introduce fundamental concepts, terminology and application of databases.
- To study and understand the design concepts and creation of relational databases.
- To study and understand the basic and advanced SQL commands.
- Provide overview of transaction management, concurrency control, database recovery and security.
- Provide an overview of advance database technologies.

Syllabus

Units	Course Content	Hr. of Teaching
I	Introduction: Database Systems, View of Data Models, Database Languages, DBMS Architecture, Database Users and Data Independence. ER Modeling: relation types, role and Structural Constraints, Extended ER Modeling Features, Design of an ER Database Schema, Reduction of ER Schema to Tables.	15
II	Relational Model: Relational Model Concepts, Relational Algebra. Introduction to SQL: SQL data types and literals, Types of SQL commands, SQL operators, Tables, views and indexes, Queries and sub queries, Aggregate functions.	10
III	Relational Database Design: Functional and Multi-valued Dependencies, Desirable Properties of Decomposition, Normalization up to 3 NF and BCNF.	10
IV	Transaction Management, Concurrency Control, Recovery Techniques, Security, Introduction to Query Processing and Query Optimization. Data warehousing, Data mining, Distributed databases, Big Data and NoSQL.	10

Texts / References Books

1. Date, C. J., An Introduction to Database Systems, AddisonWesley.
2. Silberschatz, A., Korth, H. F. and Sudharshan, S., Data Base System Concepts, McGrawHill.
3. Ullman, J. D., Principles of Database Systems, Galgotia.
4. Elmasri, R., Navathe, S.B., Fundamentals of Database Systems, Pearson Education Asia.
5. Ramakrishnan, R., Database Management Systems, McGraw-Hill Education

Learning Outcomes

After successful completion of this course, students will be able to:

- Describe the fundamental elements of relational database management systems
- Explain the basic concepts of relational data model, entity-relationship model, relational database design, relational algebra and SQL.
- Design ER-models to represent simple database application scenarios
- Convert the ER-model to relational tables, populate relational database and formulate SQL queries on data.
- Improve the database design by normalization.
- Understand the concept of a database transaction and related database facilities, including concurrency control, backup and recovery, and data object locking and protocols.
- Compare, contrast and analyze the various emerging technologies for database systems such as NoSQL.

CSCMJ44	Computer Organization	Theory	Practical	Cumulative
		3	0	3
Major		45	0	45

Course Objectives

- To study and understand the basic structure and operation of digital computer.
- To study and understand the design of arithmetic and logic unit and implementation of fixed point and floating-point arithmetic operations
- To study and understand the two types of control unit techniques.
- To study and understand the hierarchical memory system including cache memories and virtual memory
- To study and understand the different ways of communicating with I/O devices and standard I/O interfaces

Syllabus

Units	Course Content	Hr. of Teaching
I	Introduction: Components of a Computer System, Machine Instruction: Opcode and Operand, Machine's Instruction Cycle, Organization of Central Processing Unit: ALU, Control Unit and Registers (Special and General Purpose), Memory, and Input/Output.	12
II	Memory Organization: Memory Hierarchy, Cache Memory: Cache Performance, Cache Mapping Techniques (Direct, Associative, and Set-Associative) and Locality of Reference, Main Memory (DRAM and ROM), Secondary Memory, Virtual Memory, and Characteristics of Different Types of Memory.	12
III	CPU Organization: Instruction Formats, Instruction Types, Addressing Mode and its Types, Common Microprocessor Instructions, RISC and CISC, Physical Cores, Logical Cores, and Multithreading.	12
IV	I/O Organization: Peripheral devices, I/O interface, Modes of Transfer, Priority Interrupt, Direct Memory Access, Modes of Data Transfer in DMA, Input-Output Processor, and Serial Communication.	9

Texts / References Books

1. Mano, M. M. Computer system architecture. PHI.
2. Rajaraman, V., & Radhakrishnan, T. An introduction to digital computer design. PHI.
3. Stallings, W. Computer organization and architecture: Designing for performance. Prentice Hall.

Learning Outcomes

The students are expected to be able to demonstrate the following knowledge, skills and attitudes after completing this course

- To Identify and Describe Computer Components
- A detailed understanding of architecture and functionality of central processing unit.
- A depth understanding of Memory Hierarchy and various types of memory communicating with processing unit.
- Understanding of I/O devices communicating with Processing Unit and also knowing the characteristics of multi processors.
- To measure and analyze the performance of computer systems using appropriate metrics.

CSCMJ45	Numerical Computing	Theory	Practical	Cumulative
		3	1	4
Major/Minor		45	30	75

Course Objectives

- To provide a comprehensive understanding of numerical methods essential for computational problem-solving.
- To understand errors in computer arithmetic and normalization techniques.
- To solve equations using bisection, false position, and Newton-Raphson methods.
- To explore iterative methods for systems of linear equations, matrix inversion, eigenvalues, and eigenvectors, with a focus on diagonalization using Jacobi's method.
- To include polynomial interpolation, numerical differentiation, and integration techniques such as Trapezoidal and Simpson's Rules.
- To address numerical solutions to differential equations using methods like Euler's, Runge-Kutta, etc..
- To Equip students with skills critical for developing efficient algorithms and addressing complex computational challenges in today's technology-driven world.

Syllabus

Units	Course Content	Hr. of Teaching
I	Errors in Computer Arithmetic, Normalization. Bisection, False position and Newton-Raphson methods for solution of nonlinear equations. Errors in the solutions, Convergence of Solutions.	10
II	Gauss, Gauss-Siedel and Iterative methods for system of linear equations. Ill conditioned system, Pivotal Condensation, Matrix Inversion, Eigen-values, Eigen-vector, Diagonalization of Real Symmetric Matrix by Jacobi's Method.	10
III	Introduction to Finite Differences, Polynomial Interpolation using Newton's and Lagrange's formulae.Numerical Differentiation: Numerical Integration: Trapezoidal Rule, Simpson's Rule, Weddle's Rule, Gauss Quadrature Formula. Error in numerical Integration.	15
IV	Numerical Solution of differential Equations: Picards Method, Taylor's Series Method, Euler's Method, Modified Euler's Method, Runge-Kutta Method, Predictor-Corrector Method.	10

Texts / References Books

1. Rajaraman, V. Computer oriented numerical methods. PHI.
2. Acton, F. Numerical methods that work. Harper and Row.
3. Conte, S. D., & Boor, C. D. Elementary numerical analysis. McGraw-Hill.
4. Sastry, S. S. Introductory methods of numerical analysis. PHI.
5. Gerald, C. F., & Wheatley, P. O. Applied numerical analysis. Addison Wesley.

Learning Outcomes

After successful completion of this course, student will be able to

- Gain proficiency in identifying and mitigating errors in computer arithmetic and normalization techniques.
- Master methods for solving nonlinear equations, including bisection, false position, and Newton-Raphson, with an understanding of convergence and error analysis.
- Develop skills in iterative methods for systems of linear equations, matrix inversion, and eigen-decomposition, including Jacobi's method for diagonalization.
- Effectively use polynomial interpolation techniques and numerical integration methods such as Trapezoidal and Simpson's Rules.
- Become adept at solving differential equations using Picard's Method, Euler's Method, Runge-Kutta Method etc..
- Acquire skills crucial for addressing real-world computational problems and developing efficient algorithms.

Semester –V

CSCMJ51	Operating System Concepts	Theory	Practical	Cumulative
		3	1	4
Major		45	30	75

Course Objectives

- To learn the mechanisms of OS to handle processes and threads and their Communication
- To learn the mechanisms involved in memory management in contemporary OS
- To gain knowledge on distributed operating system concepts that includes architecture, Mutual exclusion algorithms, deadlock detection algorithms and agreement protocols
- To know the components and management aspects of concurrency management

Syllabus

Units	Course Content	Hr. of Teaching
I	Introduction: Definition, Design Goals, Evolution; Batch processing, Multiprogramming, Timesharing; Real-time operations; Structure and Functions of Operating System. Process Management: Process states, State Transitions, Process Control Structure, Context Switching, Process Scheduling, Threads.	10
II	Memory Management: Address Binding, Dynamic Loading and Linking Concepts, Logical and Physical Addresses, Contiguous Allocation, Fragmentation, Paging, Segmentation, Combined Systems, Virtual Memory, Demand Paging, Page fault, Page replacement algorithms, Global Vs Local Allocation, Thrashing, Working Set Model.	15
III	Concurrent Processes: Process Interaction, Shared Data and Critical Section, Mutual Exclusion, Busy form of waiting, Lock and unlock primitives, Synchronization, Classical Problems of Synchronization, Semaphores, Monitors, Conditional Critical Regions, System Deadlock, Wait for Graph, Deadlock Handling Techniques: Prevention, Avoidance, Detection and Recovery.	10
IV	File and Secondary Storage Management: File Attributes, File Types, File Access Methods, Directory Structure, Allocation Methods, Free Space management; Disk Structure, Logical and Physical View, Disk Head Scheduling.	10

Texts / References Books

1. A. Silberschatz, P. B. Galvin, G. Gagne, Operating System Concepts, Addison Wesley.
2. W. Stalling, Operating Systems: Internals and Design Principles, PHI.
3. A. S. Tanenbaum, Modern operating Systems, PHI.

Learning Outcomes

After the completion of this course the students will be able to:

- Interpret Operating System Structure, Operations, Services and Process
- Elaborate Multithreaded Programming, Process Scheduling and Synchronization
- Evaluate different memory management schemes
- Design and implement File system functionalities
- Experiment with various disk management schemes

CSCMJ53	Design and Analysis of Algorithms	Theory	Practical	Cumulative
		3	1	4
Major		45	30	75

Course Objectives

- The goal of this course is to provide a solid background in the design and analysis of the major classes of algorithms.
- At the end of the course students will be able to develop their own versions for a given computational task and to compare and contrast their performance.
- Students are also expected to develop advanced level of algorithms with low complexity.

Syllabus

Units	Course Content	Hr. of Teaching
I	Introduction to Algorithms: Time and Space complexity, Average and Worst-case analysis, Asymptotic notation, Master theorem Recurrence equations and their solution.	10
II	Algorithmic Techniques: Search techniques (backtracking and bounding), Search Trees, Sorting algorithms – Heapsort, Quick sort, Sorting in linear time (radix sort, bucket sort).	12
III	Algorithmic Paradigms: Greedy algorithms (Activity-selection problem, Huffman coding, Knapsack, Shortest path and Minimum Spanning tree in graphs), Divide and Conquer – Merge Sort, Integer Multiplication, Solving Recurrence-substitution method and recursion-tree,; Dynamic programming (0/1 Knapsack Problems, Traveling Salesman problem, Matrix multiplication, Shortest paths algorithms,, Optimal binary search trees).	12
IV	Computational complexity: Problem classes: P, NP, NP-complete, NP-hard, Examples of NP-complete problems, Cook's theorem.	11

Texts / References Books

1. T. H. Cormen, C. E. Leiserson, R. L. Rivest , C. Stein, Introduction to Algorithms, PHI.
2. M. A. Weiss, Data Structures and Problem Solving Using Java, Addison Wesley.
3. A. Aho, V. Alfred, J. Hopcroft, J. D. Ullman, The Design and Analysis of Computer Algorithms, Addison Wesley.
4. J. Kleinberg and E. Tardos, Algorithm Design, Pearson, 2006.
5. E. Horowitz, S. Sahni, S. Rajasekaran, Fundamentals of Computer Algorithms, Galgotia.

Learning Outcomes

After the completion of this course the students will be able to:

- Given an algorithm, identify the problem and solves to problems with efficient algorithms.
- Write algorithms to choosing the best one or a combination of two or more of the algorithm design techniques: Iterative, divide-n-conquer, Greedy, Dynamic Programming using appropriate data structures.
- To explore real life applications with efficient solutions.

CSCMJ55	Theory of Computation	Theory	Practical	Cumulative
		3	1	4
Major		45	30	75

Course Objectives

- To provide a comprehensive understanding of the Theory of Computation, focusing on fundamental concepts and their applications.
- To explore finite state automata, including deterministic and nondeterministic types, regular expressions, and their equivalence with finite state machines.
- To study context-free grammars, pushdown automata, their properties, and techniques for simplifying grammars and understanding derivation trees.
- To cover Turing machines, their variants, the Chomsky hierarchy, and concepts of computability.
- To examine decidability issues, including Post's correspondence problem, to understand the limits of computation and address key challenges in modern computing systems.

Syllabus

Units	Course Content	Hr. of Teaching
I	Alphabets, string, language, basic operations on language, concatenation, union, Kleene star. Finite Automata (FA): Non deterministic FA and deterministic FA, NFA with ε- moves, Regular Expressions, Equivalence of regular expression and FA, Pumping lemma, closure properties, FA minimization: Myhill-Nerode theorem and Equivalence theorem, Formal Language and Grammar: Production systems, Finite automata with output, Regular grammar.	15
II	Context free grammars, Normal forms, Simplification of CFG, Derivation trees and ambiguity. Pushdown automata: Acceptance by empty store and final state, Deterministic pushdown automata, Equivalence between pushdown automata and context-free grammars, Pumping lemma for CFL, Closure properties of CFL.	10
III	Turing machine as a model of computation, configuration of simple Turing machine, Church Turing Thesis, Universal Turing Machine, decidability, halting problem, context sensitive languages and linear bounded automata, Chomsky Hierarchy.	10
IV	Undecidability: A Language that is not Recursively Enumerable (RE), an Undecidable Problem that is RE, Undecidable Problems about Turing Machine. Post's Correspondence Problem, The Classes P and NP.	10

Texts / References Books

1. Hopcraft, J. E., Motwani, R., & Ullman, J. D. (n.d.). Introduction to automata theory, languages and computation. Pearson.
2. Linz, P. An introduction to formal language and automata. Narosa Publisher.
3. Mishra, K. L. P., &Chandrasekaran, N. Theory of computer science: Automata, languages and computation. PHI.
4. Martin, T. C. Theory of computation. Tata McGraw-Hill.

Learning Outcomes

After successful completion of this course, students will be able to:

- Gain a deep understanding of finite automata, including deterministic and nondeterministic types, and their equivalence with regular expressions, as well as concepts like the Pumping Lemma and closure properties.
- Master context-free grammars, pushdown automata, and their relationships, including normal forms, derivation trees, and ambiguity.
- Achieve proficiency in Turing machines, covering their construction, variations, and the Chomsky hierarchy, as well as concepts of computability.
- Analyze decidability issues, such as Post's correspondence problem, equipping students with critical skills to address theoretical and practical challenges in computation.

CSCMV51	Introduction to Multimedia	Theory	Practical	Cumulative
		3	1	4
Minor(VOC-2)		45	30	75

Course Objectives

- To understand Multimedia Concepts
- To apply Multimedia Tools
- To implement Multimedia Design Principle
- To explore Emerging Trends

Syllabus

Units	Course Content	Hr. of Teaching
I	Introduction to Multimedia What is multimedia, Components of multimedia, Web and Internet multimedia applications, Transition from conventional media to digital media. Computer Fonts and Hypertext: Usage of text in Multimedia, Families and faces of fonts, outline fonts, bitmap fonts International character sets and hypertext, Digital fonts techniques.	12
II	Audio fundamentals and representations Digitization of sound, frequency and bandwidth, decibel system, data rate, audio file format, Sound synthesis, MIDI, wavetable, Compression and transmission of audio on Internet, Adding sound to your multimedia project, Audio software and hardware.	12
III	Image fundamentals and representations Colour Science , Colour Models, Colour palettes, Dithering, 2D Graphics, Image Compression and File Formats :GIF, JPEG, JPEG 2000,PNG, TIFF, EXIF, PS, PDF, Basic Image Processing [Can Use Photoshop], Use of image editing software, White balance correction, Dynamic range correction, Gamma correction, Photo Retouching.	11
IV	Video and Animation Video Basics, How Video Works, Broadcast Video Standards, Analog video, Digital video, Video Recording and Tape formats, Shooting and Editing Video (Use Adobe Premier for editing), Video Compression and File Formats. Video compression based on motion compensation, MPEG-1, MPEG-2, MPEG-4, MPEG-7, MPEG-21, Animation: Cell Animation, Computer Animation, Morphing.	10

Texts / References Books

1. Tay Vaughan, "Multimedia making it work", Tata McGraw-Hill, 2008.
2. Rajneesh Aggarwal & B. B Tiwari, " Multimedia Systems", Excel Publication, New Delhi, 2007.
3. Li & Drew, "Fundamentals of Multimedia", Pearson Education, 2009.

Learning Outcomes

- Demonstrate proficiency in using multimedia software and tools for creating and editing text, images, audio, and video.
- Design and create multimedia content that integrates multiple media types effectively.
- Identify and utilize various multimedia file formats and understand their appropriate use cases.

Semester VI

CSCMJ61	Software Engineering	Theory	Practical	Cumulative
		4	0	4
Major		60	0	60

Course Objectives

- To study and understand software engineering methods and practices, and their appropriate application.
- To study and understand Software life-cycle models, software requirements and the SRS documents.
- To study and understand the role of project management including planning, scheduling, risk management, etc.
- To study and understand software architecture and design
- To study and understand software testing approaches.
- To study and understand software measurement and software risks.
- To study and understand on quality control and how to ensure good quality software.

Syllabus

Units	Course Content	Hr. of Teaching
I	Introduction: Software crisis, Software development Projects, Exploratory software development, Emergence of Software Engineering, Software life-cycle models: Waterfall model and its extensions, Rapid Application Development (RAD), Agile Development, Spiral Model etc. CMM, Software Quality, role of metrics and measurement. Requirements Analysis and Specification: SRS Building Process, Specification Languages, Validation of SRS, metrics, monitoring and control, Object Oriented analysis.	15
II	Software Project Management: Responsibilities & Complexities of Software project Management, Project Planning, Matrices for Project size estimation, Project Estimation techniques: Empirical, Heuristic, and analytical Estimation techniques, Project Scheduling techniques: Activity Network, CPM, PERT Chart, Gantt Chart, Organization & Team Structure, Risk Management, and Configuration Management.	15
III	Software Architecture & Design: Role of Software Architecture, Architecture Views, Component and Connector View, Architecture Styles for C&C View, Architecture Evaluation. Software Design and Implementation: Overview of the design Concepts, Cohesion and Coupling, Software design Approaches: Function Oriented and Object-Oriented design concepts, Design Metrics, Design Translation Process.	15
IV	Software Testing and Reliability: Basic concepts & terminologies of coding and testing, Techniques of testing, Debugging approaches, Software Maintenance, Software Reliability and Availability Models & Metrics, Software Reengineering, Software Reuse. Introduction to IEEE Standards, Case Studies.	15

Texts / References Books

1. P. Jalote, An Integrated Approach to Software Engineering, IIIrd Edition, Narosa Publishing House.
2. R. S. Pressman, Software Engineering: A Practitioner's approach, McGraw-Hill.
3. I. Sommerville, Software Engineering: Pearson Education.
4. C. Ghezzi, M. Jazayeri, D. Mandrioli, Fundamentals of Software Engineering, PHI.
5. R. Mall, Fundamentals of Software Engineering, PHI.
6. RN Taylor, N Medvidovic, EM Dashofy (2009) Software Architecture: Foundations, Theory and Practice, John Wiley.

Learning Outcomes

- How to apply the software engineering lifecycle by demonstrating competence in communication, planning, analysis, design, construction, and deployment
- An ability to work in one or more significant application domains
- Work as an individual and as part of a multidisciplinary team to develop and deliver quality software
- Demonstrate an understanding of and apply current theories, models, and techniques that provide a basis for the software lifecycle
- Demonstrate an ability to use the techniques and tools necessary for engineering practice

CSCMJ62	Compiler Design	Theory	Practical	Cumulative
		3	1	4
Major		45	30	75

Course Objectives

- To provide an understanding of compiler design and construction.
- To cover the phases of a compiler and the tool-based approach to compiler development.
- To explore lexical analysis, including tokenization, lexemes, patterns, and error reporting using tools like LEX.
- To study syntax analysis, including both top-down and bottom-up parsing with tools such as YACC.
- To address type checking, type systems, and runtime system components, including storage organization and symbol tables.
- To focuse on intermediate code generation, code optimization techniques, and the generation of efficient machine code through various optimization strategies.

Syllabus

Units	Course Content	Hr. of Teaching
I	Introduction: Translators, Various phases of compiler, tool based approach to compiler construction. Lexical analysis: token, lexeme and patterns, difficulties in lexical analysis, error reporting, implementation, regular definition, transition diagrams, LEX.	10
II	Syntax Analysis:Top Down parsing (recursive descent parsing, predictive parsing), operator precedence parsing, bottom-up parsing (SLR, LALR, Canonical LR), YACC. Syntax directed definitions: inherited and synthesized attributes, dependency graph, evaluation order, bottom-up and top-down evaluation of attributes, L-attributed and S attributed Definitions.	15
III	Type checking: type system, type expressions, structural and name equivalence of types, type conversion, overloaded functions and operators, polymorphic functions. Run time system: storage organization, activation tree, activation record, parameter passing, dynamic storage allocation, symbol table: hashing, linked list, tree structures.	10
IV	Intermediate code generation: Intermediate Representation, Translation of Declarations, Assignments, Control Flow, Boolean Expressions and Procedure Calls. Code generation and Optimization: Basic blocks and flow graphs, code generation, DAG representation of programs, code generation from DAGs, Loop Optimization, Global Optimization, Loop Optimization, Peep-Hole optimization.	10

Texts / References Books

1. Aho, A. V., & Ullman, J. D. (1977). Principles of Compiler Design (Addison-Wesley series in computer science and information processing). Addison-Wesley Longman Publishing Co., Inc.
2. Tremblay, J. P., & Sorenson, P. G. (1985). Theory and Practice of Compiler Writing. McGraw-Hill, Inc.
3. A. Holub, (2023) Compiler Design in C, PHI.

Learning Outcomes

After successful completion of this course, students will be able to:

- Understand the phases of compiler construction and the principles behind lexical analysis, including tokenization, pattern matching, and error reporting.
- Develop proficiency in syntax analysis through both top-down and bottom-up parsing methods.
- Grasp concepts related to type checking, type systems, and runtime systems, including storage organization and symbol tables.
- Acquire skills in intermediate code generation and apply optimization techniques, such as loop and global optimizations, to produce efficient machine code.

CSCMJ64	Computer Networks	Theory	Practical	Cumulative
		3	1	4
Major		45	30	75

Course Objectives

- To provide students with an overview of the concepts and fundamentals of data communication and computer networks.
- To introduce students to local, metropolitan and wide area networks use the standard OSI reference model as a framework and to the Internet protocol suite and network tools and programming using various networking technologies.

Syllabus

Units	Course Content	Hr. of Teaching
I	Introduction:Network Definition; Network Topologies; Network Classifications; Layered Network Architecture; Overview of OSI Reference Model; Overview of TCP/IP Protocol Suite. Physical Layer:Analog and Digital Signals; Digital to Digital Conversion Schemes; Analog to Digital Conversion Schemes; Parallel and Serial transmission; Digital to Analog Conversion Schemes; Analog to Analog Conversion Schemes; Multiplexing and Spread Spectrum; Transmission Media; Circuit Switching and Packet Switching.	15
II	Data Link Layer: Error Detection and Error Correction Techniques; Data Link Control-Framing and Flow control; Error Recovery Protocols- Stop and Wait ARQ, Go-Back-N ARQ, Selective-Repeat ARQ; HDLC; Point to Point Protocol. Multiple Access: Random Access Protocols; Controlled Access Protocols; Channelization - FDMA, TDMA and CDMA.	10
III	Networks Layer: Logical Addressing; Internet protocols; Address Mapping and Error Reporting; Delivery, Forwarding, and Routing.	10
IV	Transport Layer:Process-to-Process Delivery: UDP, TCP, and SCTP; Congestion Control and Quality of Service. Application Layer:Domain Name System; Remote Logging, Electronic Mail, and File Transfer; WWW, HTTP, and SNMP.	10

Texts / References Books

1. B. A. Forouzan: Data Communications and Networking, Fourth edition, THM.
2. A. S. Tanenbaum: Computer Networks, Fourth edition, PHI.
3. Douglas E. Comer: Computer Networks and Internets, Pearson.

Learning Outcomes

- Inspect the basics of data communication and various categories of networks
- Identify the technologies for error free transmission of data over internet
- Apply various routing protocols to select optimal path and relate addressing entities in Network Layer
- Implement different transport and application layer protocols which enables data communication over internet
- Configure intermediate devices used in networks

CSCMJ66	Artificial Intelligence	Theory	Practical	Cumulative
		3	1	4
Major		45	30	75

Course Objectives

- To introduce the basic principles in artificial intelligence research by covering simple representation schemes, problem solving paradigms, constraint propagation and search strategies.
- To explore the students with the areas of AI application such as knowledge representation, natural Language processing and expert systems.

Syllabus

Units	Course Content	Hr. of Teaching
I	**Introduction:** Intelligent Agents – Agents and environments - Good behavior - The nature of environments- Structure of agents- Problem Solving - Problem solving agents- Example problems- Searching for solutions- Uniformed search strategies- Avoiding repeated states	11
II	**Searching Techniques:** Informed search strategies- Heuristic function- Local search algorithms and optimistic problems- Local search in continuous spaces- Online search agents and unknown environments- Constraint satisfaction problems (CSP)- Backtracking search and Local search for CSP – Structure of problems- Adversarial Search – Games- Optimal decisions in games – Alpha – Beta Pruning	11
III	**Knowledge Representation:** First order logic – Representation revisited- Syntax and semantics for first order logic Using first order logic-Knowledge engineering in first order logic- Inference in First order logic – prepositional versus first order logic- Unification and lifting- Forward chaining – backward chaining- Resolution	12
IV	**Knowlwdge in Learning:** Learning from observations - Forms of learning - Inductive learning-Learning decision trees - Ensemble learning- Knowledge in learning – Logical formulation of learning – Explanation based learning – Learning using relevant information – Inductive logic programming- Statistical learning methods- Learning with complete data-Learning with hidden variable - EM algorithm	11

Texts / References Books

1. Artificial Intelligence – A Modern Approach, Stuart Russell, Peter Norvig, 3rd Edition, Pearson Education, 2015.
2. Artificial Intelligence, Elaine Rich and Kevin Knight, 2nd Edition, Tata McGraw-Hill, 2003.
3. Artificial Intelligence-Structures and Strategies for Complex Problem Solving, George F. Luger, Pearson Education 2002.

Learning Outcomes

- Explain the foundations and history of Artificial Intelligence, as well as the science of agent design.
- Illustrate the use of problem-solving techniques, such as the various search methods, games, and constraint satisfaction problems.
- Demonstrate AI's use of knowledge representation, through logic agents and first-order logic to address AI problems.
- Design simple software to experiment with various AI learning concepts and analyze results.
- Build self-learning and research skills to be able to tackle a topic of interest on his/her own or as part of a team.

CSCMV61	Data Analysis and Visualization	Theory	Practical	Cumulative
		3	1	4
VOC		45	30	75

Course Objectives

- The objective of this course is to equip students with the skills and knowledge necessary to perform comprehensive data analysis and visualization using Python.
- Students will learn to navigate the data science process, utilize essential Python libraries, handle and clean diverse data sets, and apply advanced techniques for data wrangling and visualization.

Syllabus

Units	Course Content	Hr. of Teaching
I	**Introduction to Data Science and Python:** Overview of Data Science, Exploratory Data Analysis (EDA), and the Data Science Process.Introduction to Python for Data Analysis: Python Shell (iPython), Jupyter Notebook, and key Python libraries (NumPy, pandas, matplotlib, SciPy, scikit-learn, statsmodels).	10
II	**Data Handling with Pandas:** Basics of Pandas: Data structures, arrays, vectorized computation, and essential functionality. Data Operations: Summarizing data, computing descriptive statistics, and handling data loading, storage, and file formats. Data Handling Techniques: Reading/writing text data, web scraping, binary formats, interacting with web APIs, and databases. Data Cleaning: Managing missing data, data transformation, and string manipulation.	15
III	**Data Wrangling and Visualization:** Data Wrangling: Hierarchical indexing, combining and merging datasets, reshaping, and pivoting. Data Visualization: Basics of matplotlib, plotting with pandas and seaborn, and other visualization tools.	10
IV	**Advanced Data Analysis:** Data Aggregation: Group by mechanics, aggregation techniques, split-apply-combine, and pivot tables. Time Series Analysis: Handling date/time data, time series basics, date ranges, frequencies, shifting, time zones, and resampling. Advanced Pandas: Working with categorical data, advanced GroupBy operations, and method chaining techniques.	10

Texts / References Books

1. McKinney, W.(2017). Python for Data Analysis: Data Wrangling with Pandas, NumPy and IPython. 2nd edition. O'Reilly Media.
2. O'Neil, C., & Schutt, R. (2013). Doing Data Science: Straight Talk from the Frontline O'Reilly Media.

Learning Outcomes

After successful completion of this course, students will be able to:

- Students will be skilled in using Python and Jupyter Notebook with essential libraries to analyze and visualize data effectively.
- They will know how to clean and transform data from various sources, manage missing values, and prepare data for analysis.
- Students will be able to combine, reshape, and organize data as needed, and will be proficient in creating and interpreting visualizations using tools like matplotlib and seaborn.
- They will have the capability to perform advanced data tasks, including data aggregation and time series analysis.

Semester- VII

CSCMJ71	Machine Learning	Theory	Practical	Cumulative
		3	1	4
Major/Minor		45	30	75

Course Objectives

- Foundational Knowledge: Introduce students to the fundamental concepts and principles of machine learning, including supervised, unsupervised, and reinforcement learning.
- Algorithm Understanding: Provide a deep understanding of various machine learning algorithms and their appropriate applications.
- Practical Skills: Develop practical skills in implementing and evaluating machine learning models using programming languages and libraries.
- Data Handling: Teach students techniques for data preprocessing, feature engineering, and data visualization.
- Ethical Considerations: Discuss ethical considerations, fairness, and biases in machine learning models and their societal impacts.

Syllabus

Units	Course Content	Hr. of Teaching
I	**Supervised Learning (Regression/Classification):** Overview for ML, Supervised Learning, Unsupervised Learning, Problems, Data, and Tools. Linear Regression, Polynomial Regression, Features, Scaling, Cost Function, Gradient Descent, Learning Rate. Distance- based methods, Nearest-Neighbours, Decision Trees, Naïve Bayes, Linear Regression, Logistic Regression, Generalized Linear Models-Support Vector Machines, Nonlinearity and Kernel Multi-class/Structured Outputs, Ranking	10
II	**Unsupervised Learning:**K-means Clustering, PCA and kernel PCA -Matrix Factorization and Matrix Completion-Generative Models (mixture models and latent factor models), Expectation Maximization, Dimensionality Reduction.	10
III	**Performance Evaluation:** Evaluating Machine Learning algorithms and Model Selection, Performance Measure, Error Analysis, Confusion Matrix, Precision and Recall Tradeoff, F1 Score, Macro F1, Accuracy, Skewed Classes Introduction to Statistical Learning Theory, Ensemble Methods (Boosting, Bagging, Random Forests).	15
IV	**Modelling and Applications:** Sparse Modeling and Estimation, Modeling Sequence/Time-Series Data, Feature Representation Learning. Discriminative vs. Generative Models, Marginalization, Conditioning, Normalization, and Conditional Independence, Bayes Theorem, Markov Random Field, Naïve Bayes Model, Decision Tree, Recent trends in various learning techniques of machine learning and classification methods for IOT applications.	10

Texts / References Books

1. Tom Mitchell, "Machine Learning", McGraw-Hill, 1997.
2. Kevin Murphy, Machine Learning: A Probabilistic Perspective, MIT Press, 2012
3. Trevor Hastie, Robert Tibshirani, Jerome Friedman, The Elements of Statistical Learning, Springer 2009
4. Christopher Bishop, Pattern Recognition and Machine Learning, Springer, 2007.

Learning Outcomes

- Conceptual Mastery: Students will understand key concepts and techniques in machine learning, including different types of learning and model evaluation metrics.
- Algorithm Application: Students will be able to select and apply suitable machine learning algorithms to solve specific problems.
- Implementation Skills: Students will be proficient in using tools such as Python, scikit-learn, TensorFlow, or PyTorch to build and evaluate machine learning models.
- Data Proficiency: Students will demonstrate the ability to preprocess and visualize data, and perform feature selection and extraction.
- Ethical Awareness: Students will recognize and address ethical issues and biases in machine learning, ensuring responsible and fair use of technology.

CSCMJ73	Research Methodology	Theory	Practical	Cumulative
		2	0	2
Major		30	0	30

Course Objectives

- To study and understand the research goals, research issues & challenges, scientific methods.
- Reviewing Literature and Research Papers; Writing Research Papers, Thesis, Reports and Project Proposals Plagiarism and Copyrights.

Syllabus

Units	Course Content	Hr. of Teaching
I	**Research Foundations:**Research: Meaning, Characteristics, Objectives, Types, Variables, Steps of research, Hypothesis, Data, Interdisciplinary research, Tran disciplinary research and Multidisciplinary research.Literature:Primary, Secondary and Tertiary sources, Problem identification, Scholarly databases, Types of research papers.Research Metrics: Journal level Metrics and Author level metrics, Publication Identifiers, Abstracting Databases, and Publishers.Terminology: Conference, Symposium, Congress, Seminar, Workshop, Colloquium, Patents.	8
II	**Research and Publication Ethics:**Introduction to Philosophy and Ethics; Ethics with respect to science and research, intellectual honesty, and research integrity; Falsification, Fabrication, and Plagiarism (FFP); plagiarism types, use of plagiarism software and open-source software tools; Usesand misuses of AI tools in researchand its boundary,; Copyrights; duplicate and redundant publications, salami slicing; selective reporting and misrepresentation of data; Definition, introduction, and importance of publication ethics; conflict of interest; Publication misconduct definition, problems that lead to unethical behavior and vice-versa, types; violation of publication ethics, authorship, and contributor ship; identification of publication misconduct, complaints, and appeals; predatory publishers and journals; subject-specific ethical issues, FFP and authorship; Complaints and appeals regarding fraud from India and abroad.	10
III	**Tools and Applications.** Meaning and Importance of Data, Sources of Data, Use of Secondary Data, Data Collection Techniques, Observation Method, Experimentation, Simulation. Types of Data, Measurement of Scales and Indices, Pilot Studies and Pre-tests.	6
IV	**Technical Paper Writing:** Writing Research Papers, Synopsis, Thesis, Reports and Project Proposals; Formatting, Appendices, Citation Formats and Style; General Conventions, Issues, Plagiarism and Copyrights. Reference Managers. Format and Style of Referencing.	6

Texts / References Books

1. Kothari, C.R., 2004. Research methodology: Methods and techniques. New Age International.
2. Cooper, D.R., Schindler, P.S. and Sun, J., 2006. Business research methods (Vol. 9). New York: McGraw-Hill Irwin.
3. Creswell, J.W. and Creswell, J.D., 2017. Research design: Qualitative, quantitative, and mixed methods approaches. Sage publications.
4. Krishnaswamy, K.N., 2006. Management Research Methodology: Integration of Principles, Methods and Techniques. Pearson Education India.
5. Sekaran, U. and Bougie, R., 2016. Research methods for business: A skill building approach. John Wiley &Sons.
6. Advanced Research Methodology by R. Barker Bausell. Scarecrow Press 2013
7. Social Sciences by Bill Taylor, Gautam Sinha, TaposhGhoshal. Prentice-Hall of India Private Limited, New Delhi. 2006

Learning Outcomes

After successful completion of this course, students will be able to:

- Understand the basic concepts of research and its methodologies, Identify appropriate research topics, select and define appropriate research problem and parameters
- Prepare a project proposal (to undertake a project)
- Organize and conduct research in a more appropriate manner, writing research reports and thesis.

CSCMJ75	Operations Research & Practical	Theory	Practical	Cumulative
		3	1	3
Major		45	30	75

Course Objectives

- Optimization Techniques Mastery: Introduce students to fundamental optimization techniques and methods used in operations research.
- Decision-Making Skills: Enhance students' abilities to make informed and effective decisions using quantitative analysis.
- Modeling Proficiency: Develop skills in formulating, analyzing, and solving linear and nonlinear models.
- Application of Tools: Provide practical experience with operations research tools and software for real-world problem-solving.
- Interdisciplinary Approach: Encourage an interdisciplinary approach to solving complex problems in various fields, including logistics, manufacturing, and service industries.

Syllabus

Units	Course Content	Hr. of Teaching
I	**Introduction to Theory of Optimization & Linear Programming:** Features of OR, Modeling in Operations Research, Classification of Models, General Solution Methods for O.R Models, Scientific Method in OR, Methodology of OR, Applications, Opportunities and Shortcomings of O.R. Applications of operation research in economics, Finance and decision making, Formulation of Mathematical Model of Linear Programming Problem.	10
II	**Graphical Solution and Simplex Method Graphical Solution:** Solution of Linear Programming Problem by Graphical Method, Special Cases: (i) Alternate Optima (ii) Unbounded Solution (iii) Infeasible Solution Simplex Method: Introduction to Simplex Method- Maximization and Minimization, Duality, primal to dual conversion only.	10
III	**Transportation Models & Assignment Models:** Balanced and Unbalanced Models of Transportation, Initial Basic Feasible Solutions (i). North-West Corner Method, (ii) Row Minima Method, (iii) Column Minima Method (iv) Matrix Minima Method, (v) Vogel's Approximation Method, Modi Method, Degeneracy. Balanced and Unbalanced Assignment Models, Hungarian Method, Maximization and Minimization.	15
IV	**Game Theory & Queuing Theory:** Game Theory: Two-Person Zero sum Games, Some Basic Terms, The Maximin-Minimax Principle, Games without Saddle Points (Mixed Strategies), Graphical solution of 2 × n and m × 2 Games, algebraic method. Queuing Theory: Introduction; Basic Definitions and Notations; Axiomatic Derivation of the Arrival & Departure (Poisson Queue). Pure Birth and Death Models; Poisson Queue Models: M/M/1 : ∞ /FIFO and M/M/1: N/ FIFO. Network Analysis: Shortest Path; Dijkstra Algorithm; Floyd Algorithm; Maximal Flow Problem (Ford-Fulkerson); PERT-CPM (Cost Analysis, Crashing, Resource Allocation excluded).	10

Texts / References Books

1. Swarup K., P.K. Gupta, and Manmohan, Operations Research, Sultan Chand: New Delhi, 12 th thoroughly revised Ed.
2. Taha, H. A. (2013). Operations research: an introduction. Pearson Education India.
3. Hillier, F. S., & Lieberman, G. J. (2015). Introduction to operations research. McGraw-Hill.
4. J.K. Sharma, Operations Research Theory; Application, Macmillan, 3rd Ed.
5. Hillier, F. S., & Lieberman, G. J. (2015). Introduction to operations research. McGraw-Hill.

Learning Outcomes

- Conceptual Understanding: Students will understand the basic concepts and techniques of operations research, including linear programming, integer programming, and network models.
- Analytical Skills: Students will be able to analyze complex problems and develop appropriate mathematical models.
- Solution Techniques: Students will learn and apply various optimization techniques to find the best possible solutions.
- Software Proficiency: Students will gain hands-on experience with operations research software and tools.
- Practical Application: Students will demonstrate the ability to apply operations research methods to real-world scenarios, improving decision-making and operational efficiency.

CSCMJ76	Cloud Computing & Practical	Theory	Practical	Cumulative
		3	1	4
Major		45	30	75

Course Objectives

- To study and understand the fundamentals and essentials of Cloud Computing.
- To provide a sound foundation of the Cloud Computing so that they are able to start using and adopting Cloud Computing services and tools in their real-life scenarios.
- To enable students exploring some important cloud computing driven commercial systems and applications.
- To expose the students to frontier areas of Cloud Computing and information systems, while providing sufficient foundations to enable further study and research.

Syllabus

Units	Course Content	Hr. of Teaching
I	Introduction to Parallel and Distributed Computing; Introduction to Cloud Computing; Characteristics and benefits of cloud computing; Historical developments and evolution of cloud computing: Distributed Systems, Virtualization, Web 2.0, Service-oriented computing, Utility Computing; Cloud Computing Reference Model.	12
II	Introduction to virtualization; Characteristics of virtualized environments; Taxonomy of virtualization techniques; Virtualization and cloud computing; Pros and cons of virtualization; Technology examples: Xen: paravirtualization, VMware: full virtualization, Microsoft Hyper-V.	9
III	Cloud Computing Architecture; Service models: Infrastructure as a Service (IaaS), Platform as a Service (PaaS), Software as a Service (SaaS); Deployment models: Public, Private, Hybrid, Community; IaaS: Introduction to IaaS, Resource Virtualization i.e. Server, Storage and Network virtualization; PaaS: Introduction to PaaS, Cloud platform & Management of Computation and Storage; SaaS: Introduction to SaaS, Cloud Services, Web services, Web 2.0, Web OS; Case studies related to IaaS, PaaS and SaaS.	12
IV	Economics of the cloud; Open Challenges in Cloud Computing; Introduction to emerging computing paradigms and research challenges: Edge Computing, Mobile Cloud Computing, Fog Computing etc.; Introduction to IoT Cloud; Study on simulators related to cloud computing and emerging computing paradigms.	12

Texts / References Books

1. R. Buyya, C. Vecchiola, S. ThamaraiSelvi, Mastering Cloud Computing, McGraw Hill Education.
2. B.Sosinsky, Cloud Computing Bible, Wiley.
3. K. Hwang, G. C. Fox,J.Dongarra, Distributed and Cloud Computing: From Parallel Processing to the Internet of Things, Morgan Kaufmann

Learning Outcomes

After successful completion of this course, student will be able to

- Explain the core concepts of the cloud computing paradigm: how and why this paradigm shift came about, the characteristics, advantages and challenges brought about by the various models and services in cloud computing.
- Apply the fundamental concepts in datacenters to understand the tradeoffs in power, efficiency and cost.
- Identify resource management fundamentals, i.e. resource abstraction, sharing and sandboxing and outline their role in managing infrastructure in cloud computing.
- Analyze various cloud programming models and apply them to solve problems on the cloud.

CSCMJ77	Soft Computing & Practical	Theory	Practical	Cumulative
		3	1	4
Major		45	30	75

Course Objectives

- Introduction to Soft Computing: Provide a comprehensive understanding of soft computing techniques and their applications.
- Conceptual Framework: Develop a solid foundation in the theoretical concepts of fuzzy logic, neural networks, and evolutionary algorithms.
- Problem-Solving Skills: Enhance students' abilities to apply soft computing methods to solve complex real-world problems.
- Interdisciplinary Knowledge: Foster an understanding of the interdisciplinary nature of soft computing and its integration with other fields.
- Practical Applications: Equip students with practical skills to implement and experiment with soft computing techniques in various domains.

Syllabus

Units	Course Content	Hr. of Teaching
I	**Introduction to Soft Computing:**Concept of computing systems, Soft computing versus Hard computing, Characteristics of Soft computing, Some applications of Soft computing techniques	10
II	**An Introduction to Artificial Neural Network:** Fundamental concepts, Evolution of NN, BasicModels of ANN, connections and learning, Terminologies such as weights, Bias, Threshold,Learning Rate etc., McCulloch-Pitts Neuron, Heb Network; Supervised Learning Network: Perceptron Network, Adaptive Linear Neuron, Multiple Adaptive Linear Neurons, BackPropagation Network, Radial Basis Function Network; Associate Memory Networks:Introduction and training algorithm for pattern association, Auto-associative Memory Network, Hetro-associative Memory Network, Bidirectional associative memory, Hopfield Network;Unsupervised Learning Network: Introduction; Fixed Weight Competitive Nets; Kohonen Self-Organizing Feature Maps; Adaptive Resonance Theory; Applications of ANN: Applications:such as recognition of characters, fabric defect identification etc.	10
III	**Introduction to Fuzzy Logic:** Classical Sets, Fuzzy Sets: operations and properties. Operations on fuzzy relations; Membership functions: Features, fuzzification, methods of membership value assignments; Defuzzification: Introduction; Lambda-Cuts for fuzzy sets and fuzzy relations; Defuzzification methods; Fuzzy Rules: Introduction; formation of rules, decomposition and aggregation of rules; fuzzy reasoning; Fuzzy inference systems (FIS) and applications: FIS methods: Mamdani and Sugeno; Applications: such as fuzzy logic control etc.	15
IV	**Genetic Algorithms:** Concept of Genetics and Evolution and its application to probabilistic search techniques, Basic GA framework and different GA architectures, GA operators: Encoding, Crossover, Selection, Mutation, etc., Solving single objective optimization problems using GAs.	10

Texts / References Books

1. Timothy J. Ross, “Fuzzy Logic with Engineering Applications,” McGraw Hill, 1995.
2. Simon Haykin, “Neural Networks” Pearson Education.
3. B. Yegnanarayana, “Artificial Neural Networks,” PHI, India, 2006.
4. S. N. Sivanandan and S. N. Deepa, “Principles of Soft Computing”, Wiley India, 2012.
5. Fakhreddine O. Karray and Clarence De Silva., “Soft Computing and Intelligent SystemsDesign, Theory, Tools and Applications,” Pearson Education, India, 2009.

Learning Outcomes

- Conceptual Clarity: Students will understand the fundamental principles of soft computing techniques such as fuzzy logic, neural networks, and genetic algorithms.
- Analytical Skills: Students will be able to analyze and design solutions for complex problems using soft computing methods.
- Implementation Skills: Students will gain proficiency in implementing soft computing algorithms and models using appropriate software tools.
- Application Insight: Students will demonstrate the ability to apply soft computing techniques to real-world problems in areas like optimization, control systems, and pattern recognition.
- Interdisciplinary Approach: Students will appreciate the interdisciplinary nature of soft computing and its potential to innovate across various fields.

CSCMJ78	Network Security and Cryptography & Practical	Theory	Practical	Cumulative
		3	1	4
Major		45	30	75

Course Objectives

- To understand basics of Cryptography and Network Security.
- To make the student learn different encryption techniques along with hashfunctions, MAC, digital signatures and their use in various protocols fornetwork security and system security.
- To learn about how to maintain the Confidentiality, Integrity and Availability of data.
- To understand various protocols for network security to protect against the threatsin the networks.

Syllabus

Units	Course Content	Hr. of Teaching
I	**Introduction:** Computer Security Concepts, The OSI Security Architecture, Security Attacks, Security Services, Security Mechanisms, A Model for Network Security. Symmetric Encryption and Message Confidentiality: Symmetric Encryption Principles, Traditional Ciphers, Stream Ciphers and Block Ciphers, Modern Symmetric Block Ciphers: DES, AES, Cipher Block Modes of Operation.	15
II	**Public-Key Cryptography and Message Authentication:** Approaches to Message Authentication, Secure Hash Functions, Message Authentication Codes, Public-Key Cryptography Principles, Public-Key Cryptography Algorithms: RSA, Digital Signatures.	10
III	**Key Distribution and User Authentication:** Symmetric Key Distribution Using Symmetric Encryption, Kerberos, Key Distribution Using Asymmetric Encryption, X.509 Certificates. Transport-Level Security: Web Security Considerations, Secure Socket Layer and Transport Layer Security, HTTPS, Secure Shell (SSH).	10
IV	**IP Security:** Overview of IP Security (IPSec), IP Security Architecture, Modes of Operation, Security Associations (SA), Authentication Header (AH), Encapsulating Security Payload (ESP), Internet Key Exchange. Electronic Mail Security: Threats to E-Mail, Requirements and Solutions, Encryption for Secure E-Mail, Secure E-Mail System.	10

Texts / References Books

1. Stalling, W., Network security essentials, Pearson education Asia publication.
2. Kahate, A., Cryptography & Network Security, Mc Graw Hill.
3. Forouzan, B. A., Cryptography and Network Security, McGraw-Hill Education.

Learning Outcomes

After successful completion of this course, student will be able to:

- Analyze and design classical encryption techniques and block ciphers.
- Understand and analyze data encryption standard.
- Understand and analyze public-key cryptography, RSA and otherpublic-key cryptosystems such as Diffie-Hellman Key Exchange etc.
- Understand key management and distribution schemes and designUser Authentication Protocols.
- Analyze and design hash and MAC algorithms, and digital signatures.
- Design network application security schemes, such as PGP, S/MIME, IPSec, SSL, TLS

CSCMJ79	Heuristics & Metaheuristics & Practical	Theory	Practical	Cumulative
		3	1	4
Major		45	30	75

Course Objectives

- Problem-Solving Techniques: Introduce students to heuristic and metaheuristic techniques for solving complex optimization problems.
- Algorithm Understanding: Provide a thorough understanding of various heuristic algorithms, such as greedy algorithms, local search, and evolutionary algorithms.
- Design and Implementation: Equip students with the skills to design, implement, and evaluate heuristic and metaheuristic algorithms.
- Application Knowledge: Demonstrate how these techniques can be applied to real-world problems in various domains, such as logistics, scheduling, and machine learning.
- Comparative Analysis: Teach students how to compare and contrast different heuristic and metaheuristic methods in terms of efficiency, accuracy, and computational complexity.

Syllabus

Units	Course Content	Hr. of Teaching
I	**Introduction to Computability Theory:** NP-Complete problems; Landscape and Search Space: topologies, meaning and importance; Traditional vs Heuristic Search; Greedy algorithms and Exact Methods; Single solution Metaheuristics; Review of Single State Methods: Hill Climbing, Tabu Search, Iterated Local Search. Models for optimization: (i) Single-Objective Optimization; (ii) Constrained Optimization; (iii) Multi-Objective Optimization; (iv) Optimization under Uncertainty; (v) Dynamic Optimization.	10
II	**Bio-Inspired Algorithms:** (i) Common concepts; (a) Selection methods; (b) Reproduction; (c) Replacement strategies; (ii) Genetic Algorithmss; (ii) Genetic Programmings (iii) AIS; (iv) Swarm Intelligence: Particle Swarm Optimization, Ant Colony Optimization, Artificial Bee Colony; (v) Differential Evolution ; and (vi) Estimation of Distribution Algorithms.	10
III	Hybrid Metaheuristics; Parallel Metaheuristics; Multi Objective Optimization by Metaheuristics; Machine Learning; Metaheuristics.	15
IV	Metaheuristics application examples in: Network Sciences; Games; Internet of Things; Computer Security; Robotics; Art and Design.	10

Texts / References Books

1. Larrañaga, P., & Lozano, J. A. (Eds.). (2001). Estimation of distribution algorithms: A new tool for evolutionary computation (Vol. 2). Springer Science & Business Media.
2. Kearns, M. J., & Vazirani, U. (1994). An introduction to computational learning theory. MIT press.
3. S. Luke, Essentials of Metaheuristics, 2015. (http://cs.gmu.edu/~sean/book/metaheuristics/).
4. Deb, K. (2001). Multi-objective optimization using evolutionary algorithms (Vol. 16). John Wiley & Sons.
5. Talbi, E. G. (2009). Metaheuristics: from design to implementation. John Wiley & Sons.

Learning Outcomes

- Algorithm Proficiency: Students will gain proficiency in various heuristic and metaheuristic algorithms.
- Problem-Solving Skills: Students will be able to apply these techniques to solve complex optimization problems effectively.
- Implementation Skills: Students will demonstrate the ability to design, implement, and test heuristic and metaheuristic algorithms using programming languages or software tools.
- Evaluation and Analysis: Students will be able to evaluate the performance of different algorithms and select the most appropriate one for a given problem.
- Practical Application: Students will understand how to apply heuristics and metaheuristics to practical problems in diverse fields, enhancing their problem-solving toolkit.

CSCMJ7R8	Knowledge & Data Discovery & Practical	Theory	Practical	Cumulative
		3	1	4
Major		45	30	75

Course Objectives

- Ability to understand the role of data mining in knowledge discovery process.
- To familiarize with various data mining functionalities and how it can be applied to various real-world problems.
- To learn about finding data characteristics and evaluating the outcome of data mining process.
- To familiarize with various machine learning algorithms used in data mining.

Syllabus

Units	Course Content	Hr. of Teaching
I	Basics of Knowledge and Data Discovery (KDD) Tasks: Classification, Regression, Time series analysis, prediction, clustering, summarization, association rules, sequence discovery. KDD vs. data mining, data discovery issues, data discovery metrics, data discovery vs data mining vs database.	10
II	Related concepts: database/ OLTP systems, information retrieval, decision support system, dimensional modeling, data warehousing, OLAP, web search engines, statistics, machine learning, pattern matching. Statistical perspective on data discovery: point estimation, models based on summarization, Bayes theorem, hypothesis testing, regression and correlation. Similarity measures, decision trees, neural networks, genetic algorithms.	10
III	Classification algorithm instatistical, distance, tree neural network, and rule framework. Hierarchical, and partitionbased clustering algorithm.Algorithm for clustering large databases, clustering with categorical attributes, association rules.	10
IV	Web content , structure , and web mining. Spatial data overview, spatial data primitives, generalization and specialization, spatial association rules, and spatial classification and clustering algorithms. Temporal data overview, modelling of temporal events, time series data analysis, transformation, and prediction. Pattern detection, sequence analysis algorithm (AprioriAll, SPADE, Generalization, Feature Extraction), temporal association rules.	15

Texts / References Books

1. J. Han and M. Kamber, “Data Mining: Concepts and Techniques”, Academic Press.
2. I. H. Witten et al., Data Mining: Practical machine Learning Tools and Techniques, Morgan Kaufmann Publisher.
3. Pang-Ning Tan, Michael Steinbach, Vipin Kumar, Introduction to Data Mining, Pearson Education, 2016
4. Margaret H. Dunham, Data Mining: Introductory and Advanced Topics, Pearson, 2002.
5. Ian H. Witten, Eibe Frank, Mark A. Hall, Christopher J. Pal, Morgan Kaufmann, 2016.

Learning Outcomes

After successful completion of this course, student will be able to

- Apply data mining functionalities on real world problems and datasets.
- Have some knowledge about the couple of data mining tools and how they can be used for large data.
- Find the characteristics of given data and may identify presence of outliers, if any.
- Pursue some advance course on data science and may help in subjects like Big Data, AI etc.

CSCMJ7R9	Distributed Systems & Practical	Theory	Practical	Cumulative
		3	1	4
Major		45	30	75

Course Objectives

- To learn core concepts such as distributed computing, concurrency, fault tolerance, and scalability to design and manage distributed architectures effectively.
- To apply principles to develop, deploy, and analyze distributed systems, including communication protocols, data consistency models, and performance optimization techniques.

Syllabus

Units	Course Content	Hr. of Teaching
I	Introduction: Definition, Goals, Types of Distributed Systems, Distributed Computing Systems, Distributed Information Systems, Distributed Pervasive Systems, System Architectures, Architectures versus Middleware, Self-Management in Distributed. Processes & Communication: Threads, Threads in Distributed Systems, Virtualization, Clients, Servers, Code Migration, Remote Procedure Call, Message-Oriented Communication, Stream-Oriented Communication, Multicast Communication.	13
II	Naming: Names, Identifiers, Addresses, Flat Naming, Structured Naming, Attribute-Based Naming. Synchronization: Clock Synchronization, Logical Clocks, Mutual Exclusion, Centralized Algorithm, Decentralized Algorithm, Distributed Algorithm, Token Ring Algorithm, Global Positioning of Nodes, Election Algorithms.	12
III	Consistency, Replication & Fault Tolerance: Introduction, Reasons for Replication, Replication as Scaling Technique, Data-Centric Consistency Models, Client-Centric Consistency Models, Replica Management, Consistency Protocols, Process Resilience, Reliable Client-Server Communication, Reliable Group Communication, Distributed Commit, Recovery.	10
IV	Distributed Shared Memory & File Systems: Hardware DSM, Design issues in DSM Systems, Implementation issues, Heterogeneous and Other DSM Systems, Distributed File Systems, File Service Architecture, Case Study: Sun Network File System, The Andrew File System.	10

Texts / References Books

1. A. S. Tanenbaum, M. V. Steen, Distributed systems: principles and paradigms, Prentice-Hall.
2. G. F. Coulouris, J. Dollimore, T. Kindberg, Distributed Systems: Concepts and Design, Addison-Wesley.
3. M. Singhal, N. G. Shivaratri, Advanced concepts in operating systems, McGraw-Hill.

Learning Outcomes

After successful completion of this course, student will be able to:

- Develop the ability to design scalable and fault-tolerant distributed systems, applying concepts such as consensus algorithms, replication, and partitioning.
- Gain hands-on experience in implementing distributed systems, including network communication, data consistency, and distributed algorithms.
- Evaluate the performance and scalability of distributed systems, using metrics and tools to identify bottlenecks and optimize efficiency.
- Develop skills to troubleshoot issues and maintain distributed systems, ensuring reliability, fault tolerance, and effective error handling.

CSCMJ7R10	Parallel Computing & Practical	Theory	Practical	Cumulative
		3	1	4
Major		45	30	75

Course Objectives

- To provide the Understanding of hardware and software work together in parallel and sequential mode.
- To understand the simple systems to complex shared resource architectures and learning parallel programming techniques.
- To discuss and understand the common software packages and libraries, learning how to write and document software packages, enhancing skills in managing simultaneous data processes, optimizing computational tasks for quicker execution.
- To understand the fundamental aspects of parallel systems, and providing an integrated view of the various facets of software development on parallel systems.

Syllabus

Units	Course Content	Hr. of Teaching
I	Introduction to Parallel Computing: Supercomputers and grand challenge problems, Modern Parallel Computers, Data Dependence Graph, Data Parallelism, Functional Parallelism, Pipelining and Data Clustering.	10
II	Interconnection Networks: Switch Network Topologies, Direct and Indirect Network Topology, Bus, Star, Ring, Mesh, Tree, Binary Tree Network, Hyper Tree Network, Hybrid, Hypercube, Perfect Shuffle Network, Torus and Butterfly Network.	10
III	Performance Analysis: Introduction, Execution Time, Speedup, Linear and Superliner Speedup, Efficacy and Efficiency, Amdahl's Law and Amdahl Effect, Gustafson-Barsis's Law, Minsky's Conjecture, The Karp-Flatt Metric, The Isoefficiency Metric, Isoefficiency Relation, Cost and Scalability.	10
IV	Parallel Computational Models: Flynn's Taxonomy, PRAM, EREW, CREW, ERCW, CRCW,Simulating CRCW, CREW & EREW, PRAM algorithms. Introduction to Parallel Algorithms: Parallel Programming Models, PVM, MPI Paradigms, Parallel Programming Language, Brent's Theorem, Simple parallel programs in MPI environments, Parallel algorithms on network, Addition of Matrices, Multiplication of Matrices.	15

Texts / References Books

1. Hwang and Briggs, Computer Architecture and Parallel Processing, McGraw Hill.
2. Crichlow, Introduction to Distributed and Parallel Computing, PHI.
3. M.J. Quinn, Designing Efficient Algorithms for Parallel Computers, McGraw-Hill.
4. V. Rajaraman, Elements of Parallel Computing, PHI.
5. Joseph JA JA, Introduction to Parallel Algorithms, Addison Wesley.

Learning Outcomes

After successful completion of this course, students will be able to:

- Describe different parallel architectures, inter-connect networks, programming models and develop an efficient parallel algorithm to solve given problem.
- Analyze and measure performance of modern parallel computing systems.
- Build the logic to parallelize the programming task.
- Develop efficient parallel algorithms for sorting and Graph.
- Develop an algorithm for CUDA Architecture.

CSCMJ7R11	Image Processing & Practical	Theory	Practical	Cumulative
		3	1	4
Major/Minor		45	30	75

Course Objectives

- To learn digital image processing fundamentals, including visual perception, image formation, and pixel operations.
- To develop skills in image enhancement through techniques like contrast stretching, histogram processing, and spatial and frequency domain filtering.
- To study image reconstruction methods from projections, such as tomography and Radon transforms, with a focus on Fourier reconstruction and fan-beam reconstruction, essential for medical imaging and diagnostics.
- To explore image compression principles, including error criteria, lossy methods like JPEG, and lossless techniques such as Huffman coding, critical for efficient data storage and transmission in the era of big data and multimedia.

Syllabus

Units	Course Content	Hr. of Teaching
I	Digital Image Fundamental: Elements of Visual Perception- Structure of the human eye, Image formation in the eye, brightness adaptation and discrimination; light and electromagnetic spectrum, image sensing and acquisition, image sampling and quantization, basic relationships between pixels, linear and nonlinear operations.	10
II	Image Enhancement: Point processing: Contrast stretching, power-law and gamma transformation. Histogram processing: histogram equalization and matching. Filtering and Restoration: Degradation function and Noise Models, Spatial Domain Filtering: Correlation and Convolution, Smoothing Linear and Nonlinear Filters, Sharpening Linear and Nonlinear Filters. Frequency Domain Filtering: Filtering: Low-pass (Smoothing) & High-Pass (Sharpening), Homomorphic Filtering, Periodic Noise Reduction and Inverse Filtering & Wiener Filtering.	15
III	Image Reconstruction from Projections: Transmission tomography, reflection tomography, emission tomography, magnetic resonance imaging, and projection based image processing. Radon transform, back projection operator, projection theorem, inverse radon transform, convolution filter back projection, reconstruction from blurred noisy projections, Fourier reconstruction, fan-beam reconstruction.	10
IV	Image Compression: Introduction, Error criterion- objective and subjective criterion,Lossy compression- transform domain compression, JPEG compression, block truncation compression, vector quantization compression; Lossless compression- Huffman coding, arithmetic coding, transformed coding, run-length coding..	10

Texts / References Books

1. A. K. Jain, Fundamentals of Digital Image Processing, Pearson Education India, 2015.
2. Rafael Gonzalez, Richard Woods, Digital Image Processing, Pearson Education India, 2017

Learning Outcomes

After successful completion of this course, students will be able to:

- Master digital image processing fundamentals, including visual perception and pixel operations.
- Enhance image quality using techniques such as contrast stretching and histogram processing.
- Gain proficiency in spatial and frequency domain filtering techniques.
- Understand and implement advanced image reconstruction methods from projections, including tomography and Radon transforms.
- Apply image compression methods, including both lossy techniques (e.g., JPEG) and lossless techniques (e.g., Huffman coding), for optimal data storage and transmission.
- Address contemporary challenges in medical imaging, multimedia, and data analysis with these skills.

Semester- VIII

CSCMJ8R1	Deep Learning	Theory	Practical	Cumulative
		3	1	4
Major/Minor		45	30	75

Course Objectives

- Core Principles: Introduce students to the fundamental concepts and theories of deep learning, including neural networks and their architectures.
- Hands-On Experience: Develop practical skills through hands-on experience with deep learning frameworks and tools.
- Model Building: Teach students how to design, train, and evaluate deep learning models for various applications.
- Advanced Techniques: Explore advanced topics such as convolutional neural networks (CNNs), recurrent neural networks (RNNs), and generative models.
- Real-World Applications: Provide an understanding of how to apply deep learning techniques to real-world problems in areas such as computer vision, natural language processing, and robotics.

Syllabus

Units	Course Content	Hr. of Teaching
I	Linear Algebra Review: Brief review of concepts from Linear Algebra. Optimization: Types of errors, bias-variance tradeoff, overfitting, underfitting, a brief review of concepts from Vector Calculus and optimization, variants of gradient descent, momentum. Logistic Regression: Basic concepts of regression and classification problems, linear models addressing regression and classification, maximum likelihood, logistic regression classifiers.	10
II	Neural Networks: Basic concepts of artificial neurons, single and multilayer perceptrons, perceptron learning algorithm, its convergence proof, different activation functions, softmax crossentropy loss function.	10
III	Recurrent Neural Networks: Discussion on Recurrent Neural Networks (RNNs), Long-Short, Term Memory (LSTM) architectures, and basics of word embedding. ConvNets: Basic concepts of Convolutional Neural Networks starting from filetering. Convolution and pooling operation and arithmetics of these. ConvNet Architectures: Discussions on famous convnet architectures AlexNet, ZFNet, VGG, C3D, GoogLeNet, ResNet, MobileNetv1.	15
IV	Introduction to Deep Reinforcement Learning, Autoencoders (standard, denoising, contractive, etc).	10

Texts / References Books

1. Goodfellow, I., Bengio, Y., Courville, A. (2016). Deep learning. MIT press. (http://www.deeplearningbook.org)
2. Nielsen, M. A. (2015). Neural networks and deep learning (Vol. 25, pp. 15-24). San Francisco, CA, USA: Determination press.
3. Chollet, F. (2021). Deep learning with Python. Simon and Schuster.
4. Géron, A. (2022). Hands-on machine learning with Scikit-Learn, Keras, and TensorFlow. Reilly Media, Inc.
5. Jones H. (2018). Deep Learning: An Essential Guide to Deep Learning for Beginners Who Want to Understand How Deep Neural Networks Work and Related to Machine Learning and Artificial Intelligence. Create space Independent Publishing

Learning Outcomes

- Conceptual Mastery: Students will understand the key principles and theories underlying deep learning and neural networks.
- Practical Skills: Students will gain proficiency in using deep learning frameworks like TensorFlow andPyTorch to build models.
- Model Development: Students will be able to design, implement, and evaluate deep learning models for various tasks.
- Advanced Knowledge: Students will have a deep understanding of advanced deep learning techniques, including CNNs, RNNs, and GANs.
- Application Ability: Students will be capable of applying deep learning methods to solve complex real-world problems in various domains.

CSCMJ8R2	Internet of Things & Practical	Theory	Practical	Cumulative
		3	1	4
Major		45	30	75

Course Objectives

- To understand the application areas of IOT.
- To realize the revolution of Internet in Mobile Devices, Cloud & Sensor Networks.
- To understand building blocks of Internet of Things and characteristics.

Syllabus

Units	Course Content	Hr. of Teaching
I	Introduction to IoT: Genesis of IoT, IoT and Digitization, IoT Challenges, Comparing IoT architectures, a simplified IoT architecture, The core IoT functional Stack, IoT data management and compute stack.	11
II	Engineering for IoT Networks: Sensors, Actuators, Smart Objects, Sensor Networks, IoT Access Technologies, IP as the IoT Network Layer, Applications protocols for IoT.	12
III	Data and Analytics for IoT: An introduction to data analytics for IoT, Machine Learning, Big data analytics tools and technology, edge streaming analytics, network analytics.	12
IV	IoT in Industry: Manufacturing, Oil and Gas, Utilities, Smart and Connected Cities, Transportation, Mining, Public Safety.	10

Texts / References Books

1. D. Hanes, G.Salgueiro, P.Grossetete, R. Barton, J. Henry, IoT Fundamentals: Networking Technologies, Protocols, and Use Cases for the Internet of Things, CISCO.
2. Rajkamal, Internet of Things, McGraw Hill Education.

Learning Outcomes

After successful completion of this course, students will be able to:

- Identify the Components that form part of IoT Architecture.
- Determine the most appropriate IoT Devices and Sensors based on Case Studies.
- Setup the connections between the Devices and Sensors.
- Evaluate the appropriate protocol for communication between IoT and to analyze the communication protocols for IoT.

CSCMJ8R3	Block chain Technology & Practical	Theory	Practical	Cumulative
		3	1	4
Major		45	30	75

Course Objectives

- The course aims to provide a comprehensive understanding of blockchain technology, and its applications.
- Students will first explore the fundamentals of distributed databases, fault tolerance, and cryptographic techniques including hash functions, digital signatures, and zero-knowledge proofs.
- Focus will be on block chain technology, covering its structure, consensus mechanisms (including Nakamoto consensus and variants), mining strategies, smart contracts, and vulnerabilities.
- Crypto currencies like Bitcoin and Ethereum will be studied in detail, along with their protocols and applications.

Syllabus

Units	Course Content	Hr. of Teaching
I	Basics: Distributed Database, Two General Problem, Byzantine General problem and Fault Tolerance, Hadoop Distributed File System, Distributed Hash Table, ASIC resistance, Turing Complete. Cryptography: Hash function, Digital Signature - ECDSA, Memory Hard Algorithm, Zero Knowledge Proof.	10
II	Blockchain: Introduction, Advantage over the conventional distributed database, Blockchain Network, Mining Mechanism, Distributed Consensus, Merkle Patricia Tree, Gas Limit, Transactions and Fee, Anonymity, Reward, Chain Policy, Life of Blockchain application, Soft and Hard Fork, Private and Public blockchain.	10
III	Distributed Consensus: Nakamoto consensus, Proof of Work, Proof of Stake, Proof of Burn, Difficulty Level, Sybil Attack, Energy Utilization, PBFT and its variants.	10
IV	Cryptocurrency: History, Distributed Ledger, Bitcoin protocols - Mining strategy and rewards, Ethereum - Construction, DAO, Smart Contract, GHOST, Vulnerability, Attacks, Sidechain, Namecoin. Blockchain Applications: Internet of Things, Medical Record Management System, Domain Name Service and future of Blockchain.	15

Texts / References Books

1. Narayanan, A., Bonneau, J., Felten, E., Miller, A., & Goldfeder, S. (2016). Bitcoin and cryptocurrency technologies: a comprehensive introduction. Princeton University Press.
2. Wattenhofer, R. (2016). The science of the blockchain. CreateSpace Independent Publishing Platform.
3. Antonopoulos, A. M. (2017). Mastering Bitcoin: Programming the open blockchain. O'Reilly Media, Inc.
4. Saurabh, K., & Saxena, A. (2020) Blockchain Technology: Concepts and Applications. Wiley.

Learning Outcomes

- This course equips students with a thorough understanding cryptography, and blockchain technology.
- The focus on blockchain covers its architecture, consensus mechanisms, mining strategies, and smart contract applications. Students will evaluate real-world applications of blockchain in sectors like IoT, healthcare, and finance, assessing both advantages and challenges.
- The course fosters critical thinking skills for analyzing blockchain protocols, identifying vulnerabilities, and proposing enhancements in security and efficiency.
- By the end of the course, students will be prepared for roles in blockchain development, cybersecurity, and other fields leveraging decentralized technologies.

CSCMJ8R4	Information Retrieval & Practical	Theory	Practical	Cumulative
		3	1	4
Major		45	30	75

Course Objectives

- To provide an overview of Information Retrieval.
- To introduce students about insights of the several topics of Information retrieval such as – Boolean retrieval model, Vector space model, Latent semantic indexing, XML and Image retrieval model.
- To provide comprehensive details about various Evaluation methods.
- To provide implementational insight about the topics covered in the course.

Syllabus

Units	Course Content	Hr. of Teaching
I	Introduction Information Retrieval: Information retrieval process, Indexing, Information retrieval model, Boolean retrieval model. Dictionary and Postings: Tokenization, Stop words, Stemming, Inverted index, Skip pointers, Phrase queries.	10
II	Tolerant Retrieval: Wild card queries, Permuterm index, Bigram index, Spelling correction, Edit distance, Jaccard coefficient, Soundex. Term Weighting and Vector Space Model: Wild card queries, Permuterm index, Bigram index, Spelling correction, Edit distance, JaccardJaccard coefficient, Soundex.	10
III	Evaluation: Precision, Recall, F-measure, E-measure, Normalized recall, Evaluation problems. Latent Semantic Indexing: Eigen vectors, Singular value decomposition, Lowrank approximation, Problems with Lexical Semantics.Query Expansion: Relevance feedback, Rocchio algorithm, Probabilistic relevance feedback, Query Expansion and its types, Query drift. Probabilistic Information Retrieval: Probabilistic relevance feedback, Probability ranking principle, Binary Independence Model, Bayesian network for text retrieval.	13
IV	XML Indexing and Search: Data vs. Text-centric XML, Text-Centric XML retrieval, Structural terms. Content BasedImage Retrieval: Introduction to content Based Image retrieval, Challenges in Image retrieval, Image representation, Indexing and retrieving images, Relevance feedback. Introduction to video retrieval.	12

Texts / References Books

1. C. D. Manning, P. Raghvan, H. Schutze, Introduction to Information Retrieval, Cambridge University Press, 2008.
2. R. Mihalcea, D. Radev, Graph based Natural Language Processing and Information Retrieval, Cambridge University Press, April 2011.
3. U.S. Tiwary, T. Siddiqui, Natural Language Processing and Information Retrieval, Oxford University Press, 2008.
4. G. S. Ingersol, T. S. Morton, A. L. Farris, Taming Text: How to Find, Organize and Manipulate It, Manning Publications, 2013.
5. S. Bird, E. Klein, E. Loper, Natural Language Processing with Python, O'Reilly Media, 2009.

Learning Outcomes

- Students will get the understanding different Information retrieval model.
- Students will get to know about evaluation methods of the information retrieval model.
- Students will get to know the challenges associated with each topic.

CSCMJ8R5	Statistical Pattern Recognition & Practical	Theory	Practical	Cumulative
		3	1	4
Major		45	30	75

Course Objectives

- To gain a profound understanding of the theories, algorithms, and applications of the state-of-the-art of statistical pattern recognition, various mathematical approaches, and the applications to image and video pattern analysis and recognition.
- This is a research-orientated course.

Syllabus

Units	Course Content	Hr. of Teaching
I	Introduction: Description of patterns, Probabilistic formulation of PR, Geometrical interpretation, Applications of PR, Scope of statistical PR. Elementary Bayes decision theory, statistical criterion and discriminant functions, linear decision functions, piecewise linear decision functions, minimum distance classifier, nonlinear classification theory, multiple pattern classification.	10
II	Representation of patterns and Feature Selection: Representation of binary random patterns – Orthogonal series expansion procedures, and Markov dependence considerations.KL expansion of patterns and its properties.Information measures of feature effectiveness, Distance measure and performance bounds, Multiclass distance measures, Feature selection criterion, Evaluation of feature subset, Algorithm of dimensionality reduction, dimensionality and sample size.	10
III	Supervised and Unsupervised Learning : Bayesian estimation for Gaussian patterns, Comments on supervised Bayesian estimation, parameter estimation of slowly varying patterns, Bayes solution to unsupervised estimation, Estimation of mixture parameters, and decision-directed estimation. Graph theoretic method, component analysis – ICA, PCA, Artificial neural network. Recursive Algorithm using stochastic approximation.	12
IV	Nonparametric methods and compound decision theory: Basic concepts and tools, Sample set construction, Nearest – Neighbor decision procedure, compound decision procedure, nonparametric estimation of multivariate density function, and nonparametric feature selection.Cluster and Mode-Seeking Techniques: Distance and similarity measures, clustering methods. Sequential pattern recognition systems: Bayes sequential decision procedure and the computational problems, Feature-ordering and selection problems, and nonparametric sequential ranking procedure. Contextual analysis in pattern recognition.	13

Texts / References Books

1. R.O. Duda, P.E. Hart and D.G. Stork, Pattern Classification, Wiley and Sons, 2001.
2. C. H. Chen, Statistical Pattern Recognition, Spartan Books, 1973.
3. Christopher M. Bishop, Pattern Recognition and Machine Learning, Springer, 2016.
4. B. SchÖlkopf and A.J. Smola, Learning with Kernels, MIT Press, 2002.
5. Jerome Friedman, Robert Tibshirani, Trevor Hastie, The Elements of Statistical Learning, Springer-Verlag , 2017.

Learning Outcomes

After successful completion of this course, students will be able to:

- Understand the core theories and algorithms of statistical pattern recognition.
- Understand the state-of-the-art of statistical pattern recognition.
- Perform parametric classifier design,nonparametric classifier design, feature selection and dimension reduction,unsupervised data clustering.
- Understand the applications such as face recognition, face detection, object detection, gesture recognition, speech recognition, etc.

CSCMJ8R6	Image Analysis and Computer Vision & Practical	Theory	Practical	Cumulative
		3	1	4
Major		45	30	75

Course Objectives

- To equip students with a comprehensive understanding of morphological image processing, including segmentation, boundary extraction, and object recognition.
- To learn set theory and logic operations with binary images, and apply morphological algorithms such as dilation, erosion, opening, closing, and hit-or-miss transformation.
- To explore techniques for detecting discontinuities, component labeling, and segmentation methods.
- To study advanced representation techniques, including Fourier descriptors.
- To emphasize real-world applications in medical image analysis, automated inspection systems, and facial recognition technology to provide practical context and enhance learning outcomes.

Syllabus

Units	Course Content	Hr. of Teaching
I	Morphological Image Processing: Basic concept of set theory, logic operation involving binary images, dilation and erosion, opening and closing, and hit-or-miss transformation. Some basic morphological algorithms – Boundary extraction, region filling, extraction of connected components, convex hull, thinning, thickening, skeletons, and pruning. Extensions to gray-scale images – Dilation, Erosion, Opening and closing, and application of gray scale morphology.	10
II	Image Segmentation: Detection of discontinuities – Point detection, line detection, edge detection – gradient operators, compass operators, Laplace operators and zero crossing, stochastic gradients, performance of edge detector operators. Amplitude thresholding or window slicing, component labeling, boundary based approaches, region-based approaches and clustering, template matching, and texture segmentation.	15
III	Boundary Extraction and Representation: Connectivity, Contour following, edge linking, Hough transform, chain code, fitting line segments, B-spline representation, Fourier descriptors, shape number, and autoregressive model. Region Representation: Run-length codes, quad-trees, topological descriptor, texture and projections.	10
IV	Moment Representation, Shape feature, Texture, Scene matching and matched filtering. Object recognition and image understanding: Patterns and pattern classes, decision theoretic and structural methods.	10

Texts / References Books

1. Jain, A. K. (2015). Fundamentals of digital image processing. Pearson Education India.
2. Gonzalez, R., & Woods, R. (2017). Digital image processing. Pearson Education India.
3. Forsyth, D., & Ponce, J. (2015). Computer vision: A modern approach. Pearson.
4. Szeliski, R. (2010). Computer vision: Algorithms and applications. Springer.
5. Prince, S. J. D. (2012). Computer vision: Models, learning, and inference. Cambridge University Press.
6. Hartley, R., & Zisserman, A. (2004). Multiple view geometry in computer vision. Cambridge University Press.
7. Soille, P. (2010). Morphological image analysis: Principles and applications. Springer.

Learning Outcomes

After successful completion of this course, students will be able to:

- Understand and apply fundamental concepts of morphological image processing, including dilation, erosion, opening, closing, and hit-or-miss transformation.
- Detect image discontinuities, perform amplitude thresholding, component labeling, and utilize various segmentation methods.
- Gain proficiency in boundary extraction, edge linking, contour following, and advanced representation techniques such as Fourier descriptors and autoregressive models.
- Learn to recognize objects using decision-theoretic and structural methods.
- Apply these techniques to real-world scenarios like medical image analysis, automated inspection systems, and facial recognition.

CSCMJ8R7	Natural Language Processing & Practical	Theory	Practical	Cumulative
		3	1	4
Major		45	30	75

Course Objectives

- This course aims to introduce the theory and methodology of natural language understanding and generation.
- Topics include stemming, lemmatization, parts of speech tagging, parsing, and machine translation.
- Employing specialized libraries, students develop applications for topic modeling, sentiment analysis, and text summarization.

Syllabus

Units	Course Content	Hr. of Teaching
I	Introduction- Human languages, models, ambiguity, processing paradigms; Phases in natural language processing, applications, Text representation in computers, encoding schemes; Linguistics resources- Introduction to corpus, elements in balanced corpus, TreeBank, PropBank, WordNet, VerbNet etc., Resource management with XML, Management of linguistic data with the help of GATE, NLTK.	10
II	Regular expressions, Finite State Automata, word recognition, lexicon, Morphology, acquisition models, Finite State Transducer, N-grams, smoothing, entropy, HMM, ME, SVM, CRF; Part of Speech tagging- Stochastic POS tagging, HMM, Transformation based tagging (TBL), Handling of unknown words, named entities, multi word expressions.	12
III	A survey on natural language grammars, lexeme, phonemes, phrases and idioms, word order, agreement, tense, aspect and mood and agreement, Context Free Grammar, spoken language syntax; Parsing- Unification, probabilistic parsing, TreeBank, Semantics- Meaning representation, semantic analysis, lexical semantics, WordNet.	11
IV	Word Sense Disambiguation- Selectional restriction, machine learning approaches, dictionary based approaches; Discourse- Reference resolution, constraints on co-reference, algorithm for pronoun resolution, text coherence, discourse structure; Applications of NLP- Spell-checking, Summarization; Information Retrieval- Vector space model, term weighting, homonymy, polysemy, synonymy, improving user queries; Machine Translation– Overview.	12

Texts / References Books

1. Daniel Jurafsky and James H Martin. Speech and Language Processing, 2e, Pearson Education, 2009.
2. James A.. Natural language Understanding 2e, Pearson Education, 1994.
3. Bharati A., Sangal R., Chaitanya V., Natural language processing: a Paninian perspective, PHI, 2000.
4. Siddiqui T., Tiwary U. S., Natural language processing and Information retrieval, OUP, 2008.

Learning Outcomes

After successful completion of this course, students will be able to:

- Extract information from text automatically using concepts and methods from natural language processing (NLP) including stemming, n-grams, POS tagging, and parsing.
- Analyze the syntax, semantics, and pragmatics of a statement written in a natural language.
- Apply machine learning algorithms to natural language processing.
- Write scripts and applications in Python to carry out natural language processing using libraries such as NLTK, Gensim, and spaCY.
- Design NLP-based AI systems for question answering, text summarization, and machine translation.
- Evaluate the performanceof NLP tools and systems.

CSCMJ8R8	Data Compression & Practical	Theory	Practical	Cumulative
		3	1	4
Major		45	30	75

Course Objectives

- To provide a comprehensive understanding of data compression techniques, including theoretical foundations and practical applications.
- To explore lossless and lossy compression methods, such as Huffman coding, arithmetic coding, and quantization techniques.
- To cover key image and video compression standards, including JPEG, JPEG-2000, H.264, and H.265 (HEVC).
- To examine the role of machine learning in data compression, focusing on neural network-based compression and autoencoders.
- To equip students with the skills to implement and evaluate various data compression algorithms.

Syllabus

Units	Course Content	Hr. of Teaching
I	Introduction to Data Compression: Overview of data compression, History and significance, Basic concepts and terminology. Information Theory and Entropy: Fundamentals of information theory, Entropy and information content, Source coding theorem, Applications and examples.	10
II	Lossless Compression Techniques: Huffman coding, Arithmetic coding, Run-length encoding (RLE), Lempel-Ziv-Welch (LZW) compression. Lossy Compression: Fundamentals of lossy compression, Quantization techniques, Rate-distortion theory.	10
III	Transform Coding: Discrete Cosine Transform, Wavelet transforms. Image Compression Standards: JPEG and JPEG-2000, Advanced image compression, Compression performance and quality metrics.	10
IV	Video Compression Techniques: Video coding basics, Motion estimation and compensation, Standards: H.264, H.265 (HEVC). Machine Learning in Data Compression: Neural network-based compression, Autoencoders for image compression.	15

Texts / References Books

1. Sayood, K. (2017). Introduction to Data Compression. Morgan Kaufmann.
2. Salomon, D., & Motta, G. (2010). Handbook of Data Compression. Springer.
3. Gonzalez, R. C., & Woods, R. E. (2018). Digital Image Processing. Pearson.

Learning Outcomes

After successful completion of this course, students will be able to:

- Understand and explain the fundamental concepts and significance of data compression.
- Gain the ability to apply lossless compression techniques such as Huffman coding, arithmetic coding, and LZW compression, and implement lossy compression methods, including quantization and rate-distortion theory.
- Utilize transform coding techniques, including Discrete Cosine Transform and wavelet transforms, and analyze and apply image and video compression standards like JPEG, JPEG-2000, H.264, and H.265 (HEVC).
- Explore the use of machine learning, particularly neural networks and autoencoders, in data compression and evaluate the performance and quality of various compression algorithms.

CSCMJ8R10	Big Data Analytics & Practical	Theory	Practical	Cumulative
		3	1	4
Major		45	30	75

Course Objectives

- This course gives an overview of Big Data, i.e. storage, retrieval and processing of big data.
- In addition, it also focuses on the "technologies", i.e., the tools/algorithms that are available for storage, processing of Big Data.
- It also helps a student to perform a variety of "analytics" on different data sets and to arrive at positive conclusions.

Syllabus

Units	Course Content	Hr. of Teaching
I	Introduction to Big Data Analytics: Nuances of big data, Value, Issues, Case for Big data, Big data options Team challenge, Big data sources, Acquisition, Nuts and Bolts of Big data. Features of Big Data, Security, Compliance, auditing and protection, Evolution of Big data, Best Practices for Big data Analytics, Big data characteristics, Volume, Veracity, Velocity, Variety	10
II	Data Analysis: Evolution of analytics, Scalability, Analytic methods, analytic tools, Pentaho Analysis approaches, Statistical significance, Business approaches, Analytic innovation, Traditional approaches, Iterative.	10
III	Stream Computing: Introduction to Streams Concepts, Stream data model and architecture , Stream Computing, Sampling data in a stream, Filtering streams, Counting distinct elements in a stream, Estimating moments, Counting oneness in a window, Decaying window , Real-time Analytics Platform(RTAP) and applications. Data stage, Statistical analysis, Intelligent scheduler.	12
IV	Predictive Analytics: Predictive Analytics, Supervised, Unsupervised learning, Neural networks, Kohen models, Normal, Deviations from normal patterns, Normal behaviors, Expert options, Variable entry , Mining Frequent item sets, Market based model, Apriori Algorithm, Handling large data sets in Main memory, Limited Pass algorithm, Counting frequent itemsets in a stream, Clustering Techniques, Hierarchical, K-Means Clustering high dimensional data. Frameworks and Applications: IBM for Big Data, Map Reduce Framework, Hadoop, Hive, Shading, and Hadoop Distributed file systems, Hbase.	13

Texts / References Books

1. Michael Berthold, David J. Hand, Intelligent Data Analysis, Springer, 2007.
2. Bill Franks, "Taming the Big Data Tidal Wave: Finding Opportunities in Huge Data Streams with Advanced Analytics", Wiley and SAS Business Series, 2012.
3. Paul Zikopoulos, Chris Eaton, Paul Zikopoulos, "Understanding Big Data: Analytics for Enterprise Class Hadoop and Streaming Data", McGraw Hill, 2011.
4. Paul Zikopoulos, Dirk deRoos, Krishnan Parasuraman, Thomas Deutsch , James Giles, David Corrigan, "Harness the Power of Big data, The big data platform", McGraw Hill, 2012.

Learning Outcomes

After successful completion of this course, students will be able to:

- Understand Big Data and its analytics in the real world.
- Analyze the Big Data framework like Hadoop and NOSQL to efficiently store and process Big Data to generate analytics.
- Design of Algorithms to solve Data Intensive Problems using Map Reduce Paradigm.
- Design and Implementation of Big Data Analytics using pig and spark to solve data intensive problems and to generate analytics.
- Implement Big Data Activities using Hive and other tools.

CSCMJ8R11	Quantum Computing & Practical	Theory	Practical	Cumulative
		3	1	4
Major		45	30	75

Course Objectives

- To learn about the basics of quantum computing and its applications.
- To learn the fundamentals of quantum computing and the differences between it and conventional computing.
- To understand the principals of Quantum Computing.

Syllabus

Units	Course Content	Hr. of Teaching
I	Introduction to Quantum Computing: Introduction of computing and Quantum Computing-Need of Quantum Computing-Deutsch's algorithm.	08
II	Linear Operators and Spectral Decomposition: Operators: Matrices as linear operators, Examples of matrices, Kernel, image and rank. Operations on matrices: Trace, Entry-wise multiplication, Inverse, Eigen values and eigen-vectors. Spectralde composition: Hermitian matrix, Unitary matrix, Positive semi-definite matrix, Singular value decomposition, Simultaneously diagonalizable matrices.	15
III	Operator Functions, Tensor Products and Postulates of Quantum mechanics: Operator functions, Tensor product, Direct sum, State of a system, Evolution of the system, Measurement of the system, Composite Systems, Quantum Teleportation.	10
IV	Computation, Quantum and Classical: Classical circuits-Quantum circuits–Algorithms: Randomized algorithms, Approximation algorithms. Deutsch-Josza, Fourier Transform and Phase Estimation: Deutsch-Jozsaalgorithm: Bernstein-Vazirani algorithm- Fourier transform: Discrete Fourier transform, Fast Fourier transform-Quantum discrete Fourier transform- Phase estimation.	12

Texts / References Books

1. Nielsen, M. A., & Chuang, I. L. (2019).Quantum computation and quantum information. Cambridge University Press.
2. Kaye, P., Laflamme, R., & Mosca, M. (2020). An introduction to quantum computing. Oxford University Press.

Learning Outcomes

On completion of this course, the student will be able to:

- Use the mathematical framework of quantum computing to solve computational problems.
- Critically read and understand scientific papers on quantum computing.
- Explain and analyze any quantum algorithms described in quantum circuit or measurement-based quantum computing models.
- Relate quantum complexity classes to the classical ones.
- Gain experience in problem solving for complex system.

BANARAS HINDU UNIVERSITY

Centre For Genetic Disorder

Faculty of Science

SYLLABI

B.Sc. Programme

In

Centre For Genetic Disorder

B.Sc. Courses (under NEP)
Centre for Genetic Disorders, Institute of Science
BANARAS HINDU UNIVERSITY

Skill Enhancement Courses (SEC)

- **Semester-I**

  CGDSE11 (3 credits): Awareness in Public Health Genomics

- **Semester-II**

  CGDSE21 (3 credits): Risk Factors for Genetic Disorders

- **Semester-III**

  CGDSE31 (3 credits): Genetic Counseling and Prevention of Genetic Disorders

Detailed Syllabus

BANARAS HINDU UNIVERSITY

(Detailed Syllabus of different Courses under NEP 2020**)**

Department of: Centre for Genetic Disorders
Faculty of: Science

<table>
<tr><td>Course Title</td><td colspan="2">CGDSE11 (3 credits): Awareness in Public Health Genomics</td></tr>
<tr><td>Category of Course</td><td colspan="2">Major / Minor / Minor (Vocational) / SEC / AEC / VAC / MD/Internship/Dissertation
(Tick any one of the above)</td></tr>
<tr><td>Credits &Hours of Teaching</td><td colspan="2">
<table>
<tr><td></td><td>Theory</td><td>Practical demonstration</td><td>Cumulative</td></tr>
<tr><td>Credits</td><td>2</td><td>1</td><td>3</td></tr>
<tr><td>Hour of Teaching (Total)</td><td>30</td><td>15</td><td>45</td></tr>
</table>
</td></tr>
<tr><td>Course Objectives (not more than 100 words)</td><td colspan="2">This course aims to make the students aware of genetic disorders prevalent in the population and to understand the importance of genetics in public health. It covers basic knowledge of genetics and variations, equipping them to apply this information in public health contexts for a better understanding.</td></tr>
<tr><td>Course Content</td><td colspan="2">The course content will be divided into a minimum of 3 Units to a maximum of 5 units along with a defined hour of teaching for each unit.</td></tr>
<tr><td colspan="3">
<table>
<tr><th>Units</th><th>Course Content</th><th>Hr. of Teaching</th></tr>
<tr><td>I</td><td>Need and applications of genetic knowledge in society</td><td>5</td></tr>
<tr><td>II</td><td>Understanding genetics (chromosomes, DNA, genes, and variations)</td><td>10</td></tr>
<tr><td>III</td><td>Genetic Disorders prevalent in the population and Classification (Chromosomal, monogenic, multifactorial, mitochondrial, metabolic)</td><td>15</td></tr>
<tr><td></td><td>Practical demonstration based on the above topics</td><td>15</td></tr>
</table>
</td></tr>
<tr><td>Texts / References</td><td colspan="2">

Strachan, T., Goodship, J., & Chinnery, P. (2014). Genetics and genomics in medicine. Garland Science.
Mikail, C. N. (2008). Public health genomics: The essentials. Jones & Bartlett Learning.
Snustad, D. P., & Simmons, M. J. (2015). Principles of genetics (7th ed.). Wiley.
Jayaraman, M. P. V. (2009). Genetics in medicine. Allied Publishers.
Khoury, M. J., Burke, W., & Thomson, E. J. (Eds.). (2000). Genetics and public health in the 21st century: Using genetic information to improve health and prevent disease. Oxford University Press. (Edited Indian Edition)
Passarge, E. (2018).Color Atlas of Genetics (5th ed.). Thieme.
Kumar, D. (Ed.). (2007).Genetic Disorders among Indian Populations. Cambridge University Press.

</td></tr>
<tr><td colspan="2">Learning Outcomes (not more than 100 words)</td><td>Upon completing the "Awareness in Public Health Genomics" course, students will be able to understand the genetic disorders, genomic concepts and their relevance to public health.</td></tr>
</table>

Course Title	**CGDSE21 (3 credits): Risk Factors for Genetic Disorders**
Category of Course[126]	Major / Minor / Minor (Vocational) / **SEC** / AEC / VAC / MD/Internship/Dissertation (Tick any one of the above)
Credits & Hours of Teaching	

	Theory	Practical demonstration	Cumulative
Credits	2	1	3
Hour of Teaching (Total)	30	15	45

Course Objectives (not more than 100 words)	This course aims to provide a comprehensive understanding of the risk factors contributing to genetic disorders, focusing on genetic variations, anticipation, pregnancy conditions, and uniparental disomy (UPD). It explores the influence of nutrition and gene-environment interactions in the manifestation and progression of genetic conditions. Additionally, the course equips students with the skills to interpret and understand genetic test reports, enabling better risk assessment and management strategies in clinical and public health settings.
Course Content	The course content will be divided into a minimum of 3 Units to a maximum of 5 units along with a defined hour of teaching for each unit.

Units	**Course Content**	**Hr. of Teaching**
I	Risk factors for prevalent genetic disorders (Genetic variations, Anticipation, pregnancy conditions, UPD)	20
II	Role of nutrition and gene-environment interactions in genetic disorders	5
III	Understanding genetic test reports	5
	Practical demonstration based on the above topics	15

Texts / References	1. Verma, I. C. (2000). *Medical Genetics in India*. ICMR. 2. Dey, S. (2014). *Essentials of Human Genetics* (6th ed.). New Central Book Agency. 3. Jain, P. K., & Aggarwal, S. S. (2009). *Principles of Medical Genetics and Genomics*. CBS Publishers & Distributors. 4. Ghai, O. P., & Gupta, P. (2019). *Ghai Essential Pediatrics* (9th ed.). CBS Publishers & Distributors. 5. Kapoor, A. (2018). *Genetic Disorders and Birth Defects in India: A Clinical Approach*. Jaypee Brothers Medical Publishers.
Learning Outcomes (not more than 100 words)	By the end of this course, students will be able to identify key risk factors for genetic disorders, including genetic variations, anticipation, pregnancy-related conditions, and uniparental disomy (UPD). They will understand the role of nutrition and gene-environment interactions in the development and management of genetic disorders. Additionally, students will develop skills to accurately interpret genetic test reports, enabling them to assess risk, guide clinical decisions, and apply preventive strategies in public health settings, particularly in diverse populations.

[126]SEC – Skill Enhancement Course; AEC – Ability Enhancement Course; VAC – Value Added Course; MD – Multidisciplinary Course

Course Title	**CGDSE31 (3 credits): Genetic Counselling and Prevention of Genetic Disorders**
Category of Course	Major / Minor / Minor (Vocational) / **SEC** / AEC / VAC / MD/Internship/Dissertation (Tick any one of the above)
Credits & Hours of Teaching	

	Theory	Practicaldemonstration	Cumulative
Credits	2	1	3
Hour of Teaching (Total)	30	15	45

Course Objectives (not more than 100 words)	This course aims to provide a comprehensive understanding of genetic counselling and prevention strategies for genetic disorders. It covers preventive measures, carrier detection, and population screening techniques. Students will gain knowledge in prenatal testing methods such as amniocentesis, chorionic villus sampling (CVS), and non-invasive prenatal testing (NIPT). Additionally, the course will address the principles of genetic counselling and ethical guidelines, including those relevant to assisted reproductive technologies (ART), equipping students to effectively support individuals and families in managing genetic risks and making informed decisions.
Course Content	The course content will be divided into a minimum of 3 Units to a maximum of 5 units along with a defined hour of teaching for each unit.

Units	**Course Content**	**Hr. of Teaching**
I	Possible preventive measures for genetic disorders	15
II	Carrier detection and population screening	5
III	Prenatal testing (Amniocentesis, CVS, NIPT)	5
IV	Geneticcounselling and Ethical guidelines (including in ART).	5
	Practical demonstration based on the above topics	15

Texts / References

1. **Knoppers, B. M., & Chadwick, R. (Eds.). (2010).***Genomics and Public Health: Legal and Socio-Ethical Perspectives*. Cambridge University Press.
2. **Snyder, M. (2016).***Genomics and Personalized Medicine: What Everyone Needs to Know*. Oxford University Press.
3. Kapoor, A. (2018). *Genetic Disorders and Birth Defects in India: A Clinical Approach*. Jaypee Brothers Medical Publishers.
4. Nair, K. S. (2017). *Genetics and Public Health in India*. ICMR.

Learning Outcomes (not more than 100 words)	Students will know how to evaluate the ethical, legal, social and genomic information in public health. Students will be able to Interpret and apply genomic data to enhance public health programs and policies which may play a significant role in future public health initiatives. Students will gain insights into the ethical considerations of personalized medicine and its impact on individuals and communities. Additionally, they will develop the ability to apply this knowledge to real-world scenarios, addressing both the benefits and challenges of genomic advancements in healthcare.

BANARAS HINDU UNIVERSITY

DST-Centre for Interdisciplinary Mathematical Sciences

SYLLABI

B.Sc. Programme

In

DST-Centre for Interdisciplinary Mathematical Sciences

BANARAS HINDU UNIVERSITY
(Detailed Syllabus of different Courses under NEP 2020)

Department of **DST-Centre of Interdisciplinary Mathematical Sciences**

Faculty of **Science**

Multidisciplinary courses (MD)

- Semester-I
  CIMMD11: Exploratory Data Analysis (3 credit)
- Semester-II

  CIMMD21: Introduction to Machine Learning (3 credit)
- Semester-III

  CIMMD31: Optimization Methods (3 credit)

Skill Enhancement Courses (SEC)

- Semester-I

  CIMSE11: Digital Literacy (3 credit)
- Semester-II

  CIMSE21: Computational Mathematics with SageMath (3 credit)
- Semester-III

  CIMSE31: Python Programming for Data Analytics (3 credit)

<table>
<tr><td>Course Title</td><td colspan="2">CIMMD11:Exploratory Data Analysis</td></tr>
<tr><td>Category of Course[127]</td><td colspan="2">MD</td></tr>
<tr><td>Credits[128]& Hour of Teaching</td><td colspan="2"><table>
<tr><th></th><th>Theory</th><th>Practical</th><th>Cumulative</th></tr>
<tr><td>Credits</td><td>2</td><td>1</td><td>3</td></tr>
<tr><td>Hour of Teaching (Total)</td><td>30</td><td>30</td><td>60</td></tr>
</table></td></tr>
<tr><td>Course Objectives (not more than 100 words)</td><td colspan="2">This course provides a comprehensive introduction to Exploratory Data Analysis (EDA) and statistical analysis. It covers the typical data formats, various types of EDA, including both graphical and non-graphical methods, and the concept of degrees of freedom. The course is designed to equip students with the skills necessary to perform detailed data analysis and interpret the results effectively.</td></tr>
<tr><td>Course Content</td><td colspan="2">The course content be divided into 3 Units along with defined hour of teaching for each unit.</td></tr>
<tr><td colspan="3"><table>
<tr><th>Units</th><th>Course Content</th><th>Hr. of Teaching</th></tr>
<tr><td>I</td><td>Introduction to EDA: Definition and importance of EDA, Typical Data Formats, Data types: Numerical, categorical, and ordinal data, Arrays, matrices, data frames, and time-series data.</td><td>10(T) +10(P)</td></tr>
<tr><td>II</td><td>Analyzing single variables using summary statistics, Identifying central tendency and dispersion. Importance of visualization in EDA, Overview of graphical tools. Univariate Graphical EDA Histograms, box plots, and kernel density plots, Interpreting shapes, outliers and patterns.</td><td>10(T) +10(P)</td></tr>
<tr><td>III</td><td>Correlation and covariance matrices, Cross-tabulations and contingency tables, Scatter plot, pair plot, and heat map, Chernoff faces, star plots, Real-world data analysis case studies, Tools and software for EDA (e.g., Excel, R/Python).</td><td>10(T) +10(P)</td></tr>
</table></td></tr>
<tr><td>Texts / References</td><td colspan="2">1. James, G., Witten, D., Hastie, T., Tibshirani, R. (2013). An Introduction to Statistical Learning: With Applications in R. Germany: Springer New York.
2. Tukey, John W. (1977). Exploratory data analysis. Addison-Wesley Pub. Co.
3. Murray, S. (2013). Interactive data visualization for the web (1st ed). O'Reilly Media.
4. R. Gnandesikan (1997): Methods for Statistical Data Analysis of Multivariate Observations, Second edition, Wiley.
5. Healy K (2019). Data Visualization: A Practical Introduction. Princeton University Press, Princeton.</td></tr>
<tr><td>Learning Outcomes (not more than 100 words)</td><td colspan="2">By the end of this course, students will have a thorough understanding of EDA techniques, both graphical and non-graphical, for univariate and multivariate data. They will be able to apply these techniques to real-world datasets using various tools and software, making them proficient in uncovering insights, patterns, and relationships in data.</td></tr>
</table>

[127] SEC – Skill Enhancement Course; AEC – Ability Enhancement Course; VAC – Value Added Course; MD – Multidisciplinary Course

[128] 1 Credit (Theory) = 15 Hours; 1 Credit (Practical) = 30 Hours

<table>
<tr><td>Course Title</td><td colspan="2">CIMMD21: Introduction to Machine Learning</td></tr>
<tr><td>Category of Course[129]</td><td colspan="2">MD</td></tr>
<tr><td>Credits[130]& Hour of Teaching</td><td colspan="2">
<table>
<tr><td></td><td>Theory</td><td>Practical</td><td>Cumulative</td></tr>
<tr><td>Credits</td><td>2</td><td>1</td><td>3</td></tr>
<tr><td>Hour of Teaching (Total)</td><td>30</td><td>30</td><td>60</td></tr>
</table>
</td></tr>
<tr><td>Course Objectives (not more than 100 words)</td><td colspan="2">The objectives of the course are as follows
● To understand the basic concept of machine learning.
● To be able to formulate different machine learning problems corresponding to different applications.
● To understand machine learning algorithms with their strengths and weaknesses.
● To be able to solve real world problems through machine learning.</td></tr>
<tr><td>Course Content</td><td colspan="2">The course content is divided into 4 Units along with defined hour of teaching for each unit.</td></tr>
<tr><td colspan="3">
<table>
<tr><th>Units</th><th>Course Content</th><th>Hr. of Teaching</th></tr>
<tr><td>I</td><td>Fundamentals of Machine Learning:
Designing a Learning System, Styles of Learning; Supervised learning; Unsupervised learning: types of unsupervised learning, Challenges of Unsupervised learning; Semi-Supervised learning</td><td>6(T) + 6(P)</td></tr>
<tr><td>II</td><td>Regression: Simple and multiple linear regression, autocorrelation and multicollinearity in regression, regularization and variable selection in regression</td><td>8(T) + 8(P)</td></tr>
<tr><td>III</td><td>Classification: Naive Bayes, Nearest Neighbor and Linear Classification Models, Logistic Regression, Support Vector Machine, Linear and Quadratic discriminant Analysis, Decision tree Classification</td><td>8(T) + 8(P)</td></tr>
<tr><td>IV</td><td>Clustering: Fundamental concept of clustering, Hierarchical Clustering, K-means Clustering</td><td>8(T) + 8(P)</td></tr>
</table>
</td></tr>
<tr><td>Texts / References</td><td colspan="2">1. Bishop, C. M., & Nasrabadi, N. M. (2006). Pattern recognition and machine learning New York: springer.
2. Hastie, T., Tibshirani, R., & Friedman, J. (2009). An introduction to statistical learning, Springer.
3. Hastie, T., Tibshirani, R., Friedman, J. H., & Friedman, J. H. (2009). The elements of statistical learning: data mining, inference, and prediction, New York: springer.
4. Murphy, K. P. (2022). Probabilistic machine learning: an introduction. MIT press.
5. Montgomery, D. C., Peck, E. A., & Vining, G. G. (2021). Introduction to linear regression analysis. John Wiley & Sons.
6. Brian S. Everitt, Sabine Landau, Morven Leese, Daniel Stah (2011). Cluster Analysis, John Wiley & Sons</td></tr>
<tr><td>Learning Outcomes (not more than 100 words)</td><td colspan="2">By studying this course, students will able to understand the fundamental concepts and applications of machine learning. Besides, they will also able to know about advantage and shortcomings of widely used machine learning algorithm.</td></tr>
</table>

[129] SEC – Skill Enhancement Course; AEC – Ability Enhancement Course; VAC – Value Added Course; MD – Multidisciplinary Course

[130] 1 Credit (Theory) = 15 Hours; 1 Credit (Practical) = 30 Hours

Course Title	**CIMMD31: Optimization Methods**
Category of Course[131]	MD
Credits[132]& Hour of Teaching	

	Theory	Practical	Cumulative
Credits	3	0	3
Hour of Teaching (Total)	45	0	45

Course Objectives (not more than 100 words)	This course will enable the students to: 1. know how to solve optimization problems using simplex method. 2. learn techniques to solve duality in LPP, assignment and transportation problems. 3. solve integer and mixed integer programming problem. 4. to understand transportation and assignment problems and its applications in day-to-day life.
Course Content	The course content be divided into minimum 3 Units to maximum 5 units along with defined hour of teaching for each unit.

Units	**Course Content**	**Hr. of Teaching**
I	Linear programs formulation through examples from engineering / business decision making problems; preliminary theory and geometry of linear programs.	15
II	Basic feasible solution; simplex method, variants of simplex method like two phase method and revised simplex method; duality and its principles, interpretation of dual variables, dual simplex method, primal-dual method.	15
III	Linear integer programs, their applications in real decision-making problems, cutting plane and branch and bound methods, transportation problems, assignment problems, network maximum flow problems.	15

Texts / References	1. H.A. Taha: Operation Research-An introduction, Printice Hall of India(2019). 2. J.K. Sharma: Operations Research Theory and Applications, Sixth Edition, Trinity Press (2008). 3. P.K. Gupta and D.S. Hira: Operations Research-An introduction, Sultan Chand & Sons, New Delhi, (2002).
Learning Outcomes (not more than 100 words)	The students will have a clear understanding about the fundamentals of Operation Research and its techniques used in different fields like optimization problems, transportation, duality etc. and can apply concepts and knowledge of Operation Research to solve the problems facing in day-to-day life.

[131] SEC – Skill Enhancement Course; AEC – Ability Enhancement Course; VAC – Value Added Course; MD – Multidisciplinary Course

[132] 1 Credit (Theory) = 15 Hours; 1 Credit (Practical) = 30 Hours

Course Title	**CIMSE11:Digital Literacy**
Category of Course[133]	SEC

Credits[134]& Hour of Teaching

	Theory	**Practical**	**Cumulative**
Credits	2	1	3
Hour of Teaching (Total)	30	30	60

Course Objectives (not more than 100 words)	The objective of the course is as follows: to get the idea of full-stack web applications using client-side (HTML, JavaScript) and server-side (Python) technologies. to understand the Android ecosystem and applications on Android to understand security issues of financial applications - online banking, UPI, and blockchain technology. to get the idea of AI technologies, including machine learning and large language models, prompt engineering
Course Content	The course content be divided into 4 Units along with defined hour of teaching for each unit.

Units	**Course Content**	**Hr. of Teaching**
I	Developing applications for the web: Client side technologies; server side technologies, Python, HTML, Javascript;	10(T) + 10(P)
II	The android ecosystem: mobile hardware platforms; the operating system; security setting; play store;	3(T) + 3(P)
III	Financial Technologies: Online banking - mobile apps; UPI; Security guideline - multi factor authentication; spoofing; money transfer: NEFT/RTGS; Blockchain technology;	7(T) + 7(P)
IV	AI technologies: Model based AI; Data-based AI; Machine learning; LLMs; Chatgpt, Bing; Prompt engineering	10(T) + 10(P)

Texts / References

1. Jon Duckett, HTML and CSS: Design and Build Websites First Edition, John Wiley & Sons
2. Jon Duckett, JavaScript and jQuery: Interactive Front-End Web Development, Wiley, 2018
3. Miquel Grinberg, Flask Web Development 2e: Developing Web Applications with Python, Edition 2,O'Reilly, 2018
4. William S Vincent, Django for Beginners: Build Websites with Python and Django
5. Bill Phillips, Chris Stewart, Brian Hardy and Kristin Marsicano, Android Programming: The Big Nerd Ranch Guide, Pearson Technology Group, 2nd Edision, 2015
6. Nikolay Elenkov, Android Security Internals An In-Depth Guide to Android's Security Architecture, William Pollock, No Starch Press, Inc, 2015
7. Jeffry R. Simpson, FinTech: Financial Technology and Modern Finance in the 21st Century
8. Daniel Drescher, Blockchain Basics: A Non-Technical Introduction in 25 Steps, Edition 1, APRESS, 2017
9. Bishop, C. M., & Nasrabadi, N. M. (2006). Pattern recognition and machine learning New York: springer.
10. Kublik, Sandra ; Saboo, Shubham, GPT-3: Building Innovative NLP Products Using Large Language Models, O'Reilly Media, 2022

Learning Outcomes (not more than 100 words)	After studying this course students will have a good understanding of Developing Applications for the Web with both client side and server side technologies. They will also be familiar with the Android Ecosystem. They will be able to understand the principles of financial and blockchain technology. They will be able to utilize AI technologies particularly Machine learning and large language models.

[133] SEC – Skill Enhancement Course; AEC – Ability Enhancement Course; VAC – Value Added Course; MD – Multidisciplinary Course

[134] 1 Credit (Theory) = 15 Hours; 1 Credit (Practical) = 30 Hours

Course Title	**CIMSE21: Computational Mathematics with SageMath**
Category of Course[135]	SEC
Credits[136]& Hour of Teaching	

	Theory	**Practical**	**Cumulative**
Credits	2	1	3
Hour of Teaching (Total)	30	30	60

Course Objectives (not more than 100 words)	This course will enable the students to use SageMath, a Python based free and open source computer algebra system (CAS) to explore concepts in Calculus, Applied Linear Algebra and Differential equations. The course will begin with a quick introduction to SageMath software along with plotting 2D and 3D objects. The main focus will be on using SageMath to explore topics in Calculus, Applied Linear Algebra and Differential equations along with several applications.
Course Content	The course content be divided into minimum 3 Units to maximum 5 units along with defined hour of teaching for each unit.

Units	**Course Content**	**Hr. of Teaching**
I	Introduction and Installation of SageMath, Exploring integers in SageMath, Solving Equations in SageMath, 2d Plotting with SageMath, 3d Plotting with SageMath, Calculus of one variable with SageMath , Applications of derivatives, Integrals in SageMath, Applications of Integrals, Partial Derivatives and gradients, jacobians, Local maximum-minimum, Application of local maximum and minimum, Applications to least square problems, Lagrange Multipliers	10(T)+10(P)
II	Working with vectors in SageMath, RREF and Solving system of linear Equations, Vector Spaces in SageMath, Linear Transformations with SageMath, Eigenvalues and Eigenvectors with SageMath, Numerical Solution of algebraic equations, Numerical Solutions of system of linear equations, Applications of linear algebra with SageMath	10(T)+10(P)
III	Formulation and Solution of Ordinary Differential Equations(ODE) with SageMath, Initial Value ODE with SageMath, Applications of ODE with SageMath	10(T)+10(P)

Texts / References	1. www.sagemath.org 2. Mathematical Computation with Sage by Paul Zimmermann available from on http://www.sagemath.org 3. A First Course in Linear Algebra by Robert Beezer available online http://linear.ups.edu/
Learning Outcomes (not more than 100 words)	The students will be able to understand the basic computational mathematics: Calculus, Applied Linear Algebra and Differential equations through SageMath.

[135] SEC – Skill Enhancement Course; AEC – Ability Enhancement Course; VAC – Value Added Course; MD – Multidisciplinary Course

[136] 1 Credit (Theory) = 15 Hours; 1 Credit (Practical) = 30 Hours

<table>
<tr><td>Course Title</td><td>CIMSE31: Python Programming for Data Analytics</td></tr>
<tr><td>Category of Course[137]</td><td>SEC</td></tr>
<tr><td>Credits[138]& Hour of Teaching</td><td>
<table>
<tr><td></td><td>Theory</td><td>Practical</td><td>Cumulative</td></tr>
<tr><td>Credits</td><td>2</td><td>1</td><td>3</td></tr>
<tr><td>Hour of Teaching (Total)</td><td>30</td><td>30</td><td>60</td></tr>
</table>
</td></tr>
<tr><td>Course Objectives (not more than 100 words)</td><td>The objective of the course is as follows
● to understand the fundamental concepts of Python programming
● to be able to to construct selection and iterative control structures
● to understand working with lists, tuples, dictionaries, and sets for efficient data storage and retrieval.
● to get the idea of functions and recursion
● Working with Libraries for Data Analytics
● to get the skills of data manipulation and visualization</td></tr>
<tr><td>Course Content</td><td>The course content be divided into 3 Units along with defined hour of teaching for each unit.</td></tr>
<tr><td colspan="2">
<table>
<tr><th>Units</th><th>Course Content</th><th>Hr. of Teaching</th></tr>
<tr><td>I</td><td>Introduction to Python, Control Structures and Functions: Control Flow, Functions, Error Handling, Data Structures in Python: Lists, Tuples, Dictionaries, Sets</td><td>10(T) + 10(P)</td></tr>
<tr><td>II</td><td>Working with Libraries for Data Analytics: NumPy: Introduction to arrays, array operations, basic linear algebra; Pandas: DataFrames, Series, basic operations, loading data from CSV; Matplotlib: Introduction to plotting, basic visualizations (line, bar, scatter plots)</td><td>10(T) + 10(P)</td></tr>
<tr><td>III</td><td>Data Manipulation with Pandas: Data Cleaning, Data Aggregation, Data Analysis; Data Visualization with Matplotlib and Seaborn: Advanced Plotting with Matplotlib, Seaborn</td><td>10(T) + 10(P)</td></tr>
</table>
</td></tr>
<tr><td>Texts / References</td><td>1. Eric Matthes, Python Crash Course A Hands on, Project based Introduction to Programming, 2016, William Pollock, No Starch Press, Inc.
2. Al Sweigart, Automate the Boring Stuff with Python, Practical Programming for Total beginners, 2nd Edition, 2019, No Starch Press, Inc.
3. Paul Barry, Head First Python: A Learner's Guide to the Fundamentals of Python Programming, A Brain-Friendly Guide, Third Edition, 2023, Oreilly
4. David Beazley, Brian K. Jones, Python Cookbook: Recipes for Mastering Python 3 3rd Edition, , Oreilly</td></tr>
<tr><td>Learning Outcomes (not more than 100 words)</td><td>By studying this course, students will have proficiency in python basics. They will be able to effectively use data structures. They will have data manipulation and visualization skills. They will be able to write and debug basic control structures such as loops and conditional statements.</td></tr>
</table>

[137] SEC – Skill Enhancement Course; AEC – Ability Enhancement Course; VAC – Value Added Course; MD – Multidisciplinary Course

[138] 1 Credit (Theory) = 15 Hours; 1 Credit (Practical) = 30 Hours

BANARAS HINDU UNIVERSITY

Department of Environmental Science

Faculty of Science

SYLLABI

B.Sc. Programme

In

Environmental Science

Faculty of Science

Value Added Course: Environmental Science

Course Title & Code	**Environmental Science – ENVA11**
Category of Course[139]	Major / Minor / Minor (Vocational) / SEC / AEC / **VAC** / MD/Internship/Dissertation (Tick any one of the above)
Credits[140]& Hour of Teaching	

	Theory	Practical	Cumulative
Credits	02	00	02
Teaching Hours (Total)	30	00	30

Course Objectives (not more than 100 words)	To provide students with a broad interdisciplinary framework to understand the complex environmental challenges being faced by humanity, and to equip them to live sustainably and in harmony with nature.
Course Content	The course content is divided into 5 units along with defined hours of teaching for each unit.

Units	Course Content	Teaching Hours
I	**Human and the Environment** Human-Environment Interactions: Historical and current perspectives including the Neolithic period, industrialization, and current human population growth; The development of environmental ethics and the rise of environmentalism.	4
II	**Environment and Natural Resources** Components of the Environment: atmosphere, hydrosphere, lithosphere, and biosphere; Natural resources: physical and biological.	7
III	**Ecosystem and Biodiversity** Basic concepts of ecosystem; Biotic and abiotic components; Nutrient and energy flow in ecosystems; Overview of terrestrial and aquatic ecosystems; Ecosystem services; Biodiversity: threats, conservation and management.	6
IV	**Environmental Issues** Environmental pollution; Global climate change and ozone layer depletion; Hazards, disasters, and their management; Human migration and its environmental impacts; Urbanization and its challenges; Pandemics and communicable diseases in relation to the environment.	7
V	**Environmental Management and Sustainable Development** Environmental protection, management and legislation in India; Key international environmental treaties and policies. Sustainable development concepts: Tragedy of commons; UN-Sustainable Development Goals; Environmental education; Nature-friendly lifestyle and nature-based solutions.	6

Texts / References	• Barucha E (2012) Textbook for Environmental Studies. University Grants Commission, Universities Press. • De AK (2017) Environmental Chemistry. 8th Edition, New Age International Publishers. • Hassenzahl DM, Hager MC, Gift NY, Berg LR, Raven PH (2018) Environment. Wiley. • Harris F (2012) Global Environmental Issues. 2nd Edition, Wiley-Blackwell. • Kellar E. (2021) Introduction to Environmental Geology, 5th Edition, Pearson. • Sharma PD (2018) Ecology and the Environment. Rastogi Publishers. • Singh JS, Singh SP, Gupta SR (2021). Ecology, Environmental Science and Conservation. S. Chand Publishing.

[139] SEC – Skill Enhancement Course; AEC – Ability Enhancement Course; VAC – Value Added Course; MD – Multidisciplinary Course

[140] 1 Credit (Theory) = 15 Hours; 1 Credit (Practical) = 30 Hours

	• Theodore MK, Theodore L (2024) Introduction to Environmental Management. 2nd Edition, CRC Press, Taylor & Francis Group. • Valdiya K. S. (2004) Geology, Environment and Society, University Press.
Reports/Magazines	• Down to Earth, Centre for Science and Environment, New Delhi • The State of India's Environment reports, Centre for Science and Environment, New Delhi. • Survey of the Environment, The Hindu • The Global Biodiversity Outlook, UNEP • The Global Environmental Outlook, UNEP
Learning Outcomes (not more than 100 words)	This value-added course (VAC) is designed to help students: (i) Gain a deep understanding of the human-environment interactions, and the sustainable utilization of natural resources. (ii) Understand the concept of sustainable development and global efforts to achieve these goals. (iii) Embrace a nature-friendly lifestyle that promotes the well-being of both people and the planet.

BANARAS HINDU UNIVERSITY

Department of Geology

Faculty of Science

SYLLABI

B.Sc. (Hons.) Programme

In

Geology

COURSE STRUCTURE FOR 4-YEAR UG GEOLOGY, NEP-2020 Department of Geology, Banaras Hindu University		
Semester	**Courses**	**Credits**
I	ESMJ11: Elements of Earth Sciences	3
	ESMJ12: Practical connected with ESMJ11	1
	ESMD11: Evolving Earth	3
	ESSE11: Smartphone Geosciences	2
	ESSE12: Practical connected with ESSE11	1
	Minor same as major ESMJ11, ESMJ12	3+1
	VA (To be offered by the University)	2+2
	AE (To be offered by the University)	2
	Total Credits	**20**
II	ESMJ21: Minerals and Earth Material	3
	ESMJ22: Practical connected with ESMJ21	1
	ESMD21: Earth, Environment and Society	3
	ESSE21: Gemology	2
	ESSE22: Practical connected with ESSE21	1
	Minor same as major ESMJ21, ESMJ22	3+1
	VA (To be offered by the University)	2+2
	AE (To be offered by the University)	2
	Total Credits	**20**
III	ESMJ31: Physical Geology	3
	ESMJ32: Elementary Structural Geology	3
	ESMJ33: Practical connected with ESMJ31	1
	ESMJ34: Practical connected with ESMJ32	1
	ESMD31: Rocks, Minerals and Fossils	3
	ESSE31: Geological Field Training	3
	ESMV31: Minerals and Earth Material*	3
	ESMV32: Practical connected with ESMV31*	1
	AE (To be offered by the University)	2
	** Students may opt any four-credit course from Online SWAYAM courses approved by the Department.*	
	Total Credits	**20**
IV	ESMJ41: Petrology and Economic Geology	3
	ESMJ42: Paleontology and Stratigraphy	3
	ESMJ43:Environmental Geology and Hydrogeology	3
	ESMJ44:Essentials of Remote Sensing	2
	ESMJ45: Practical connected with ESMJ41	1
	ESMJ46: Practical connected with ESMJ42	1
	ESMJ47: Practical connected with ESMJ43	1
	ES-Minor: same as major ESMJ43and ESMJ47*	4
	AE (To be offered by the University)	2
	** Students may opt any four credit course from Online SWAYAM courses approved by the Department.*	
	Total Credits	**20**

V	ESMJ51: Metamorphic Petrology	3
	ESMJ52: Sedimentary Petrology	3
	ESMJ53:Igneous Petrology	3
	ESMJ54:Mineralogy and Crystallography	3
	ESMJ55: Practical connected with ESMJ -51 and ESMJ -52	1
	ESMJ 56: Practical connected with ESMJ -53 and ESMJ -54	1
	ESMV51: Geoarcheology and Museology *	2+2
	ESIN-51: (Internship): [Students can do internship after first to fourth semester during summer vacation]	2
	**Students may opt any four-credit course from Online SWAYAM courses approved by the Department.*	
	Total Credits	**20**
VI	ESMJ61: Structural Geology	3
	ESMJ62: Economic Geology	3
	ESMJ63: Paleontology	3
	ESMJ64: Stratigraphy	3
	ESMJ65: Practical connected with ESMJ61 and ESMJ62	1
	ESMJ66: Practical connected with ESMJ63 and ESMJ64	1
	ESMJ67: Field Geology	2
	ESMV61: Agriculture Geology *	2+2
	**Students may opt any four credit course from Online SWAYAM courses approved by the Department.*	
	Total Credits	**20**
VII-H	***Any fourmajor elective courses from ESMJ71 to ESMJ75 form the list with connected practical (3 credit each)***	4x3
	ESMJ71: Geomorphology and Geotectonics	2
	ESMJ72: Foundations of Engineering Geology and Surveying	2
	ESMJ73: Geochemistry and Instrumentation	2
	ESMJ74: Exploration Geosciences	2
	ESMJ75: Fuel Geology	2
	ESMJ76: Practical connected with ESMJ71	1
	ESMJ77: Practical connected with ESMJ72	1
	ESMJ78: Practical connected with ESMJ73	1
	ESMJ79: Practical connected with ESMJ74	1
	ESMJ710: Practical connected with ESMJ75	1
	ESMJ711: Advanced Geological Field Training	4
	ES-Minor: same as major ESMJ71 and ESMJ75*	4
	** Students may opt any four credit course from Online SWAYAM courses approved by the Department.*	
	Total Credits	**20**

VIII-H	***Any four major elective courses from ESMJ81 to ESMJ85 along with connected practical (4 credit each)***	**4x4**
	ESMJ81: Marine Geology, Oceanography and Climate	3
	ESMJ82: Georesource and Mineral Policy	3
	ESMJ83: Ground Water Hydrology and Soil Geology	3
	ESMJ84: Remote Sensing and GIS	3
	ESMJ85: Basin Analysis	3
	ESMJ86: Practical connected with ESMJ81	1
	ESMJ87: Practical connected with ESMJ82	1
	ESMJ88: Practical connected with ESMJ83	1
	ESMJ89: Practical connected with ESMJ84	1
	ESMJ810: Practical connected with ESMJ85	1
	ES-Minor: same as major ESMJ84 and ESMJ89*	3+1
	** Students may opt any four credit course from Online SWAYAM courses approved by the Department.*	
	Total Credits	**20**
	Research Students	
VII-R	***Same as VII-H***	**20**
VIII-R	***Any one major elective courses from ESMJ81 to ESMJ85 along with connected practical (4 credit each)(List Same as VIII-H)***	**(3+1)**
	ES-Minor: same as major ESMJ71 and ESMJ75*	4
	ES-DS8R1: Dissertation	12
	** Students may opt any four credit course from Online SWAYAM courses approved by the Department.*	
	Total Credits	**20**

SEC – Skill Enhancement Course;
AEC – Ability Enhancement Course;
VAC – Value Added Course;
MD – Multidisciplinary Course

1 Credit (Theory) = 15 Hours

1 Credit (Practical) = 30 Hours

Semester: I

Course Title	**ESMJ11: Elements of Earth Sciences**
Category of Course	**Major**

Credits& Hour of Teaching	Theory	Practical	Cumulative
Credits	03	----	03
Hour of Teaching (Total)	45	----	45

Course Objectives (not more than 100 words)	The objective of this paper is to provide students with a foundational understanding of Earth as a whole and its place in the solar system, while also introducing the geological time scale and structural geology concepts.
Course Content	The course content be divided into minimum 3 Units to maximum 5 units along with defined hour of teaching for each unit.

Units	**Course Content**	**Hr. of Teaching**
I	Earth as a planet, its origin, size, shape, mass, density, rotational and revolutional parameters. The internal constitution of the earth, core, mantle, and crust; Overall composition of the Earth and comparison to other planetary bodies.	10
II	Catastrophism, Neptunism, Plutonism, Uniformitarianism, law of superposition, law of faunal succession, and law of original horizontality. Origin and evolution of atmosphere, hydrosphere and biosphere. Weathering, Erosion, and Mass wasting- processes and types.	10
III	Earthquakes & distribution of earthquake belts; Volcanoes, its types& distribution of volcanic belts on Earth; Geological time scale; Major events in the earth's history through Geological time, Age of the Earth & basic idea on dating.	10
IV	Introduction to planar and linear structures; Identification of primary structures, and secondary structures, folds, faults, and joints. Measurements of the orientation of planar and linear structures, strike, dip, pitch, and plunge.	15

Texts / References	1. Holmes, A. (1992): Principles of Physical Geology, Vol.1, Chapman and Hall, London. 2. H. H. Read and J. Watson (1961).Introduction to Geology, Vol.1. Macmillan. 3. Grotzinger,J.,Jordan,T.H.,Press,F.,&Siever,R.(2010).Understanding Earth. Macmillan Higher Education. 4. Billings, M.P.(2016):Structural Geology, Pearson. 5. Park, R. G.(2017):Foundations of Structural Geology. Routledge. 6. Lisle, R.J.(2004):Geological Structures and Maps: A Practical Guide, Third edition. Elsevier
Learning Outcomes (not more than 100 words)	The paper equips students with a fundamental understanding of Earth's physical attributes and its solar system context. Students will also gain insights into key geological theories and structural geology concepts.

Course Title	**ESMJ12: Practical connected with ESMJ11**
Category of Course	**Major**
Credits& Hour of Teaching	

	Theory	Practical	Cumulative
Credits	---	01	01
Hour of Teaching (Total)	---	30	30

Course Objectives (not more than 100 words)	The objective of this practical paper is to provide students with hands-on experience in geomorphologic models, the use of a clinometer compass, and exercises on structural problems, enhancing their practical skills in geological analysis and interpretation.
Course Content	The course content be divided into minimum 3 Units to maximum 5 units along with defined hour of teaching for each unit.

Units	**Course Content**	**Hr. of Teaching**
	Study of important geomorphological models; study of clinometer compass; exercises on structural problems; completion of outcrops; drawing and interpretation of sections across elementary representative geological structures	30

Texts / References	1. Leet, L.D. and Judson, S.(1969): Physical Geology, Prentice Hall., Read, H.H. (1993) Introduction to Geology, 2. Billings, M.P.(2016):Structural Geology, Pearson. 3. Murck, B.W., & Skinner, B.J.(2015).Visualizing geology. John Wiley& Sons. 4. Lisle, R.J.(2004):Geological Structures and Maps: A Practical Guide, Third edition. Elsevier 5. Compton, R.A. (1985): Geology in the Field, John Wiley and Sons.
Learning Outcomes (not more than 100 words)	Upon completing this paper, students will gain proficiency in analyzing important geomorphological models and using a clinometer compass. They will be adept at solving structural problems, completing outcrops, and drawing and interpreting sections across elementary representative geological structures.

Course Title	**ESSE11: Smartphone Geosciences**
Category of Course	**SEC**

Credits& Hour of Teaching		Theory	Practical	Cumulative
	Credits	02	---	02
	Hour of Teaching (Total)	30	---	30

Course Objectives (not more than 100 words)	To be effective, geoscience education is adapting to this changing environment by applying the use of smartphone technology. To implement experiential learning is considered instrumental to accomplishingthe ready access to knowledge through Smartphone. Perceived ease of use of a smartphone in learning activities, The movability of smartphone devices has the potential to transformgeosciences education, accessing worldwide knowledge system, and Entrepreneurship Skill Development.
Course Content	The course content be divided into minimum 3 Units to maximum 5 units along with defined hour of teaching for each unit.

Units	**Course Content**	**Hr. of Teaching**
I	Fundamentals of operating systems in smartphone, Geology Apps, AI Tools, ChatGPT, IoT, Multimedia Tools, Social media Apps for geology. MS Office Automation for report writing and presentation.	10
II	Smartphone assisted geological fieldwork, orientation of digital maps in field, marking location in digital map, bearing (front and back) using smartphone. GPS App, NAVIC, Digital Compass App.	10
III	Basic field measurement techniques using smartphone: Bedding dip and strike, Litholog measurement with smartphone, Development of digital catalogue with credentials of rock types, structures and texture of rocks, use of smartphone lens in field.	05
IV	Digital reading contours and topography using smartphone, Google Earth, Google Map, Bhuvan. Concepts of digital map reading, Distance, height, elevation and place approximation.	05

Texts / References	1. ElizabethWoyke(2014)TheSmartphone:AnatomyofanIndustry.TheNewPress 2. Daniel Miller, et al.,(2021) The Global Smartphone: Beyond a Youth Technology. UCL Press, pp1-295. 3. Sujit Kumar Mishra (2020)Fundamentals of Android App Development. BPB Publications. 4. Francisco Yus (2022) Smart phone Communication: Interactions in the App Ecosystem. Rout ledge is an imprint of the Taylor & Francis Group, pp1-318. 5. Michael J. Jipping (2020) Smartphone Operating System Concepts with Symbian OS: A Tutorial Guide. John Wiley & Sons, Ltd., England, pp 1-338. 6. Jeff McWherter and Scott Gowell (2012) Professional Mobile Application Development. John Wiley & Sons Inc. 7. Mike James (1984) Artificial Intelligence in BASIC. Newnes Technical Books, Butter worth & Co Publishers Ltd., pp 1-124. 8. Ahmed El- Rabbany (2007) Introduction to GPS: The Global Positioning System. Artech House, London, pp 1-176.
Learning Outcomes (not more than 100 words)	Geoscientificexplorationandclassroom exercises can help diverse sets of studentsbecome more aware of the Earth andtheir environment by using basic apps on smart phones. Students will be able to achieve scientific literacy with digital content available in the public domains and internet portals. Adopt interactive learning through the use of quizzes, games, and flashcards over Smartphone. Manage a virtual classroom, send assignments, search and share useful materials, and communicate with students by Smartphone applications. Build awareness about ethical issues related to Social Media and Web Platforms.

Course Title	**ESSE12: Practical connected with ESSE11**
Category of Course	**SEC**
Credits& Hour of Teaching	

	Theory	Practical	Cumulative
Credits	---	01	01
Hour of Teaching (Total)	---	30	30

Course Objectives (not more than 100 words)	Application of smart phone is gradually becoming a compelling learning tool used to skill enhance educationand entrepreneurship. To regulatepracticalityof smartphone in students' academic achievement with development of earning skill from digital resources.
Course Content	The course content be divided into minimum 3 Units to maximum 5 units along with defined hour of teaching for each unit.

Units	**Course Content**	**Hr. of Teaching**
I	Application digital apps using smartphone, measurements in open playground using digital GPS & NAVIC systems apps,	10
II	Geological Field Training with smartphone,	10
III	Multimedia Tools, Social media Apps for geology.	5
IV	Content Writing and Presentation using AI Tools.	5

Texts / References	1. Indian Space Research Organisation (ISRO): https://www.isro.gov.in. 2. ISRO-NRSC (2023) BHUVAN-SUVIDHA, DRISHTI: Manual for Field Data Collection using Smartphone application using Android. https://bhuvan.nrsc.gov.in. 3. National Aeronautics and Space Administration (NASA): https://www.nasa.gov. 4. Introduction: GooESe Earth User Guide. https://earth.gooESe.com. 5. Daniel Miller, et al., (2021) The Global Smartphone: Beyond a Youth Technology. UCL Press, pp. 1-295. 6. Peggy Anne Salz and Jennifer Moranz (2013) The Everything Guide to Mobile Apps: A Practical Guide to Affordable Mobile App Development for Your Business. PENGUIN. 7. Jerome DiMarzio and J DiMarzio (2016) Beginning Android Programming with Android Studio. Wrox Press. 8. Cameron Banga and Josh Weinhold (2014) *Essential Mobile Interaction Design: Perfecting Interface Design in Mobile Apps.* Addison-Wesley Professional.
Learning Outcomes (not more than 100 words)	Students have learned the fundamentals of field techniques using smartphone and they have improved their field credentials with the application of smartphone apps in field trips and semester-long field courses, and summer field camps. Use smartphone technology in the classroom: managing groups, interacting, communicating, and sharing materials. Structure information, better analyzes, comprehend, synthesize, recall, and generate new ideas using technological tools.

Course Title	**ESMD11: Evolving Earth**
Category of Course	**MD**

Credits& Hour of Teaching

	Theory	Practical	Cumulative
Credits	03	---	03
Hour of Teaching (Total)	45	---	45

Course Objectives (not more than 100 words)

This course aims to train the students:

- about the basics of Geology, its scope and various branches of Geology with fundamental concepts of plate tectonics
- To introduce the aspects of the Earth and Planetary system and its changes with time
- To emphasize knowledge of the solar system, planets, and geological time scale.
- To provide the fundamental ideas about different structures formed on earth surfaces.

Course Content

The course content be divided into minimum 3 Units to maximum 5 units along with defined hour of teaching for each unit.

Units	**Course Content**	**Hr. of Teaching**
I	Introduction to Earth Sciences, meaning and scope; Sub-disciplines and relationship with other branches of sciences	10
II	Plate tectonics; Geological time scale; Mass extinction; Ice ages	10
III	Introduction and origin of the solar system; Structure and composition of the earth.	10
IV	Basics of geological structures: bedding, fold and fault	15

Texts / References

1. Holmes, A. (1987): Principles of Physical Geology. Nelson, New York, 3rd edition.
2. Singh, S. (2003): Physical Geography (English and Hindi editions). PrayagPustakBhawan, Allahabad.
3. Hills, E. S. (1963): Elements of Structural Geology. Farrold and Sons, London.
4. Billings, M. P. (1972): Structural Geology. Prentice Hall.

Learning Outcomes (not more than 100 words)

Upon completing this course, students will be able to:

- Gain Knowledge about the history of Earth and planetary system and development with information on the formations of different types of plate boundaries
- Acquire knowledge of the early solar system, Earth's structure and composition, and key events in past geological periods.
- Know basic terminologies and concepts in structural geology

Course Title	**Same as major ESMJ11 and ESMJ12**
Category of Course	**Minor**

Credits& Hour of Teaching

	Theory	Practical	Cumulative
Credits	03	01	04
Hour of Teaching (Total)	45	30	75

		Credit
Value Added Course(VA)	To be Offered by the University	2 + 2
Ability Enhancement Course(AE)	To be Offered by the University	2

Semester: II

Course Title	**ESMJ21: Minerals and Earth Material**
Category of Course	**Major**

Credits& Hour of Teaching	Theory	Practical	Cumulative
Credits	03	---	03
Hour of Teaching (Total)	45	---	45

Course Objectives (not more than 100 words)	Identify the minerals and materials of the solid Earth. Recognize the most common rock-forming minerals, their compositions and to identify them based on their macroscopic and microscopiccharacteristics. To understand the fundamental principles of mineralogy, optical mineralogy and crystallography.
Course Content	The course content be divided into minimum 3 Units to maximum 5 units along with defined hour of teaching for each unit.

Units	Course Content	Hr. of Teaching
I	**Fundamentals of Mineralogy:** Concepts and classification of minerals; mineral forming processes (igneous or magmatism, sedimentation and metamorphism); General physical properties of minerals (color, form, habit, shape, luster, streak, cleavage, fracture, hardness, specific gravity) with other special properties (tenacity, odors/aromas/smells, transparency, hygroscopic, magnetic nature).	10
II	**Mineralogy:** Chemical composition and diagnostic physical properties of rock forming minerals mentioned below: olivine,pyroxene (augite, hypersthene),quartz, feldspar (orthoclase, microcline, albite, labradorite), nepheline, mica (muscovite, biotite), tremolite, hornblende, secondary minerals (serpentine, talc, chlorite, kaolinite), apatite, carbonate (calcite, dolomite),garnet,aluminosilicate (kyanite, sillimanite, andalusite), staurolite, topaz, tourmaline, corundum, gypsum, graphite.	10
III	**Optical Mineralogy:** Nature of light, optics of light, critical angle and total internal reflection, polarization, double refraction, Nicol prism, optically isotropic and anisotropic substances; sample preparation techniques for optical microscopy, polarizing microscope; common optical properties observed under plane polarized light (PPL) and crossed polarized light (CPL/XPL); optical properties of common rock-forming minerals: quartz, feldspar (orthoclase, microcline, plagioclase), garnet, mica (biotite, muscovite), pyroxene (augite, hypersthene), amphibole (hornblende), olivine, and calcite.	15
IV	**Fundamentals of Crystallography:** Crystal, elementary idea of crystal structure; Elements of crystal symmetry; Introduction to different crystals systems;Parts of crystal - face, edge, apex, solid angle and interfacialangle; Crystallographic axes and angles; Parameters and indices; Common crystal forms –Cube, rhombohedron, hexagons, octahedron, dodecahedron,dome, prism,pyramid and pinacoid;	10

Texts / References	1. Berry, L.G., Mason, B. and Dietrich, R.V. (2004) Mineralogy. CBS Publication. 2. Ford, W.E. (2006) Danas Textbook of Mineralogy. CBS Publication. 3. Gribble, C.D. (2005) Rutley's Element of Mineralogy. CBS Publication. 4. Dexter Perkins (2015) Mineralogy. Pearson Education India. 5. Nesse, D.W. (2016) Optical Mineralogy, McGraw Hill Publication. 6. Kerr, P. F. (2014) Optical Mineralogy. McGraw-Hill. 7. Verma, P. K. (2010) Optical Mineralogy. Ane Books Pvt Ltd. 8. Phillips, F.C (1977) Introduction to Crystallography, Longman Group Publication. 9. Sharma, R.S. and Sharma, A. (2013) Crystallography and Mineralogy - Concepts and Methods. Geological society of India, Bengaluru. 10. Philpotts, A. and Klein, C. (2012) Earth Materials: Introduction to Mineralogy and Petrology. Cambridge University Press.
Learning Outcomes (not more than 100 words)	The study of this course strengthens students' knowledge for understanding the fundamentals of the minerals and materials occur on the Earth. The knowledge of the concepts in physical properties of minerals would enable the students to understand the common natural resources of the earth and relate them to their field observations and also, in understanding the framework of the rock forming processes.

Course Title	**ESMJ22: Practical connected with ESMJ21**
Category of Course	**Major**

Credits& Hour of Teaching		Theory	Practical	Cumulative
	Credits	---	01	01
	Hour of Teaching (Total)	---	30	30

Course Objectives (not more than 100 words)	Practical knowledge to recognize the most common rock-forming minerals, their compositions and to identify them based on their macroscopic and microscopic characteristics in hand specimen.
Course Content	The course content be divided into minimum 3 Units to maximum 5 units along with defined hour of teaching for each unit.

Units	**Course Content**	**Hr. of Teaching**
I	Learning of physical properties of minerals in hand specimen Silicates: Olivine, Garnet, Andalusite, Sillimanite, Kyanite, Staurolite, Beryl, Tourmaline, Augite, Actinolite, Tremolite, Hornblende, Serpentine, Talc, Muscovite, Biotite, Phlogopite, Quartz, Orthoclase, Plagioclase, Microcline, Nepheline, Sodalite, Zeolite.	10
II	Sulfides and Oxides of Copper, Sulfur, Graphite, Pyrite, Corundum, Magnetite Hydroxides, Halides, Carbonates, Sulfates, Phosphates: Psilomelane, Fluorite, Calcite, Malachite, Gypsum, Apatite.	10
III	Use of polarizing microscope; Study of optical properties of important rock forming minerals. Study of physical properties of minerals mentioned in theory course	5
IV	Study of elements of symmetry of representative crystals system: isometric, hexagonal, tetragonal, orthorhombic, monoclinic, triclinic	5

Texts / References	1. Gribble, C.D. (2005) Rutley's Element of Mineralogy. CBS Publication. 2. Ford, W.E.(2006) Danas Text Book of Mineralogy, CBS Publication. 3. Dexter Perkins(2015) Mineralogy. Pearson Education India. 4. Nesse, D.W.(2016) Optical Mineralogy, McGraw Hill Publication. 5. Kerr, P.F.(2014)Optical Mineralogy. McGraw-Hill. 6. Verma, P.K.(2010)Optical Mineralogy. Ane Books PvtLtd. 7. Phillips, F.C (1977)Introduction to Crystallography, Longman Group Publication.
Learning Outcomes (not more than 100 words)	The study of this course strengthens students' knowledge forunderstanding the fundamentals of the minerals and materials occur on the Earth. The practical knowledge of the physical properties of minerals would enable the students to understand the common rock forming mineral on the Earth.

Course Title	**ESMD21: Earth, Environment and Society**
Category of Course	**MD**

Credits& Hour of Teaching

	Theory	Practical	Cumulative
Credits	03	---	03
Hour of Teaching (Total)	45	---	45

Course Objectives (not more than 100 words)

This course aims to train the students
- To associate the naturally occurring landforms with erosion and depositional action of the rivers, wind and Glaciers.
- To know the brief ideas about concepts of hydrological cycles
- Idea about the atmosphere and ocean system and its significance

Course Content

The course content be divided into minimum 3 Units to maximum 5 units along with defined hour of teaching for each unit.

Units	**Course Content**	**Hr. of Teaching**
I	Physical division of India; Geological hazards: floods, earthquakes, volcanoes, tsunami, landslides. weathering and erosion, geological work of rivers, wind and Glaciers,	10
II	Atmosphere: structure and composition;	10
III	Hydrological cycle; groundwater/watershed management	10
IV	Introduction to ocean system. Significance,	10
V	Preservation and introduction of geo-heritage sites in India.	05

Texts / References

1. Gautam, A. (2006): Advanced Geography of India, ShardaPustakBhawan, Allahabad.
2. Bryant, E. (1985): Natural Hazards, Cambridge University Press.
3. Holmes, A. (1987): Principles of Physical Geology. Nelson, New York, 3rd edition.
4. Singh, S. (2003): Physical Geography (English and Hindi editions). PrayagPustakBhawan, Allahabad.
5. Lal, D. S. (2007): Climatology, ShardaPustakBhawan, Allahabad.
6. Strahler, A. N. and Strahler, A. H. (1973): Environmental Geoscience, Hamilton Publishing Co.
7. Davies, S. N. and De Wiest, R. J. N. (1966): Hydrogeology, John Wiley & Sons.
8. Garrison, T. (1998): Oceanography, Wordsworth Company, Belmont..

Learning Outcomes (not more than 100 words)

Upon completing this course, students will be able to
- Understand the depositional and erosional processes associated with various natural agents, such as Rivers, wind, glaciers, etc.
- Acquire basic knowledge about the atmosphere, hydrological cycles and ocean system and their significance

Know about Geo-heritage sites in India and their preservation

Course Title	**ESSE21: Gemology**
Category of Course	**SEC**
Credits& Hour of Teaching	

	Theory	Practical	Cumulative
Credits	02	---	30
Hour of Teaching (Total)	30	---	30

Course Objectives (not more than 100 words)	The course contains physical characterization and classification of gemstones, application of advanced techniques to gemstone identification, genesis of gemstones and Indian distribution, and Synthetic gemstones and their identification.
Course Content	The course content be divided into minimum 3 Units to maximum 5 units along with defined hour of teaching for each unit.

Units	**Course Content**	**Hr. of Teaching**
I	Gem and gemstones; General characteristics and chemical composition of gemstones; Physical characteristics - form, cleavage, fracture, hardness, specific gravity, and tenacity.	6
II	Optical characteristics - colour, luster, the playofcolour, refractive index, reflectivity, diaphaneity pleochroism, dispersion; Classification of gemstones.	6
III	Application of ultraviolet rays, x-rays, and infra-red rays in gem identification; Electrical thermal and magnetic characters of gems;	6
IV	Systematic description, genesis, mode of occurrence, distribution in India, and important world occurrences of precious and semi-precious stones.	6
V	Synthetic gemstones - methods of synthesis and their characteristics and identification; Gem enhancement methods and their identification: Colourless / colored impregnation, heat treatment, coating, irradiation, diffusion, treatment.	6

Texts / References	1. Karanth, R. V. (2000): Gems and Gem Industry in India, Memoir-45, Geological Society of India, Bangalore. 2. Brocardo, G. (1981): Minerals and Gemstone - An Identification Guide, David and Charles, London. 3. Bruton, Eric F. G. A. (1970): Diamonds, Chilton Book Company. Max Bauer (1968): Precious Stones, Vol. I and II, Dover, New York. 4. Orlov, Yu. L. (1973): The Mineralogy of the Diamond, John Wiley. 5. Rajendran, S. (2007): Mineral Exploration: Recent Strategies. 6. Vilson, M. (1967): Gems, Heinemann, London.
Learning Outcomes (not more than 100 words)	Gemology is a fascinating scientific field that entails the comprehensive study of both natural and artificial gemstone materials. As a specialized branch of mineralogy, gemology involves the meticulous examination of gemstones' physical and chemical properties to discern their unique characteristics. Further, it also helps to differentiate between natural and synthetic gemstones. This knowledge is decisive in ensuring the authenticity and value of gemstones in various applications, including jewelry, art, and scientific research.

Course Title	**ESSE22: Practical connected with ESSE21**
Category of Course	**SEC**
Credits& Hour of Teaching	

	Theory	Practical	Cumulative
Credits	---	01	01
Hour of Teaching (Total)	---	30	30

Course Objectives (not more than 100 words)	To identify the precious and semi-precious gems
Course Content	The course content be divided into minimum 3 Units to maximum 5 units along with defined hour of teaching for each unit.

Units	**Course Content**	**Hr. of Teaching**
	Studyofdiagnosticphysicalpropertiesofpreciousandsemi-preciousgems.	30

Texts / References	1. Brocardo,G.(1981):MineralsandGemstone-Anidentificationguide,DavidandCharles,London. 2. BrutonEricF.G.A.(1970):Diamonds,ChiltonBookCompany. 3. MaxBauer(1968): Precious Stones,Vol.IandII,Dover,NewYork.
Learning Outcomes (not more than 100 words)	Students can able to identify gems in hand specimens using physical properties like hardness heat sensitivity, affect a gem's durability and cut and help gemologists with identifications.

Course Title	**Same as major ESMJ21 and ESMJ22**
Category of Course	**Minor**
Credits& Hour of Teaching	

	Theory	Practical	Cumulative
Credits	03	01	04
Hour of Teaching (Total)	45	30	75

		Credit
Value Added Course (VA)	To be Offered by the University	2 + 2
Ability Enhancement Course (AE)	To be Offered by the University	2

Semester: III

Course Title	**ESMJ31: Physical Geology**
Category of Course	**Major**

Credits& Hour of Teaching		Theory	Practical	Cumulative
	Credits	03	---	03
	Hour of Teaching (Total)	45	---	45

Course Objectives (not more than 100 words)	Study the different geomorphic processes, Nature of weathering and erosion on the Earth's surface Evolution of landscape Concept of Isostacy and plate tectonics Erosional and depositional work of different natural agencies
Course Content	The course content be divided into minimum 3 Units to maximum 5 units along with defined hour of teaching for each unit.

Units	**Course Content**	**Hr. of Teaching**
I	Exogenic and endogenic geomorphic processes; Weathering and erosion	10
II	Soil, soil formation, soilprofile, and soil type;	5
III	Evolution of landscape; Origin of oceans, continents, and mountains; Classification of mountains;	10
IV	Concept and theories of isostasy; Origin and significance of mid-oceanic ridges and trenches; Seafloor spreading & continental drift; A brief idea about plate tectonics and distribution of plates.	10
V	A detailed account of the geological work of natural agencies; Glaciers,groundwater and springs, rivers,lakes, ocean, and wind.	10

Texts / References	1. Holmes, Arthur (1992): Principles of Physical Geology, Vol. 1, Chapman and Hall, London. 2. Leet, L. D. and Judson, S. (1969): Physical Geology, Prentice Hall. 3. Mallory, B. F. and Cargo, D. N. (1979): Physical Geology, McGraw Hill. 4. Monrow, James S. (1986): Physical Geology: Exploring the Earth, Booke Cole, Australia. 5. Ritter, Dale F. (1986): Processes of Geomorphology, Wm. C. Brown Publishers. 6. Singh, S. (2001): Geomorphology, PrayagPustakBhandar, Allahabad.
Learning Outcomes (not more than 100 words)	This study covers both endogenic and exogenic geomorphic processes, which are important to understanding soil development and different landscapes.Isostacy and plate tectonics enhance our understanding of the Earth's dynamics.The erosion and depositional activity of different natural agencies and the development of related geomorphic features.

Course Title	**ESMJ32: Elementary Structural Geology**
Category of Course	**Major**

Credits& Hour of Teaching	Theory	Practical	Cumulative
Credits	03	---	03
Hour of Teaching (Total)	45	---	45

Course Objectives (not more than 100 words)	The course aims to introduce undergraduate students to its basic principles, analysis methods and field characteristics. Overall goal is to provide a good understanding of how earth's rock deforms at different levels of the lithosphere. Students develop a basic appreciation of rock deformation at different temperatures and pressures and different scales and understand the difference between brittle and ductile deformation regimes. Students study diverse geometries and types of structures in the field and learn to relate them to the deformation regime.
Course Content	The course content be divided into minimum 3 Units to maximum 5 units along with defined hour of teaching for each unit.

Units	**Course Content**	**Hr. of Teaching**
I	An introduction to various planar and linear geological structures, including the concepts of outcrop, and strike-dip. Detailed examination of the clinometer compass and its application in the field. Analysis of how topography influences outcrop patterns, with a focus on the application of rule of 'V's.	12
II	Definition and identification of the components of folds along with the geometrical classification of folds and methods for recognizing folds in the field. Discussion on the causes of folding and its geological significance.	12
III	Definition and classification of various types of unconformities. Introduction to the concepts of overlap, onlap, offlap, overstep, outlier, and inlier. Methods for recognizing unconformities in the field and discussion of their geological significance.	12
IV	Definition and detailed description of the components of faults and joints, with a focus on their geometric and genetic classification. Exploration of the effects of faulting on outcrops and the characteristic features that indicate faulting in the field. Examination of the causes and significance of faulting, with an emphasis on structures such as horst and graben, autochthon, allochothon, window, and klippe. Analysis of the characteristics of fractures and joints, including different fracture modes and their implications in geological studies.	9

Texts / References	1. Billings, M. P. (2016): Structural Geology, Pearson. 2. Dennis, J. G. (1972): Structural Geology, Ronald Press Company, New York. 3. Hills, E. S. (1963): Elements of Structural Geology, Farrold and Sons, London. 4. Park, R. G. (2017): Foundations of Structural Geology, Routledge. 5. Ramsay, J. G. (2004): Folding and Fracture of Rocks, The Blackburn Press. 6. Fossen, H. (2010): Structural Geology, Cambridge University Press.
Learning Outcomes (not more than 100 words)	On completion of the course the student should have the following learning outcomes: Basic understanding of linear and planar structures and measuring, plotting and interpreting structural field data. Comprehend how to describe and classify brittle and ductile structures, including, folds, faults, joints and unconformities. Knows how to read simple geological maps and geological cross sections.

Course Title	**ESMJ33: Practical connected with ESMJ31**
Category of Course	**Major**
Credits& Hour of Teaching	

	Theory	Practical	Cumulative
Credits	---	01	01
Hour of Teaching (Total)	---	30	30

Course Objectives (not more than 100 words)	Practical exercises will be provided on what is learned about different types of physical structures in the Theory course (ES-CC-211).
Course Content	The course content be divided into minimum 3 Units to maximum 5 units along with defined hour of teaching for each unit.

Units	**Course Content**	**Hr. of Teaching**
I	Study of Toposheets: Boundary Information of toposheet, Topographic features.	06
II	Cultural features:Man-made features, Land-use / Land cover.	06
III	Hydrological features: Drainage patterns.	06
IV	Extractions of Plateau, hill, Ridge, Valley, Escarpment, and Deep Gorges based on contours.	06
V	Study of Geomorphological features from Aerial photos under a pocket stereoscope.	06

Texts / References	1. Holmes, Arthur (1992): Principles of Physical Geology, Vol. 1, Chapman and Hall, London. 2. Leet, L. D. and Judson, S. (1969): Physical Geology, Prentice Hall. 3. Mallory, B. F. and Cargo, D. N. (1979): Physical Geology, McGraw Hill. 4. Monrow, James S. (1986): Physical Geology: Exploring the Earth, Booke Cole, Australia. 5. Ritter, Dale F. (1986): Processes of Geomorphology, Wm. C. Brown Publishers. 6. Singh, S. (2001): Geomorphology, PrayagPustakBhandar, Allahabad.
Learning Outcomes (not more than 100 words)	After these practical exercises, the students will be able to visualize the physical features, geological structures, and man-made features on the toposheet. They will also be able to extract drainage patterns and different geomorphic features through Aerial photographs.

Course Title	**ESMJ34: Practical connected with ESMJ32**
Category of Course	**Major**
Credits& Hour of Teaching	

	Theory	Practical	Cumulative
Credits	---	01	01
Hour of Teaching (Total)	---	30	30

Course Objectives (not more than 100 words)	There will be practical exercises on what is learnt about different types of structures in the Theory course (ES-CC-212).
Course Content	The course content be divided into minimum 3 Units to maximum 5 units along with defined hour of teaching for each unit.

Units	**Course Content**	**Hr. of Teaching**
I	Practice problems focused on determining true and apparent dips, strike, true and vertical thicknesses, and the width of outcrops in geological structures.	10
II	Calculation of strike, dip, and bed thicknesses using geological maps. Techniques for completing outcrop maps and the use of a clinometer compass for accurate measurement of dip and strike.	10
III	Interpretation of outcrops of folded rock units on both horizontal and sloping surfaces. Construction of geological cross-sections and analysis to infer the geological history of the region along with application of rule of 'V's.	10

Texts / References	1. Billings, M. P. (2016): Structural Geology, Pearson. 2. Lisle, R. J. (2004): Geological Structures and Maps: A Practical Guide, Third Edition. Elsevier. 3. Marshak, S. and Mitra, G. (1988): Basic Methods of Structural Geology, Prentice Hall. 4. Bennison, G. M. (1993): An Introduction to Geological Structures and Maps, Edward Arnold, London. 5. Ragan, D. M. (2009): Structural Geology: An Introduction to Geometrical Technique, Cambridge University Press. 6. Rowland, S. M., Duebendorfer, E. M., and Schiefelbein (2007): Structural Analysis & Synthesis: A Laboratory Course in Structural Geology, Blackwell Publishing Ltd.
Learning Outcomes (not more than 100 words)	After going through these practical exercises, the students will be able to visualize the relationship between the physical features of the field and the geological structures. Student will also be able to make desired measurement of the subsurface structural features from the ground surface data.

Course Title	**ESMD31: Rocks, Minerals and Fossils**
Category of Course	**MD**

Credits& Hour of Teaching		Theory	Practical	Cumulative
	Credits	03	---	03
	Hour of Teaching (Total)	45	---	45

Course Objectives (not more than 100 words)

This course aims to train the students

- to know the different types of rocks, such as Igneous, sedimentary, and metamorphic rocks and related textures,
- to understand the ideas of understanding of different rock types based on their origin.
- to train in identifying the properties of common rock-forming minerals and their occurrences in India

To introduce fundamental aspects of paleontology and its application in Geology

Course Content

The course content be divided into minimum 3 Units to maximum 5 units along with defined hour of teaching for each unit.

Units	Course Content	Hr. of Teaching
I	Rockcycle,abriefintroductionofIgneous,sedimentaryandmetamorphicrocks,	10
II	Physical and chemical properties of minerals, mineral resource of India.	15
III	Paleontology,definitionandscope,fossildefinition,modeofoccurrenceanduseoffossil.Geologicaltimescale	10
IV	Evolution of life is representative of life of different geological periods.	10

Texts / References

1. **Cornelis Klein and A. R. Philpotts (2013):***Earth Materials: Introduction to Mineralogy and Petrology*. Cambridge University Press.
2. **Read, H. H. (1968):***Rutley's Element of Mineralogy* (Rev. Ed.). Thomas Murby and Co.
3. **Blatt, H. and Tracy, R. J. (1996):***Petrology: Igneous, Sedimentary, Metamorphic.* W. H. Freeman and Co., New York.
4. **Gokhale, K. V. G. K. and Rao, T. C. (1983):***Ore Deposits of India.* East-West Press Pvt. Ltd.
5. **Jain, P. C. and Anantharaman, M. S. (1983):***Palaeontology: Evolution and Animal Distribution.* Vishal Publ.
6. **Prothero, D. R. (2004):***Bringing Fossils to Life: An Introduction to Paleontology* (2nd Ed.). McGraw-Hill.

Learning Outcomes (not more than 100 words)

Upon completing this course, students will be able to

- Understand the different types of rock types and their formation in different tectonic environments
- Know the fundamentals of mineralogy and common rock-forming minerals

Basics of Paleontology and Distribution of different fossil assemblages in geological history.

Course Title	**ESSE31: Geological Field Training**
Category of Course	**SEC**

Credits& Hour of Teaching

	Theory	Practical	Cumulative
Credits	---	03	03
Hour of Teaching (Total)	---	90	90

Course Objectives (not more than 100 words)	To impart the introductory level field training to the students to visualize various rock types in their natural environment and their natural relationship to one another. It seeks to describeand explain the surface feature and underground structure of the lithosphere based upon observations and inferences.To learn to use field equipments such as clinometers and other equipments and measuring and recording of field data and information. It seeks to describe.
Course Content	The course content be divided into minimum 3 Units to maximum 5 units along with defined hour of teaching for each unit.

Units	**Course Content**	**Hr. of Teaching**
I	There will be a field visit in a suitable area with the following objectives: • To observe and identify the various ongoing weathering, erosional, and depositional features. • To acquaint with the various types of rocks observable in the area. • To distinguish between in situ and transported rocks. • To identify the various basic characters of the rocks on their outcrops. • Hands-on exercises with clinometer, compass, and other geological equipment. • Measuring and recording the dip and strikes of the rocks. • Marking the locations of the outcrops and plotting of the structural data on a base map. • To write a brief inventory report on the geological setup of the visited area.	90

Texts / References	1. Compton, R. A. (1985): Geology in the Field, John Wiley and Sons. 2. Freeman, T. (1999): Procedures in Field Geology, Blackwell Science. 3. Geological Field Techniques (2010), edited by Angela L. Coe, Wiley-Blackwell. 4. Lahee, F. H. (1987): Field Geology, Indian edn., CBS Publishers and Distributors.
Learning Outcomes (not more than 100 words)	After going through these practical exercises in the field, the students will be able to visualize and experience the different geological processes that are going on the earth and inside the earth. Students will be able to know the occurrence of various rock types and different deformation structures found in the rocks in nature.

Course Title	**ESMV31: Minerals and Earth Material**
Category of Course	**VOC**

Credits& Hour of Teaching		Theory	Practical	Cumulative
	Credits	03	---	03
	Hour of Teaching (Total)	45	---	45

Course Objectives (not more than 100 words)	Identify the minerals and materials of the solid Earth. Recognize the most common rock-forming minerals, their compositions and beable to identify them based on their macroscopic and microscopiccharacteristics. To understand the fundamental principles of mineralogy, optical mineralogy and crystallography.
Course Content	The course content be divided into minimum 3 Units to maximum 5 units along with defined hour of teaching for each unit.

Units	**Course Content**	**Hr. of Teaching**
I	**Fundamentals of Mineralogy:** Minerals, definition and classification; Processes of mineral formation (magmatic, post-magmatic, pegmatitic, weathering, sedimentary, and metamorphic); Common physical properties of minerals (form and shape, color, streak, luster, cleavage, fracture, hardness, tenacity, transparency, specific gravity, magnetic nature).	10
II	**Mineralogy:** Chemical composition and diagnostic physical properties of rock-forming minerals mentioned below: quartz, orthoclase, microcline, albite, labradorite, nepheline, muscovite, biotite, augite, hypersthene, tremolite, hornblende, olivine, serpentine, talc, chlorite, apatite, calcite, dolomite, garnet, kyanite, sillimanite, andalusite, staurolite, topaz, tourmaline, corundum, gypsum, graphite, and kaolinite.	10
III	**Optical Mineralogy:** Nature of Light, Optics of Light, Critical Angle and Total Internal Reflection, Polarization of Light, Double Refraction, Nicol Prism and Its Construction, Sample Preparation Techniques for Optical Microscopy, Polarizing Microscope, Its Parts and Functioning; Optically Isotropic and Anisotropic Substances, Common Optical Properties Observed Under Polarized Light and Crossed Nicols; Optical Properties of Some Common Rock-Forming Minerals (quartz, orthoclase, microcline, plagioclase, garnet, biotite, muscovite, augite, hypersthene, hornblende, olivine, and calcite).	15
IV	**Fundamentals of Crystallography:** Crystal, elementary idea of crystal structure; Parts of crystal - face, edge, apex, solid angle and interfacial angle; Crystallographic axes and angles; Parameters and indices; Common crystal forms - dome, prism, pyramid, and pinacoid; Elements of crystal symmetry; Introduction to different crystal systems.	10

Texts / References	1. Berry, L. G., Mason, B., and Dietrich, R. V. (2004): Mineralogy, CBS Publication. 2. Ford, W. E. (2002): Dana's Textbook of Mineralogy, CBS Publication. 3. Gribble, C. D. (2005): Rutley's Elements of Mineralogy, CBS Publication. 4. Perkins, Dexter (2015): Mineralogy, Pearson Education India. 5. Nesse, D. W. (2016): Optical Mineralogy, McGraw-Hill Publication. 6. Kerr, P. F. (2014): Optical Mineralogy, McGraw-Hill. 7. Verma, P. K. (2010): Optical Mineralogy, Ane Books Pvt Ltd. 8. Phillips, F. C. (1977): Introduction to Crystallography, Longman Group Publication. 9. Sharma, R. S. and Sharma, A. (2013): Crystallography and Mineralogy - Concepts and Methods, Geological Society of India, Bengaluru. 10. Philpotts, A. and Klein, C. (2012): Earth Materials: Introduction to Mineralogy and Petrology, Cambridge University Press.
Learning Outcomes (not more than 100 words)	The study of this course strengthens students' knowledge forunderstanding the fundamentals of the minerals and materials occur on the Earth. The knowledge of the concepts in physical properties of minerals would enable the students to understand common natural resources of the earth and relate them to their field observations and also, in understanding the framework of the rock forming processes.

Course Title	**ESMV32: Practical connected with ESMV31**
Category of Course	**Minor**

Credits& Hour of Teaching	Theory	Practical	Cumulative
Credits		01	01
Hour of Teaching (Total)		30	30

Course Objectives (not more than 100 words)	Practical knowledge to recognize the most common rock-forming minerals, their compositions and be able to identify them based on their macroscopic and microscopic characteristics in hand specimens.
Course Content	The course content be divided into minimum 3 Units to maximum 5 units along with defined hour of teaching for each unit.

Units	**Course Content**	**Hr. of Teaching**
I	Study of physical properties of minerals in hand specimen Silicates: Olivine, Garnet, Andalusite, Sillimanite, Kyanite, Staurolite, Beryl, Tourmaline, Augite, Actinolite, Tremolite, Hornblende, Serpentine, Talc, Muscovite, Biotite, Phlogopite, Quartz, Orthoclase, Plagioclase, Microcline, Nepheline, Sodalite, Zeolite.	10
II	Sulfides and Oxides of Copper, Sulfur, Graphite, Pyrite, Corundum, Magnetite, Hydroxides, Halides, Carbonates, Sulfates, Phosphates: Psilomelane, Fluorite, Calcite, Malachite, Gypsum, Apatite.	10
III	Use of polarizing microscope; Study of optical properties of important rock forming minerals. Study of physical properties of minerals mentioned in theory course.	5
IV	Study of elements of symmetry of representative crystals from each system mentioned in theory course.	5

Texts / References	1. Gribble, C. D. (2005): Rutley's Elements of Mineralogy, CBS Publication. 2. Ford, W. E. (2006): Dana's Textbook of Mineralogy, CBS Publication. 3. Perkins, Dexter (2015): Mineralogy, Pearson Education India. 4. Nesse, D. W. (2016): Optical Mineralogy, McGraw-Hill Publication. 5. Kerr, P. F. (2014): Optical Mineralogy, McGraw-Hill. 6. Verma, P. K. (2010): Optical Mineralogy, Ane Books Pvt Ltd. 7. Phillips, F. C. (1977): Introduction to Crystallography, Longman Group Publication.
Learning Outcomes (not more than 100 words)	The study of this course strengthens students' knowledge forunderstanding the fundamentals of the minerals and materials occur on the Earth. The practical knowledge of the physical properties of minerals would enable the students to understand common rock forming mineral on the Earth.

		Credit
Ability Enhancement Course (AE)	To be Offered by the University	2

Semester: IV

Course Title	**ESMJ41: Petrology and Economic Geology**
Category of Course	**Major**

Credits& Hour of Teaching		Theory	Practical	Cumulative
	Credits	03	---	03
	Hour of Teaching (Total)	45	---	45

Course Objectives (not more than 100 words)	• To understand the origin, composition, and evolution of igneous rocks, and the processes of formation, including melting, crystallization, magmatic differentiation, and assimilation. • To focus on identifying common sedimentary rocks, the classification and the petrographic description and sedimentary structures. • To recognize metamorphic rocks, textures, structures, and assemblages and to provide details of metamorphic processes, agents, and types of metamorphism. • To have a basic idea about concepts of economic geology, and economic resources of India such as minerals, rocks, coal and petroleum.
Course Content	The course content be divided into minimum 3 Units to maximum 5 units along with defined hour of teaching for each unit.

Units	**Course Content**	**Hr. of Teaching**
I	Igneous Petrology: Magma: definition, its composition and types; Phase rule and its application toH_2O and SiO_2 systems; Common igneous textures; Magmatic differentiation and assimilation; Introduction to mineralogical classification; Brief petrographic description of common igneous rocks (granite, diorite, syenite, gabbro, dolerite, basalt, rhyolite,trachyte,pyroxeniteandperidotite)	11
II	**Sedimentary Petrology:** Sedimentary rocks and their significance; Formation of sedimentary rocks; Classification of sedimentary rocks; Primary sedimentary structures (bedding and stratification, ripple marks, cross-bedding, graded bedding, mud cracks, raindrop imprints); Texture of sedimentary rocks; Sedimentary rock-forming minerals; Petrographic description of important rock types (sandstone, siltstone, conglomerate, breccia, shale, limestone, dolostone).	11
III	Metamorphic Petrology:Introduction, Limits of metamorphism, Factor controlling metamorphism, Types of metamorphism, Nomenclature and classification of metamorphic rocks, Recognition of rock-structure and textures, Metamorphic grade and isograde, Regional, thermal, and progressive metamorphism of mafic igneous, calcareous, and pelitic rocks,Common metamorphic rocks such as slate, phyllite, schist, gneiss, hornfels, marble, and quartzite, along with their parent compositions (protoliths).	11
IV	**Economic Geology:** Definitions of Economic Geology, Ore Geology, Mineral Deposit, Ore Deposit, Ore, Ore Mineral, Gangue, Grade, Resource, and Reserve; Classification of Mineral Deposits; Styles of Mineralization and Morphology of Mineral Deposits; Chemical composition, diagnostic characters, uses, and Indian distribution of: Magnetite, Hematite, Chromite, Psilomelane, Pyrolusite, Chalcopyrite, Galena, Sphalerite, Gold, Magnesite, Bauxite, Pyrite, Diamond, Muscovite, Beryl, Fluorite, Gypsum, Barite, Halite, Phosphorite, Talc, Kyanite, Graphite, Asbestos, Monazite, and Corundum; Definition of Coal; Physical characteristics and composition of Coal; Classification of Coal; Uses of Coal; Distribution of Coal Deposits in India; Elementary idea about Petroleum, Uses, and distribution in India..	12

Texts / References	1. **Best, M. G. (2002).***Igneous and Metamorphic Petrology*. Blackwell Science. 2. **Blatt, H., & Tracy, R. J. (1996).***Petrology: Igneous, Sedimentary, Metamorphic*. W. H. Freeman and Co., New York. 3. **Ehlers, E. G., & Blatt, H. (1982).***Igneous, Sedimentary and Metamorphic Petrology*. CBS Publ. Huang. 4. **Winkler, H. G. F. (1967).***Petrogenesis of Metamorphic Rocks.* Springer-Verlag. 5. **Winter, J. D. (2010).***Principles of Igneous and Metamorphic Petrology* (2nd ed.). Pearson Education Ltd. 6. **Tucker, M. E. (2001).***Sedimentary Petrology: An Introduction to the Origin of Sedimentary Rocks.* 7. **Sengupta, S. (1994).***Introduction to Sedimentology*.Routledge. 8. **Boggs, S. (2013).***Principles of Sedimentology and Stratigraphy*. *Pearson.* 9. **Bateman, A. M., & Jensen, M. L. (1990).***Economic Mineral Deposits*. John Wiley. 10. **Chandra, D., & Singh, R. M. (2003*).Petroleum (Indian Context).* Tara Book Agency. 11. **Chandra, D., Singh, R. M., & Singh, M. P. (2000).***Textbook of Coal (Indian Context).* Tara Book Agency. 12. **Evans, A. M. (1993).***Ore Geology and Industrial Minerals: An Introduction.* John Wiley & Sons. 13. **Evans, A. M. (1997).***An Introduction to Economic Geology and its Environmental Impact*. John Wiley & Sons. 14. **Misra, K. (2000).***Understanding Mineral Deposits.* Springer Science & Business Media. 15. **Pohl, W. L. (2011).***Economic Geology: Principles and Practice*. John Wiley & Sons. 16. **Prasad, U. (2006).***Economic Geology: Economic Mineral Deposits.* CBS Publishers. 17. **Tyrrell, G. W. (1978).***The Principles of Petrology*. Springer. 18. **Klein, C. (2008).***Minerals and Rocks: Exercises in Crystal and Mineral Chemistry, Crystallography, X-Ray Powder Diffraction, Mineral and Rock Identification, and Ore Mineralogy*. John Wiley & Sons. 19. **Perkins, D. (2014).***Mineralogy*. Pearson Education Limited. 20. **Verma, P. K. (2010).***Optical Mineralogy* (Four Colour). Ane Books Pvt Ltd.
Learning Outcomes (not more than 100 words)	The students are expected to have basic knowledge of • Igneous rocks mineral composition, texture, and other physical characteristics.Processes of magma generation, differentiation, and crystallization, and how these processes influence the composition and texture of igneous rocks. • Sedimentary rocks, the basic process of sedimentation (physical and chemical), deposition and digenesis.Different classification of sedimentary rocks, their structures, textures and variability. • The metamorphism processes and metamorphic textures. Understand the conditions of metamorphism and the protolith of metamorphic rocks. • Basic concepts of economic geology and economic significance of certain mineral resources. Elementary knowledge of coal and petroleum.

Course Title	**ESMJ42: Paleontology and Stratigraphy**
Category of Course	**Major**

Credits& Hour of Teaching		Theory	Practical	Cumulative
	Credits	03	---	03
	Hour of Teaching (Total)	45	---	45

Course Objectives (not more than 100 words)	To study the modes of preservations of fossils and their morphology which is crucial for understanding the overall history of life and earth?However, stratigraphy aims at the organization of rock sequences in their proper order of occurrence according to their relative time of formation.
Course Content	The course content be divided into minimum 3 Units to maximum 5 units along with defined hour of teaching for each unit.

Units	**Course Content**	**Hr. of Teaching**
I	Paleontology:Definition, subdivision and scope of paleontology; Relationship of paleontology with other branches of geology; Fossils, their different kinds,requisites and various modes of preservation; Incompleteness of fossil records; Ideas about the evolution of life and adaptation to different environments.	10
II	Systematic classification of organisms; Study of the important morphological characters and geological distribution of Trilobita, Graptoloidea, Anthozoa and Echinoidea.	14
III	Stratigraphy:Definition and scope of stratigraphy, its relationship with other branches of geology; Laws of stratigraphy;Geological Time Scale; Stratigraphic nomenclature and classification; rock units, time units and time-rock units; Physica land tectonic divisions of India and their salient features.	07
IV	Concept of craton; Mobile belt and shield; Tectonic framework of the Indian shield; Evolution of granite-greenstone belts; Indian cratons (Aravalli, Dharwar, Singhbhum, Bastar and Bundelkhand); Eastern Ghats mobilebelt, Southern Granulite Terrain and the Central IndianTectonic Zone;Precambrians of the Extra-peninsular India.	14

Texts / References	1. **Black, R. M. (1988).***The Elements of Palaeontology.* Cambridge Univ. 2. **Boggs, S. (2001).***Principles of Sedimentology and Stratigraphy*. Prentice Hall. 3. **Krishnan, M. S. (1968).***Geology of India and Burma.* Higgibothon, Madras. 4. **Kumar, R. (1985).***Historical Geology and Stratigraphy of India.* Wiley Eastern Ltd. 5. **Benton, Michael J., & Harper, David A. T. (2020).***Introduction to Paleobiology and the Fossil Record.* John Wiley & Sons Ltd. 6. **Foote, M., & Miller, A. I. (2007).***Principles of Paleontology*. John Wiley & Sons Ltd. 7. **Brookfield, M. E. (2004).***Principles of Stratigraphy.* Wiley Blackwell. 8. **Moore, R. C., Lalicker, C. G., & Fischer, A. G. (1997).***Invertebrate Fossils.* CBS Publ. 9. **Nield, E. W., & Tucker, V. C. T. (1985).***Palaeontology: An Introduction.*Pergamon Press. 10. **Prothero, D. R. (2004).***Bringing Fossils to Life: An Introduction to Paleontology* (2nd ed.). McGraw-Hill. 11. **Shrock, R. R., &Twenhoffel, W. H. (1952).***Principles of Invertebrate Paleontology.* CBS Publ. 12. **Wadia, D. N. (1966).***Geology of India.*English Language Publ. 13. **Weller, J. M. (1960).***Stratigraphic Principles and Practices.* Universal Book. 14. **Woods, H. (1985).***Palaeontology Invertebrate*. CBS Publ. 15. **Jain, P. C., &Anantharaman, M. S. (1983).***Palaeontology: Evolution and Animal Distribution.* Vishal Publ.
Learning Outcomes (not more than 100 words)	By the end of this course, students will understand the scope of paleontology and its relationship with other geological fields. They will be proficient in identifying and classifying fossils, understanding fossilization processes, and the origin of life. Students will analyze the morphology and distribution of various fossil groups. In stratigraphy, they will grasp its principles, the Geological Time Scale, stratigraphic classification, and the structural subdivisions of India. Additionally, students will comprehend the tectonic framework of the Indian shield, including cratons, mobile belts, and Precambrian of extra-peninsular regions.This will provide a holistic idea of Indian geology to students.

Course Title	**ESMJ43:Environmental Geology and Hydrogeology**
Category of Course	**Major**

Credits& Hour of Teaching		Theory	Practical	Cumulative
	Credits	03	---	03
	Hour of Teaching (Total)	45	---	45

Course Objectives (not more than 100 words)	This course aims to comprehensively understand Earth's processes and their interaction with human activities. Key objectives include examining geological hazardssuch as landslides and earthquakes and their societal impact. It also focuses on groundwater systems, contaminant transport, and remediation strategies to safeguard water resources. The course emphasizes practical applications in environmental management and sustainability, equipping students with skills to assess geological factors in land-use planning, infrastructure development, and natural resource conservation. Through case studies and fieldwork, students develop critical thinking and problem-solving abilities essential for addressing contemporary environmental challenges
Course Content	The course content be divided into minimum 3 Units to maximum 5 units along with defined hour of teaching for each unit.

Units	Course Content	Hr. of Teaching
I	**Environmental Geology:**Introduction to Environmental Geology and it's domains. Population,Growth& Sustainability; environmental risk, human interaction & conflict.	10
II	**Weather & Climate:** Climate classification and change. Atmospheric composition and hazards; Ozone depletion, Lithosphere—Earthquakes & seismic hazard, Landslides. Human impact on environment; Environmental legislation.	10
III	**Hydrogeology:** Definition of hydrogeology, hydrological cycle and the role of groundwater in the hydrological cycle, hydrological components: precipitation, infiltration, evaporation & transpiration, origin of groundwater, vertical distribution of groundwater, types of aquifers, springs, hydrogeological properties of water-bearing rock—porosity, permeability, specific yield and specific retention, storage coefficient, hydraulic conductivity.	15
IV	**Groundwater Quality:** Physical and chemical properties of water, quality criteria for different uses. Introduction to surface and subsurface methods of groundwater exploration.	10

Texts / References	**Environmental Geology** 1. **Reichard, J. S. (2018).***Environmental Geology*. McGraw-Hill. 2. **Valdiya, K. S. (2013).***Environmental Geology*. McGraw-Hill. 3. **Montgomery, C. W., &Szablewski, G. S. (2023).***Environmental Geology*. McGraw-Hill. 4. **Keller, E. A. (2012).***Introduction to Environmental Geology*. Prentice Hall. 5. **Erikson, J. (2002).***Environmental Geology: Facing the Challenges on Our Changing Earth.* Facts on File. **Hydrogeology** 1. **Todd, D. K. (2006).***Groundwater Hydrology* (2nd ed.). John Wiley & Sons, N.Y. 2. **Karanth, K. R. (1989).***Hydrogeology*. Tata McGraw-Hill Publishing. 3. **Raghunath, H. M. (1990).***Groundwater*. Wiley Eastern Ltd. 4. **Subramaniam, V. (2000).***Water*. Kingston Publishing, London.
Learning Outcomes (not more than 100 words)	Upon completing Environmental Geology and Hydrogeology, students will: 1. Understand geological processes affecting environmental quality, including hazards like landslides and earthquakes. 2. Analyze hydrogeological systems, including groundwater flow, contamination mechanisms, and remediation strategies. 3. Apply geological knowledge to assess the environmental impacts of human activities on landscapes and water resources. 4. Develop mapping and interpreting geological data skills to support environmental planning and resource management. 5. Evaluate sustainable practices and policies for mitigating geological risks and preserving natural environments. Demonstrate proficiency in communicating geological concepts and solutions to diverse stakeholders, promoting informed decision-making in environmental management.

Course Title	**ESMJ44:Essentials of Remote Sensing**
Category of Course	**Major**
Credits& Hour of Teaching	

	Theory	Practical	Cumulative
Credits	02	---	02
Hour of Teaching (Total)	30	---	30

Course Objectives (not more than 100 words)	The course aims to develop a basic understanding of Remote sensing and different space missions. It also includes the different image interpretation techniques and identification of landforms through remote sensing data.
Course Content	The course content be divided into minimum 3 Units to maximum 5 units along with defined hour of teaching for each unit.

Units	**Course Content**	**Hr. of Teaching**
I	Basic concepts of remote sensing; Indian space mission.	06
II	Elementsofphotogeology;Aerialphotos–types, scale, resolution, properties of aerial photos, stereoscopic parallax, relief displacement, vertical exaggeration.	06
III	Types of Remote Sensing Data; Resolution	06
IV	Elements of Image Interpretation;	06
V	Elements of Image Patterns–Landforms, Drainage, Erosion Details,etc.	06

Texts / References	1. **Gupta, R. P. (1991).***Remote Sensing Geology*. Springer-Verlag. 2. **Lillesand, T. M., & Kiefer, R. W. (1987).***Remote Sensing and Image Interpretation*. 3. **Siegal, B. S., & Gillespie, A. R. (1980).***Remote Sensing in Geology*. John Wiley. 4. **Campbell, J. B. (2002).***Introduction to Remote Sensing*(5th ed.). Taylor & Francis, London. 5. **Allum, J. A. E. (1985).***Photogeology and Regional Mapping.* 6. **Curran, P. J. (1985).***Principles of Remote Sensing. Longman, London.* 7. **Deekshatulu, B. L., &Rajan, Y. S. (Eds.) (1984).***Remote Sensing.*Indian Academy of Science, Bangalore. 8. **Pandey, S. N. (2007).***Principles and Applications of Photogeology.*
Learning Outcomes (not more than 100 words)	Upon completion of this course, students will have a thorough understanding of the physics of geospatial technology, as well as a better understanding of the interpretation of remote sensing data.

Course Title	**ESMJ45: Practical connected with ESMJ41**
Category of Course	**Major**

Credits& Hour of Teaching

	Theory	Practical	Cumulative
Credits	---	01	01
Hour of Teaching (Total)	---	30	30

Course Objectives (not more than 100 words)	Megascopic and microscopic study of the following rock types: gneiss, schist, quartzite, marble, phyllite and slate.To observe the physical and optical properties of certain minerals of economic importance in hand specimens and to know the Indian distribution of major mineral deposits, coal deposits and petroleum deposits by plotting their location of major deposits on the map of India.
Course Content	The course content be divided into minimum 3 Units to maximum 5 units along with defined hour of teaching for each unit.

Units	**Course Content**	**Hr. of Teaching**
I	**Petrology:** Megascopic and microscopic study of the following rock types: granite, syenite, nephelinesyenite, diorite, gabbro, peridotite, rhyolite, trachyte, dolerite, basalt, sandstone, conglomerate, breccia, shale, limestone, gneiss, schist, quartzite, marble, phyllite, and slate..	15
II	**Economic Geology:** Study of ore and economic minerals in hand specimens as detailed in thetheorysyllabus;Preparation of maps showing the distribution of important metallic andnon-metallic mineral deposits, and important coal and oilfields of India.	15

Texts / References

1. MacKenzie, W. S., Donaldson, C. H., and Guilford, C., (1982). Atlas of Igneous Rocks and Their Textures.
2. Lewis D.W., and McConchie D., (2012). Practical Sedimentology.
3. Prasad, U., (2019). Economic Geology CBS Publishers & Distributors, NewDelhi.
4. Deb, M., and Sarkar S. C., (2017) Minerals and Allied Natural Resources and their Sustainable Development. Springer Singapore.
5. Adams, A. E., MacKenzie, W. S., and C. Guilford., (1984). Atlas of Sedimentary Rocks Under the Microscope.
6. Yardley, B., W., D., MacKenzie, W. S., and Guilford, C., (1990) Atlas of Metamorphic Rocks and Their Textures

Learning Outcomes (not more than 100 words)	In practical of igneous, sedimentary, metamorphic petrology and economic geology, students will gain the ability to identify and classify various rock types and their textures using hand samples and thin sections. They will develop skills in interpreting magmatic processes, depositional environments, and metamorphic conditions through physical and optical properties. Additionally, they will enhance their understanding of resource exploration by evaluating economic minerals and deposits and integrating practical data with theoretical concepts.

Course Title	**ESMJ46: Practical connected with ESMJ42**
Category of Course	**Major**

Credits& Hour of Teaching		Theory	Practical	Cumulative
	Credits	---	01	01
	Hour of Teaching (Total)	---	30	30

Course Objectives (not more than 100 words)	There will be practical exercises to learn about different types of fossils and rock types and their modes of occurrence in India.
Course Content	The course content be divided into minimum 3 Units to maximum 5 units along with defined hour of teaching for each unit.

Units	Course Content	Hr. of Teaching
I	**Palaeontology:** Study of modes of preservation of fossils.	5
II	Study of morphological characters of about 30 genera pertaining to Trilobita, Graptoloidea, Echinoidea, and Anthozoa..	10
III	**Stratigraphy:** Preparation of lithostratigraphic maps of India showing distribution of the following –Aravalli, Dharwar, and SinghbhumSupergroups.	7
IV	Studyofimportantrocktypesoftheabovementionedstratigraphicunits	8

Texts / References

1. **Black, R. M. (1988).***The Elements of Palaeontology.* Cambridge Univ.
2. **Boggs, S. (2001*).Principles of Sedimentology and Stratigraphy*.** Prentice Hall.
3. **Krishnan, M. S. (1968).***Geology of India and Burma.* Higgibothon, Madras.
4. **Kumar, R. (1985).***Historical Geology and Stratigraphy of India.* Wiley Eastern Ltd.
5. **Benton, Michael J., & Harper, David A. T. (2020).***Introduction to Paleobiology and the Fossil Record.* John Wiley & Sons Ltd.
6. **Foote, Michael, & Miller, Arnold I.***Principles of Paleontology*. John Wiley & Sons Ltd.
7. **Brookfield, Michael E.***Principles of Stratigraphy.* Wiley Blackwell.
8. **Moore, R. C., Lalicker, C. G., & Fischer, A. G. (1997).***Invertebrate Fossils.* CBS Publ.
9. **Nield, E. W., & Tucker, V. C. T. (1985).***Palaeontology: An Introduction.*Pergamon Press.
10. **Prothero, D. R. (2004).***Bringing Fossils to Life: An Introduction to Paleontology*(2nd ed.). McGraw-Hill.
11. **Shrock, R. R., &Twenhoffel, W. H. (1952).***Principles of Invertebrate Paleontology*. CBS Publ.
12. **Wadia, D. N. (1966).***Geology of India.* English Language Publ.
13. **Weller, J. M. (1960).***Stratigraphic Principles and Practices.* Universal Book.
14. **Woods, H. (1985).***Palaeontology Invertebrate.* CBS Publ.
15. **Jain, P. C., &Anantharaman, M. S. (1983).***Palaeontology: Evolution and Animal Distribution.* Vishal Publ.

Learning Outcomes (not more than 100 words)	After going through these practical exercises, the students will be able to identify different types of fossils and their modes of preservation in nature. Students will also be able to identify different types of stratigraphic rocks and their geological importance.

Course Title	**ESMJ47: Practical connected with ESMJ43**
Category of Course	**Major**

Credits& Hour of Teaching				
		Theory	Practical	Cumulative
	Credits	---	01	01
	Hour of Teaching (Total)	---	30	30

Course Objectives (not more than 100 words)	The Environmental Geology and Hydrogeology theory course aims to provide students with a comprehensive understanding of the Earth's geological processes and their impact on water resources. Objectives include developing knowledge of soil and rock formation, groundwater flow dynamics, and the interactions between geological formations and water systems; understanding the principles of aquifer properties and groundwater contamination; learning to assess the environmental impact of geological and human activities on water resources; and equipping students with the skills to apply geological and hydrogeological concepts in environmental assessments, resource management, and sustainability practices. This course prepares students for advanced studies and careers in geosciences and environmental management.
Course Content	The course content be divided into minimum 3 Units to maximum 5 units along with defined hour of teaching for each unit.

Units	**Course Content**	**Hr. of Teaching**
I	Groundwater table contouring from piezo meter data, demarcation of flow direction,statusofsurface and subsurface water interaction on water table contour maps;Physico-chemical analysis ofgroundwater; Ion balancing of water chemistry data to estimate error in analysis, and methods ofgraphical representation of water quality data and its application, Earthquake hazard zonation;Landslidehazardzonation.	30

Texts / References

Environmental Geology

1. **Reichard, J. S. (2018).***Environmental Geology*. McGraw-Hill.
2. **Valdiya, K. S. (2013).***Environmental Geology*. McGraw-Hill.
3. **Montgomery, C. W., &Szablewski, G. S. (2023*).Environmental Geology*.** McGraw-Hill.
4. **Keller, E. A. (2012).***Introduction to Environmental Geology.* Prentice Hall.
5. **Erikson, J. (2002).***Environmental Geology: Facing the Challenges on Our Changing Earth.* Facts on File.

Hydrogeology

1. **Todd, D. K. (2006).***Groundwater Hydrology* (2nd ed.). John Wiley & Sons, N.Y.
2. **Karanth, K. R. (1989).***Hydrogeology.* Tata McGraw-Hill Publishing.
3. **Raghunath, H. M. (1990*).Groundwater*.** Wiley Eastern Ltd.
4. **Subramaniam, V. (2000).***Water*. Kingston Publishing, London.

Learning Outcomes (not more than 100 words)	Upon completing the Environmental Geology and Hydrogeology Practical course, students will: 1. Gain hands-on experience identifying and analyzing geological materials and groundwater systems. 2. Learn to conduct field sampling, perform laboratory tests on soil and rock properties, and analyze groundwater flow and contamination using advanced equipment. 3. Ability to interpret geological maps, applies hydrogeological modeling techniques, and assesses the impact of human activities on water resources. 4. Develop data analysis, critical thinking, and problem-solving skills, preparing them to tackle environmental and hydrological issues effectively. Essential for environmental consulting, research, and resource management careers.

Course Title	**Same as major ESMJ43and ESMJ47**
Category of Course	**Minor**

Credits& Hour of Teaching				
		Theory	Practical	Cumulative
	Credits	03	01	04
	Hour of Teaching (Total)	45	30	75

		Credit
Ability Enhancement Course (AE)	To be Offered by the University	2

Semester: V

Course Title	**ESMJ51: Metamorphic Petrology**
Category of Course	**Major**

Credits& Hour of Teaching	Theory	Practical	Cumulative
Credits	03	---	03
Hour of Teaching (Total)	45	---	45

Course Objectives (not more than 100 words)	The course aims to provide a comprehensive understanding of the principles governing metamorphic processes, including phase rule application and mineralogical phase rules. Students will learn to classify metamorphic facies and facies series, analyze mineral assemblages using ACF, AKF, and AFM diagrams, and explore the progressive metamorphism of different rock types. Additionally, the course will cover metamorphic differentiation, the impact of plate tectonics on metamorphism, and the application of thermodynamic laws to metamorphic petrology.
Course Content	The course content be divided into minimum 3 Units to maximum 5 units along with defined hour of teaching for each unit.

Units	**Course Content**	**Hr. of Teaching**
I	Introduction, Phase Rules, Gibbs phase Rule, Goldschmidt's Mineralogical Phase Rule, Principles of metamorphic reactions, Classification and concepts of Metamorphic Facies and Facies Series	09
II	Phase diagram for metamorphic mineral assemblages, ACF, AKF, AFM diagrams, Prograde, retrograde and polymetamorphism.	09
III	Progressive metamorphism of (a) Ultramafic rocks in $MgO - Al_2O_3 - SiO_2 - H_2O$ diagram, (b) Basic rocks in $CaO - FeO - MgO - Al_2O_3 - SiO_2$ diagrams, (c) Pelitic rocks in $K_2O - FeO\text{-}MgO\text{-}Al_2O_3\text{-}SiO_2$ diagram, (d) Calcareous rocks in $CaO - MgO - SiO_2 - CO_2 - H_2O$ diagram.	09
IV	Relationship between metamorphism and plate tectonics, Metamorphic Differentiation	09
V	Thermodynamic laws and their applications in metamorphic petrology	09

Texts / References	1. **Blatt, H., & Tracy, R. J. (1996).***Petrology: Igneous, Sedimentary, Metamorphic*,W. H. Freeman & Co., New York. 2. **Bucher, K., & Martin, F. (2002).***Petrogenesis of Metamorphic Rocks* (7th Rev. ed.). Springer–Verlag. 3. **Ehlers, E. G., & Blatt, H. (1982).***Igneous, Sedimentary and Metamorphic Petrology*. CBS Publ. 4. **Mason, R. (1978).***Petrology of Metamorphic Rocks.* CBS Publ. 5. **Philpotts, A. R. (1994).***Principles of Igneous and Metamorphic Petrology.* Prentice Hall. 6. **Powell, R. (1978).***Equilibrium Thermodynamics in Petrology: An Introduction.* Harper & Row Publishers, London. 7. **Rastogy, R. P., & Mishra, R. R. (1993).***An Introduction to Chemical Thermodynamics.* Vikash Publishing House. 8. **Spry, A. (1976).***Metamorphic Textures* .Pergamon Press. 9. **Vernon, R. H., & Clarke, G. L. (2008).***Principles of Metamorphic Petrology*. Cambridge University Press. Cambridge, New York, Melbourne, Madrid, Cape Town, Singapore, São Paulo, Delhi. 10. **Winkler, H. G. C. (1967).***Petrogenesis of Metamorphic Rocks.* Narosa Publ. 11. **Winter, J. D. (2001).***An Introduction to Igneous and Metamorphic Petrology*. Prentice Hall. 12. **Wood, B. J., & Fraser, D. G. (1976).***Elementary Thermodynamics for Geologists*. Oxford University Press, London. 13. **Yardley, B. W. D. (1989).***An Introduction to Metamorphic Petrology*. Longman Scientific and Technical, New York.
Learning Outcomes (not more than 100 words)	The course will assist to understand the metamorphic processes in depth knowledge. Students will learn to classify metamorphic facies and chemographic diagrams for mineral assemblage projections of different metamorphic rocks. Students will learn the importance of metamorphism to reconstruct the tectonic plates.

Course Title	**ESMJ52: Sedimentary Petrology**
Category of Course	**Major**

Credits& Hour of Teaching

	Theory	Practical	Cumulative
Credits	03	---	03
Hour of Teaching (Total)	45	---	45

Course Objectives (not more than 100 words)	This course is designed to give knowledge related to sedimentary processes such as weathering erosion and sedimentation. Also, the students will learn about the classification of various sedimentary rock types, their textures, mineralogy and diagenetic realms. They will get acquaintedwith various sedimentary structures and petrographic details of various sedimentary rock. Furthermore, this course will impart knowledge about various depositional environments and provenances.
Course Content	The course content be divided into minimum 3 Units to maximum 5 units along with defined hour of teaching for each unit.

Units	**Course Content**	**Hr. of Teaching**
I	Sedimentary rocks forming processes; Classification and characterization of rudaceous, arenaceous, argillaceous and calcareous rocks; Primary and secondary sedimentary structures; Mineralogical attributes, textural properties and diagenetic processes of sedimentary rocks.	15
II	Petrography of major siliciclastic and carbonate rocks namely conglomerate, breccia, quartzarenite, arkose, lithic arenite, quartzwake, felspathicwacke, lithicwacke, mudrocks / shale, limestones: crystalline, micritic and sparitic.	15
III	Heavy minerals analyses and their importance in provenance interpretations; Processes and tectonic settings of various depositional environments like fluvial, Deltaic, coastal and deep-marine.	15

Texts / References

1. **Ehlers, E. G., & Blatt, H. (1982).***Igneous, Sedimentary, and Metamorphic Petrology*. CBS Publ.
2. **Greensmith, J. T. (1984).***Petrology of Sedimentary Rocks*. Thomas Murby Publ.
3. **Hatch, F. H., Rastall, R. H., & Black, M. (1938).***Petrology of Sedimentary Rocks*. Thomas Murby Publ.
4. **Pettijohn, F. J. (1957).***Sedimentary Rocks (*3rd ed.). Oxford Book Co.
5. **Donald, R. P., & Schwab, F. (1996).***Sedimentary Geology*. W. H. Freeman and Company, New York.
6. **Boggs, S. (2006).***Principles of Sedimentology and Stratigraphy*. Prentice Hall.

Learning Outcomes (not more than 100 words)	Through this course, the students will learn about the various sedimentary processes and products. Moreover, they will learn about the rock types, their textures and mineralogy, details of sedimentary structures and diagenesis. They will also learn about the sources of various sediments and their depositional environments.

Course Title	**ESMJ53:Igneous Petrology**
Category of Course	**Major**

Credits& Hour of Teaching		Theory	Practical	Cumulative
	Credits	03	---	03
	Hour of Teaching (Total)	45	---	45

Course Objectives (not more than 100 words)	The objective of the Igneous Petrology course is to provide students with an in-depth understanding of the origin, classification, and evolution of igneous rocks. The course aims to equip students with the skills to interpret igneous textures, understand phase equilibria, and apply classification systems. Additionally, it seeks to develop students' ability to analyze a variety of igneous rocks within the context of their petrogenesis, with an emphasis on Indian examples.
Course Content	The course content be divided into minimum 3 Units to maximum 5 units along with defined hour of teaching for each unit.

Units	**Course Content**	**Hr. of Teaching**
I	**Magma:** Its physics, nature, factors affecting magma and its evolution. Thermal structure of the earth and melting of mantle. Plate tectonics and generation of different magmas in various tectonic settings.	08
II	**Concept of primary and secondary magma.** Magma series, dynamics, differentiation, emplacement, and crystallization of the magma. Magma mixing, mingling, and immiscibility. Plume magmatism and hotspots. Mantle metasomatism. Mantle heterogeneities.	07
III	**Partial melting**(batch and fractional melting), **crystal fractionation** (equilibrium and fractional (Rayleigh) crystallization), **contamination**(AFC process) and dynamic melting.The **phase equilibrium** of binary (Ab-An, Ab-Or, Di-An, Fo-Si) and ternary (Di-Ab-An, Di-Fo-Si, Di-Fo-An, Ne-Ks-Si, Fo-An-Si) systems and their relation to magma genesis and crystallization in the light of modern experimental works.	15
IV	**IUGS classification of the igneous rocks.** CIPW Norm. **Petrology and petrogenesis of the following igneous rocks** with suitable Indian examples: (i) **Peridotites, komatiites, gabbros, basalts, anorthosites, ophiolites.** (ii) **Large Igneous Provinces, mafic dyke swarms, boninites, and layered complexes.** (iii) **Alkaline rocks, carbonatites, kimberlites, lamproites, kamafugites, and lamprophyres.** (iv) **Granitoids, adakites, and sanukitoids.**	15

Texts / References	1. **Winter, J. D. (2010).***Principles of Igneous and Metamorphic Petrology*. Pearson Prentice Hall. 2. **Gill, R. (2010).***Igneous Rocks and Processes: A Practical Guide.* John Wiley & Sons. 3. **Sen, G. (2014).***Petrology: Principles and Practice.* Springer-Verlag. 4. **Philpotts, A., & Ague, J. (2009).***Principles of Igneous and Metamorphic Petrology*. Cambridge University Press. 5. **Cox, K. G., Bell, J. D., & Pankhurst, R. J. (1979).***The Interpretation of Igneous Rocks.* Chapman and Hall Publishing. 6. **Wilson, M. (1989).***Igneous Petrogenesis: A Global Tectonic Approach.* Chapman and Hall Publishing. 7. **Frost, B. R., & Frost, C. D. (2014).***Essentials of Igneous and Metamorphic Petrology*. Cambridge University Press.
Learning Outcomes (not more than 100 words)	By completing this course, students will gain a comprehensive understanding of igneous rocks and the processes leading to their formation. They will learn about the physics and nature of magma, including its differentiation and crystallization, the Earth's thermal structure, mantle melting, and the role of plate tectonics in magma generation. Students will understand primary and secondary magmas, magma dynamics, and the significance of plume magmatism, hot spots, and mantle heterogeneities. They will explore phase equilibria in binary and ternary systems, interpret igneous textures, and apply IUGS classification to identify igneous rocks, focusing on Indian examples.

Course Title	**ESMJ54:Mineralogy and Crystallography**
Category of Course	**Major**

Credits& Hour of Teaching			
	Theory	Practical	Cumulative
Credits	03	---	03
Hour of Teaching (Total)	45	---	45

Course Objectives (not more than 100 words)	1. To get acquainted with the various silicate structures of rock forming minerals and mineral groups. 2. To identify the structural formulae, classification, atomic structure, polymorphic/structural transformations and related processes in silicate minerals. 3. To learn the various principles of Optical crystallography with the application of the concepts of optical mineralogy for uniaxial and biaxial minerals. 4. To learn about the 32 crystals classes belonging to 7 crystal systems along with the description of the different normal classes and about the development of X ray crystallography. 5. To get acquainted with the applications of Electron Micro Probe analyses and Scanning electron Microscopy in mineral sciences.
Course Content	The course content be divided into minimum 3 Units to maximum 5 units along with defined hour of teaching for each unit.

Units	**Course Content**	**Hr. of Teaching**
I	An in-depth examination of the structural categories of silicate minerals. Detailed methodologies for preparing thin sections used in mineralogical analysis. Comprehensive Study of Significant Silicate Mineral Groups: Nesosilicates (Olivine, Garnet, Aluminosilicate); Cyclosilicates (Beryl); Inosilicates (Pyroxene, Amphibole); Phyllosilicates (Kaolinite, Serpentine, Mica); Tectosilicates (Feldspar, Feldspathoid). Aspects to be covered for each mineral groups: General and structural formulae; Classification and atomic structure; Polymorphism and structural transformations; Isomorphism and pseudomorphism; Chemical composition including elemental substitutions and solid solution mechanisms; Experimental data on pressure-temperature stability conditions; Modes of occurrence and alteration processes.	15
II	Study of light interaction with crystals exhibiting one and two optic axes. Indicatrix Construction and Analysis: Understanding the geometric representation of refractive indices in different crystal systems. Examination of colour variation in minerals when viewed under polarized light from different orientations. Analysis and interpretation of interference patterns to determine optical properties and orientations of crystals. Measurement and significance of the optic axial angle (2V) and extinction angle (2E) in mineral identification.	10
III	Classification of Crystal Systems and characterization of all 32 crystal classes and their respective normal classes.Crystal Projection Techniques (Spherical Projection &Stereographic Projection)with applications and utility of projection methods in crystallographic studies.Twinning and Twin Laws: Exploration of common twin types, associated twin laws, and examples of twinning phenomena in various minerals.Overview of the 14 Bravais lattices and their significance in defining crystal structures.	10
IV	Tracing the evolution and milestones in the field of X-ray crystallography. Derivation and theoretical underpinnings of Bragg's Law. Application of Bragg's Law in determining crystal structures through X-ray diffraction methods. Utilization of X-ray in mineral science. Principles and methodologies of electron microprobe analysis (EMPA) in quantitative mineral chemistry. Application of scanning electron microscopy (SEM) for detailed morphological and compositional studies of mineral specimens.	10

Texts / References	1. **Berry, L. G., Mason, B., & Dietrich, R. V. (1985).***Mineralogy: Concepts, Descriptions, and Determinations*. CBS Publishers. 2. **Dana, E. S., & Ford, W. E. (2002).***A Textbook of Mineralogy* (Reprint). 3. **Deer, W. A., Howie, R. A., &Zussman, J. (2013).***An Introduction to the Rock-Forming Minerals*. ELBS and Longman. 4. **Gribble, C. D. (2005).***Rutley's Elements of Mineralogy*. Springer. 5. **Kerr, P. F. (1977).***Optical Mineralogy.* McGraw Hill. 6. **Nesse, D. W. (1986).***Optical Mineralogy*. McGraw Hill.

	7. **Perkins, D. (2013).***Mineralogy*. Prentice Hall. 8. **Phillips, F. C. (1971).***Introduction to Crystallography*. Longman Group Publication. 9. **Verma, P. K. (2010).***Optical Mineralogy*. CRC Press. 10. **Sharma, R. S., & Sharma, A. (2013).***Crystallography and Mineralogy*. Geological Society of India. 11. **Reed, S. J. B. (1996).***Electron Microprobe Analysis and Scanning Electron Microscopy in Geology*. Cambridge University Press.
Learning Outcomes (not more than 100 words)	1. The learners would be able to identify and differentiate between various silicate structures found in rock forming minerals. 2. The learners would be able to appraise the role of various elemental and structural transformations in silicate minerals. 3. The learners would be able to understand various crystallographic properties of uniaxial and biaxial crystals based on optical parameters like Indicatrix, pleochroism, Interference figures, crystal orientation, 2V and 2E angles. 4. The learners would be able to apply the concept of symmetry elements w.r.t. 32 crystal classes and twinning in crystals. 5. The learners would be able to understand the importance and application of EPMA and SEM in understanding various physico- chemical characteristics of minerals.

Course Title	**ESMJ55: Practical connected with ESMJ -51 and ESMJ -52**			
Category of Course	**Major**			
Credits&Hour of Teaching		Theory	Practical	Cumulative
	Credits	---	01	01
	Hour of Teaching (Total)	---	30	30
Course Objectives (not more than 100 words)	To impart the knowledge about the various metamorphic and sedimentary rocks in terms of their megascopic and microscopic details. To provide knowledge on classifying metamorphic rocks into facies, subfacies, and zones using graphical representation techniques (ACF, AKF, and AFM diagrams). To infer the genesis of sedimentary rock types from various sedimentary processes such as clast generation, chemical and biochemical.			
Course Content	The course content be divided into minimum 3 Units to maximum 5 units along with defined hour of teaching for each unit.			

Units	**Course Content**	**Hr. of Teaching**
I	Study of metamorphic rocks of different metamorphic facies in Hand Specimen - slate, phyllite, schist, gneiss, marble, quartzite, charnockite, hornfels, khondalite	10
II	Study of Metamorphic Rocks (slate, phyllite, schist, gneiss, marble, quartzite, charnockite, hornfels, khondalite) in thin sections belonging to different facies with emphasis on texture/structure, mineral composition, parent rock, metamorphic facies / subfacies / zone to which the rock can be assigned and graphical representation of the assemblage in ACF, AKF and AFM diagrams.	10
III	Megascopic examination of conglomerate, breccia, quartz arenite, arkose, lithic arenite, quartzwacke, feldspathicwacke, lithicwacke(grewacke), mudrocks/shale and carbonates (micrite, sparite and accretionarylimestones).	07
IV	Examination of some common heavy minerals in grain mounts	03

Texts / References	1. Kerr, P.F., (1959). Optical Mineralogy. McGraw-Hill Book Company Inc., New York, pp.442. 2. Mackenzie, W.S., and Guilford, C., (1993). Atlas of Rock-Forming Minerals in Thin Section. Longman Scientific and Technical, EnESand, pp. 98. 3. Moorhouse, W.W., (1985). The Study of Rocks in Thin Section (Indian Edition). CBS Publications and Distributors, Delhi, pp. 514. 4. Passchier, C.W., and Trouw, R.A.J., (1996) Microtectonics. Springer – Verlag Publications, pp. 289 (with 254 figures). 5. Phillips, R. W., and Griffen, D.T., (1986). Optical Mineralogy – The Non-opaque Minerals (Indian Edition). CBS Publishers and Distributors, Delhi, pp. 677. 6. Spry, A. (1976). Metamorphic Textures, Pergamon Press.

	7. Williams, H., Turner, F.J. and Gilbert, C.M., (Indian Edition, 1985). Petrography: An Introduction to the Study of Rocks in Thin Sections. CBS Publishers and Printers, Delhi, pp. 626. 8. Yardley, B.W.D., MacKenzie, W.S., and Guilford, C., (1995). Atlas of Metamorphic Rocks and Their Textures. Longman Scientific and Technical, EnESand, pp. 120. 9. Collins, J.D., and Thompson, D.B., (1982). Sedimentary structures. George Allen and Unwin, London. 10. Lindholm, R.C., (1987). A practical approach to sedimentology. Allen and Unwin, London. 11. Tucker, M.E., (1981). Sedimentary Petrology: An introduction. Wiley and Sons, New York.
Learning Outcomes (not more than 100 words)	The students will be skilled in identifying various metamorphic and sedimentary rocks in the field as well as in the laboratory. This will help them in visualizing their origin as sub-surface and surface processes.

Course Title	**ESMJ 56: Practical connected with ESMJ -53 and ESMJ -54**
Category of Course	**Major**
Credits& Hour of Teaching	

	Theory	Practical	Cumulative
Credits	---	01	01
Hour of Teaching (Total)	---	30	30

Course Objectives (not more than 100 words)	The objective of the course is to equip students with hands-on skills in analyzing igneous rocks and minerals. Students will learn to identify rock-forming minerals and Igneous rocks in hand specimens and thin sections. Additionally, students will understand and represent the symmetry elements of crystals in 32 symmetry classes and their stereograms, preparing them for advanced geological research. In general, through practical exercises, students will gain a deeper understanding of geological processes and improve their analytical and observational skills, preparing them for advanced studies in geosciences.
Course Content	The course content be divided into minimum 3 Units to maximum 5 units along with defined hour of teaching for each unit.

Units	**Course Content**	**Hr. of Teaching**
I	**Megascopic and microscopic study of different igneous rocks.** Calculation of CIPW Norms. **Identification of rock-forming minerals** in hand specimens. Determination of length-fast and length-slow characters of minerals. Scheme of pleochroism and absorption of a given mineral in thin section. Determination of extinction angles and composition of plagioclase. **Study of interference figures** of uniaxial and biaxial crystals, determination of optic signs.**Goniometer** and its use in measuring interfacial angles of crystals and calculation of axial ratio. Representation of symmetry elements of crystals belonging to 32 classes of symmetry and study of their stereograms.	30

Texts / References	1. **J. D. Winter (2010).***Principles of Igneous and Metamorphic Petrology.* Pearson Prentice Hall. 2. **Robin Gill (2010).***Igneous Rocks and Processes: A Practical Guide*. John Wiley & Sons. 3. **GautamSen (2014).***Petrology: Principles and Practice.* Springer-Verlag Publisher. 4. **A. Philpotts and J. Ague (2009).***Principles of Igneous and Metamorphic Petrology*. Cambridge University Press. 5. **K. G. Cox, J. D. Bell, and R. J. Pankhurst (1979).***The Interpretation of Igneous Rocks.* Chapman and Hall Publishing. 6. **M. Wilson (1989).***Igneous Petrogenesis: A Global Tectonic Approach*. Chapman and Hall Publishing. 7. **B. R. Frost and C. D. Frost (2014).***Essentials of Igneous and Metamorphic Petrology*. Cambridge University Press. 8. **Berry, L. G., Mason, B., and Dietrich, R. V. (1985).***Mineralogy: Concepts, Descriptions, and Determinations.* CBS Publishers. 9. **Dana, E. S., and Ford, W. E. (2002).***A Textbook of Mineralogy* (Reprint). 10. **Deer, W. A., Howie, R. A., &Zussman, J. (2013).***An Introduction to the Rock-Forming*

	Minerals. ELBS and Longman. 11. **Gribble, C. D. (2005).***Rutley's Elements of Mineralogy*. Springer. 12. **Kerr, P. F. (1977).***Optical Mineralogy*. McGraw Hill. 13. **Nesse, D. W. (1986).***Optical Mineralogy*. McGraw Hill. 14. **Perkins, D. (2013).***Mineralogy*. Prentice Hall. 15. **Phillips, F. C. (1971).***Introduction to Crystallography*. Longman Group Publication. 16. **Verma, P. K. (2010).***Optical Mineralogy*. CRC Press. 17. **Sharma, R. S., and Sharma, A. (2013).***Crystallography and Mineralogy*. Geological Society of India. 18. **Reed, S. J. B. (1996).***Electron Microprobe Analysis and Scanning Electron Microscopy in Geology*. Cambridge University Press.
Learning Outcomes (not more than 100 words)	By completing this course, students will develop expertise in identifying and analyzing igneous rocks and minerals both megascopically and microscopically. They will master the calculation of CIPW norms and the determination of mineral optical properties such as pleochroism, extinction angles, and optic signs. Students will gain proficiency in using a goniometer to measure interfacial angles and calculate axial ratios. Additionally, they will understand the symmetry elements of crystals and their representation in stereograms. This course will enhance their practical skills in mineralogy and crystallography, preparing them for advanced geological research.

Course Title	**ESMV51: Geoarcheology and Museology**			
Category of Course	**Minor**			
Credits& Hour of Teaching		Theory	Practical	Cumulative
	Credits	02	02	04
	Hour of Teaching (Total)	30	60	90
Course Objectives (not more than 100 words)	This course aims to introduce students to the fundamental principles and practices of geoarchaeology and museology. Students will learn geological methods and applications in archaeology, including site analysis, dating techniques, and case studies. The course also covers curatorial practices, artifact conservation, museum management, and emerging technologies in museology. Emphasis is placed on understanding the interplay between geology and archaeology, and the role of museums in preserving and presenting historical artifacts.			
Course Content	The course content be divided into minimum 3 Units to maximum 5 units along with defined hour of teaching for each unit.			

Units	**Course Content**	**Hr. of Teaching**
I	**Geoarchaeology:**Introduction to geoarchaeology; Geological applications in archaeology; Methods in geoarchaeology; Post-depositional processes of archaeological sites; Pedostratigraphy and archeostratigraphy in geoarchaeology;	10
II	Paleoclimate, paleovegetation, human evolution and migration; Geomorphology; Dating methods; Geoarchaeological case studies.	10
III	**Museology:** Introduction to museology; Curatorial practices and artifact conservation; Outsourcing of archives; Management of museums; Emerging technologies in museology; Future trends and collaboration.	10
IV	Fieldwork in local geoarchaeological sitesLaboratory techniques in geoarchaeology: sediment processing for grain size analysis, microfossils, and mineralogy.Visit to the local museum or cultural heritage site; Preparation of report of the museum visit; Cataloguing (inventory and documentation) of specimens in the museum.	60

Texts / References	**Geoarchaeology:** 1. Rapp, G.R., Hill, C.L., and Hill, M.C.L., 2006. Geoarchaeology: The Earth-Science Approach to Archaeological Interpretation. Yale University Press. 2. Cordova, C., 2018. Geoarchaeology: The Human-Environmental Approach. Bloomsbury Publishing. 3. Pitul'ko, V.V., and Pavlova, E.Y., 2016. Geoarchaeology and Radiocarbon Chronology of Stone Age Northeast Asia. Texas A&M University Press. 4. Dincauze, D.F., 2000. Environmental Archaeology: Principles and Practice. Cambridge University Press.

	5. Waters, M.R., 1992. Principles of Geoarchaeology: A North American Perspective. University of Arizona Press. 6. Goldberg, P., Macphail, R., Carey, C., &Zhuang, Y., (2022). Practical and Theoretical Geoarchaeology (2nd ed.). Wiley. Museology: 1. Ambrose, T., and Paine, C., 2006. Museum Basics: The International Handbook. Routledge. 2. Matassa, F., 2011. Museum Collections Management. Facet Publishing. 3. Macdonald, S., ed., 2011. A Companion to Museum Studies. John Wiley & Sons. 4. Imam, J.Md., 2018. Introduction to Museology. World Heritage Inc. 5. Pearce, S.M., ed., 1994. Interpreting Objects and Collections. Psychology Press. 6. Weil, S., 2012. Making Museums Matter. Smithsonian Institution.
Learning Outcomes (not more than 100 words)	Upon completion of this course, students will be able to apply geological methods to archaeological research, including site analysis and dating techniques They will analyze the role of paleoclimate and geomorphology in human evolution and migration, and implement curatorial practices and conservation techniques for artifact preservation. Additionally, students will manage museum operations, utilize emerging technologies in museology, and evaluate case studies to identify successful geoarchaeological and museological practices. They will also be equipped to collaborate effectively in multidisciplinary teams to address challenges in archaeology and museum studies.

Course Title	**ESIN-51: (Internship): [Students can do internship after first to fourth semester during summer vacation]**
Category of Course	**Internship**
Credits& Hour of Teaching	

	Theory	Practical	Cumulative
Credits	---	02	02
Hour of Teaching (Total)	---	60	60

Course Objectives (not more than 100 words)	The course objectives of an internship in geology typically focus on providing students with practical, hands-on experience that complements their academic studies. Here are some common objectives for a geology internship course: 1. Develop practical skills in fieldwork, including data collection, geological mapping, and rock and mineral sampling. 2. Gain experience with laboratory analyses and techniques used to study geological samples and data.
Course Content	The course content be divided into minimum 3 Units to maximum 5 units along with defined hour of teaching for each unit.

Units	**Course Content**	**Hr. of Teaching**
I	Internshipistobedoneduringvacation	60

Texts / References	
Learning Outcomes (not more than 100 words)	The learning outcomes of an internship in geology are to reflect the knowledge, skills, and experiences gained through hands-on, practical engagement in the field. 1. It will demonstrate proficiency in fieldwork techniques, including geological mapping and sample collection. 2. It will provide hands-on experience with laboratory analyses and interpret the results accurately.

Semester: VI

Course Title	**ESMJ61: Structural Geology**
Category of Course	**Major**
Credits& Hour of Teaching	

	Theory	Practical	Cumulative
Credits	03	---	03
Hour of Teaching (Total)	45	---	45

Course Objectives (not more than 100 words)	The course focuses on advanced level knowledge on selected topics of structural geology and associated laws of physics related to deformation behavior of rocks.
Course Content	The course content be divided into minimum 3 Units to maximum 5 units along with defined hour of teaching for each unit.

Units	**Course Content**	**Hr. of Teaching**
I	Examination of the properties of rocks and the factors that influence them. Introduction to the concept of stress and two-dimensional stress analysis. Overview of rock failure theories, with a focus on the causes and dynamics of fracturing and faulting.	10
II	Investigation into the mechanics and causes of folding. Genetic classification of folds and analysis of fold superposition patterns. Study of strain distribution within folds and its implications.	5
III	Detailed analysis of two-dimensional strain, including the properties and geological significance of strain ellipses and ellipsoids. Identification of strain markers and methods for measuring strain in naturally deformed rocks.	10
IV	Introduction to fold-thrust belts, including the concepts of thin- and thick-skinned deformation, decollement. Introduction to shear zones (both brittle and ductile). Analysis of the geometry and products of shear zones, with a focus on mylonites and cataclastites.	10
V	Exploration of the origin and significance of planar and linear fabrics in deformed rocks. Application of stereographic and equal-area projections in structural analysis, including the use of π and β diagrams. Geometric analysis of simple and complex macroscopic structures, with an introduction to petrofabric analysis.	10

Texts / References	1. Davis, G.H., Reynolds, S.J., and Kluth, C.F. (2012). Structural Geology of Rocks and Regions (3rd Ed.). Wiley. 2. Fossen, H. (2016). Structural Geology (2nd Ed.). Cambridge University Press. 3. Hobbs, B.E., Means, W.D., and Williams, P.F. (1976). An Outline of Structural Geology. John Wiley and Sons, New York. 4. Ramsay, J.G. (2004). Folding and Fracturing of Rocks. The Blackburn Press. 5. Ramsay, J.G., and Huber, M.I. (1983). Techniques of Modern Structural Geology Vol. I and Vol. II. Academic Press. 6. Twiss, R.J., and Moores, E.M. (2006). Structural Geology (Second Edition). W.H. Freeman.
Learning Outcomes (not more than 100 words)	The student is expected to know about the concept of geological stress, strain and various theories to explain the behavior of rocks in ideal and non-ideal conditions. The student will also learn where the various types of deformational structure would be found and how to study them under natural conditions

Course Title	**ESMJ62: Economic Geology**
Category of Course	**Major**

Credits& Hour of Teaching	Theory	Practical	Cumulative
Credits	03	---	03
Hour of Teaching (Total)	45	---	45

Course Objectives (not more than 100 words)	To introduce the basic concept of mineral economics, ore forming processes and classification of economic mineral deposits. To introduce fundamental aspects of origin, mode of occurrences and the distribution of economic mineral deposits in India.
Course Content	The course content be divided into minimum 3 Units to maximum 5 units along with defined hour of teaching for each unit.

Units	**Course Content**	**Hr. of Teaching**
I	Fundamental of economic geology: minerals, ores, and gangues; Tenor of ores; Common mode of occurrences, forms and structures of mineral deposits; Basic concepts of ore-genesis, paragenesis, paragenetic sequence and zoning in metallic ore deposits, Importance of economic geology.	10
II	Ore forming minerals, Processes of formation of ore deposits; origin and mode of occurrences of metallic mineral deposits of iron, manganese, gold, copper, aluminium, lead, zinc, chromite, magnesium, tin, tungsten, with their economic uses and Indian Distribution.	10
III	Processes of formation of mineral deposits; Concepts on Magmatic processes, Hydrothermal processes, Metamorphic processes and Sedimentary or surficial processes.	10
IV	Origin and Mode of occurrences of Non-metallic mineral deposits with particular reference to the industries (Cement, Glass, Ceramics, Refractory, Fertilizer, Chemicals, Abrasive and Gemstones) and their Indian distribution.	10
V	Origin and processes of formation, mode of occurrence, economic uses and distribution of coal and petroleum deposits in India; Detail geological study of atomic fuels deposits of uranium, thorium and rare earth elements deposits in India.	05

Texts / References	1. Mead L. Jense, and Alan M. Bateman (2013) Economic Mineral Deposits. Third Edition, John Wiley and Sons. 2. AshokeMookherjee (2000): Ore Genesis-A Holistic Approach, Allied Publisher. 3. Umeshwar Prasad (2019) Economic Geology. CBS Publishers & Distributors, New Delhi. 4. Anthony M. Evans (2006) Ore Geology and Industrial Minerals: An Introduction. Third Edition, Blackwell Science. 5. R. K. Sinha and N. L. Sharma (2019) Mineral Economics. Fourth Edition, Oxford & IBH Publishing. 6. Sanjay Kumar Tiwari (2019) Ore Geology, Economic Minerals and Mineral Economics. Atlantic Publishers & Distributors Pvt Ltd. 7. Walter L Pohl (2010) Economic Geology: Principles and Practice. First Edition, John Wiley. 8. Mihir Deb and Sanjib Chandra Sarkar (2017) Minerals and Allied Natural Resources and their Sustainable Development. Springer Singapore. 9. John Ridley (2013) Ore Deposit Geology. Cambridge University Press. 10. Laurence Robb (2005) Introduction to Ore-Forming Processes. John Wiley & Sons.
Learning Outcomes (not more than 100 words)	Upon successful completion, students will have the knowledge and skills to: Recognize common ore and economic minerals in hand specimens Demonstrate knowledge with a wide range of mineral deposits, including recognizing the overall geometry, zonation and alteration patterns associated with specific classes of metallic mineral deposits. Relate overall geometry, zonation and alteration patterns of rock associations to specific classes of metallic mineral deposits. Evaluate different geological processes of element enrichment to from economic mineral deposits.

Course Title	**ESMJ63: Paleontology**
Category of Course	**Major**
Credits& Hour of Teaching	

	Theory	Practical	Cumulative
Credits	03	---	03
Hour of Teaching (Total)	45	---	45

Course Objectives (not more than 100 words)	To understand the history of evolution of life for better comprehension of geodynamic evolution of the earth through geological time.
Course Content	The course content be divided into minimum 3 Units to maximum 5 units along with defined hour of teaching for each unit.

Units	**Course Content**	**Hr. of Teaching**
I	Applicative dimensions of paleontology in geology; Index fossils; Modern concept of the origin of life; Lamark's and Darwin's theories of organic evolution with suitable evidences.	10
II	Sampling and processing techniques in macro and micro-fossil; System of binomial nomenclature in taxonomic studies; Species concept;Composition of hard parts;Growth of individual organism.	10
III	A detailed account of diagnostic morphological features and geological distribution of the invertebrate fossil groups as under: Brachiopoda, Bivalvia, Gastropoda, Cephalopoda; Stratigraphic implications of ammonites and conodonts; Microfossils and their different kinds.	15
IV	The study of various ways of preservation and broad features of plant fossils; Preliminary ideas of Gondwana flora; Elementary knowledge about vertebrate classes and significance of Indian vertebrate fauna.	10

Texts / References	1. Black, R.M., (1988). The Elements of Palaeontology, Cambridge Univ. 2. Clarkson, E.N.K., (1986). Invertebrate Palaeontology and Evolution, Allen and Unwin Publ. 3. Jain, P.C. and Anantharaman, M.S., (1983). Palaeontology: Evolution and Animal Distribution, Vishal Publ. 4. Lehmann, U., (1983). Fossils Invertebrate, Cambridge Univ. Press. 5. Benton, Michael J. (2014). Vertebrate Paleontology. Blackwell Publ., Chapman and Hall. 6. Benton, Michael J. and Harper, David A.T., (2020). Introduction to Paleobiology and the Fossil Record. John Wiley & Sons Ltd. 7. Foote, M. and Miller, A.I., (2007). Principals of Paleontology. John Wiley & Sons Ltd. 8. Moore, R.C., Lalicker, C.G. and Fischer, A.G., (1997). Invertebrate Fossils, CBS Publ. 9. Nield, E.W. and Tucker, V.C.T., (1985). Palaeontology: An Introduction, Pergmon Press. 10. Prothero, D.R., (2004). Bringing Fossil to Life – An Introduction to Paleontology (2nd Ed.), McGraw Hill. 11. Shrock, R.R. and Twenhoffel,W.H., (1952). Principles of Invertebrate Paleontology, CBS Publ. 12. Raup, D.M. and Stanley, S.M., (1985). Principles of Palaeontology, CBS Publ. 13. Stebbins, (1979). Process of Organic Evolution (3rd Ed.) Prentice Hall. 14. Woods, H., (1985). Palaeontology Invertebrate, CBS Publ. 15. Doyle, P., (2014). Understanding fossils, An introduction to Invertebrate Paleontology. John Wiley & Sons.
Learning Outcomes (not more than 100 words)	The study of palaeontology plays crucial role in the development of high resolution biostratigraphy, assigning the ages to the rock successions and their global correlations. Such study is of great significance in understanding palaeogeography,palaeoenvironment, palaeodeposition and palaeoclimate. This study will enhance the geological concepts of students essential for any kind of geological exploration.

Course Title	**ESMJ64: Stratigraphy**
Category of Course	**Major**

Credits& Hour of Teaching

	Theory	Practical	Cumulative
Credits	03	---	03
Hour of Teaching (Total)	45	---	45

Course Objectives (not more than 100 words)	The course focuses on concept of stratigraphy and geologically important stratigraphic boundaries in India and their equivalents.
Course Content	The course content is divided into minimum 4 units along with defined hours of teaching for each unit.

	Course Content	**Hr. of Teaching**
I	Concept of facies, refinementand correlation in stratigraphy;Conceptof sequence stratigraphy and paleobiogeography; A brief introduction of Bio-magneto-seismic-chemo-andeventstratigraphy.	11
II	CuddapahandVindhyansupergroupsandtheirequivalents,Precambrian/Cambrianboundary. Stratigraphic sequence of the Paleozoic of Kashmir and Gondwana Supergroup,	11
III	Permian/TriassicBoundaryinIndia.A detailed outline of Lithostratigraphic framework and fossil content of Triassic of Spiti, Jurassic of Kachchh and Cretaceous of Tiruchirapalli.	11
IV	Cretaceous/PaleogeneBoundaryinIndia.The lithostratigraphy and fossil content of the following: Paleogene of Assam,Kachchh and Andaman, Siwaliks of Jammu and Himachal Pradesh and KarewasofKashmir.Stratigraphic study of Deccan, Rajmahal Trap and Intertrappean beds.	12

Texts / References

1. Boggs, S. (2001). Principles of Sedimentology and Stratigraphy. Prentice Hall.
2. Dunbar, C.O. and Rodgers, J. (1957). Principles of Stratigraphy. John Wiley and Sons.
3. Krishnan, M.S. (1968). Geology of India and Burma. Higgibothon, Madras.
4. Kumar, R. (1985). Historical Geology and Stratigraphy of India. Wiley Eastern Ltd.
5. Wadia, D.N. (1966). Geology of India. English Language Publ.
6. Kumar, R. (2022). Fundamentals of Historical Geology and Stratigraphy of India. New Age International Publishers.
7. Brookfield, M.E. Principles of Stratigraphy. Wiley Blackwell.
8. Weller, J.M. (1960). Stratigraphic Principles and Practices. Universal Book.
9. Valdiya, K.S. (2016). Geodynamic Evolution of India (2nd Edition). Springer.
10. Krishna, J. (2017). The Indian Mesozoic Chronicle: Sequence Stratigraphic Approach. Springer, Singapore.
11. Ramakrishna, M. and Vaidyanadhan, R. (2010). Geology of India (Vol. 1 & 2). Geological Society of India, Bangalore.
12. Sharma, R.S. (2010). Cratons and Fold Belts of India. Springer.
13. Chetty, T.R.K. (2018). Proterozoic Orogens of India: A Critical Window to Gondwana. Elsevier.
14. Sarkar, S.C. and Gupta, A. (2012). Crustal Evolution and Metallogeny in India. Cambridge University Press.
15. Doyle, P. Understanding Fossils: An Introduction to Invertebrate Paleontology. John Wiley & Sons.
16. Prothero, D.R. Bringing Fossils to Life: An Introduction to Paleobiology. Columbia University Press, New York.

Learning Outcomes (not more than 100 words)	After going through these exercises, the students will be able to know different types of boundary problems in India and Their equivalents. They will also able to learn about the geologically important stratigraphic rocks associated with different Supergroups in India.

Course Title	**ESMJ65: Practical connected with ESMJ61 and ESMJ62**
Category of Course	**Major**

Credits& Hour of Teaching

	Theory	Practical	Cumulative
Credits	---	01	01
Hour of Teaching (Total)	---	30	30

Course Objectives (not more than 100 words)	The course focuses on advanced level practical exercises on structural geology and economic geology.Practical knowledge to recognize the most common ore and economic minerals used in the industry, their compositions and be able to identify them based on their macroscopic and physical characteristics in hand specimen.Knowledge of Indian distribution of economic mineral deposits and their industrial applications.
Course Content	The course content be divided into minimum 3 Units to maximum 5 units along with defined hour of teaching for each unit.

Units	**Course Content**	**Hr. of Teaching**
I	Practice problems focused on solving complex orthographic challenges, with an emphasis on interpreting and extracting detailed information from intricate geological maps.	8
II	Advanced-level exercises utilizing stereographic nets for the analysis and interpretation of geological data, including orientation and structural relationships.Practice in calculating strain from geological strain markers, focusing on advanced techniques and methodologies for quantifying deformation in natural rock formations.	7
III	**Economic Geology:**Study of ore and economic minerals in hand specimen of iron ores, manganese ores, bauxite, galena, sphalerite, chromite, magnesite, wolframite and cassiterite, etc.	8
IV	Preparation of maps showing distribution of important metallic and non-metallic, industrial minerals deposits;Distribution of important atomic fuels, coal and oil fields of India.	7

Texts / References

Structural Geology:

1. Groshong, R.H. and Groshong, R.H. (2006). 3-D Structural Geology. Springer-Verlag Berlin Heidelberg.
2. Lisle, R.J. and Leyshon, P.R. (2004). Stereographic Projection Techniques for Geologists and Civil Engineers (2nd edition). Cambridge University Press.
3. Lisle, R.J. (2020). Geological Structures and Maps: A Practical Guide. Butterworth-Heinemann.
4. Marshak, S. and Mitra, G. (1988). Basic Methods of Structural Geology. Prentice Hall.
5. Ragan, D.M. (2009). Structural Geology: An Introduction to Geometrical Techniques (Fourth Edition). Cambridge University Press.
6. Rowland, S.M., Duebendorfer, E.M. and Schiefelbein, I.M. (2007). Structural Analysis and Synthesis: A Laboratory Course in Structural Geology (3rd edition). Wiley-Blackwell.

Economic Geology:

1. Mookherjee, A. (2000). Ore Genesis: A Holistic Approach. Allied Publisher.
2. Prasad, U. (2019). Economic Geology. CBS Publishers & Distributors, New Delhi.
3. Deb, M. and Sarkar, S.C. (2017). Minerals and Allied Natural Resources and Their Sustainable Development. Springer Singapore.
4. Singh, Y. (2020). Rare Earth Element Resources: Indian Context. Springer Cham.
5. Aswathanarayana, U. (1985). Principles of Nuclear Geology. Routledge, 1st edition.

Learning Outcomes (not more than 100 words)

The student will be learning the advanced level and complex structural geological problems. Practical connected with hand specimen studies of the economic minerals as a practice of identifying minerals with their characters. Maps showing distribution of occurrences of such minerals will also be practiced.

Upon successful completion, students will have the knowledge and skills to: Recognize common ore and economic minerals in hand specimens Demonstrate knowledge with a wide range of mineral deposits in India specific classes of metallic, industrial, ceramic, cement and fuel mineral deposits.

Course Title	**ESMJ66: Practical connected with ESMJ63 and ESMJ64**
Category of Course	**Major**

Credits& Hour of Teaching	Theory	Practical	Cumulative
Credits	---	01	01
Hour of Teaching (Total)	---	30	30

Course Objectives (not more than 100 words)	There will be practical exercises to learn about detail morphological features of different types of fossils. Students will also be able to learn about the different sedimentary basins including land/sea distributionin reference to India.
Course Content	The course content be divided into minimum 3 Units to maximum 5 units along with defined hour of teaching for each unit.

Units	Course Content	Hr. of Teaching
I	**Paleontology:** Study of morphological characters, systematic positions, and age of about 30 representative genera belonging to the following groups: Brachiopoda, Bivalvia, Cephalopoda, and Gastropoda. A detailed systematic description of the following genera: Rhynchonella, Terebratula, Arca, Modiolus, Perisphinctes, Nautilus, Natica, and Conus.	10
II	**Stratigraphy:** Distribution of the following geological formations on a sedimentary basin map of India: CuddapahSupergroup, VindhyanSupergroup, Marine Lower Permian, GondwanaSupergroup, Marine Mesozoics, Deccan Traps and equivalents, Marine Cenozoic, and Siwalik Group.	10
III	Preparation of land/sea distribution on sedimentary basin map of India during Late Precambrian/Early Cambrian, Early Permian, Jurassic, Cretaceous, and Eocene; Study of rocks from important Indian stratigraphic horizons. Some selected exercises on stratigraphic classification.	10

Texts / References	1. **Black, R. M. (1988):***The Elements of Palaeontology*, Cambridge University Press. 2. **Clarkson, E. N. K. (1986):***Invertebrate Palaeontology and Evolution*, Allen and Unwin Publishers. 3. **Jain, P. C. and Anantharaman, M. S. (1983):***Palaeontology: Evolution and Animal Distribution*, Vishal Publishers. 4. **Lehmann, U. (1983):***Fossils Invertebrate*, Cambridge University Press. 5. **Michael J. Benton & David A. T. Harper (2020):***Introduction to Paleobiology and the Fossil Record*, John Wiley & Sons Ltd. 6. **Michael Foote & Arnold I. Miller:***Principles of Paleontology*, John Wiley & Sons Ltd. 7. **Moore, R. C., Lalicker, C. G. & Fischer, A. G. (1997):***Invertebrate Fossils*, CBSPublishers. 8. **Nield, E. W. & Tucker, V. C. T. (1985):***Palaeontology: An Introduction*, Pergamon Press. 9. **Prothero, D. R. (2004):***Bringing Fossils to Life – An Introduction to Paleontology*(2nd Ed.), McGraw Hill. 10. **Rastogi (1988):***Organic Evolution*,Kedarnath and Ramnath Publishers. 11. **Raup, D. M. & Stanley, S. M. (1985):***Principles of Palaeontology*, CBSPublishers. 12. **Shrock, R. R. &Twenhoffel, W. H. (1952):***Principles of Invertebrate Paleontology*,CBSPublishers. 13. **Stebbins (1979):***Process of Organic Evolution* (3rd Ed.), Prentice Hall. 14. **Woods, H. (1985):***Palaeontology Invertebrate*CBSPublishers. 15. **Peter Doyle:***Understanding Fossils, An Introduction to Invertebrate Paleontology*, John Wiley & Sons. 16. **Donald R. Prothero:***Bringing Fossils to Life; An Introduction to Paleobiology*, Columbia University Press, New York.
Learning Outcomes (not more than 100 words)	The student will be learning the morphological features of geologically important fossils. Practical connected with hand specimen studies of the stratigraphic rocks as a practice of identifying minerals with their characters. Maps showing distribution of occurrences of such stratigraphic rocks and land/sea distribution will also be practiced.

Course Title	**ESMJ67: Field Geology**
Category of Course	**Major**

Credits& Hour of Teaching		Theory	Practical	Cumulative
	Credits	---	02	02
	Hour of Teaching (Total)	---	60	60

Course Objectives (not more than 100 words)	The course focuses on advanced level of geological field training in a suitable area within the country.
Course Content	The course content be divided into minimum 3 Units to maximum 5 units along with defined hour of teaching for each unit.

Units	**Course Content**	**Hr. of Teaching**
I	A field visit will be conducted to selected outstation locations, designed to provide hands-on geological field training. This training will focus on various aspects of geology, with an emphasis on applying the knowledge acquired from different branches of geology studied so far.	60

Texts / References	
Learning Outcomes (not more than 100 words)	The student will have first and experience the real exercises what professional geologists need to perform during their field visits under the guidance of their teachers.

Course Title	**ESMV61: Agriculture Geology**
Category of Course	**VOC**

Credits& Hour of Teaching		Theory	Practical	Cumulative
	Credits	02	02	04
	Hour of Teaching (Total)	30	60	90

Course Objectives (not more than 100 words)	Educate students about agriculture with knowledge of geology in cultivation. Develop operational resources for the efficient and cost effective implementation of agriculture education involving concept of mineralogy and geology.
Course Content	The course content be divided into minimum 3 Units to maximum 5 units along with defined hour of teaching for each unit.

Units	**Course Content**	**Hr. of Teaching**
I	Introductiontoagrogeology,edaphology,micronutrients,agrominerals(apatite,carbonate, malachite,scoria,zeolite,clay),etc.	5
II	**Soil Science and Pedology:** Mineralogy and structure of soil, soil forming processes, soil classification and mapping, physical, chemical, biological and fertility properties of soil, pedogeochemistry, soil management and conservation.	10
III	**Basic in Agronomy:**Agroindustries, Agroecosystems, Agro-climatic Zones, Manures and Fertilizers, Weeds, Herbicides, Insecticides, Fungicides..	5
IV	Types of Soil, Distribution of Soil in India, Soil Taxonomy, Cropping and Farming System, Harvesting, Organic Agriculture, Crop Profiles, Soil and Water Conservation, Sustainable Agriculture.	10
V	Study of soil forming rocks and minerals. Determination of physical properties of soil. Study of soil profile in field. Study of soil map of India. Estimation of soil loss. Measurement of soil loss. Preparation of contour maps. Assessing entrepreneurial potential, problem solving ability, managerial skills and achievement motivation, exercise in creativity, time audit, preparation of business plan and proposal writing, visit to entrepreneurship development institute and entrepreneurs. Pollution case studies - Field work: A visit to village to understand the problems being encountered by the villagers / farmers; Listening and note taking, writing skills, oral presentation skills; field diary and lab record; indexing, footnote and bibliographic procedures.	30

VI	Identification of crops, seeds, fertilizers, pesticides and tillage implements; Studies on cropping pattern of different dry land areas in the country and demarcation of dry land area on map of India. Plotting and study of demand and supply curves and calculation of elasticities; Study of relationship between market arrivals and prices of some selected commodities. To get acquainted with university extension system. Group discussion - exercise; handling and use of audio-visual equipment's, digital camera and LCD projector; preparation and use of audio-visual aids, preparation of extension literature – leaflet, booklet, folder, pamphlet news stories and success stories; Presentation skills exercise; micro teaching exercise; Reading and comprehension of general and technical articles, precise writing, summarizing, abstracting; individual and group presentations.	30

Texts / References	1. S. C. Panda (2018) A Hand Book of Agriculture. AGROBIOS (INDIA), pp 1304. 2. S. Jothimani (2022) Text Book of Soil Science for Agriculture and Geology. Integrated Publications, New Delhi, pp 230. 3. S. C. Dutta (2022) Textbook on Physical Chemistry and Mineralogy of Soils. Indian Council of Agricultural Research, pp 360. 4. A. N. Puri (2015) Soil Science: An Elementary Text Book. New India Publishing Agency, pp 140. 5. H. D. Foth (1991) Fundamentals of Soil Science. 8th Edition, John Wiley & Sons Inc., pp 400. 6. Craig C. Sheaffer and Kristine M. Moncada (2016) Introduction to Agronomy Food, Crops, and Environment. Delmar Cengage Learning; 2nd edition, pp 608. 7. B. Chandrasekaran, K. Annadurai and E. Somasundaram (2010) A Text Book of Agronomy, pp 835. New Age International (P) Limited, Publishers, New Delhi. 8. Bipin B. Mishra (2020) The Soils of India. Springer Cham, pp 281.
Learning Outcomes (not more than 100 words)	Students will reveal knowledge of the legal and ethical environment impacting agriculture organizations and exhibit an understanding geological concept. Students will be able to reveal critical thinking and problem-solving skills in the agricultural industry with the knowledge of geology as they apply to a variety of animal and or plant production systems.

Semester: VII – H

Course Title	**ESMJ71: Geomorphology and Geotectonics**
Category of Course	**Major**

Credits& Hour of Teaching		Theory	Practical	Cumulative
	Credits	03	---	03
	Hour of Teaching (Total)	45	---	45

Course Objectives (not more than 100 words)	The course consists of the significance of geomorphology, development of denudational landforms, different morphometric and morphotectonic indicators, geomorphology of India, and application of geomorphology in different branches of geology. Geotectonics course will help students understand the history of plate tectonics and how it shaped our planet earth and also it will deduce the knowledge of plate tectonics and use it as a tool for understanding mountain building activities on the earth.
Course Content	The course content be divided into minimum 3 Units to maximum 5 units along with defined hour of teaching for each unit.

Units	**Course Content**	**Hr. of Teaching**
I	Exploration of basic concepts and the significance of geomorphology. Study of the erosion cycle, fluvial landforms, and drainage patterns. Analysis of landform evolution in aeolian, marine, glacial, and karst environments. Introduction to morphometric analysis, morpho-chronology, and the role of neotectonics, including geomorphological indicators, active faults, drainage modifications, and recurrent seismic activity.	7
II	Examination of the geomorphological characteristics of the Peninsular, Extra-Peninsular regions, and the Indo-Gangetic plains. Discussion on the applications of geomorphology in mineral prospecting, civil engineering, military operations, hydrogeology, and environmental studies.	7
III	Overview of geotectonic principles, including the theories of continental drift, seafloor spreading, and convection currents. Study of paleomagnetism, polar wandering, and the reversal of Earth's magnetic field. Analysis of the geomagnetic timescale and the key geotectonic features of oceans, continents, and continental margins.	7
IV	Detailed study of plate tectonics, including the principles governing plate movements, force balance, and mantle plume models. Examination of orogeny and epeirogeny, and the structural anatomy of orogenic belts.	7
V	Analysis of the geodynamic processes that have shaped the evolution of the Himalayan mountain range.	2

Texts / References

Geomorphology:

1. Small, R. J. (1978): Study of Landforms: A Textbook of Geomorphology (2nd Edition), Cambridge University Press.
2. Burbank, D. W., & Anderson, R. S. (2011): Tectonic Geomorphology, John Wiley & Sons.
3. Sharma, H. S. (1990): Indian Geomorphology, Concept Publishing Co., New Delhi.
4. Thornbury, W. D. (2004): Principles of Geomorphology (2nd Edition), CBS Publication.
5. Kale, V. S., and Avijit Gupta (2010): Introduction to Geomorphology, University Press.
6. Bloom, A. L. (2011): Geomorphology: A Systematic Analysis of Late Cenozoic Landforms (3rd Edition), Rawat Publications.

Geotectonics:

1. Moores, Eldridge M., and Twiss, Robert J. (2015): Tectonics, W. H. Freeman.
2. Condie, Kent C. (1989): Plate Tectonics and Crustal Evolution (3rd Edition), Butterworth-Heinemann Ltd.
3. Windley, B. (1995): The Evolving Continents (3rd Edition), Wiley-Blackwell.
4. Davies, G. F. (1999): Dynamic Earth: Plates, Plumes and Mantle Convection, Cambridge University Press.
5. Keller, E. A., and Pinter, N. (2001): Active Tectonics (2nd Edition), Pearson Publications.
6. Kearey, P., Klepeis, K. A., and Vine, F. J. (2009): Global Tectonics (3rd Edition), Wiley-Blackwell.

Learning Outcomes (not more than 100 words)	After completing the course, the students will be able to understand the significance and application of geomorphology in different geological prospecting. They will also be familiar with continental drift theory, sea floor spreading, and paleomagnetism, and they may gain a better understanding of plate tectonics and the evolution of the Himalayas.
Course Title	**ESMJ72: Foundations of Engineering Geology and Surveying**
Category of Course	**Major**

Credits& Hour of Teaching

	Theory	Practical	Cumulative
Credits	03	---	03
Hour of Teaching (Total)	45	---	45

Course Objectives (not more than 100 words)	To study and identify different types natural materials like rocks & soil with reference to geohazards, construction and excavation. • To know the physico-mechanical properties of rocks and rockmass • To know the importance of testing and geotechncial considerations for slopes, tunnel and dam construction.To attain the knowledge about the basics of surveying and theatrical background.
Course Content	The course content be divided into minimum 3 Units to maximum 5 units along with defined hour of teaching for each unit.

Units	**Course Content**	**Hr. of Teaching**
I	Geotechnicalpropertiesofrockandsoil,aggregates and ground investigation methods, Rockmass description and classification schemes, types of strength- uniaxial compressive strength, tensile strength, shear stringed, laboratory tests.	15
II	Engineering geological considerations for dam, roads and tunnels. Ground subsidence, slope stability & rock excavation. Fundamental Concepts and principles; Primary division and classification of surveys; Common methods of surveying: Reconnaissance survey, Offsetting, Radiation, and triangulation; Open and close traversing; Leveling. Accuracy and errors in surveying; Basic elements of map preparation and map reading;	15
III	Working principles and use of different Surveying Instruments: Chain, Plane Table, Prismatic Compass, Dumpy Level, Theodolite and Total Station. Concept of Global Navigation Satellite Systems (GNSS): GPS and Navic.	15

Texts / References

Foundations of Engineering Geology:

1. S. Gangopadhyay (2012): Engineering Geology, Oxford Press.
2. T. Waltham (2009): Foundations of Engineering Geology (Third Edition), Taylor & Francis.
3. D. G. Price (2009): Engineering Geology - Principles & Practice, Springer.

Surveying:

1. Bernhard Hofmann-Wellenhof, Herbert Lichtenegger, and James Collins (2012): Global Positioning System: Theory and Practice (4th Edition), Springer Science & Business Media.
2. Punmia, B. C., Jain, A. K., and Jain, A. K. (2016): Surveying, Vol. 1 & Vol. 2, Laxmi Publications (P) Limited, New Delhi.
3. Ray Chowdhary, K. P. (1987): Surveying (Plane and Geodetic), Oxford & IBH Pub. Co., New Delhi.
4. Shahani, P. B. (1978): Textbook of Surveying, Vol. I, Oxford & IBH Pub. Co., New Delhi.
5. Venkataramaiah, C. (2011): Textbook of Surveying, Orient Blackswan Private Limited, New Delhi.

Learning Outcomes (not more than 100 words)	The students will get the basic knowledge about natural material vis-avis construction and excavation. • The students will understand the influence of natural processes and geological factors on civil structures and help them to take decision while planning, design and execution stage of the structures in their professional life. • The students will know the significance of geological investigations for civil engineering projects and site selection as well as engineering geological testing. The student will be able to comprehend the fundamentals of surveying and their uses in geological sciences.

Course Title	**ESMJ73: Geochemistry and Instrumentation**
Category of Course	**Major**

Credits& Hour of Teaching		Theory	Practical	Cumulative
	Credits	03	---	03
	Hour of Teaching (Total)	45	---	45

Course Objectives (not more than 100 words)	The objective of the course is to equip students with a deep understanding of Earth's chemical composition and processes, as well as the modern analytical techniques used to study them. Students will learn to analyze geochemical data, understand geochemical cycles and isotope systems, and apply thermodynamic principles to geological processes. The course aims to develop proficiency in using advanced geochemical instruments and techniques, ensuring students can conduct precise and accurate geochemical analyses. Ultimately, students will be prepared to apply their knowledge to address fundamental problems in geoscience using geochemistry as a proxy.
Course Content	The course content be divided into minimum 3 Units to maximum 5 units along with defined hour of teaching for each unit.

Units	**Course Content**	**Hr. of Teaching**
I	**Geochemistry:** Earth System Science and various reservoirs. Introduction to the chemical composition and properties of the atmosphere, lithosphere, hydrosphere, and biosphere. Geochemical cycles. Concept of biogeochemical cycle. Concept of equilibrium. Entropy, enthalpy, Gibbs free energy, and laws of thermodynamics and their applications in geosystems. Meteorites, their classification, mineralogy, and origin. Geochemical classification of elements. Element partitioning in mineral/rock formation and the concept of distribution coefficient. Utility of trace elements in the petrogenesis of rocks. Importance of REE (Rare Earth Elements) in petrogenetic interpretations. Interpretation of REE patterns. Mineral formula calculations and their implications in understanding the physico-chemical conditions of magmas. Sampling procedures and introduction to state-of-the-art instruments &important analytical techniques used in geochemistry and their applications	15
II	Importance of isotopic study in the field of earthscience, Stable isotope geochemistry of carbon, oxygen, and sulphur and its applications. Non-traditional isotopes and their applications. Radiogenic isotopes. Decay scheme of K-Ar, U-Pb, Rb-Sr and Sm-Nd.Radiometric dating of single minerals and whole rocks. Petrogenetic implicationsof Sm-Nd,Rb-Sr,Re-Os andPb-Pbsystems. C^{14}dating and its application in geosciences. Introduction to sedimentary geochemistry. Geochemical processes involved in rock weathering andsoilformation.MineralstabilityinEh-Phdiagrams.	15
III	Instrumentation An overview of instrumentation techniques in Geosciences. Their role and importance in addressing fundamental and applied aspects. Sample preparation techniques for various instruments. Precision, accuracy, calibration, and standards. Destructive and non-destructive techniques. Principle and application of the following instrumental techniques in Mineral Sciences: • Microscopes • UV Lamp • X-ray Diffractometer • Image Analyzer • Electron Probe Micro Analyzer • Scanning Electron Microscope • Infrared Spectrometer • Raman Spectroscope • FTIR (Fourier Transform Infrared Spectroscopy) Principle and application of the following instrumental techniques in Geochemistry:	15

	• Atomic Absorption Spectrometer • X-ray Fluorescence Spectrometer • X-ray Photoelectron Spectroscopy • Inductively Coupled Plasma Analyzers • Isotope Ratio Mass Spectrometer • Thermal Ionization Mass Spectrometer • Laser-Based Instruments Laboratory accreditation, maintenance, and quality control.	

Texts / References	**Geochemistry:** 1. Robin Gill (2015): Chemical Fundamentals of Geology and Environmental Geoscience, John Wiley & Sons Ltd. 2. Alan P. Dickins (2005): Radiogenic Isotope Geology, Cambridge University Press. 3. Hoefs, J. (1980): Stable Isotope Geochemistry, Springer and Verlag. 4. Hugh R. Rollinson (2007): Early Earth Systems: A Geochemical Approach, Blackwell Publishing Ltd. 5. Gunter Faure (1977): Principles of Isotope Geology, John Wiley & Sons Ltd. 6. Hugh R. Rollinson and V. Pease (2022): Using Geochemical Data: Evaluation, Presentation and Interpretation, Pearson Prentice Hall. 7. Potts, P. J. (1992): A Handbook of Silicate Rock Analysis, Springer. 8. Albarde Francis (2003): Geochemistry - Introduction, Cambridge University Press. 9. Kula C. Misra (2012): Introduction to Geochemistry: Principles and Applications, Wiley-Blackwell. **Instrumentation** 1. Dhanaraju, R. (2009): Handbook of Geochemistry: Techniques and Applications in Mineral Exploration, Geological Society of India. 2. Perkins, D. (2013): Mineralogy, Prentice Hall. 3. Reed, S. J. B. (2006): Electron Microprobe Analysis and Scanning Electron Microscopy in Geology, Cambridge University Press. 4. J. Carey (2016): Geoscience: Instrumentation and Analytical Techniques.
Learning Outcomes (not more than 100 words)	By completing the course, students will achieve a thorough understanding of the chemical composition and properties of Earth's atmosphere, hydrosphere, lithosphere, and biosphere. They will learn to analyze the distribution and behavior of chemical elements in rocks and minerals. Students will gain skill in knowing the basic fundamentals of modern geochemical instrumentation and techniques. They will develop knowledge in interpreting geochemical data, understanding isotopic systems, and applying geochemical principles to solve geological problems. Additionally, students will be equipped to conduct independent research and contribute to advancements in geosciences through the use of geochemical tools and methodologies.

Course Title	**ESMJ74: Exploration Geosciences**
Category of Course	**Major**

Credits& Hour of Teaching	Theory	Practical	Cumulative
Credits	03	---	03
Hour of Teaching (Total)	45	---	45

Course Objectives (not more than 100 words)	This course educates students on the principles and practices for locating and evaluating mineral and petroleum resources. Key objectives include understanding geological methods for mineral exploration, criteria for effective mineral search, and stages of exploration. The course covers geochemical exploration techniques, including dispersion mechanisms and mapping. Additionally, it introduces geophysical methods such as gravity, magnetic, electrical, and seismic techniques for subsurface imaging. Students also learn about well-logging methods, porosity, permeability, and drilling techniques relevant to exploration. Overall, the course prepares students to apply interdisciplinary approaches in geological and geophysical data interpretation to assess and delineate mineral and petroleum prospects effectively.
Course Content	The course content be divided into minimum 3 Units to maximum 5 units along with defined hour of teaching for each unit.

Units	**Course Content**	**Hr. of Teaching**
I	Principles of geological methods for mineral exploration, including criteria and guidelines for mineral prospecting. Exploration stages: an overview of geochemical exploration, its methodologies, and the significance of dispersion; geochemical mapping. Introduction to geobotanical exploration techniques	15
II	Core principles of geological methods for petroleum exploration, including identification and characterization of petroleum source rocks. Analysis of organic matter's quantity, type, and maturation, along with the fundamentals of petroleum generation and migration. Evaluation of oil and gas prospects using geochemical modeling.	10
III	Overview of geophysics, including fundamental theories of gravity and magnetic methods, as well as the densities and magnetic susceptibilities of rocks and minerals. Examination of the electrical properties of rocks and minerals, self-potential, D.C. resistivity, and induced polarization (IP) methods. Introduction to electromagnetic (EM) induction, fundamentals of seismic theory, reflection and refraction methods. Understanding the principles of radioactivity and the radioactivity of rocks and minerals	10
IV	Well-logging and drilling: Understanding the borehole environment and key concepts such as porosity, permeability, and saturation. Overview of well logging methods and their interpretation. Exploration drilling: objectives, types, and advantages.	10

Texts / References	1. Moon, C. J., Michael, K. G., Whateley, and Evans, A. M. (2006): Introduction to Mineral Exploration, Blackwell Publishing House. 2. Banerjee, P. K., and Ghosh, S. (1997): Elements of Prospecting for Non-Fuel Mineral Deposits. 3. Tissot, B. P., and Welte, D. H. (1984): Petroleum Formation and Occurrence, Springer–Verlag. 4. North, F. K. (1985): Petroleum Geology, Allen &Unwin. 5. Selley, R. C. (1998): Elements of Petroleum Geology, Academic Press. 6. Schlumberger: Log Interpretation Principles/Application, Schlumberger Wireline& Testing, 225 Schlumberger Drive, Sugar Land, Texas 77478. 7. Musset, A. E., and Khan, M. A. (2000): An Introduction to Geological Geophysics, Cambridge University Press. 8. Lille, R. (1998): Whole Earth Geophysics: An Introductory Textbook for Geologists and Geophysicists, Pearson; 1st edition.
Learning Outcomes (not more than 100 words)	Upon completing Exploration Geosciences, students will: 1. Apply fundamental geological methods to identify and assess mineral and petroleum resources. 2. Analyze criteria and techniques for effective mineral exploration and petroleum prospecting. 3. Demonstrate proficiency in geochemical and geophysical exploration methods, including interpreting data from gravity, magnetic, electrical, and seismic surveys. 4. Evaluate the geological factors influencing resource distribution and quality. 5. Utilize well-logging techniques to interpret subsurface characteristics such as porosity, permeability, and fluid saturation.

Course Title	**ESMJ75: Fuel Geology**
Category of Course	**Major**

Credits& Hour of Teaching

	Theory	Practical	Cumulative
Credits	03	---	03
Hour of Teaching (Total)	45	---	45

Course Objectives (not more than 100 words)	To learn about the important sources of energy and laying conceptual foundation about their origin, formation and deposits. Understanding the geological framework of these natural exhaustible resources.
Course Content	The course content be divided into minimum 3 Units to maximum 5 units along with defined hour of teaching for each unit.

Units	**Course Content**	**Hr. of Teaching**
I	**Coal Geology:** Definition and origin of coal. Chemical characteristics of coal. Coal petrology – concept and classification of 'Coallithotypes' and 'maceral'. Techniques and methods of coal microscopy. Elementary knowledge of the application of reflectance and fluorescence microscopy.	10
II	**Application of coal petrology:** Classification of coal in terms of rank, grade, and type. Classification for coking and non-coking coals. Elementary idea about coal preparation.	10
III	Elementary idea about Coal Bed Methane and Underground Coal Gasification. Geological andgeographical distribution of coal and lignite deposits in India.Coal exploration and estimation of coal reserves. Indian coal reserves and production of coal in India.	10
IV	Petroleum Geology:Petroleum – its composition. Origin (Formation of source rocks-kerogen,organic maturation and thermal cracking of kerogen) and migration of petroleum.Reservoirrocks-porosityandpermeability.Reservoirtraps–structural, stratigraphic and combinationtraps.Oilfieldfluids–water, oil and gas. On shore and offshore petroliferous basins of India.	15

Texts / References	1. Isabel Suárez-Ruiz, John Crelling. 2008. Applied Coal Petrology: The Role of Petrology in Coal Utilization, Academic Press. 2.Taylor, G.H., Teichmuller, M., Davis, A., Diessel, C.F.K., Littke, R., and Robert P. 1998. Organic Petrology, GebruderBorntraeger, Stuttgart. 3.Chandra, D., Singh, R.M., Singh, M.P. 2000. Textbook of Coal (Indian context), Tara Book Agency, Varanasi. 4. Singh, M.P. (Ed.) 1998. Coal and Organic Petrology, Hindustan Publishing Corporation, New Delhi. 5. Scott, A.C. 1987. Coal and Coal-bearing Strata: Recent Advances, The Geological Society of London, Publication no. 32, Blackwell Scientific Publications. 6. Stach, E., Mackowsky, M.-Th., Taylor, G.H., Chandra, D., Teichmuller, M., and Teichmuller, R. 1982. Stach Textbook of Coal Petrology, GebruderBorntraeger, Stuttgart. 7. Holson, G.D. and Tiratso, E.N. 1985. Introduction to Petroleum Geology, Gulf Publishing, Houston, Texas.Tissot, B.P. and Welte, D.H. 1984. Petroleum Formation and Occurrence, Springer-Verlag. 8. North, F.K. 1985. Petroleum Geology, Allen &Unwin.
Learning Outcomes (not more than 100 words)	Coal and Petroleum as a natural resource in the geological realm.

Course Title	**ESMJ76: Practical connected with ESMJ71**
Category of Course	**Major**

Credits& Hour of Teaching	Theory	Practical	Cumulative
Credits	---	01	01
Hour of Teaching (Total)	---	30	30

Course Objectives (not more than 100 words)	The course ES-CC-411 includes practical exercises on drainage extraction, hypsometric analysis, and geomorphological study using topographic sheets, aerial photos, and satellite imagery. It also encompasses the study of different geotectonic maps of the major plates of the Earth.
Course Content	The course content be divided into minimum 3 Units to maximum 5 units along with defined hour of teaching for each unit.

Units	**Course Content**	**Hr. of Teaching**
I	Geomorphology:Drainage and Slope Morphometry, Hypsometry	6
II	Geomorphology through toposheets	6
III	Geomorphology through aerial photos and satellite Imagery, and Terrain aspect mapping.	6
IV	Geotectonics:Analysis of geotectonic maps focusing on the major lithospheric plates and their movements. Examination of key geotectonic features such as mid-oceanic ridges, aseismic ridges, island arcs, trenches, subduction zones, fracture zones, hot spots, and triple junctions.	6
V	Exploration of the characteristics and development of contemporary continental margins and orogenic belts. Detailed study of plate tectonic maps across different geological time periods, focusing on the evolution and interaction of tectonic plates throughout Earth's history.	6

Texts / References

Geomorphology:

1. Small, R.J. 1978. Study of Landforms: A Textbook of Geomorphology (2nd Edition), Cambridge University Press.
2. Halis, J.R. 1983. Applied Geomorphology.
3. Thornbury, W.D. 2004. Principles of Geomorphology. 2nd Edition, CBS Publication.
4. Kale, V.S. and Avijit Gupta 2010. Introduction to Geomorphology, University Press.
5. Bloom, A.L. 2011. Geomorphology: A Systematic Analysis of Late Cenozoic Landforms. 3rd Edition, Rawat Publications.
6. Summerfield, M.A. 2011. Geomorphology and Global Tectonics, Wiley India Pvt Ltd.

Geotectonics:

1. Gass, I.G. et al. 1982. Understanding the Earth, Artemis Press (Pvt) Ltd., U.K.
2. Condie, Kent C. 1989. Plate Tectonics and Crustal Evolution. 3rd Edition, Butterworth-Heinemann Ltd.
3. Windley, B. 1995. The Evolving Continents. 3rd Edition, Wiley-Blackwell.
4. Davies, G.F. 1999. Dynamic Earth: Plates, Plumes and Mantle Convection, Cambridge University Press.
5. Keller, E.A. and Pinter, N. 2001. Active Tectonics. 2nd Edition, Pearson Publications.
6. Kearey, P., Klepeis, K.A. and Vine, F.J. 2009. Global Tectonics. 3rd Edition, Wiley-Blackwell.

Learning Outcomes (not more than 100 words)	After completing the practical exercises in course ES-CC-411, students will gain a better understanding of subsurface geology, including lithology and deformation based on surface manifestations. They will also acquire knowledge about different plate boundaries and their interrelationship on Earth.

Course Title	**ESMJ77: Practical connected with ESMJ72**
Category of Course	**Major**

Credits& Hour of Teaching	Theory	Practical	Cumulative
Credits	---	01	01
Hour of Teaching (Total)	---		30

Course Objectives (not more than 100 words)	To study and identify different types natural materials like rocks & soil with reference to geohazards, construction and excavation. • To know the physico-mechanical properties of rocks and rockmass • To know the importance of testing and geotechncial considerations for slopes, tunnel and dam construction. • To have field knowledge about the basics of surveying and theatrical background.
Course Content	The course content be divided into minimum 3 Units to maximum 5 units along with defined hour of teaching for each unit.

Units	**Course Content**	**Hr. of Teaching**
I	**Engineering Geology:** Testing for UCS, Testing for Point Load Strength, Testing for Tensile Strength, Kinematic Analysis for Slope Instability, Slake Durability Index, Analytical Solutions for Stability Analysis, Graphical Solutions for Slope Instability, Sieve Analysis, Python Programming for Geo-engineering Applications.	15
II	**Surveying:** Laboratory and field exercises by surveying instruments viz. Chain, Prismatic Compass, Plane Table, Dumpy Level, Theodolite, and Total Station: Survey of a piece of land by means of common methods of surveying using the suitable surveying instruments.	15

Texts / References	Foundations of Engineering Geology 1. S. Gangopadhyay, 2012, Engineering Geology, Oxford Press. 2. T. Waltham, 2009, Foundations of Engineering Geology (Third edition), Taylor & Francis. 3. D. G. Price, 2009, Engineering Geology - Principles & Practice, Springer. Surveying 1. Bernhard Hofmann-Wellenhof, Herbert Lichtenegger, James Collins, 2012: Global Positioning System: Theory and Practice, 4th edition, Springer Science & Business Media. 2. Punmia, B.C., Jain, A.K., and Jain, A.K., (2016): Surveying, Vol. 1 & Vol. 2, Laxmi Publications (P) Limited, New Delhi. 3. Ray Chowdhary, K.P., (1987): Surveying (Plane and Geodetic), Oxford & IBH Pub. Co., New Delhi. 4. Shahani, P.B., (1978): Textbook of Surveying, Vol. I, Oxford & IBH Pub. Co., New Delhi. 5. Venkataramaiah, C. (2011): Textbook of Surveying, Orient BlackswanPrivate Limited, New Delhi.
Learning Outcomes (not more than 100 words)	The students will get the basic knowledge about natural material vis-avis construction and excavation. • The students will understand the influence of natural processes and geological factors on civil structures and help them to take decision while planning, design and execution stage of the structures in their professional life. • The students will know the significance of geological investigations for civil engineering projects and site selection as well as engineering geological testing. The student will be able to comprehend the fundamentals of surveying and their uses in geological sciences.

Course Title	**ESMJ78: Practical connected with ESMJ73**
Category of Course	**Major**
Credits& Hour of Teaching	

	Theory	Practical	Cumulative
Credits	---	01	01
Hour of Teaching (Total)	---	30	30

Course Objectives (not more than 100 words)	The objective of the paper is to provide students with hands-on experience in analyzing and interpreting rock samples using geochemistry as a proxy. Students will learn to perform rock analyses, calculate mineral formulas, and prepare and interpret geochemical diagrams and models. The course aims to develop practical skills in data plotting and interpretation, including rare earth element (REE) analysis, and to apply geochemical modeling to understand geological processes. Ultimately, students will be equipped with the practical expertise needed to handle geochemical data and conduct advanced research in geosciences.
Course Content	The course content be divided into minimum 3 Units to maximum 5 units along with defined hour of teaching for each unit.

Units	**Course Content**	**Hr. of Teaching**
I	Rock analyses (Rapid method of silicate analysis); Mineral formula calculations; Preparation ofclassificatory and variation diagrams and their interpretation; Plotting of REE data and theirinterpretation;Geochemicalmodeling.	30

Texts / References	1. Robin Gill (2015) Chemical Fundamentals of Geology and Environmental Geoscience, John Wiley & Sons Ltd. 2. Alan P. Dickins (2005) Radiogenic Isotope Geology, Cambridge University Press. 3. Hoefs, J. (1980) Stable Isotope Geochemistry, Springer and Verlag. 4. Hugh R. Rollinson (2007) Early Earth Systems: A Geochemical Approach, Blackwell Publishing Ltd. 5. Gunter Faure (1977) Principles of Isotope Geology, John Wiley & Sons Ltd. 6. Hugh R. Rollinson and V. Pease (2022) Using Geochemical Data: Evaluation, Presentation and Interpretation, Pearson Prentice Hall. 7. Potts, P.J. (1992) A Handbook of Silicate Rock Analysis, Springer. 8. Albarde Francis (2003) Geochemistry - Introduction, Cambridge University Press. 9. Kula C. Misra (2012) Introduction to Geochemistry: Principles and Applications, Wiley-Blackwell. 10. Instrumentation in Geosciences 11. Dhanaraju, R. (2009) Handbook of Geochemistry: Techniques and Applications in Mineral Exploration, Geological Society of India. 12. Perkins, D. (2013) Mineralogy, Prentice Hall. 13. Reed, S.J.B. (2006) Electron Microprobe Analysis and Scanning Electron Microscopy in Geology, Cambridge University Press. 14. J. Carey (2016) Geoscience: Instrumentation and Analytical Techniques.
Learning Outcomes (not more than 100 words)	Upon completing the paper, students will gain ability in analyzing rocks using rapid silicate analysis methods. They will be skilled in calculating mineral formulas from EPMA data, preparing and interpreting classificatory and variation diagrams, and plotting and interpreting rare earth element (REE) data. Students will develop the ability to perform geochemical modeling to understand and predict igneous processes. This practical experience will enhance their capability to apply geochemical techniques to geological problems, interpret complex geochemical data, and contribute to advanced geochemical research and analysis.

Course Title	**ESMJ79: Practical connected with ESMJ74**
Category of Course	**Major**

Credits& Hour of Teaching	Theory	Practical	Cumulative
Credits	02	---	02
Hour of Teaching (Total)	30	---	30

Course Objectives (not more than 100 words)	This course gives hands-on training in using geological and geophysical instruments for mineral and petroleum exploration. Practicing geochemical analysis techniques to interpret mineralization indicators. Conducting geophysical data acquisition and processing for subsurface imaging. Interpreting well-logging data to evaluate reservoir characteristics such as porosity and permeability. Enhancing skills in geological mapping and integrating data sets to identify exploration targets. Collaborating effectively in teams to solve practical problems and present findings through comprehensive laboratory reports.
Course Content	The course content be divided into minimum 3 Units to maximum 5 units along with defined hour of teaching for each unit.

Units	**Course Content**	**Hr. of Teaching**
I	Development of geological cross sections using borehole data; delineating stripping boundaries on geological cross sections and calculating ore reserves. Creation of geological maps and sections to infer geological history about petroleum prospects, along with oil reserve estimation. Interpret geophysical maps and computational techniques for analyzing and interpreting well-log data.	30

Texts / References

1. Moon, C.J., Micheal, K.G., Whateley, and Evans, A.M. (2006) Introduction to Mineral Exploration, Blackwell Publishing House.
2. Banerjee, P.K. and Ghosh, S. (1997) Elements of Prospecting for Non-Fuel Mineral Deposits.
3. Tissot, B.P. and Welte, D.H. (1984) Petroleum Formation and Occurrence, Springer-Verlag.
4. North, F.K. (1985) Petroleum Geology, Allen &Unwin.
5. Selley, R.C. (1998) Elements of Petroleum Geology, Academic Press.
6. Schlumberger Log Interpretation Principles/Application, Schlumberger Wireline& Testing 225, Schlumberger Drive Sugarland, Texas 77478.
7. Musset, A.E. and Khan, M.A. (2000) An Introduction to Geological Geophysics, Cambridge University Press.
8. Lille, R. (1998) Whole Earth Geophysics: An Introductory Textbook for Geologists and Geophysicists, Pearson; 1st edition.

Learning Outcomes (not more than 100 words)

Upon completing the Exploration Geosciences Practical course, students will:

1. Demonstrate proficiency in using geological and geophysical instruments for practical mineral and petroleum exploration.
2. Apply geochemical analysis techniques to interpret indicators of mineralization.
3. Conduct geophysical data acquisition and processing to interpret subsurface structures and resources.
4. Interpret well-logging data to evaluate reservoir properties such as porosity and permeability.
5. Develop skills in geological mapping and integrating diverse datasets to identify exploration targets accurately.

Collaborate effectively in teams to solve practical challenges and communicate findings through detailed laboratory reports, preparing them for professional roles in exploration geoscience.

Course Title	**ESMJ710: Practical connected with ESMJ75**
Category of Course	**Major**

Credits& Hour of Teaching		Theory	Practical	Cumulative
	Credits	---	01	01
	Hour of Teaching (Total)	---	30	30

Course Objectives (not more than 100 words)	To learn about the important sources of energy and laying conceptual foundation about their origin, formation and deposits. Understanding the geological framework of these natural exhaustible resources.
Course Content	The course content be divided into minimum 3 Units to maximum 5 units along with defined hour of teaching for each unit.

Units	**Course Content**	**Hr. of Teaching**
I	Macroscopic characterization of banded coals.Completion of outcrop in the given maps andcalculation of coal reserve.Preparation of polished particulate mounts of coal.Microscopicexaminationofpolishedparticulatemounts(identificationofmacerals).	15
II	Macroscopic and microscopic study of cores and well cuttings.Study of geological maps andsectionsofimportantoilfieldsofIndia	15

Texts / References	1. Isabel Suárez-Ruiz, John Crelling. (2008) Applied Coal Petrology: The Role of Petrology in Coal Utilization, Academic Press. 2. Taylor, G.H., Teichmuller, M., Davis, A., Diessel, C.F.K., Littke, R., and Robert, P. (1998) Organic Petrology, GebruderBorntraeger, Stuttgart. 3. Chandra, D., Singh, R.M., Singh, M.P. (2000) Textbook of Coal (Indian Context), Tara Book Agency, Varanasi. 4. Singh, M.P. (Ed.) (1998) Coal and Organic Petrology, Hindustan Publishing Corporation, New Delhi. 5. Scott, A.C. (1987) Coal and Coal-Bearing Strata: Recent Advances, The Geological Society of London, Publication No. 32, Blackwell Scientific Publications. 6. Stach, E., Mackowsky, M.-Th., Taylor, G.H., Chandra, D., Teichmuller, M., and Teichmuller, R. (1982) Stach Textbook of Coal Petrology, GebruderBorntraeger, Stuttgart. 7. Holson, G.D. and Tiratso, E.N. (1985) Introduction to Petroleum Geology, Gulf Publishing, Houston, Texas. 8. Selley, R.C. (1998) Elements of Petroleum Geology, Academic Press.
Learning Outcomes (not more than 100 words)	Coal and Petroleum as a natural resource in the geological realm.

Course Title	**ESMJ711: Advanced Geological Field Training**
Category of Course	**Major**
Credits& Hour of Teaching	

	Theory	Practical	Cumulative
Credits	---	04	04
Hour of Teaching (Total)	---	120	120

Course Objectives (not more than 100 words)	The students will travel to a region with interesting and accessible geology and use traditional and modern tools to understand the geology of the region. Students will then produce a field report, including analysis of various geological data and relevant cross-sections. The course aims to familiarize students with the real-world conditions and challenges faced by professional geoscientists. Additionally, students will visit scientific organizations, mining sites, institutes, and companies of national repute to gain insights into the professional working environment and operational practices in the field of geosciences.
Course Content	The course content be divided into minimum 3 Units to maximum 5 units along with defined hour of teaching for each unit.

Units	**Course Content**	**Hr. of Teaching**
	Comprehensive field training will be provided at selected outstation locations within the country. Students are also expected to visit prominent scientific organizations, mining sites, dams/tunnels/excavations and institutes to gain familiarity with the practical fieldwork and operational environments of professional geoscientists.	120

Texts / References	
Learning Outcomes (not more than 100 words)	1. Students will gain practical knowledge and skills through direct involvement in geological fieldwork conducted at various outstation locations within the country. It will bridge the gap between classroom learning and field application, enabling students to apply theoretical concepts in real-world scenarios. 2. Students will have the chance to interact with professionals and experts in the field, providing opportunities for networking and future career development. They will know the actual conditions and challenges encountered by professional geoscientists in the field, enhancing their readiness for future professional roles. 3. By visiting scientific organizations, mining sites, institutes, and companies of national repute, students will gain valuable insights into the operational practices and professional working environments within the geosciences sector. 4. It will help students develop critical thinking and problem-solving skills pertinent to geological challenges.

Course Title	**Same as major ESMJ71 and ESMJ75**
Category of Course	**Minor**
Credits& Hour of Teaching	

	Theory	Practical	Cumulative
Credits	4	---	04
Hour of Teaching (Total)	60	---	60

Semester VIII- H

Course Title	**ESMJ81: Marine Geology, Oceanography and Climate**
Category of Course	**Major**

Credits& Hour of Teaching		Theory	Practical	Cumulative
	Credits	03	---	03
	Hour of Teaching (Total)	45	---	45

Course Objectives (not more than 100 words)	The course introduces the origin and evolution of oceans, focusing on their physical, chemical, and biological changes throughout the geological past. It covers various micropaleontological techniques to reconstruct past climates and oceanic conditions. The course also explores various oceanic processes and their impacts on climate and the environment. Additionally, it addresses the application of these studies to understand the dynamics of monsoons and Global warming, providing an overview of climate policies and Global agreements.
Course Content	The course content be divided into minimum 3 Units to maximum 5 units along with defined hour of teaching for each unit.

Units	Course Content	Hr. of Teaching
I	**An Introduction to Marine Geology:** Origin and morphology of the ocean floor, ocean margins, and coastal features. Marine sediments, their types, deposition, distribution, and diagenetic changes. Mineral resources.	15
II	**Micropaleontology:** Definition and scope, microfossil types, analysis techniques, and applications in paleoceanographic/paleoclimatic reconstructions.	15
III	Physical and chemical properties of seawater, ocean currents and circulations; fundamentals ofclimatology:Ocean's role in climate change, Global warming and greenhouse gases; an overview ofclimatepolicyand GlobalagreementslikettheKyotoProtocolandParisAgreement.	15

Texts / References	1. **Pratul Kumar Saraswati and M.S. Srinivasan, 2016.***Micropaleontology: Principles and Applications.* Springer Cham Heidelberg New York Dordrecht London. 2. **Alan P.T. and Harold V.T., 2019.***Essentials of Oceanography*. Pearson Education. 3. **Wright, J.M. and Colling, A., 2013.***Seawater: Its Composition, Properties and Behaviour: Prepared by an Open University Course Team.* Elsevier. 4. **Kennett, James P., 1982.***Marine Geology*. Prentice-Hall, Englewood Cliffs, N.J. 5. **Rohli, R.V. and Vega, A.J., 2017.***Climatology*. Jones & Bartlett Learning. 6. **John L. Mero, 1964.***Mineral Resources of the Sea.* Elsevier Publishing Company, University of Virginia.
Learning Outcomes (not more than 100 words)	By the end of this course, students will be able to understand the role of oceans in regulating climate and sustaining life on Earth. They will be proficient in using micropaleontological techniques to reconstruct past climates and oceanic conditions, gaining insights into the mechanisms behind various climatic and oceanographic processes. Additionally, they will understand the dynamics of monsoons and Global warming and be familiar with relevant climate policies and Global agreements.

Course Title	**ESMJ82: Georesource and Mineral Policy**
Category of Course	**Major**

Credits& Hour of Teaching		Theory	Practical	Cumulative
	Credits	03	---	03
	Hour of Teaching (Total)	45	---	45

Course Objectives (not more than 100 words)	This course is an introductory course for Georesource. Promote best practices for efficient and sustainable mineral production, use, recycling, and environmental rehabilitation Provide an overview of the legal and policy framework on the mining sectors at national and international framework. To understand the causal forces which have been transforming the laws and policies on the mineral industries.
Course Content	The course content be divided into minimum 3 Units to maximum 5 units along with defined hour of teaching for each unit.

Units	**Course Content**	**Hr. of Teaching**
I	Concepts of Georesources**,** Classification of Georesources**,** Renewable and Non-Renewable Resources**,** Mineral, Energy, Water, and Land Resources**.** Greenfield and Brownfield Georesources**.**	10
II	Classification of Mineral Resources**,** Mineral Resource Exploration**,** Feasibility and Production**,** Preservation of Environment and Sustainable Development of Mineral Resources**,** Mineral Conservation**,** World Mineral Resources and Reserves**.** Geopolitics on Mineral Resources**,** Blue Economy**,** Marine Mineral Resources**.**	10
III	Concept of Mineral Economics**,** Mineral Industry in India**,** Definition of Mineral and Mineral Deposit in Commercial and Legal Literature**.** Mineral Laws and Taxation**,** Mineral Market**,** Internal and External Trade**,** Demand and Supply**,** Consumption and Substitution**.**	10
IV	National Mineral Policy and Legislation, Mines and Minerals (Development & Regulation) Act inIndia, Law of Sea (UNCLOS), International Seabed Authority (ISA), Exclusive economic zones(EEZ),Legal continental shelf(LCS).	15

Texts / References	1. K.L. Shrivastava and Arun Kumar (2014) Geo-Resources. Scientific Publishers, pp 672. 2. J. Craig, D. Vaughan and B. Skinner (2010) Earth Resources and the Environment. Pearson Publication, pp 528. 3. S.E. Kesler and A.C. Simon (2010) Mineral Resources, Economics and the Environment. Cambridge University Press, pp 392. 4. K.S. Valdiya (2016) Environmental Geology. Second Edition, McGraw Hill Education India Pvt. Ltd. 5. R.K. Sinha and N.L. Sharma (2019) Mineral Economics. 4th Edition, Oxford & IBH Publishing, pp 410. 6. K.N. Jetli (2011) Mineral Resources and Policy in India. New Century Publications, pp 356. 7. Fillmore C.F. Earney (2002) Marine Mineral Resources. Taylor & Francis, pp 405. 8. Pradeep Kumar Jain (2021) Mineral Policy, Mining Laws and Development, 2nd Edition, Scientific Publishers, pp 290. 9. P.L. Billon (2005) Geopolitics of Resource Wars: Resource Dependence, Governance and Violence. Frank Cass Publishers, pp 277. 10. Indian Mineral Year Book, Indian Bureau of Mines. 11. M.S. Cato (2009) Green Economics. Earthscan Publishing, London, pp 224. 12. A.M. Hussen (2000) Principles of Environmental Economics. Routledge London, pp 354.
Learning Outcomes (not more than 100 words)	Demonstrate proficiency in practical skills used in the evaluation of mineral resources. Be able to apply knowledge and skills within all study specializations in a social economics. Use and evaluate the appropriate strategies and methods for exploration of natural resources. Apply the scientific approaches being applied to exploration and production from natural resources. Interpret and analyze the geological characteristics of the mineral deposits to develop and planning and formulate national mineral policy.

Course Title	**ESMJ83: Ground Water Hydrology and Soil Geology**
Category of Course	**Major**

Credits& Hour of Teaching		Theory	Practical	Cumulative
	Credits	02	---	02
	Hour of Teaching (Total)	30	---	30

Course Objectives (not more than 100 words)	The course focuses on teaching basic concepts and principles of soil science and it's association with groundwater hydrology. Course covers the fundamentals soil genesis, soil types, it's mechanical roperies, subsurface flow and transport, relation of groundwater flow to soil, introductory groundwater chemistry, and the management of contaminated groundwater. The objective is to train students through case studies and fieldwork, which help to develop critical thinking and problem-solving abilities essential for addressing contemporary soil and groundwater-related challenges.
Course Content	The course content be divided into minimum 3 Units to maximum 5 units along with defined hour of teaching for each unit.

Units	**Course Content**	**Hr. of Teaching**
I	Introduction and basic concepts of hydrogeology: Scope of hydrogeology and its societal relevance, Hydrologic cycle, water budget, Hydrological Components: Precipitation, Evapotranspiration, run-off, infiltration and subsurface movement of water. Origin of water on Earth, Vertical distribution of groundwater, Types of aquifers, Hydrogeological properties of water-bearing rock – porosity, permeability, transmissivity, storage coefficient, specific yield and specific retention, Groundwater level and its fluctuations, springs.	07
II	Groundwater flow, Darcy's law and its validity, intrinsic permeability and hydraulic conductivity, Basic concepts of Well hydraulics and Groundwater exploration, Steady flow in confined and unconfined aquifers. Groundwater. Physical and chemical properties of groundwater and its quality, Graphic representation of chemical data, Environmental isotopes and its application in hydrogeological studies. Sea water intrusion in coastal aquifers. Artificial recharge of groundwater, Surface and subsurface water interaction, Groundwater Provinces of India	08
III	Soil Geology:Concept of soil, components of soil, Processes of soil formation; factors affecting oilformation;soil profile; Phase relationshipand grain size analysis; Classifications of soil,mineral and chemical composition of soils, Soil organic matter form and function; mineral stability during weathering; A brief introduction to methods of soil conservation. Concepts of soil structure andfabric: Soil fabric, soil structure, soil texture and field grading units;Peds and pedalilty, size and shape of peds, pedality, primary, secondary and tertiary structures and their interpretation;Voids-concepts,size,shape,arrangementandmorphological classification.	08
IV	**Paleosols -** Field recognition, description, origin and causes; paleosol in stratigraphic records; significance of paleosols; paleosols and human evolution. **Calcrete -** Definition, classification, calcrete formation, pedogeniccalcrete profiles, macrofeatures in calcretes, micromorphology (petrography), calcretes from Quaternary and ancient sedimentary sequences; significance of calcretes. **Laterite -** Characteristics, genesis, Indian occurrences.	07

Texts / References

Groundwater Hydrology:

1. Todd, D.K. (2006). Groundwater Hydrology, 2nd Ed., John Wiley & Sons, N.Y.
2. Davis, S.N., and DeWeist, R.J.M. (1966). Hydrogeology, John Wiley & Sons Inc., N.Y.
3. Karanth, K.R. (1987). Groundwater: Assessment, Development and Management, Tata McGraw-Hill Pub. Co. Ltd.

Soil Geology:

1. Braddy, N.C. Nature and Properties of Soils.
2. Gerrard, A.J.J. Soil and Landforms.
3. GovindaRajan, S.V., &GopalaRao, K.H.G. Studies of Soils of India.

<table>
<tr><td></td><td>4. Gurrison, S. (1989). The Chemistry of Soils, Oxford University Press.
5. Hunt, C.B. Geology of Soils.
6. Jeffe, J.S. The A.B.C. of Soils.
7. Terzaghi, K., & Pock, R.G. Soil Mechanics in Engineering.
8. Taylor, D.W. Fundamentals of Soil Mechanics.
9. Wright, V. Paul (Editor). Paleosols: Their Recognition and Interpretation, Blackwell Scientific Publication.
10. Wright, V. Paul, and Tucker, M.E. (1991). Calcretes, Blackwell Scientific Publication.</td></tr>
<tr><td>Learning Outcomes (not more than 100 words)</td><td>1. Analyze hydrogeological systems, including groundwater quality and the causes of groundwater quality deterioration.
2. Apply hydrogeological and soil science knowledge to assess the impacts of human activities on soil and water resources.
3. Develop skills in mapping and interpreting hydrogeological and soil data to support environmental planning and resource management.
4. Evaluate sustainable practices and policies for preserving natural resources.
5. Demonstrate proficiency in communicating geological concepts and solutions to diverse stakeholders, promoting informed decision-making in environmental management.</td></tr>
<tr><td>Course Title</td><td>ESMJ84: Remote Sensing and GIS</td></tr>
<tr><td>Category of Course</td><td>Major</td></tr>
<tr><td>Credits& Hour of Teaching</td><td>
<table>
<tr><td></td><td>Theory</td><td>Practical</td><td>Cumulative</td></tr>
<tr><td>Credits</td><td>02</td><td>---</td><td>02</td></tr>
<tr><td>Hour of Teaching (Total)</td><td>30</td><td>---</td><td>30</td></tr>
</table>
</td></tr>
<tr><td>Course Objectives (not more than 100 words)</td><td>To understand the principles, applications, trends, and pertinent issues of geographical information systems and sciences, including remote sensing (RS), cartography, and Global positioning systems (GPS).</td></tr>
<tr><td>Course Content</td><td>The course content be divided into minimum 3 Units to maximum 5 units along with defined hour of teaching for each unit.</td></tr>
<tr><td colspan="2">
<table>
<tr><th>Units</th><th>Course Content</th><th>Hr. of Teaching</th></tr>
<tr><td>I</td><td>Electromagnetic Radiation – characteristics, remote sensing regions, and bands; general characteristics of remote sensing satellites, its orbital parameters, and sensors; natural objects spectra – soil, rock, water, and vegetation.</td><td>06</td></tr>
<tr><td>II</td><td>Digital Image Processing – characteristics of remote sensing data, georeferencing, preprocessing/correction, enhancements, and classification; elements of photo and imagery pattern and interpretation; application in geology.</td><td>09</td></tr>
<tr><td>III</td><td>Hyperspectral, Thermal, and Microwave Remote Sensing; remote sensing applications in interpreting structure and tectonics, lithological mapping, mineral resources, groundwater potentials, and environmental monitoring.</td><td>09</td></tr>
<tr><td>IV</td><td>Concept of Datum and Types; different map projection systems; principles and components of GIS; remote sensing data integration with GIS; applications of GIS in various geological studies.</td><td>06</td></tr>
</table>
</td></tr>
<tr><td>Texts / References</td><td>1. Drury, S.A. (2001): Image Interpretation in Geology, Allen and Unwin.
2. Gupta, R.P. (1991): Remote Sensing Geology, Springer-Verlag.
3. Lillesand, T.M. and Kiefer, R.W. (1987): Remote Sensing and Image Interpretation, John Wiley.
4. B.S. and Gillespie, A.R. (1980): Remote Sensing in Geology, John Wiley.
5. Burrough, P.A. and McDonnell, R.A. (1998): Principles of Geographic Information Systems.</td></tr>
<tr><td>Learning Outcomes (not more than 100 words)</td><td>The course enhances technical skills and competence in data and information acquisition, extraction, management and analysis; spatial and statistical modelling; mapping and visualization. Further, the course helps develop applications of environmental remote sensing and GIS which can directly enhance service delivery on geology, land use management, ground water management/prospects, agriculture, forestry, food and water security, disaster management, etc.</td></tr>
</table>

Course Title	**ESMJ85: Basin Analysis**
Category of Course	**Major**

Credits& Hour of Teaching		Theory	Practical	Cumulative
	Credits	02	---	02
	Hour of Teaching (Total)	30	---	30

Course Objectives (not more than 100 words)	To develop concept of the basin analysis. Moreover, the students will acquire knowledge about the various tools involved in basin analysis. They will get firsthand knowledge about the allogenic and autogenic controls and evolution of the sedimentary basins. Furthermore, they will study details of the facies analysis, depositional environments and sequence stratigraphy, besides Quaternary Sedimentology.
Course Content	The course content be divided into minimum 3 Units to maximum 5 units along with defined hour of teaching for each unit.

Units	**Course Content**	**Hr. of Teaching**
I	Principles of basin analysis; Methods and techniques of basin analysis; Tectonic classification of sedimentary basins, factors and processes controlling sedimentation; Sedimentary basins and their geothermal evolution.	10
II	Facies analysis, sedimentary facies and facies models with Indian examples; Sediment dispersal patterns and paleocurrent analysis. Depositional environments of different sedimentary basins such as fluvial, shallow marine, and deep	10
III	Facies analysis, sedimentary facies and facies models with Indian examples; Sediment dispersal patterns and paleocurrent analysis. Depositional environments of different sedimentary basins such as fluvial, shallow marine, and deep	10

Texts / References	1. Allen, P.A., and Allen, J.R.L. (2005): Basin Analysis: Principles and Application, Blackwell Publishing. 2. Miall, A.D. (2000): Principles of Basin Analysis, Springer-Verlag. 3. Perry, C.T., and Taylor, K.G. (2006): Environmental Sedimentology, Blackwell Publishing, U.K. 4. Reading, H.G. (1996): Sedimentary Environments and Facies, Blackwell Scientific Publishing. 5. Reineck, H.E., and Singh, I.B. (1978): Depositional Sedimentary Environments, Springer-Verlag.
Learning Outcomes (not more than 100 words)	This is an applied course that is related to hydrocarbon industry. In this course, the students will acquire knowledge about the various tools involved in basin analysis. They will get knowledge about the allogenic and autogenic controls and tectonic evolution of the sedimentary basins, facies analysis, sequence stratigraphy and Quaternary Sedimentology.

Course Title	**ESMJ86: Practical connected with ESMJ81**
Category of Course	**Major**

Credits& Hour of Teaching		Theory	Practical	Cumulative
	Credits	---	01	01
	Hour of Teaching (Total)	---	30	30

Course Objectives (not more than 100 words)	This course aims to study the identification of various microfossils based on their morphology. It also includes the study of sea floor sediment and bottom topography, as well as laboratory techniques for sample processing. Additionally, the course covers various computer applications used in this field of study.
Course Content	The course content be divided into minimum 3 Units to maximum 5 units along with defined hour of teaching for each unit.

Units	**Course Content**	**Hr. of Teaching**
I	Types of microfossils- calcareous, siliceous, phosphatic and organic walled microfossils.	14

II	Study of major sea-floor features.Study of ocean floor sediments/ rocks/ minerals.	6
III	Grain size analysis of ocean floor sediments.Use of Ocean Data view in location plot and data visualization	10

Texts / References	1. Pratul Kumar Saraswati and M.S. Srinivasan (2016): Micropaleontology: Principles and Applications, Springer, Cham, Heidelberg, New York, Dordrecht, London. 2. Kennett, James P. (1982): Marine Geology, Prentice-Hall, Englewood Cliffs, N.J. 3. Burk, C.A. and Drake, C.L. (2013): The Geology of Continental Margins, Springer.
Learning Outcomes (not more than 100 words)	By the end of this course, students will be able to identify various microfossils and understand various seafloor features. They will be proficient infield techniques for data and sample collections, laboratory techniques for sample processingand skilled in using computer applications relevant to oceanographic studies, enabling them to conduct comprehensive research in marine geology and climatology.

Course Title	**ESMJ87: Practical connected with ESMJ82**
Category of Course	**Major**
Credits& Hour of Teaching	

	Theory	Practical	Cumulative
Credits		01	01
Hour of Teaching (Total)		30	30

Course Objectives (not more than 100 words)	This course is ideal for newcomers to learn about natural resources and their practical assessment. Practical knowledge to strategic analysis for mineral resource classification and their economic evaluations. To develop scientific and technical knowledge of report writing on mineral policy.
Course Content	The course content be divided into minimum 3 Units to maximum 5 units along with defined hour of teaching for each unit.

Units	**Course Content**	**Hr. of Teaching**
I	Study of United Nations Framework Classification (UNFC) for Georesources as detailed in the theory syllabus.	05
II	Mineral Resource Valuation Techniques: Cur-off Grades, Tonnage Factor, Specifications, Reserve Estimation.	10
III	Analysis and graphical representation of important Georesources. Preparation of maps showing distribution of important Georesources of India and World.	10
IV	Learning and report writing on national and international mineral policy.	05

Texts / References	1. R.K. Sinha and N.L. Sharma (2019): Mineral Economics, 4th Edition, Oxford & IBH Publishing, pp. 410. 2. G.S. Roonwal (2018): Mineral Exploration: Practical Application, Springer Nature Singapore, pp. 1-298. 3. J.H. Reedman (1979): Techniques in Mineral Exploration, Applied Science Publishers Ltd., London, pp. 1-533. 4. M.E. Rossi and C.V. Deutsch (2014): Mineral Resource Estimation, Springer Dordrecht Heidelberg, pp. 1-332. 5. Haddon F. King (1982): A Guide to the Understanding of Ore Reserve Estimation, Australasian Institute of Mining and Metallurgy, Australia, pp. 1-21. 6. Indian Minerals Yearbook, Indian Bureau of Mines, Ministry of Mines, Government of India. 7. National Mineral Policy, Ministry of Mines. https://mines.gov.in 8. United Nations Framework Classification for Fossil Energy and Mineral Reserves and Resources.
Learning Outcomes (not more than 100 words)	Demonstrate understanding of the position of the minerals industry in the Global economy. Deliberate the essential concepts of mineral reserve estimation using geoscientific methods, including the concepts of ore reserve estimation. Apply the knowledge gained to understanding, reviewing, and performing mineral reserve estimations.

Course Title	**ESMJ88: Practical connected with ESMJ83**			
Category of Course	**Major**			
Credits& Hour of Teaching		Theory	Practical	Cumulative
	Credits	---	01	01
	Hour of Teaching (Total)	---	30	30
Course Objectives (not more than 100 words)	The Environmental Geology and Hydrogeology theory course aims to provide students with a comprehensive understanding of the Earth's geological processes and their impact on water resources. Objectives include developing knowledge of soil and rock formation, groundwater flow dynamics, and the interactions between geological formations and water systems; understanding the principles of aquifer properties and groundwater contamination. Develop skill to assess the environmental impact of geological processes and human activities on water resources; and equipping students with the skills to apply geological and hydrogeological concepts in environmental assessments, resource management, and sustainability practices. This course prepares students for advanced studies and careers in hydrogeology and environmental management.			
Course Content	The course content be divided into minimum 3 Units to maximum 5 units along with defined hour of teaching for each unit.			

Units	**Course Content**	**Hr. of Teaching**
I	**Water balance computation of a micro watershed:** Preparation and interpretation of water level contour maps and depth to water level maps. Delineation of hydrological boundaries on water table contour maps and analysis of hydrographs for differing groundwater conditions. Estimation of aquifer properties such as hydraulic conductivity, storage coefficient, and transmissivity. Analysis of hydrographs for various components	15
II	**Physico-chemical analysis of groundwater and graphical presentation of water quality:** Determination of groundwater suitability for drinking and irrigation purposes. Simple numerical problems related to: determination of permeability in field and laboratory, groundwater flow, well hydraulics, etc.	15

Texts / References	1. Todd, D. K. (2006). Groundwater Hydrology, 2nd Ed., John Wiley & Sons, N.Y. 2. Davis, S. N., and DeWeist, R. J. M. (1966). Hydrogeology, John Wiley & Sons Inc., N.Y. 3. Karanth, K. R. (1987). Groundwater: Assessment, Development and Management, Tata McGraw-Hill Pub. Co. Ltd.
Learning Outcomes (not more than 100 words)	Upon completing the Environmental Geology and Hydrogeology Practical course, students will: 1. Ability to interpret hydrogeological data and maps to assess the impact of human activities on water resources. 2. Gain knowledge of groundwater occurrence, distribution, and movement through analyzing the piezometer data. . 3. Develop data analysis, critical thinking, and problem-solving skills, preparing them to tackle environmental and hydrological issues effectively. Essential for environmental consulting, research, and water resource management careers.

Course Title	**ESMJ89: Practical connected with ESMJ84**			
Category of Course	**Major**			
Credits& Hour of Teaching		Theory	Practical	Cumulative
	Credits	---	01	01
	Hour of Teaching (Total)	---	30	30
Course Objectives (not more than 100 words)	It is to focus on hands-on experience and the application of theoretical knowledge of aerial photographs, satellite images and GIS to real-world scenarios. 1. Learn to use aerial photos and satellite images for geological interpretation. 2. Learn to integrate remote sensing data with other GIS data sources. 3. Understand the process of georeferencing and digitizing spatial data.			
Course Content	The course content be divided into minimum 3 Units to maximum 5 units along with defined hour of teaching for each unit.			

Units	Course Content	Hr. of Teaching
I	Geomorphologythroughaerialphotosandsatelliteimagery;Terrainaspectmapping;Determination of scale in aerial photos, measurement of heights of objects from aerial photos,study and interpretation of stereo pair aerial photos; Preparation of interpretation keys,thematic mapping romaerialphotosandsatelliteimages–structure,lithology,landforms,minerals,soils,groundwater;ApplicationofGISingeologicalstudies.	30

Texts / References	1. Drury, S. A. (2001). Image Interpretation in Geology, Allen and Unwin. 2. Gupta, R. P. (1991). Remote Sensing Geology, Springer-Verlag. 3. Lillesand, T. M., and Kiefer, R. W. (1987). Remote Sensing and Image Interpretation, John Wiley. 4. B. S. and Gillespie, A. R. (1980). Remote Sensing in Geology, John Wiley. 5. Burrough, P. A., and McDonnell, R. A. (1998). Principles of Geographic Information Systems
Learning Outcomes (not more than 100 words)	Students will gain practical skills and knowledge in handling aerial photos, satellite images, and GIS, enabling them to effectively use these technologies in various professional applications.

Course Title	**ESMJ810: Practical connected with ESMJ85**
Category of Course	**Major**
Credits& Hour of Teaching	

	Theory	Practical	Cumulative
Credits	---	01	01
Hour of Teaching (Total)	---	30	30

Course Objectives (not more than 100 words)	This course is designed to impart the practical knowledge regarding the basin analysis. Here, the students are trained to use various tools for basin analysis. This also involves the students to interpret various seismic profiles in a sequence stratigraphic framework.
Course Content	The course content be divided into minimum 3 Units to maximum 5 units along with defined hour of teaching for each unit.

Units	Course Content	Hr. of Teaching
	• Study of isopach and facies maps. • Study of facies assemblages of different sedimentary environments. • Preparation of lithologs from facies maps. • Correlation of lithological profiles of important Indian sedimentary basins. • Preparation of rose diagrams and statistical analysis of the paleocurrent data. • Detailed study of seismic profiles in a sequence stratigraphic framework.	30

Texts / References	1. Perry, C. T. and Taylor, K. G. (2006): Environmental Sedimentology, Blackwell Publ., U.K. 2. Reading, H. G. (1996): Sedimentary Environments and Facies, Blackwell Scientific Publ. 3. Emery, D. and Myers, K. (1996): Sequence Stratigraphy, Blackwell Science Ltd. 4. Haq, B. U. (1995): Sequence Stratigraphy and Depositional Response to Eustatic, Tectonic, and Climatic Forcing, Springer.
Learning Outcomes(not more than 100 words)	The students will learn about the various tools involved in the basin analysis. They will learn to interpret the lithologsand seismic profiles that can be used for petroleum exploration.

Course Title	**Same as major ESMJ84 and ESMJ89**			
Category of Course	**Minor**			
Credits& Hour of Teaching		Theory	Practical	Cumulative
	Credits	03	01	04
	Hour of Teaching (Total)	45	30	75

Research Students

Semester: VII -R

Same as VII-H

Semester: VIII –R

Any one major elective courses from ESMJ81 to ESMJ85 along with connected practical (4 credit each)(List Same as VIII-H)
ES-Minor: same as major ESMJ84 and ESMJ89*
ES-DS8R1: Dissertation

Course Title	**ES-DS8R1: Dissertation**			
Category of Course	**Major**			
Credits& Hour of Teaching		Theory	Practical	Cumulative
	Credits	---	12	12
	Hour of Teaching (Total)	---	360	360
Course Objectives (not more than 100 words)	Aims to contribute new knowledge or insights to the field of Earth Science. Here are some common objectives for such research: 1. To deepen the understanding of geological processes, structures, or phenomena. 2. To address a particular problem or question in geology 3. To develop or refine methodologies for geological investigation. 4. To apply geological knowledge to practical issues, such as natural resource management, environmental protection, or geohazard mitigation. 5. To test specific hypotheses related to geological theories or models, using empirical data or simulations to validate or refute them. 6. To provide new or updated geological maps that improves the understanding of geological formations and structures in a specific region. 7. To document and analyze the geological history of an area, providing insights into past climates, tectonic events, or biological evolution.			
Course Content	The course content be divided into minimum 3 Units to maximum 5 units along with defined hour of teaching for each unit.			

Units	**Course Content**	**Hr. of Teaching**
I	Research work under supervision of a research guide is to be submitted in the form of a dissertation	360

Texts / References	
Learning Outcomes (not more than 100 words)	The learning outcomes of a research dissertation in geology typically reflect both the specific achievements of the project and the broader skills developed during the research process. Advanced understanding of geological concepts, theories, and processes relevant to your research topic. Awareness of current research trends, techniques, and findings in the field of geology.

BANARAS HINDU UNIVERSITY

Department of Geophysics

Faculty of Science

SYLLABI

B.Sc. Programme

In

Geophysics

BANARAS HINDU UNIVERSITY
(Detailed Syllabus of different Courses under NEP 2020)

Department of Geophysics,
Faculty of Science, BHU

Course Title	**Solid Earth, Atmosphere and Ocean (GPHMD31)**
Category of Course[141]	Major / Minor / Minor (Vocational) / SEC / AEC / VAC / **MD**/Internship/Dissertation (Tick any one of the above)

Credits[142]& Hour of Teaching		Theory	Practical	Cumulative
	Credits	03	Nil	Nil
	Hour of Teaching (Total)	45	Nil	Nil

Course Objectives (not more than 100 words)	To create awareness about our mother earth structure and events occurs inside the earth. To know about the Fundamentals of earth atmosphere systems, atmospheric structure and weather events, monsoon systems, air pollution, physical properties of oceans.
Course Content	The course content be divided into minimum 3 Units to maximum 5 units along with defined hour of teaching for each unit.

Units	**Course Content**	**Hr. of Teaching**
I	Origin of Earth, Internal structure of the Earth, Chemical and physical properties of Earth, Overview of mineral exploration, groundwater exploration and hydrocarbon exploration, Introduction to geophysical instruments	12
II	Introduction to Plate tectonics, Propagation and characteristics of seismic waves,Introduction to earthquake and its parameters, Types of earthquakes and their causes, magnitude, and intensity scale, Global and Indian seismicity, Ring of fire, Site characterization for seismic hazard analysis	10
III	Introduction to Atmosphere: Composition and structure. Evaporation, condensation, cloud and precipitation, Tropical Cyclone, Anticyclone, Airmass, Front, Jet Stream, Solar and terrestrial radiation, Albedo, Green House Effect.	12
IV	General Circulation of the Atmosphere, Monsoon (NE and SW), Weather Systems, Climate Change, Air Pollution, Properties and effects of ozone, aerosols, air quality index, Basics of weather forecasting, Oceans around the globe: Physical properties and Circulations.	11

Texts / References	1. Benjamin Franklin Howell Jr: **Introduction to Geophysics,** Literary Licensing, LLC.(ISBN-13: 978-1258246310). 2. Frank D. Stacey and Paul M. Davis:**Physicsof the Earth**, Cambridge University Press.(ISBN 13: 978-0521873628). 3. David Gubbins: **Seismology and Plate Tectonics**, Cambridge University Press.(ISBN 13: 9780521379953). 4. William Lowrie: **Fundamentals of Geophysics**, Cambridge University Press.(ISBN 13:978-0521675963). 5. Robert J. Lilly: **Whole Earth Geophysics**, Pearson Press. (ISBN 13: 978-0134905174). 6. John M. Bird: **Plate Tectonics**, American Geophysical Union.(ISBN: 0875902235). 7. Horace Robert Byers: General Meteorology (IV- Edition), McGraw-Hill Inc.,US. (ISBN 13: 978-0070095007). 8..Sverre Petterssen: Introduction to Meteorology, Read Books (IBSN 13: 978-1406718225). 9. Robert Henson and C. Donald Ahrens: Essentials of Meteorology: An Invitation to the Atmosphere, Brooks/Cole. (ISBN 13: 978-1305628458). 10. P.K. Das: The monsoons (India, the land and the people), National Book Trust. (ISBN 13: 978-8123711232). 11. Paul R. Pinet: Invitation to Oceanography, Jones and Bartlett Publishers, Inc. (ISBN 13: 978-1284164695).
Learning Outcomes (not more than 100 words)	Course structure will deliver strong understanding about dynamical changes in earth, atmosphere and oceanic regime. The course will be helpful in making the students a responsible citizen of the world. They will learn various natural calamities and hazards that the biosphere can be subjected to, and also be aware about the possible solutions and methods of survival.

[141] SEC – Skill Enhancement Course; AEC – Ability Enhancement Course; VAC – Value Added Course; MD – Multidisciplinary Course

[142] 1 Credit (Theory) = 15 Hours; 1 Credit (Practical) = 30 Hours

BANARAS HINDU UNIVERSITY

Department of Geography

Faculty of Science

SYLLABI

B.Sc. (Hons.) Programme

In

Geography

DEPARTMENT OF GEOGRAPHY
BANARAS HINDU UNIVERSITY, VARANASI-221005
Syllabus
NEP Course Structure for Four Year Undergraduate Geography Program

Semester	Courses	Paper Code	Name of the Paper	Credits
I	Major	GGRMJ11	Physical Geography	3
	Major	GGRMJ12	Map Reading and Interpretation	1
	Minor	GGRMN11	Physical Geography	3
	Minor	GGRMN12	Map Reading and Interpretation	1
	MD1	GGRMD11	Introduction to Earth System	3
	SEC1	GGRSE11	Man and Environment	3
	AEC1	-	MIL	2
	VA C1V AC2	- -	To be offered by the Institute To be offered by the Institute	2 2
			Total Credits	**20**

Semester	Courses	Paper Code	Name of the Paper	Credits
II	Major	GGRMJ21	Human Geography	3
	Major	GGRMJ22	Map Projection and Weather Map	1
	Minor	GGRMN21	Human Geography	3
	Minor	GGRMN22	Map Projection and Weather Map	1
	MD2	GGRMD21	Environmental Ethics and Sustainability	3
	SEC2	GGRSE21	Basics of Remote Sensing	3
	AEC2	-	ENG1	2
	VA C3V AC4	- -	To be offered by the Institute To be offered by the Institute	2 2
			Total Credits	**20**

Note: Students may have the option to take Offline aswellas Onlinecourses.However,studentsmaytakeup to the 40% of the credits from Online courses in each category. Further, the capping of 40% may berelaxedto 60% for Coursesin"Others"category toenablethem toCredit moreinterestingcourses. StudentswillhavetopaytheFeesforOnlineCourses.

Semester	Courses	Paper Code	Name of the Paper	Credits
III	Major	GGRMJ31	Economic Geography	3
	Major	GGRMJ32	Surveying	1
	Major	GGRMJ33	Geography of India	4
	Minor Voc1	GGRMV31	Basics of Geographical Information System	4
	MD3	GGRMD31	Global Environmental Challenges	3
	SEC3	GGRSE31	Geography of Tourism	3
	AEC3	-	To b offered by the Institute	2
			Total Credits	**20**

Semester	Courses	Paper Code	Name of the Paper	Credits
IV	Major	GGRMJ41	Evolution of Geographical Thought	4
	Major	GGRMJ42	Environmental Geography	4
	Major	GGRMJ43	Geomorphology	4
	Major	GGRMJ44	Advanced Map Projection and Geological Map	2
	Minor Voc 2	-	To be offered by the Institute	4
	AEC4	-	To be offered by the Institute	2
			Total Credits	**20**

Note: Students may have the option to take Offline aswellas Onlinecourses.However,studentsmaytakeup to the 40% of the credits from Online courses in each category. Further, the capping of 40% may berelaxedto 60% for Coursesin"Others"category toenablethem toCredit moreinterestingcourses. Students will have to pay the Fees for Online Courses.

Semester	Courses	Paper Code	Name of the Paper	Credits
V	Major	GGRMJ51	Climatology	4
	Major	GGRMJ52	World Regional Geography	4
	Major	GGRMJ53	Population Geography	4
	Major	GGRMJ54	Cartographic Techniques	2
	Minor Voc 3	GGRMV51	Hazards & Disaster Risk Reduction	4
	Internship	GGRIN51	Internship1	2
			Total Credits	**20**

Semester	Courses	Paper Code	Name of the Paper	Credits
VI	Major	GGRMJ61	Advanced Remote Sensing& Geographical Information System	4
	Major	GGRMJ62	Oceanography	4
	Major	GGRMJ63	Remote Sensing and Geographical Information System techniques	2
	Major	GGRMJ64	Quantitative Methods in Geography	2
	Elective (Any one)	GGRMJ65A GGRMJ65B GGRMJ65C GGRMJ65D GGRMJ65E	Hydrology Geography of Settlement Resource Geography Social Geography Cultural Geography	4
	Minor Voc4	GGRMV61	Geography of Health and Wellbeing	4
			Total Credits	**20**

Note: Students may have the option to take Offline aswellas Onlinecourses.However,studentsmaytakeup to the 40% of the credits from Online courses in each category. Further, the capping of 40% may berelaxedto 60% for Coursesin"Others"category toenablethem toCredit moreinterestingcourses. Students will have to pay the Fees for Online Courses.

Semester	Courses	Paper Code	Name of the Paper	Credits
VII	Major	GGRMJ71	Research Methodology	4
	Major	GGRMJ72	Environmental Studies	4
	Major	GGRMJ73	Geographical Field Training and Report writing	2
	Elective (Any one)	GGRMJ74A GGRMJ74B GGRMJ74C GGRMJ74D GGRMJ74E GGRMJ74F GGRMJ74G	Advanced Geographical Thought Advances in Population Studies Urban Geography Regional Planning Advanced Geographical Information System Rural and Urban Planning Geography of Migration & Diaspora	4
	Minor	GGRMN71	Research Methodology	4
	Internship	GGRIN71	Internship2	2
			Total Credits	**20**

Semester	Courses	Paper Code	Name of the Paper	Credits
VIII	Major	GGRMJ81	Advanced Surveying	2
	Major	GGRMJ82	Environmental Quality Analysis	2
	Elective (Any Three)	GGRMJ83A GGRMJ83B GGRMJ83C GGRMJ83D GGRMJ83E GGRMJ83F GGRMJ83G GGRMJ83H GGRMJ83I	Biogeography Advanced Remote Sensing Sensing Advances in Urban Planning Industrial Geography Gender Geography Agriculture Geography Environmental Hazards & Disaster Risk Reduction Ecotourism & Geo heritage Fluvial Geomorphology	12 (4X3)
	Minor	GGRMN81	Advanced Surveying	2
	Minor	GGRMN82	Environmental Quality Analysis	2
			Total Credits	**20**

Note: Students may have the option to take Offline aswellas Onlinecourses.However,studentsmaytakeup to the 40% of the credits from Online courses in each category. Further, the capping of 40% may berelaxedto 60% for Coursesin"Others"category toenablethem toCredit moreinterestingcourses. Students will have to pay the Fees for Online Courses.

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Semester-VII

Semester	Courses	Paper Code	Name of the Paper	Credits
VII	Major	GGRMJ7R1	Research Methodology	4
	Major	GGRMJ7R2	Environmental Studies	4
	Major	GGRMJ7R3	Geographical Field Training & Report writing	2
	Elective (Any one)	GGRMJ7R4A GGRMJ7R4B GGRMJ7R4C GGRMJ7R4D GGRMJ7R4E GGRMJ7R4F GGRMJ7R4G	Advanced Geographical Thought Advances in Population Studies Urban Geography Regional Planning Advanced Geographical Information System Rural and Urban Planning Geography of Migration & Diaspora	4
	Minor	GGRMJ7R4B	Research Methodology	4
	Intern	GGRMJ7R4C	Internship2	2
			Total Credits	20

Semester-VIII

Semester	Courses	Paper Code	Name of the Paper	Credits
VIII	Major	GGRMJ8R1	Advanced Surveying	2
	Major	GGRMJ8R2	Environmental Quality Analysis	2
	Major	GGRDS8R1	Dissertation	12
	Minor	GGRMN8R1	Advanced Surveying	2
	Minor	GGRMN8R2	Environmental Quality Analysis	2
			Total Credits	20

Course	**B.Sc./B.A.FirstYear:Semester-I**			
Course Title	**GGRMJ11:PhysicalGeography**			
Category of Course	**Major**			
Credits &Hour of Teaching		Theory	Practical	Cumulative
	Credits	3		
	Hour of Teaching (Total)	45		
Course Objectives	• Toexplainstudents aboutthebasic concepts ofphysical geography. • Toexplainstudentsofphysicalfeatureswiththeformationofoceanand land. • Toexplainstudents about varioustheoriesrelated to earth'smovement. • Toacquaint students about atmospheric and hydrological processes.			
Course Content	The course content is divided into 3 Units.			
Units	**Course Content**			**Hr. of Teaching**
I	**The Earth System:** Earth in the solar system; Hypotheses Of the origin of the Earth (Jeans and Jeffreys, Russel) ;Interior of earth. Rocks:origin and classification; Gradational processes; Works of running water, wind, glacier.			15
II	**Atmosphere:** Composition and structure of atmosphere; Insolation; Temperature: vertical and horizontal distribution; Pressure belts and wind systems, Seasonal and local winds.			15
III	**Hydrosphere:** Theories of origin of ocean basin (Tetrahedral);Temperatureandsalinityofoceanwater;Oceancu rrents;Tides;Coralreefs.			15

SEC-Skill Enhancement Course, AEC Ability Enhancement Course; VAC Value Added Course: MD-Multidisciplinary Course1Credit (Theory)=15Hours;1Credit(Practical)=30Hours

Texts/References	1. Barry,R.G.andChorley,R.J.(1998):Atmosphere,WeatherandClimate. Routledge, London. 2. Bryant,H. R.(2001):PhysicalGeographyMadeSimple,RupaandCompany. New Delhi 3. Bunnett,R. B.(2003):PhysicalGeographyinDiagrams, (4th GCSEedition),PearsonEducation(Singapore)Private Ltd., Singapore. 4. Garrison,T.(1998):Oceanography,WordsworthCompany. Belmont. 5. Lake,P.(1979):PhysicalGeography, CambridgeUniversityPress,Cambridge. 6. Leong,G.C.(2003):CertificatePhysicalandHumanGeography,OxfordUniversityPress,New Delhi. 7. Monkhouse,F. J.(1979):PhysicalGeography.Methuen, London 8. Singh,M. B.(2001):*Bhoutik Bhugol,*TaraBookAgency, Varanasi 9. Singh,S.(2003):PhysicalGeography.Prayag Pustak Bhawan,Allahabad; 10. Strahler,A.N.andStrahler,A. M.(1992):ModernPhysicalGeography.JohnWileyandSons,NewYork. 11. Trewartha,G. T.,Robinson,A.H.,Hammond,E. H.,andHorn,A. T.(1976/1990):FundamentalsofPhysicalGeography, (3rd edition), McGraw-Hill, New York. 12. Holden,J.(2022):PhysicalGeography:TheBasics,(2ndEdition),Routledge,London.
Learning Outcomes	• Students would develop basic concepts of physical geography. • They would get acquainted with physical features of the earth. • They would understand about physical processes of the earth.

Course	**B.Sc./B.A.FirstYear:Semester-I**			
Course Title	**GGRMJ12:Map Reading and Interpretation**			
Category of Course	**Major**			
Credits &Hour of Teaching		Theory	Practical	Cumulative
	Credits		**1**	
	Hour of Teaching (Total)		**30**	
Course Objectives	• To introduce the students to the basics of maps and scales. • To explain the students of various physical features by contours. • To introduce the students to topo sheets. • To acquaint the knowledge in cartography.			
Course Content	Thecoursecontentisdividedinto1Unit.			
Units	**Course Content**			**Hr. of Teaching**
I	**ScalesandReliefeatures:**Constructionofscale:simple,diagonal and comparative;Representation of relief features by contours;			15
II	**Profiles and Topographical Map**: Profiles (serial, super imposed, projected and composite). Indexing, numbering and scale system, Interpretation of topographical sheet.			15

SEC-Skill Enhancement Course, AEC Ability Enhancement Course; VAC Value Added
Course: MD-Multidisciplinary Course1Credit(Theory)=15Hours;1Credit(Practical)=30Hours

Texts/References	1. Monkhouse,F.J.andWilkinson,F. J.(1972):MapsandDiagrams.Methuen,London. 2. Raisz,E.(1962):GeneralCartography, (5thedition), JohnWileyandSons,NewYork. 3. Robinson,A. H., Morrison,J. L.andMuehrcke,P.C.(1984):ElementsofCartography, John Wiley and Sons, New York. 4. SarkarA.(2013):QuantitativeGeography: : techniques and presentations.OrientBlackSwanPrivateLimited, New Delhi. 5. Sarkar,A.K.(1997):PracticalGeography:ASystematicApproach.OrientLongman,Kolkata. 6. Sharma,J.P (2010): Prayogik Bhoogol,RastogiPublication, Meerut. Singh,R.L.andSingh,RanaP.B.(1993):ElementsofPracticalGeography, Kalyani Publishers, New Delhi.
Learning Outcomes	• Students get acquainted about the skills making scales. • Students developed skills to draw relief features with the help of contours and acquaint them about the knowledge of relief features with the help of profiles. • Studentget familiar with the knowledge of indexing,numberingandscales of topographical maps. Students get acquainted with the knowledgeoftopographical maps and their interpretation.

Course	**B.Sc./B.A.FirstYear:Semester-I**			
Course Title	**GGRMN11**:**Physical Geography**			
Category of Course	**Minor**			
Credits &Hourof Teaching		Theory	Practical	Cumulative
	Credits	3		
	Hour of Teaching (Total)	45		
CourseObjectives	• Toexplainstudents aboutthebasic concepts ofphysical geography. • Toexplainstudentsofphysicalfeatureswiththeformationofoceanand land. • Toexplainstudents about varioustheoriesrelated to earth'smovement. • Toacquaint students about atmospheric and hydrological processes.			
CourseContent	Thecoursecontentisdividedinto3Units.			
Units	**CourseContent**			**Hr.of Teaching**
I	**TheEarthSystem:**Earthinthesolarsystem;Hypothesesoftheorigin oftheEarth(JeansandJeffreys,Russel);Interioroftheearth.Rocks:or iginandclassification;Gradationalprocesses;Worksofrunningwate r,wind,glacier			15
II	**Atmosphere:** Composition and structure of atmosphere; Insolation; Temperature: vertical and horizontal distribution;Pressurebelts and wind systems, Seasonal and localwinds			15
III	**Hydrosphere:**Theories of origin of ocean basin (Tetrahedral); Temperature and salinity of ocean water; Ocean currents;Tides;Coralreefs			15

SEC-SkillEnhancementCourse, AECAbilityEnhancementCourse; VACValueAdded
Course: MD-MultidisciplinaryCourse1Credit(Theory)=15Hours;1Credit(Practical)=30Hours

Texts/References	1. Barry,R.G.andChorley,R.J.(1998):Atmosphere,WeatherandClimate. Routledge, London. 2. Bryant,H. R.(2001):PhysicalGeographyMadeSimple,RupaandCompany. New Delhi 3. Bunnett,R. B.(2003):PhysicalGeographyinDiagrams, (4th GCSEedition),PearsonEducation(Singapore)Private Ltd., Singapore. 4. Garrison,T.(1998):Oceanography,WordsworthCompany. Belmont. 5. Lake,P.(1979):PhysicalGeography, CambridgeUniversityPress,Cambridge. 6. Leong,G.C.(2003):CertificatePhysicalandHumanGeography,OxfordUniversityPress, New Delhi. 7. Monkhouse,F. J.(1979):PhysicalGeography.Methuen, London 8. Singh,M. B.(2001):*Bhoutik Bhugol*,TaraBookAgency, Varanasi 9. Singh,S.(2003):PhysicalGeography.Prayag Pustak Bhawan,Allahabad; 10. Strahler,A.N.andStrahler,A. M.(1992):ModernPhysicalGeography.JohnWileyandSons,NewYork. 11. Trewartha,G. T.,Robinson,A.H.,Hammond,E. H.,andHorn,A. T.(1976/1990):FundamentalsofPhysicalGeography, (3rd edition), McGraw-Hill, New York. 12. Holden,J.(2022): Physical Geography: The Basics, (2nd Edition),Routledge,London.
Learning Outcomes	• Students would develop basic concepts ofphysicalgeography. • They would get acquainted with physical features of the earth. • They would understand about physical processes of the earth.

Course	**B.Sc./ B.A.FirstYear:Semester-I**			
CourseTitle	**GGRMN12:Map Reading and Interpretation**			
Category of Course	**Minor**			
Credits&Hourof Teaching		Theory	Practical	Cumulative
	Credits		1	
	Hour of Teaching (Total)		30	
CourseObjectives	• Tointroducethestudentstothebasicsofmapsandscales. • Toexplainthestudentsofvariousphysicalfeaturesbycontours. • Tointroducethestudentstotoposheets. • Toacquaintheknowledgeincartography.			
CourseContent	Thecoursecontentisdividedinto1Unit.			
Units	**Course Content**			**Hr. of Teaching**
I	**ScalesandReliefeatures:**Constructionofscale:simple,diagonal and comparative;Representation of Relief features by contours;			15
II	**ProfilesandTopographicalMap**:Profiles(serial,superimposed, projected and composite). Indexing, numbering and scale system, Interpretation of topographical sheet.			15

SEC-Skill Enhancement Course, AEC Ability Enhancement Course; VAC Value Added Course: MD-Multidisciplinary Course1 Credit (Theory)=15Hours;1Credit(Practical)=30Hours

Texts/References	1. Monkhouse,F.J.andWilkinson,F.J.(1972):MapsandDiagrams.Methuen,London. 2. Raisz,E.(1962):GeneralCartography.JohnWileyandSons,NewYork.5thedition. 3. Robinson,A.,Sale,R.Morrison,J.andMuehrcke,P.C.(1984):ElementsofCartography, 4. SarkarA.(2013):QuantitativeGeography,OrientBlackSwanPrivateLimited 5. Sarkar,A.K.(1997):PracticalGeography:ASystematicApproach.OrientLongmanKolkata 6. Sharma,J.P:PrayogikBhoogol,RastogiPublication Singh,R.L.andSingh,RanaP.B.(1993):ElementsofPracticalGeography.(English editions).
Learning Outcomes	• Students get acquainted about the skills making scales. • Students developed skills to draw relief features with the help of contours and acquaint them about the knowledge of relief features with the help of profiles. • Studentget familiar with the knowledge of indexing,numbering and scales of topographical maps. • Students get acquainted with the knowledgeoftopographical maps and their interpretation.

Course	**B.Sc./B.A.FirstYear:Semester-I**			
Course Title	**GGRMD11**:**Introduction to Earth System**			
Category of Course	**Multi-Disciplinary-1**			
Credits & Hour of Teaching		Theory	Practical	Cumulative
	Credits	3		
	Hour of Teaching (Total)	45		
Course Objectives	• To introduce the students to the basics of rotation and revolution. • Toexplainthestudentsofphysicalfeatureswiththeformationoflithosphere. • To introduce the students to various theories related earth's movement • To acquaint the knowledge in biosphere.			
Course Content	Thecoursecontentisdividedinto3Units.			
Units	**Course Content**			**Hr.of Teaching**
I	**The Earth System:** Earth's Movement; Rotation, Revolution**;** Interiorof the earth. Gradational processes; wind, river and glacier; Types ofrocks.			15
II	**Atmosphere:** Composition and structure; Insolation; Distribution of temperature; Pressure belts and wind systems, seasonalandlocalwinds.			15
III	**Hydrosphere:** Origin of ocean basin; Temperature and salinity of ocean water; Ocean currents; Coral reefs and tides.			15

SEC-Skill Enhancement Course, AEC Ability Enhancement Course; VAC Value Added
Course: MD-Multidisciplinary Course1Credit(Theory)=15Hours;1Credit(Practical)=30Hours

Texts/References	1. Barry, R.G.and Chorley,R.J.(1998):Atmosphere, Weather and Climate .Routledge ,London. 2. Bryant,H.Richard(2001):PhysicalGeographyMadeSimple,RupaandCompany.NewDelhi 3. Bunnett,R.B.(2003):PhysicalGeographyinDiagrams,FourthGCSEditi on,PearsonEducation(Singapore)PrivateLtd. 4. Garrison,T.(1998):Oceanography,WordsworthCompany.Belmont. 5. Lake, P. (1979): Physical Geography (English and Hindi editions), Cambridge UniversityPress,Cambridge. 6. LeongGohCheng(2003):CertificatePhysicalandHumanGeography,Oxf ordUniversityPress,NewDelhi. **7.** Monkhouse ,F.J.(1979): Physical Geography.Methuen,London Singh, M.B.(2001): *Bhoutik Bhugol*,Tara Book Agency,Varanasi
Learning Outcomes	• Students would develop understanding of gradational processes. • They would get acquainted with the knowledge of movement of land and ocean. • They would develop an overview about the planetary system.

Course	**B.Sc./B.A.FirstYear:Semester-I**			
Course Title	**GGRSE11:Man and Environment**			
Category of Course	**SEC-SkillEnhancementCource-1**			
Credits & Hour of Teaching		Theory	Practical	Cumulative
	Credits	3		
	Hour of Teaching (Total)	45		
Course Objectives	• Tointroducethestudentstothebasicsofmanandenvironmentrelationships. • To explain the students of evolution of man and different biomes. • To introduce the students to forms and functions of ecosystems • To acquaint the knowledge in climate change and environmental conservation			
Course Content	Thecoursecontentisdividedinto3Units.			
Units	**Course Content**			**Hr. of Teaching**
I	**Evolution of Man**; Human Race: Bases and classification; Human Adaptation in different environment :selected tribes.			15
II	**Man'sinteractionwithenvironment**,Biomes:Meaningandtypes ;MajorBiomes:Rainforest,Savannah,Tundra.			15
III	**Environment: Meaning and Components ;** Food Pyramid; Forms and Functions of Ecosystems: Terrestrial, Aquatic; Biodiversity;ClimaticChange;EnvironmentalConservationand Management.			15

SEC-Skill Enhancement Course, AEC Ability Enhancement Course; VAC Value Added Course: MD-Multidisciplinary Course1 Credit(Theory)=15Hours;1Credit(Practical)=30Hours

Texts/References	1. Chisholm, M.(1985):HumanGeography,2ndedition,PenguinBooks,London. 2. deBlij,H.J.(1996):HumanGeography:Culture,SocietyandSpace,.2ndedition.JohnWileyandSons,NewYork. 3. Johnston, R. J., Gregory, D., Pratt, G. and Watts, M. (2000): The Dictionary of Human Geography. 4th edition, BasilBlackwellPublishers, Oxford. 4. Kaushik, S.D.and Sharma,A.K.(1996):PrinciplesofHumanGeography (inHindi),Rastogi 5. Odum, P.E.and Barret,W.G.(2005):Fundamentals of Ecology, Thomson Asia Pvt Ltd,Singapur. 6. Huggett ,R.J.(1998):Fundamentals of Biogeography, Routledge, London. Saxena,H.M.(2000):EnvironmentalManagement.RawatPublications.,Jaipu randNewDelhi.
Learning Outcomes	• Students would get acquainted with knowledge of man and environment relationships. • They would get acquainted with knowledge of human evolution and adaptations. • They would develop knowledge of concepts of climatic change; environmental conservation and management.

Course	**B.Sc./B.A.FirstYear:Semester-II**			
CourseTitle	**GGRMJ21:Human Geography**			
Category of Course	**Major**			
Credits&Hourof Teaching		Theory	Practical	Cumulative
	Credits	3		
	Hour of Teaching (Total)	45		
CourseObjectives	• Tointroducethenature,scopeandapproachesofhumangeography. • Toexplainthestudentsofhumanadaptationin`environment. • Tointroducethestudentstovarioustheoriesofpopulation. • Toacquaintheknowledgeinurbansettlementandtheirgrowthpatterns.			
CourseContent	Thecoursecontentisdividedinto3Units.			
Units	**Course Content**			**Hr.of Teaching**
I	**Human Geography: N**ature, scope and Approaches of human geography ;Schools of thought in human geography :determinism, possibilism, neo-determinismand Probabilism.			15
II	**HumanRaceandSociety:**EvolutionandClassificationofraces;Characteristicsofracesandtheirbroaddistribution;Humanadaptationtoenvironment;Eskimo,Masai,Bushman;Indiatribes:Tharu,Naga, Bhil.			15
III	**PopulationandSettlements:**PopulationGrowthandMajorhumanagglomerations;DemographicTransitionTheory;Migration:Types, Causesand Consequences; Rural settlement: characteristics, types and patterns in India :Urban settlements: evolution and classification.			15

SEC-SkillEnhancementCourse, AECAbilityEnhancementCourse; VACValueAdded
Course: MD-MultidisciplinaryCourse1Credit(Theory)=15Hours;1Credit(Practical)=30Hours

Texts/References	1. Anderson,K.(2006):RacesandcrisesofHumanDevelopment,Routledge,LondonandNew Delhi 2. Bhende,A.A.andKanetkar,T.(1978):PrinciplesofPopulationStudies,HimalayanPublishingHouse,Mumbai. 3. Chisholm,M.(1985):HumanGeography,2ndedition,PenguinBooks,London. 4. Fellman,J.D.,Arthur,G.,Judith,G.,Hopkins,J.andDan,S.(2007):HumanGeography: LandscapesofHumanActivities.MNGraw-Hill,NewYork.10thedition. 5. Haggett,P.(2004):Geography:AModernSynthesis.8thedition,HarperandRow,NewYork 6. Hussain,M.(1994):HumanGeography,RawatPublications,Jaipur. 7. Johnston,R.J.,Gregory,D.,Pratt,G.andWatts,M.(2009):TheDictionaryofHumanGeography.5thedition, Basil Blackwell Publishers,Oxford. 8. Kaushik,S.D.andSharma,A.K.(1996):PrinciplesofHumanGeography(inHindi),RastogiPublication,Meerut. 9. Norton,W.(2008):HumanGeography,OxfordUniversityPress,NewYork.5thed. 10. Smith,D.M.(1977):HumanGeography-A Welfare Approach, Edward Arnold (Publishers)Ltd.,London. 11. Stoddard, R.H., Wishart, D.J. and Blouet, B.W. (1986): Human Geography. Prentice-Hall, EnglewoodCliffs,New Jersey.
Learning Outcomes	• Students would develop understanding about the meaning and fieldofhumangeography. • They would get acquainted with theknowledgeofevolutionandclassificationof human races. • They would understand thetheoriesofpopulationand migration. • They would become awareaboutruralandurbansettlements.

Course	**B.Sc./B.A.FirstYear:Semester-II**			
CourseTitle	**GGRMJ22:Map Projection and Weather Map**			
Category of Course	**Major**			
Credits&Hourof Teaching		Theory	Practical	Cumulative
	Credits		1	
	Hour of Teaching (Total)		30	
CourseObjectives	• Tointroducethestudentsabouttheearthrepresentation. • Toexplainthestudentsaboutclassificationofmapprojections. • Tointroducethestudentsaboutintroductiontoweathermaps.			
CourseContent	Thecoursecontentisdividedinto1Unit.			
Units	**CourseContent**			**Hr.of Teaching**
I	**Map Projection (Perspective Projection)**:Introduction and Classification of Map projections; Cylindrical: equal area; Bonne's; Zenithal Projection: Gnomonic, Stereographic and Orthographic			15
II	**Weather Map:** Introduction to weather map, Conventionalsignandsymbols;InterpretationofIndiandailyweather map:JulyOctoberandJanuarymonths			15

SEC-SkillEnhancementCourse, AECAbilityEnhancementCourse; VACValueAdded
Course: MD-MultidisciplinaryCourse1Credit(Theory)=15Hours;1Credit(Practical)=30Hours

Texts/References	1. Hinks,A,R,(1921):MapProjection,CambridgeUniversityPress,London, 2. Misra,R.PandRameshA.(1989):FundamentalsofCartography,ConceptPublishing Company,NewDelhi. 3. Monkhouse,F.J.andWilkinson,F.J.(1985):MapsandDiagrams.Methuen,London. 4. Raise,E,(1962):PrinciplesofCartography,MNGrawHill,NewYork. 5. Robinson,A.H.,Sale,R.,Morrison,J,andMuehrcke,P,C(1984):ElementsofCartography, 5th edition,John WileyandSons,New York, 6. Sarkar,A.K,(1997):PracticalGeography:ASystematicApproach,OrientLongman,Kolkata, 7. Sharma,J,p,(2001):PrayogikBhugol,RastogiPublication,Meerut3rd edition, 8. Singh,R,LandSingh,RanaP,B(1993):ElementsofPracticalGeography,(HindiandEnglishedition),KalyaniPublishers, New Delhi, Steers,J,A,(1965):AnIntroductiontotheStudyofMapProjection,Universityo fLondonPress,London.
Learning Outcomes	• Students would get knowledge theknowledgeof principles and types ofmapprojections. • Studentwill be able to understand weathersymbols. • Students would get acquainted with the knowledge of representation of atmospheric features on maps.

Course	**B.Sc./B.A.FirstYear:Semester-II**			
CourseTitle	**GGRMN21:Human Geography**			
Category of Course	**Minor**			
Credits&Hourof Teaching		Theory	Practical	Cumulative
	Credits	3		
	Hour of Teaching (Total)	45		
CourseObjectives	• Tointroducethenature,scope and approaches of human geography. • Toexplainthestudentsabouthumanadaptationtoenvironment. • Tointroducethestudentstovarioustheoriesofpopulation. • Toacquaintheknowledgeinurbansettlementandtheirgrowthpatterns.			
CourseContent	Thecoursecontentisdividedinto3Units.			
Units	**CourseContent**			**Hr.of Teaching**
I	**Human Geography: N**ature, scope and Approaches of human geography; Schools of thought in human geography: determinism, possibilism, neo-determinism and Probabilism.			15
II	**Human Raceand Society:** Evolution and Classification of races; Characteristics of races and their broad distribution; Human adaptation to environment; Eskimo, Masai, Bushman; Indiatribes: Tharu, Naga, Bhil.			15
III	**Population and Settlement:** Population Growth and Major human agglomerations; Demographic TransitionTheory; Migration: Types, Causes andConsequences; Ruralsettlement: characteristics, types and patterns in India: Urban settlements: evolution and classification.			15

SEC-SkillEnhancementCourse, AECAbilityEnhancementCourse; VACValueAdded
Course: MD-Multidisciplinary Course1Credit (Theory)=15Hours;1Credit(Practical)=30Hours

Texts/References	1. Anderson,K.(2006):Racesandcrisesof HumanDevelopment,Routledge,LondonandNewDelhi 2. Bhende,A.A.andKanetkar,T.(1978):PrinciplesofPopulationStudies,HimalayanPublishingHouse,Mumbai. 3. Chisholm,M.(1985):HumanGeography,2ndedition,PenguinBooks,London. 4. Fellman, J. D., Arthur, G., Judith, G., Hopkins, J. and Dan, S. (2007): Human Geography: Landscapes of HumanActivities.MNGraw-Hill, New York. 10th edition. 5. Haggett,P.(2004):Geography:A Modern Synthesis.8thedition,HarperandRow,NewYork 6. Hussain,M.(1994):HumanGeography,RawatPublications,Jaipur. 7. Johnston,R.J.,Gregory,D.,Pratt,G.andWatts,M.(2009):TheDictionaryofHumanGeography.5thedition,BasilBlackwell Publishers, Oxford. 8. Kaushik, S.D.and Sharma,A.K.(1996):Principles of HumanGeography(in Hindi),RastogiPublication,Meerut. 9. Norton,W.(2008):HumanGeography,OxfordUniversityPress,NewYork.5thed. **10.** Stoddard, R.H., Wishart, D.J. and Blouet, B.W. (1986): Human Geography. Prentice-Hall, Englewood Cliffs, NewJersey.
Learning Outcomes	• Students would develop understanding about the meaning and fieldofhumangeography. • They would get acquainted with theknowledgeofevolutionandclassificationof human races. • They would understand thetheoriesofpopulationand migration. • They would become awareaboutruralandurbansettlements.

Course	**B.Sc./B.A.FirstYear:Semester-II**			
CourseTitle	**GGRMN22:Map Projection and Weather Map**			
Category of Course	**Major**			
Credits&Hourof Teaching		Theory	Practical	Cumulative
	Credits		1	
	Hour of Teaching (Total)		30	
CourseObjectives	• Tointroducethestudentsabouttheearthrepresentation. • Toexplainthestudentsaboutclassificationofmapprojections • TointroducethestudentstoIntroductiontoweathermap			
CourseContent	Thecoursecontentisdividedinto1Units.			
Units	**CourseContent**			**Hr.of Teaching**
I	**Map Projection (Graphical)**: Introduction and Classification of Map projections; Cylindrical: equal area; Bonne's; Zenithal Projection: Gnomonic, Stereographic and Orthographic.			15
II	**Weather Map:** Introduction to weather map, Conventional sign and symbols; Interpretation of Indian daily weather map: July,October and January months.			15

SEC-SkillEnhancementCourse, AECAbilityEnhancementCourse; VACValueAdded
Course: MD-MultidisciplinaryCourse1Credit(Theory)=15Hours;1Credit(Practical)=30Hours

Texts/References	1. Hinks,A,R,(1921):MapProjection,CambridgeUniversityPress,London, 2. Misra,R.PandRameshA.(1989):FundamentalsofCartography,ConceptPublishing Company,NewDelhi. 3. Monkhouse,F.J.andWilkinson,F.J.(1985):MapsandDiagrams.Methuen,London. 4. Raise,E,(1962):PrinciplesofCartography,MNGrawHill,NewYork. 5. Robinson,A.H.,Sale,R.,Morrison,J,andMuehrcke,P,C(1984):ElementsofCartography,5th edition,John WileyandSons,New York, 6. Sarkar,A.K,(1997):PracticalGeography:ASystematicApproach,OrientLongman,Kolkata 7. Sharma,J,p,(2001):PrayogikBhugol,RastogiPublication,Meerut3rd edition, 8. Singh,R,LandSingh,RanaP,B(1993):ElementsofPracticalGeography,(HindiandEnglishedition),KalyaniPublishers, New Delhi, 9. Steers,J,A,(1965):AnIntroductiontotheStudyofMapProjection,Universityof LondonPress,London.
Learning Outcomes	• Students would get knowledge of principles and types ofmapprojections. • Student would develop knowledge of weathersymbols. • Students would get acquainted with the knowledge of representationofatmosphericfeaturesonmaps.

Course	**B.Sc./B.A.FirstYear:Semester-II**			
CourseTitle	**GGRMD21:Environmental Ethics and Sustainability**			
Category of Course	**Multi-Disciplinary-2**			
Credits&Hourof Teaching		Theory	Practical	Cumulative
	Credits	3		
	Hour of Teaching (Total)	45		
CourseObjectives	• Tointroducethestudentstothebasicsofenvironmentalethics. • Toexplainthestudentsofvarioustheories. • Tointroducethestudentsofgreendevelopmentandbiodiversity • Toacquaintheknowledgeaboutsustainability:conceptandtypes;majorapproaches.			
CourseContent	Thecoursecontentisdividedinto3Units.			
Units	**CourseContent**			**Hr.of Teaching**
I	**EnvironmentalEthics**:Concept and meaning; science, ethics and environment;Moraltheories- anthropocentrism,biocentrism, ecocentrism, deepecology; Population growth and resource linkages; Ecological niche.			15
II	**Decolonial Environmentalism**; Idea of green development; Biodiversity and natural capital assessment; Environmental justice and activism; Environmental legislations in India; Indian traditional knowledge system and ecological values;			15
III	**Sustainability**:Conceptandtypes;Majorapproaches;Sustainable habitat;Biodiversity challenges and restoration; Regional threats of climate change and mitigation; Geopolitics of food production; Principles of sustainability; Implications and impacts of Sustainable Development Goals.			15

SEC-SkillEnhancementCourse, AECAbilityEnhancementCourse; VACValueAdded
Course: MD-MultidisciplinaryCourse1Credit(Theory)=15Hours;1Credit(Practical)=30Hours

Texts/References	1. Ahlawat,Ajay(2019).SustainableDevelopmentGoals-Directive Principles for Sustainable Indiaby2030,Notion Press, NewDelhi 2. Edwards,AndresR.andDavidW.Orr(2005).TheSustainabilityRevolution:Portraitof aParadigmShift,New SocietyPublishers, Canada 3. Tomar,AnjaniSinghandAmitKumarKashyap(2021).SustainableDevelopment:India andBeyond,BhartiPublications, NewDelhi 4. Smith,KimberlyK.(2018).ExploringEnvironmentalEthics:AnIntroduction,SpringerCham 5. Tiwari, DevendraNath and Ananda Msihra (2012). Environmental Ethics: Indian Perspectives, Banaras Hindu University, Varanasi **6.** Zagonari,Fabio(2022).EnvironmentalEthics,SustainabilityandDecisions-LiteratureProblemsandSuggestedSolutions ,SpringerCham
Learning Outcomes	• Students would inculcate the value ofenvironmentalethics. • Students would get acquainted with the knowledgeofenvironmentalism. • Student would understand concepts of biodiversitychallengesandrestoration. • Students would develop awareness about environmental threats and gain knowledge about SustainableDevelopmentGoals..

Course	**B.Sc./B.A.FirstYear:Semester-II**			
CourseTitle	**GGRSE21:Basics of Remote Sensing**			
Category of Course	**SEC-SkillEnhancementCource-2**			
Credits&Hourof Teaching		Theory	Practical	Cumulative
	Credits	3		
	Hour of Teaching (Total)	45		
CourseObjectives	• To introducethestudentstothebasicsofremotesensing. • ToexplainthestudentsofSpectralregionsandbands. • TointroducethestudentsaboutRemoteSensingsatellites:Platformsandsensors • ToacquainttheknowledgeinRemoteSensingapplicationinresourcemapping.			
CourseContent	Thecoursecontentisdividedinto3Units.			
Units	**Course Content**			**Hr.of Teaching**
I	**RemoteSensing**:ConceptandScope;Electro-magnetic Radiation: Characteristics, Spectral regions and Bands; Interaction with earth surface features and atmosphere; Spectral Signature			15
II	**Types of Remote Sensing**: Air borne and Space borne; Aerial photos:Types and Characteristics;RemoteSensing satellites: Platforms and sensors			15
III	**Visual and Digital image processing techniques**: Remote Sensing application in resource mapping and environmental monitoring			15

SEC-SkillEnhancementCourse, AECAbilityEnhancementCourse; VACValueAdded
Course: MD-MultidisciplinaryCourse1Credit(Theory)=15Hours;1Credit(Practical)=30Hours

Texts/References	1. Curran,P.J.(1985):PrinciplesofRemoteSensing,Longman,London 2. Lillesand, T.M. and Kiefer, R.W. (2000): Remote Sensing and Image Interpretation. 4th edition. John Wiley andSons,New York 3. Campbell,J.B.(2002):Introduction toRemoteSensing.5thedition,TaylorandFrancis,London 4. Bhatta,B.(2010):RemoteSensingandGIS,OxfordUniversityPress,NewDelhi. **5.** NagPrithvishandKudratM.(1998):DigitalRemoteSensing,ConceptPublishingCompany,NewDelhi
Learning Outcomes	• Students would inculcate the value ofenvironmentalethics. • Students would get acquainted with the knowledgeofenvironmentalism. • Student would understand concepts of biodiversitychallengesandrestoration. • Students would develop awareness about environmental threats and gain knowledge about SustainableDevelopmentGoals..

Course	**B.Sc./B.A.SecondYear:Semester-III**			
Course Title	**GGRMJ31:Economic Geography**			
Category of Course	**Major**			
Credits &Hour of Teaching		Theory	Practical	Cumulative
	Credits	3		
	Hour of Teaching (Total)	45		
Course Objectives	• Tointroducethestudentstothebasicsofeconomicgeography. • Toexplainthestudentstothelocationofeconomicactivities. • Tointroducethestudentsaboutagriculturalregionsandtypesofindustri • ToacquainttheknowledgeaboutworldtransportationandSEZs.			
Course Content	Thecoursecontentisdividedinto3Units.			
Units	**Course Content**			**Hr.of Teaching**
I	**ConceptualAspects:**Meaning,conceptandscopeofEconomicGeography;Classificationofeconomicactivity;LocationalTheories: Agriculture(VonThunen),Industry(Weber)			15
II	**Primary activities:** Agriculture**,** Fishing, Forestry, and mining ; Agricultural Region of D. Whittlesey; **Secondary activities:** Types and locational factors of industries ;Iron and Steel and Cotton textiles industry; Industrial regions of World;			15
III	**Tertiary and other specialized activities:** World transportation: Sea routes and major trans-continental railways; International trade and World Trade Organization(WTO):patterns and trends; Special Economic Zones (SEZs) and Technology Parks			15

SEC-SkillEnhancementCourse, AECAbilityEnhancementCourse; VACValueAdded
Course: MD-MultidisciplinaryCourse1Credit(Theory)=15Hours;1Credit(Practical)=30Hours

Texts/References	1. Alexander,J.W.(1988):EconomicGeography.Prentice-Hall,NewDelhi 2. Bagchi-SenS.andSmithH.L.,2006:EconomicGeography:Past,PresentandFuture,TaylorandFrancis. 3. Bryson,J.,Henry,N.,Keeble,D.andMartin,R.(eds.)(1999):TheEconomicGeography Reader:ProducingandConsuming Global Capitalism. John WileyandSons, Inc,NewYork. 4. Clark,G.L.,Gertler,M.S.andFeldman,M.P.(eds.)(2000):TheOxfordHandbookofEconomicGeography.Oxford UniversityPress, USA. 5. Coe,N.(2007):EconomicGeography:AContemporaryIntroduction.BlackwellPublishers,Inc.,Massachusetts. 6. Hanink,D.M.(1997):PrinciplesandApplicationsofEconomicGeography:Economy,Policy,Environment.JohnWiley andSons, Inc, NewYork. 7. Hartshorne,T.A.andAlexander,J.W.(1988):EconomicGeography(3rdrevisededition)EnglewoodCliff,NewJersey,PrenticeHall 8. HodderB.W.andLeeRoger,1974:Economic Geography,TaylorandFrancis
Learning Outcomes	• Studentswouldunderstandthebasicsof economicgeography. • Acquainttheknowledgeofthelocationofprimaryandsecondaryactivities. • Studentsunderstandtheagriculturalandindustrialregions. • StudentswouldbeawareoftertiaryactivitiesandSEZs.

Course	**B.Sc./B.A.SecondYear:Semester-III**			
CourseTitle	**GGRMJ32:Surveying**			
Category of Course	**Major**			
Credits&Hourof Teaching		Theory	Practical	Cumulative
	Credits		1	
	Hour of Teaching (Total)		30	
CourseObjectives	• Tointroducethestudentstothebasicsofsurveyingmethod. • ToexplainthestudentstoChainTapeSurveying;PlaneTableSurveying • TointroducethestudentsaboutIndianClinometerandPrismaticCompass surveying. • ToacquainttheknowledgeaboutModernSurveyingTechniques			
CourseContent	Thecoursecontentisdividedinto1Unit.			
Units	**CourseContent**			**Hr.of Teaching**
I	**BasicsofSurveying:**Meaningandscope;Chain& Tape,PlainTable ;IndianClinometer			15
II	**ModernSurveying:** Prismatic Compass,GPS			15

SEC-SkillEnhancementCourse, AECAbilityEnhancementCourse; VACValueAdded
Course: MD-MultidisciplinaryCourse1Credit(Theory)=15Hours;1Credit(Practical)=30Hours

Texts/References	1. Monkhouse,F.J.&Wilkinson,F.J.(1985)MapsandDiagrams.Methuen,London 2. Raisz,E(1962)GeneralCartography.JohnWiley&Sons,NewYork. 3. Sharma,J.P.(2001)PrayogikBhoogol.RastogiPub,Meerut. 4. SinghR.L.&Singh,RanaPB(1993)ElementsofPracticalGeography(H indi&EnglishEdition), Kalyani Publishers,NewDelhi. 5. Singh,LR(2006)FundamentalsofPracticalGeography.ShardaPustakBhawan,Allahabad.
Learning Outcomes	• Studentswouldgetknowledgeofthebasicsofsurveyingmethods. • AcquainttheknowledgeofIndianclinometer. • Studentswouldunderstandthe Prismatic Compasssurveying. • To make students aware of the use and applications of GPS.

Course	**B.Sc./B.A.SecondYear:Semester-III**			
CourseTitle	**GGRMJ33:Geography of India**			
Category of Course	**Major**			
Credits&Hourof Teaching		Theory	Practical	Cumulative
	Credits	4		
	Hour of Teaching (Total)	60		
CourseObjectives	• Tointroducethestudentstothebasicsofphysiographyandresources. • Toexplainthestudentstoaboutagriculturesystemof India. • Tointroducethestudentsaboutindustry,transportandtradesystemofIndiaTo acquaintheknowledgeaboutmajorgeographicalregions.			
CourseContent	Thecoursecontentisdividedinto4Units.			
Units	**Course Content**			**Hr.of Teaching**
I	**Physiography and Resources:** Geology; Physiographic division; Drainage systems; Climate and climatic regions; Soils and natural vegetation; Mineral and power resources: iron ore and coal.			15
II	**Agriculture:**Meansofirrigation;Majorcrops:rice,wheat,cotton,sugarcaneandtea;Agriculturalregions;GreenRevolutionanditsconsequences;Multipurposeprojects:Damodarvalley and Bhakhra Nangal.			15
III	**Industry, Transport, and Trade:** Major industries: iron and steel, cotton textile and sugar; Transport network and trade: structure and recent trends; Special Economic Zones (S E Z s) and Exclusive Economic Zones (EEZs)			15
IV	**Regionalization:** Geographical Region: R.L.Singh; Economic Region: P.SenGupta and Cultural Region: N.K.Bose ;Regional studies: Garhwal Himalaya Region, Middle Ganga PlainandIndianDesert.			15

SEC-Skill Enhancement Course, AEC Ability Enhancement Course; VAC Value Added Course: MD-Multidisciplinary Course1 Credit (Theory)=15Hours;1Credit(Practical)=30Hours

Texts/References	1. 54Chauhan,P.R.andPrasad,M.(2003):BharatKaVrihad Bhugol, Vasundhara Prakashan, Gorakhpur. 2. Gautam,A.(2006):AdvancedGeographyofIndia,Sharda PustakBhawan,Allahabad 3. Khullar,D.R.(2007):India:AComprehensiveGeography,KalyaniPublishers,New Delhi 4. Nag,P.andGupta,S.S.(1992):Geography ofIndia,ConceptPublishingCompany,New Delhi. 5. Rao,B.P.(2007):Bharatkee BhaugolikSameeksha,VasundharaPrakashan,Gorakhpur. 6. Sharma,T.C.andCoutinho,O.(2003): EconomicandCommercial GeographyofIndia,VikasPublishing House Private Ltd. New Delhi. 7. Singh,J.(2003):India:AComprehensiveSystematicGeography.GyanodayaPrakashan, Gorakhpur 8. Singh,J.(2001):Bharat:BhougolikAadharAvamAyam,Gyanodaya Prakashan, Gorakhpur. 9. Singh,R.L.(ed.)(1971):India:ARegionalGeography.NationalGeographicalSocietyofIndia,Varanasi. 10. Spate,O.H.K.,LearmonthA.T.A.andFarmer,B.H.(1996):India, Pakistan and SriLanka. Methuen, London, 7th edition. 11. Tiwari, R.C.(2007):GeographyofIndia,Prayag Pustak Bhawan,Allahabad.
Learning Outcomes	• Studentswouldgetknowledgeofthephysiographyof India. • AcquainttheknowledgeofIndianclimateandvegetation. • Studentswillbe awareoftheagriculturalsystemofIndia • Studentsshouldunderstandthe industry,transport,tradeand regions.

Course	**B.Sc./B.A.SecondYear:Semester-III**			
Course Title	**GGRMV31:Basics of Geographical Information System**			
Category of Course	**Minor Voc**			
Credits & Hour of Teaching		Theory	Practical	Cumulative
	Credits	4		
	Hour of Teaching (Total)	60		
Course Objectives	• TointroducethestudentstothebasicsofGISMapping. • Toexplainthestudentstoaboutscanning,digitization&editing, • Tointroducethestudentsaboutgeoreferencing. • Toacquaintthe knowledgeofcartographicconventions.			
Course Content	Thecoursecontentisdividedinto4Units.			
Units	**Course Content**			**Hr.of Teaching**
I	**Fundamentals of Geographical Information System:** Definition, Evolution of GIS, Components of Geographical Information System; Recent advances in GIS; Coordinate systems, Datums and projections in GIS; GIS Software(OpenSource and commercial)			15
II	**GeographicalInformationSystemData:**RasterandVectordatamodels;DataBaseManagementSystem(DBMS):DataSources;DataQuality:meaning,measures,componentsandmanagement;GeographicalInformationSystem Data Standards: meaning, classification, and components.			15
III	**GeographicalInformationSystemDataAnalysis**:RasterDataAnalysis: Local, neighbourhood and regional operations- overlay analysis, map algebra; Vector Data Analysis: Concept of Topology; Proximity Analysis: Buffering, Thiessen Polygon; Essentials of Map Composition.			15
IV	**Applications of Geographical Information System:**Land use/Land Cover Mapping, geological and geomorphological; Water Resource Management, Disaster Management and Mitigation			15

SEC-SkillEnhancementCourse, AECAbilityEnhancementCourse; VACValueAdded Course: MD-MultidisciplinaryCourse1Credit(Theory)=15Hours;1Credit(Practical)=30Hours

Texts/References	1. Bhatia,J.B.(2008)RemoteSensing&GIS,Oxford. 2. Bonham,CarterG.F.(1995):InformationSystemsforGeoscientists–Modelling with GIS. Pergamon,Oxford. 3. Burrough,P.A.(1986)PrinciplesofGISforLandResourceAssessment,Oxford. 4. Burrough, P.A. and MNDonnell, R. (1998): Principles of Geographic Information Systems. Oxford UniversityPress,Oxford.London 5. Chang, K.T. (2003): Introduction to Geographic Information Systems. Tata MNGraw Hill Publications Company,NewDelhi. 6. Chauniyal,D.D.(2004):RemoteSensingandGeographicInformationSystems.(inHindi) .ShardaPustakBhawan,Allahabad. 7. ESRI(1993):UnderstandingGIS.Redlands,USA 8. FraserTaylor,D.R.(1991):GeographicInformationSystems.PergamonPress,Oxford. 9. Goodchild, M.F.; Park, B. O. and Steyaert, L. T. (eds.) (1993): Environmental Modelling with GIS. OxfordUniversityPress, Oxford. 10. Guptill,S.C.,andMorrison,J.L.(1995):ElementsofSpatialDataQuality.Elsevier/Pergamon,Oxford.
Learning Outcomes	• Studentswouldget theconceptsofGIS. • Studentswouldbeawareoftypes ofdatamodels andDBMS • Theywouldbeabletounderstandtherasterandvectordataanalysis. • StudentswouldunderstandtheapplicationsofGeographicalInformationSystems.

Course	**B.Sc./B.A.SecondYear:Semester-III**			
CourseTitle	**GGRMD31:Global Environmental Challenges**			
Category of Course	**Multi-Disciplinary-III**			
Credits&Hourof Teaching		Theory	Practical	Cumulative
	Credits	3		
	Hour of Teaching (Total)	45		
CourseObjectives	• Tointroducethestudentsaboutbiodiversitylossanddegradation, • ToexplainthestudentstoaboutFoodandwaterinsecurity;energycrisis, • Tointroducethestudentsaboutclimatechange. • Toacquaintheknowledgeofoceanchangesanditsglobalimpacts.			
CourseContent	Thecoursecontentisdividedinto4Units.			
Units	**CourseContent**			**Hr.of Teaching**
I	**LandRelatedIssues**:Populationexplosion,Biodiversityloss,Land degradation and desertification, Soil and waterdegradation,Solid waste, Food and water insecurity; Energycrisis; Forced migration; Infectious disease and pandemic.			15
II	**Atmosphere Related Issues**: AirPollution, Green house gases and ozone depletion, Atomicradiation, Global warming, Flood and famine.ClimateChange.			15
III	**Ocean Related Issues**: Melting icecaps and sealevelrise, Ocean acidification, Overfishing,Commercial whaling, Protecting ocean sanctuaries, Conflicts on territorial water.			15

SEC-SkillEnhancementCourse, AECAbilityEnhancementCourse; VACValueAdded
Course: MD-MultidisciplinaryCourse1Credit(Theory)=15Hours;1Credit(Practical)=30Hours

Texts/References	1. GiacomoCao,RobertoOrrù(2014):CurrentEnvironmentalIssuesandChallenges, SpringerNature. 2. Mal,Suraj(eds.)(2017):ClimateChange,ExtremeEventsandDisasterRiskReduction, SpringerNature. 3. Nakanishi,Yumiko(2016);ContemporaryIssuesinEnvironmentalLaw,SpringerNature. 4. Peszko,Grzegorzandet.al.(2023):AirPollutionandClimateChange, Washington,DC:WorldBankGroup. 5. Sharma,Rahul(2019):EnvironmentalIssuesofDeep-SeaMining,SpringerNature. **6.** Uimonen,Peterand Whalley, John(1997): Environmental Issues in theNewWorldTradingSystem, SpringerNature.
Learning Outcomes	• StudentswouldgetknowledgeofbiodiversityLossandsoiland water degradation. • Studentswouldbeawareofglobalwarmingandclimatechange. • Studentswouldbeabletounderstandtheoceanacidification. • Studentswouldunderstandtheconflictsonterritorialwater.

Course	**B.Sc./B.A.SecondYear:Semester-III**			
CourseTitle	**GGRSE31:Geography of Tourism**			
Category of Course	**SEC-SkillEnhancementCourse-III**			
Credits&Hourof Teaching		Theory	Practical	Cumulative
	Credits	3		
	Hour of Teaching (Total)	45		
CourseObjectives	• Tointroducethestudentsonnature,andscopeofGeographyofTourism. • ToexplainthestudentsaboutTourismasanindustry. • TointroducethestudentsaboutModelsofEcotourism;ImpactsofTourism • ToacquaintthenowledgeofSustainableTourismDevelopmentPlanning.			
CourseContent	Thecoursecontentisdividedinto3Units.			
Units	**CourseContent**			**Hr.of Teaching**
I	**Conceptual:** Nature, and Scope of Geography of Tourism; Data sources;Typology of Tourism: developed and developing world; Tourism as an industry; Drivers of Tourism; Tourism and Regional Economy; Concept of heritage an ditstypes.			15
II	**System of Tourism and Impacts:** Tourism Multiplier and Forecasting Methods; Trends and Pattern of tourism in the World; Models of Ecotourism; Impacts of Tourism-Socio-cultural problems and Environmental degradation.			15
III	**PolicyandPlanning for Heritage-Tourism inIndia:** Of Cultural Heritage: Conservation and Revitalization; Legislation and Acts; Sustainable Tourism Development Planning; Role of tourism in development.			15

SEC-SkillEnhancementCourse, AECAbilityEnhancementCourse; VACValueAdded
Course: MD-MultidisciplinaryCourse1Credit(Theory)=15Hours;1Credit(Practical)=30Hours

Texts/References	1. BhatiaA.K.(1996):TourismDevelopment:PrinciplesandPractices,SterlingPublishers,New 2. Carter,EandG.Lowman(1994):Ecotourism,JohnWileyandSons,NewYork, 3. CharlesR.Goeldner,J.R.BrentRitchie(2009);Tourism:Principles,Practices,Philos ophies,JohnWiley &Sons 4. ChristopherMLaw(2009);UrbanTourism:TheVisitorEconomyandtheGrowthofL argeCities,ContinuumDelhi 5. KamraK.K.andMohinderChand(2007):BasicsofTourism:Theory,OperationandPractice, 6. KanishakaPublishersNewDelhi 7. MinistryofTourism (2011);Strategic ActionPlan for Tourismin India, MinistryofTourism,Government of India 8. Prasad,SheelaandKapilKumarGavsker(2016):'TheNew'Love'StoryoftheTaj Mahal-UrbanPlanningintheAgeofHeritageTourisminAgra',EconomicandPoliticalWe ekly,LI(5):40-48 9. Robinson,H.A.(1996):GeographyofTourism,MacdonaldandEvans,London 10. Williams,Stephen(1998):TourismGeography,Routledge,London
Learning Outcomes	• Students would gettheknowledge ofconceptsoftourism anditstypology. • Studentswillbeawareoftourismasanindustry anditsspatialpatterns. • Studentswouldlearnthe modelsofecotourismandtheimpactsoftourism. • Studentswouldunderstandthe heritage: conservationandrevitalization.

Course	**B.Sc./B.A.SecondYear:Semester-IV**			
CourseTitle	**GGRMJ41:Evolution of Geographical Thought**			
Category of Course	**Major**			
Credits&Hourof Teaching		Theory	Practical	Cumulative
	Credits	4		
	Hour of Teaching (Total)	60		
CourseObjectives	• Tointroducethestudentsonhistoryofgeographicalknowledge. • Toexplainthestudentsaboutcontributionofvariousscholarsandgeographers. • Tointroducethestudentsaboutapproachesingeography. • ToacquainttheknowledgeofIndianscholarsingeographicalknowledge.			
CourseContent	Thecoursecontentisdividedinto4Units.			
Units	**CourseContent**			**Hr.of Teaching**
I	**Geography and Geographical Concepts**: Early origins of geographical thinking regarding philosophies; Age of exploration and impact of discoveries.			
II	**Schools of Geography:** Evolution of geographical thinking and disciplinary trends in Germany, France, Britain and United States of America;			
III	**ContemporaryThemes:**Positivism, Quantitative Revolution, Behaviouralism, Humanism, Radicalism, Feminism, Post-Modernism and Post Colonialism.			
IV	**Geography in India:** Geographical knowledge in ancient India, Teaching and Research in geography during colonial and post-colonial periods; Geography teaching and researchin21st century: challenges and opportunities; Geography inplanning, policy and regional development.			

SEC-SkillEnhancementCourse, AECAbilityEnhancementCourse; VACValueAdded Course: MD-MultidisciplinaryCourse1Credit(Theory)=15Hours;1Credit(Practical)=30Hours

Texts/References	1. Daniels,P.,Bradshaw,M.,Shaw,D.andSidaway,J.(2000):AnIntroductiontoHumanGeography.Issuesforthe21stCentury. PrenticeHall,London. 2. Dear, M.J. and Flusty, S. (2002): The Spaces of Postmodernity: Readings in Human Geography. BlackwellPublishers,Oxford. 3. Dikshit,R.D.(2004):GeographicalThought.ACriticalHistoryofIdeas.Prentice-HallIndia,NewDelhi. 4. Harvey,M.E.and Holly,P.B.(2002):ThemesinGeographicThought.RawatPublications,NewDelhi. 5. Hubbard,P.,Kitchin,R.,Bartley,B.andFuller,D.(2002):ThinkingGeographicallly:Space,Theory andContemporary HumanGeography. Continuum, London. 6. Johnston,R.J.andSidaway,J.D.(2004):GeographyandGeographers.6thedition,EdwardArnold,London. 7. Martin,G.,(2005):AllPossibleWorlds.AHistoryofGeographicalIdeas.4thedition,OxfordUniversityPress,New York. 8. Peet,R.(1998):ModernGeographicalThought.BlackwellPublishersInc.,Massachusetts. 9. Taylor,G.(ed.)(1953):Geographyin the TwentiethCentury.Methuen andCompanyLtd.andCompany,London. 10. Tuan,Yi-Fu(1977): Space and Place. The Perspective of Experience. Edward Arnold,London.
Learning Outcomes	• Studentswouldgettheknowledge ofgeographicalideas. • Studentswouldbeawareofvariousschoolsofthought. • Studentswouldbeabletounderstandcontemporarythemesandapproaches. • StudentswouldunderstandtheIndianpolicyandregionaldevelopment.

Course	**B.Sc./B.A.SecondYear:Semester-IV**			
CourseTitle	**GGRMJ42:Environmental Geography**			
Category of Course	**Major**			
Credits&Hourof Teaching		Theory	Practical	Cumulative
	Credits	4		
	Hour of Teaching (Total)	60		
CourseObjectives	• Tointroducethestudentsonnatureandscopeofenvironmentalgeography • Toexplainthestudentsaboutmanandenvironmentrelationships. • Tointroducethestudentsto factorsofenvironmentaldegradation. • Toacquainttheknowledgeofenvironmentalconservationandmanagement..			
CourseContent	Thecoursecontentisdividedinto4Units.			
Units	**CourseContent**			**Hr.of Teaching**
I	**Concept:**Natureand scope of environmental geography; Environment and its components; Ecosystem; Biodiversity; Biogeochemical cycles;Ecological succession; Deep Ecology.			15
II	**Man-Environment Relationship:** Approaches (deterministic, possibilistic and ecological); Historical evolution; Human ecological Adaption; Forms and functions of ecosystems(terrestrial and aquatic).			15
III	**Global Environmental challenges:** Environmental degradation; pollution; hazards and disaster (FloodTechnological);GlobalandRegionalEcologicalChange;Urbanheatisland;Climatic change.			15
IV	**Environmental Management:** Environmental			15

SEC-SkillEnhancementCourse, AECAbilityEnhancementCourse; VACValueAdded
Course: MD-MultidisciplinaryCourse1Credit(Theory)=15Hours;1Credit(Practical)=30Hours

Texts/References	1. ChandnaR.C.(2002):EnvironmentalGeography,Kalyani,Ludhiana. 2. Cunninghum W. P. and Cunninghum M. A. (2004): Principals of EnvironmentalScience: Inquiry andApplications,TataMacgrawHill, New Delhi. 3. DeBlij,H.J.(1996):HumanGeography:Culture,Societyand Space, 2nd edition. John Wiley and Sons,NewYork. 4. GoudieA.(2001):TheNatureoftheEnvironment,Blackwell,Oxford. 5. Huggett,R.J.(1998):FundamentalsofBiogeography,Routledge,London. 6. Johnston,R.J.,Gregory,D.,Pratt,G.andWatts,M.(2000):TheDictionaryofHumanGeography.4thedition,BasilBlackwell Publishers, Oxford. 7. MillerG.T.(2004):EnvironmentalScience:WorkingwiththeEarth,Thomson BrooksCole,Singapore. 8. Odum,E.P.etal,(2005):FundamentalsofEcology,CengageLearningIndia. 9. Saxena,H.M.(2000):EnvironmentalManagement.RawatPublications.,JaipurandNewDelhi. 10. Singh,S.(2001):ParyavaranBhugol,PrayagPustakBhawan, Allahabad.(inHindi).
Learning Outcomes	• Students wouldbeabletounderstandtheenvironmentalaspects. • Studentswouldbeawareof varioustypesofenvironmentsandtheirfunctions. • Studentswouldunderstandthecontemporarythemesandapproaches. • Studentswouldunderstandenvironmentalmanagement.

Course	B.Sc./B.A.SecondYear:Semester-IV			
CourseTitle	**GGRMJ43:Geomorphology**			
Category of Course	**Major**			
Credits&Hourof Teaching		Theory	Practical	Cumulative
	Credits	4		
	Hour of Teaching (Total)	60		
CourseObjectives	• Tointroducethestudentsonnatureandscopeofgeomorphology. • Toexplainthestudentsaboutfundamentalconcepts. • Tointroducethestudentsaboutcontributionsofgeomorphologists. • Toacquaintheknowledgeofregionalgeomorphology...			
CourseContent	Thecoursecontentisdividedinto4Units.			

Units	Course Content	Hr.of Teaching
I	**Basic Concepts:** Meaning, nature, scope and aspects of geomorphology; Principles and basis of geological time-scale;Fundamental concepts: uniform itarianism and dynamic equilibrium; Relief and differential rate of the geomorphic process.	15
II	**Instability of the Earth:** Isostasy (Airy and Pratt); plate tectonics;Folded andFaultedstructureand topography, earthquake, volcanicity, masswasting; The cycle of erosion:contributionsofDavisandPenck.	15
III	**GradationProcesses:**Geomorphicagentsandprocesses:fluvial,aeolian,glacial,peri-glacial, marine and karst; Types and patterns of drainage, Channel: types and pattern.	15
IV	**AppliedGeomorphologyandRegionalLandscape:**Geomorphologyandeconomicdeposits;Geomorphologyinengineeringconstruction;Geomorphologyingroundwaterstudies,Geomorphologyandsoil;RegionalgeomorphologyofUttarakhandHimalaya,ChhotanagpurplateauandMiddleGangaPlain	15

SEC-SkillEnhancementCourse, AECAbilityEnhancementCourse; VACValueAdded
Course: MD-MultidisciplinaryCourse1Credit(Theory)=15Hours;1Credit(Practical)=30Hours

Texts/References	1. Bloom,A.L.(1992):Geomorphology–ASystematicAnalysis.Prentice-HallIndia,NewDelhi. 2. Chorley,R.J.,Schumm,S.A.andSugdenD.E.(1984):Geomorphology.Methuen,London 3. Dayal,P.(1994):AtextbookofGeomorphology,KalyaniPublishers,NewDelhi. 4. Holmes,A.(1987):PrinciplesofPhysicalGeology.Nelson,NewYork,3rdedition. 5. Kale,V.andGupta,A.(2001):Elements ofGeomorphology.OxfordUniversityPress,Delhi. 6. Singh,S.(2004): Geomorphology,PrayagPustakBhawan,Allahabad 7. Skinner,B.J.andPorter,S.C.(1996):TheDynamicEarth.JohnWileyandSons,NewYork, 8. Sparks,B.W.(1969):Geomorphology.Longman,London. 9. Stoddard,D.R.(ed.)(1996):ProcessandForminGeomorphology.Routledge,London. 10. Thornbury,W.D.(1990):PrinciplesofGeomorphology.WileyEasternEdition,NewYork.
Learning Outcomes	• Studentswouldbeabletogetknowledgeofbasicconceptsofgeomorphology. • Studentswouldbeawareofthedifferentialrateofthegeomorphic process. • Studentswouldunderstandcontemporarythemesandapproaches. • Studentswouldunderstandtheappliedgeomorphologyandregionallandscape.

Course	**B.Sc./B.A.SecondYear:Semester-IV**			
CourseTitle	**GGRMJ44:Advanced Map Projection and Geological Map**			
Category of Course	**Major**			
Credits&Hourof Teaching		Theory	Practical	Cumulative
	Credits		2	
	Hour of Teaching (Total)		60	
CourseObjectives	• TointroducethestudentsonClassificationofmapprojections. • ToexplainthestudentsaboutElementsofgeologicalmaps....			
CourseContent				
Units	**CourseContent**			**Hr.of Teaching**
I	**Map Projection (Mathematical):** Meaning, Classification and scope of map projections; Conical: Sinusoidal, Interrupted Sinusoidal and Mollweide; Cylindrical: Mercator's and Gall'sprojection; International projections			30
II	**Geological Map:** Elements of geological maps; Beds and bedding plane; Strike, Dip; Completion of outcrop ;geological structure(uniclinal,folded,faultedandunconformable)andtheirdescription.			30

SEC-SkillEnhancementCourse, AECAbilityEnhancementCourse; VACValueAdded
Course: MD-MultidisciplinaryCourse1Credit(Theory)=15Hours;1Credit(Practical)=30Hours

Texts/References	1. Blyth,F.G.H.,(1965):GeologicalMapsandTheirInterpretation.EdwardArnold(Publisher) Ltd.,London. 2. Hinks,A.R.(1921):MapProjection,CambridgeUniversity Press,London. 3. Mishra,R.N.andSharma,P.K.,(2023):PracticalGeography:MethodsandTechniques.PareekPublications,Jaipur. 4. Mishra,R.P.andRameshA.(1989):FundamentalsofCartography,ConceptPublishingCompany,NewDelhi. 5. Monkhouse,F.J.andWilkinson,F.J.(1985):MapsandDiagrams.Methuen,London. 6. Robinson,A.H.,Sale,R.,Morrison,J.andMuehrcke,P.C.(1984):ElementsofCartography.5th edition,JohnWileyand Sons, New York. 7. Sarkar,A.K.(1997):PracticalGeography:ASystematicApproachOrientLongman,Kolkata .Sharma,J.P.(2001):PrayogikBhugol. RastogiPublication,Meerut3rd edition. 8. Singh, R.L. and Singh, Rana P.B. (1993): Elements of Practical Geography (Hindiand Englisheditions). KalyaniPublishers, New Delhi. 9. Steers,J.A.(1965):AnIntroductiontotheStudyofMapProjection.University ofLondonPress,London.
Learning Outcomes	• Studentswouldbeabletounderstandthebasicconceptsofcartography. • Studentswouldbeawareofmapprojection. • Studentswouldbeabletounderstandthegeologicalstructureandtheirdescription.

Course	**B.Sc./B.A.ThirdYear:Semester-V**			
CourseTitle	**GGRMJ51:Climatology**			
Category of Course	**Major**			
Credits&Hourof Teaching		Theory	Practical	Cumulative
	Credits	4		
	Hour of Teaching (Total)	60		
CourseObjectives	• Toacquaint thestudentsabout the natureandscopeof climatology. • Tomake the students understand the concept of Heat budget, laws of horizontal motion and air masses. • Todevelop an understanding of climate change and its impact among students.			
CourseContent	Thecoursecontentisdividedinto4Units.			
Units	**CourseContent**			**Hr.of Teaching**
I	**Basics of Climatology**: Meaning and scope; Development and recent trends in climatology; Subdivisions of climatology; Elements of weather and climate; Data sources for climatological studies.			15
II	**Functions of Atmosphere**: Composition and structure of atmosphere;insolation; Heat budget; Air stability; Laws of horizontal motion; general atmospheric circulation; AirMasses: classification and characteristics			15
III	**WeatherPhenomena**:CloudsandPrecipitation:formationandtypes;Fronts:sourceregions,typesandassociated weather; Cyclones: tropical and temperate; Monsoon, jet-stream and their significance with reference to India.			15
IV	**ClimateandHumanResponse**:Climaticclassification:KöppenandThornthwaite;Climatechange: causes, evidence and hypotheses, impacts and mitigation			15

SEC-SkillEnhancementCourse, AECAbilityEnhancementCourse; VACValueAdded
Course: MD-MultidisciplinaryCourse1Credit(Theory)=15Hours;1Credit(Practical)=30Hours

Texts/References	1. Barry,R.G.andCarleton,M.(2001):SynopticandDynamicClimatology,Routledge,London. 2. Chorley,R.J.(2001):Atmosphere,WeatherandClimate.Methuen,London. 3. Critchfield,H.J.(2002):GeneralClimatology.Prentice-HallofIndia,NewDelhi. 4. Finch,J.C.andTrewartha,G.T.:ElementsofWeatherandClimate.Prentice-Hall,London. 5. Kendrew,W.C.(1998):Climatology.EdwardArnold,London.5thedition. 6. Lal,D.S.(1986):Climatology.ChaitanyaPublications,Allahabad. 7. Oliver,J.E.andHidore,J.J.(2003):Climatology:AnAtmosphericScience,PearsonEducationPrivateLtd,Patparganj, Delhi. 8. Robinson,P.J. andHenderson,S.(1999):ContemporaryClimatology, 2ndedition,Pearson EducationLtd.,Harlow,UK 9. Singh,M.B.(1998):JalvayuAvamSamudraVigyan.TaraBookAgency,Varanasi. **10.** Singh,M.B.(1999):JalvayuAvamJalVigyan.TaraBookAgency,Varanasi,
Learning Outcomes	• The students will be able to learn about thestructure and composition of atmosphere. • They will be able to distinguish between various types of cyclones, and air masses, associated climate and weather changes. • They will develop an understanding of the concept, causes and impact of climate change.

Course	**B.Sc./B.A.ThirdYear:Semester-V**			
Course Title	**GGRMJ52:World Regional Geography**			
Category of Course	**Major**			
Credits &Hour of Teaching		Theory	Practical	Cumulative
	Credits	4		
	Hour of Teaching (Total)	60		
Course Objectives	To introduce the students about region and regionalization. To make the students understand the distribution and characteristics of agricultural and industrial regions of the world. Toacquaintthestudents about the physical, economic and cultural aspects of Japan, Brazil and select countries of South Asia.			
CourseContent	Thecoursecontentisdividedinto4Units.			
Units	**CourseContent**			**Hr.of Teaching**
I	**Concepts:**Region and Regionalization; Bases of Regionalization; Typesof Regions; Bases & Approaches of classification and characteristics of Developed and Developing World; Levels of Development: Developed, Developing,Under-developed and Least developed World			15
II	**Major Regions of the World:** Natural regions, Climatic regions, Cultural regions, Agricultural regions, Industrial regions,Population resource regions			15
III	**RegionalStudyofJapanandBrazil:**Physiography,Climate,Soil,Vegetation,Mineral,PowerResources(IronoreandCoal),IndustriesandPopulation			15
IV	**Regional study of South Asia:** Physiography, Climate, Soil, Vegetation,MineralandPowerResources,Population,StrategicImportanceofSouthAsia.			15

SEC-SkillEnhancementCourse, AECAbilityEnhancementCourse; VACValueAdded Course: MD-MultidisciplinaryCourse1Credit(Theory)=15Hours;1Credit(Practical)=30Hours

Texts/References	1. Blij,H.J.De,(1971):Geography:RegionsandConcepts,JohnWileyandSons. 2. ClavalP.l,(1998):AnIntroductiontoRegionalGeography, Black well Publishers, Oxford and Massachusetts. 3. FriedmannJ.andAlonsoW.(1975):RegionalPolicy-Readings in Theory and Applications, MIT Press,Massachusetts. 4. Gavsker. K. K. (2014). Conceptualizing the *Region*: An Overview of Recent Developments and Relevance, InternationalJournalof Innovative ResearchandPractices,2(12):8-20 5. GoreC.G.,(1984):RegionsinQuestion: Space, Development Theory and Regional Policy, Methuen,London. 6. GoreC.G.,KöhlerG.,ReichU. P. and Ziesemer T.,(1996): Questioning Development; Essays on the Theory, Policies and Practice of Development Intervention, Metropolis- Verlag,Marburg. 7. HaynesJ.,(2008):DevelopmentStudies,PolityShortIntroductionSeries. 8. JohnsonE.A.J.,(1970):TheOrganizationofSpaceinDevelopingCountries,MITPress,Massachusetts. 9. PeetR.,(1999):TheoriesofDevelopment,TheGuilfordPress,NewYork 10. Rai,G.,(2016):RegionalGeographyoftheWorld(*inHindi*),WisdomBooks,Varanasi 11. Rai,G.,(2019):Asia:RegionalGeography(*inHindi*),WisdomPublications, Varanasi. 12. Rai,G.,(2019):RegionalStudyofSouthEastAsia(*inHindi*),WisdomPublications,Varanasi.
Learning Outcomes	• The students will learn about the basis of classification and characteristics of a region. • They will get familiarized with the distinguishing characteristics of developed, developing and under-developed countries. • They will learn the concept and characteristics of population resource region. • They will gain knowledge of the physical, economic and cultural aspects of Japan, Brazil and select countries of South Asia.

Course	**B.Sc./B.A.ThirdYear:Semester-V**			
CourseTitle	**GGRMJ53:Population Geography**			
Category of Course	**Major**			
Credits&Hourof Teaching		Theory	Practical	Cumulative
	Credits	4		
	Hour of Teaching (Total)	60		
CourseObjectives	• Tomake the students understand meaning,scopeanddevelopmentofpopulationgeography. • Tofamiliarizethem with the concept, determinants and characteristics of fertility, mortality and migration. • Tomake them understand the populationcharacteristics and policiesofIndia. • To familiarize them with the trends and distribution of world population, urbanization and population problems.			
CourseContent	Thecoursecontentisdividedinto4Units.			

Units	**CourseContent**	**Hr.of Teaching**
I	**BasicConcepts:**Meaning,scopeanddevelopmentofpopulationgeography;RelationshipofPopulationgeographywithotherbranchesofsocialsciences;Sourcesandtypesofpopulationdata:census,samplesurvey,vitalregistrationsystem.	15
II	**PopulationDynamics:**Measures,trendsandpatternofFertilityandMortality;Concept,types,determinantsandconsequencesofMigration;Theoriesof population growth: Malthusian, Demographic Transition Theory;	15
III	**World Population:**Populationdistributionand growth; Population agglomerations; Urbanization trends and patterns; Human Resource Development: indicators and patterns; Population problems.	15
IV	**PopulationCharacteristicsinIndia:**Population distribution, Density And Growth; Literacy; Age and Sex composition; Population Policies of India.	15

SEC-SkillEnhancementCourse, AECAbilityEnhancementCourse; VACValueAdded Course: MD-MultidisciplinaryCourse1Credit(Theory)=15Hours;1Credit(Practical)=30Hours

Texts/References	1. Chandana,R.C.(2006):Geography ofpopulation.KalyaniPublisher NewDelhi. 2. Clarke,J.I.(1972):PopulationGeography.PergamonPress,Oxford. 3. Demko,G.J.,Rose,H.M.,andSchnell,G.A.(1970):PopulationGeography.AReaderMNGraw-Hill,NewYork. 4. Dube,K.K.andSingh,M.B.(1994):JansankhyaBhoogol,RawatPublications,Jaipur. 5. Garnier,B.J.(1993):GeographyofPopulation.3rdedition,Longman,London. 6. Jones,H.R.(1981):APopulation Geography.HarperandRow,NewYork. 7. Peters,G.L.and Larkin,R.P.(1983):PopulationGeography:Problems,ConceptsandProspects.Kendall/Hunt,Dubuque,IA. 8. Trewartha,G.T.(1985):AGeographyofPopulation:WorldPatterns.Jhon Wiley and Sons,NewYork. 9. Zelinsky,W.(1966):AProloguetoPopulationGeography,PrenticeHall,New Jersey.
Learning Outcomes	• Studentswouldbeabletounderstand the developmentofpopulationgeography • StudentswouldbeabletolearnaboutPopulationagglomerations. • They eill be Acquaintedtheknowledgeof Populationproblems. • Studentswouldbeabletounderstandtheregionalvariations.

Course	**B.Sc./B.A.ThirdYear:Semester-V**			
CourseTitle	**GGRMJ54:CartographicTechniques**			
Category of Course	**Major**			
Credits&Hourof Teaching		Theory	Practical	Cumulative
	Credits		2	
	Hour of Teaching (Total)		60	
CourseObjectives	• TointroducethestudentsonNatureandtypesofdata. • ToexplainthestudentsaboutDistributionmaps.			
CourseContent	Thecoursecontentisdividedinto2Units.			
Units	**CourseContent**			**Hr.of Teaching**
I	**Representation of Data:** Nature and types of data; Representationof data:bar diagram, histogram, frequency curve, linegraph, ogive, piechart; Trafficflow diagram; Slope analysis: Smith and Wentworthmethods.			30
II	**Distribution Maps and Diagrams:** Rain fall dispersion diagram, water balance graph Distribution maps: dot, isopleth, choropleth, choro chromatic and choros chematic. Graded and nongraded shadings.			30

SEC-SkillEnhancementCourse, AECAbilityEnhancementCourse; VACValueAdded
Course: MD-MultidisciplinaryCourse1Credit(Theory)=15Hours;1Credit(Practical)=30Hours

Texts/References	1. Blyth,F.G.H.,(1965):GeologicalMapsand Their Interpretation.EdwardArnold(Publisher)Ltd.,London. 2. Hinks,A.R.(1921):MapProjection,CambridgeUniversityPress,London. 3. Mishra,R.N.andSharma,P.K.,(2023):PracticalGeography:MethodsandTechniques.PareekPublications,Jaipur. 4. Mishra,R.P.andRameshA.(1989):FundamentalsofCartography,ConceptPublishingCompany,NewDelhi. 5. Monkhouse,F.J.andWilkinson,F.J.(1985):MapsandDiagrams.Methuen,London. 6. Robinson,A.H.,Sale, R., Morrison, J. and Muehrcke, P.C.(1984): Elements of Cartography. 5th edition, John WileyandSons, New York. 7. Sarkar,A.K.(1997):PracticalGeography:ASystematicApproachOrientLongman,Kolkata. 8. Sharma,J.P.(2001):PrayogikBhugol.RastogiPublication,Meerut3rdedition. 9. Singh,R.L.andSingh,RanaP.B.(1993):ElementsofPracticalGeography.(HindiandEnglisheditions).KalyaniPublishers,New Delhi. **10.** Steers,J.A.(1965):AnIntroductiontotheStudyofMapProjection.UniversityofLondonPress,London.
Learning Outcomes	• Studentswouldbeabletounderstand the knowledgeonbasicconceptsofcartography. • They will be able to knowaboutoneandtwostandardparallels. • Studentswouldbeabletounderstand the geologicalstructureandtheirdescription.

Course	B.Sc./B.A.ThirdYear:Semester-V			
CourseTitle	**GGRMV51:Hazards & Disaster Risk Reduction**			
Category of Course	**Minor Voc**			
Credits&Hourof Teaching		Theory	Practical	Cumulative
	Credits	4		
	Hour of Teaching (Total)	60		
CourseObjectives	• Tointroducethemeaning,concepts,anddefinitionsofdisaster. • Toexplaindisastermanagementcycle:prevention,mitigationandpreparedness. • Tointroducethestudentsaboutenvironmentalhealth. • ToacquainttheknowledgeofriskmanagementinIndia.			
CourseContent	Thecoursecontentisdividedinto4Units.			

Units	CourseContent	Hr.of Teaching
I	**Introduction to Disasters:** Concepts, and definitions (Disaster, Hazard, Vulnerability, Resilience, Risks; Disasters: Classification; Causes, Impacts & Approaches to Disaster Risk Reduction: Social, economic, political, environmental, health, psychosocial, etc.	15
II	**Differential impacts**: in terms of caste, class, gender, age, location, disability Global trends in disasters; Disaster management cycle: prevention, mitigation and preparedness; myths and social responces.	15
III	**Disaster Risk Management in India:** Community based Disaster Risk Reduction, Structural- nonstructural measures; Hazard and vulnerability profile of India, Institutional arrangements, Disastermitigation.	15
IV	**Case Studies:** Landslide, Cloud burst, Mitigation,Response and Preparedness, Disaster Mitigation Act and Policy, Other related policies, plans , programs and legislation.	15

SEC-SkillEnhancementCourse, AECAbilityEnhancementCourse; VACValueAdded
Course: MD-MultidisciplinaryCourse1Credit(Theory)=15Hours;1Credit(Practical)=30Hours

Texts/References	1. AlexanderDavid,Introductionin 'ConfrontingCatastrophe',OxfordUniversityPress,2000 2. AndhariaJ.VulnerabilityinDisasterDiscourse,JTCDM,TataInstituteofSocialSciences WorkingPaperno.8,2008 3. Blaikie,P,CannonT,DavisI,WisnerB1997.AtRiskNaturalHazards,Peoples'Vulnerability andDisasters,Routledge. 4. CoppolaPDamon,2007.Introductionto InternationalDisasterManagement, 5. Carter,Nick1991.DisasterManagement:ADisasterManager'sHandbook.AsianDe velopmentBank,ManilaPhilippines. 6. Cuny,F.1983.DevelopmentandDisasters,OxfordUniversityPress.DocumentonWorld SummitonSustainableDevelopment2002. 7. Govt.ofIndia:DisasterManagementAct2005,GovernmentofIndia,NewDelhi.Go vernmentofIndia,2009.NationalDisasterManagementPolicy, 8. GuptaAnilK,SreejaS.Nair.2011EnvironmentalKnowledgeforDisaster Risk Management, NIDM,NewDelhi 9. Kapur,Anu&others,2005:Disastersin IndiaStudiesofgrimreality,RawatPublishers, Jaipur 10. KapurAnu2010:VulnerableIndia:AGeographicalStudy of Disasters, IIA Sand Sage Publishers,NewDelhi.
Learning Outcomes	• Studentswouldbeabletounderstandthe knowledge of Disaster, Hazard, Vulnerability. • Studentswouldbeabletounderstandthe knowledge about **S**ocial, economic, political environment. • Theywillbe Acquainted the knowledge of Population problems with disaster. • Student should understand the Hazard and Vulnerability profile of India.

Course	B.Sc./B.A.ThirdYear:Semester-V			
CourseTitle	**GGRIN51:Internship**			
Category of Course	**Internship-1**			
Credits&Hourof Teaching		Theory	Practical	Cumulative
	Credits	2		
	Hour of Teaching (Total)	30		

Course	B.Sc./B.A.ThirdYear:Semester-VI			
CourseTitle	**GGRMJ61:Advanced Remote Sensing and Geographical Information System**			
Category of Course	**Major**			
Credits&Hourof Teaching		Theory	Practical	Cumulative
	Credits	4		
	Hour of Teaching (Total)	60		
CourseObjectives	• To introduce the Meaning,Concepts,and basics of remote sensing. • To explain Characteristics and spectral bands. • To introduce the students about remote sensing processes. • To acquaint the knowledge of satellite data interpretation.			
CourseContent	Thecoursecontentisdividedinto4Units.			

Units	CourseContent	Hr.of Teaching
I	**BasicsofRemoteSensing**:Definition,scope,andhistoryofDevelopment;Types of Remote Sensing: basis and classification; Electromagnetic Radiation(EMR): Characteristics and spectral bands; EMR interaction with the Atmosphere ,and Earth's Surface (Land,soilandwater); Atmospheric Windows; Spectral Signature;Acquisitionofremotesensingdata	15
II	**Remote Sensing Processes:** Platforms and Sensors: Types and characteristics;AerialPhotographs:Typesanditsgeometry;Remote SensingData:Types,characteristicsand sources; Image Resolution; Satellite Data Interpretation: Visual and digital image interpretation ;Interpretation keys, Techniques in image interpretation	15
III	**Fundamentals of GIS:** Definition, Evolution and Components of Geographical information system; Recent advances in Geographical Information System;Coordinate systems, Datums and projections in Geographical InformationSystem;Raster and Vector data models; GIS data quality, errors, input, geo-referencing,digitization,editing,query,andoutput.Typesand characteristicsofmap,contentsandlayoutinGeographicalInformationSystem.	15
IV	**ApplicationsofRemoteSensingandGeographicalInformation System:** Land use/Land Cover Mapping ,Geological and geomorphological mappingandwaterresourcemanagement,.	15

SEC-SkillEnhancementCourse, AECAbilityEnhancementCourse; VACValueAdded Course: MD-MultidisciplinaryCourse1Credit(Theory)=15Hours;1Credit(Practical)=30Hours

Texts/References	1. Bolstad,P.(2005).GISFundamentals:AFirstTextonGeographicInformationSystems.EiderPress. 2. Elangovan,K.(2006).GIS:Fundamentals,ApplicationsandImplementations. NewIndiaPublishing. 3. Jensen,J.R.(2009).RemoteSensingofTheEnvironment:AnEarthResourcePerspective2/E.PearsonEducation India. 4. Lillesand,T.,Kiefer,R.W.,&Chipman,J.(2014).RemoteSensingandImageInterpretation. JohnWiley&Sons.

	5. Panigrahi,N.(2009).GeographicalInformationScience.UniversitiesPress. 6. Rees,W.G.(2012).PhysicalPrinciplesofRemote Sensing.CambridgeUniversityPress. **7.** Sabins,F.F.(2007).RemoteSensing:PrinciplesandApplications.WavelandPress.
Learning Outcomes	• Studentswould be able to learn theknowledgeofresponsepatternofearthfeatures. • Studentswould be able to awareaboutplatformsandsensors. • They will be acquaintedabout visualanddigitalimageinterpretation. • Studentshouldunderstandthespatialandnon-spatialdataattributes.

Course	**B.Sc./B.A.ThirdYear:Semester-VI**			
CourseTitle	**GGRMJ62:Oceanography**			
Category of Course	**Major**			
Credits&Hourof Teaching		Theory	Practical	Cumulative
	Credits	4		
	Hour of Teaching (Total)	60		
CourseObjectives	• TointroducetheMeaning,Concepts,andbasicsofremotesensing. • ToexplainCharacteristicsandspectralbands. • Tointroducethestudentsaboutremotesensingprocesses. • Toacquainttheknowledgeofsatellitedatainterpretation.			
CourseContent	Thecoursecontentisdividedinto4Units.			
Units	**CourseContent**			**Hr.of Teaching**
I	**Basic Concepts:** Meaning and scope of oceanography; Origin of oceans; Ocean basins: continental shelf, continental slope,deepseaplains, ocean deeps, submarine canyons.			15
II	**Properties and Circulation:** Physical and chemical properties of sea water: temperature, density, salinity; Circulation of ocean water:tidesandcurrents.			15
III	**MarineLifeandDeposits:**Classificationanddistributionofmarinedeposits,Coralreefs:origin,types,characteristicsandtheories.			15
IV	**HumanOceanRelation:**Mineralandenergyresources;Indian Ocean Realm;Geo-politicsofIndianocean;Maritime security; Global warming and sea level change.			15

SEC-SkillEnhancementCourse, AECAbilityEnhancementCourse; VACValueAdded
Course: MD-MultidisciplinaryCourse1Credit(Theory)=15Hours;1Credit(Practical)=30Hours

Texts/References	1. CuchlaineA.M.King,(1965),Oceanographyforgeographers,EdwardArnoldLtd,London 2. GerhardNeumann,WillardJ.Pierson,Jr.(1966),Principles Physical Oceanography,Prentic-Hall,Inc.EnglewoodCliffs,N.J. 3. Lal,D.S.(2009),ClimatologyandOceanography,ShardaPustakBhavan,Allahabad. 4. MNPherson,Kenneth.(1993).TheIndianOcean:AHistoryofPeopleandtheSea.Oxford: OxfordUniversityPress 5. Pearson,Michael.(2003).TheIndianOcean.Routledge,London. 6. Sverdrup,HaraldUlrik;Johnson,MartinWiggo;Fleming,RichardH.(1942).TheOceans,TheirPhysics,Chemistry,andGeneralBiology.NewYork:Prentice-Hall. 7. Sverdrup,KeithA.,Duxbury,AlynC.,Duxbury,AlisonB.(2006).FundamentalsofOceanography,MNGraw-Hill 8. TalleyL.D.,PickardG.L.,EmeryW.J.andSwiftJ.H.(2011).DescriptivePhysicalOceanography:AnIntroduction(SixthEditionElsevier,Boston. 9. Vatal,M., Sharma,R.C.(2011) ,ChaitanyaPublishingHouse,Allahabad.

Learning Outcomes	• Studentswouldbeabletounderstand the knowledge of submarine canyons. • Studentswouldbeabletolearn the knowledge about Circulation of ocean water. • They will be acquaintedabout the knowledge of Marine Life and Deposits. • Studentswouldbeabletounderstand to Global warming and seal evel change.

Course	**B.Sc./B.A.ThirdYear:Semester-VI**			
CourseTitle	**GGRMJ63: Remote Sensing and Geographical Information SystemTechniques**			
Category of Course	**Major**			
Credits&Hourof Teaching		Theory	Practical	Cumulative
	Credits		2	
	Hour of Teaching (Total)		60	
CourseObjectives	• TointroducetheMeaning,Concepts,andbasicsofremotesensing. • ToexplainCharacteristicsandspectralbands. • Tointroducethestudentsaboutremotesensingprocesses. • Toacquainttheknowledgeofsatellitedatainterpretation.			
CourseContent	Thecoursecontentisdividedinto2Units.			
Units	**CourseContent**			**Hr.of Teaching**
I	**RemoteSensingDataCollectionandInterpretation:**Datasources; Elements of Aerial Photo and Satellite Image Interpretation; Preparation of the maticmaps viz. Land use/ Land cover, and geomorphological mapping			30
II	**Geographical Information System Data and its Analysis:** Data sources:Bhuvan; Image Registration, Creation of Personal Geodatabase: Digitizationand creation of shape files: Point, Line and Polygon, adding attributes Data error corrections; Spatialandnon-Spatial Data Query; Spatial analysis methods (overlay,buffering,andinterpolation)			30

SEC-SkillEnhancementCourse, AECAbilityEnhancementCourse; VACValueAdded
Course: MD-MultidisciplinaryCourse1Credit(Theory)=15Hours;1Credit(Practical)=30Hours

Texts/References	1. Claudia,K.,Stefan,D.,2014.QuantitativeRemoteSensinginThermalInfrared,11,Springer,281p 2. De- Jong,Steven,M Vander Meer, F.D., 2004. Remote Sensing Image Analysis: IncludingtheSpatialDomain:Including the SpatialDomain,5,Springer, 359p. 3. JamesB.Campbell&RandolphH.Wynne.,Introduction to Remote Sensing, The Guilford Press,2011. **4.** Rencz,A.N.,2008.RemoteSensingfortheEarthSciences,ManualofRemoteSensing,3,ASPRS,703p.Van-dr-Meer, F.,DeJong, S .,2006.Imagingspectrometry: Basic principles and prospectiveapplications(The Netherlands: SpringerPublishers), 451p.
Learning Outcomes	• Studentswouldbeabletounderstand the knowledge of pattern of earth features. • Students wouldbeabletolearn the knowledge about platforms and sensors • Acquaintedtheknowledgeofvisualanddigitalimageinterpretation. StudentshouldunderstandtheSpatial analysismethods.

Course	**B.Sc./B.A.ThirdYear:Semester-VI**			
Course Title	**GGRMJ64:Quantitative Methods in Geography**			
Category of Course	**Major**			
Credits&Hourof Teaching		Theory	Practical	Cumulative
	Credits		2	
	Hour of Teaching (Total)		60	
CourseObjectives	• Tointroducethefrequencydistribution. • Toexplainmeasuresofdispersion. • Tointroducethestudentsaboutcorrelation.			
CourseContent	Thecoursecontentisdividedinto2Units.			
Units	**CourseContent**			**Hr.of Teaching**
I	**Central Tendency and Dispersion**: Frequency distribution; Mean, median, mode; Measures of dispersion: mean deviation, standard deviation, Coefficient of variation.			30
II	**Correlation and Regression**: Correlation (Karl Pearson and Spearman) and Scatter diagram; Regression analysis; Location quotient, Lorenz curve, Gini Coefficient.			30

SEC-SkillEnhancementCourse, AECAbilityEnhancementCourse; VACValueAdded
Course: MD-MultidisciplinaryCourse1Credit(Theory)=15Hours;1Credit(Practical)=30Hours

Texts/References	1. Bhagwathi,V.andPillai,R.S.N.(2003):PracticalStatistics,SultanChandandCompany,NewDelhi 2. Ebdon,D.(1977):StatisticsinGeography:APracticalApproach,BlackwellPublishersInc.,Massachusetts 3. Gregory,S.(1973):StatisticalMethodsandtheGeographer,Longman,London. 4. Gupta,S.P.(1998):AdvancedPracticalStatistics,SultanChandandCompany,NewDelhi 5. Mahmood,A.(1986):StatisticalMethodsinGeographicalStudies,RajeshPublications,NewDelhi 6. Zamir,A.(2002):StatisticalGeography:MethodsandApplications,RawatPublications,Jaipur.
Learning Outcomes	• Studentswouldbeabletounderstand the knowledgeofmeandeviation,standarddeviation. • They will be madeawareaboutmean,median,mode. • They will be acquainted fortheknowledgeofLocationquotient

Course	**B.Sc./B.A.ThirdYear:Semester-VI**			
Course Title	**GGRMJ65A:Hydrology**			
Category of Course	**Major**			
Credits & Hour of Teaching		Theory	Practical	Cumulative
	Credits	4		
	Hour of Teaching (Total)	60		
Course Objectives	• TointroducethemeaningandscopeofHydrology. • Toexplaintheprocessofevaporation. • Tointroducethestudentsaboutfactorscontrollinginfiltration. • ToacquaintheknowledgeofStreamflowmeasurement.			
CourseContent	Thecoursecontentisdividedinto4Units.			
Units	**Course Content**			**Hr.of Teaching**
I	**Bases of Hydrology**: Nature, scope and development to Hydrology; Hydrological cycle; Man's Influence on the hydrological cycle; Precipitation: formation process, types, characteristics and measurements.			15
II	**Water Losses**: Interception: factors Affecting			15
III	**Water Disposition:** Infiltration: infiltration process and factors controlling infiltration; Soil moisture and its zones: storage of soil moisture, factors affectingsoilmoisturestorage;Runoff:itssourcesandcomponents,factorsaffectingrunoff;Riverregimes.			15
IV	**Assessment and Conservation**: Stream flow measurement: interpretation of steam flow data, Hydrograph: components and separation; Ground water: oMJurrence, storage, recharge and discharge; Floods: estimation and control; Appraisal of water resources; Water policies and conservation in India.			15

SEC-SkillEnhancementCourse, AECAbilityEnhancementCourse; VACValueAdded Course: MD-MultidisciplinaryCourse1Credit(Theory)=15Hours;1Credit(Practical)=30Hours

Texts/References	1. Chow,V.T.,D.R.MaidmentandL.W.Mays(1988):AppliedHydrology.MNGraw-Hill 2. DingmanL.S.(2002):PhysicalHydrology.2nded.WavelandPressInc.,USA. 3. Rai,V.K.(1993):WaterResourcePlanningandDevelopment,DeepandDeepPublication,NewDelhi 4. HannC.T.(1995):StatisticalMethodsinHydrology.FirstEast-WestPressEdition,NewDelhi. 5. Singh,M.B.(1999):ClimatologyandHydrology.TaraBookAgency,Varanasi.(InHindi). 6. Ward,R.C.andRobinson,M.(2000):PrinciplesofHydrology.MNGrawHill,NewYork. 7. SubramanyaK.(2004):EngineeringHydrology.TataMNGraw-Hill,NewDelhi. 8. JainS.K.,AgarwalP.K.andSinghV.P.(2007):HydrologyandWaterResourcesofIndia.Springer,TheNetherlands. 9. RaghunathH.M.(2006):Hydrology.NewAgeInternational(P)Ltd.,NewDelhi. 10. ShawE.M(2004):HydrologyinPractice.3rded,RoutledgePublishers,London. 11. Singh G., VenkataramanC., Sastry G. and JoshiB.P. (1990):Manualof Soil and WaterConservationPractices. Oxford and
Learning Outcomes	• Studentswouldbeabletounderstand the knowledgeofsubmarinecanyons. • Studentswouldbeabletolearn the knowledgeaboutCirculationofoceanwater. • Studentswouldbeabletounderstand the knowledgeof MarineLifeandDeposits. • StudentshouldunderstandtheGlobalwarmingandsealevelchange.

Course	**B.Sc./B.A.ThirdYear:Semester-VI**			
CourseTitle	**GGRMJ65B:Geography of Settlement**			
Category of Course	**Major**			
Credits&Hourof Teaching		Theory	Practical	Cumulative
	Credits	4		
	Hour of Teaching (Total)	60		
CourseObjectives	• Tointroducethemeaningandscopeofsettlementgeography. • Toexplaintheprocessesofsettlementgrowth. • Tointroducethestudentsaboutfactorsaffectingsettlement. • ToacquainttheknowledgeofConceptofurbanplanning.			
CourseContent	Thecoursecontentisdividedinto4Units.			
Units	**CourseContent**			**Hr.of Teaching**
I	**Conceptual Introduction:** Defining human settlements; Nature and scope of Settlement Geography; Concep to frural and urban Settlements; Origin and Growth of urban settlements; Concept of megacities,globalcityandedgescity.			15
II	**Location,MorphologyandGrowth**:Site,Situation,TypesandPatterns;InternalMorphologyofRuralandUrbanSettlements; Ecological Processes of Settlement Growth;Rural-urban fringe;Umlandandhinterland			15
III	**Distributional Characteristics of Settlements:** Size and spacing of cities:Rank-sizerule, Law of Primate City; Functional classification of urban settlements; Settlement Hierarchy-Christaller's Central Place Theory; AugustLosch's Theory			15
IV	**UrbanRegionandPlanning**CharacteristicsofMetropolitanregion–AcaseofDelhi and Varanasi; Rural Housing Planning and Policies; Conceptof urban planning			15

SEC-SkillEnhancementCourse, AECAbilityEnhancementCourse; VACValueAdded Course: MD-MultidisciplinaryCourse1Credit(Theory)=15Hours;1Credit(Practical)=30Hours

Texts/References	1. Chisholm,M.(1970)RuralSettlementandLandUse.London:Hutchinson. 2. Daniel,P.(2002).GeographyofSettlement,NewDelhi:RawatPublications,Jaipur. 3. Doxiadis,C.A.Ekistics.(1968).AnIntroductiontoScienceofHumanSettlements, 4. Hudson,F.S.(1976):AGeographyofSettlements.MacDonaldandEvans,NewYork. 5. Money,D.C.(1972).PatternsofSettlements,London:EvanBrothers 6. Ramachandran,R.,(1991):UrbanisationandUrbanSystemsinIndia.OxfordUniversityPress,Delhi. 7. SinghR.Y.,1994:TheGeographyofSettlement,RawatPublication,NewDelhi. 8. Stanley,B.,Jack,W.andDonald,Z.(eds.)(2003):CitiesoftheWorld.RowmanandLittlefield,NewYorkandOxford. 9. Wood,M.(2005):RuralGeography:Processes,ResponsesandExperiencesofRuralRestructuring.SagePublication, London.
Learning Outcomes	• Studentswouldbeabletounderstand the knowledge of settlementanditspatterns. • Studentswouldbeabletolearn aboutRuralandUrbanSettlements. • AcquaintedtheknowledgeofFunctionalclassificationofurbansettlements. • StudentshouldunderstandtheCharacteristicsofMetropolitanregion.

Course	**B.Sc./B.A.ThirdYear:Semester-VI**			
CourseTitle	**GGRMJ65C:Resource Geography**			
Category of Course	**Major**			
Credits&Hourof Teaching		Theory	Practical	Cumulative
	Credits	4		
	Hour of Teaching (Total)	60		
CourseObjectives	• Tointroducethemeaningandscopeofresource geography. • Toexplainthedistributionandpatternof.resources • TointroducethenaturalresourcesinIndia. • Toacquaintthetheoriesofagriculturalandindustriallocation.			
CourseContent	Thecoursecontentisdividedinto4Units.			

Units	**Course Content**	**Hr.of Teaching**
I	**Basic Concepts**: Nature and scope of Resource Geography; Concept and classification of resources; Distribution and pattern of resources: Land, water, minerals (Ironore, Bauxite, Copper) and power resources; Non-conventional sources of energy, Scientific and technological innovation and resources.	15
II	**Human Resource and Locational Aspects**: Human Resource: concept, classification, determinants and problems;Theoriesofagriculturalandindustriallocation:VonThunen,Weber,LoschandHoover	15
III	**Problems and Conservation of Resource:** Nature and Production of Resources; Resource Scarcity; World energy utilization and its crisis; Sustainable development, Resource conservation; National Policies and Programmes on Natural Resources in India: Land, Forest and Water	15
IV	**Regional Perspectives:** World economic development; Concept of developed and developing nations; Concepts of North-South and First, Second, Third and FourthWorlds	15

SEC-SkillEnhancementCourse, AECAbilityEnhancementCourse; VACValueAdded Course: MD-MultidisciplinaryCourse1Credit(Theory)=15Hours;1Credit(Practical)=30Hours

Texts/References

1. Burton,I.andKates,R.W.(1978):ReadingsinResourceManagementandConservation.MNGrawHills,NewYork
2. Clark,G.L.,Feldman,M.P.andGertler,M.S.(eds.)(2000):TheOxfordHandbookofEconomicGeography.OxfordUniversityPress,OxfordandNewYork.
3. Ehrlich,P.R., Ehrlich, R.H. andHoldren, J.P. (1998):Ecoscience:Population, Resources andDevelopment.2ndedition.FreemanandCompany,SanFrancisco.
4. SheppardE.andTrerorI.B.(ed.)(2003):ACompaniontoEconomic Geography,BlackwellPublication,U.K.andUSA.
5. MMJarty,H.M.andJamesB.L.(1976):APrefacetoEconomicGeography.PrenticeHall,NewJersey.
6. Mitra,A.(2000):ResourceStudies;ShridharPublishers.,Kolkata.
7. Ramesh,A.(ed.)(1984):ResourceGeography.HeritagePublishers,NewDelhi.
8. Singh,J.(2000):SansadhanBhoogol,GyanodayaPrakashan,Gorakhpur
9. Singh,K.N.andSingh,J.(2003):ArthikBhoogolKeMoolTatva,GyanodayaPrakashan,Gorakhpur.
10. TodaroM.P.andSmithS.C.(2004):EconomicDevelopment,PearsonEducation,(Singapore)PrivateLtd.Singapore

Learning Outcomes	• Students would be able to understand the knowledge of settlement and its patterns. • Students will be made aware about rural and urban settlements. • AcquaintedtheknowledgeofFunctionalclassificationofurbansettlements. • Student will understand the characteristics of metropolitan region.

Course	**B.Sc./B.A.ThirdYear:Semester-VI**			
Course Title	**GGRMJ65D:Social Geography**			
Category of Course	**Major**			
Credits &Hour of Teaching		Theory	Practical	Cumulative
	Credits	4		
	Hour of Teaching (Total)	60		
Course Objectives	• Tointroducethemeaningandscopeofsocialgeography. • Toexplainthesocialdifferentiationandspatialjustice • Tointroducethelanguageandreligioninindia. • Toacquaintthetribesandtheirevolution.			
Course Content	Thecoursecontentisdividedinto4Units.			

Units	**Course Content**	**Hr.of Teaching**
I	**Concept and Approaches**: Meaning of social geography; Concepts: society, community, social structure and relations; Social differentiation and stratification: space, social space, social morphology, social-spatial, spatial justice, Spatial inclusion and exclusion;	15
II	**Social differentiation and region formation**: Bases of social region formation: ethnicity, tribes, dialect, language and religion.	15
III	**Regional basis of Indian Society**: Peopling of India; Evolution of social regions; Tribes: Characteristics and their distribution; Caste: concept, characteristics and classification, Linguistic regions of India; Particularly Vulnerable Tribes Groups (PVTGs), Unity in diversity.	15
IV	**Geography of Social Well-being in India**: Concepts of social wellbeing; Social geographical perspectives on crime, healthcare, education and housing; Geography of men and women; Social impact assessment; Social policies and planning.	15

SEC-SkillEnhancementCourse, AECAbilityEnhancementCourse; VACValueAdded Course: MD-MultidisciplinaryCourse1Credit(Theory)=15Hours;1Credit(Practical)=30Hours

Texts/References	1. Ahmad,A.(1999):SocialGeography. RawatPublications,JaipurandNewDelhi. 2. Anderson,K.(2006):RaceandCrisesofHumanDevelopment.Routledge, LondonandNew Delhi. 3. Betizlle,A.(1983):EqualityandInequality,OxfordUniversityPress,NewDelhi 4. Brewer,J.D.(2000):Ethnography,OpenUniversityPress,Buckingham,Philadelphia,FirstEditi on. 5. Coates,B.E.,Johnston,R.J.andKnox,P.L.(1977):GeographyandInequality,OxfordUniversity Press,O xford,London. 6. Eyles,J.(ed.)(1986):SocialGeographyinInternationalPerspective.RowmanandLittlefield,Ne wJerseyand LosAngeles. 7. Dubey.S.C.(1991):IndianSociety.NationalBookTrust,NewDelhi. 8. Forde,C.D.(1934):Habitat,EconomyandSociety,MethuenandCompany, London 9. Gregory,D.andLarry,J.(eds.)(1985):SocialRelationsandSpatialStructures.MNMillan,London 10. Gore,M.S.(1985):SocialAspectsofDevelopment,RawatPublications,Jaipur
Learning Outcomes	• Studentswouldbeabletounderstand the knowledgeofsocialgroups. • Studentswouldbeabletounderstandaboutcommunity, socialstructureandrelations. • They will be acquaintedtheknowledgeofFunctionalclassification. • Studentshouldunderstandthelinguisticregionsofindia.

Course	**B.Sc./B.A.ThirdYear:Semester-VI**			
Course Title	**GGRMJ65E:Cultural Geography**			
Category of Course	**Major**			
Credits&Hourof Teaching		Theory	Practical	Cumulative
	Credits	4		
	Hour of Teaching (Total)	60		
CourseObjectives	• Tointroducethemeaningandscopeofculturalgeography. • Toexplaintheculture, society and civilization • TointroducetheCulturalturninhumangeography. • ToacquainttheGeographyoffoodandhousetype.			
CourseContent	Thecoursecontentisdividedinto4Units.			
Units	**CourseContent**			**Hr.of Teaching**
I	**ConceptsandApproaches:** Meaning of cultural geography; Concepts:culture, society, civilization, cultural hearth, cultural area, core, domain, sphere, cultural realm, place-making and cultural landscape; Approaches to the study of cultural geography;			15
II	**EvolutionofCulture:** Evolutionofearlyhumangroups;Beginningsofcivilizations;Processofformationofculturalregions:culturalregionsoftheworld,vernacularregions;Evolutionofcultural landscapes: globalization and culture.			15
III	**Cultural processes:** Language and dialect: Classification and regions, language and identity, language and nationalism; Language in the landscape: Religions: religion,identityandconflict,religiouslandscapes			15
IV	**Geographical basis of Indian Culture:** Linguistic and dialect regions of India; Multi lingual states; Folk cultures; Geography of food and house type ;Geography pilgrimage; Cultural regions of India.			15

SEC-SkillEnhancementCourse, AECAbilityEnhancementCourse; VACValueAdded Course: MD-MultidisciplinaryCourse1Credit(Theory)=15Hours;1Credit(Practical)=30Hours

Texts/References	1. Appadurai,A.1996:ModernityAtLarge:CulturalDimensions Of Globalization.Minneapolis:UniversityofMinnesotaPress. 2. Barber,C.L.1965.TheStoryofLanguage.London:TheEnglishLanguageBookSocietyandPanBooksLtd. 3. Bhardwaj,S.M.1973.HinduPlacesofPilgrimageinIndia.Berkeley:UniversityofCaliforniaPress. 4. Blunt,A.,Gruffudd,P.,May,J.andOgborn,M.2003:Culturalgeographyinpractice.London:Arnold. 5. Crang,M.1998:CulturalGeography.London:Routledge. 6. Kosambi,D.D.1972.TheCultureandCivilizationofAncientIndiainHistoricalOutline.NewDelhi:VikasPublications. 7. Maloney,C.1974.PeopleofSouthAsia.NewYork:WinstonNorton. 8. Norton,W.2006.CulturalGeography.Environments.Landscapes.Identities.Inequalities(2nded.).Toronto:OxfordUniversityPress. 9. Parekh,B.2000:Multiculturalism:CulturalDiversityandPoliticalTheory.London:Macmillan Press. 10. Sopher,DavidE.,ed.1980.AnExplorationofIndia:GeographicalPerspectivesonSocietyandCulture.Ithaca,NewYork:CornellUniversityPress.
Learning Outcomes	• Studentswouldbeabletounderstand the knowledge of culturallandscape. • Studentswouldbeabletounderstand the knowledge about Evolution of early human groups. • Studentswouldbeabletolearn languageandnationalism. • StudentshouldunderstandtheLinguisticanddialectregions.

Course	**B.Sc./B.A.ThirdYear:Semester-VI**			
Course Title	**GGRMV61:Geography of Health and Well being**			
Category of Course	**MinorVoc**			
Credits &Hourof Teaching		Theory	Practical	Cumulative
	Credits	4		
	Hour of Teaching (Total)	60		
Course Objectives	• Tointroduce themeaningandscopeofhealthgeography. • Toexplainthedeterminantsofhealthquality • Tointroducethegeographical inequalityinprovisionofhealthcare, • Toacquaintthediseaseecology,Impactofcleanair,adequatewater.			
Course Content	Thecoursecontentisdividedinto4Units.			
Units	**Course Content**			**Hr.of Teaching**
I	**Geography of Health as a sub-discipline of Human Geography**: Definition, scope, approaches, historical development and key contributors ; Determinants of health; Quality of life: Concept and measurement; Disease burden; Epidemiological transition.			15
II	**Spatial Patterns:** Disease burden at global, regional and national scales; Globalization, migration,and spatial diffusion of diseases; Geographical in equality in provision, a MJess, and use of health care services.			15
III	**Environment and Health**: Disease ecology, Impact of clean air, adequate water, improved sanitation and hygiene on health; built environment and health; Therapeutic land scapes; climate change and health.			15
IV	**Indian Context:** Public health system, National health policy, Major health and disease control programs: National Programme for Prevention & Control of Non-Communicable Diseases(NP-NCD), Revised National Tuberculosis Control Programme (RNTCP), National Vector Borne Disease Control Programme, National Health Mission, Ayushman-Bharat.			15

SEC-SkillEnhancementCourse, AECAbilityEnhancementCourse; VACValueAdded
Course: MD-MultidisciplinaryCourse1Credit(Theory)=15Hours;1Credit(Practical)=30Hours

Texts/References	1. Gatrell,C.A.andElliott,J.S.(2014):GeographiesofHealth:AnIntroduction.Wiley-Blackwell.3rdEd. 2. Meade,M.andEMNh,M.(2010):MedicalGeography.GuilfordPress.3rd Ed. 3. EMNh,M.,Root,D.E.,Carrel,M.(2017):Healthandmedicalgeography.GuilfordPress.4thEd. 4. Soja,E.W.(2010):SeekingSpatialJustice.UniversityofMinnesotaPress.Minneapolis. 5. Bonita,R.,Beaglehole,R.,Kjellström,T.&WorldHealthOrganization.()2006:Basicepidemiology.World HealthOrganization. 2nd Ed. 6. Grekousis,G.(2020):SpatialAnalysisMethodsandPractice:Describe-Explore-ExplainThroughGIS.Cambridge UniversityPress.NewYork. 1st Ed. 7. Darmofal,D.(2015):SpatialAnalysisfortheSocialSciences.CambridgeUniversityPress.NewYork.1stEd. **8.** Reddy,S.K.(2019):MakeHealthinIndia:ReachingaBillionPlus.OrientBlackSwan.1stEd.
Learning Outcomes	• Students will be introduced to the historical development, and key contributors. • Studentswouldbeabletounderstandabout spatialdiffusion ofdiseases. • They will learn the knowledge of improved sanitation and hygiene on health • StudentshouldunderstandtheNationalhealthpolicy,Majorhealthanddisease.

Course	B.Sc./B.A.FourthYear:Semester-VII			
CourseTitle	**GGRMJ71:Research Methodology**			
Category of Course	**Major**			
Credits&Hourof Teaching		Theory	Practical	Cumulative
	Credits	4		
	Hour of Teaching (Total)	60		
CourseObjectives	• Tointroducetheconceptandsignificanceofresearchgeography. • Toexplainthephilosophyandgeographyrelations. • Tointroducestudentsaboutresearchprocessanddesignanddatacollection • Toacquaintthestudentswithdataanalysis,reportwritingandstructure.			
CourseContent	Thecoursecontentisdividedinto4Units.			

Units	CourseContent	Hr.of Teaching
I	**Research in Geography:** Concept and significance of research in geography; Production of geographical knowledge; Philosophy and Geography: Ontology, Epistemology, Methodology and Methods;PositivistandNon-PositivistResearch	15
II	**ResearchProcessandDesign:**ResearchProcess;Researchdesigns :quantitative(experimentalandsurvey),qualitative(ethnography,groundedtheory,casestudy,phenomenological),mixedmethod(sequential,concurrent,and transformative);EthicsinResearch.	15
III	**Data Collection Methods:** Primary data collection: questionnaires, observation,key information interviews, in-depth interviews, focus group discussion; Sources of data; Samplingandsamplesizedetermination;Qualitycontrolchecks;	15
IV	**Data Analysis and Dissemination:** Data analysis: Quantitative (variables, scales, univariate, bivariate, and multivariate analysis), Qualitative (thematic analysis); Writing reports and research papers: structure,referencing,plagiarism.	15

SEC-SkillEnhancementCourse, AECAbilityEnhancementCourse; VACValueAdded Course: MD-MultidisciplinaryCourse1Credit(Theory)=15Hours;1Credit(Practical)=30Hours

Texts/References	1. Ahuja,R.(2001):Research Methods.RawatPublications,Jaipurand NewDelhi. 2. Denzin,N.K.andLincoln,Y.S.,(eds.)(2000):HandbookofQualitativeResearch.Thousand OaksCA.SagePublications. 3. Flowerdew,R.and Martin,D.(eds.)(1997):MethodsinHumanGeography. AGuideforStudentsDoingaResearchProject. Longman, Harlow. 4. Kitchin,R.andTate,N.,(2001):ConductingResearchintoHumanGeography: Theory.MethodologyandPractice.Prentice-Hall, London. 5. Limb,M.(2001):QualitativeMethodologiesforGeographers:IssueandDebates.Edward Arnold,London. 6. Mishra,H.N.&Singh,V.P.(2002):ResearchMethodologyin Geography,RawatPublications,Jaipur. 7. Neuman,Lawrence(2020):SocialResearchMethods:QualitativeandQuantitativeApproach,Pearson 8. Rogers,A.andViles,H.A.(2003):TheStudent'sCompaniontoGeography.Blackwell Publishers,Oxford.Indianreprintavailable. 9. Silverman,D.(1993):InterpretingQualitativeData:MethodsforAnalysingTalk,TextandInteraction.SagePublications,London. 10. Tandon,B.C.(1997):ResearchMethodologyinSocialSciences,ChaitanyaPub.,Allahaba.
Learning Outcomes	• They would be able to enhance the learning on geographical research and its perspectives. • Students will be made aware about themes, approaches and recent developments. • They will be acquainted the knowledge of types of research designs and ethics. • Student should understand the data collection, analysis and presentation.

Course	**B.Sc./B.A.FourthYear:Semester-VII**			
CourseTitle	**GGRMJ72:Environmental Studies**			
Category of Course	**Major**			
Credits&Hourof Teaching		Theory	Practical	Cumulative
	Credits	4		
	Hour of Teaching (Total)	60		
CourseObjectives	• Tointroducestudentstotypesandcomponents ofenvironment. • Toexplainthedistributionandclassificationofnaturalresources. • Tointroducestudentsaboutenvironmentissuesandmonitoring. • Toacquaintthestudentswithenvironmentalconflictsandgeopolitics.			
CourseContent	Thecoursecontentisdividedinto4Units.			
Units	**CourseContent**			**Hr.of Teaching**
I	**Environmentalconcepts**:Meaning,typesandcomponentsoftheenvironment;ApproachestoEnvironmentalStudies;Ecosystem:componentsandclassification;Geo-biochemical cycles: carbon, nitrogen and phosphorus.			15
II	**NaturalResourcesandBiodiversity**:DistributionandclassificationofNatural Resources: Land, Water,Forest and Energy; Biodiversity:Extinctionandconservation;Biomesoftheworld.			15
III	**Environmental problems and management**: Environmental Issues in Tropical, Temperate and Polar Ecosystems; Pollution: air, water, soil and solid waste; Hazards: earthquake and flood; Environmentalmonitoring;Environmentaleducation,Environmental policiesandlegislations.			15
IV	**TrendsinEnvironmentalstudies**:Environmentalconflicts;Environmentandgeopolitics;transnationalmovement;Environmentaljustice;Environmentalgeoinformatics:Environmentalsurveillance;Environmentalmapping.			15

SEC-SkillEnhancementCourse, AECAbilityEnhancementCourse; VACValueAdded
Course: MD-MultidisciplinaryCourse1Credit(Theory)=15Hours;1Credit(Practical)=30Hours

Texts/References	1. Anjuneyulu, Y.(2004): Introduction to Environmental Science. B.S. Publications,Hyderabad. 2. Blaikie,P.,Cannon,T.andDavis,I.(eds.)(2004):AtRisk:NaturalHazards,PeoplesVulnerabilityandDisasters.Routledge,London. 3. Huggett,R.J.(1998):Fundamentals ofBiogeography.Routledge,London. 4. Kayastha,S.L.andKumraV.K.(1986):EnvironmentalStudies.TaraBookAgency,Varanasi. 5. Kumaraswamy, K., Alagappa Moses., A and Vasanthy, M. (2004) Environmental Studies, Bharathidasan University, Tiruchirappalli. 6. Nag,P.,Kumra,V.K. and Singh, J.(1990): Geography and Environmental IssuesatLocal,RegionalandNationalLevels.(in3vols.),ConceptPublishing Company,NewDelhi. 7. Odum,E.P.(1975):Ecology.RowmanandLittlefield,Lanham. USA. 8. Rajagopalan,R.(2005):EnvironmentalStudies. OxfordUniversityPress, NewDelhi. 9. Saxena, H.M., 2012: Environmental Studies, Rawat Publications, Jaipur. 10. UNEP (2007): The fourth Global Environment Outlook – environment for development (GEO-4). United Nations Environment Program.
Learning Outcomes	• Students would be able to learn types, components of environment and approaches. • Students will be made aware about distribution and biodiversity challenges. • They will get the knowledge of environmental issues, monitoring and policies. • Student should understand the environmentgeopolitics,justice and mapping.

Course	**B.Sc./B.A.FourthYear:Semester-VII**			
Course Title	**GGRMJ73:Geographical Field Training and Report Writing**			
Category of Course	**Major**			
Credits &Hourof Teaching		Theory	Practical	Cumulative
	Credits		2	
	Hour of Teaching (Total)		60	
Course Objectives	• To introduce students,the meaning andobjectivesofgeographicalfieldtraining. • To explain field as a laboratory of geography. • Tounderstandvariouscontentsoffieldtraining. • Totrainstudentsonfieldbasedreportwriting.			
Course Content	Thecoursecontentisdividedinto2Units.			
Units	**CourseContent**			**Hr.of Teaching**
I	**Principles of Field Training:** Meaning and objectives of field training; Field as a laboratory of geography; Bases of selection of field, Contents of field training: physical, social, economic and cultural; Field training techniques; Field training-based report writing			30
II	**Field Visit:** Students will visit any one of the following geographical regions of physical and human interest for field training: Himalayan Region, Vindhyan Plateau, Thar Desert and Aravali Hills, Coastal region, East and North-easternIndia.			30

SEC-SkillEnhancementCourse, AECAbilityEnhancementCourse; VACValueAdded Course: MD-MultidisciplinaryCourse1Credit(Theory)=15Hours;1Credit(Practical)=30Hours

Texts/References	1. Archer,J.E.and Dalton, T.H. (1968): Field Work in Geography. William Clowes and SonsLtd.LondonandBeMJles. 2. Bolton,T.andNewbury,P.A.(1968):GeographythroughFieldwork.BlandfordPress,London. 3. Jones,P.A.(1968):FieldWorkinGeography. Longmans,GreenandCompanyLtd.,LondonandHarlow. 4. Lousenbury,J.F. andAldrich,F.T. (1986): Introduction toGeographic FieldMethodsandTechniques.CharlesE. MerrillPublishing.Company,Colombus. 5. Pugh,J.C.(1975):SurveyingforFieldScientists.MethuenandCompanyLtd.London. 6. Parsons, Tony and Knight, Peter G. (2005): How to do your Dissertation in Geography and RelatedDisciplines. Routledge,London. 2nd Ed. 7. Kitchen,RobandTate,NicholasJ.(2009):ConductingResearchintoHumanGeography:Theory,Methodology&Practice.PrenticeHall-Pearson,HarlowU.K.2ndEd. 8. Hay,Iain(ed.)(2005):QualitativeResearchMethodsinHumanGeography.OxfordUniversityPress,Melbourne. 2ndEd. 9. Hay,Iain(ed.)(2004):CommunicatinginGeographyandtheEnvironmentalSciences.OxfordUniversityPress, Melbourne.2ndEd. 10. Stoddard,RobertH.(1982):FieldTechniquesandResearchMethodsinGeography.Kendall/HuntPub.Dubuque IO.
Learning Outcomes	• Enhance students' understanding of the importance of fieldwork in geographical studies. • Increase awareness of key aspects and phenomena observed in the field. • Familiarize students with essential techniques used in fieldwork. • Enable students to effectively write reports based on field training experiences.

Course	**B.Sc./B.A.FourthYear:Semester-VII**			
CourseTitle	**GGRMJ74A:Advanced Geographical Thought**			
Category of Course	**Major**			
Credits&Hourof Teaching		Theory	Practical	Cumulative
	Credits	4		
	Hour of Teaching (Total)	60		
CourseObjectives	• Tointroducestudentstherecentnatureofgeographicalknowledge. • Toexplainnewenvironmentalismandmajorapproachesingeography. • Tounderstandvariousparadigmsandcontributionsofgeographers. • TotrainstudentsoncontributionsofIndiangeographersandscholars.			
CourseContent	Thecoursecontentisdividedinto4Units.			
Units	**CourseContent**			**Hr.of Teaching**
I	**Basic Concepts:** Nature of geographical knowledge; Man-environment interaction: new environmentalism; Concepts: space,place,environment,time And Spatial organization Culture and; cultural and scape.			15
II	**Modern Approaches:** Quantitative geography; Humanistic geography: phenomenology and exist entialism; Contributions of Carl SauerandYi-Fu Tuan.			15
III	**Contemporary Trends:** Qualitative paradigm; Post-modernism and Post- structuralism; Social theory and De/reconstruction Welfare/Marxist; /Radical geography; Contributions of David Harvey;Feministgeography.			15
IV	**TrendsofIndianGeography:**ColonialandPostcolonialgeography ;Contributions of Indian geographers ;Impact of thoughts of Gandhi,NehruandAmbedkaronIndiangeography;Indiangeography:issuesandchallenges.			15

SEC-SkillEnhancementCourse, AECAbilityEnhancementCourse; VACValueAdded Course: MD-MultidisciplinaryCourse1Credit(Theory)=15Hours;1Credit(Practical)=30Hours

Texts/References	1. Daniels,P.,Bradshaw,M.,Shaw,D.andSidaway,J.(2000):AnIntroductiontoHumanGeography.Issuesforthe21st Century.Prentice Hall,London. 2. Dear,M.J.andFlusty,S.(2002):TheSpacesofPostmodernity:ReadingsinHumanGeography.BlackwellPublishers,Oxford. 3. Dikshit, R.D.(2004): GeographicalThought. ACriticalHistoryofIdeas.Prentice-Hall India,NewDelhi. 4. Harvey,M.E.and Holly, P.B.(2002): Themes in Geographic Thought. Rawat Publications, NewDelhi. 5. Hubbard,P.,Kitchin,R.,Bartley,B.andFuller,D.(2002):ThinkingGeographically:Space, TheoryandContemporaryHumanGeography. Continuum,London. 6. Johnston,R.J.andSidaway,J.D.(2004):GeographyandGeographers.6th edition,Edward Arnold,London. 7. Kapur,A.,(ed.)(2001):Indian Geography-Voice of Concern. Concept Publishing. Company, New Delhi. 8. Martin,G.,(2005):AllPossibleWorlds.AHistoryofGeographicalIdeas.4th edition,Oxford UniversityPress,NewYork. 9. Mathews,J.A.,andHerbert,D.T.(eds.)(2004):UnifyingGeography.CommonHeritage, SharedFuture.Routledge,London. 10. Soja,E.(1989):Post-modern Geographies. Verso Press, London. Reprinted 1997: Rawat Publications,JaipurandNewDelhi 11. Taylor, G.(ed.)(1953):GeographyintheTwentieth Century. Mathuen and Company Ltd. And Company,London. 12. Tuan,Yi-Fu(1977): Space and Place. The Perspective of Experience. EdwardArnold,London.

Learning Outcomes	• Enhance students' understanding of the evolving nature of geographical knowledge. • Familiarize students with various modern approaches in geography. • Acquaint students with contemporary trends and significant contributions in the field. • Enable students to understand trends in Indian geography

Course	**B.Sc./B.A.FourthYear:Semester-VII**			
CourseTitle	**GGRMJ74B:Advances in Population Studies**			
Category of Course	**Major**			
Credits&Hourof Teaching		Theory	Practical	Cumulative
	Credits	4		
	Hour of Teaching (Total)	60		
CourseObjectives	• Tointroducestudentsaboutthemeaning,scopeandapproachestoPopulation Studies. • Toexplainthefactors,determinantsandpatterns&theoriesofpopulation. • Tounderstandcomposition,structureand factorsofchangeinpopulation. • Totrainstudentsonpopulationpolicies andcontemporaryissues.			
CourseContent	Thecoursecontentisdividedinto4Units.			

Units	**CourseContent**	**Hr.of Teaching**
I	**BasicsofPopulationStudies**:Meaning,ScopeandapproachestoPopulationstudies;SourcesofPopulationdatawithspecialreferencetoIndia;DemographicDividend; Recent trends in population studies.	15
II	**PopulationDistribution,DensityandGrowth**:Factors,DeterminantsandPatterns;TheoriesofPopulationGrowth:Malthusiantheory and Demographic Transition Theory; Concept of Under, Over and OptimumPopulation;PopulationResourceRegion.	15
III	**Population Composition and Migration**: Age-Sex, Literacy, Rural-Urban, OMJupation structure; Fertility; Mortality; Migration: Concept,Types,DeterminantsandTheories;	15
IV	**Population policies and issues**:PopulationPoliciesin DevelopedandDevelopingcountriesincludingIndia;Contemporary Issues in Population Geography-Ageing Population, Sex Ratio, Diseases, Epidemics and Population Problems; Population and Environment Interface; Population and Development: Human Development Index; New Research areas in Population Geography;	15

SEC-SkillEnhancementCourse, AECAbilityEnhancementCourse; VACValueAdded Course: MD-MultidisciplinaryCourse1Credit(Theory)=15Hours;1Credit(Practical)=30Hours

Texts/References	1. Chandna,R.C.(2010)PopulationGeography,KalyaniPublisher.NewDelhi 2. Hassan,M.I.(2020)PopulationGeography:ASystematicExploration,RoutledgeIndiaPvt. Ltdl,NewDelhi 1. Tiwari,R.C.(2007)GeographyofIndia.PrayagPustakBhawan,Allahabad 2. BarrettH.R.,1995:PopulationGeography,OliverandBoyd. 3. BhendeA.andKanitkarT.,2000:PrinciplesofPopulationStudies,HimalayaPublishingHouse. 4. ChandnaR.C.andSidhuM.S.,1980:AnIntroductiontoPopulationGeography,Kalyani Publishers 5. Jones,H.R.,2000:PopulationGeography,3rded.PaulChapman,London. 6. LutzW.,WarrenC.S.and Scherbov S., 2004: The End of the World Population Growth in the21stCentury,Earthscan 7. NewboldK.B.,2009:PopulationGeography:ToolsandIssues,Rowmanand Little field Publishers 8. PacioneM.,1986:PopulationGeography:ProgressandProspect,TaylorandFrancis. 9. WilsonM.G.A.,1968:PopulationGeography,Nelson.

Learning Outcomes	• Students will enhance the learningon the basics of Population Geography. • They will make students aware about various factors affecting population growth. • They will be acquainted the knowledge of composition and structure of population. • Student should understand population issues and policies.

Course	**B.Sc./B.A.FourthYear:Semester-VII**			
CourseTitle	**GGRMJ74C:Urban Geography**			
Category of Course	**Major**			
Credits&Hourof Teaching		Theory	Practical	Cumulative
	Credits	4		
	Hour of Teaching (Total)	60		
CourseObjectives	• Tointroducestudentsthenature,scopeandrecenttrendsinurbangeography. • Toexplaintheoriginandevolutionofurbansettlementsandtheircharacteristics. • Tounderstandthecitysizeand urbanstructuremodels. • Totrainstudents onurbangrowthandcontemporaryissues inplanning.			
CourseContent	Thecoursecontentisdividedinto4Units.			
Units	**CourseContent**			**Hr.of Teaching**
I	**Bases:**Nature,scopeandrecenttrendsinurbangeography;Urbanpopulation:characteristics,processesandtrends;Methodologyinurbanstudies;Origin and Evolution of Urban settlements:bazaar-based and colonial based; distribution of urbancentres.			15
II	**Characteristics:**Characteristicsofcitiesindifferenthistoricalperiods:pre- industrial,industrialandpost- industrial; Functional classification of urban centres urban transportation; National Urban Information System.			15
III	**Spatiality and Models:**Size and spacing ofcities:rank-size rule ;law of theprimatecity;Urbanhierarchies; Central place theory (ChristallerandLoch);Urbanlanduseandfunctionalmorphology:functionalareasandperi-urban areas; Theories of urban structure: Burgess,Hoyt, Harris and Ullman, Mann, andWhite.			15
IV	**Issues and Planning:** Urban sprawl; urban problems: environmental, poverty,inequality, slums, transportation, housing, segregation and crime; Planned cities: Chandigarh and Jaipur; ConceptofsmartcityinIndia;NationalUrbanPolicy; MasterPlan:AcasestudyofVaranasi.			15

SEC-SkillEnhancementCourse, AECAbilityEnhancementCourse; VACValueAdded Course: MD-MultidisciplinaryCourse1Credit(Theory)=15Hours;1Credit(Practical)=30Hours

Texts/References	1. Bridge,B.andWatson,S. (Eds.)(2000):ACompaniontotheCity. Blackwell,Oxford. 2. Carter,H.(1995):TheStudyofUrbanGeography.4th ed.Reprintedin2000byRawat Publications,JaipurandNewDelhi. 3. Dutt, A. Allen, K. Nobel,G., Venugopal G. and Subbiah S. (eds.)(2003): Challenges to AsianUrbanisation in the 21st Century.KluwerAcademic Publishers,DordrechtandLondon. 4. Hall,T.(2001):UrbanGeography.2nd edition.RoutledgeLondon. 5. Mayer,H.andCohn,C.F.(1959):ReadingsinUrbanGeography,UniversityofChicagoPress,Chicago 6. Pacione,M.(2005):UrbanGeography:AGlobalPerspective.Routledge,LondonandNewYork. 7. Ramachandran,R.,(1991)UrbanizationandUrbanSystemsinIndia.OxfordUniversityPress,Delhi. 8. Singh,R.L.(1955):Banaras.AStudyinUrbanGeography.NandKishoreandBrothersBanaras 9. Singh,H.H.(1972):Kanpur:AStudyinUrbanGeography,Indrasini Publications,Varanasi

	10. Stanley,B.,Jack, W.andDonald,Z.(eds.)(2003):CitiesoftheWorld. RowmanandLittlefield, NewYorkandOxford. 11. Tripathi,V.K.,Jha,D.K.andHarshwardhanR.(eds.)(2018):AdvancesinUrbanStudiesinIndia.R.K.Books,NewDelhi.
Learning Outcomes	• Enhancingstudent'slearningonbasesandgrowthofUrbanGeography. • Students will be made aware about various factors affecting urban population. • They will be familiarized the knowledge of composition, urban structure and functions. • Studentshouldunderstandcontemporaryurbanpopulationissues, policiesandplanning.

Course	**B.Sc./B.A.FourthYear:Semester-VII**			
CourseTitle	**GGRMJ74D:Regional Planning**			
Category of Course	**Major**			
Credits&Hourof Teaching		Theory	Practical	Cumulative
	Credits	4		
	Hour of Teaching (Total)	60		
CourseObjectives	• Tointroducestudentstheconcept,nature,andscopeofregionalplanning. • Todescribetheories,approachesandgeographicalissuesofregionalplanning. • Tounderstandtheevolutionandgrowthofregionalplanningin India • Totrainstudentsoncontemporaryregionaldevelopmentissuesandplanning.			
CourseContent	Thecoursecontentisdividedinto4Units.			
Units	**CourseContent**			**Hr.of Teaching**
I	**ConceptualBackground**:Concept,Natureandscopeofregionalplanning; Theories and approachesof regional planning, Concept of Planning region,PlanningregionsofIndia;Decentralizedplanning			15
II	**Regional Development**: Regional imbalances and in equalities inIndia;Regional planning and national development; Economic development and regional development; Role of agriculture, industry and infrastructure in regional development.			15
III	**Regional Planning**: Evolution of Regional Planning in India; Regional planning and National development; Planning for regional development,Integratedregionalplanning,Multi-level planning, Surveyforplanning:diagnostic,techno-Economic and regional			15
IV	**PlanningandPolicyinIndia**:RegionaldevelopmentstrategyinIndia;ChangingparadigmofplanninginIndia.Nationalandstatelevelplanning,Locallevelplanning;NationalCapitalRegion;PlanningforEasternUttarPradesh.NitiAayog.			15

SEC-SkillEnhancementCourse, AECAbilityEnhancementCourse; VACValueAdded
Course: MD-MultidisciplinaryCourse1Credit(Theory)=15Hours;1Credit(Practical)=30Hours

Texts/References	1. Chandna,R.C.(2000):RegionalPlanning:AComprehensiveText.KalyaniPublishers,NewDelhi. 2. Chaudhuri,J.R.(2001):AnIntroductiontoDevelopmentandRegionalPlanning withspecialreferencetoIndia.Orient Longman,Hyderabad. 3. Friedmann,J.andAlonso,W.(ed.)(1973):RegionalDevelopmentandPlanning.TheMITPress,Mass. 4. Kuklinski,A.R.(1972):GrowthPolesandGrowthCentresinRegionalPlanning.MoutonandCo.,Paris. 5. Misra,R.P.(ed.)(1992):RegionalPlanning:Concepts,Techniques,Policiesand CaseStudies.2nd Edition.Concept PublishingCompany,NewDelhi. 6. Pathak,C.R.(2003):SpatialStructureandProcessesofDevelopmentinIndia.RegionalScienceAssociation,Kolkata.

	7. Sanyal,B.M.(2001):DecentralizedPlanning:ThemesandIssues.ConceptPublishingCompany,NewDelhi. 8. Sharma, P. V., Rao, V. L., and Pathak, C. R. (eds.) (2000): Sustainable Regional Development (with specialreference to Andhra Pradesh). Regional Science Association, Kolkata and School of Economics, AndhraUniversity, Vishakhapatnam. 9. Sundaram,K.V.(1997):DecentralizedMultilevelPlanning:PrinciplesandPractice(AsianandAfricanExperiences).Concept Publishing Company,NewDelhi. 10. Sundaram,K.V.(2004):TheTroddenPath:EssaysonRegionalandMicroLevelPlanning.AnaunyaPublications.,NewDelhi.
Learning Outcomes	• Deepen students' understanding of the fundamental aspects of regional planning. • Increase awareness of the factors and issues related to regional imbalances. • Familiarize students with the evolution of regional planning in India. • Studentshouldunderstandcontemporaryregionaldevelopmentstrategy.

Course	**B.Sc./B.A.FourthYear:Semester-VII**			
CourseTitle	**GGRMJ74E:Advanced Geographical Information System**			
Category of Course	**Major**			
Credits&Hourof Teaching		Theory	Practical	Cumulative
	Credits	4		
	Hour of Teaching (Total)	60		
CourseObjectives	• Tointroducestudents,thebasicsofGISanditsdevelopments. • Todescribeandexplaindatatypesandmodels,structuresanddataquality. • Todevelop students' understanding of spatial data analysis. • Totrainstudentsonrecentadvancesanditsapplications.			
CourseContent	Thecoursecontentisdividedinto4Units.			
Units	**CourseContent**			**Hr.of Teaching**
I	**Concepts of Geographical Information System:** Development of GeographicalInformation System**,** Terminologies; Data types, characteristics and sources;DataModels-Conceptual, Logical, and Physical;DataStructures-Hierarchical, Relational and Objectoriented			15
II	**DataBaseandStandards:**DataBaseManagementSystem(DBMS);DataQuality:meaning,measures,componentsandmanagement; Geographical Information System Data Standards: meaning, classification, and components.			15
III	**Spatial Data Analysis:** Raster Data Analysis**:** Local; neighborhood and regional operations-Overlay Analysis, Map Algebra;VectorDataAnalysis:ConceptofTopologyandTopologicalAnalysis;ProximityAnalysis:Buffering,ThiessenPolygon; Network Analysis; Multi-Criteria Analysis; Data Interpolation: IDW and Kriging.			15
IV	**Recent Advances and Applications:** Web GIS, Global Positioning System (GPS)and Mobile mapping; Machine learning; Artificial Intelligence (AI); Geographical Information System Software and programming.; Geographical Information System Applications: Land Use Planning, Site Suitability Analysis, Water Resource Management, Disaster Management and Mitigation.			15

SEC-SkillEnhancementCourse, AECAbilityEnhancementCourse; VACValueAdded Course: MD-MultidisciplinaryCourse1Credit(Theory)=15Hours;1Credit(Practical)=30Hours

Texts/References	1. Bolstad,P.(2005).GISFundamentals:AFirstTextOnGeographicInformationSystems.EiderPress. 2. Burrough,P.A.andMNDonnell,R.(1998):PrinciplesofGeographicInformationSystems.OxfordUniversityPress,Oxford. 3. Demers,M.N.(2000):FundamentalsofGeographic InformationSystems.JohnWileyandSons,Singapore. 4. Demers,M.N.(2008).FundamentalsofGeographicInformationSystems.JohnWiley&Sons. 5. Fu,P.,&Sun,J.(2010).WebGIS:PrinciplesandApplications.Esri Press. 6. Hofmann-Wellenhof,B.,Lichtenegger,H.,&Wasle,E.(2007).GNSS–GlobalNavigationSatellite 7. Korte,G. M.(2002):TheGISBook.On WordPress:ThomsonLearning,NewYorkand Singapore. 8. Maguirre,D.J.,MichaelF.G.andDavidW.R.(1999):GeographicalInformati onSystems:PrinciplesandApplication.GeoInformationInternational,Vol.2 ,LongmanPublication.,NewYork. 9. Martin,D.(1996):GeographicInformationSystems:SocioeconomicImplications.Routledge,London. 10. MichaelF.G.andKaranK.K.(ed.)(1990):IntroductiontoGIS.NCGIA, SantaBarbara,California. 11. Ripple,W.J.(ed.)(1989):FundamentalsofGeographicInformationSystems:ACompendium.ASPRS/ACSM,FallsChurch. 12. Star,J.andEstes,J.(1990):Geographic InformationSystems–An Introduction.Prentice-Hall,EnglewoodCliffs,NewJersey. 13. Worboys,M.F.(1995):GIS:AComputingPerspective.Taylorand Francis,London.
Learning Outcomes	• Enhance students' understanding of the fundamental aspects of GIS. • Familiarize students with key terminologies, data types, sources, and data models in GIS • Students should be able to understand spatial data analysis and GISDataStandards. • Studentshouldunderstandnatureofspatialdata,softwaresandapplications

Course	**B.Sc./B.A.FourthYear:Semester-VII**			
Course Title	**GGRMJ74F:Rural and Urban Planning**			
Category of Course	**Major**			
Credits &Hour of Teaching		Theory	Practical	Cumulative
	Credits	4		
	Hour of Teaching (Total)	60		
Course Objectives	• Tointroducestudentsaboutthebasicsandconceptsofruralandurbanplanning. • To describe and explain approachesoruralplanningandinfrastructure. • Tounderstandandcomprehendtechniquesofurbanplanningandlandusesmodels. • To train students on urban planning approaches, systems and case studies.			
Course Content	Thecoursecontentisdividedinto4Units.			
Units	**Course Content**			**Hr.of Teaching**
I	**ConceptofRuralPlanning:**Conceptandapproachesofruralplanning;Policiesandprogrammesofruraldevelopment;Basicinfrastructuresforruraldevelopment;Decentralizedplanning;Socialimpactassessmentanalysisforruralplanning;Urban-rurallinkageapproachtoplanning.			15
II	**ApproachestoRuralPlanning:**Landuseplanning:concepts,principlesandclassification; Carrying capacity of land; Agricultural efficiency; Rural land patterns and issues of land acquisitioninIndia;Ruralinfrastructure;MicrofinanceandMicroEnterprises;Locallevelplanning;PURA;VillageInformationSystem			15

III	**Concept of Urban Planning:** Concept and approaches of urban planning; Techniques and methods of urban planning: Urban land use: patterns and models; Urban renewal and redevelopment; Urban governance: Urban infrastructure; Master plan: A case study of Varanasi.	15
IV	**Approaches to Urban Planning:** Garden cities, City as an organism, New and satellite town, global city, sustainable smart cities; Transportation planning: Mass transit system; Heritage conservation; Urban planning: A case study of Chandigarh; National Urban Information system.	15

SEC-SkillEnhancementCourse, AECAbilityEnhancementCourse; VACValueAdded
Course: MD-MultidisciplinaryCourse1Credit(Theory)=15Hours;1Credit(Practical)=30Hours

Texts/References	**1.** Bhat,L.S.(1976):MicroLevel Planningin India.K.B.Pub.NewDelhi. **2.** Desai,A.R.(1990):RuralDevelopment.PopularPrakashan,Bombay. **3.** Desai, V. and Potter, R. (eds.) (2002): The Arnold Companion of Development Studies. Arnold, London. Found, W.C.(1982):Theoretical ApproachtoRural LandUsePattern.MethuenandCompanyLtd.,London. **4.** Hall,P.(1992):Urban andRegionalPlanning.Routledge,London. **5.** Jr. Chapin S. F., Kaiser, E. J. Godschalk, D. R. (1995): Rural and Urban Land-use Planning. University of Illinois PressUrbanq andChicago **6.** Krishnamurthy,J.(2000):RuralDevelopment.ProblemsandProspects.RawatPublications,Jaipur. **7.** Lejonhud, K. (2003): Indian Villages inTransformation: A Longitudinal Study of Three Villages inUttar Pradesh.Karlstad UniversityStudies, Karlstad. **8.** Misra, R. P. and Achyutha, R. N. (1998): Micro-Level Rural Planning: Principles, Methods and Case Studies. ConceptPublishing. Company, NewDelhi. **9.** Misra, R. P. and Misra, K. (eds.) (1998): Million Cities of India: SustainableDevelopmentFoundation,New Delhi. Banaras Hindu University Institute of Science,DepartmentofGeography M.Sc./M.A.Two-Year Semester Course Outline, 2019-2028 **10.** Sundaram,K.V.(1977): Urban and Regional Planningin India. Vikas, NewDelhi. Varanasi, Pub
Learning Outcomes	• Enhance students' understanding of fundamental concepts in rural planning. • Increase awareness of various approaches to rural planning. • Familiarize students with urban planning practices and urban land use models. • Enable students to understand planning practices in India as well as in other contexts.

Course	**B.Sc./B.A.FourthYear:Semester-VII**			
Course Title	**GGRMJ74G:Geography of Migration and Diaspora**			
Category of Course	**Major**			
Credits &Hour of Teaching		Theory	Practical	Cumulative
	Credits	4		
	Hour of Teaching (Total)	60		
Course Objectives	• TointroducestudentsaboutmeaningdefinitionsandtypesofMigration. • To describeandexplainSpatialdimensionofInternalMigrationinIndia. • TounderstandandcomprehenddeterminantsofInternationalMigration. • TotrainstudentsonIndiandiaspora:identity,ethnicityandcitizenship.			
Course Content	Thecoursecontentisdividedinto4Units.			
Units	**CourseContent**			**Hr.of Teaching**
I	**BasicConcepts**:Meaning,DefinitionsandTypesofMigrationandDiaspora;CausesandConsequencesofMigration;LawsandTheories			15

	ofMigration;SourcesandDataofMigrationandDiaspora.	
II	**Internal Migration**: Spatial Dimension of Internal Migration in India: Inter-State andIntra-State; Trends and Patterns of Internal Migration; Reasons, Streams and Consequences of Internal Migration.	15
III	**International Migration and Diaspora**: Determinants of International Migration; Globalization, International Migration and Diaspora; Illegal Migration: Causes and Consequences; Role of Organizations: International Organization for Migration(IOM),United Nations High Commissioner for Refugees(UNHCR)	15
IV	**Indian Diaspora**: Indian Diaspora across Continents and Countries; Indian Diaspora: Identity, Ethnicity, Citizenship,PeopleofIndianOrigin,Remittances;Challengesfaced byIndianDiaspora.	15

SEC-SkillEnhancementCourse, AECAbilityEnhancementCourse; VACValueAdded
Course: MD-MultidisciplinaryCourse1Credit(Theory)=15Hours;1Credit(Practical)=30Hours

Texts/References	1. Cohen,Robin1997.GlobalDiaspora:AnIntroduction.London:UCLPress. 2. Jana Evans Braziel and Anita Mannur. 2003. "Nation, Migration, Globalization: Points of Contention inDiasporaStudies." In: Theorizing Diaspora .Ed.Braziel and Mannur.Oxford:Blackwell,pp.1-10. 3. KimD.Butler.2002."DefiningDiaspora,RefiningaDiscourse,"Diaspora10, 189-219. 4. Gilroy,Paul.2003."TheBlackAtlanticasaCountercultureofModernity. "In:TheorizingDiaspora.Ed.BrazielandMannur.Oxford:Blackwell, pp. 49-80. 5. Stephen Castles and Mark J. Miller. 1998. The Age of Migration: International Populations Movements in theModern World. London:Macmillan. 6. Hall,Stuart.2003."CulturalIdentityandDiaspora."In:TheorizingDias pora.Ed.BrazielandMannur.Oxford:Blackwell, pp. 233-246. 7. Thapan,Meenkashi(ed.).2005.TransnationalMigrationandthePoli ticsofIdentity.NewDelhi:Sage.Textbooks 8. Vertovec,Steven and Robin Cohen(eds.).1999. Migration,DiasporaandTransnationalism.London:EdwardElgar. 9. Hegde,R.&Sahoo,A.K.(eds.).2018.RoutledgeHandbookoftheIndi anDiaspora.NewYork:Routledge. 10. Cohen,Robin.(eds.).2018. RoutledgeH and book of Diaspora Studies.London:RoutledgePublications.
Learning Outcomes	• Enhance students' understanding of the causes and consequences of migration. • Increase awareness of trends and patterns in internal migration. • Familiarize students with international migration and diaspora. • Enable students to understand the characteristics of the Indian diaspora.

Course	**B.Sc./B.A.FourthYear:Semester-VII**			
CourseTitle	**GGRMN71:ResearchMethodology**			
Category of Course	**Minor**			
Credits&Hourof Teaching		Theory	Practical	Cumulative
	Credits	4		
	Hour of Teaching (Total)	60		
CourseObjectives	• Tointroducetheconceptandsignificanceofresearchgeography. • Toexplainthephilosophyandgeographyrelations. • Tointroducestudentsaboutresearchprocessanddesignanddatacollection.			

	• Toacquaintthestudentswithdataanalysis,reportwritingandstructure.	
CourseContent	Thecoursecontentisdividedinto4Units.	
Units	**Course Content**	**Hr.of Teaching**
I	**ResearchinGeography:**Conceptandsignificanceofresearching eography;Productionofgeographicalknowledge;Philosophyand Geography:Ontology,Epistemology,MethodologyandMethods; PositivistandNon-PositivistResearch	15
II	**ResearchProcessandDesign:**ResearchProcess;Researchdesig ns:quantitative(experimental and survey), qualitative (ethnography, grounded theory, case study, phenomenological), mixed method (sequential, concurrent, and transformative);Ethics in Research	15
III	**Data Collection Methods:** Primary data collection: questionnaires, observation, key information interviews ,in-depth interviews, focus group discussion; Sources of secondary data; Sampling and sample size determination; Quality control checks; Data cleaning.	15
IV	**Data Analysis and Dissemination:** Data analysis: Quantitative (variables, scales,univariate, bivariate, and multivariate analysis), Qualitative (thematic analysis); Writing reports and research papers: structure, referencing, plagiarism.	15

SEC-SkillEnhancementCourse, AECAbilityEnhancementCourse; VACValueAdded Course: MD-MultidisciplinaryCourse1Credit(Theory)=15Hours;1Credit(Practical)=30Hours

Texts/References	1. Ahuja,R.(2001):ResearchMethods.RawatPublications,Jaipurand NewDelhi. 2. Denzin,N.K.andLincoln,Y.S.,(eds.)(2000):HandbookofQualitativeResearch.Thousand OaksCA.SagePublications. 3. Flowerdew,R.andMartin,D.(eds.)(1997):MethodsinHuman Geography.AGuideforStudentsDoingaResearchProject. Longman, Harlow. 4. Kitchin,R.andTate,N.,(2001):ConductingResearchintoHumanGeography:Theory. MethodologyandPractice.Prentice-Hall, London. 5. Limb,M.(2001):QualitativeMethodologiesforGeographers:IssueandDebates.Edward Arnold,London. 6. Mishra,H.N.&Singh,V.P.(2002):Research Methodologyin Geography, Rawat Publications, Jaipur. 7. Neuman,Lawrence(2020):SocialResearchMethods:QualitativeandQuantitativeApproach, Pearson 8. Rogers, A. and Viles, H. A. (2003): The Student's Companion to Geography. Blackwell Publishers,Oxford.Indianreprintavailable. 9. Silverman,D.(1993):InterpretingQualitativeData:MethodsforAnalysingTalk,Text and Interaction.SagePublications,London. 10. Tandon,B.C.(1997):ResearchMethodologyinSocialSciences,Chaitanya Pub., Allahabad.
Learning Outcomes	• They would be able to enhance the learning on geographical research and its perspectives. • Students will be made aware about themes, approaches and recent developments. • They will be acquainted the knowledge of types of research designs and ethics. • Student should understand the data collection, analysis and presentation..

Course	**B.Sc./B.A.FourthYear:Semester-VII**			
Course Title	**GGRIN71:Internship**			
Category of Course	**Internship-2**			
Credits &Hour of Teaching		Theory	Practical	Cumulative
	Credits	2		
	Hour of Teaching (Total)	30		

Course	**B.Sc./B.A.FourthYear:Semester-VIII**			
Course Title	**GGRMJ83C:Advances in Urban Planning**			
Category of Course	**Major**			
Credits &Hourof Teaching		Theory	Practical	Cumulative
	Credits	4		
	Hour of Teaching (Total)	60		
Course Objectives	• Tointroducestudentsaboutformsofurbanizationandrecenturbangrowth. • Todescribeandexplainevolutionofurbanplanning,paradigmsandrealestatefactors. • Tounderstandandcomprehendurbangovernanceandmanagement practices. • Totrainstudentsoncasesstudiesofurbanplanningandregenerationandnewprobjects.			
Course Content	Thecoursecontentisdividedinto4Units.			
Units	**CourseContent**			**Hr.of Teaching**
I	**ConceptualandTheoreticalBackground:**Changingformsofurbanisation;Growthofcities; Stages of urban development; Evolution of urban planning; Objects of urban planning, Economic justification for urban planning; Principles of urban planning			15
II	**UrbanTransitions:**Urbanrevolution;FordistandPost-Fordistcity; Land economics and urban restructuring; Paradigmsin urban planning; Post modern urbanism; New urbanism; Cities and globalization;Impactsoflargeurbanprojects;Realestateandcities; Righttothecity;			15
III	**Governance and Management:** Inclusive city challenge; Local urban governance; Climate change and urban resilience; Urbanecologyandsustainableurbandevelopment; Measuring sustainability; Smart urban growth; Urban ecology in sustainable urban development; Problems and remedies of urbanization; Local Agenda 21 and urban management;			15
IV	**CasesofUrbanPracticesinIndia:**Natureofurbanregenerationand renewal;Spatiality of the slum (re)development; Transport :transit -oriented development; and Peri-urban growth; Urban participatory process under the CAA; Urban planning reforms			15

SEC-SkillEnhancementCourse, AECAbilityEnhancementCourse; VACValueAdded Course: MD-MultidisciplinaryCourse1Credit(Theory)=15Hours;1Credit(Practical)=30Hours

Texts/References	1. Bansal,S.C.(2010):UrbanGeography,MeenakshiPrakashan,Meerut 2. Baud,I.S.A.andWit, J.de (2008): New Forms of Urban Governance in India: Shifts, Models, Networks and Contestations,Sage;NewDelhi 3. Cadwallader,Martin(1986):UrbanGeography,PrenticeHall,NewJersey 4. Dickinson,R.E. (1964):CityandRegion, Routledge,London 5. Das,AmiyaKumar(2007):UrbanPlanninginIndia,RawatPublications,Jaipur 6. Kumar,Ashok,SanjeevVidyarthiandPoonamPrakash(2020):CityPlanninginIndia,Routledge,NewDelhi

	7. Gavsker,KapilKumar(2012): India'sUrbanDevelopment-Revitalizing PlanninginNeoliberalTimes&IntegratingGovernance,LambertAcademic Publishing, Germany 8. Kundu,A(1992):UrbanDevelopment andUrbanResearchinIndia,KhannaPublication,NewDelhi 9. MayerH.M.andKohn,C.F.(eds.)(1958):ReadingsinUrbanGeography,UniversityofChicagoPress,Chicago 10. Prasad, Sheela and Kapil Kumar Gavsker (2016): 'The New 'Love' Story of the Taj Mahal- Urban Planning in the Age ofHeritageTourisminAgra', Economic andPolitical Weekly,LI(5):40-48 11. Ramachandran,R.(1989):UrbanisationandUrbanSystemsinIndia,Oxford,NewDelhi. 12. Singh,K.and Steinberg, F.(eds.)(1987), Urban Indiain Crisis, New Age International, NewDelhi
Learning Outcomes	• Enhancingstudent'slearningonnewformsofurbanizationanditspatterns. • To make students aware about urban growth and urban planning. • Familiarize students of local urban governance and concept to inclusivity. • Student should understand urban regeneration, renewal and peri-urban growth management.

Course	**B.Sc./B.A.FourthYear:Semester-VIII**			
CourseTitle	**GGRMJ83D:Industrial Geography**			
Category of Course	**Major**			
Credits&Hourof Teaching		Theory	Practical	Cumulative
	Credits	4		
	Hour of Teaching (Total)	60		
CourseObjectives	• Tointroducestudentsaboutmeaningandscopeofindustrialgeography. • TodescribeandexplainFactorsofindustriallocation;Linkageinindustries. • Tounderstandlocalizationanddistributionofiron&steel,cotton textile and sugar industries. • Totrainstudentsonindustrialdevelopmentandpolicies..			
CourseContent	Thecoursecontentisdividedinto4Units.			
Units	**CourseContent**			**Hr.of Teaching**
I	**Basic Concepts:** Meaning and scope of industrial geography; Recent trends in industrial geography; Classification of industries; Concept of industrialization, industrial complex and industrial estate; Role of industries in regional development.			15
II	**Location Factors and Theories:** Factors of industrial location; Linkage in industries; Theories of industrial location: Weber, Hoover, Lösch and Smith.			15
III	**The spatial arrangement of Industries:** Localization anddistributionofiron&steel,cottontextileandsugarindustries;Basesofidentificationofindustrialregions;Industrialregionsoftheu.S.A. and West Europe.			15
IV	**Industrialization in India**: Industrial development and policies; Industrial regions and complexes; Impact of globalization on industries; Problems of industrialization; Environmental impact of industrialization; Tourism as an industry; Tourism in Uttar Pradesh. Special economic zones.			15

SEC-SkillEnhancementCourse, AECAbilityEnhancementCourse; VACValueAdded Course: MD-MultidisciplinaryCourse1Credit(Theory)=15Hours;1Credit(Practical)=30Hours

Texts/References	1. Alexanderson,C.(1967):GeographyofManufacturing.Prentice-HallofIndia,NewDelhi 2. Behari,Bepin,1976.RuralIndustrializationinIndia.VikasPublishingHousePvt. Ltd.NewDelhi, 3. Clark,G.L.,Gertler,M.S.andFeldman,M.P.(eds.)2000.TheOxfordHandbookofEconomicGeography.OxfordUniversityPress,USA. 4. Coe, N.2007.Economic Geography: A Contemporary Introduction. Blackwell Publishers, Inc., Massachusetts. 5. Dicken,P.andLloyd,P.1990/1977.LocationinSpace.NewYork:Harper&Row 6. Hoover, E.M.(1948):Location and Space Economy. MNGraw-Hill,NewYork. 7. Hudson,R.2005.Economic Geographies: Circuits, Flows and Spaces. Sage Publications, London. 8. Mackinnon, D. and Cumbers,A.2007.Introductionto Economic Geography:Globalization,UnevenDevelopmentandPlace.PrenticeHall,Inc.,NewYork 9. Miller, E.(1962):Geography of Manufacturing. Prentice-Hall, Engle wood Cliffs, New Jersey. 10. RileyR.C.1973.IndustrialGeography,ChattoandWindusLtd.London. 11. Sharma,V.N.2001.IndustrialDevelopmentandPlanninginIndia.RadhaPublications, New Delhi. 12. Sheppard,E.andBarnes,T.J.(eds.)2002.ACompaniontoEconomicGeography.BlackwellPublishers,Inc.,Massachusetts.
Learning Outcomes	• Enhancing student's learning on growth of industrial geography. • To make students aware factors and major theories of industrial location. • Familiarize students' about localization and distribution of major industries. • Student should understand nature of industrialization inIndia.

Course	**B.Sc./B.A.FourthYear:Semester-VIII**			
CourseTitle	**GGRMJ83E:Gender Geography**			
Category of Course	**Major**			
Credits&Hourof Teaching		Theory	Practical	Cumulative
	Credits	4		
	Hour of Teaching (Total)	60		
CourseObjectives	• Tointroducestudentsaboutmeaningandscopeofgendergeography. • Todescribeandexplainmajorapproachestowomenanddevelopment. • Tounderstandsocio-spatialconstructionofgender • Totrainstudentsonmappingwomen'slivesandviolenceagainstwomen.			
CourseContent	Thecoursecontentisdividedinto4Units.			
Units	**CourseContent**			**Hr.of Teaching**
I	**Conceptualizing Gender:** Meaning and Scope of Gender Geography, Basic Concepts: sex,gender, sexuality, power, gender inequality; Feminism; Waves of feminism; Feminism inIndia;HistoryofIndianWomen'sMovement.			15
II	**Gender and Development:** Approaches to women and development: WID, WAD& GAD; Gender empowerment measures(GEM); Sustainable development and gender, Global gendergap(GGP); Womenand natural resource management(NRM), Gendermainstreaming;Genderbudgeting.			15
III	**Gender, Identity and Space:** Socio-spatial construction of gender: class, caste, religion, sexuality and age; Public and private spaces: gender and work, gender and migration, sexual harassment: domestic and at work places; Legislative			15

	measurements: Domestic Violence act (2005), Protection of women against sexual harassment at workplace act(2013), Criminal law (Amendment)act-2013	
IV	**Gendered Nature of House work**; Girls Education; Women's Employment; Feminization of Poverty; Gender Violence; Women in Decision Making; HumanTrafficking.	15

SEC-SkillEnhancementCourse, AECAbilityEnhancementCourse; VACValueAdded Course: MD-MultidisciplinaryCourse1Credit(Theory)=15Hours;1Credit(Practical)=30Hours

Texts/References	1. Bedi,Tarini(2006).FeministTheoryandtheRight-Wing: ShivSena Women Mobilize Mumbai.JournalofInternationalWomen'sStudies,7(4),51-68, available at :http: // vc. bridgew.edu/jiws/vol7/iss4/4 2. Bhatt,ArchanaPathak(2008).TheSitaSyndrome:ExaminingtheCommunicative Aspects of DomesticViolence from a South Asian Perspective, Journal of International Women'sStudies,9(3),155-173. Available at: http: // vc .bridge w. edu/ jiws/vol9/iss3/9 3. Hall, Jennifer (2002): The Next Generation: Can There Be a Feminist Geography without Gender? The Great Lakes Geographer,9 (1),19-27, available at: http: // geography. uwo.ca / research /great_ lakes _geographer /GLG volume9/Hall.pdf 4. Hanson,Susan(2005):Geographyandfeminism,WorldsinCollision,AnnalsoftheAssociationofAmericanGeographers,82 (4). 5. Harris,Ashleigh(2003):FromSuffragisttoApologist:TheLossofFeministPoliticsina PoliticallyCorrectPatriarchy.JournalofInternationalWomen's Studies,4(2),91-99, available at: http://vc.bridgew.edu/jiws/vol4/iss2/8 6. Haas, Hein de (2008): Migration and Development: A Theoretical Perspective, Working Paper, 09, International MigrationInstitute, JamesMartin 21st Century School. 7. MNDowell,Linda(1999):Gender,identityandplace:understandingfeministgeographies.PolityPress,Minnesota. 8. Mitra, Aditi; Bhatia, Manjeet; and Chatterjee, Sobha (2013): Perspectives on Women's Studies from India: Strengths, Struggle sand Implications for Programs in the U.S.,JournalofInternationalWomen'sStudies,14(3),194-209, available at : http://vc.bridgew.edu/jiws/vol14/iss3/14 9. Pamela,MossandAl-Hindi Karen Falconer An Introduction: Feminisms ,Geographies, Knowledges, 10. Sen, Samita (2000): Toward a Feminist Politics? The Indian Women's Movement in Historical Perspective, policy researchreport ongender and development, The World Bank, Working Paper Series No. 9, Seager, Joni (2009): The Penguin Atlas of women in theWorld,FourthEdition,Brighton:MyraidEditions,PenguinGroup
Learning Outcomes	• Enhancing student's learning on growth of gender geography. • Students will be made aware about the factors affecting women's lives. • They will be able to know about gender development approaches and programmes. • Student should understand gendered nature of house work and its implications.

Course	**B.Sc./B.A.FourthYear:Semester-VIII**			
Course Title	**GGRMJ83F:Agriculture Geography**			
Category of Course	**Major**			
Credits &Hourof Teaching		Theory	Practical	Cumulative
	Credits	4		
	Hour of Teaching (Total)	60		
Course Objectives	• Tointroducestudentsaboutmeaningandscopeofagriculturegeography. • Todescribeandexplaincropconcentrationandcropdiversification. • TounderstandConceptsofagriculturalland-use and carrying capacity and models. • TotrainstudentsonAgro-climatic regions of India; Reforms in Indian agriculture.			
Course Content	Thecoursecontentisdividedinto4Units.			

Units	**CourseContent**	**Hr.of Teaching**
I	**BasicConcepts:**Meaningandscopeofagriculturalgeography;Approachestoagricultural geography; Physical, cultural and institutional factors affecting agricultural distribution and productivity.	15
II	**Agricultural Patterns:** Crop concentration and crop diversification;Delineationofcropcombinationregions;Agriculturalregionsoftheworld;AgriculturalSystems(subsistence,plantationandcommercialfarming).	15
III	**Land use and Productivity:** Concepts of agricultural land-use and carrying capacity; Model of Agricultural Land use (Von Thunen);Land use pattern and planning; Measures Of agricultural efficiency and productivity.	15
IV	**Indian Agriculture:** Agro-climatic regions of India; Reforms in Indian agriculture with special reference to land and institutional reforms; Agricultural revolutions in India; Organic and contract farming; Agricultural planning and policies inIndia.	15

SEC-SkillEnhancementCourse, AECAbilityEnhancementCourse; VACValueAdded Course: MD-MultidisciplinaryCourse1Credit(Theory)=15Hours;1Credit(Practical)=30Hours

Texts/References	1. Dumont,R.(1970):TypesofRuralEconomy:StudiesinWorld Agriculture,DouglasManin,Londonethuen 2. Gregor,H.P.(1970):GeographyofAgriculture.Prentice-Hall,NewYork. 3. Husain,M.(1996):SystematicAgriculturalGeography,RawatPublications,Jaipur. 4. Misra,R.P.(1967): DiffusionofAgriculturalInnovations,UniversityofMysore,Mysore. 5. Mohammad,A.(1978):StudiesinAgriculturalGeography,RajeshPublications,NewDelhi 6. Morgan,W.B.andNorton,R.J.C.(1971):AgriculturalGeography.Methuen,London. 7. Sauer,O.C.(1969):AgriculturalOriginsand Dispersals.MITPress,Cambridge. 8. Shafi,M.(2006):AgriculturalGeography,PearsonEducation,NewDelhi. 9. Sen,Sudhir(1975):ReapingtheGreenRevolution.TataMNGraw-Hill,NewDelhi 10. Shafi,M.(2000):Agricultural Geography of SouthAsia, MNMillan, Delhi 11. Singh,B.B.(1979):*KrishiBhugol*.TaraPublications,Varanasi. 12. Singh,J.andDhillon,S.S.(2000):AgriculturalGeography.TataMNGrawHill,NewDelhi. 13. Singh,S.(1994):AgriculturalDevelopmentinIndia:ARegionalAnalysis,KaushalPublications,Shillong. 14. Symons,L.(1967):AgriculturalGeography.GeorgeBellandSons,London.15. TarrantJ.R.(1974):AgriculturalGeography. JohnWileyandSons, NewYork.
Learning Outcomes	• Enhancingstudent'slearningonnatureandapproachesofagriculturegeography • Students will be made aware to agricultural patterns and their measurements. • Students will be able to develop the knowledge of land use and productivity. • Student should understand agricultural regions and their characteristics..

Course	**B.Sc./B.A.FourthYear:Semester-VIII**			
CourseTitle	**GGRMJ83G:Environmental Hazards and Disaster Risk Reduction**			
Category of Course	**Major**			
Credits&Hourof Teaching		Theory	Practical	Cumulative
	Credits	4		
	Hour of Teaching (Total)	60		
CourseObjectives	• Tointroducestudentsaboutmeaningandscopeofenvironmentalhazards • Todescribeandexplainriskreductionstrategies. • TounderstandConceptsofhazardidentificationandmapping. • Totrainstudentsoninternationalandnationalinitiatives.			
CourseContent	Thecoursecontentisdividedinto4Units.			
Units	**CourseContent**			**Hr.of Teaching**
I	**UnderstandingEnvironmentalHazards:**ConceptsandDefinitionofEnvironmentalHazards,Disaster,Risk,andResilience,BasesofClassificationandTypesofHazards,Characteristics,spatio-temporal distribution, impact sand risk reduction measures of Major geological hazards: Volcanic eruption, Earthquakes,TsunamiandLandslides; Majorhydro-meteoro logica hazards: Floods,Drought,Cyclones,Cloudburs.			15
II	**Disaster Risk Reduction Process:** Paradigm and approachesindisaster management, Concepts of Disaster Risk Reduction, Disaster Management Cycle, Pre-disasterstage-preparedness, prevention, mitigation; On disasterstage-response,Post-disasterstage-Relief,Recovery,Rehabilitation.			15
III	**TechniquesandMethods:**Processofhazardidentificationandmapping,Indicatorsandfactorsofvulnerability,Riskassessmentprocess			15
IV	**International and National initiatives:** UN and its Programmes: International Decade ofNatural Disaster Reduction (IDNDR), International Strategy for Disaster Risk Reduction(ISDR), Hyogo Framework for Action (HFA) – 2005,Major hazards profileofIndia: Flood, drought, earthquake, tsunami,cyclones;Institutions:NationalDisasterManagementAuthority (NDMA), National Institute of Disaster Management (NIDM),Policy: Disaster managementact 2005, Disaster management system in India.			15

SEC-SkillEnhancementCourse, AECAbilityEnhancementCourse; VACValueAdded Course: MD-MultidisciplinaryCourse1Credit(Theory)=15Hours;1Credit(Practical)=30Hours

Texts/References	1. Alexander,D.(1993):NaturalDisasters,Springer,Berlin 2. Bolt,B.A.et.al.(ed.)(1950):GeologicalHazards,Springer,Verlag,NewYork. 3. Burton,I.et.al.(1978)EnvironmentasHazards,O.P.O.,NewYork. 4. Goudie,A.(1990):GeomorphologicalTechniques,UnwinHyman, London 5. Hart,M.G.(1986):Geomorphology:PureandApplied,GeorgeAllenandUnwin,London 6. Kusky,T.(2012):EncyclopediaoftheHazardousEarth,VivaBooks,NewDelhi 7. Petak, W.J. and Atkinson,A.D. (1982): Natural Hazards Risk Assessment and Public Policy, Sprinager,Verlay, NewYork. 8. Roy, P.S.et.al.(2000):NaturalDisasterandtheirMitigation,ITCPublication. 9. Valdiya,K.S.(1987):EnvironmentalGeology,TataMNGrawHill,NewDelhi 10. White,G.F.(ed)(1974):NaturalHazards,Local,NationalandGlobal,OxfordUniversity Press,London.
Learning Outcomes	• Enhancingstudent'slearningonnatureofhazardsandtheirdetection. • Students will be able to develop theknowledgeofapproachesindisastermanagement. • Students will be able to learn the knowledge of oftechnique sand methods of disaster management. • Studentshouldunderstandmajorprogrammes,policies andcasestudies.

CourseTitle	**GGRMJ83H:Ecotourism & Geoheritage**			
Category of Course	**Major**			
Credits&Hourof Teaching		Theory	Practical	Cumulative
	Credits	4		
	Hour of Teaching (Total)	60		
CourseObjectives	• Tointroducestudentsthenatureandscopeof Geographyofeco-tourism. • Todescribeandexplaintourismmultiplierandforecastingmethods. • Tounderstandandcomprehendculturalheritage-basedtourism. • Totrainstudents on tourism and ecotourism in India & characteristics of tourismplan.			
CourseContent	Thecoursecontentisdividedinto4Units.			
Units	**CourseContent**			**Hr.of Teaching**
I	**Conceptual:**Nature,and Scope of Geography of eco-tourism; Dat sources; Typology of Tourism:developed and developing world; Tourism asanindustry; Drivers of Tourism; Tourism and Regional Economy; Conceptof heritage and its types.			15
II	**SystemofTourismandImpacts;** Tourism Multiplier and Forecasting Methods; Trends and Pattern of tourism in theWorld; Models of Ecotourism; Impacts of Tourism-Socio-cultural problems and Environmental degradation.			15
III	**Concept of Historic Urban Landscapes;** Concept and Classification of heritage;Built heritage conservation; Cultural heritage-based tourism; Major National Parks, Beaches and Resorts of India; Built Heritage Conservation; Cultural Heritage Based Tourism; Legislation and Acts; SustainableTourismDevelopment Planning			15
IV	**PolicyandPlanningforHeritage;**Tourism in India; Characteristics of Tourism Plan; Cases of Cultural Heritage:ConservationandRevitalization;LegislationandActs;SustainableTourismDevelopmentPlanning.			15

SEC-SkillEnhancementCourse, AECAbilityEnhancementCourse; VACValueAdded Course: MD-MultidisciplinaryCourse1Credit(Theory)=15Hours;1Credit(Practical)=30Hours

Texts/References	**1.** BhatiaA.K.(1996):TourismDevelopment:PrinciplesandPractices,SterlingPublishers,New York **2.** Carter,EandG.Lowman(1994):Ecotoursim,JohnWileyandSons,NewYork, **3.** CharlesR.Goeldner,J.R.BrentRitchie(2009);Tourism:Principles,Practices,Philosophies,JohnWiley&Sons **4.** ChristopherMLaw(2009);UrbanTourism:TheVisitorEconomyandtheGrowthofLargeCities,ContinuumDelhi **5.** KamraK.K.andMohinderChand(2007):BasicsofTourism:Theory,OperationandPractice,KanishakaPublishersNewDelhi **6.** MinistryofTourism(2011);StrategicActionPlanforTourisminIndia,MinistryofTourism,GovernmentofIndia **7.** Prasad,Sheela andKapil KumarGavsker(2016): „TheNew„Love" StoryoftheTajMahal-Urban PlanningintheAgeof Heritage Tourismin Agra",Economicand PoliticalWeekly, LI(5): 40-48 **8.** Robinson, H.A. (1996):Geography of Tourism, Macdonald and Evans, London **9.** 9.9.Williams, Stephen (1998):TourismGeography,Routledge,London
Learning Outcomes	• Enhancingstudent'slearningoncausesandconsequencesofMigration • Students will be able to develop theknowledgeof trends and patterns of InternalMigration. • They will be learning the knowledge of International Migration and Diaspora. • Studentshouldunderstand Indiandiasporaanditscharacteristics.

CourseTitle	**GGRMJ83I:Fluvial Geomorphology**			
Category of Course	**Major**			
Credits&Hourof Teaching		Theory	Practical	Cumulative
	Credits	4		
	Hour of Teaching (Total)	60		
CourseObjectives	• Tointroducestudentsthebasicsandconceptsofdrainagebasinandgeometry. • Todescribeandexplainchannelmorphologyanddepositionalenvironment. • Tounderstandandcomprehendlargeriversystemsandtheiractions. • Totrainstudentsonrivermanagementandrestoration.			
CourseContent	Thecoursecontentisdividedinto4Units.			
Units	**CourseContent**			**Hr.of Teaching**
I	**OverviewofRiverProcessesandHydraulics:** Drainage basin evolution; divide, channel network, overview of open-channel flow& Geometry overlandflow, nodes and their classification; erosion and transport in river channel, Typesof flow.			15
II	**ChannelMorphology&FluvialDepositionalEnvironment:**Thebank-full channel: Hydraulic geometry, Flowregimesanddominantdischarge;Aggradationinthefluvialsystem:aggradationasanormalphaseofvalleyevolution,Climaticchange,alluvialvalleys,terrace,Riverlongprofiles:Gradedstreams, base level, downstream fining channel alluvium, bar, Multi-threadchannels,avulsions,floodplains,DeltaandAlluvialfans.			15
III	**LargeRiverintheTropics:** Channel characteristics, hydrology and morphology, recent problems of Amazon, Zambezi, Ganga-Brahmaputra system,Kosi.			15
IV	**River Management & Restoration:** River health assessment, framework and principles, indicators, management and operational issues, casestudies, Impact of Climatic & anthropogenic change on river.			15

SEC-SkillEnhancementCourse, AECAbilityEnhancementCourse; VACValueAdded Course: MD-MultidisciplinaryCourse1Credit(Theory)=15Hours;1Credit(Practical)=30Hours

Texts/References	1. C.R.Thorne(Editor),RichardD.Hey(Editor),MalcolmD.Newson(Editor),Applied FluvialGeomorphologyforRiverEngineering and Management, byJohnWileyandSons,1998. ISBN:978-0-471-96968-6 2. DavidKnightonFluvialFormsandProcesses:ANewPerspective,JohnWiley andSons,1998.ISBN13:9780340663134 3. S.LawrenceDingman,FluvialHydraulics,OxfordUniversityPress,2009.ISBN978-0-19-517286-7. 4. RoCharlton,FundamentalsofFluvialGeomorphology,Routledge,2007 5. King,C.A.M.TechniquesinGeomorphology,EdwardArnold,1967 6. KirstieA.Fryirs,GaryJ.Brierley,2012 GeomorphicAnalysisofRiverSystems:AnApproachtoReadingtheLandscape, Wiley-Blackwell 7. Miller,1964FluvialProcessesinGeomorphology, byLunaBergereLeopold,MarkleyGordonWolman, JohnPreston 8. Rivermorphology,2006,R.J.garde,NewAgeInternational(P)Limited,Publisher,New Delhi **9.** Small, R.J.TheStudyofLandforms– A Textbook of Geomorphology, CambridgeUniversityPress,1970

Learning Outcomes	• Enhancingstudent'slearningondrainagebasinevolution;divide,channel network. • Students will be able to develop the knowledge about hydraulic geometry, flowregimesanddominantdischarge. • They will learntheknowledgeofchannelcharacteristics. • Studentshouldunderstandriverhealthassessmentandimpactsofclimatic change.

Course	**B.Sc./B.A.FourthYear:Semester-VIII**			
CourseTitle	**GGRMN81:Advance Surveying**			
Category of Course	**Minor**			
Credits&Hourof Teaching		Theory	Practical	Cumulative
	Credits		2	
	Hour of Teaching (Total)		60	
CourseObjectives	• TointroducestudentssurveyinstrumentsTheodolite,Dumpy Level, Total Station and workingprinciples. • To train students on GPS survey: Elements and segments;GPS Satellites.			
CourseContent	Thecoursecontentisdividedinto2Units.			

Units	**CourseContent**	**Hr.of Teaching**
I	**SurveyInstruments:**Theodolite,DumpyLevel,TotalStationand GPS;Fundamentals of Total Station: parts, characteristics, advantages anddisadvantages; Working Principles: settings, measurement (angular andlinear),open and closedtraverse	30
II	**GPSSurvey:** Elements and segments; GPSSatellites: Global Navigation Satellite System (GNSS), Indian Regional Navigation SatelliteSystem(IRNSS);MobileMapping; location-basedsurvey(LBS).	30

SEC-SkillEnhancementCourse, AECAbilityEnhancementCourse; VACValueAdded Course: MD-MultidisciplinaryCourse1Credit(Theory)=15Hours;1Credit(Practical)=30Hours

Texts/References	1. Rueger, J.M. Electronic Distance Measurement,Springer-Verlag, Berlin, 4th Edition,1996. 2. Satheesh Gopi,R Sathish Kumar, N.madhu, " Advanced Surveying, Total Station GPS and Remote Sensing " PearsonEducation, 2ndEdition,2017 3. R.Subramanian,SurveyingandLevelling,OxfordUniversityPress,SecondEdition,2012. 4. Laurila,S.H.ElectronicSurveyinginPractice,JohnWileyandSonsInc,1983. 5. GuochengXu,GPSTheory,AlgorithmsandApplications,Springer–Verlag,Berlin,3rdEdition,2016. 6. AlfredLeick,GPSsatellitesurveying,JohnWileyandSonsInc.,4thEdition,2015. **7.** SeeberG,SatelliteGeodesy,WalterDeGruyter,Berlin,2ndEdition,2003
Learning Outcomes	• Enhancingstudent'slearningonsurveyinstruments-parts,characteristics,advantagesanddisadvantages • StudentshouldunderstandGPSsurveyanditsimportance.

Course	**B.Sc./B.A.FourthYear:Semester-VIII**			
CourseTitle	**GGRMN82:Environmental Quality Analysis**			
Category of Course	**Minor**			
Credits&Hourof Teaching		Theory	Practical	Cumulative
	Credits		2	
	Hour of Teaching (Total)		60	
CourseObjectives	• Tointroducestudentssoilandwaterqualityassessment. • Totrainstudentsonair,noiseandsolidwasteassessment			
CourseContent	Thecoursecontentisdividedinto2Units.			
Units	**CourseContent**			**Hr.of Teaching**
I	**Soil and water analysis**: Soil health kundali: Calcium, magnesium, nitrogen,oxygen, humus, phosphorus, alkalinity and salinity, moisture (wet and dry),Water quality analysis: temperature, pH, DO, BOD and Water Quality Index(surfaceandgroundwater), Pointand non-pointsources ofpollution.			30
II	**Air and Noise analysis and Solid waste**: Air quality analysis:SO_2,NO_2,CO_2, PM 2.5, PM 10, Air Quality Index; Noise levels: Indoor and outdoor(Peak andnonpeakhours of day andnight);MeasuringEMRby electric, magnetic, ultrasonic equipment; Solidwaste: Environmental ImpactAssessmentof awaste disposal and processingsite.			30

SEC-SkillEnhancementCourse, AECAbilityEnhancementCourse; VACValueAdded Course: MD-MultidisciplinaryCourse1Credit(Theory)=15Hours;1Credit(Practical)=30Hours

Texts/References	1. Rathi,A.Kumar,(2021)HandbookofEnvironmentalimpactassessment:conceptan dpractice,Cambridgescholar publishing, New Castle,UK. 2. Rump,H.Hand Krist,H.(Eds) (1992):LaboratoryManualfortheExaminationofWater,WasteWaterand Soil, Weinheim:VCH PublishersIns,Germany. 3. U.S.EnvironmentalProtectionAgency,(2017):QualityAssuranceHandbookforAirP ollutionMeasurement Systems Volume II, Office of Air Quality Planning and Standards, Air Quality AssessmentDivision,North Carolina,USA
Learning Outcomes	• Enhancingstudent'slearningonsoilandwateranalysisonselectparameters. • Studentstolearnaboutenvironmentalparametersofair,noiseandsolidwaste.

For Honours Degree with Research

Course	**B.Sc./B.A.FourthYear:Semester-VII**			
CourseTitle	**GGRMJ7R1:ResearchMethodology**			
Category of Course	**Major**			
Credits&Hourof Teaching		Theory	Practical	Cumulative
	Credits	4		
	Hour of Teaching (Total)	60		
CourseObjectives	• Tointroducetheconceptandsignificanceofresearchgeography. • Toexplainthephilosophyandgeographyrelations. • Tointroducestudentsaboutresearchprocessanddesignanddatacollection • Toacquaintthestudentswithdataanalysis,reportwritingandstructure.			
CourseContent	Thecoursecontentisdividedinto4Units.			
Units	**CourseContent**			**Hr.of Teaching**

I	**Research in Geography:** Concept and significance of research in geography; Production of geographical knowledge; Philosophy and Geography: Ontology, Epistemology, Methodology andMethods;PositivistandNon-PositivistResearch	15
II	**Research Process and Design :**ResearchProcess;Researchdesigns:quantitative(experimentalandsurvey),qualitative(ethnography,groundedtheory,casestudy,phenomenological),mixedmethod(sequential,concurrent,andtransformative);EthicsinResearch	15
III	**Data Collection Methods:** Primary data collection: questionnaires ,bservation,key information interviews, in-depth interviews, focus group discussion; Sources of secondary data; Sampling and sample size determination;Quality control checks;Data cleaning.	15
IV	**Data Analysis and Dissemination:** Data analysis: Quantitative (variables, scales, univariate, bivariate, and multi variateanalysis) , Qualitative (thematicanalysis); Writing reports and research papers:structure,referencing,plagiarism.	15

SEC-SkillEnhancementCourse, AECAbilityEnhancementCourse; VACValueAdded Course: MD-Multidisciplinary Course1Credit(Theory)=15Hours;1Credit(Practical)=30Hours

Texts/References	1. Ahuja,R.(2001):Research Methods.RawatPublications,Jaipurand NewDelhi. 2. Denzin,N.K.andLincoln,Y.S.,(eds.)(2000):HandbookofQualitativeResearch.ThousandOaksCA.SagePublications. 3. Flowerdew,R.and Martin,D.(eds.)(1997):MethodsinHumanGeography.AGuideforStudentsDoingaResearchProject. Longman, Harlow. 4. Kitchin,R.andTate,N.,(2001):ConductingResearchintoHumanGeography:Theory.MethodologyandPractice.Prentice-Hall, London. 5. Limb,M.(2001):QualitativeMethodologiesforGeographers:IssueandDebates.Edward Arnold,London. 6. Mishra,H.N.&Singh,V.P.(2002):ResearchMethodologyin Geography,RawatPublications,Jaipur. 7. Neuman,Lawrence(2020):SocialResearchMethods:QualitativeandQuantitativeApproach,Pearson 8. Rogers,A.andViles,H.A.(2003):TheStudent'sCompaniontoGeography.BlackwellPublishers,Oxford.Indianreprintavailable. 9. Silverman,D.(1993):InterpretingQualitativeData:MethodsforAnalysingTalk,TextandInteraction.SagePublications,London. 10. Tandon,B.C.(1997):ResearchMethodologyinSocialSciences,ChaitanyaPub.,Allahabad.
Learning Outcomes	• They would be able to enhance the learning on geographical research and its perspectives. • Students will be made aware about themes, approaches and recent developments. • They will be acquainted the knowledge of types of research designs andethics. • Studentshouldunderstandthedatacollection, analysisandpresentation.

Course	**B.Sc./B.A.FourthYear:Semester-VII**			
CourseTitle	**GGRMJ7R2:Environmental Studies**			
Category of Course	**Major**			
Credits&Hourof Teaching		Theory	Practical	Cumulative
	Credits	4		
	Hour of Teaching (Total)	60		
CourseObjectives	• Tointroducestudentstotypesandcomponentsofenvironment.			

	• Toexplainthedistributionandclassificationofnaturalresources. • Tointroducestudentsaboutenvironmentissuesandmonitoring. • Toacquaintthestudentswithenvironmentalconflictsandgeopolitics.	
CourseContent	Thecoursecontentisdividedinto4Units.	
Units	**CourseContent**	**Hr.of Teaching**
I	**Environmentalconcepts**:Meaning,typesandcomponentsoftheenvironment;ApproachestoEnvironmentalStudies;Ecosystem:components andclassification;Geo-biochemical cycles: carbon, nitrogen and phosphorus.	15
II	**NaturalResourcesandBiodiversity**:Distribution and classification of NaturalResources: Land, Water, Forest and Energy; Biodiversity: Extinction and conservation; Biomes of the world.	15
III	**Environmental problems and management**: EnvironmentalIssuesin Tropical, Temperate and PolarEcosystems;Pollution:air,water,soilandsolidwaste;Hazards :earthquakeandflood;Environmentalmonitoring;Environmentaleducation,Environmentalpoliciesandlegislations.	15
IV	**TrendsinEnvironmentalstudies**:Environmental conflicts; Environment and geopolitics; transnational movement; Environmental justice; Environmental geoinformatics: Environmentalsurveillance;Environmentalmapping.	15

SEC-SkillEnhancementCourse, AECAbilityEnhancementCourse; VACValueAdded Course: MD-MultidisciplinaryCourse1Credit(Theory)=15Hours;1Credit(Practical)=30Hours

Texts/References	1. Anjuneyulu,Y.(2004):IntroductiontoEnvironmentalScience.B.S.Publications,Hyderabad. 2. Blaikie,P.,Cannon,T.andDavis,I.(eds.)(2004):AtRisk:NaturalHazards,PeoplesVulnerability andDisasters.Routledge,London. 3. Huggett,R.J.(1998):FundamentalofBiogeography.Routledge,London. 4. Kayastha,S.L.andKumraV.K.(1986):EnvironmentalStudies.TaraBook Agency,Varanasi. 5. Kumaraswamy,K.,AlagappaMoses.,A&Vasanthy,M.(2004)*EnvironmentalStudies*,BharathidasanUniversity,Tiruchirappalli. 6. Nag,P.,Kumra,V.K.andSingh,J.(1990):GeographyandEnvironmentalIssuesatLocal,RegionalandNationalLevels.(in3vols.),ConceptPublishingCompany,NewDelhi. 7. Odum,E.P.(1975):Ecology.RowmanandLittlefield,LanhamUSA. 8. Rajagopalan,R.(2005):EnvironmentalStudies:FroMNrisistoCure,OxfordUniversityPress,New 9. Saxena,H.M.,2012:EnvironmentalStudies,RawatPublications,Jaipur. 10. UNEP,(2007):GlobalEnvironmentOutlook:GEO4:EnvironmentforDevelopment,UnitedNationsEnvironmentProgramm
Learning Outcomes	• Enhancingstudent'slearningontypes,componentsofenvironmentand approaches. • Tomakestudentsawareaboutdistributionandbiodiversitychallenges. • Acquaintedtheknowledgeofenvironmentalissues,monitoring and policies. • Studentshouldunderstandtheenvironmentgeopolitics,justiceandmapping.

Course	**B.Sc./B.A.FourthYear:Semester-VII**			
CourseTitle	**GGRMJ7R3:Geographical Field Training and Report Writing**			
Category of Course	**Major**			
Credits&Hourof Teaching		Theory	Practical	Cumulative
	Credits		2	

	Hour of Teaching (Total)		60	
CourseObjectives	• Tointroducestudents,themeaningandobjectivesofgeographicalfieldtraining • Toexplainfieldasalaboratoryofgeography. • Tounderstandvariouscontentsoffieldtraining. • Totrainstudentsonfieldbasedreportwriting.			
CourseContent	Thecoursecontentisdividedinto2Units.			
Units	**CourseContent**			**Hr.of Teaching**
I	**Principles of Field Training:** Meaning and objectives of field training; Fieldasa laboratory of geography; Contents of field training: physical, social, economic and cultural; Field trainingtechniques;Field training-based report writing.			30
II	**Field Visit:** Students will visit any one of the following geographical regionsof physical and human interest for field training: Himalayan Region, VindhyanPlateau, Thar Desert and Aravali Hills, Coastal region, East and North-easternIndia.			30

SEC-SkillEnhancementCourse, AECAbilityEnhancementCourse; VACValueAdded Course: MD-MultidisciplinaryCourse1Credit(Theory)=15Hours;1Credit(Practical)=30Hours

Texts/References	1. Archer,J.E.and Dalton, T.H.(1968): Field Workin Geography. William ClowesandSonsLtd.LondonandBeMJles. 2. Bolton,T.andNewbury,P.A.(1968):GeographythroughFieldwork.BlandfordPress,London. 3. Jones,P.A.(1968):FieldWorkinGeography. Longmans, Green and CompanyLtd.,London and Harlow. 4. Lousenbury,J.F. andAldrich,F.T. (1986): Introduction toGeographic FieldMethodsandTechniques.CharlesE. Merrill Publishing. Company, Colombus. 5. Pugh,J.C.(1975):SurveyingforFieldScientists.MethuenandCompanyLtd.London. 6. Parsons, Tony and Knight, Peter G. (2005): How to do your Dissertation in Geography and RelatedDisciplines. Routledge, London. 2ndEd. 7. Kitchen,RobandTate,NicholasJ.(2009):ConductingResearchintoHumanGe ography:Theory,Methodology&Practice.PrenticeHall-Pearson,HarlowU.K.2ndEd. 8. Hay,Iain(ed.)(2005):QualitativeResearchMethodsinHumanGeography.OxfordUn iversityPress,Melbourne. 2ndEd. 9. Hay,Iain(ed.)(2004):CommunicatinginGeographyandtheEnvironmentalScience s.OxfordUniversityPress, Melbourne.2ndEd. 10. Stoddard,RobertH.(1982):FieldTechniquesandResearchMethodsinGeography.Kendal l/HuntPub.Dubuque IO.
Learning Outcomes	• Enhancingstudent'slearningonimportanceoffieldingeographicalknowledge. • Tomakestudentsawareaboutvariousimportantaspectsoffieldphenomenon. • Acquaintedtheknowledgeofmajortechniques. • Studentshouldunderstandthefieldtraining-basedreport writing..

Course	**B.Sc./B.A.FourthYear:Semester-VII**			
CourseTitle	**GGRMJ7R4A:Advanced Geographical Thought**			
Category of Course	**Major**			
Credits&Hourof Teaching		Theory	Practical	Cumulative
	Credits	4		
	Hour of Teaching (Total)	60		
CourseObjectives	• Tointroducestudentstherecentnatureofgeographicalknowledge. • Toexplainnewenvironmentalismandmajorapproachesingeography. • Tounderstandvariousparadigmsandcontributionsofgeographers.			

	• TotrainstudentsoncontributionsofIndiangeographersandscholars.	
CourseContent	Thecoursecontentisdividedinto4Units.	
Units	**CourseContent**	**Hr.of Teaching**
I	**Basic Concepts:** Nature of geographical knowledge;Man-environment interaction: new environmentalism; Concepts: space, place, environment, time and spatial organisation; Culture and culturall and scape.	15
II	**Modern Approaches:** Quantitative geography; Humanistic geography: phenomenology and existentialism; Contributions of CarlSauer and Yi-FuTuan.	15
III	**Contemporary Trends:** Qualitative paradigm; post-modernism and post-structuralism; Socialtheory and De/reconstruction. Welfare/Marxist/ Radical geography: contributions of David Harvey,Feministgeography.	15
IV	**TrendsofIndianGeography:**Colonial and Postcolonial geography;Contributions of Indian geographers; Impact of thoughts of Gandhi, Nehru and Ambedkar on Indian geography; Indian geography: issues and challenges.	15

SEC-SkillEnhancementCourse, AECAbilityEnhancementCourse; VACValueAdded Course: MD-MultidisciplinaryCourse1Credit(Theory)=15Hours;1Credit(Practical)=30Hours

Texts/References	1. Daniels,P.,Bradshaw,M.,Shaw,D.andSidaway,J.(2000):AnIntroductiontoHuman Geography.Issuesforthe21st Century.Prentice Hall,London. 2. Dear,M.J.andFlusty,S.(2002):TheSpacesofPostmodernity:ReadingsinHumanGeography.BlackwellPublishers,Oxford. 3. Dikshit, R.D.(2004): GeographicalThought. ACriticalHistoryofIdeas.Prentice-Hall India, NewDelhi. 4. Harvey,M.E.and Holly, P.B. (2002): Themes in Geographic Thought. Rawat Publications,NewDelhi. 5. Hubbard,P.,Kitchin,R.,Bartley,B.andFuller,D.(2002):ThinkingGeographically:Space, TheoryandContemporaryHumanGeography. Continuum,London. 6. Johnston,R.J.andSidaway,J.D.(2004):GeographyandGeographers.6th edition,Edward Arnold,London. 7. Kapur,A.,(ed.)(2001):IndianGeography-Voice of Concern. Concept Publishing. Company,NewDelhi. 8. Martin,G.,(2005):AllPossibleWorlds.AHistoryofGeographicalIdeas.4th edition,Oxford UniversityPress,NewYork. 9. Mathews,J.A.,andHerbert,D.T.(eds.)(2004):UnifyingGeography.CommonHeritage, SharedFuture.Routledge,London. 10. Soja,E.(1989):Post-modern Geographies. Verso Press, London. Reprinted 1997: Rawat Publications,JaipurandNewDelhi 11. Taylor, G.(ed.)(1953):GeographyintheTwentieth Century .Mathuen and Company Ltd. and Company,London. 12. Tuan,Yi-Fu(1977): Space and Place. The Perspective of Experience. Edward Arnold,London
Learning Outcomes	• Enhancingstudent'slearningonchangingnaturegeographicalknowledge. • Tomakestudentsawareaboutvariousmodernapproaches. • Acquaintedtheknowledgeofcontemporarytrendsandcontributions. • StudentshouldunderstandtheIndia'sroleinpostcolonialgeography.

Course	**B.Sc./B.A.FourthYear:Semester-VII**			
CourseTitle	**GGRMJ7R4B:Advances in Population Studies**			
Category of Course	**Major**			
Credits&Hourof Teaching		Theory	Practical	Cumulative
	Credits	4		
	Hour of			

	Teaching (Total)	60		
CourseObjectives	• Tointroducestudentsthemeaning,scopeandapproachestoPopulationStudies. • Toexplainthefactors,determinantsandpatterns&theoriesofpopulation. • Tounderstandcomposition,structureand factorsofchangeinpopulation. • Totrainstudents onpopulationpolicies andcontemporaryissues.			
CourseContent	Thecoursecontentisdividedinto4Units.			
Units	**CourseContent**			**Hr.of Teaching**
I	**BasicsofPopulationStudies**:Meaning,ScopeandapproachestoPopulationstudies;SourcesofPopulationdatawithspecialreferenceto India;DemographicDividend;Recenttrendsinpopulationstudies.			15
II	**Population Distribution, Density and Growth**: Factors, Determinants and Patterns; Theories of Population Growth: Malthusian theory and Demographic Transition Theory; Concept of Under, Over and Optimum Population; Population Resource Region.			15
III	**PopulationCompositionandMigration**:Age-Sex, Literacy, Rural-Urban, Occupation structure; Fertility; Mortality; Migration: Concept, Types, Determinants and Theories;			15
IV	**Population policies and issues**: Population Policies in Developed and Developingcountries (A Case of India); Contemporary Issues in Population Geography-AgeingPopulation, Sex Ratio, Diseases, Epidemics and Population Problems; Population and Environment Interface; Population and Development: Human Development Index; New Research areas inPopulation Geography;			15

SEC-SkillEnhancementCourse, AECAbilityEnhancementCourse; VACValueAdded Course: MD-MultidisciplinaryCourse1Credit(Theory)=15Hours;1Credit(Practical)=30Hours

Texts/References	1. Chandna,R.C.(2010)PopulationGeography,KalyaniPublisher.NewDelhi 2. Hassan,M.I.(2020)PopulationGeography:ASystematicExploration,RoutledgeIndiaPvt. Ltdl,NewDelhi 3. Tiwari,R.C.(2007)GeographyofIndia.PrayagPustakBhawan,Allahabad 4. BarrettH.R.,1995:PopulationGeography,OliverandBoyd. 5. BhendeA.andKanitkarT.,2000:PrinciplesofPopulationStudies,HimalayaPublishingHouse. 6. ChandnaR.C.andSidhuM.S.,1980:AnIntroductiontoPopulationGeography,Kalyani Publishers 7. Jones,H.R.,2000:PopulationGeography,3rded.PaulChapman, London. 8. LutzW.,WarrenC.S.and Scherbov S., 2004: The End of the World PopulationGrowthinthe21stCentury,Earthscan 9. NewboldK.B.,2009:PopulationGeography:ToolsandIssues,Rowmanand Little field Publishers 10. PacioneM.,1986:PopulationGeography:ProgressandProspect,TaylorandFrancis. 11. WilsonM.G.A.,1968:PopulationGeography,Nelson.
Learning Outcomes	• Enhancingstudent'slearningonbasicsofpopulationGeography. • TomakestudentsawareaboutvariousfactorsaffectingpopulationgrowtAcquaintedthe knowledgeofcompositionandstructureofpopulation. • Studentshouldunderstandpopulationissuesandpolicies.

Course	**B.Sc./B.A.FourthYear:Semester-VII**			
CourseTitle	**GGRMJ7R4C:Urban Geography**			
Category of Course	**Major**			
Credits&Hourof Teaching		Theory	Practical	Cumulative
	Credits	4		
	Hour of Teaching (Total)	60		
CourseObjectives	• Tointroducestudentsthenature,scopeandrecenttrendsinurbangeography. • Toexplaintheoriginandevolutionofurbansettlementsandtheircharacteristics • Tounderstandthecitysizeand urbanstructuremodels. • Totrainstudents onurbangrowthandcontemporaryissues inplanning.			
CourseContent	Thecoursecontentisdividedinto4Units.			
Units	**CourseContent**			**Hr.of Teaching**
I	**Bases:**Nature,scopeandrecenttrendsinurbangeography;Urbanpopulation:characteristics, processes and trends; Methodology in urban studies; Origin and evolutionofurbansettlements:bazaar-based and colonial based;distributionofurbancentres.			15
II	**Characteristics:**Characteristicsofcitiesindifferenthistoricalperiods:pre-industrial,industrialandpost-industrial;Functionalclassificationofurbancentresurbantransportation;NationalUrbanInformationSystem.			15
III	**Spatiality and Models:** Size and spacing of cities: rank-size rule; law of the primate city; Urban hierarchies; Central place theory (Christaller and Loch); Urban land use and functional morphology: functionalareasandperi-urbanareas; Theories of urban structure: Burgess ,Hoyt, Harris and Ullman, Mann, and White.			15
IV	**IssuesandPlanning:**Urbansprawl;urbanproblems:environmental,poverty,inequality,slums,transportation,housing,segregationandcrime;Plannedcities:Chandigarh and Jaipur; smart city in India; National Urban Policy; Master Plan: A case study of Varanasi.			15

SEC-SkillEnhancementCourse, AECAbilityEnhancementCourse; VACValueAdded Course: MD-MultidisciplinaryCourse1Credit(Theory)=15Hours;1Credit(Practical)=30Hours

Texts/References	1. Bridge,B.andWatson,S. (Eds.)(2000):ACompaniontotheCity. Blackwell,Oxford. 2. Carter,H.(1995):TheStudyofUrbanGeography.4th ed.Reprintedin2000byRawat Publications,JaipurandNewDelhi. 3. Dutt,A.Allen,K.Nobel,G.,VenugopalG.andSubbiahS.(eds.)(2003):ChallengestoAsianUrbanisationinthe21stCentury.KluwerAcademic Publishers, Dordrecht and London. 4. Hall,T.(2001):UrbanGeography.2nd edition.RoutledgeLondon. 5. Mayer,H.andCohn,C.F.(1959):ReadingsinUrbanGeography,UniversityofChicagoPress,Chicago 6. Pacione,M.(2005):UrbanGeography:AGlobalPerspective.Routledge,LondonandNewYork. 7. Ramachandran,R.,(1991)UrbanizationandUrbanSystemsinIndia.OxfordUniversityPress,Delhi. 8. Singh,R.L.(1955):Banaras.AStudyinUrbanGeography.NandKishoreandBrothersBanaras 9. Singh,H.H.(1972):Kanpur:AStudyinUrbanGeography,Indrasini Publications,Varanasi 10. Stanley,B.,Jack, W.andDonald,Z.(eds.)(2003):CitiesoftheWorld. RowmanandLittlefield, NewYorkandOxford. 11. Tripathi,V.K.,Jha,D.K.andHarshwardhanR.(eds.)(2018):AdvancesinUrbanStudiesin India.R.K.Books,NewDelhi.
Learning Outcomes	• Enhancingstudent'slearningonbasesandgrowthofUrbanGeography.

	• Tomakestudentsawareaboutvariousfactorsaffectingurbanpopulation. • Acquaintedtheknowledgeofcomposition,urbanstructureandfunctions. • Studentshouldunderstandcontemporaryurbanpopulationissues,policiesandplanning.

Course	**B.Sc./B.A.FourthYear:Semester-VII**			
CourseTitle	**GGRMJ7R4D:Regional Planning**			
Category of Course	**Major**			
Credits&Hour of Teaching		Theory	Practical	Cumulative
	Credits	4		
	Hour of Teaching (Total)	60		
CourseObjectives	• Tointroducestudentstheconcept, nature,and scope of regional planning. • Todescribetheories,approachesandgeographicalissuesofregionalplanning • Tounderstandtheevolutionandgrowthofregional planninginIndia • Totrainstudentsoncontemporaryregionaldevelopmentissuesandplanning.			
CourseContent	Thecoursecontentisdividedinto4Units.			

Units	**CourseContent**	**Hr.of Teaching**
I	**ConceptualBackground**:Concept,Natureandscopeofregionalplanning;Theories and approaches of regional planning, Concept of Planning region, Planning regions of India; Decentralized planning	15
II	**RegionalDevelopment**:Regionalimbalancesandinequalitiesin India;Regionalplanningandnationaldevelopment;Economicdevelopmentandregionaldevelopment;Role of agriculture, industry and infrastructure in regional development.	15
III	**RegionalPlanning**:EvolutionofRegionalPlanninginIndia;Regionalplanning and National development; Planning for regional development,Integratedregionalplanning,Multi-level planning, Survey for planning:diagnostic,techno-economicandregional	15
IV	**PlanningandPolicyinIndia**:Regional development strategy in India;Changing paradigm of planning in India.National and state level planning,Locallevelplanning;NationalCapitalRegion; Planning for Eastern Uttar Pradesh.	15

SEC-SkillEnhancementCourse, AECAbilityEnhancementCourse; VACValueAdded
Course: MD-Multidisciplinary Course1Credit(Theory)=15Hours;1Credit(Practical)=30Hours

Texts/References	1. Chandna,R.C.(2000):RegionalPlanning:AComprehensiveText.KalyaniPublishers.,NewDelhi. 2. Chaudhuri,J.R.(2001):AnIntroductiontoDevelopmentandRegionalPlanning withspecialreferencetoIndia.Orient Longman,Hyderabad. 3. Friedmann,J.andAlonso,W.(ed.)(1973):RegionalDevelopmentandPlanning.The MITPress,Mass. 4. Kuklinski,A.R.(1972):GrowthPolesandGrowthCentresinRegionalPlanning.MoutonandCo.,Paris. 5. Misra,R.P.(ed.)(1992):RegionalPlanning:Concepts,Techniques,Policiesand CaseStudies.2ndedition.Concept Publishing Company.,NewDelhi. 6. Pathak,C.R.(2003):SpatialStructureandProcessesofDevelopmentinIndia.RegionalScienceAssociation.,Kolkata. 7. Sanyal,B.M.(2001):DecentralizedPlanning:ThemesandIssues.ConceptPublishingCompany,NewDelhi. 8. Sharma, P. V., Rao, V. L., and Pathak, C. R. (eds.) (2000): Sustainable Regional Development (with specialreference to Andhra Pradesh). Regional Science. Association, Kolkata and School of Economics, AndhraUniversity, Vishakhapatnam. 9. Sundaram,K.V.(1997):DecentralizedMultilevelPlanning:PrinciplesandPracti

	ce(AsianandAfricanExperiences).Concept PublishingCompany,NewDelhi. 10. Sundaram,K.V.(2004):TheTroddenPath:EssaysonRegionalandMicroLevelPlanning.AnaunyaPublications.,NewDelhi.
Learning Outcomes	• Enhancingstudent'slearningonmajorfundamentalaspectsofregionalplanning. • Tomakestudentsawareaboutvariousfactorsandissuesofregionalimbalances. • Acquaintedtheknowledgeofevolutionofregional planninginIndia. • Studentshouldunderstandcontemporaryregionaldevelopmentstrategy.

BANARAS HINDU UNIVERSITY

Department of Home Science

Faculty of Science

SYLLABI

B.Sc. (Hons.) Programme

In

Home Science

DEPARTMENT OF HOME SCIENCE
BANARAS HINDU UNIVERSITY, VARANASI-221005
Syllabus
NEP Course Structure for Four Year Undergraduate Home Science Program

Semester	Course code	Course name	Credits
Semester - I	HSCMJ11	Introduction to Community Science	4
	HSCMN11	Introduction to Community Science	4
	HSCMD11	Introduction to Community Science	3
	AE11	Language	2
	HSCSE11	Therapeutic Nutrition and Diet Counselling	3 (2+1)
	HSCSE12	Practical based on HSCSE11	
	HSCVA11	Offered by the University	4
		Total Credits	20

Semester	Course code	Course name	Credits
Semester-II	HSCMJ21	Fundamentals of Nutrition and Food Science	4 (3+1)
	HSCMJ22	Practical based on HSCMJ21	
	HSCMN21	Fundamentals of Nutrition and Food Science	4 (3+1)
	HSCMN22	Practical based on HSCMN21	
	HSCMD21	Basics of Human Development	3
	AE21	Language	2
	HSCSE21	Textile Surface Design and Basic Stitching	3 (1+2)
	HSCSE22	Practical based on HSCSE21	
	HSCVA21	Offered by the University	2
	HSCVA22	Offered by the University	2
		Total Credits	20

Semester	Course code	Course name	Credits
Semester-III	HSCMJ31	Family Resource Management	4
	HSCMJ32	Apparel Designing	4(2+2)
	HSCMJ33	Practical based on HSCMJ32	
	HSCMV31	Basic Dress Designing Skill	4(2+2)
	HSCMV32	Practical based on HSCMV31	
	HSCMD31	Introduction to Clothing & Textiles	3
	AE31	Offered by the University	2
	HSCSE31	Computer Applications	3(1+2)
	HSCSE32	Practical based on HSCSE31	
		Total Credits	20

Semester	Course code	Course name	Credits
Semester-IV	HSCMJ41	Fundamentals of Human Development	5 (3+2)
	HSCMJ42	Practical based on HSCMJ41	
	HSCMJ43	Rural Development and Outreach Programme	5 (3+2)
	HSCMJ44	Practical based on HSCMJ43	
	HSCMJ45	Public Nutrition and Health	4 (2+2)
	HSCMJ46	Practical based on HSCMJ45	
	HSCMN41	Public Nutrition and Health	4 (2+2)
	HSCMN42	Practical based on HSCMN41	
	AE41	Offered by the University	2
		Total Credits	20
Semester	**Course code**	**Course name**	**Credits**

Semester-V	HSCMJ51	Textiles; Care and Selection	5 (3+2)
	HSCMJ52	Practical based on HSCMJ51	
	HSCMJ53	NGO Management and Advocacy	4(2+2)
	HSCMJ54	Practical based on HSCMJ53	
	HSCMJ55	Human Nutrition	5 (3+2)
	HSCMJ56	Practical based on HSCMJ55	
	HSCMV51	Bakery and Confectionary	4(2+2)
	HSCMV52	Practical based on HSCMV51	
	HSCIN51	Internship	2
		Total Credits	20

Semester-VI	HSCMJ61	Advanced Human Development	4 (3+1)
	HSCMJ62	Practical based on HSCMJ61	
	HSCMJ63	Family Finance Management and Consumer Education	5 (3+2)
	HSCMJ64	Practical based on HSCMJ63	
	HSCMJ65	Teaching and Learning in Extension	4 (2+2)
	HSCMJ66	Practical based on HSCMJ65	
	HSCMJ67	Traditional Textiles and Costumes of India	3
	HSCMV61	Organisational Communication	4 (2+2)
	HSCMV62	Practical based on HSCMV61	
		Total Credits	20

Note:A * Student will choose any one scheme from the offered schemes-
Scheme-I - 4-Year UG Degree (Honours)
Scheme-II- 4-Year UG Degree (Honours with Research)
** Student will choose any one branch (Honours) in 4th year of graduation -
1. Foods and Nutrition 2. Extension and Communication 3. Clothing and Textiles 4. Human Development and Family Studies
5. Family Resource Management

Foods and Nutrition (Semester VII and VIII)

Scheme-I - 4 - Years UG Degree (Honours)			
Semester	**Course code**	**Course name**	**Credits**
Semester-VII	HSCMJ71	Technical Writing	4
	HSCMJ72	Food Safety and Microbiology	5 (3+2)
	HSCMJ73	Practical based on HSCMJ72	
	HSCMJ74	Applied Food Science	5 (3+2)
	HSCMJ75	Practical based on HSCMJ74	
	HSCMJ76	Social and health Issues in Society	2
	HSCMN71	Technical Writing	4
		Total Credits	20

Semester	**Course code**	**Course name**	**Credits**
Semester-VIII	HSCMJ81	Statistics and Computer Application	4 (3+1)
	HSCMJ82	Practical based on HSCMJ81	
	HSCMJ83	Nutritional Biochemistry	5 (3+2)
	HSCMJ84	Practical based on HSCMJ83	
	HSCMJ85	Community Nutrition	4 (3+1)
	HSCMJ86	Practical based on HSCMJ85	
	HSCMJ87	Food Quality Analysis	3(2+1)
	HSCMJ88	Practical based on HSCMJ87	
	HSCMN81	Statistics and Computer Application	4 (3+1)
	HSCMN82	Practical based on HSCMN81	
		Total Credits	20

Scheme-II- 4-Years UG Degree (Honours with Research)			
Semester	**Course code**	**Course name**	**Credits**
Semester-VII	HSCMJ7R1	Research Methodology and Scientific Writing	**4**
	HSCMJ7R2	Food Safety and Microbiology	5 (3+2)
	HSCMJ7R3	Practical based on HSCMJ7R2	
	HSCMJ7R4	Applied Food Science	5 (3+2)
	HSCMJ7R5	Practical based on HSCMJ7R4	
	HSCMJ7R6	Social and Health Issues in Society	2
	HSCMN7R1	Research Methodology and Scientific Writing	4
		Total Credits	20

Semester	**Course code**	**Course name**	**Credits**
Semester-VIII	HSCMJ8R1	Statistics and Computer Application	4(3+1)
	HSCMJ8R2	Practical based on HSCMJ8R1	
	HSCDS8R1	Project/Dissertation	12
	HSCMN8R1	Statistics and Computer Application	4 (3+1)
	HSCMN8R2	Practical based on HSCMN8R1	
		Total Credits	20

Extension and Communication (Semester VII and VIII)

Scheme-I - 4 - Years UG Degree (Honours)			
Semester	**Course code**	**Course name**	**Credits**
Semester-VII	HSCMJ71	Technical Writing	**4**
	HSCMJ77	Participatory Programme Management	5 (3+2)
	HSCMJ78	Practical based on HSCMJ77	
	HSCMJ79	Development Communication	5 (3+2)
	HSCMJ710	Practical based on HSCMJ79	
	HSCMJ76	Social and Health Issues in Society	2
	HSCMN71	Technical Writing	4
		Total Credits	20

Semester	**Course code**	**Course name**	**Credits**
Semester-VIII	HSCMJ81	Statistics and Computer Application	4 (3+1)
	HSCMJ82	Practical based on HSCMJ81	
	HSCMJ89	Dynamics of Groups and Leadership Development	5 (3+2)
	HSCMJ810	Practical based on HSCMJ89	
	HSCMJ811	Diffusion and Adoption of Innovation	4 (3+1)
	HSCMJ812	Practical based on HSCMJ811	
	HSCMJ813	Social Entrepreneurship	3
	HSCMN81	Statistics and Computer Application	4 (3+1)
	HSCMN82	Practical based on HSCMN81	
		Total Credits	20

Scheme-II- 4-Years UG Degree (Honours with Research)			
Semester	**Course code**	**Course name**	**Credits**
Semester-VII	HSCMJ7R1	Research Methodology and Scientific Writing	4
	HSCMJ7R7	Participatory Programme Management	5 (3+2)
	HSCMJ7R8	Practical based on HSCMJ7R7	
	HSCMJ7R9	Development Communication	5 (3+2)
	HSCMJ7R10	Practical based on HSC7R9	
	HSCMJ7R6	Social and Health Issues in Society	2
	HSCMN7R1	Research Methodology and Scientific Writing	4
		Total Credits	20

Semester	**Course code**	**Course name**	**Credits**
Semester-VIII	HSCMJ8R1	Statistics and Computer Application	4(3+1)
	HSCMJ8R2	Practical based on HSCMJ8R1	
	HSCDS8R1	Project/Dissertation	12
	HSCMN8R1	Statistics and Computer Application	4 (3+1)
	HSCMN8R2	Practical based on HSCMN8R1	
		Total Credits	20

Clothing and Textiles (Semester VII and VIII)

Scheme-II- 4-Years UG Degree (Honours with Research)			
Semester	**Course code**	**Course name**	**Credits**
Semester-VII	HSCMJ71	Technical Writing	4
	HSCMJ711	Textile Testing and Quality Control	5 (3+2)
	HSCMJ712	Practical based on HSCMJ711	
	HSCMJ713	Draping, Pattern Making and Grading	5 (3+2)
	HSCMJ714	Practical based on HSCMJ713	
	HSCMJ76	Social and Health Issues in Society	2
	HSCMN71	Technical Writing	4
		Total Credits	20

Semester	**Course code**	**Course name**	**Credits**
Semester-VIII	HSCMJ81	Statistics and Computer Application	4 (3+1)
	HSCMJ82	Practical based on HSCMJ81	
	HSCMJ814	Fashion Design and Illustration	5 (3+2)
	HSCMJ815	Practical based on HSCMJ814	
	HSCMJ816	Eco-Friendly Textiles; Processing and Finishes	4 (3+1)
	HSCMJ817	Practical based on HSCMJ816	
	HSCMJ818	Garment Production Technology and Management	3
	HSCMN81	Statistics and Computer Application	4 (3+1)
	HSCMN82	Practical based on HSCMN81	
		Total Credits	20

Scheme-II- 4-Years UG Degree (Honours with Research)			
Semester	**Course code**	**Course name**	**Credits**
Semester-VII	HSCMJ7R1	Research Methodology and Scientific Writing	4
	HSCMJ7R11	Textile Testing and Quality Control	5 (3+2)
	HSCMJ7R12	Practical based on HSCMJ7R11	
	HSCMJ7R13	Draping, Pattern Making and Grading	5 (3+2)
	HSCMJ7R14	Practical based on HSCMJ7R13	
	HSCMJ7R6	Social and Health Issues in Society	2
	HSCMN7R1	Research Methodology and Scientific Writing	4
		Total Credits	20

Semester	Course code	Course name	Credits
Semester-VIII	HSCMJ8R1	Statistics and Computer Application	4(3+1)
	HSCMJ8R2	Practical based on HSCMJ8R1	
	HSCDS8R1	Project/Dissertation	12
	HSCMN8R1	Statistics and Computer Application	4 (3+1)
	HSCMN8R2	Practical based on HSCMN8R1	
		Total Credits	20

Human Development and Family Studies (Semester VII and VIII)

Scheme-I - 4 - Years UG Degree (Honours)			
Semester	**Course code**	**Course name**	**Credits**
Semester-VII	HSCMJ71	Technical Writing	4
	HSCMJ715	Gender Issues in Human Development and Relationships	5 (3+2)
	HSCMJ716	Practical based on HSCMJ715	
	HSCMJ717	Family Ecology, Cultural Diversity and Therapy	5 (3+2)
	HSCMJ718	Practical based on HSCMJ717	
	HSCMJ76	Social and Health Issues in Society	2
	HSCMN71	Technical Writing	4
		Total Credits	20

Semester	Course code	Course name	Credits
Semester-VIII	HSCMJ81	Statistics and Computer Application	4 (3+1)
	HSCMJ82	Practical based on HSCMJ81	
	HSCMJ819	Methods and Techniques of Assessment in Human Development	5 (3+2)
	HSCMJ820	Practical based on HSCMJ819	
	HSCMJ821	Programme Development for Vulnerable Families	4 (3+1)
	HSCMJ822	Practical based on HSCMJ821	
	HSCMJ823	Dynamics of Human Development	3
	HSCMN81	Statistics and Computer Application	4 (3+1)
	HSCMN82	Practical based on HSCMN81	
		Total Credits	20

Scheme-II- 4-Years UG Degree (Honours with Research)			
Semester	**Course code**	**Course name**	**Credits**
Semester-VII	HSCMJ7R1	Research Methodology and Scientific Writing	4
	HSCMJ7R15	Gender Issues in Human Development and Relationships	5 (3+2)
	HSCMJ7R16	Practical based on HSCMJ7R15	
	HSCMJ7R17	Family Ecology, Cultural Diversity and Therapy	5 (3+2)
	HSCMJ7R18	Practical based on HSCMJ7R17	
	HSCMJ7R6	Social and Health Issues in Society	4
	HSCMN7R1	Research Methodology and Scientific Writing	2
		Total Credits	20

Semester	Course code	Course name	Credits
Semester-VIII	HSCMJ8R1	Statistics and Computer Application	4(3+1)
	HSCMJ8R2	Practical based on HSCMJ8R1	
	HSCDS8R1	Project/Dissertation	12
	HSCMN8R1	Statistics and Computer Application	4 (3+1)
	HSCMN8R2	Practical based on HSCMN8R1	
		Total Credits	20

Family Resource Management (Semester VII and VIII)

Scheme-I- 4 – Years UG Degree (Honours)			
Semester	**Course code**	**Course name**	**Credits**
Semester-VII	HSCMJ71	Technical Writing	4
	HSCMJ719	Consumer Product Safety and Legislation	5 (3+2)
	HSCMJ720	Practical based on HSCMJ719	
	HSCMJ721	Ergonomics and Appropriate Technology	5 (3+2)
	HSCMJ722	Practical based on HSCMJ721	
	HSCMJ76	Social and Health Issues in Society	2
	HSCMN71	Technical Writing	4
		Total Credits	20

Semester	**Course code**	**Course name**	**Credits**
Semester-VIII	HSCMJ81	Statistics and Computer Application	4 (3+1)
	HSCMJ82	Practical based on HSCMJ81	
	HSCMJ824	Family Finance and Personal Financial Management	5 (3+2)
	HSCMJ825	Practical based on HSCMJ824	
	HSCMJ826	Interior Designing and Landscaping	
	HSCMJ827	Practical based on HSCMJ826	4 (3+1)
	HSCMJ828	Advertising and Labelling information	3
	HSCMN81	Statistics and Computer Application	4 (3+1)
	HSCMN82	Practical based on HSCMN81	
		Total Credits	20

Scheme-II- 4-Years UG Degree (Honours with Research)			
Semester	**Course code**	**Course name**	**Credits**
Semester-VII	HSCMJ7R1	Research Methodology and Scientific Writing	4
	HSCMJ7R19	Consumer Product Safety and Legislation	5 (3+2)
	HSCMJ7R20	Practical based on HSCMJ7R19	
	HSCMJ7R21	Ergonomics and Appropriate Technology	5 (3+2)
	HSCMJ7R22	Practical based on HSCMJ7R21	
	HSCMJ7R6	Social and Health Issues in Society	2
	HSCMN7R1	Research Methodology and Scientific Writing	4
		Total Credits	20

Semester	**Course code**	**Course name**	**Credits**
Semester-VIII	HSCMJ8R1	Statistics and Computer Application	4(3+1)
	HSCMJ8R2	Practical based on HSCMJ8R1	
	HSCDS8R1	Project/Dissertation	12
	HSCMN8R1	Statistics and Computer Application	4 (3+1)
	HSCMN8R2	Practical based on HSCMN8R1	
		Total Credits	20

BANARAS HINDU UNIVERSITY
(Detailed Syllabus of different Courses under NEP 2020)
Department of Home Science
Faculty of Science

Semester -I

Course Title	**Introduction to Community Science (HSCMJ11)**
Category of Course	**Major**
Credits& Hours of Teaching	

	Theory	Practical	Cumulative
Credits	04	-	04
Hours of Teaching (Total)	60	-	60

Course Objectives	To provide fundamental knowledge regarding the basic concept of Community Science and its different branches: Food and Nutrition, Extension & Communication, Textiles &Clothing, Human Development and Family Resource Management

Course Content

Units	Course Content	Hr. of Teaching
I	**Introduction to Community Science (Home Science)** • Definition, Meaning, Scope and Significance of Community Science, Brief introduction of branches of Home Science (Community Science) **Introduction to Food and Nutrition** • Basic definitions of Food andNutrition- Nutrition, Balanced Diet, Food Pyramid, My Healthy Plate, Rainbow Diet etc. • Composition, functions and classification of food • Food Groups and its significance • Preliminary preparations in cooking • Principles, Objectives and Methods of cooking: its advantages and disadvantages	12
II	**Introduction to Extension Education** • Concept of Education, Extension Education, adult education, distance education, Formal, Non-Formal and Informal Education • Concept, Meaning, objectives, Scope, principles and philosophy of Extension Education, Extension Worker- Qualities and Role • Extension in Community Science/Home Science: Concept, Scope and its role in national development	12
III	**Introduction to Human Development** • Meaning and importance of Human Development • Meaning of terms "Growth and "Development", Principles of Human Development • Different stages of Human Development • Define physical, motor, social, emotional, cognitive and language development and personality development	12
IV	**Introduction to Textile& Clothing** • Importance of studying textiles, Concepts and classification of textile fibres; Natural fibres and Man-made fibres (Basic components, degree of polymerization, properties, uses and care) • Basic terminology related to Technical-textiles; nano textile, agro textile, smart textile, geo textile, medical textile, ecofriendly textiles, auto-mobile textile, sports textile, industrial textile, Home Textile • Basic Principles of Clothing construction, Sewing equipment's and other tools required for drafting, cutting, stitching, basic Sewing machine; parts, uses and care.	12
V	**Introduction to Family Resource management** • Meaning and importance of family resource management • Process of management; planning, controlling andevaluation • Types, of resources. Classification and characteristics of resources. • Time management • Energy management • Money management	12

	• Decision making in family	
Texts / References	1. Srilakshmi, B - Nutrition Science, New Age International Publishers, seventh edition 2. Swaminathan, M. (1997), Essentials of Food and Nutrition, vol I &II, Second edition, Bangalore, BAPPCO 3. Hurlock, B. E. Child Development, McGraw Hill Education, Indian Edition, Sixth Edition 4. Corbman, B.P (1983). Textiles: Fiber to Fabric (6th Edition). New York: McGraw Hill Publication 5. Ray, G.L. Extension Communication and Management, Kalyani Publisher 6. Mullick, P. Textbook of Home Science, Kalyani Publisher 7. Singh, B. Aahar Vigyan Evam Poshan, Hindi Edition, Panchsheel Prakashan	
Learning Outcomes	• Understanding of holistic approaches of Community Science like availability of proper nutrition for health, basics of clothing. • Concept and stages of development of Children. • Importance of Extension education in the community and the knowledge of management of vital resources.	

Course Title	**Introduction to Community Science (HSCMN11)**			
Category of Course	**Minor**			
Credits & Hours of Teaching		Theory	Practical	Cumulative
	Credits	04	NA	04
	Hours of Teaching (Total)	60	NA	60
Course Objectives	To provide fundamental knowledge regarding the basic concept of Community Science and its several sections includes Food and Nutrition, Extension Education, Textiles, Child Development and Family Resource Management			

Course Content

Units	Course Content	Hr. of Teaching
I	**Introduction to Community Science (Home Science)** • Definition, Meaning, Scope and Significance of Community Science, Brief introduction of branches of Home Science (Community Science) **Introduction to Food and Nutrition** • Basic definitions in Food and Nutrition- Nutrition, Balanced Diet, Food Pyramid, My Healthy Plate, Rainbow Diet • Composition, Functions and Classification of Food • Food Groups and its significance • Preliminary Preparation in cooking • Principles, Objectives and Methods of cooking: its advantages and disadvantages	12
II	I**ntroduction to Extension Education** • Concept of Education, Extension Education, adult education, distance education, Formal, Non Formal and Informal Education • Concept, Meaning, objectives, Scope, principles and philosophy of Extension Education, Extension Worker- Qualities and Role • Extension in Community Science/Home Science: Concept, Scope and its role in national development	12
III	**Introduction to Human Development** • Meaning and importance of Human Development • Meaning of terms "Growth and "Development", Principles of Human Development • Different stages of Human Development • Define physical, motor, social, emotional, cognitive and language development and personality development	12
IV	**Introduction to Textile** • Importance of studying textiles, Concepts and classification of textile fibres; Natural	12

	fibres and Man-made fibres (Basic components, degree of polymerization, properties, uses and care) • Basic terminology related to Technical-textiles; nano textile, agro textile, smart textile, geo textile, medical textile, ecofriendly textiles, auto-mobile textile, sports textile, industrial textile, Home Textile • Basic Principles of Clothing construction, Sewing equipment's and other tools required for drafting, cutting, stitching, basic Sewing machine; parts, uses and care.	
V	**Introduction to Family Resource management** • Meaning and importance of family resource management • Process of management; planning, controlling and evaluation • Types, of resources. Classification and characteristics of resources. • Time management • Energy management • Money management • Decision making in family	12

Texts / References	1. Srilakshmi, B - Nutrition Science, New Age International Publishers, seventh edition 2. Swaminathan, M. (1997), Essentials of Food and Nutrition, vol I &II, Second edition, Bangalore, BAPPCO 3. Hurlock, B. E. Child Development, McGraw Hill Education, Indian Edition, Sixth Edition 4. Corbman, B.P (1983). Textiles: Fiber to Fabric (6th Edition). New York: McGraw Hill Publication 5. Ray, G.L. Extension Communication and Management, Kalyani Publisher 6. Mullick, P. Textbook of Home Science, Kalyani Publisher 7. Singh, B. Aahar Vigyan Evam Poshan, Hindi Edition, Panchsheel Prakashan
Learning Outcomes	• Understanding of holistic approaches of Community Science like availability of proper nutrition for health, basics of clothing. • Concept and stages of development of Children. • Importance of Extension education in the community and the knowledge of management of vital resources.

Course Title	**Introduction to Community Science (HSCMD11)**
Category of Course	**Multi Disciplinary**

Credits & Hours of Teaching	Theory	Practical	Cumulative
Credits	03	NA	03
Hours of Teaching (Total)	45	NA	45

Course Objectives	To provide fundamental knowledge regarding the basic concept of Community Science and its several sections includes Food and Nutrition, Extension Education, Textiles, Child Development and Family Resource Management

Course Content

Units	Course Content	Hr. of Teaching
I	**Introduction to Community Science** • Definition, Meaning, Scope and Significance of Community Science • Branches of Community Science and its role in the development of the Nation • Role of Nutrition for Nutritional well-being of Nation	09
II	I**ntroduction to Extension Education** • Concept of Education, Extension Education, adult education, distance education, Formal, Non Formal and Informal Education • Concept, Meaning, objectives, Scope, principles and philosophy of Extension Education, Extension Worker- Qualities and Role • Extension in Community Science/Home Science: Concept, Scope and its role in national development	09
III	**Introduction to Human Development**	09

	• Meaning and importance of Human Development • Meaning of terms "Growth and "Development", Principles of Human Development • Different stages of Human Development • Define physical, motor, social, emotional, cognitive and language development and personality development	
IV	**Introduction to Textile** • Importance of studying textiles, Concepts and classification of textile fibres; Natural fibres and Man-made fibres (Basic components, degree of polymerization, properties, uses and care)	09
V	**Introduction to Family Resource management** • Meaning and importance of family resource management • Process of management; planning, controlling and evaluation • Types, of resources. Classification and characteristics of resources.	09

Texts / References	1. Srilakshmi, B - Nutrition Science, New Age International Publishers, seventh edition 2. Swaminathan, M. (1997), Essentials of Food and Nutrition, Vol. I &II, Second edition, Bangalore, BAPPCO 3. Hurlock, B. E. Child Development, McGraw Hill Education, Indian Edition, Sixth Edition 4. Corbman, B.P (1983). Textiles: Fiber to Fabric (6th Edition). New York: McGraw Hill Publication 5. Ray, G.L. Extension Communication and Management, Kalyani Publisher 6. Mullick, P. Textbook of Home Science, Kalyani Publisher 7. Singh, B. Aahar Vigyan Evam Poshan, Hindi Edition, Panchsheel Prakashan
Learning Outcomes	• Understanding of holistic approaches of Community Science like availability of proper nutrition for health, basics of clothing. • Concept and stages of development of Children. • Importance of Extension education in the community and the knowledge of management of vital resources.

Course Title	**Language (HSCAE11)**			
Category of Course[143]	**AEC -1**			
Credits[144]& Hours of Teaching		Theory	Practical	Cumulative
	Credits	02	-	02
	Hours of Teaching (Total)	30	-	30
Course Objectives	NA			
Course content				
I	NA			
II	NA			
III	NA			
IV	NA			
V	NA			
Text References	NA			
Learning Oucomes	NA			

[143] SEC – Skill Enhancement Course; AEC – Ability Enhancement Course; VAC – Value Added Course; MD – Multidisciplinary Course

[144] 1 Credit (Theory) = 15 Hours; 1 Credit (Practical) = 30 Hours

Course Title	**Therapeutic Nutrition and Diet Counseling (HSCSE11and HSCSE12)**
Category of Course[145]	**SEC**

Credits[146]& Hours of Teaching		Theory	Practical	Cumulative
	Credits	2	1	3
	Hours of Teaching (Total)	30	30	60

Course Objectives	To provide fundamental concept and role of the diet therapy to treat different disease conditions.

Course Content

Units	Course Content	Hr. of Teaching
I	**Concept of Therapeutic Nutrition and Diet** • Purpose and principles of therapeutic diets, • Modification of normal diet and classification of therapeutic diet, • Routine hospital diets – regular diet, soft diet, clear diet and full fluid diet, • Basic concept and methods of – Oral feeding, Tube feeding, parenteral feeding & intravenous feeding. • Collection of background data – socio-economic, medical and dietary history of patients.	10
II	**Etiology, clinical features and nutritional management of the following conditions-** • **Weight management-** Underweight, Overweight or Obesity • **Gastro-Intestinal Tract-** Diarrhoea**,** Constipation, Esophagitis**,** Gastritis**,** Peptic ulcer**,** Ulcerative Colitis Tropical Sprue and Celiac Disease, • **Liver, Biliary Tract and Pancreas -** Jaundice and Viral Hepatitis, Cirrhosis of Liver, Hepatic Coma, Cholecystitis and Cholelithiasis, Acute and Chronic Pancreatitis • **Cardiovascular Diseases –** Hypertension, Atherosclerosis, Hyperlipidaemia, Myocardial Infarction • **Renal and Urinary Diseases –** Nephritis (type I & II), Acute & Chronic Renal Failure, Renal Calculi. • **Metabolic and Endocrine Disorders** – Gout, Diabetes Mellitus, Hypo and Hyperthyroidism • **Infectious Diseases**- Fever (typhoid, tuberculosis) • **Surgery and Injury** – Gastrectomy, Burns and Fractures. • **Dietary deficiency Disorders**- PEM, Anaemia (Iron and Folic Acid deficiency, Pernicious Anaemia) • **Miscellaneous**– Cancer	15
III	**Food and Drug Interaction** • Drugs affecting appetite and food intake • Drugs affecting absorption, metabolism and excretion of nutrients	05
PRACTICAL		
I	Planning and Preparation of liquid diet, soft diet, high and low-calorie diet, with modified fat and carbohydrate level,	10
II	Planning and preparation of low and moderate cost diet for the treatment of PEM and Anaemia	10
III	Preparation of diet chart for the following conditions- • Fever with Diarrhoea • Peptic ulcer with Hyperlipidaemia	10

[145] SEC – Skill Enhancement Course; AEC – Ability Enhancement Course; VAC – Value Added Course; MD – Multidisciplinary Course

[146] 1 Credit (Theory) = 15 Hours; 1 Credit (Practical) = 30 Hours

	• Hypertension with Diabetes mellitus • Acute hepatitis.	
Texts / References	1. Shrilaxmi, B. (2016). Dietetics. New Age International. 2. Khanna K., Gupta S., Passi S.J, Seth R., Mahana R., &Puri S. (2020). Textbook of Nutrition and Dietetics. Elite Publishing House. 3. Swaminathan M. (2015). Advanced Text – Book on Food & Nutrition Volume-2. The Bangalore Printing & Publishing Co., LTD. 4. Joshi S.A. Nutrition and Dietetics, Tata McGraw Hill Publications, New Delhi. 5. Antia F.P.,& Philip A. Clinical Nutrition and Dietetics, Oxford Publishing Company.	
Learning Outcomes	Understanding of modification of normal diet to therapeutic diet in different disease conditions, planning and preparation of several diets during specific diseased condition.	

Course Title	**Offered by the University (HSCVA11)**			
Category of Course[147]	VAC-1			
Credits[148]& Hours of Teaching		Theory	Practical	Cumulative
	Credits	04	NA	04
	Hours of Teaching (Total)	60	NA	60
Course Objectives	NA			

Course Content

Units	**Course Content**	**Hr. of Teaching**
I	NA	
II	NA	
III	NA	
IV	NA	
V	NA	

Texts / References	NA
Learning Outcomes	NA

Semester –II

Course Title	**Fundamentals of Nutrition and Food Science(HSCMJ21 andHSCMJ22)**			
Category of Course[149]	**Major**			
Credits[150]& Hours of Teaching		Theory	Practical	Cumulative
	Credits	03	01	04
	Hours of Teaching (Total)	45	30	75
Course Objectives	• To provide basic knowledge of Nutrition and common understandings of health • To introduce several food groups and to perform different experiments to determine nutrient requirements of Individuals			

Course Content

Units	**Course Content**	**Hr. of Teaching**

[147] SEC – Skill Enhancement Course; AEC – Ability Enhancement Course; VAC – Value Added Course; MD – Multidisciplinary Course

[148] 1 Credit (Theory) = 15 Hours; 1 Credit (Practical) = 30 Hours

[149] SEC – Skill Enhancement Course; AEC – Ability Enhancement Course; VAC – Value Added Course; MD – Multidisciplinary Course

[150] 1 Credit (Theory) = 15 Hours; 1 Credit (Practical) = 30 Hours

I	Basics terms of Nutrition: Nutrients, Phytochemicals, Antioxidants, Functional Foods, Nutritional status, Body Mass Index, Nutraceuticals etc	05
II	Relationship of nutrition to health, growth and human welfare: Role of nutrients in the body and Nutritional deficiencies	10
III	Recommended Dietary Allowances (RDA): Factors affecting RDA, General principle for deriving RDA, Reference Men & Women and Basal Metabolism- Factors affecting rate of BMR	10
IV	Nutrients and its importance: Macro Nutrients- Carbohydrate, Protein, Fats, Micro Nutrients- Vitamins and Minerals and Water	10
V	Importance, functions and nutritive value of foods: Cereals and Millets, Pulses and Legumes, Milk and Milk Products, Egg, Meat and Fish, Fats and Oils, Fruits & Vegetables, Sugar and Jaggery, Spices and condiments	10
Practical		
I	Understanding food composition table and exchange list	15
II	Learning food frequency table	05
III	Calculation of energy expenditure of individuals Dietary plans for life span stages according to demographic profile and RDA.	10

Texts / References	1. Srilakshmi, B. Food Science, New Age International Publishers, Seventh edition 2. Bamji, S.M., Rao, P.N., and Reddy, V. (2003). Textbook of Human Nutrition. Oxford and IBH Publishing Co Pvt Ltd. 3. Swaminathan, M. (1997), Essentials of Food and Nutrition, VolI& II, Second edition, Bangalore, BAPPCO 4. Shakuntala, M.N., Shadakshara swamy, M. (1998). Foods, Facts and principles New age international publishers, New Delhi. 5. Srilakshmi, B. Nutrition Science, New Age International Publishers, seventh edition 6. Singh, B. Aahar Vigyan Evam Poshan, Hindi Edition, Panchsheel Prakashan,
Learning Outcomes	Learning of basic terms of Nutrition, understanding of different concepts related to health and nutrition, nutritional deficiencies and nutritive values of basic food groups.

Course Title	**Fundamentals of Nutrition and Food Science(HSCMN21 andHSCMN22)**			
Category of Course[151]	**Minor**			
Credits[152]& Hours of Teaching		Theory	Practical	Cumulative
	Credits	03	01	04
	Hours of Teaching (Total)	45	30	75
Course Objectives	• To provide basic knowledge of Nutrition and common understandings of health • To introduce several food groups and to perform different experiments to determine nutrient requirements of Individuals			

Course Content

Units	**Course Content**	**Hr. of Teaching**
I	Basics terms of Nutrition: Nutrients, Phytochemicals, Antioxidants, Functional Foods, Nutritional status, Body Mass Index, Nutraceuticals etc.	05
II	Relationship of nutrition to health, growth and human welfare: Role of nutrients in the body and Nutritional deficiencies	10
III	Recommended Dietary Allowances (RDA): Factors affecting RDA, General principle for deriving RDA, Reference Men & Women and Basal Metabolism- Factors affecting rate of BMR	10
IV	Nutrients and its importance: Macro Nutrients- Carbohydrate, Protein, Fats, Micro Nutrients- Vitamins and Minerals and Water	10

[151] SEC – Skill Enhancement Course; AEC – Ability Enhancement Course; VAC – Value Added Course; MD – Multidisciplinary Course

[152] 1 Credit (Theory) = 15 Hours; 1 Credit (Practical) = 30 Hours

V	Importance, functions and nutritive value of foods: Cereals and Millets, Pulses and Legumes, Milk and Milk Products, Egg, Meat and Fish, Fats and Oils, Fruits & Vegetables, Sugar and Jaggery, Spices and condiments	10
Practical		
I	Understanding food composition table and exchange list	15
II	Learning food frequency table	05
III	Calculation of energy expenditure of individuals Dietary plans for life span stages according to demographic profile and RDA	10

Texts / References	1. Srilakshmi, B. Food Science, New Age International Publishers, Seventh edition 2. Bamji, S.M., Rao, P.N., and Reddy, V. (2003). Textbook of Human Nutrition. Oxford and IBH Publishing Co Pvt Ltd. 3. Swaminathan, M. (1997), Essentials of Food and Nutrition, VolI& II, Second edition, Bangalore, BAPPCO 4. Shakuntala, M.N., Shadakshara swamy, M. (1998). Foods, Facts and principles New age international publishers, New Delhi. 5. Srilakshmi, B. Nutrition Science, New Age International Publishers, seventh edition 6. Singh, B. Aahar Vigyan Evam Poshan, Hindi Edition, Panchsheel Prakashan,
Learning Outcomes	• Learning of basic terms of Nutrition, understanding of different concepts related to health and nutrition, nutritional deficiencies and nutritive values of basic food groups. • Knowledge of performing calculations to determine nutrient requirement of individuals

Course Title	**Basics of Human Development (HSCMD21)**			
Category of Course[153]	Multi-Disciplinary			
Credits[154]& Hours of Teaching		Theory	Practical	Cumulative
	Credits	03	NA	03
	Hours of Teaching (Total)	45	NA	45
Course Objectives	▪ To develop basic understanding of human development.			
	▪ To learn about the principles of human development.			
	▪ To gain knowledge about characteristics of different stages of human development.			

Course Content

Units	**Course Content**	**Hr. of Teaching**
I	Need and Scope of Human Development,	03
II	Principles of Development	08
III	Stages of Human Development; Characteristics and Hazards of different stages of life span; Prenatal, Infancy, Early, Middle and Late Childhood, Puberty, Early and Late Adolescence, Early, Middle, Late Adulthood and Old age. Developmental Task.	16
IV	Reproductive System (Male & Female), Conception. Prenatal Development, Maternal health and Care during pregnancy, Hazards during prenatal development, Birth Process and Complications, Postnatal care of the mother and new born	16
V	Study of developmental Pattern in brief.	02

Texts / References	1. Elizabeth B. Hurlock; child Development (sixth edition); McGraw Hill Education (India) private limited (2017). 2. 2. Dr. Vrinda Singh; Manav Vikas Evam ParivarikSambandh (Human Development & Family Relationship; panchsheelprkashan (2019). India. 3. Prof. Kamlesh Sharma, Dr. Lalita Sharma; Baal Vikas(Child Development); star publication Agra(Hindi),(2020), India. 4. . Ross & Wilson; Anatomy and Physiology in Health and Illness (thirteenth edition);Shree Ram publication (2021). 5. Neeta Aggarwal & Dr. Akanksha Tripathi; Manav Vikas (paperback,1 st edition,

[153] SEC – Skill Enhancement Course; AEC – Ability Enhancement Course; VAC – Value Added Course; MD – Multidisciplinary Course

[154] 1 Credit (Theory) = 15 Hours; 1 Credit (Practical) = 30 Hours

	Hindi),Agrawal publications, India.
Learning Outcomes	▪ Understanding will be developed about the concepts of human growth and development. ▪ Basic knowledge of the male and female reproductive system. ▪ Awareness among the students about care in different stages of life.

Course Title	Language (HSCAE21)
Category of Course[155]	AEC -2
Credits[156]& Hour of Teaching	

	Theory	Practical	Cumulative
Credits	02	NA	02
Hour of Teaching (Total)	30	NA	30

Course Objectives	NA

Course Content

Units	Course Content	Hr. of Teaching
I	NA	
II	NA	
III	NA	
IV	NA	
V	NA	

Texts / References	NA
Learning Outcomes	NA

[155] SEC – Skill Enhancement Course; AEC – Ability Enhancement Course; VAC – Value Added Course; MD – Multidisciplinary Course

[156] 1 Credit (Theory) = 15 Hours; 1 Credit (Practical) = 30 Hours

Course Title	**Textile Surface Design and Basic Stitching (HSCSE21 and HSCSE22)**
Category of Course[157]	Skill Enhancement Course

Credits[158]& Hours of Teaching

	Theory	Practical	Cumulative
Credits	01	02	03
Hours of Teaching (Total)	15	60	75

Course Objectives

- To impart knowledge regarding the fundamentals of textile surface designing and basic stitching
- To develop an understanding of different stitching methods used in clothing construction.
- To make Students learn various techniques to create surface designs on fabric
- To enhance students' creativity, designing skills and technical skills in textile designing and sewing

Course Content

Units	Course Content	Hr. of Teaching
I	**Introduction to Textile Surface Designing** Overview of textile surface designing, Understanding principles and elements of design, Introduction to various techniques of textile surface designing; Printing, Dyeing, Embroidery Stitches& other embellishment	06
II	**Dyeing & Printing techniques** Introduction to various methods of dyeing & printing; solid dyeing, tie & dye, batik, Block, Stencil, screen, spray printing	02
III	**Embroidery Stitches & other embellishment techniques** Introduction to various embroidery stitches, applique & patch, Bead & sequins work	04
IV	**Basic Stitching Process** Working of simple Sewing machine, Design details; Seam, Pleats, gathers, smoking, darts, tucks, loops, fasteners, yokes	03
PRACTICAL		
I	Development of samples using solid dyeing and Printing; Block printing, screen printing, stencil & spray printing, tie & dye and Batik	10
II	Making samples by using various embroidery stitch running, buttonhole, herringbone, chain, satin, stem, French knot, feather, fly etc. stitches.	10
III	Practicing other embellishment techniques; aariwork, mirror work, appliqué work, patch work and bead &sequins work, quilts.	10
IV	Practicing basic seam on straight line, curves and corners, Development of samples of different seams, darts, tucks, smoking, pleats, gathers, pockets, collars, loops, fasteners	20
V	Project Development Stitching and embellishing self-designed fabric projects (Cushion covers//table mats/apron/kurta/Jacket/child frock/wall hanging etc.	10

Texts / References

1. Haynes Christine (2014). *The Complete Photo Guide to Clothing Construction*. United States: Quarry Books.
2. The Reader's Digest Association (2010). *Reader's Digest New Complete Guide to Sewing*. New York: Trusted Media Brand.
3. Mullick, P. (2002). *Garment Construction Skills.* New Delhi: Kalyani Publishers.
4. **Kallal** Mary J. (1985). *Clothing Construction*. London: Prentice Hall

Learning Outcomes

By the end of the course, students will be able to:

- Understand the principles and elements of textile surface designing.
- Acquire understanding for design concepts and transfer them onto fabric.
- Apply basic stitches for textile construction and embellishment.
- Demonstrate proficiency in various surface design techniques.
- Create textile samples and finished projects using learned techniques.
- Practice proper safety measures while working with textiles and stitching tools

[157] SEC – Skill Enhancement Course; AEC – Ability Enhancement Course; VAC – Value Added Course; MD – Multidisciplinary Course

[158] 1 Credit (Theory) = 15 Hours; 1 Credit (Practical) = 30 Hours

Course Title	**Offered by the University (HSCVA21)**
Category of Course	VAC-2
Credits& Hours of Teaching	

	Theory	Practical	Cumulative
Credits	02	NA	02
Hours of Teaching (Total)	30	NA	30

Course Objectives	NA
Course Content	

Units	**Course Content**	**Hr. of Teaching**
I	NA	
II	NA	
III	NA	
IV	NA	
V	NA	

Texts / References	NA
Learning Outcomes	NA

Course Title	Offered by the University (HSCVA22)
Category of Course[159]	VAC-3
Credits[160]& Hour of Teaching	

	Theory	Practical	Cumulative
Credits	02	NA	02
Hour of Teaching (Total)	30	NA	30

Course Objectives	A
Course Content	

Units	**Course Content**	**Hr. of Teaching**
I	NA	
II	NA	
III	NA	
IV	NA	
V	NA	

Texts / References	NA
Learning Outcomes	NA

[159] SEC – Skill Enhancement Course; AEC – Ability Enhancement Course; VAC – Value Added Course; MD – Multidisciplinary Course

[160] 1 Credit (Theory) = 15 Hours; 1 Credit (Practical) = 30 Hours

Semester –III

Course Title	**Family Resource Management (HSCMJ31)**			
Category of Course[161]	**Major**			
Credits[162]& Hours of Teaching		Theory	Practical	Cumulative
	Credits	04	-	04
	Hours of Teaching (Total)	60	-	60
Course Objectives	▪ To develop basic understanding about family resource management. ▪ To learn about the steps of home management. ▪ To gain knowledge about different stages of family life cycle.			

Course Content

Units	**Course Content**	**Hr. of Teaching**
I	Meaning and importance of family resource management Family: Meaning, Definition, Characteristics, Types, functions and Stages of Family Life Cycle	12
II	Resources: Concept and Types, Importance of resources, Characteristics, factors affecting utilization of resources, methods to maximize the use of resources	10
III	Management: Introduction, Development of management process, Management process: Planning; steps of planning, characteristics of planning, controlling; steps in controlling, adjustment, Evaluation; types of evaluation, Relationship between Planning, Controlling and Evaluation	14
IV	Energy management: Fatigue, Reasons for fatigue, Types of fatigue, Measures to relieve or avoid fatigue, Work-Simplification; Advantages of work simplification, Techniques of work Simplification, Mundel's classes of change	12
V	Elements of Arts; Line, Shape, Texture, Design, Light, Colour and Shape Principles of Designs; Harmony, Proportion, Balance, Emphasis, Rhythm Colour; Meaning, Prangs Colour System Qualities or Dimensions of Colours, Classification of Colours, Colour Wheel, Types of Colour schemes.Flower arrangements; Types of Flower Arrangement, Rules for Flower Arrangement, Japanese flower arrangement in brief. Ergonomics; Meaning, Principles, Benefits of Ergonomics.	12

Texts / References	1. Tami J. Moore, Sylvia M. Asay ; Family Resource Management; SAGE piblications, Inc; third edition (2017). 2. Maike Andresen Christian Nowak; Human Resource Management Practices, Springer International Publishing AG. India 3. Imam Nadaf ; Diploma in family management: your family members are the potential energy of your life ; Notion Press; 1st edition (2017), India . 4. Bela Bhargava; Family Resource Management & Interior Decoration, university book house pvt. Ltd, First Reprint edition (2018), india 5. Premavathy Seetharaman , Sonia Vatra , PreetiMehra ; An introduction to family resource management;CBS publisher, (2019) India , 6. Dr.Brinda Singh ; Home Management & Interior Decoration; panchsheelprakashan , seventeenth edition (2023), india 7. Premlata Mullick , Text Book Of Home Science; Kalyani publishers (2012) India.
Learning Outcomes	▪ To understand the concepts of human and non-human resources. ▪ Deep knowledge about the steps of decision making. ▪ Learn about the concept of time, energy and money management. ▪ To study about the principles of art and design.

[161] SEC – Skill Enhancement Course; AEC – Ability Enhancement Course; VAC – Value Added Course; MD – Multidisciplinary Course

[162] 1 Credit (Theory) = 15 Hours; 1 Credit (Practical) = 30 Hours

Course Title	Apparel Designing (HSCMJ32 and HSCMJ33)
Category of Course	**Major**

Credits & Hours of Teaching

	Theory	Practical	Cumulative
Credits	02	02	04
Hours of Teaching (Total)	30	60	90

Course Objectives

- To make students learn fundamental techniques of apparel design and its application
- To impart comprehensive understanding and enable students to learn structural design as well as applied design details in apparel construction
- To lead students through the step-by-step entire apparel design process.
- To make the students familiar with multiple pattern-making techniques.
- To enhance students' creativity and skills in apparel designing and sewing
- To impart skills for applying structural and applied designing techniques in apparel construction

Course Content

Units	Course Content	Hr. of Teaching
I	**Introduction to Apparel Designing** Components of Apparel design; silhouette, texture, colour, details, and their application in relation to different figures, Basic principles of apparel designing, Sources of inspiration for designing; current fashion trends, Steps for apparel designing; analyzing body measurements, designing/sketching of dress details, pattern making, layout preparation and marking, cutting, stitching, applied designing.	7
II	**Body measurements &Fabric selection** Body measurements; types, procedures, and precautions while taking body measurements for different garments, Standard textile fabric terms; chiffon, georgette, cambric, denim, gabardine, poplin and velvet etc, Selection & calculation of fabric required for different apparel; gown, topper, shirt, T-shirt, pants, kurta, skirt, jackets etc.	5
III	**Pattern-making & Layout preparation** Techniques of Pattern making; Drafting, flat pattern, draping, Dart manipulation; Pivot method and slash & spread method. Understanding the commercial paper pattern, Pattern envelop, Guide sheet, Layout types and preparation for different garments.	4
IV	**Apparel designing Details; structural and applied designing** **Structural designing details;** machine stitches/seams – plain seam and it's finishing, french, lapped, run and fell, decorative seams- slot, piped. Disposal of fullness; darts, princess line, pleats, tucks, gathers, smoking, shirring, pockets; patch, inseam, welt, Plackets and fasteners, sleeves; plain, cap, flared, gathered, puffed, Necklines, Collar – baby, cape, Chinese, mandarian, stand, peter pan, sailor, shirt, Yokes- straight, round, V shape, U shape Understanding the use of facing, interfacing, interlining, underlining and lining **Applied designing details;** Hand Stitches- Running, basting, back, buttonhole, hemming, overcasting, picko Basic Embroidery stitches- blanket, buttonhole, chain, couching, french knot, fly, feather, herringbone, lazy daisy, running, stem, satin, sequence and mirror work, patchwork, application of Trimmings	7
V	**Sewing &Fitting** Basic principles of sewing, Equipment's required for Measuring, marking, cutting, and stitching; Sewing machine- types, parts, care, handling and problems. Factors affecting good fit, problems and remedies.	7

PRACTICAL		
I	Application of components & principles of apparel Designing, Application of Drafting, flat Pattern and Draping, Drafting of Child Bodice & sleeve Block and Adult Bodice & sleeve Block, Dart manipulation	10
II	Drafting of Blouse, Shirt, Kurta, Pant and Salwar, Importance of grain-line, Calculation of fabric, Understanding of Body measurements.	10
III	Development of samples- Basic stitching (learning machine stitch), seams; plain seam and it's finishing, french, lapped, run and fell, decorative seams- slot, piped, Disposal of fullness; darts, princess line, pleats, tucks, gathers, smoking, shirring, Pockets; patch, inseam, welt, Plackets and fasteners, Hand Stitches; Running, basting, back, buttonhole, hemming, overcasting, picko Basic Embroidery stitches; blanket, buttonhole, chain, couching, french knot, fly, feather, herringbone, lazy daisy, running, stem, satin, sequence and mirror work, patch work, application of Trimmings	20
IV	Drafting & Construction of Samples- Sleeves; plain, cap, flared, gathered, puffed, Necklines finishing with piping & facing, Collar; baby, cape, Chinese, mandarian, stand, peter pan, sailor, shirt, Yokes- straight, round, V shape, U shape	10
V	Project Development- Designing & construction of any one Complete article with structural and Applied designs Portfolio Development and Understanding of different measures to start up Apparel design and development related Business; procedures and guidance	10

Texts / References	1. Haynes Christine (2014). ***The Complete Photo Guide to Clothing Construction.*** **United States:** Quarry Books. 2. Mullick, P. (2002). *Garment Construction Skills.* New Delhi: Kalyani Publishers. 3. **Kallal** Mary J. (1985). ***Clothing Construction.*** **London:** Prentice Hall 4. Armstrong, H.J., (2009). *Pattern Making for Fashion Design.* New York: Harper Collins Publishers Inc. 5. Doongaji (1975). *Basic Process & Clothing Construction*, New Delhi, Raj Book Dep. 6. The Reader's Digest Association (2010). *Reader's Digest NewComplete Guide to Sewing*. New York: Trusted Media Brands.
Learning Outcomes	Upon completion of the course, students will be able to; • Understand and apply core elements of dress design for diverse body types. • Acquire proficiency in various pre-preparatory processes involved in fabric preparation for garment construction & get familiar with fabric grain & its importance. • Understand the procedure of taking accurate body measurements and selecting appropriate fabric for garments. • Create patterns for garments using different pattern-making techniques. • Utilize knowledge of body measurements for garment fitting. • Design and construct garments incorporating structural and applied techniques.

Course Title	**Basic Dress Designing Skill (HSCMV31 and HSCMV32)**			
Category of Course[163]	Minor (VOC-1)			
Credits[164]& Hours of Teaching		Theory	Practical	Cumulative
	Credits	02	02	04
	Hours of Teaching (Total)	30	60	90

[163] SEC – Skill Enhancement Course; AEC – Ability Enhancement Course; VAC – Value Added Course; MD – Multidisciplinary Course

[164] 1 Credit (Theory) = 15 Hours; 1 Credit (Practical) = 30 Hours

Course Objectives	• To make students learn fundamental techniques of dress design and its application • To impart comprehensive understanding and enable students to learn structural design as well as applied design details in clothing construction • To lead students through the step-by-step entire dress design process • To make the students familiar with multiple pattern-making techniques • To enhance students' creativity and skills in dress designing and sewing • To impart skills for applying structural and applied designing techniques in clothing construction • To promote hands-on experience with dress designing skills

Course Content

Units	Course Content	Hr. of Teaching
I	**Introduction to Dress Designing** Components of dress design; silhouette, texture, colour, details, and their application in relation to different figures, Basic principles of dress designing, Sources of inspiration for designing; current fashion trends, Steps for dress designing; analyzing body measurements, designing/sketching of dress details, pattern making, layout preparation and marking, cutting, stitching, applied designing.	7
II	**Body measurements &Fabric selection** Body measurements; types, procedures, and precautions while taking body measurements for different garments, Standard textile fabric terms; chiffon, georgette, cambric, denim, gabardine, poplin and velvet etc, Selection & calculation of fabric required for different dresses; gown, topper, shirt, T-shirt, pants, kurta, skirt, jackets etc.	5
III	**Pattern-making & Layout preparation** Techniques of Pattern making; Drafting, flat pattern, draping, Dart manipulation; Pivot method and slash & spread method. Understanding the commercial paper pattern, Pattern envelop, Guide sheet, Layout types and preparation for different garments.	4
IV	**Dress designing Details; structural and applied designing** **Structural designing details;** machine stitches/seams – plain seam and it's finishing, french, lapped, run and fell, decorative seams- slot, piped. Disposal of fullness; darts, princess line, pleats, tucks, gathers, smoking, shirring, pockets; patch, inseam, welt, Plackets and fasteners, sleeves; plain, cap, flared, gathered, puffed, Necklines, Collar – baby, cape, Chinese, mandarian, stand, peter pan, sailor, shirt, Yokes- straight, round, V shape, U shape Understanding the use of facing, interfacing, interlining, underlining and lining **Applied designing details;** Hand Stitches- Running, basting, back, buttonhole, hemming, overcasting, picko Basic Embroidery stitches- blanket, buttonhole, chain, couching, french knot, fly, feather, herringbone, lazy daisy, running, stem, satin, sequence and mirror work, patchwork, application of Trimmings	7
V	**Sewing &Fitting** Basic principles of sewing, Equipment's required for Measuring, marking, cutting, and stitching; Sewing machine- types, parts, care, handling and problems.Factors affecting good fit, problems and remedies.	7
PRACTICAL		
I	Application of components & principles of dress Designing, Application of Drafting, flat Pattern and Draping, Drafting of Child Bodice & sleeve Block and Adult Bodice & sleeve Block, Dart manipulation	10
II	Drafting of Blouse, Shirt, Kurta, Pant and Salwar, Importance of grain-line, Calculation of fabric, Understanding of Body measurements.	10
III	Development of samples- Basic stitching (learning machine stitch), seams; plain seam and it's finishing, french, lapped, run and fell, decorative seams- slot, piped, Disposal of fullness; darts, princess line, pleats, tucks, gathers, smoking, shirring, Pockets; patch, inseam, welt, Plackets and fasteners, Hand Stitches; Running, basting, back, buttonhole, hemming, overcasting, picko Basic Embroidery stitches; blanket, buttonhole, chain, couching, French knot, fly, feather, herringbone, lazy daisy, running, stem, satin, sequence and mirror work, patch	20

	work, application of Trimmings	
IV	Drafting & Construction of Samples- Sleeves; plain, cap, flared, gathered, puffed, Necklines finishing with piping & facing, Collar; baby, cape, Chinese, mandarin, stand, peter pan, sailor, shirt, Yokes- straight, round, V shape, U shape	10
V	Project Development- Designing & construction of any one Complete article with structural and Applied designs Portfolio Development and Understanding of different measures to start up a dressmaking business; procedures and guidance	10

Texts / References	1. Haynes Christine (2014). ***The Complete Photo Guide to Clothing Construction*. United States:** Quarry Books. 2. Mullick, P. (2002). *Garment Construction Skills.* New Delhi: Kalyani Publishers. 3. **Kallal** Mary J. (1985). ***Clothing Construction*. London:** Prentice Hall 4. Armstrong, H.J., (2009). *Pattern Making for Fashion Design*. New York: Harper Collins Publishers Inc. 5. Doongaji (1975). *Basic Process & Clothing Construction*, New Delhi, Raj Book Dep. 6. The Reader's Digest Association (2010). *Reader's Digest NewComplete Guide to Sewing*. New York: Trusted Media Brands
Learning Outcomes	Upon completion of the course, students will be able to; • Understand and apply core elements of dress design for diverse body types. • Acquire proficiency in various pre-preparatory processes involved in fabric preparation for garment construction & get familiar with fabric grain & its importance. • Understand the procedure of taking accurate body measurements and selecting appropriate fabric for garments. • Create patterns for garments using different pattern-making techniques. • Utilize knowledge of body measurements for garment fitting.

Course Title	**Introduction to Clothing & Textiles (HSCMD31)**
Category of Course[165]	**Multi Disciplinary**

Credits[166]& Hours of Teaching	Theory	Practical	Cumulative
Credits	03	-	03
Hours of Teaching (Total)	45	-	45

Course Objectives	• To familiarize the students with different properties of textile fibers, yarn and fabric • To impart knowledge on laundry process and garment care • To give detailed knowledge about understanding and usage of elements and principles for creating a good design in clothing

Course Content

Units	Course Content	Hr. of Teaching
I	**Textile Fundamentals** Importance of studying textiles, properties of textiles, natural and man-made fibers; properties and uses, Identification of textile fibers.	8
II	**Fiber spinning**; Mechanical and Chemical spinning method, Basic terminology related to production and manufacturing of yarn from different fibers, yarn definition, Blending	6
III	**Fabric Manufacturing Techniques** Understanding Weaving, Knitting, Braiding, Nets, & Laces; Definition & terminology: warp, weft, selvedge, grain, bias, Comparison between knits and woven; Weaving defects	8

[165] SEC – Skill Enhancement Course; AEC – Ability Enhancement Course; VAC – Value Added Course; MD – Multidisciplinary Course

[166] 1 Credit (Theory) = 15 Hours; 1 Credit (Practical) = 30 Hours

IV	**Clothing and Home-textile** Importance of Clothing; physiological, psychological and social aspect of clothing. Different types of clothes; business wear, sportswear, traditional wear, casual wear, party wear etc. Labelling to help consumer in intelligent selection and care, Precautions to be observed during purchase of clothing, Definition and intelligent buying & care of table linen, towels and bathroom ensemble, Buying guidelines for bed sheet, pillow slips, blanket. Selection of upholstery, carpet and cushion materials,	10
V	**Basics to Design** Elements and Principles of Design, Types of design (structural and decorative); **Laundry** Washing equipment's, washing principles and washing methods, Dry-cleaning, procedure of stain removal, Care of different fiber fabrics (Washing, Ironing, and Storage).	13

Texts / References	1. Murthy H.V. Sreenivasa (2016). *Introduction to Textile fibers,* Revised edition. New Delhi: Woodhead Publishing India Pvt. Ltd 2. Kadolph Sara j. (2015). Textiles (11th ed.) United states: Pearson Education Limited 3. Corbman, B.P. (1983). *Textiles: Fiber to Fabric* (6th ed.). New York: McGraw Hill Publication. 4. Dantyagi, S. (2006). *Fundamentals of Textiles and their Care* (5th ed.). Delhi: Orient Longman private ltd. 5. Deulkar, D. (1982). *Household textiles and Laundry Work.* Delhi: Atma ram and Sons. 6. सिंहवृन्दा. (2020). वस्त्रविज्ञानएवमपरिधान, पंचशीलप्रकाशन, जयपुर
Learning Outcomes	By the end of the course, students will be able to:- • Understand and identify the attributes of different textile fibers, Yarn, Fabric. • Understand nature and behavior of various textile materials. • Identify basic weaves and their variations. • Apply effective textile care, including laundering, stain removal and proper storage considering fabric types.

Course Title	**Offered by the University (HSCAE31)**			
Category of Course[167]	AEC -3			
Credits[168]& Hours of Teaching		Theory	Practical	Cumulative
	Credits	02	NA	02
	Hours of Teaching (Total)	30	NA	30
Course Objectives	NA			

Course Content

Units	**Course Content**	**Hr. of Teaching**
I	NA	
II	NA	
III	NA	
IV	NA	
V	NA	

Texts / References	NA
Learning Outcomes	NA

[167] SEC – Skill Enhancement Course; AEC – Ability Enhancement Course; VAC – Value Added Course; MD – Multidisciplinary Course

[168] 1 Credit (Theory) = 15 Hours; 1 Credit (Practical) = 30 Hours

Course Title	**Computer Applications (HSCSE31 and HSCSE32)**
Category of Course[169]	Skill Enhancement Course

Credits[170]&Hours of Teaching

	Theory	Practical	Cumulative
Credits	01	02	03
Hours of Teaching (Total)	15	60	75

Course Objectives

- To learn about the basics of computer and its application
- To learn about the processing of data
- To acquire knowledge and understanding of various image file formats
- To enable the students to design brochures, certificates, cards, pamphlets etc.

Course Content

Units	**Course Content**	**Hr. of Teaching**
I	Basics of computer: generations of computer, software and hardware, Input-output devices, operating system, computer memory, computer networks	06
II	Basic introduction, functioning and application of Microsoft Office and Paint, use of ArtificialIntelligencein project management	03
III	Data Processing: Processing and Analysing data on Excel sheet	04
IV	Various image file formats; JPEG, PDF, TIFF, BMP, PNG, GIF etc.	02

PRACTICAL

Units	**Course Content**	**Hr. of Teaching**
I	• Creating document on word using different tools of page setting, paragraph editing and designing. • Creating professional slides for presentations using PowerPoint.	10
II	Processing and Analysing of data using excel sheet	20
III	Designing of brochures, certificates, cards, pamphlets etc. through computer-based designing	10
IV	Working on Google Workspace using its cloud-based tools for productivity and collaboration- • Communication tools: Gmail, Contacts, Calendar, Meet, and Chat • Storage: Drive • Content creation: Google Docs Editors, which includes Google Docs, Google Sheets, Google Slides, Google Drawings, and Google Forms	12
V	Designing for the World Wide Web: Developing for the Web, Text for the Web, Images for the Web, Sound for the Web, Animation for the Web, Video for the Web.	08

Texts / References

1. Sinha, P.K. & Sinha Priti (2004). *Computer Fundamentals.* Delhi: BPB Publications; 8th Edition
2. Penn, J (2020). *Data Analysis With Excel : Learn Step-By-Step How To Analyze Data With Excel, Formulas, Business Modeling And Grasp Spreadsheets To The Fullest.* Kindle eBook
3. Nigam, M. (2019). *Data Analysis with Excel.* New Delhi*:* BPB Publications; First Edition
4. Kumar, B. (2017). *Mastering Ms Office: Computer Skill Development*. New Delhi: V&S Publishers

Learning Outcomes

Upon completion of the course, students will be able to;

- Understand about the application and fundamentals of computer
- Develop brochures, certificates, cards, pamphlets etc
- Create an understanding of processing of data

[169] SEC – Skill Enhancement Course; AEC – Ability Enhancement Course; VAC – Value Added Course; MD – Multidisciplinary Course

[170] 1 Credit (Theory) = 15 Hours; 1 Credit (Practical) = 30 Hours

Semester –IV

Course Title	**Fundamentals of Human Development (HSCMJ41 and HSCMJ42)**
Category of Course[171]	Major

Credits[172]& Hours of Teaching		Theory	Practical	Cumulative
	Credits	03	02	05
	Hours of Teaching (Total)	45	60	105

Course Objectives	• To make the students familiar with different methods studying human development • To provide knowledge of theories given by different psychologists • To gain practical experiences in the field of human development.

Course Content

Units	**Course Content**	**Hr. of Teaching**
I	Methods of studying human development; case study, interview, naturalistic observation and laboratory observation, experimental method, data collection methods: cross sectional and longitudinal and sequential studies, Ethics in research on human being	05
II	Introduction to theories of human development; Piaget's theory of cognitive development, Psychosexual theory of Sigmund Freud (Defense Mechanism, stages of psychosexual development; id, ego, super-ego). Psychosocial theory of Erik-Erikson. Traditional learning theories; Pavlov, Watson, and Skinner. Social learning theory (Bandura). Kohlberg's theory of Moral Development. Theories of language Acquisition. Maslow's self - actualization theory. Theory of Attachment; Bowlby.	10
III	Early Childhood Education and Management; Meaning, Objectives, Importance of ECCE. Philosophy of Early Childhood Education (Pre-basic Education of Gandhiji, Maria Montessori, Gijubhaibadheka, Frobel). ECCE center; Infrastructure and building, Staff, Equipments, record keeping, parent teacher meeting. Importance of Science, nature, music, role plays and stories in ECCE programs.	10
IV	Child Guidance and Counseling; Guidance; meaning and definition, principles of guidance, need of guidance, types of guidance; Educational guidance, Vocational guidance, Personal guidance. Counseling; Meaning and Definition, principles of counseling, Elements of counseling, need for counseling, aims and objectives of counseling, role of counselor, counseling process, and types of counseling, pre-marital and marital counseling	15
V	Meaning and Objectives of Nari Niketan, Creche, Old age Home, Day Care Centre	5
PRACTICAL		
I	Visit to any one pre-school centre situated in Varanasi city.	04
II	Study of all development patterns in different age groups • Infancy • Babyhood • Pre-school child • School going child • Child in puberty	28
III	Study of all development patterns in different age groups • Adolescent • Adult • Old age person	20
IV	Visit to Old Age Home	04
V	Visit to Creche	04

[171] SEC – Skill Enhancement Course; AEC – Ability Enhancement Course; VAC – Value Added Course; MD – Multidisciplinary Course

[172] 1 Credit (Theory) = 15 Hours; 1 Credit (Practical) = 30 Hours

Texts / References	1.Tami J. Moore, Sylvia M. Asay; Family Resource Management; SAGE publications, Inc;third edition (2017). 2. Maike Andresen Christian Nowak ; Human Resource Management Practices, Springer International Publishing AG. India 3. Imam Nadaf;Diploma in family management: your family members are the potential energy of your life; Notion Press; 1st edition (2017), India . 4.BelaBhargava; Family Resource Management & Interior Decoration, university book house pvt. Ltd, First Reprint edition (2018), India 5.PremavathySeetharaman Sonia Vatra, PreetiMehra; An introduction to family resource management;CBS publisher, (2019) India , 6.Dr.Brinda Singh; Home Management & Interior Decoration; panchsheelprakashan , seventeenth edition (2023), India 7.PremlataMullick, Text Book of Home Science; Kalyani publishers (2012) India.
Learning Outcomes	Upon completion of the course students will be able to : ▪ Use different methods of data collection and have knowledge about research ethics. ▪ To facilitate the students to understand the theories of human developments. ▪ To learn about the objectives of Early Childhood Care & Education.

Course Title	**Rural Development and Outreach Programme (HSCMJ43 and HSCMJ44)**			
Category of Course[173]	Major			
Credits[174]& Hours of Teaching		Theory	Practical	Cumulative
	Credits	03	02	05
	Hours of Teaching (Total)	45	60	105
Course Objectives	• Students gain hands-on experience in developing and implementing rural development projects. • It opens up job prospects in government, NGOs, and international development organizations focused on rural areas. • Students learn how to make a positive difference in the lives of rural communities. • The course teaches students about sustainable practices that can be applied to real-world challenges in rural settings. • To identify various organization working in the rural areas, • To know about the different programmes running by Govt. for the rural people			

Course Content

Units	**Course Content**	**Hr. of Teaching**
I	**Rural development** Definition; Issues and concepts; Historical perspective of community development in India and emerged changes since inception to current era.	05
II	**Approaches to rural development** Concept and characteristic features Gandhian approach, community development approach, target approach, area approach, minimum need approach, integrated or holistic approach, participatory development approach.	07
III	**Key principles of Rural development** Community participation - definition and scope; Inclusion; Equality; Collective action; Empowerment and community development process.	08
IV	**Rural development and governance in India** Rural development policy in India; rural development perspectives in five-year plans.	10
V	**Cross cutting edges of rural development**	15

[173] SEC – Skill Enhancement Course; AEC – Ability Enhancement Course; VAC – Value Added Course; MD – Multidisciplinary Course

[174] 1 Credit (Theory) = 15 Hours; 1 Credit (Practical) = 30 Hours

	Horizontal edges - education, health, women empowerment, skill development, agriculture and caste occupations; **Outreach of rural development** General orientation to outreach models - precede model, evaluation and indicator metrics; Outreach of urban; Rural and tribal community development programmes; Impact - economic and social perspectives	
PRACTICAL		
I	Identify the various organizations working in the rural areas for community empowerment. Selection of rural development programme and detailed description of the programme in terms of objectives, targets, inputs, expected outputs and outcome	20
II	Visit to programme operating area and interaction with stakeholders implementing agency, personnel and beneficiaries. Identify the project evaluation criteria and submit the report of the programme in terms of objectives, targets, inputs, expected outputs and outcome	20
III	Visit of Rural/ Community organizations (any Four) and submit report- • PHC • NGO • Panchayat • Anganwadi • Women Organisation's School • Cooperative Society	20

Texts / References	1. Jerry WR and Gary P. 2014. *Introduction to Community Development*: *Theory, Practice, andService-Learning.* 1st Edition, *ISBN*-13: 978-1412974622 ISBN-10: 1412974623 2. Manohar P. 2014. S*ocial and Community Development Practice* http://dx.doi.org/10.4135/ 3. Marianne R, Woodside and Tricia McClam. 2015. *An Introduction to Human Services.* 8th Edition, ISBN-13: 978-1285749907 ISBN-10: 1285749901 4. Patil AR. 2013. *Community Organization and Development*: *An Indian Perspective*. PHI 5. Learning Private Limited, Delhi 110092ISBN 978-81-203-4694-9 6. Rhonda P and Robert P. 2015. *An Introduction to Community Development* (*Volume 1*) 2nd Edition, ISBN-13: 978-0415703550 ISBN-10: 0415703557 7. *A Step by Step Guide to 'Turning Outward' in Your Community.* American LibraryAssociation. http://www.ala.org/tools/sites/ala.org.tools/files 8. From Project to Branch Integration and Sustainability: Community-Led Work.
Learning Outcomes	After successful completion of the curse the students will be able to: • Comprehend and differentiate OD processes and HRD strategies • Critically analyze different approach of rural development • Plan and execute special project • Analyze the results and write report. • Participants will gain a thorough understanding of rural development concepts and practices.

Course Title	**Public Nutrition and Health (HSCMJ45 and HSCMJ46)**			
Category of Course	Major			
Credits & Hours of Teaching		Theory	Practical	Cumulative
	Credits	02	02	04
	Hours of Teaching (Total)	30	60	90
Course Objectives	• To explore the concepts of food, nutrition and health in order to promote optimal well-being across the life span • To conduct the thorough nutritional assessment of vulnerable groups in order to identify their unique dietary needs and develop strategies to support their health and health of their infants • To provide fundamental concept of the role diet therapy to treat different disease conditions			

	• To equip individuals with essential knowledge and skills in safety education to effectively promote health and respond to emergencies in various settings

Course Content

Units	Course Content	Hr. of Teaching
I	Concept of Food, Nutrition and Health, Nutritional Assessment of Childhood, Adolescence, Elderly and Old age	10
II	Nutritional Assessment of Vulnerable Groups (pregnant and lactating women)	05
III	Public Health and Diseases: Non communicable diseases, food borne diseases and water borne diseases, reemerging diseases (TB, Malaria etc.), Vector borne diseases (dengue, chikungunya)	10
IV	Safety Education in Health promotion: First aid and emergency care	05
PRACTICAL		
I	Assessment of Nutritional status of Childhood, Adolescence, Elderly and Old age	25
II	Visit to local health center to assess the health status of individuals	25
III	Planning and preparation of nutritional recipes for pregnant and lactating women	10

Texts / References	1. Shrilaxmi, B. (2016). Dietetics. New Age International. 2. Khanna K., Gupta S., Passi S.J, Seth R., Mahana R., &Puri S. (2020). Textbook of Nutrition and Dietetics. Elite Publishing House. 3. Swaminathan M. (2015). Advanced Text – Book on Food & Nutrition Volume-2. The Bangalore Printing & Publishing Co., LTD. 4. Joshi S.A. Nutrition and Dietetics, Tata McGraw Hill Publications, New Delhi. 5. Antia F.P., & Philip A. Clinical Nutrition and Dietetics, Oxford Publishing Company.
Learning Outcomes	After the end of the course, students will able to learn • About concept of health and nutritional assessment • About trends of communicable diseases • Planning and preparation of new recipes for vulnerable groups

Course Title	**Public Nutrition and Health (HSCMN41 andHSCMN42)**
Category of Course[175]	Minor

Credits[176]& Hours of Teaching

	Theory	Practical	Cumulative
Credits	02	02	04
Hours of Teaching (Total)	30	60	90

Course Objectives	• To explore the concepts of food, nutrition and health in order to promote optimal well-being across the life span • To conduct the thorough nutritional assessment of vulnerable groups in order to identify their unique dietary needs and develop strategies to support their health and health of their infants • To provide fundamental concept of the role diet therapy to treat different disease conditions • To equip individuals with essential knowledge and skills in safety education to effectively promote health and respond to emergencies in various settings

Course Content

Units	Course Content	Hr. of Teaching
I	Concept of Food, Nutrition and Health, Nutritional Assessment of Childhood, Adolescence, Elderly and Old age	10
II	Nutritional Assessment of Vulnerable Groups (pregnant and lactating women)	05
III	Public Health and Diseases: Non communicable diseases, food borne diseases and water borne diseases, reemerging diseases (TB, Malaria etc.), Vector borne diseases	10

[175] SEC – Skill Enhancement Course; AEC – Ability Enhancement Course; VAC – Value Added Course; MD – Multidisciplinary Course

[176] 1 Credit (Theory) = 15 Hours; 1 Credit (Practical) = 30 Hours

	(dengue, chikungunya)	
IV	Safety Education in Health promotion: First aid and emergency care	05
Practical		
I	Assessment of Nutritional status of Childhood, Adolescence, Elderly and Old age	25
II	Visit to local health center to assess the health status of individuals	25
III	Planning and preparation of nutritional recipes for pregnant and lactating women	10

Texts / References	1. Shrilaxmi, B. (2016). Dietetics. New Age International. 2. Khanna K., Gupta S., Passi S.J, Seth R., Mahana R., &Puri S. (2020). Textbook of Nutrition and Dietetics. Elite Publishing House. 3. Swaminathan M. (2015). Advanced Text – Book on Food & Nutrition Volume-2. The Bangalore Printing & Publishing Co., LTD. 4. Joshi S.A. Nutrition and Dietetics, Tata McGraw Hill Publications, New Delhi. 5. Antia F.P., & Philip A. Clinical Nutrition and Dietetics, Oxford Publishing Company.
Learning Outcomes	After the end of the course, students will able to learn • About concept of health and nutritional assessment • About trends of communicable diseases • Planning and preparation of new recipes for vulnerable groups

Course Title	**Offered by the University (HSCAE41)**
Category of Course[177]	AEC -4
Credits[178]& Hour of Teaching	Credits: Theory 02, Practical NA, Cumulative 02 Hour of Teaching (Total): Theory 30, Practical NA, Cumulative 30
Course Objectives	NA

Course Content

Units	**Course Content**	**Hr. of Teaching**
I	NA	
II	NA	
III	NA	
IV	NA	
V	NA	

Texts / References	NA
Learning Outcomes (not more than 100 words)	NA

[177] SEC – Skill Enhancement Course; AEC – Ability Enhancement Course; VAC – Value Added Course; MD – Multidisciplinary Course

[178] 1 Credit (Theory) = 15 Hours; 1 Credit (Practical) = 30 Hours

Semester –V

Course Title	**Textiles; Care and Selection (HSCMJ51 and HSCMJ52)**
Category of Course[179]	Major
Credits[180]& Hours of Teaching	

	Theory	Practical	Cumulative
Credits	3	2	5
Hours of Teaching (Total)	45	60	105

Course Objectives

- To make the students familiar with uses of different textiles
- To facilitate the students to understand and analyze the type of fabric
- To educate the students about different techniques of textile printing & finishing
- To guide students about purchasing and taking care of different types of textiles article
- To impart skills related to identification of different textile components
- To enhance students' proficiency and creativity in motif arrangement and weaving process of fabric.

Course Content

Units	**Course Content**	**Hr. of Teaching**
I	Importance of studying textiles, properties of textiles, natural and man-made fibers; properties and uses, Fiber spinning; Mechanical and Chemical spinning method, Basic terminology related to production and manufacturing of yarn from different fibers, Blending. Minor fibers; properties and uses, New generation textile fibres; origin, components, characteristics and uses, Eco-friendly fibers; definition and concept.	15
II	Fabric Construction; weaving, basic loom, parts and operations, types of basic weaves and other fabric construction methods; knitting, felting and non-woven, knotting, crocheting, braiding.	6
III	Fabric finishes: Processes of removing impurities from fabric; scouring, degumming, bleaching, carbonizing. Basic finishes that alter texture; felting, singeing, stiffening, decatizing, delustering, calendering, beetling, napping, flocking, burnt out design, tentering, shearing and brushing. Functional finishes - water proofing, water repellent, shrinkage control, flame retardation, mildew proof, moth proof, anti-bacterial, anti-static.	5
IV	Dyeing & printing- Classification of dyes; Natural and synthetic dyes; Direct dye, acid dye, basic dye, vat dye, sulphur dye, azoic dye, mordant dye, disperse dye, reactive dye, pigment dye. Techniques of dyeing; Solution dyeing, fibre and yarn dyeing, piece dyeing, cross dyeing, union dyeing. Printing: Different styles of Printing, Hand printing methods; block printing, stencil, screen printing, spray printing, tie & dye, batik, warp printing. Machine printing; roller, screen printing, heat transfer printing, flock printing, Textile dyeing and printing auxiliaries used for different textile processing	8

[179] SEC – Skill Enhancement Course; AEC – Ability Enhancement Course; VAC – Value Added Course; MD – Multidisciplinary Course

[180] 1 Credit (Theory) = 15 Hours; 1 Credit (Practical) = 30 Hours

V	Laundry Agents- water, soap, detergent, Blueing& stiffening agents and stain removers, Washing equipment's, washing principles and washing methods, Dry-cleaning, procedure of stain removal, Care of different fiber fabrics (Washing, Ironing, Storage): cotton, wool, silk and man-made. Labelling to help consumer in intelligent selection and care, Precautions to be observed during purchase of textile, Definition and intelligent buying & care of table linen, towels and bathroom ensemble, Buying guidelines for bed sheet, pillow slips, blanket. Selection of upholstery, carpet and cushion materials.	11
PRACTICAL		
I	Identification of Textile Fiber Identification of Yarns Identification of Fabrics Study of Loom; Parts & operation, Preparation of basic weaves; graph & ribbon interlacement, Warp and weft yarn counting in fabric. Development of samples of weaving, knitting, crocheting, knotting	22
II	Dyeing of cotton with natural & synthetic dyes.Preparation of sample by Tie & Dye Techniques, Batik, Block printing, Stencil printing, screen printing & spray Printing.	16
III	Process of Designing, Textile motifs, Motif development; geometric, simplified, stylized, naturalized, abstract and ornamental, Textile motif; repeat and patterns, different arrangement/placements	4
IV	Group discussion of care (Laundering, ironing, storage) of different fabric articles, practicing laundering, Bleaching, blueing, starching and Stain removal, Identification & Collection of different label, understanding of care label; symbols and instructions	13
V	Project development; Make any one article of Weaving/Knitting/Crocheting/ Knotting/Tie & Dye/Printing.	5

Texts / References	1. Murthy H.V. Sreenivasa (2016). *Introduction to Textile fibers*, Revised edition. New Delhi: Woodhead Publishing India Pvt. Ltd 2. Kadolph Sara j. (2015). Textiles (11th ed.) United states: Pearson Education Limited 3. Corbman, B.P. (1983). *Textiles: Fiber to Fabric* (6th ed.). New York: McGraw Hill Publication. 4. Dantyagi, S. (2006). *Fundamentals of Textiles and their Care* (5th ed.). Delhi: Orient Longman private ltd. 5. Deulkar, D. (1982). *Household textiles and Laundry Work*. Delhi: Atma ram and Sons. 6. Gohl, E. P. G. & Vilensky, L. D. (1981). *Textiles-for modern living*. Melbourne: Longman Cheshire. 7. Joseph, M. L. (1986). *Introductory Textile Science*. New York: Holt, Rinehart and Winston.
Learning Outcomes	Upon completion of the course students will be able to; • Select and evaluate textile material critically for the specific end use. • Acquire knowledge for various types of materials, reagents, equipment's and processes involved in care of textiles. • Purchase and utilize textile articles intelligently and more effectively. • Identify, Select and evaluate textile material critically for the specific end use. • Use various types of materials, reagents, equipment's and processes involved in care of textiles.

Course Title	NGO Management and Advocacy (HSCMJ53 and HSCMJ54)
Category of Course[181]	Major

Credits[182]& Hours of Teaching	Theory	Practical	Cumulative
Credits	2	2	4
Hours of Teaching (Total)	30	60	90

Course Objectives

- To develop key management competencies and analytical in the management of NGOs
- To develop understanding about the legal framework of NGOs and various issues/risk associated with NGOs.
- To develop basic understanding regarding the structure and functioning of NGOs with effective strategies for networking and fundraising
- To inculcate understanding of communication campaigning and advocacy with the importance of effective campaigning in achieving objectives and changing public policy through mediums like media, legislation, marketing, and advertising.

Course Content

Units	Course Content	Hr. of Teaching
I	Introduction to Non-governmental Organizations • Meaning of NGO and GO and private sector • Difference between Government Organizations and NGO • Relationship between NGO, GO and private sector • Characteristics of good NGO • Structure of NGO • Functions of NGO • Classification of NGOs • Historical evolution of NGOs • Growth and status of NGOs in India • Contribution and Role of NGOs in development • Mapping Voluntarism in the Third sectors • 1Challenges faced by NGOs.	10
II	Management of Non-governmental Organizations • Organizational types and structures • Registration of NGO • Legal Procedures for establishment of NGOs • Overview of Societies Registrations Act, India's Companies Act, Charitable Endowment Act and FCRA, Memorandum of Association and Bye-Laws • Tax Relief Under Section 80G • Management of NGOs • NGO management competencies • Human Resource Management- Human Resource Policy, Staffing and Salaries • Selection and training of Personnel • Managing people and teams in NGOs • Communication and Networking in NGOs • Planning, Implementation and Evaluation strategy under NGO • Fundraising • Resource mobilization	8
III	Introduction to Advocacy • Concept and relevance of Advocacy • Types or approaches of Advocacy • Steps in planning an Advocacy Campaigns	12

[181] SEC – Skill Enhancement Course; AEC – Ability Enhancement Course; VAC – Value Added Course; MD – Multidisciplinary Course

[182] 1 Credit (Theory) = 15 Hours; 1 Credit (Practical) = 30 Hours

	• Tools and Techniques of Advocacy • Elements of an advocacy strategy • Advocacy Planning Cycle - planning advocacy campaigns for different stakeholders • Case studies of advocacy campaigns • Community Advocacy • Media Advocacy • Relationship between advocacy, programme communication and social mobilization	
PRACTICAL		
I	Visit to non-government organizations Profiling of NGOs	18
II	Evaluation of promotional/IEC materials developed by NGOs Case studies and Evaluation of Advocacy Initiatives/ Campaigns	22
III	Planning an advocacy campaign	20

Texts / References	
	1. R. Kumar, S. L. Goel. (2005). Administration and Management of NGOs: Text and Case Studies Paperback. Deep & Deep Publications, India. ISBN 8176296015. 2. S. Chandra (2003). Guidelines for NGO Management in India. Kanishka Distributors, New Delhi. ISBN 978-8173916038. D. Lewis (2001). Management of Non-Governmental Development Organization. Second Edition, Routledge, New York. ISBN 9780203002162. 3. Subedi, N R, (2008). Advocacy Strategies and Approaches: A Training of Trainers Manual. International Centre for Integrated Mountain Development (ICIMOD). ISBN : 9291150830 4. Abraham, A. (2003). Formation and Management of NGOs. Third Edition, Universal Law Publishing Co. Pvt Ltd., New Delhi. ISBN 9350350122. Suggested Readings: 5. Sundar, P. (2013). Business and Community: The Story of Corporate Social Responsibility in India. New Delhi, Sage Publication. ISBN 978-81-321-0955-6. 6. Agarwal, S.K. (2008). Corporate Social Responsibility in India, Sage publication Pvt. Ltd. https://doi.org/10.4135/9788132100027. 7. Lewis. D. (2014). Non-governmental Organizations: Management and Development. 3rd Edition. Routledge. ISBN 9781138294097. Til, J.V. (1988). Mapping the Third Sector: Voluntarism in a Changing Social Economy. Foundation Centre, New York. ISBN 0879542403.
Learning Outcomes	• Gain an understanding of the unique nature of the non-government sector and distinguish it from the government (public) and business (for-profit) sectors. • the historical, theoretical, and legal perspectives on non-government organizations, as well as current trends and issues of consequence to non-government organizations. • Develop an understanding of management techniques and leadership skills for enhancing the effectiveness of non-government organizations. • Be able to design and assess the effectiveness of governance models, volunteer programs, organizational capacity, and inter-organizational relationships. • Develop an understanding of advocacy skills and knowledge and also key stages involved in developing an advocacy strategy.

Course Title	**Human Nutrition (HSCMJ55and HSCMJ56)**
Category of Course[183]	Major

Credits[184]& Hours of Teaching		Theory	Practical	Cumulative
	Credits	3	2	**05**
	Hours of Teaching (Total)	45	60	**105**

Course Objectives	• To gain knowledge about composition of human body and nutrition • To understand the chemistry of macro & micro nutrients

Course Content

Units	Course Content	Hr. of Teaching
I	• Concept and scope of Nutrition, Brief history of Nutritional Science. Relation of nutrition to health, optimum nutrition, adequate nutrition, malnutrition. • Food Guide-Basic five food groups (How to use according to RDA) • Composition of human body, structure and functions of digestive organs, excretion of waste products, study of urine, sweat and faces, blood body fluids and hormones.	15
II	• Utilization of Food in the body: - Digestion, absorption transport & utilization of Macro and micro nutrients. • Role of fibers in human nutrition. • Carbohydrates: Functions, classification, food sources, storage in body. • Fats & oils: composition, saturated and unsaturated fatty acids, classification, food sources, function of fats. • Proteins - composition, sources, essential & non-essential amino acids, functions, Protein deficiency. • Water - as a nutrient, function, sources, requirement, water balance & effect of deficiency. • Minerals - macro & micronutrients. - functions, sources. Bioavailability and deficiency of Calcium, Iron, Iodine, Sodium & Potassium (in very brief) 12. Vitamins (water & fat soluble) - definition, classification & functions	15
III	• Effect of cooking & heat processing on the nutritive value of foods. • Processed supplementary foods. • Food sanitation in hygiene	15

PRACTICAL		
I	• Preparation of dishes rich in Energy, protein, fat, fiber, calcium, iron, vitamin A, vitamin C, thiamine, riboflavin and niacin.	20
II	• Reactions of different types of fats (saponification and iodine value). • Reactions of proteins.	20
III	• Reaction of mono, Di and polysaccharides and their identification in unknown mixtures, Iodine test for cooked and uncooked starch & dextrin.	20

Texts / References

1. Srilakshmi, B - Nutrition Science, New Age International Publishers, seventh edition
2. Swaminathan, M. (1997), Essentials of Food and Nutrition, vol I &II, Second edition, Bangalore, BAPPCO
3. Singh, B. AaharVigyan Evam Poshan, Hindi Edition, Panchsheel Prakashan,
4. Sundararaj P and Siddhu A. (1995). Quantitative tests and Quantitative procedures in Biochemistry - A practical manual, Wheeler Publishing.
5. Lehinger A.K., Nelson D.L. and Cox M.M. (1993), 2nd Ed. Principles of Biochemistry, CBS Publishers and Distributors.

[183] SEC – Skill Enhancement Course; AEC – Ability Enhancement Course; VAC – Value Added Course; MD – Multidisciplinary Course

[184] 1 Credit (Theory) = 15 Hours; 1 Credit (Practical) = 30 Hours

	6. Guyton A.C., Hall J.E. (1996): Textbook of Medical Physiology, 9th Ed. Prism Books (Pvt.) Ltd., Bangalore.
Learning Outcomes	• Upon the completion of the course students will able to understand the relation between nutrition and human body, Role of macro and micro nutrients in the human body. • Learning of nutrient rich dishes preparation, identification of the major nutrients in the foods

Course Title	**Bakery and Confectionery (HSCMV51 and HSCMV52)**			
Category of Course[185]	Minor (Vocational)			
Credits[186]& Hours of Teaching		Theory	Practical	Cumulative
	Credits	2	2	4
	Hours of Teaching (Total)	30	60	90
Course Objectives	To develop foundational knowledge of baking industry To inculcate knowledge of baking and confectionery and depth inputs about ingredients requiring for baking To prepare several baked products			

Course Content

Units	**Course Content**	**Hr. of Teaching**
I	**Introduction to Bakery and confectionery:** Introduction and scope of bakery, Bakery terms and organization chart for bakery.	5
II	• **Wheat and Flour:** Different types of flour, Constituents of flour, pH value of flour, water absorption power of flour, Gluten, diastatic capacity of flour, grade of flour, Temperature and weight conversions. • **Bread making:** Raw materials required for bread making (flour, Yeast, water, sugar, salt, milk etc.), bread improvers, methods of bread making, characteristics of good bread. Bread faults and their remedies.	10
III	• **Basic Sponges and Cakes**: Pastry technique and principles. Principles behind making of sponge. Baking and cooling of sponges. Basic sponges and their uses. Equipment used in sponges and cakes making • **Role of Yeast in Bakery industry:** Basics of knowledge of baker's yeast and its role in fermentation of dough and condition influenced its working, effects of over and under fermentation.	5
IV	**Cookies and Biscuits:** preparation of various types of cookies and biscuits, factors affecting the quality of biscuits or cookies, storage of confectioneries.	5
V	**Bakery Layout:** Approval required to set up a bakery unit, Government bye – laws, selection of sites, equipment, Layout design, electricity, quality control of the products.	5
PRACTICAL		
I	Introduction to basic equipment required for bakery	20
II	Different types of cake and cookies preparation	20
III	Preparation of bread.	20

Texts / References	1. Textbook of Bakery and Confectionery (2023), Yogambal Sivalingam, 3rd Edition, PHI Learning Pvt. Ltd. ISBN- 978-9391818890 2. Textbook of Bakery and Confectionery, Gupta, Amit Kumar, Generic Publishers, ISBN-978-B08X77TZHX 3. Foods Facts and Principles, N Shakuntala Manay& M. Shadakharaswamy, 5th Edition, New Age International Publishers, ISBN-978-9395161091
Learning Outcomes	Upon completion of the course, the students will able to learn about the Preparation of baked product Gain understanding of several ingredients needed for preparation

[185] SEC – Skill Enhancement Course; AEC – Ability Enhancement Course; VAC – Value Added Course; MD – Multidisciplinary Course

[186] 1 Credit (Theory) = 15 Hours; 1 Credit (Practical) = 30 Hours

Course Title	**Internship (HSCIN51)**			
Category of Course[187]	Internship			
Credits[188]& Hours of Teaching		Theory	Practical	Cumulative
	Credits	-	02	02
	Hours of Teaching (Total)	-	60	60
Course Objectives	NA			

Course Content

Units	**Course Content**	**Hr. of Teaching**
I	NA	
I	NA	
III	NA	
IV	NA	
V	NA	

Texts / References	NA
Learning Outcomes	NA

Semester –VI

Course Title	**Advanced Human Development (HSCMJ61 and HSCMJ62)**			
Category of Course[189]	Major			
Credits[190]& Hours of Teaching		Theory	Practical	Cumulative
	Credits	03	01	04
	Hours of Teaching (Total)	45	30	75
Course Objectives	• To provide knowledge regarding the concept of family life education. • To educate the students about different types of disability • To gain practical experiences in various institutions of special needs. • To study about marital adjustment in different time span of marriage			

Course Content

Units	**Course Content**	**Hr. of Teaching**
I	**Family life education:** meaning, need, importance and objectives of family life education. IVF and AI pregnancy and its management.	06
II	**Parent education:** meaning, need, importance and objectives of parent education.	04
III	**Child with special needs:** concept of children with special needs, definition, types of exceptional children, history of studying disability in India. Classification of different types of disabilities; Visual Impairment, Hearing Impairment, Mental Retardation, Physical	20

[187] SEC – Skill Enhancement Course; AEC – Ability Enhancement Course; VAC – Value Added Course; MD – Multidisciplinary Course

[188] 1 Credit (Theory) = 15 Hours; 1 Credit (Practical) = 30 Hours

[189] SEC – Skill Enhancement Course; AEC – Ability Enhancement Course; VAC – Value Added Course; MD – Multidisciplinary Course

[190] 1 Credit (Theory) = 15 Hours; 1 Credit (Practical) = 30 Hours

	Disability, Learning Disability	
IV	Holistic Approach of Rehabilitation, empowerment of person with disabilities, role of guardian, teacher and society	08
V	Brief introduction of CARA (Central Adoption Resource Authority), PNDT (Pre-natal Diagnostic Technique) Act, POCSO (the protection of children from sexual offences Act).	07
PRACTICAL		
I	Visit to various institutions related to special need children. • Blind school • Integrated children care centre • Deaf and Dumb school	10
II	Study of relationship in different types of families. • Nuclear family • Joint family • Working women	10
III	Presentation by student on any one topic	10

Texts / References	1. Park K. ;Parks Textbook of Preventive and Social Medicine (English,Hardcover),Banarsidas Bhanot Publishers 27 th edition(2023). 2. Dr. R.A. Joseph; Aspects of Rehabilitation; samakalan publishers, Varanasi(2014), India. 3. K.C. Panda ;Education of Exceptional Children; Vikas Publication House Pvt Ltd, India. 4. Aprajita Chowdhary, David K. Carson & Carson; Family Life Education in India:perspectives, challenges, and applications, Rawat publication. India 5. Deepa Chaudhury ; Parenting tips for Indian parents : pre –conception to adulthood, nation press publication, India (2017).
Learning Outcomes	After completion of the course students will be able to: ▪ Understand the concept and importance of parent education and family life education. ▪ Learn about the needs of different disabled children.

Course Title	**Family Finance Management and Consumer Education (HSCMJ63 andHSCMJ64)**
Category of Course[191]	Major

Credits[192]& Hours of Teaching

	Theory	Practical	Cumulative
Credits	03	02	05
Hours of Teaching (Total)	45	60	105

Course Objectives

- To provide comprehensive study of the concept of the family finance management and it's importance.
- To impart knowledge of family income, expenditure and budgeting for prudent financial management.
- To be familiarized with rights and responsibilities of consumer, changing trends in consumerism, issues faced by consumers and tools of communication with consumers for educating them.

Course Content

Units	**Course Content**	**Hr. of Teaching**
I	**Family finance** - • Family finance Management: Meaning, purpose and importance of family finance management. • Process of financial management: Planning, controlling and evaluation.	15

[191] SEC – Skill Enhancement Course; AEC – Ability Enhancement Course; VAC – Value Added Course; MD – Multidisciplinary Course

[192] 1 Credit (Theory) = 15 Hours; 1 Credit (Practical) = 30 Hours

	• Income: Concept of income, types of income, sources of family income. • Expenditure: Meaning of family expenditure, different items of expenditure, factors affecting family expenditure. • Budgeting: Objective and importance of family budget, types of budgets. • Investment: Meaning, time value of money, principals of investment, types of investment - bank and post office deposits, shares bonds and mutual funds. • Insurance: Meaning, importance and types of insurance. • Planning for future : • Financial goals: Paying of debts, buying home, building emergency funds and saving for retirement.	
II	Consumer Education: Consumer education: Meaning, importance, and scope of consumer education. Consumer rights: Right to safety, right to choose, right to be informed, right to be consumer education, right to be heard, right to seek redressal , consumer protection act and other legislations for consumer and product safety. Consumer responsibilities: Ask yourself, be critically aware, be organized, practice sustainable consumption, be responsible to environment. Consumer issues and challenges: Changing trends in consumerism, consumer finance, multiple tax structure, gender issues in consumerism, marketing and gender consumerism, green consumerism - definition objectives and necessity of green consumerism. Communication tools for consumer education : Consumer communication - importance and types, communication media and social change, media and consumer demand, advertising as a mode of communication, trends and impart of advertising on consumer.	15
III	Online marketing: Evolution, growth and challenges, legislative framework.	15
PRACTICAL		
I	Study of effects of different factors on consumption pattern of household.	10
II	Project work: Analysis of expenditure pattern of different income groups in urban and rural areas.	30
III	Analysis of impact of advertising and social media on consumption trends. Study of measures taken by government for promoting green consumption for environmental safety in urban areas	20

Texts / References	1. Consumer Economics - The Consumer In Our Society, Mel J. Zelenak, Holcomb Hathway, Publisher 14 Edition - 2005 2. Home Management and Family Finance-Veena Gandotra, Publishers and Distribution Dominant- -1993 3. The Family Financial Bank, Victory M.Caron - 2017 4. Basic Financial Management: Dr. R P. Rustogi, Publishers Sultan Chand and Sons -2017 5. K.K. Dewett and J.D. Varma JD.2017 Elementary Economic Theory. S. Chand & Company Ltd. New Delhi 6. Consumer Economic: Issues and Behavior, 4th Edition and Elizabeth B. Goldsmith 7. Consumer Economic. Dr. Manju Patni Star publication, Agra - 2020 8. Consumer Economic (Hindi) Dr Naresh Chandra Tripathi, Garima Tripathi,Publishers: Shri Vinod Pustak Mandir, 2020 9. Consumer Education & Economic Mcgraw Hill, 2008 10. Economic Issues for Consumer , Miller Roger LeRoy, Publisher - West Publishing Co - 1975 11. Consumer Economics, Wyllie, Eugene D , Publisher - Thomson South - Western -1987 12. Sparks C. 2008, Globalization , Development and Mass Media, Sage Publications. 13. Law of Consumer Protection,Prof.V.K. Agarwal , 4th Edition , Bharat Law House Pvt. Ltd. 14. Customer Relationship Management Emerging Concepts, Tools and Applications , Jagdish N. Seth and others , Mcgraw Hill Education, 2015 15. Ahuja HL, 2012 Modern Micro Economics: Theory and Application , Chand Company Ltd. New Delhi. 16. Consumer Education, Veena Gandotra , Ami Divatia, Dominant Publishers & Distributors - 2013 17. Consumer Behaviour, Leon G. Schiffman,Joseph Wisenblit, S. Ramesh Kumar Pearson Education, 12th Edition - 2018 18. Consumer Protection Law , Dr. S. R. Myneni , 2nd Edition, Publisher - Asia Law House – 2021
Learning Outcomes	After successful completion of the course student with be able - • To manage limited financial income optimally on consumption and investment. • To take prudent financial decision for family and society. • To provide knowledge of consumer rights and responsibilities through different communication media.

Course Title	**Teaching and Learning in Extension (HSCMJ65 and HSCMJ66)**
Category of Course[193]	Major

Credits[194]& Hours of Teaching	Theory	Practical	Cumulative
Credits	2	2	4
Hours of Teaching (Total)	30	60	90

Course Objectives	Objectives – • To make students aware of concept teaching and learning and its importance in extension education. • .To orient students about various teaching methods.

Course Content

Units	Course Content	Hr. of Teaching
I	• Concept of Learning, elements & principles involved in learning, Type of learners, Effective learning situation • Extension Teaching - Concept, Definition, Steps and Factors Affecting Teaching • Teaching methods in Extension – concept and importance, classification of Methods - according to use, nature, form, learning objectives	7
II	• Purpose, procedure, advantages, and limitations of each teaching method	7

[193] SEC – Skill Enhancement Course; AEC – Ability Enhancement Course; VAC – Value Added Course; MD – Multidisciplinary Course

[194] 1 Credit (Theory) = 15 Hours; 1 Credit (Practical) = 30 Hours

III	• Factors affecting the use and selection of Teaching Methods. • Teaching and learning through e-resources – Moocs / online platform	6
IV	• Teaching Aid- concept and selection Criteria • Classification of teaching aids based on material used in the teaching-learning process • Projected and non-projected • Audio, Visual and Audio –visual	6
V	• Concept, importance, strategies for development and uses, advantages and limitations of each teaching Aid • Cone of Experience	4
PRACTICAL		
I	Development of skill in Planning, preparation, and use of the following Audio -Visual aids (any four):- • Audio aids • Visual aids and • Audio Visual	24
II	Development of skills in planning and use of extension teaching methods • Demonstration, • Drama • Interactive lecture • Group discussion	26
III	Practice the mass communication techniques- • Role Play • Puppetry	10

Texts / References

1. Dahama O.P. (1988) : Education and Communication for Development , , Oxford and IBH Publishing Co. Pvt. Ltd. New –Delhi
2. Directorate of Adult Education, Govt. of India (1994): New Delhi, Literacy Digest. National Literacy Mission.
3. Hussain Institute for non-formal and continuing education.
4. Jain, R. (1993) Mass Media and Rural Development. Voll. II Manak Publication Pvt. Ltd. New-Delhi
5. Kindervalter, Suzanne (1979): Non-formal Education as an Empowering Process , Centre for International Education , 285 , Hills House South Amherst , Massachuseets 01003. USA. University of Massachusetts.
6. Mistry S.P.(1998) Non Formal Education 1998 Radha Publications 437814B , Ansari Road , Darya Ganj. New Delhi – 1100002.
7. Pankajam G. (2000) – Extension – Third Dimension of Education, Gyan Publishing House, New –Delhi
8. Ray.G.L. (2015) Extension Communication and Management, Kalyani Publication,
9. Pillai , K.S. (1993) : ABC of Non-Formal Education , 17-B , Indraprasth Estate, New Delhi , Indian Adult Education Association.
10. Rajani R. Stirurr – Non-Formal Education for Development. APH Publishing Corporation , 5 , Ansari Road Darya Ganj New Delhi – 1 , 10002
11. Reddy R.S. (1999) – Adult and Non- Formal EducationCommon wealth Publisher.
12. Sharma SR (1997) – Reflections on Continuing and Non – Formal Education –Pointer Publisher , S.M.S. Highway , Jaipur.
13. Singh dev Raj (1995) -Infrastructure Planning for non-formal Education –Commonwealth Publishers.
14. Singh UK , Sudarshan KN. (1996) Non-Formal and continuing Education Discovery Publishing House , 4831/24 , Ansari Road , Darya Ganj , New-Delhi- 110002.
15. Srinivasn , Iyer (1977) : Perspectives on Non-Formal Adult Learning 251 , Park Avenue South , New York 10010 U.S.A. World Education Inc.
16. Supe , S.V. (1997) An Introduction to Extension Education. Oxford IBH Publishing Co. Pvt. Ltd. , New-Delhi.
17. Uttam Kumar Singh and A K Nayak , (1997) Extension Education, Commonwealth Publishers in association with Dr. Zakir Hussain Institute of Non-formal and Continuing Education.
18. Dhama, O.P (2019) Education and communication for Development, Kalyani Publication

Learning Outcomes	1. Students will be able to differentiate between various teaching methods 2. Students can understand the importance of each teaching aid and procedure to develop and use it for effective teaching.

Course Title	**Traditional Textiles and Costumes of India (HSCMJ67)**
Category of Course[195]	Major

Credits[196]& Hours of Teaching		Theory	Practical	Cumulative
	Credits	3	-	3
	Hours of Teaching (Total)	45	-	45

Course Objectives	• To enable students to gain knowledge on the arts and designing of historic costumes and textiles of India. • To understand about the different woven, painted, dyed, printed and embroidered textiles of India.

Course Content

Units	**Course Content**	**Hr. of Teaching**
I	Traditional embroidered textiles; Kashida of Kashmir & Bihar, Kantha of Bengal, Kasuti of Karnataka, Embroidery of Kutch &Kathiavar, Phulkari of Punjab, Chikankari of Lucknow, Manipuri Embroidery, Chamba Rumal, Quilting of Bihar etc.	8
II	Dyed & Printed textiles; Patola, Pochampalli, Ikat of Orissa, Tie & Dye of Tamil Nadu, Printing of Rajasthan (Sanganeri, Bagru, Dabu) Block print of Madhya Pradesh.	6
III	Painted textiles; Kalamkari, Madhubani, Picchwai, Patchitrra, Warli,	6
IV	Woven Textiles; Brocades, Shawls of Kashmir, Muslins of Bengal, Silk of Karnataka, Cotton of Kerala,	6
V	Sociological, physical and psychological aspect of clothing, Famous traditional Indian attire*; Saree, Dhoti, Pagdi, Kurta, Salwar, Lungi* etc.Traditional costumes of Different States of India Traditional *saree* of different States of India	19

Texts / References	1. Bhatnagar Parul (2004). *Traditional Indian Costumes & Textiles*, Chandigarh: Abhishek publications. 2. Gillow & Barnard (2008). *TraditionalIndian Textiles.* London: Thames & Hudson. 3. Kumar Ritu (2008). *Costumes and Textiles of Royal India*. India: Antique collectors club. 4. Neumann & Neumann (2020). Textiles of India. London: Prestel
Learning Outcomes	Upon completion of the course, students will be able to; • Understand the traditional costumes and textiles of India. • Choose and utilize traditional accessories in costumes designing. • Differentiate different textiles and costumes of India.

Course Title	**Organizational Communication (HSCMV61 and HSCMV62)**
Category of Course[197]	Minor (Vocational)

Credits[198]& Hour of Teaching		Theory	Practical	Cumulative
	Credits	2	2	4
	Hour of Teaching (Total)	30	60	90

Course Objectives	• To develop competency of students in effective communication skills. • To plan an effective communication strategy • To understand formal and organizational communication

Course Content

[195] SEC – Skill Enhancement Course; AEC – Ability Enhancement Course; VAC – Value Added Course; MD – Multidisciplinary Course

[196] 1 Credit (Theory) = 15 Hours; 1 Credit (Practical) = 30 Hours

[197] SEC – Skill Enhancement Course; AEC – Ability Enhancement Course; VAC – Value Added Course; MD – Multidisciplinary Course

[198] 1 Credit (Theory) = 15 Hours; 1 Credit (Practical) = 30 Hours

Units	Course Content	Hr. of Teaching
I	Communication: An Introduction • Definition, Nature and Scope of Communication • Importance and objectives of Communication • Process and Elements of Communication • Essentials of Communication • Ten Commandments of Communication • Barrier of Communication	5
II	Communication in Organizations- Formal Vs Informal, Written vs Oral and Horizontal(Lateral), Vertical(Downward) & Vertical(Upward) Communication	6
III	• Verbal or Oral Communication- • Effective Speaking- Principles, Techniques of Effective Speech • Interpersonal communication – Interview, its type and techniques • Advantages and Disadvantages of Oral Communication Mechanical Devices used in Verbal/Oral Communication	7
IV	Effective Listening- • The Art of Listening, Meaning, Nature and Importance of Listening Principle of Good listening, Observations in Listening, barrier in listening and Guidelines for effective listening , Note Making	5
V	Effective Writing- • The objective of Written Communication, • Various media are used for written communication – their merits and demerits Reading Skills- • Purpose, Process, Methodologies, • Non-Verbal Communication- Importance, Forms, Kinesics, and Functions of non-verbal Communication • Professional communication skills - preparing and doing (making) Presentations- Do's and Don'ts, drafting email, writing Notices, writing minutes of meetings and press releases	7
PRACTICAL		
I	1. Speaking Skills: Introducing yourself, describing a person, place, situation, and event, giving instruction, making inquiries – at a bank, post-office, air-port, hospital, reservation counter and role play 2. Reading skills: o Reading Rates o Skimming and scanning skills. o Intensive and extensive reading. o Comprehension of general and technical articles	22
II	1. Writing skills o Effective writing- Sentence and paragraph construction o Precise writing- Summarizing o Referencing skills 2. Written forms o Business letters o Emails o Job application letter- Cover letter, Resume o Letter to the editor and social appeals o Report Writing: Format, Structure and Types, Technical Reports, Description and Proposal Presentation Skills: o 4Ps (Planning, Preparation, Practice, Presentation), Outlining; o Effective use of A/V aids and Modes of Delivery o Treatment of reports for presentation. o Practice in using media in oral presentation o Individual and Group Presentations	22

III	1. Interview skills: - ○ Face to Face and Telephonic interviews ○ Content • Preparing questions • Communication skills during Interview (with emphasis on intonations, pronunciation, confidence, dictation, audible, moderate, speech speed etc. 2. Non-verbal Communication and Body Language: • Understanding body language of interviewer (body posture, appearance etc.)	16

Texts / References	1. Basic communication skills for Technology, Andreja. J. Ruther Ford, 2nd Edition,Pearson Education, 2011 2. Communication skills, Sanjay Kumar, Pushpalata, 1 stEdition, Oxford Press, 2011 3. Organizational Behaviour, Stephen .P. Robbins, 1st Edition, Pearson, 2013 4. Brilliant- Communication skills, Gill Hasson, 1 stEdition, Pearson Life, 2011 5. The Ace of Soft Skills: Attitude, Communication and Etiquette for success, GopalaSwamy Ramesh, 5 thEdition, Pearson, 2013 6. Developing your influencing skills, Deborah Dalley, Lois Burton, Margaret, Greenhall, 1st Edition Universe of Learning LTD, 2010 7. Communication skills for professionals, Konar nira, 2ndEdition, New arrivals –PHI, 2011 8. Personality development and soft skills, Barun K Mitra, 1 stEdition, Oxford Press,2011 9. Soft skill for everyone, Butter Field, 1st Edition, Cengage Learning india pvt.ltd,2011 10. Soft skills and professional communication, Francis Peters SJ, 1stEdition, McGraw Hill Education, 2011 11. Effective communication, John Adair, 4thEdition, Pan Mac Millan,2009 12. Bringing out the best in people, Aubrey Daniels, 2 ndEdition, Mc Graw Hill, 1999
Learning Outcomes	• Understanding different communication skill • Differentiate between formal and informal communication • Develop skills of effective reding and listening skills.

Semester –VII

****Student will choose any one paper according to selected branch in VII and VIII Semester**

Food and Nutrition

Course Title	**Technical writing (HSCMJ71)**			
Category of Course[199]	Major			
Credits[200]& Hours of Teaching		Theory	Practical	Cumulative
	Credits	4	NA	4
	Hours of Teaching (Total)	60	NA	60
Course Objectives	To address the issue in selecting a research problem. To understand the tools and techniques needed for completing research To learn about writing scientifically			

Course Content

Units	Course Content	Hr. of Teaching
I	**RESEARCH METHODS**	10

[199] SEC – Skill Enhancement Course; AEC – Ability Enhancement Course; VAC – Value Added Course; MD – Multidisciplinary Course

[200] 1 Credit (Theory) = 15 Hours; 1 Credit (Practical) = 30 Hours

	Science, scientific methods, scientific approach: Role of statistics and research in Home Science discipline: Objectives of research: Explanation, control and prediction.	
II	**Types of Research:** Historical, survey, experimental, case study, social research, participative research. Definition and Identification of a Research Problem, Selection of research problem, Justification, Theory, hypothesis, basic assumptions, limitations and delimitations of the problem. Types of variables	10
III	**Theory of probability:** Population and sample, Probability sampling: systematic random sampling, two stages and multi stage sampling, cluster sampling, Non-Probability sampling: purposive, quota and volunteer sampling/snowball sampling. Basic Principles of Research Design and hypothesises: Purposes of research design; Fundamental, applied and action exploratory and descriptive experimental, survey and case study, ex-post facto, Longitudinal and cross sectional	15
IV	**Qualitative Research Methods:** Theory and design in qualitative research, Definition and types of qualitative research, Methods and techniques of data collection, Informal group discussions, Interviews; Key informants, in-depth interviews, Observations	15
V	**Critical analysis of research.**	10

Texts / References	1. Bandarkar, P.L. and Wilkinson, T.S. (200): Methodology and Techniques of Social Research, Himalaya Publishing House, Mimbai. 2. Bhatnagar, G.L. (1990): Research Methods and Measurements in Behavioural and Soxial Sciences, Agri. Cole Publishing Academy, New Delhi. 3. Dooley, D. (1995): Strategies for interpreting Qualitative Data; Saga Publications, Claifornia. 4. Gay, L.R. (1981, 2nd Ed.): Educational Research, Charles, E. Merill, Columbus, Ohio. 5. Long, J.S. (Ed.) (1988): Common Problems Proper Solutions: Avoiding Errors in Quantitative Research Beverly Hills, Sage Publications, California. 6. Mukherjee, R. (1989): The Quality of lIfe: Valuation in Social Research, Saga Publications, New Delhi. 7. Stranss, A. and Corbin, J. (1990): Basis of Qualitative Research: Grounded Theory Procedures and Techniques, Saga Publications, California.
Learning Outcomes	Understanding of statistical techniques, learning of various statistical test used to approve hypotheses and uses of computer in research

Course Title	**Food Safety and Microbiology (HSCMJ72 and HSCMJ73)**			
Category of Course[201]	**Major**			
Credits[202]& Hours of Teaching		Theory	Practical	Cumulative
	Credits	3	2	**05**
	Hours of Teaching (Total)	45	60	**105**
Course Objectives	To provide fundamental concept of the microorganism associated with food and their characteristics. This course also provides the concept of preservation and microbiological safety in various food operations.			

Course Content

Units	**Course Content**	**Hr. of Teaching**
I	**Introduction to Food Microbiology** • Definition and scope of Microbiology • History of Microorganism in food- Food Preservation, spoilage Infections and Legislations	5
II	**Microorganism in Food**	10

[201] SEC – Skill Enhancement Course; AEC – Ability Enhancement Course; VAC – Value Added Course; MD – Multidisciplinary Course

[202] 1 Credit (Theory) = 15 Hours; 1 Credit (Practical) = 30 Hours

	• **Taxonomy, Role and Significance of microorganisms in food-**Food Borne Bacteria, Food Borne Moulds, Food Borne Yeasts, Viruses and Parasite • **Factors affecting growth of Microorganism–**Intrinsic Parameters, Extrinsic Parameters, Bacterial Growth Curve • **Food Borne Diseases: Origin and symptoms -** Types- Food Borne Infections, Intoxications and Toxic infection	
III	**Cultivation of Microorganism** • Repair, detection and sampling of microorganism • Methods of sampling and detection- a. Conventional Methods of isolation-Pure culture methods (Standard Plate Count), Membrane filter technique, Most probable number, Direct microscopic count, electronic counter, dye reduction test b. Rapid Methods of isolation-Physical Methods: Biosensors, Flow Cytometry, Microcalorimetry. Biological/ Immunological Methods: Fluorescent Antibody, Radioimmunoassay, ELISA, Gel Diffusion. Molecular GeneticMethods- Polymerase Chain Reaction, Chemical Methods: Thermostable Nuclease, Adenosine Triphosphate Measurement • Bioassay	10
IV	**Cultivation of Microorganism** • Repair, detection and sampling of microorganism • Methods of sampling and detection- a. Conventional Methods of isolation-Pure culture methods (Standard Plate Count), Membrane filter technique, Most probable number, Direct microscopic count, electronic counter, Dye reduction test b. Rapid Methods of isolation-Physical Methods: Biosensors, Flow Cytometry, Microcalorimetry. Biological/ Immunological Methods: Fluorescent Antibody, Radioimmunoassay, ELISA, Gel Diffusion. Molecular Genetic Methods- Polymerase Chain Reaction, Chemical Methods: Thermostable Nuclease, Adenosine Triphosphate Measurement • Bioassay	10
V	**Food Safety and Quality Control** • **Concept of Food Safety Management, GHP and GMP** • HACCP. ISO 22000 • Food Laws, Regulations and Standards **Control of Microorganism in Foods:** Principles and methods of preservation, Physical Methods of Food Preservation- Dehydration,Freezing, Cool Storage, Heat Treatment, Irradiation, Chemical Methods, Biopreservatives esp. Bacteriocins, Introduction to Hurdle concept and Non Thermal Methods	10

PRACTICAL		
I	• Understanding Morphology and Structural Features of Various Microorganism: Preparing different types of media. • Learning of different instruments used in microbiology laboratory	20
II	• Staining of bacteria: Gram's Staining, acid-fast spore, capsule and Flagellar Staining, Motility of bacteria, Staining of yeast and molds. • HACCP plan for a food process	20
III	• Microbiological analysis for- Water (Most Probable Number), Milk (Methylene Blue Reduction Test), Curd and probiotic count, adulteration test for microorganism detection.	20

Texts / References	1. Jay, B. J., Loessner,J. M., Golden, A. D.Modern Food Microbiology. Seventh Edition. Food Science Text Series. 2. Frazier, W.C.&Westhoff, D.C.(2014). Food Microbiology. Fifth Edition. TMH Publication, New Delhi. 3. Garbutt, J. (1997). Essentials of Food Microbiology. Arnold London. 4. Mathur, P. (2018). Food Safety and Quality Control. 1st Edition. Orient Blackswan Private Ltd. India.

	5. Ravishashankar, R. &Jamuna, B. (2015). MicrobialFood Safety and Food Preservation. CRC Press, Boca Raton.
Learning Outcomes	• Develop understanding of important genera of microorganism associated with food and their characteristics, their growth pattern and parameters. • Develop learning about various preservation and control techniques in various food operations.

Course Title	**Applied Food Science (HSCMJ74 and HSCMJ75)**			
Category of Course[203]	**Major**			
Credits[204]& Hours of Teaching		Theory (T)	Practical (P)	Cumulative
	Credits	3	2	**05**
	Hours of Teaching (Total)	45	60	**105**
Course Objectives	The goal of the course is to give students a systematic understanding of the chemistry of food ingredients such as proteins, fats, and carbohydrates as well as pigments. Students will also gain insight into the additives that are important to the processed food industry.			

Course Content

Units	**Course Content**	**Hr. of Teaching**
I	**Properties of food**- physical, chemical and functional, Protein Structure and properties, factors affecting properties and its interaction with other food constituents- Denaturation, Coagulation.	05
II	• **Carbohydrate**: Structure and properties, factors affecting properties and its interaction with other food **a. Sugar-** Structure and properties, their application in food system, crystallization, caramelization, Maillard reaction and its industrial application, factors affecting properties and its interaction with other food constituents- Sweetness, preservation, appearance, freezing point, fermentation **b. Starches-** Structure and properties, factors affecting properties and its interaction with other food constituents- Starch gelatinization, Dextrinization, Functional properties- Thickening property, binding properties. Introduction to polysaccharides, Resistant starch, Genetically Modified Starch, Non-starch polysaccharide, dietary fibre	15
III	• **Lipids**: Structure and properties, factors affecting properties and its interaction with other food constituents- Rancidity, emulsion, Role of Food lipids in flavour.	10
IV	• **Food pigments, colorants and additives:** Pigments in animal and plant tissues, Food colours; Types and properties, regulatory aspects, safety issues.	10
V	• **Food adulteration**: Its types and contaminant & Detection **Beverages:** Harvesting, processing and by-products; Coffee, tea, cocoa, alcoholic beverages.	05
Practical		
I.	• Preparation and preservation of Jam and Jellies and pickles • Drying and dehydration of fruits and vegetables	20
II	• Spray drying of Milk • Preparation of fermented products • Sensory evaluation of food items	20

[203] SEC – Skill Enhancement Course; AEC – Ability Enhancement Course; VAC – Value Added Course; MD – Multidisciplinary Course

[204] 1 Credit (Theory) = 15 Hours; 1 Credit (Practical) = 30 Hours

III	• Identification of food packaging materials • Determination of quality of eggs • Quality analysis of water from different sources	20

Texts / References	1. B. Srilakshmi - Food Science, New Age International Publishers, 8th edition 2. Shakuntala, M. N., Shadaksharaswamy, M. (1998). Foods, Facts and principles, new age international publishers, New Delhi. 3. BIS standards for food products and analysis manual. 4. Manuals of methods of analysis of various food products, FSSAI, 2016
Learning Outcomes	• To provide learning of chemistry of components like proteins, carbohydrates and lipids. This course will also enable learning of food additives that are relevant to processed food industry.

Course Title	**Social and health issues in Society (HSCMJ76)**			
Category of Course[205]	Major			
Credits[206]& Hour of Teaching		Theory	Practical	Cumulative
	Credits	2	--	2
	Hour of Teaching (Total)	30	--	30
Course Objectives	• To inculcate a positive outlook on health and well-being among students • To increase student's understanding of National development policies of Government and Non-Government organization			

Course Content

Units	**Course Content**	**Hr. of Teaching**
I	Health & well-being • Mental health & wellbeing • Physical • Emotional • Social	05
II	Policies to improve health in different age group by Government & Non-governmental organization with recent trends • Health care system in India • Disabilities	05
III	Policies regarding societal issues in different stages of life of human being by Government &Non-governmental organization • Child protection acts • Gender Issues- Women empowerment, Gender Gap, Triple Talaq , Sexual Harassment at Workplace • Poverty related issues	10
IV	Role of traditional media and modern media in development communication- • Communication technology • Gender in extension (Issues & prospects)	10

Texts / References	1. Park, K. (2019). Preventive and social medicine. Banarsidas Bhanot Publishers. Edition-27, ISBN-9789382219194. 2. Dhama,O.P., &Bhatnagar,O.P.(1987). Extension and communication for development. Oxford & IBH Publishing Co .Edition- 2nd,ISBN – 9786459990314. 3. Ahuja,R. (2000). Bhartiya Samaj. Rawat Publications. Edition- 2007, ISBN - 8170336392. 4. Srivastava,D.N. AsamanyaManovigyan. Sahitya Prakashan Agra. Edition- 13th.

[205] SEC – Skill Enhancement Course; AEC – Ability Enhancement Course; VAC – Value Added Course; MD – Multidisciplinary Course

[206] 1 Credit (Theory) = 15 Hours; 1 Credit (Practical) = 30 Hours

	5. India Year Book (2024) Publications Division, Ministry of Information and Broadcasting, Government of India.
Learning Outcomes	• Students will develop skills to critically evaluate and analyze health and well-being policies, understanding their effectiveness for various age groups and disabilities. • They will gain insights into the impact of legal frameworks like the Child Protection Act and societal policies on development and integration. • Students will assess the roles of traditional and modern media in health communication and explore how gender issues influence extension services, proposing strategies for improved gender equity.

Course Title	**Technical writing (HSCMN71)**
Category of Course[207]	Minor
Credits[208]& Hours of Teaching	

	Theory	Practical	Cumulative
Credits	4	NA	4
Hours of Teaching (Total)	60	NA	60

Course Objectives	• To address the issue in selecting a research problem. • To understand the tools and techniques needed for completing research • To learn about writing scientifically

Course Content

Units	Course Content	Hr. of Teaching
I	**RESEARCH METHODS** **Science, scientific methods, scientific approach: Role** of statistics and research in Home Science discipline: Objectives of research: Explanation, control and prediction.	10
II	**Types of Research:** Historical, survey, experimental, case study, social research, participative research. Definition and Identification of a Research Problem, Selection of research problem, Justification, Theory, hypothesis, basic assumptions, limitations and delimitations of the problem. Types of variables	10
III	**Theory of probability:** Population and sample, Probability sampling: systematic random sampling, two stages and multi stage sampling, cluster sampling, Non-Probability sampling: purposive, quota and volunteer sampling/snowball sampling. Basic Principles of Research Design and hypothesises: Purposes of research design; Fundamental, applied and action exploratory and descriptive experimental, survey and case study, ex-post facto, Longitudinal and cross sectional	15
IV	**Qualitative Research Methods:** Theory and design in qualitative research, Definition and types of qualitative research, Methods and techniques of data collection, Informal group discussions, Interviews; Key informants, in-depth interviews, Observations	15
V	**Critical analysis of research.**	10

Texts / References	1. Bandarkar, P.L. and Wilkinson, T.S. (200): Methodology and Techniques of Social Research, Himalaya Publishing House, Mimbai. 2. Bhatnagar, G.L. (1990): Research Methods and Measurements in Behavioural and Soxial Sciences, Agri. Cole Publishing Academy, New Delhi. 3. Dooley, D. (1995): Strategies for interpreting Qualitative Data; Saga Publications, Claifornia. 4. Gay, L.R. (1981, 2nd Ed.): Educational Research, Charles, E. Merill, Columbus, Ohio. 5. Long, J.S. (Ed.) (1988): Common Problems Proper Solutions: Avoiding Errors in Quantitative Research Beverly Hills, Sage Publications, California.

[207] SEC – Skill Enhancement Course; AEC – Ability Enhancement Course; VAC – Value Added Course; MD – Multidisciplinary Course

[208] 1 Credit (Theory) = 15 Hours; 1 Credit (Practical) = 30 Hours

	6. Mukherjee, R. (1989): The Quality of lIfe: Valuation in Social Research, Saga Publications, New Delhi. 7. Stranss, A. and Corbin, J. (1990): Basis of Qualitative Research: Grounded Theory Procedures and Techniques, Saga Publications, California.
Learning Outcomes	Understanding of statistical techniques, learning of various statistical test used to approve hypotheses and uses of computer in research

Extension and Communication

Course Title	**Participatory Programme Management (HSCMJ77 and HSCMJ78)**			
Category of Course[209]	**Major**			
Credits[210]& Hours of Teaching		Theory	Practical	Cumulative
	Credits	3	2	5
	Hours of Teaching (Total)	45	60	105
Course Objectives	• To understand the key concepts and skills in effective programme designing and evaluation • To demonstrate the ability to develop, implement, and constructively evaluate program and evaluation plans. • To develop tools for monitoring and evaluation of extension programmes • To develop skill in designing an extension programme (Home Science Based) to bring change in knowledge, skill and attitude			

Course Content

Units	**Course Content**	**Hr. of Teaching**
I	• Overview to PPM - Concept, Meaning and Importance. • Types of Participation in Development. • Advantages and disadvantages of participation by different stakeholders • Programme designing in extension– Meaning of programme planning, principles of programme building process, steps involved in programme building process, programme development cycle, planning models and frameworks, planning and developing teaching methods, precautions used in programme building	13
II	• Role of Government and Non-Profit Techniques of participatory planning - RRA, PRA, PLA and their application in extension. • Approaches of participatory planning - cooperative, democratic, bottom up and down. • Situation analysis, Needs and Objectives– Types of needs, methods of identifying needs • Objectives- types, levels and characteristics	8
III	• Participatory planning – Engaging the community and other stakeholders, organisations and committees • Role of officials, non-officials, groups and agencies in programme building process for extension work. • Utilisation of local infrastructure	7
IV	• Programme budgeting, marketing and strategic planning • Sources of budget • Management of budget, • Marketing strategies, steps.	8
V	• Monitoring and Evaluations–Approaches to monitoring, principles, indicators	9

[209] SEC – Skill Enhancement Course; AEC – Ability Enhancement Course; VAC – Value Added Course; MD – Multidisciplinary Course

[210] 1 Credit (Theory) = 15 Hours; 1 Credit (Practical) = 30 Hours

	• Evaluation -meaning, purpose, elements, steps, criteria for evaluation, types of evaluation, methods of evaluation, Challenges and issues in monitoring and evaluation • Ethical issues in monitoring and evaluation. • Documentation and follow up – Need for documentation, methods, meaning and need for follow up, methods	
PRACTICAL		
I	○ Identification of the background information of the community ○ Identification of community needs using participatory methods (any four) a) Social mapping b) Transect walk c) Focus group discussion d) Matrix raking e) Seasonal calendar f) Chapati diagram	20
II	○ Planning a two/three days programme on one of the selected needs ○ Collection of subject matter /content for the designed programme and their presentation ○ Preparation of teaching aids ○ Implementation of the planned programme	28
III	○ Evaluation of the programme (Designing questionnaire / tool for pre post test ○ Report writing	12

Texts / References

1. Sharma,FL, Shri Ram, (2013)Extension Teaching Methods,Agrotech Publishing company, Udaipur
2. Dangi, KL and Santhosh Devi Samota, (2013) Agrotech Publishing Academy, Udaipur
3. Mikkelsen, Britha,(2002), Methods for development work and research.New Delhi:Sage Publications
4. Dale R, (2004) Evaluating Development programmes and projects.New Delhi: Sage Publications
5. Reddy,A(1998) Extension education,Sree lakshmi press,Bapatala
6. Gopal lal Jain,(1997) Rural development,Mangaldeep publications,Jaipur
7. Subah Singh Yadav,Ramkumar, Rural Development and poverty alleviation,Pinter Publishers,Jaipur
8. Misganaw, Seraw,(2011) Extension programme planning and evaluation.LAP Lambert Academic Publishing,

Learning Outcomes	Students will be able to - • To develop the ability to demonstrate, implement and constructively evaluate programme. • To invent tools for monitoring and evaluation of extension programmes • To examine the strategies and approaches in monitoring and evaluating the extension programme

Course Title	**Development Communication (HSCMJ79 and HSCMJ710)**			
Category of Course[211]	Major			
Credits[212]& Hours of Teaching		Theory	Practical	Cumulative
	Credits	3	2	5
	Hours of Teaching (Total)	45	60	105
Course Objectives	• To familiarize students with global perspective of development communication issues • To impart analytical skills with regard to the process of development communication • To understand the role and use of media in attaining sustainable development goals. • To analyze the indicators of development • To design media for development			

[211] SEC – Skill Enhancement Course; AEC – Ability Enhancement Course; VAC – Value Added Course; MD – Multidisciplinary Course

[212] 1 Credit (Theory) = 15 Hours; 1 Credit (Practical) = 30 Hours

Course Content

Units	Course Content	Hr. of Teaching
I	**Concept : Development and Communication** Communication process – concept, elements and their characteristics, communication competence and empathy, communication effectiveness and credibility, feedback in communication, social networks , Barriers in communication, Message – Meaning, dimensions of a message, characteristics of a good message, Message treatment and effectiveness, distortion of message. Concept of Development as a goal, development as a process, Indicators of Development-Human, development Index, gender empowerment measure, human poverty index etc.	10
II	**Development Communication** Definition, prerequisites of development communication, communication links in development communication, development effort, role and significance of development communication, communication links in development, Models of development communication; independent model, Dependency model, Basic needs model, New paradigm of development, approaches to development communication; Diffusion and Extension approach to development communication, planned Strategies for development communication.	10
III	**National and international perspectives of development communication** National and international perspectives; Evolution of development communication concept; Government and non-government initiatives; Government and nongovernment organisations - FAO, UNDP, WHO, UNICEF, CARE and strategies. National projects of development communication - SITE, Jhabnaetc, case studies on development communication	10
IV	**Media and Development Communication** Understanding the role of traditional and modern media in development communication, Development Journalism- roles and responsibilities of a development reporter, ethics in, reporting, specialized skills required and issues in development reporting News reporting: definition of news, ingredients and qualities of news, news value, types of news reports, structure of news, ICTs: scope in development communication	5
V	**Participatory development communication** Participatory approaches in development communication, planning a Development Communication Campaign, Implementation of Development Communication Project, role of NGOs in development communication, need for information and communication policy for development, Development support communication, Challenges in a participatory development communication, participatory communication and civil society. **Research perspectives of development communication** Emerging issues; Measurable and variables of development communication; Existing research projects; Research lag and supporting organizations, Use of Information technology for development communication research.	10
PRACTICAL		
I	o Analysis of development indicators - national and international perspectives o Critical analysis of selected development initiatives	20
II	o Analysis of media for development communication o Designing media for development communication	20
III	o Evaluate strategies used by development agencies for implementation of development programmes	20

Texts / References	1. Mody, Bella (1991), Designing messages for development communication- An audience participation based approach, Sage, Delhi. 2. Melkote, R. Srinivas and Steeves, H. Leslie (2015), Communication for Development in the third world.Theory and practice of empowerment, Sage, New Delhi. 3. Narula, Uma (2014). Handbook of Communication- Models, Perspectives, Strategies, Atlantic, New Delhi. 4. Sen, Amartya (2000). Development as Freedom, Oxford University Press, New Delhi. 5. *Development Communication- A Resource manual for teaching , Asian Mass Communication Research Centre 39 Newton Road , Singapore.* 6. Servaes, J. (Ed.) (2008). Communication for Development and Social Change, Sage, New Delhi. Sinha, 7. Dipankar. (2013), Development Communication- Contexts for the twenty-first century, Orient Black Swan, New Delhi
Learning Outcomes	• Understand the process of development communication in various national and international organizations • Raise awareness among students about global and local development challenges. • Plan and disseminate communication media on development issues • Encourage ethical and socially responsible communication policies. • Students will learn how to create clear and impactful messages for development projects. • Students will understand how to use different media, like radio and social media, to spread important information.

Clothing & Textiles

Course Title	Textile Testing and Quality Control (HSCMJ711 and HSCMJ712)
Category of Course[213]	Major
Credits[214]& Hours of Teaching	

	Theory	Practical	Cumulative
Credits	3	2	5
Hours of Teaching (Total)	45	60	105

Course Objectives	• To educate the students about the techniques used to analyse textile fibre, yarns and fabrics for end-use performance. • To make the student help in acquiring knowledge and understanding of various structural properties of textiles and relate them to end use fabric performance and product. • To familiarize the students about the different testing equipment, their underlying principles, the international accepted standards, test methods and language of Measurement. • To expedite the students to analyse and interpret the results and predict the general textile testing.

Units	**Course Content**	**Hr. of Teaching**
I	Introduction to Textile Testing; Concept and Scope, Application areas, Use of Statistics in Data Management, Sampling Procedures	05
II	Total Quality Management (TQM) approach in the field of Textiles & Clothing	05
III	Standardization; Standards for Fabric Performance, Organizations for Standardization (National and International), Quality Control of Textile products, Quality Standards as applicable to various types of Textiles (Garments, yardage, knits, woven, carpets, processing, dyeing)	10

[213] SEC – Skill Enhancement Course; AEC – Ability Enhancement Course; VAC – Value Added Course; MD – Multidisciplinary Course

[214] 1 Credit (Theory) = 15 Hours; 1 Credit (Practical) = 30 Hours

IV	Properties of textiles at different stages: processing and their principles of measurement • Fibres – length, fineness, evenness • Yarn – strength, evenness, openness, load, elongation, crimp • Fabrics – strength, elongation, shrinkage, thickness, cover, air permeability, crease recovery, weight, comfort, stiffness, flammability, repellency, colour fastness • Garment Finishing – colour fastness, shrinkage • Concept of Fabric faults as related to stages of manufacture and the remedies.	15
V	Concept of Statistical Quality Control; Sampling, Test methods used, Tolerance limits, CV%	10

Practical

I	Physical Testing of Textiles using appropriate standardized procedures • Fibres – length, diameter, fineness • Yarn – count, heaviness, twist, crimp, strength • Fabric – thread count, thickness, air porosity, abrasion, strength (Tensile, Tear, Bursting) water vapour permeability, cover, stiffness, drapability, crease recovery, pilling, abrasion	10
II	Chemical Testing • Identification of fibres • Binary Fabrics, blend composition • Shrinkage, water, oil repellency • Sensitivity to various reagents • Colour fastness	20
III	Mechanical Testing • Seam Strength • Identification of fabric weave • Threat count	15
IV	Inspection of Final Garment	15

Texts / References	1. Booth, J.E. (1968) *Principles of Textile Testing* (3rd ed.) London: Newnes-Butterworth 2. Collier, B. J., & Epps, H. H. (1998). *Textile testing and analysis*. Upper Saddle River, NJ: Prentice Hall 3. Skinkle, J. H. (1949). *Textile testing*. New York: Chemical Publishing Co., Inc. 4. Grover, E. B., Grover, E. B., & Hamby, D. S. (2011). *Handbook of textile testing and quality control*. Wiley India Pvt Ltd **5.** Bureau of Indian Standards. (1986) Manual of BIS and ISI standards related to textiles in India. **https://www.bis.gov.in/ministry-of-textile** 6. American Society for Testing and Materials (1898). Annual book of ASTM standards. ASTM International. https://www.astm.org/products-services/standards-and-publications/standards/textile-standards.html
Learning Outcomes	By the end of the course, students will be able to: • Learn different techniques involved in fibre, yarn and fabric preparation • Understand about the fabric performances • Acquire efficiency over different testing methods of textiles.

Course Title	**Draping, Pattern Making and Grading (HSCMJ713 and HSCMJ714)**
Category of Course[215]	Major
Credits[216]& Hours of Teaching	

	Theory	Practical	Cumulative
Credits	3	2	5
Hours of Teaching (Total)	45	60	105

Course Objectives

- To enable the students to make pattern from sketch/photograph
- To enable the students to obtain perfect fit and harmony between the fabric and design of the garment
- To develop an understanding of a sample pattern using industrial sample room procedure
- To develop an understanding of the use of design elements in the process of range development

Units	Course Content	Hr. of Teaching
I	Introduction to draping and silhouette of the individual- Dress form, Elements of fabric – woven, knitted.	05
II	Development of the Ladies and Kids block and garments by Flat pattern and draping.	05
III	Development of pattern with variation in • One-piece dresses • Two-piece dresses • Dart less dresses (Incorporating various collars, sleeves, yokes, necklines, pockets and plackets etc.)	10
IV	Draping of bodice block and skirt block and their variation, draping of asymmetrical designs and preparing patterns. Drafting	10
V	Pattern markings, Pattern envelope and Guide sheet.	15

PRACTICAL

I	Developing draping Pattern for garments Introduction to grading terminology and methodology; track or stack method, Grading standard size blocks to various sizes	18
II	Procedure for grading blocks to various sizes • Children – bodice block, sleeve block, skirt & shorts block • Women – bodice block, sleeve block, skirt & short block	20
III	Preparation of Portfolio Preparing 2 patterns with complete sets of markings Designing and preparing pattern envelope (front and back) Preparing markers for 3 different fabric width and designs (stripes, plaids) Preparing guide sheet Preparing 3 accompanying pattern promotional items.	22

Texts / References

1. Crawform, C.A. (2018). *The Art of Fashion Draping* (5th ed.). New York: Bloomsbury Academic.
2. Stringer, P.C. (1992). *Pattern Drafting for Dressmaking* (1st ed.). B T Batsford Ltd.
3. Hillhouse, M.S. and Mansfield, E.A. (1948). *Dress Design, Draping and Flat Pattern Making* (1st ed.). London: Houghton Mifflin Company.
4. Shelden, M.G. (1974). *Design through Draping* (2nd ed.) USA: Burgers Publishing Company.
5. Brockman, H.L. (1965). *Theory of Fashion Design* (1st ed.). New York: John Wiley and Sons.
6. Strickland, G. (1956). *A Tailoring Manual* (3rd ed.). New York: Macmillan

[215] SEC – Skill Enhancement Course; AEC – Ability Enhancement Course; VAC – Value Added Course; MD – Multidisciplinary Course

[216] 1 Credit (Theory) = 15 Hours; 1 Credit (Practical) = 30 Hours

	Company. 7. Pepin H. (1942). *Modern Pattern Design* (2nd ed.). New York: Funk & Wagnalls. 8. Cooklin, G., Hayes, S. G., McLoughlin, J., & Fairclough, D. (2011). *Garment Technology for Fashion Designers* (2nd ed.). John Wiley & Sons. 9. Ireland. P.J. (1996), *Fashion Design Illustration: Men* (1st ed.). Batsford Ltd.
Learning Outcomes	By the end of the course, students will develop understanding about: • The principles of draping and get to know about the various tools and equipment used for draping. • The cutting and sketching of pattern, draping procedure of dresses, sample preparation and grading of the material.

Human Development and Family Studies

Course Title	**Gender issues in Human Development and Relationships (HSCMJ715 and HSCMJ716)**			
Category of Course[217]	Major			
Credits[218]& Hours of Teaching		Theory	Practical	Cumulative
	Credits	3	2	5
	Hours of Teaching (Total)	45	60	105
Course Objectives	• To orient the students regarding the gender issues in human development and family relationships. • To impart experiences regarding gender issues, family practices and biases prevalent in Indian Society. • To understand about gender analysis, orientation and role of mass media, • To familiarize with NGO, and other organization • To know about gender role			

Course Content

Units	Course Content	Hr. of Teaching
I	**Unit I: Gender perspectives and theories** Concept of gender- biological and socio-cultural connotations.Historical perspectives. Gender differences in human development.Gender theories- Gender Orientationtheory of Sandra Bem. Gender Schema theory, theory of Ego Development andGender. Gender Stratification theory by Blumberg. Gender Identity Formation theory.	10
II	**Unit II: Gender discrimination, gap and parity** Gender equality and development.Gender inequalities in human development– dimensions, causes and consequences.Gender discrimination indicators- globalgender gaps.Gender Development Index, Global Gender Gap Index and GenderParity Index. Demographic challenges to family ecology- gender role socialization.	10
III	**Unit III: Gender violence and empowerment** Gender violence- dowry harassment and deaths, suicides, prostitution, sexualharassment and exploitation and prevention. Family violence, amniocentesis, femalefeticide, infanticide, eve teasing. Gender empowerment strategies- working towardsfamily solidarity and social well-being. Gender main streaming- concept, policy ofUnited Nations, objectives, requirements and principles. Empowering lives of women by controlling – patriarchy system, women's sexuality, fertility, labour, lack ofvisibility. Gender budgeting.	15
IV	**Unit IV: Changing trends in status of women**	10

[217] SEC – Skill Enhancement Course; AEC – Ability Enhancement Course; VAC – Value Added Course; MD – Multidisciplinary Course

[218] 1 Credit (Theory) = 15 Hours; 1 Credit (Practical) = 30 Hours

	Status of women in India. Various plans and policies designed for achieving genderequality. Changing trends in gender role orientation- early civilization, preindependence,post independent India, contemporary times, socio economic impact on the family and society, cultural impact on the family. Gender role portrayal inmass media.Gender stereotyping in schools. Gender issues at workplace.	
PRACTICAL		
I	Gender analysis of mass media: Print media and E-media and report writing Study of adopted socialization practices for children of both genders and report writing	20
II	Case studies of three generations on dynamics of gender orientation, Gender roles and responsibilities, report presentation and discussion Views of adolescents on their gender role orientation- designing questions survey through questionnaire, report presentation	20
III	Case studies on changing trends of roles and responsibilities of women and men report writing Visits to women welfare Govt. organizations/ agencies/ NGOs, presentation of report and class discussion	20

Texts / References	1. Banddarage A. 1997. Women Population and Global Crisis - A Political and EconomicalAnalysis.Zed books, London. 2. Barnett RC, Biner L and Baruch GK. 1987. Gender Stress. The Free Press, New York. 3. Chanana K. 1989. Gender and the Household Domain.Sage Publications, New Delhi. 4. Kapadia S and Gala J. 2015. Gender Across Cultures: Sex and Socialization in Childhood. Sage Publications, New Delhi. 5. Kumar CS. 2017. Gender Socialization and The Making of Gender in The Indian Context. Sage Publications. New Delhi. 6. Menon L. 1997. Gender Issues and Social Dynamics.KAnishka Publishers and Distributors, New Delhi. 7. Sudha DK. 2000. Gender Roles. A.P.H. Publishing Corporation, New Delhi.
Learning Outcomes	• Learning of gender roles, orientation and issues • Understanding of role of several organizations

Course Title	**Family Ecology, Cultural Diversity and Therapy (HSCMJ717&HSCMJ718)**
Category of Course[219]	Major

Credits[220]& Hours of Teaching		Theory	Practical	Cumulative
	Credits	3	2	5
	Hours of Teaching (Total)	45	60	105

Course Objectives	• To orient the students regarding family as an institution. • To impart knowledge about family transitions and impact of social change and Development • To sensitize the students, regarding the theories and issues pertaining to cultural difference in family studies. • To orient the students regarding various methods and techniques of family therapy. • To know about conflict resolution • To learn role-playing • To gain knowledge of Genogram construction

Course Content

Units	**Course Content**	**Hr. of Teaching**
I	**Families in India and Family relationships**	10

[219] SEC – Skill Enhancement Course; AEC – Ability Enhancement Course; VAC – Value Added Course; MD – Multidisciplinary Course

[220] 1 Credit (Theory) = 15 Hours; 1 Credit (Practical) = 30 Hours

	Families in India - Types of traditional and modern family structures based on different dimensions (Marriage type, nature of residence, nature of authority, nature of relations among the family members, nature of kin composition, single parent families, unrelated families etc.). Families in rural, tribal, and agrarian community – status of women, children, elderly, and men in these families. Family as a social system. Socialization within the family. Models of parenting. Parent child relationships. Family cohesion, conflict and family disorganization –impact on children. Effect of childbirth on marital life. Child abuse. Family interactions and delinquency. Improving family communication and interpersonal relations.	
II	**Family under transition, Family stressors and resilience** Family transitions. Change and continuity over life cycle. Impact of social change on family and changing family patterns in India. Religion and family. Family as an institution under stress. Family crisis. Poverty and children. Stressors and family relations - with special reference to family disruption, sickness, divorce, substance abuse and disability. Family's adaptation to stress.Family resilience and protective factors for promotion of family resilience, Intergenerational family dynamics in management of family conflicts and negative patterns.	15
III	**Culture, family and diversities in family life and challenges** Culture- definition, components and characteristics of culture. Agents of cultural influences- school, family, community and other social groups. Cultural factors and impact on families. Elements of India's diverse culture – religion, philosophy, cuisine, language, fine arts, dance, music. Diversities in family life – ethnic, linguistic, regional, etc. Effect of urbanization, secularization, westernization, technological advancement, globalization and other such developments on families in general and agrarian in particular. Challenges before families across cultures. Legal provisions – emerging cultural trends. Research trends in cross-cultural family studies, methodological issues.	10
IV	**Family therapy – orientation, types and theoretical perspectives** Family Therapy – concept, need, significance, areas, scope, goals and application of marriage and family therapies. Evolution of family therapy. Early models and basic techniques of family therapy- group process and communications analysis. Theoretical developments in marital and family therapy. Approaches in family therapy - Social Learning approach, Psychoanalytic, Behavioural, Systems approach. Social Constructionism theory. Attachment theory. Classic schools of family therapy- Bowenian Family Systems therapy, Strategic, Structured, Communication and Experiential therapies, Psychodynamic Therapy, Cognitive- Behaviour family therapy and integrated family therapy. Contemporary marital therapies. Family therapy in the 21st century and its application to multicultural, single parent and disorganized families, solution focused therapy, narrative therapy and integrative models. Application of family therapy in depression, substance abuse, schizophrenia and eating disorders.	10
PRACTICAL		
I	Conflict Resolution Role-plays - Create role-playing exercises that involve family conflicts and resolutions. Students can practice mediating conflicts and developing strategies for effective communication and resolution.	10
II	Comparative Analysis Project-Students choose two families—Both from different cultures. They analyze and compare aspects such as family roles, marriage customs, child-rearing practices, and conflict resolution strategies.	10
III	Role-Playing Difficult Scenarios-Create role-playing exercises involving challenging family scenarios, such as conflict resolution, crisis management, or working with resistant clients. Students can take on different roles, including therapist, client, and family members.	10
IV	Genogram Construction-Have students create genograms of a family of their choice (real or fictional), incorporating family relationships, patterns, and histories. Students can then analyze the genogram using different theoretical lenses	14
V	Cultural Competency Training-Conduct training sessions on cultural competence, focusing on how to address and incorporate cultural differences in family therapy. This	16

	could include case studies or role-plays that highlight cultural nuances Interviews with Families in Transition-Have students conduct interviews with families who have experienced or are experiencing significant transitions (e.g., migration, loss of a family member, economic changes). Students should focus on how these transitions have impacted family dynamics and resilience strategies used.	

Texts / References	1. Ballard SM and Taylor AC. 2012. *Family Life Education with Diverse Populations*. Sage Publications, Los Angeles. 2. Brislin RW. 1990. *Applied Cross Cultural Psychology*. Sage Publications, New Delhi. 3. Carson DK, Carson CK and Chowdhury A. 2007. *Indian Families at the Crossroads*. Gyan Publishing House, New Delhi. 4. Ratra A, Kaur P, Chhikara S, Varma T and Chawla P. 2006. *Marriage and Family-InDiverse and Changing Scenario.* Deep & Deep Publications Pvt. Ltd, New Delhi. 5. Carr A. 2008. *Family Therapy – Concepts, Process and Practice*. 2nd Ed., John Wiley & Sons Ltd, Chichester. 6. Carson DK, Carson CK, Chowdhury A. 2007. *Indian Families at The Crossroads*. Gyan Publishing House, New Delhi.
Learning Outcomes	• Understanding of family as an institution, learning of family transition, cultural differences in family studies and techniques applied in family therapy. • Students can practice mediating conflicts and developing strategies for effective communication and resolution. • Students can then analyze the Genogram using different theoretical

Family Resource Management

Course Title	**Consumer Product Safety and Legislation** (HSCMJ719 and HSCMJ720)
Category of Course[221]	Major

Credits[222]& Hours of Teaching	Theory	Practical	Cumulative
Credits	3	2	**05**
Hours of Teaching (Total)	45	60	**105**

Course Objectives	• To know about the basics of consumer safety. • To know about the consumer rights • To aware about the different acts related to safety and liabilities, redressal and complaints of consumers • To impart field related knowledge of consumer safety and product hazards and redressal.

Course Content

Units	Course Content	Hr. of Teaching
I	•**Introduction-**Meaning, Definition, scope and Importance. •**Product related Hazards-**Physical hazards, Health hazards and Environment hazards. •**Production formation and Labeling** Brand Labels, Information Labels Descriptive Labels and grade labels. •**Product Liability** Meaning, Liability of manufacture trader, importance	15
II	**Provision of the product Safey &liabilities under various Laws-** •Consumer protection ACT, 2019(CPA) •Sale of goods ACT,1930(SGA)	20

[221] SEC – Skill Enhancement Course; AEC – Ability Enhancement Course; VAC – Value Added Course; MD – Multidisciplinary Course

[222] 1 Credit (Theory) = 15 Hours; 1 Credit (Practical) = 30 Hours

	•Indian contract ACT, 1872 •Bureau of Indian Standard ACT,2016(BIS) •Consumer protection (Direct Selling) Rules,2021 •Consumer protection (Ecommerce Rules, 2020) •Food safety and standard Act,2006 (FASSAI) •Medical Devices Rules, (2017) •Motor Vehicle ACT,1940(MVA)	
III	• **Mechanism of consumer redressal**-Time limit for complaint filling, Burden of proving fault/defect, Noncompliance with the regulatory standards, non-issue of adequate information on labels.	05
IV	• **Redressal of consumer complaints**-Rectification of defects, return of price paid, compensation for the damage and mental agony, recall of the product.	05

Practical		
I	• Project work on requirements of product safety education to consumers and its implementation.	20
II	• Survey of consumer product-hazards and redressal.	20
III	• Market analysis on different safety measures used in types of food products	20

Texts / References	1. Banddarage A. 1997. Women Population and Global Crisis - A Political and EconomicalAnalysis.Zed books, London. 2. Barnett RC, Biner L and Baruch GK. 1987. Gender Stress. The Free Press, New York. 3. Chanana K. 1989. Gender and the Household Domain.Sage Publications, New Delhi. 4. Kapadia S and Gala J. 2015. Gender Across Cultures: Sex and Socialization in Childhood. Sage Publications, New Delhi. 5. Kumar CS. 2017. Gender Socialization and The Making of Gender in The Indian Context. Sage Publications. New Delhi. 6. Menon L. 1997. Gender Issues and Social Dynamics.Kanishka Publishers and Distributors, New Delhi. 7. Sudha DK. 2000. Gender Roles. A.P.H. Publishing Corporation, New Delhi.
Learning Outcomes	• Understanding of consumer rights, safety, liabilities, redressal and complaints • Understanding of consumer safety education, product hazards and handling of problems.

Course Title	**Ergonomics and Appropriate Technology (HSCMJ721 and HSCMJ722)**			
Category of Course[223]	Major			
Credits[224]& Hours of Teaching		Theory	Practical	Cumulative
	Credits	3	2	**05**
	Hours of Teaching (Total)	45	60	**105**
Course Objectives	• To impart the fundamental knowledge, scope and importance of Ergonomics. • To provide the understandings of hazards, and tools of Ergonomics • To gain information about anthropometry and ergonomics • To gain knowledge of employee satisfaction in work environment • To understand the relationship between man, machine and environment			

Course Content

Units	**Course Content**	**Hr. of Teaching**
I	• **Definition and meaning of ergonomics.** • Scope of ergonomics - In work spaces, sports, leisure and healthy, safety.	10

[223] SEC – Skill Enhancement Course; AEC – Ability Enhancement Course; VAC – Value Added Course; MD – Multidisciplinary Course

[224] 1 Credit (Theory) = 15 Hours; 1 Credit (Practical) = 30 Hours

	• **Types of ergonomics:** Physical ergonomics, Cognitive ergonomics, Organisation ergonomics	
II	• **Ergonomics Hazards and injuries-** • Ergonomics hazards - Repetitive movements, Manual handling, Workplace design. Ergonomics Injuries - Repetitive stress injuries (RSI), Repetitive motion injuries (RMIs), Cumulative Trauma Disorder (CTDs)	10
III	• **Importance of ergonomics -** Efficiency of work, Physical efficiency, Training efficiency. • **Benefits of ergonomics in workplace-** • Benefits regarding- production cost, Productivity, quality, employee engagement, safety culture.	10
IV	• **Ergonomic process and tools-** Physical assessment, Employee injury history, Benefits of ergonomics assessments • **Ergonomic assessment tools-** NIOSH Lifting equation (National institute for occupational safety and health), RULA (Rapid upper limb assessment), HAV (Hand arm vibration calculator)	10
V	• **Anthropometry-** Definition, meaning and types Elements of anthropometry-Height, weight, BMI (Body mass index) Body circumferences (waist, hip, limbs)	05

PRACTICAL		
I	• Survey on finding out different sources of satisfaction of employee needs in the work environment.	30
II	• To know the relationship between man, machine and environment.	15
III	• Application of ergonomics to improve productivity and safety in different field	15

Texts / References	1. Patni. M., (2015), Ergonomics, Star Publications, 1st Edition, ISBN- 9789381246511. 2. Shrilakshmi,B., Nutrition Science, New Age Publishers Pvt. Ltd, 6th Edition, ISBN-9789386418883.
Learning Outcomes	• Learning of fundamentals of Ergonomics, different types of hazards, ergonomics in workplaces, assessment and anthropometry • Understanding of employee satisfaction in workplace, and the relationship between man, machine and environment

Semester –VIII

Course Title	**Statistics and Computer Application (HSCMJ81 And HSCMJ82)**
Category of Course[225]	Major
Credits[226]& Hours of Teaching	

	Theory	Practical	Cumulative
Credits	3	1	4
Hours of Teaching (Total)	45	30	75

Course	• To enable the students to develop knowledge in statistical tools and computer applications.

[225] SEC – Skill Enhancement Course; AEC – Ability Enhancement Course; VAC – Value Added Course; MD – Multidisciplinary Course

[226] 1 Credit (Theory) = 15 Hours; 1 Credit (Practical) = 30 Hours

Objectives	• To understand the meaning of correlation, regression analysis for estimation and prediction purposes. • To discuss about the needs of various statistical test in Home Science discipline. • To teach the students how to organize, analyze, interpret and present the research data effectively. • To demonstrate the understanding of descriptive statistics by practical application of quantitative reasoning and data visualization • To demonstrate the use of correlation, regression analysis and association for estimation and prediction purposes.

Course Content

Units	Course Content	Hr. of Teaching
I	Introduction to Statistics - Definition, importance and scope of statistics, Descriptive and Inferential statistics. Data Management; Raw data, ungrouped frequency distribution, grouped frequency distribution, relative frequency table, cumulative frequency tables, how to convert raw data to the form of a frequency distribution, Graphs; histogram, frequency polygon, frequency curve, ogives. Scales of measurement-nominal, ordinal, interval and ratio scales. Coding of data.	8
II	Measures of central tendency; Definition, arithmetic mean; simple and weighted arithmetic mean, median, mode, geometric mean, their uses, merits and demerits, Partition values – quartiles and percentiles, Measures of dispersion; Definition, Absolute and relative measures of dispersion; range, variance, standard deviation, standard error, coefficient of variation.	10
III	Normal Distribution and its applications, Probability- classical approach, random variable- discrete and continuous random variables, Normal random variable, characteristics and properties of a normal curve, standard normal distribution, converting raw scores into standard normalized scores, standard normal curve.	6
IV	Correlation, Regression and Association of Attributes, Linear correlation- meaning and types of correlation, scatter diagram, Karl Pearson's coefficient of correlation, Spearman's Rank correlation coefficient, Linear Regression and Prediction: Concept of regression lines and regression equations, use of regression lines, role of coefficient of alienation in prediction.	8
V	Testing of Hypotheses; Definition, concepts of statistical hypothesis-simple and composite, null hypothesis, alternative hypothesis, test of a statistical hypothesis, critical region, Type I error, Type II error, significance level, confidence level. Parametric test- Testing of hypothesis concerning the mean of a population, testing the equality of means of two populations, Testing of hypothesis concerning the proportion of a population, testing the equality of proportions of two populations, chi-square test, F test, ANOVA concepts, ANOVA-single factor, Non parametric; chi-square test- testing goodness of fit, independence of attributes. Computer; importance and uses in research & statistics, Basic features of Microsoft word and Excel, Statistical analysis using Excel sheet and SPSS, tabular & graphical representation of data using computer, frequency distribution; Histogram, pie diagram, scatter diagram graphs using Excel.	13
PRACTICAL		
I	Preparation of different types of tables with research data on computer. Graphical representation of research data; Different types of statistical graphs and their uses in statistics, Line graph; types and different uses, pie diagram, scatter diagram etc. Preparation of Frequency distribution curves and graphs- histogram, frequency polygon and ogives through computer.	10
II	Discussing and solving practical problems of Statistics -Related to central tendency; mean, median, mode, partition values, dispersion; standard deviation, mean deviation, concept of Skewness and kurtosis and their measures etc., and hypothesis and hypothesis testing; Correlation, chi-square, t-test, Z - test, ANOVA.	10
III	Basic Statistical tools in computer for research and data analysis; MS-word, MS-Excel, SPSS etc. Learn about SPSS software and Solving above given statistical problems using Excel	10

	sheet and SPSS.	
Texts / References	1. Kothari, C. R. (2014). *Research Methodology – methods and techniques*, 3rd edition, New Delhi: New age International Publishers 2. Gupta, S. C., & Kapoor, V. K. (2020). Fundamentals of mathematical statistics. New Delhi: Sultan Chand & Sons. 3. Gupta, S. P. (2001). Statistical Methods, New Delhi: Sultan Chand & Sons. 4. Gupta, S. P. (2001). Advanced Practical Statistics. New Delhi: S. Chand and Company Ltd., 5. Landau, S. (2019). A handbook of statistical analyses using SPSS. London: Chapman & Hall. 6. Singh, V. P. (2009). Simplified MS Office 2007. New Delhi: Computech Publications Limited. 7. Wackerly, D., Mendenhall, W., & Scheaffer, R. L. (2008). Mathematical statistics with applications. USA: Thomson Learning	
Learning Outcomes	By the end of course the students will be able to; • Discuss the significance of statistics in the discipline of Home Science. • Describes the basic concepts of statistical inferences and test of significance. • Apply the appropriate statistical techniques for analysis and interpretation of data. • Understand working on a computer system and assess of MS- WORD, MS-EXCEL. • Analyze Research data through various test as chi-square, mean, median, mode, standard deviations, t-test etc. and present result through graphical presentation and tabulation using computer	

Course Title	**Nutritional Biochemistry (HSCMJ83 and HSCMJ84)**			
Category of Course[227]	Major			
Credits[228]& Hours of Teaching		Theory	Practical	Cumulative
	Credits	3	2	**05**
	Hours of Teaching (Total)	45	60	**105**
Course Objectives	• To provide core knowledge of application of biochemistry in different areas, metabolism of basic nutrients required for the sustenance of the life, to educate about the activity of enzymes required for several biological reaction • To learn the detection method of sugar, protein and cholesterol in food and blood samples.			

Course Content

Units	Course Content	Hr. of Teaching
I	**Introduction to Biochemistry** Scope and importance Biochemistry, Familiarization with different phenomenon Surface tension, Colloidal state, Osmotic pressure, Permeability, Water activity, Entropy	05
II	**Introduction to Carbohydrate Metabolism** • Classes of carbohydrate along with structures (monosaccharides, disaccharides, oligosaccharides and polysaccharides) • Properties and dietary importance of starch, sucrose, lactose, glucose and fructose • Metabolism: Glycolysis, Tricarboxylic acid (TCA) cycle, Gluconeogenesis.	20

[227] SEC – Skill Enhancement Course; AEC – Ability Enhancement Course; VAC – Value Added Course; MD – Multidisciplinary Course

[228] 1 Credit (Theory) = 15 Hours; 1 Credit (Practical) = 30 Hours

III	**Introduction to Protein Metabolism** • Classes, properties, functions and secondary structure of protein (alpha helix, beta pleated sheets) • Classification of Amino acids- essential and non-essential • Basic concept and definition of: Complete and incomplete protein, biological value, Protein Efficiency Ratio. • Metabolism: Deamination, Transamination and Urea Cycle.	10
IV	**Introduction to Lipid Metabolism** • Classification of lipids • Properties and function of fats, oils and fatty acids (MUFA, PUFA, SFA,TFA) • Metabolism: Beta-oxidation of fatty acids**.**	05
V	**Basics of Enzymes** • Definition and classification of enzymes • Properties of enzymes and factors affecting enzyme activity • Brief idea of model of enzyme action (lock and Key model) • Basics concept of enzyme inhibition	05

Practical		
I	• **Basic Instruments/Equipment used in Laboratories and its important working tips:** • pH meter • Spectrophotometer • Fluorimetry • Electrophoresis • Colorimeter • Centrifuge • Desiccator, Oven, Electronic Digital Balance etc.	30
II	• Qualitative detection of protein (Biuret-ninhydrin)	20
III	• Qualitative detection of Sugar (Molisch's test, Benedict's test, Iodine test), non-reducing sugars (hydrolysis test)	10

Texts / References	1. B. Srilakshmi - Nutrition Science, New Age International Publishers, seventh edition 2. Swaminathan, M. (1997), Essentials of Food and Nutrition, vol I Second edition, Bangalore, BAPPCO 3. Park,K. (2017), Parks Textbook of Preventive and Social Medicine, 24thed.Jabalpur M/s,Banarasidas Bhanot.
Learning Outcomes	• Learning about the concept of health and nutrition, dealing with common nutritional diseases, gathering knowledge of several nutritional programmes being implemented to combat the diseases. • In hand experiences in solving nutrition and health related problems related to community, a better understanding of several problems prevailing in the community

Course Title	**Community Nutrition (HSCMJ85 and HSCMJ86)**
Category of Course[229]	Major

Credits[230]& Hours of Teaching		Theory	Practical	Cumulative
	Credits	3	1	**04**
	Hours of Teaching (Total)	45	30	**75**

Course Objectives	• To provide knowledge regarding the basic concept of health, nutrition, healthcare services and their impact in the community in Indian Context. • To gain practical experiences in the field of community nutrition

Course Content

Units	Course Content	Hr. of Teaching
I	**Concept of Community Nutrition** • Basics of community and community nutrition, concept of health and Well-being (Quality of Life), • Behavioural Change Intervention in Community Settings • Health Care System in India with special reference to Primary Health Care (PHC), Vital Health Statistics, • Assessment of Nutritional Status- Introduction to ABCD Methods, • Role of Community nutritionist as an essential part of the Health Care Delivery System.	10
II	**Approaches for Improving Nutrition and Health status of the community** • Health based interventions including immunization, provision of safe drinking water, prevention and management of diarrhoeal diseases. • Education based intervention including growth monitoring and promotion. • Concept of Food Security, Participation of women in Income generation with special reference to nutrition profile of the family.	10
III	**Food choices of community and Nutrition Education** • Factor affecting food choices of the consumers (cultural,psychological, lifestyle) • Basic concept of Nutrition Education, Methods used in nutrition education (Lecture, group discussion, role play, storytelling, demonstration, exhibition etc).	10
IV	**National programmes for Improving Health and Nutrition Status of the community** • Evolution of Health Policy in India (NHP), • Programmes for communicable disease control (diarrhoeal disease control, Universal Immunization Programme, National AIDS Control programme, National Malaria eradication programme, National Tuberculosis programme,programmes for non-communicable diseases (Blindness Control programme, diabetes control programme, national mental health programme, child survival and safe motherhood programmes etc.	10
V	**Policies and Programmes related to Nutrition in India** Concept, Aim and prevention strategy of the Policy and Programmes- National Nutrition Policy, Integrated Child Development Services Scheme , Prevention of Blindness due to Vitamin A Deficiency, National Nutritional anaemia Control programme, Iodine Deficiency disorder control programme, Mid-day-meal programme, PM Poshan etc. **Role of International and National Agencies in combating nutritional deficiency diseases** Functions of the International and National Organization – WHO, FAO, UNICEF,	05

[229] SEC – Skill Enhancement Course; AEC – Ability Enhancement Course; VAC – Value Added Course; MD – Multidisciplinary Course

[230] 1 Credit (Theory) = 15 Hours; 1 Credit (Practical) = 30 Hours

	CARE, ICAR, ICMR, NIN, FNB, CFTRI, NNMB.	

Practical		
I	• Visit to any Anganwadi Centre or school for nutritional assessment of the children	10
II	• Visit to Primary Health Centers	10
III	• **Nutritional surveillance;** epidemiological studies of diet and also the development, implementation and evaluation of dietary recommendations and goals.	10

Texts / References	1. B. Srilakshmi - Nutrition Science, New Age International Publishers, seventh edition 2. Swaminathan, M. (1997), Essentials of Food and Nutrition, vol I Second edition, Bangalore, BAPPCO 3. Park,K. (2017), Parks Textbook of Preventive and Social Medicine, 24th ed.Jabalpur M/s,Banarasidas Bhanot.
Learning Outcomes	• Learning about the concept of health and nutrition, dealing with common nutritional diseases, gathering knowledge of several nutritional programmes being implemented to combat the diseases. • In hand experiences in solving nutrition and health related problems related to community, a better understanding of several problems prevailing in the community

Course Title	**Food Quality Analysis (HSCMJ87 and HSCMJ88)**			
Category of Course[231]	Major			
Credits[232]& Hours of Teaching		Theory	Practical	Cumulative
	Credits	2	1	**03**
	Hours of Teaching (Total)	30	30	**60**
Course Objectives	• To provide fundamental concept of the microorganism associated with food and their characteristics. • To provide the concept of preservation and microbiological safety in various food operations.			
Course Content				

[231] SEC – Skill Enhancement Course; AEC – Ability Enhancement Course; VAC – Value Added Course; MD – Multidisciplinary Course

[232] 1 Credit (Theory) = 15 Hours; 1 Credit (Practical) = 30 Hours

Units	Course Content	Hr. of Teaching
I	**Basic terms used in Food Quality Analysis** • Standard Solution (Normal, Molar, Molal, Buffer Solution). • pH and Hydrogen ion concentration • Preliminary concepts of free fatty acid, Acid value, Saponification, Refractive Index, Iodine value, RM and PV value of fats. • Moisture and Ash content in different foods • Conceptoftitration	10
II	**Principle, Technique and Applications of the following methods-** • Colorimetry • Spectrophotometry • Electrophoresis (Paper and Gel) • Chromatography (Paper, Thin Layer, Gas, High Performance) • Photometry for analysis for minerals in different foods	15
III	**Basic methods of nutrient analysis of foods:** • Kjeldahland Dumas Method for analysis of protein • Anthronemethod for analysis carbohydrates. • Quantitative method for Ash Content analysis in different foods. • Methods for Determination of crude fibre in different foods.	5
PRACTICAL		
I	**Experiments on the following-** • Preparation of standard Solutions • Determination of pH in different foods using pH meter	10
II	• Acid-base titration • Carbohydrate determination using Spectrophotometer	10
III	• Determination of crude fibre in different foods • Determination of ash content in different foods	10
Texts / References	1. Instrumental methods of analysis By Dr. B. K. Sharma. 2. A first course in food analysis By A. Y. Sathe. 3. Hand book of analysis and quality control for fruit & vegetable products By S. Ranganathan. **4.** Food science chemistry & experimental food By Dr. M. Swaminathan.	
Learning Outcomes	• Learning of principles and techniques of analysis of different nutrients present in foods • Knowledge of performing several experiments to determine nutrient content in foods.	

Course Title	**Statistics and Computer Application (HSCMN81 and HSCMN82)**			
Category of Course[233]	Minor			
Credits[234]& Hour of Teaching		Theory	Practical	Cumulative
	Credits	3	1	4
	Hour of Teaching (Total)	45	30	75
Course Objectives	• To enable the students to develop knowledge in statistical tools and computer applications.			

[233] SEC – Skill Enhancement Course; AEC – Ability Enhancement Course; VAC – Value Added Course; MD – Multidisciplinary Course

[234] 1 Credit (Theory) = 15 Hours; 1 Credit (Practical) = 30 Hours

	• To understand the meaning of correlation, regression analysis for estimation and prediction purposes. • To discuss about the needs of various statistical test in Home Science discipline. • To teach the students how to organize, analyze, interpret and present the research data effectively. • To demonstrate the understanding of descriptive statistics by practical application of quantitative reasoning and data visualization • To demonstrate the use of correlation, regression analysis and association for estimation and prediction purposes.

Course Content

Units	Course Content	Hr. of Teaching
I	Introduction to Statistics - Definition, importance and scope of statistics, Descriptive and Inferential statistics. Data Management; Raw data, ungrouped frequency distribution, grouped frequency distribution, relative frequency table, cumulative frequency tables, how to convert raw data to the form of a frequency distribution, Graphs; histogram, frequency polygon, frequency curve, ogives. Scales of measurement-nominal, ordinal, interval and ratio scales. Coding of data.	8
II	Measures of central tendency; Definition, arithmetic mean; simple and weighted arithmetic mean, median, mode, geometric mean, their uses, merits and demerits, Partition values – quartiles and percentiles, Measures of dispersion; Definition, Absolute and relative measures of dispersion; range, variance, standard deviation, standard error, coefficient of variation.	10
III	Normal Distribution and its applications, Probability- classical approach, random variable- discrete and continuous random variables, Normal random variable, characteristics and properties of a normal curve, standard normal distribution, converting raw scores into standard normalized scores, standard normal curve.	6
IV	Correlation, Regression and Association of Attributes, Linear correlation- meaning and types of correlation, scatter diagram, Karl Pearson's coefficient of correlation, Spearman's Rank correlation coefficient, Linear Regression and Prediction: Concept of regression lines and regression equations, use of regression lines, role of coefficient of alienation in prediction.	8
V	Testing of Hypotheses; Definition, concepts of statistical hypothesis-simple and composite, null hypothesis, alternative hypothesis, test of a statistical hypothesis, critical region, Type I error, Type II error, significance level, confidence level. Parametric test- Testing of hypothesis concerning the mean of a population, testing the equality of means of two populations, Testing of hypothesis concerning the proportion of a population, testing the equality of proportions of two populations, chi-square test, F test, ANOVA concepts, ANOVA-single factor, Non parametric; chi-square test- testing goodness of fit, independence of attributes. Computer; importance and uses in research & statistics, Basic features of Microsoft word and Excel, Statistical analysis using Excel sheet and SPSS, tabular & graphical representation of data using computer, frequency distribution; Histogram, pie diagram, scatter diagram graphs using Excel.	13
PRACTICAL		
I	Preparation of different types of tables with research data on computer. Graphical representation of research data; Different types of statistical graphs and their uses in statistics, Line graph; types and different uses, pie diagram, scatter diagram etc. Preparation of Frequency distribution curves and graphs- histogram, frequency polygon and ogives through computer.	10
II	Discussing and solving practical problems of Statistics -Related to central tendency; mean, median, mode, partition values, dispersion; standard deviation, mean deviation, concept of Skewness and kurtosis and their measures etc., and hypothesis and hypothesis testing; Correlation, chi-square, t-test, Z - test, ANOVA.	10
III	Basic Statistical tools in computer for research and data analysis; MS-word, MS-Excel, SPSS etc. Learn about SPSS software and Solving above given statistical problems using	10

	Excel sheet and SPSS.	
Texts / References	1. Kothari, C. R. (2014). *Research Methodology – methods and techniques*, 3rd edition, New Delhi: New age International Publishers 2. Gupta, S. C., & Kapoor, V. K. (2020). Fundamentals of mathematical statistics. New Delhi: Sultan Chand & Sons. 3. Gupta, S. P. (2001). Statistical Methods, New Delhi: Sultan Chand & Sons. 4. Gupta, S. P. (2001). Advanced Practical Statistics. New Delhi: S. Chand and Company Ltd., 5. Landau, S. (2019). A handbook of statistical analyses using SPSS. London: Chapman & Hall. 6. Singh, V. P. (2009). Simplified MS Office 2007. New Delhi: Computech Publications Limited. 7. Wackerly, D., Mendenhall, W., & Scheaffer, R. L. (2008). Mathematical statistics with applications. USA: Thomson Learning	
Learning Outcomes	By the end of course the students will be able to; • Discuss the significance of statistics in the discipline of Home Science. • Describes the basic concepts of statistical inferences and test of significance. • Apply the appropriate statistical techniques for analysis and interpretation of data. • Understand working on a computer system and assess of MS- WORD, MS-EXCEL. • Analyze Research data through various test as chi-square, mean, median, mode, standard deviations, t-test etc. and present result through graphical presentation and tabulation using computer	

Extension and Communication

Course Title	**Dynamics of Groups and Leadership Development (HSCMJ89 andHSCMJ810)**			
Category of Course[235]	Major			
Credits[236]& Hour of Teaching		Theory	Practical	Cumulative
	Credits	3	2	5
	Hour of Teaching (Total)	45	60	105
Course Objectives	1. To develop an understanding about group behavior and dynamics for effective communication and group management 2. To acquaint students with techniques for sustainable group dynamics 3. To considerate the relationship of effective leadership in development			

Course Content

Units	**Course Content**	**Hr. of Teaching**
I	BASICS OF GROUP/ SOCIAL GROUP • Working with Groups & Teams- • Introduction to group: Meaning, characteristics, types and functions • Stages and process of group formation • Group norms and structure- Values Ethics and Morals • Understanding group behaviour – Definitions, Theories - social comparison, cognitive dissonance, self-presentation, drive, social impact, self-attention, social cognition • Individual; Interpersonal and human behaviour and dimensions	9
II	**GROUP DYNAMICS-**	6

[235] SEC – Skill Enhancement Course; AEC – Ability Enhancement Course; VAC – Value Added Course; MD – Multidisciplinary Course

[236] 1 Credit (Theory) = 15 Hours; 1 Credit (Practical) = 30 Hours

	Concept, features, principles, various roles and actions, techniques for managing group dynamics	
III	**ASPECTS OF GROUP DYNAMICS** - • Cooperation, competition, communication, Group pressure, Group cohesiveness, Group leadership • Measurement of group dynamics - tools and techniques, group break down - causes and solutions, , Weaknesses and myths, Crowds and the mob mentality, Diversity and difference; • Group dynamic skills - training and development. • Group norms-types, group norms development, social influence, changing group norms • Diversity in group dynamics- definition, types, impotence in a group	10
IV	**LEADER AND LEADERSHIP DEVELOPMENT** • Leeder and leadership- concept, types and importance of leadership • Roles, functions and characteristics of a leader • Evolution and growth of leadership • Leadership traits and ethics, attitude, behaviour, personality traits • Selection techniques of leader • Theories (Trait Theory, Behavioural theories, Contingency Theories, Transactional Theories and Transformational Leadership Theory) • Training for developing leadership • Difference between a Leader and a Manager	10
V	**MANAGEMENT OF GROUP** • Team building- concept, &7 C's of team building, benefits • Group problem-solving and decision-making - meaning, importance, and techniques • Conflict management; types of conflicts, sources of conflicts, positive and negative outcomes, Approaches to conflict management • Stress management; Active listening and feedback; Achieving cooperative group structure • Decision-making- concept and Process, Advantages, and disadvantages	10
PRACTICAL		
I	Understand the process of SWOT and practice it. Developing skills in planning and conducting small group communication. -Meetings -Focus group discussion/Group discussion -Debate	12
II	Develop skills in writing of minutes of meeting Study of variousgroups (Formal and Informal) and presentations of reports for the same (Objective, activities, problems/challenges, sources of Conflicts, approaches of conflict management, Future plans etc.) • Family • Friend circle • A yoga club • Corporate company • An athletic team • Youth clubs • Caste-based groups • Mahila mandals • Self-help group	26
III	Identify the leadership development activities and select the leader for various groups	22

Texts / References

1. Avery, G. C. (2005). *Understanding Leadership*. London: Sage Publications
2. Donelson R. Forsyth, Group Dynamics, Fifth edition , 2006
3. Encyclopedia of Management (2009). Leadership Theories and Studies. In Encyclopedia of Management. http://www.enotes.com/management-encyclopedia/leadership-theories-studies

<table>
<tr><td colspan="2">4. French, J. R. P. Jr. and Raven, B. (1962). The bases of social power. In D. Cartwright (Ed), Group Dynamics: Research and Theory (pp. 259-269). New York: Harper and Row.
5. Likert, R. (1967). New patterns of management. New York: McGraw-Hil
6. Northouse, P. G. (2007). Leadership: theory and practice. 4th ed. Thousand Oaks, CA: Sage Publications
7. R. Kreitner, A. Kinicki. Organizational Behavior, 9th edition, McGraw-Hill, New York, 2010.</td></tr>
<tr><td>Learning Outcomes</td><td>• Analyze the features and developmental stages of groups and team process
• Critically evaluate the theoretical concepts of group behaviour in a real situation
• Able to measure group dynamics
• Demonstrate group dynamic skills
• Apply problem-solving skills and higher-level thinking strategies
• Develop and selection of effective leadership skills</td></tr>
</table>

Course Title	**Diffusion and Adoption of Innovation (HSCMJ811 andHSCMJ812)**
Category of Course[237]	Major

Credits[238]& Hours of Teaching		Theory	Practical	Cumulative
	Credits	3	1	4
	Hours of Teaching (Total)	45	30	75

Course Objectives

- To define diffusion and enumerate the elements of diffusion.
- To explain the processes of adoption and innovation, as well as diffusion of innovation.
- To identify characteristics of innovation, rate of adoption and adopter categories.
- To study the community processes,
- To analyze the adoption studies

Course Content

Units	**Course Content**	**Hr. of Teaching**
I	**Definition of Diffusion, Innovation and Adoption** Diffusion, innovation and adoption - concept and meaning, elements, traditions of research on diffusion, the generation of innovations, innovation-development process, tracing the innovation-development process, converting research into practice.	10
II	**Innovation Decision Process** The adoption process-concept and stages, dynamic nature of stages, covert and overt processes at stages, the innovation-decision process – a critical appraisal of the new formulation.	05
III	**Adopter categories** Innovativeness and adopter categories, adopter categories as ideal types, characteristics of adopter categories, Perceived attributes of Innovation and their rate of adoption, factors influencing rate of adoption.	10
IV	**Role of extension in diffusion of innovation** Diffusion effect and concept of over adoption, opinion leadership, change agent and characteristics of opinion leaders, monomorphic and polymorphic opinion leadership, multi-step flow of innovation, concepts of homophily and heterophily and their influence on flow of innovations.	10
V	**Types of innovation-decisions** optional, collective and authority and contingent innovation decisions, consequences of innovation-decisions – desirable or undesirable, director indirect, anticipated or unanticipated consequences, decision making – meaning, theories, process, steps, factors influencing decision – making. **Critique of the current approach** Consequences of Innovation, desirable versus undesirable consequences, direct versus indirect consequences, anticipated versus unanticipated consequences. types and gap widening effect, generations of Innovation and Knowledge Sharing. Criticism of diffusion research.	10
PRACTICAL		
I	Case studies in individual and community adoption process. Content analysis of adoption studies.	10
II	Identification of adopter categories on a selected technology. Identification of opinion leaders, Sources of information at different stages of adoption on a selected technology.	10
III	Study of factors increasing or retarding the rate of adoption. Presentation of reports on adoption and diffusion of innovations.	10

Texts /	1. Ban, A. W. Van den and Hawkins, H. S. Hawkins (1996) Agricultural Extension,

[237] SEC – Skill Enhancement Course; AEC – Ability Enhancement Course; VAC – Value Added Course; MD – Multidisciplinary Course

[238] 1 Credit (Theory) = 15 Hours; 1 Credit (Practical) = 30 Hours

References	Blackwell Science, Second edition, 294p 2. Leeuwis Cees (2003) Communication for Rural Innovation: Rethinking Agricultural Ex Rogers, 3. E.M. (1995). Diffusion of Innovations (4th ed.). New York: Free Press. tension, . 4. Dearing, James W. (2008) Evolution of Diffusion and Dissemination Theory, J Public Health Management Practice, 14(2), 99–108, 5. MANAGE (2007) Course 102 Communication and Diffusion of Agricultural Innovations Post Graduate Diploma in Agricultural Extension Management (PGDAEM), Published by National Institute of Agricultural Extension Management, Rajendranagar, India, 6. Richard E. Just and David Zilberman (1983), "Stochastic Structure, Farm Size, and Technology Adoption in Developing Agriculture," Oxford Economic Papers, Vol. 35, No. 2 (July, 1983), pp. 307-328.
Learning Outcomes	1. Students have knowledge about innovations spread among the rural society by getting into the insights of diffusion concept and adoption process. 2. Students understand about various concepts related to diffusion and adoption of innovations. 3. Students can carry out research on adoption and diffusion of innovations-Employability 4. Understanding of adoption process in the community 5. Learning of several factors affecting adoption

Course Title	**Social Entrepreneurship (HSCMJ813)**			
Category of Course[239]	Major			
Credits[240]& Hours of Teaching		Theory	Practical	Cumulative
	Credits	3	-	3
	Hours of Teaching (Total)	45	-	45
Course Objectives	• To provide conceptual inputs regarding different types of entrepreneurships. • To sensitize and motivate the students towards entrepreneurship management. • To orient and impart knowledge towards identifying and implementing entrepreneurship opportunities. • To develop management skills for entrepreneurship management.			

Course Content

Units	**Course Content**	**Hr. of Teaching**
I	• Conceptual Analysis- Meaning, definition, characteristics and types of entrepreneurships, entrepreneur and enterprise. • Merits and demerits of entrepreneurship. • Role of enterprise in national and global economy	8
II	• Social Entrepreneurship- Meaning, nature and significance • Developing social entrepreneurial competencies – requirements and understandings the process, interpersonal skills, creativity, assertiveness achievement, factors affecting entrepreneur's role.	8
III	• Launching and organizing an enterprise- Environment scanning – information sources, schemes of assistance, problems. Enterprise selection, market assessment, enterprise feasibility study, SWOT Analysis. • Resource mobilization – finance, Technology raw material, site and manpower. Costing, marketing management and quality control.	10
IV	• Project formulation- Meaning, types, project identification, generation of project idea, sources of project, screening, project formulation – steps	10

[239] SEC – Skill Enhancement Course; AEC – Ability Enhancement Course; VAC – Value Added Course; MD – Multidisciplinary Course

[240] 1 Credit (Theory) = 15 Hours; 1 Credit (Practical) = 30 Hours

	involved • Project reporting- Writing a business plan through planning, mobilization of resources and market surveys.	
V	• Government policies and schemes for support in enterprise development and management. • Agencies for training, infrastructure, financial help, and marketing- DIC, SIDO, NSIC, TCO, SISI, STEP, STED, KITCO, CIDCO, KVIC	9

Texts / References

1. Gupta.C.B& Sreenivasan N.P, Entrepreneurship Development in India, New Delhi,
2. Sultan Chand, 2007. Desai. V, Dynamics of entrepreneurial development & management, Mumbai, Himalaya publishing house, 2011.
3. Khanka .S.S., entrepreneurial development, S Chand & Co Ltd., Ram Nagar, New Delhi,
4. 2009
5. Jain, N.K &Varshney.R.L, Entrepreneurship Development-RBSA publications, Jaipur, 2009.
6. Journals:
7. Indian Journal of Social Entrepreneurship Entrepreneurship
8. Development and Management
9. International journal of gender and entrepreneurship

Learning Outcomes	Students will be able - • To exemplify the concepts of entrepreneurship management and develop skills towards it • To attribute resource mobilization, enterprise selection, assessment, marketing and quality control in organizing an enterprise • To identify gender issues in entrepreneurship development • To create business plans for setting up of enterprise

Clothing and Textiles

Course Title	**Fashion Design and Illustration (HSCMJ814 and HSCMJ815)**
Category of Course[241]	Major

Credits[242]& Hours of Teaching	Theory	Practical	Cumulative
Credits	3	2	**05**
Hours of Teaching (Total)	45	60	**105**

Course Objectives	• To understand the principles of design and elements of design, • To learn about fashion forecasting • To know about sketching

Units	Course Content	Hr. of Teaching
I	Elements and Principles used in dress design • Composition – With one element, With more than one element • Colour; its sensitivity and composition in dress • Components of fashion: Silhouette, Details, Colour, Fabric Texture	05
II	Sketching Garments and Accessories; • Sketching garment details: Necklines and collars, Sleeve details, Skirts and pants, Blouses, Coats and Jackets, Drawing and Fastenings, Tassels and Tucks, Frill fringes and Gathers, Cowls and Cascades, Hemlines and Insertions, Lacing, Macrame and Patchwork, Pleats, Quilting and Ties, Shirring, Smocking and zips, Yokes and skirts • Sketching of Accessories: Hats and head gear, Footwear, Bags and purses,	15

[241] SEC – Skill Enhancement Course; AEC – Ability Enhancement Course; VAC – Value Added Course; MD – Multidisciplinary Course

[242] 1 Credit (Theory) = 15 Hours; 1 Credit (Practical) = 30 Hours

	Jewellery	
III	Fashion Illustration • Colour matching using different mediums • Basic Rendering: Stripes, Checks, Gingham, Plaids, Patterns and Textures • Reducing print and shading • Rendering a line of garments based on themes (anyone): Beachwear, Swimwear, Casual wear, Sportswear, Nightwear, Cocktail wear, Evening wear, Ramp wear, Executive wear, Traditional Indian Costume	20
IV	Fashion forecasting, Study of markets and segment	05

PRACTICAL		
I	Sketching • Sketching of different sections of Croquis (front, back and side view) • Garment and garment details • Accessories	15
II	Preparation of Mood Board, Theme Board and Colour Board	20
III	Developing a line of garments on a theme (any two of the following); • Casual wear • Sportswear • Cocktail wear • Executive wear	10
IV	Sketching • Basic rendering techniques • Developing a line of garments based on a theme	05
V	Understanding and sketching theme based on fashion forecast • Sourcing of raw materials • Developing line, based on fabric and theme selected • Spec sheet study • Sampling • Garment analysis • Costing – construction of garments • Line presentation • Use of sale promotion material Designing of 5 garments for a selected theme; drafting and making patterns for thesame Construction of any 2 garments.	10

Texts / References	1. Tate, S.L. (2004). Inside Fashion Design Harper and Row (5th ed.). New York: Pearson/Prentice Hall. 2. Samuel, K. (1986). Life Styles, Fashion Styles (2nd ed.). Orbis London: TBS The Book Service Ltd. 3. Milbank, C.R. (1985). COUTURE, The Great Fashion Designers (1st ed.) Stewart, Tabori & Chang. 4. Carter, E. (1977). The Changing World of Fashion (2nd ed.). New York: G.P. Putnam's Sons. 5. Rubin, L.G. (1976). The World of Fashion (3rd ed.). San Fransisco: Canfield Press 6. Castelino, M. (1994). Fashion Kaleidoscope (1st ed.). BPI India Pvt Ltd. 7. Walz, B. and Morris, B. (1978). The fashion Makers, Random House
Learning Outcomes	After completion of the course, students will be able to; • Understand the composition of dress design, including working with one and multiple elements • Explore colour sensitivity and its role in dress composition. • Identify the key components of fashion, such as silhouette, details, color, and fabric texture. • Develop skills in sketching garment details, including necklines, collars, sleeves, skirts, pants, blouses, coats, jackets, and various fastenings. • Understand of the core knowledge of fashion themes based on forecasting, analyze

	garment construction costs, prepare line presentations, and utilizing sales promotion materials.
Course Title	**Eco-Friendly Textiles; Processing and Finishes(HSCMJ816 andHSCMJ817)**
Category of Course[243]	Major

Credits[244]& Hours of Teaching		Theory	Practical	Cumulative
	Credits	3	1	**04**
	Hours of Teaching (Total)	45	30	**75**

Course Objectives	• To make the students aware about the needs and importance of eco-friendly textiles • To educate them about the eco-textile processing • To make them efficient in the processing of natural dyes • To understand the labeling standards used in eco-friendly textile products

Course Content

Units	**Course Content**	**Hr. of Teaching**
I	Eco-friendly Fibers; Introduction, Needs and Importance Ecology; Production ecology, Human ecology and Disposal ecology. Natural fibers; Importance of natural fibers in textiles, Major fibers used in textiles - cotton, jute, linen, and silk. Minor fibers used in textiles - sisal, pineapple, coir, nettle. Protein fibers - soya, spider silk. Extraction or preparation methods of natural fiber-retting and its methods, decortications by hand and machine. Recent findings of natural fibers in the textile industry.	10
II	**Eco-Textile Processing** Eco textile processing and its role in sustainable development, Enzyme meaning; properties of enzymes used in textiles, application of enzymes in Textile processing- Bio-desizing, bio-scouring, bio-bleaching, bio-polishing, bio-stoning, enzymatic degumming and enzymatic retting; Methods and uses.	10
III	**Natural Dyes** History and Importance, Types of Natural dyes, Sources; plant, animals and minerals, Dye Extraction methods;Ultrasonic and microwave extraction, enzymatic extraction, solvent extraction, supercritical carbon dioxide extraction Application of dyes on fabrics, Mordants; natural mordants; Importance, Mordanting techniques; pre, meta, and post mordanting. Importance of natural dyed fabrics.	10
IV	**Natural Finishes, Eco-labeling, and standards, Importance of natural finishes** Traditional plants and herbs are used in natural finishing. Recent Natural finishes on textiles-. Enzyme technology, Foam technology, Supercritical carbon-di-oxide dyeing, and Plasma technology. Eco-labeling and various eco-standards for textiles - Eco-auditing. Ethical Manufacturing: Ethical and environmental issues relating to the textile and fashion industry. Ethical Standard Practices for sourcing sustainable fashion clothing and accessories. Corporate Social responsibility in Environment protection –Importance –Environmental impacts of textile industries.	15

PRACTICAL		
I	• Group discussion on the concept of eco-friendly processing. • Preparation of dye shade chart using natural dyes from various dye sources and mordants.	18

[243] SEC – Skill Enhancement Course; AEC – Ability Enhancement Course; VAC – Value Added Course; MD – Multidisciplinary Course

[244] 1 Credit (Theory) = 15 Hours; 1 Credit (Practical) = 30 Hours

II	Performany two of the following in textile processing: • **Bio-desizing**:Using amylases to remove starch-based sizing. • **Bio-scouring**: Applying enzymes to clean fibers. • **Bio-bleaching**: Using enzymes for eco-friendly bleaching. • **Bio-polishing**: Enhancing fabric surface smoothness. • **Enzymaticdegumming**: Removing sericin from silk. • **Enzymatic retting**: Extracting fibers from plant materials	8
III	• Design a campaign or brochure promoting eco-friendly textiles.	4

Texts / References	1. Muthu, S. S. (Ed.). (2017). *Sustainable Fibres and Textiles* (1st ed.). Woodhead Publishing. 2. Sheikh, J. N., & Teli, M. D. (2024). *Sustainable Textile Chemical Processing* (1st ed.). CRC Press 3. Periyasamy, A. P., & Venkatesan, H. (2018). *Eco-Materials in Textile Finishing* Springer, Cham 4. Mirraftab, M. and Horrocks, A.R. (2007). Eco-textiles: The way Forward for sustainable development in textiles. Florida: CRC Press. 5. Slater, K. (2003). Environment Impact of Textiles: Production, Process and Protection. Florida: CRC Press.
Learning Outcomes	After completion of the course, students will be able to; • Understand and explore the importance of natural fibers in textiles • Learn about the importance of natural dyes and explore different types of natural dyes (Plant, animal, mineral) • Understand the importance of natural finishes in textile processing and recognize traditional plants and herbs used for natural finishing. • Explore recent advancements in natural finishes. • Learn about eco-labeling standards and their relevance in the textile industry

Course Title	**Garment Production Technology and Management (HSCMJ818)**			
Category of Course[245]	Major			
Credits[246]& Hours of Teaching		Theory	Practical	Cumulative
	Credits	3	-	**04**
	Hours of Teaching (Total)	45	-	**75**
Course Objectives	● To enable the students to get acquainted with the latest garment/clothing manufacturing technology related to the current practice in the clothing industry ● To make the students aware of the influence of garment retailing on the clothing production process ● To impart knowledge about the latest electronic equipment and machines used in the garment industry ● To make students aware of the importance of maintaining quality standards during production			

Course Content

Units	**Course Content**	**Hr. of Teaching**
I	Introduction to the background and structure of the garment/clothing industry, Role and importance of textile and Garment Industry in the Indian economy, Problems and prospects of textile and garment industry. • Textile policy • Textile industry Management: Management hierarchy, responsibilities, coordination, organization, management aids, factors influencing management organization, Comparative organization of different textile groups, Organization	15

[245] SEC – Skill Enhancement Course; AEC – Ability Enhancement Course; VAC – Value Added Course; MD – Multidisciplinary Course

[246] 1 Credit (Theory) = 15 Hours; 1 Credit (Practical) = 30 Hours

	of senior management, organization of productive functions, Department management	
II	The organization of a garment factory, Principles of Management, Various Departments like: a) Design Department b) Marketing Department c) Finance Department d) Purchasing Department e) Production Department f) Operations Department	10
III	Manufacturing Technology 1. Cutting & Cutting Room- Market Planning, Efficiency, Method & Use of worker plan, Methods of spreading of fabric and requirements of the spreading process, Cutting the fabric – objectives and methods of cutting fabric 2. Fusing Technology 3. Sewing Technology: Sewing – properties, types, Stitch – types, Sewing Machines – Feed mechanisms, machine needles, Sewing threads – type of fiber, construction and finish, thread size, thread package, thread costs, thread properties and seam performance, Sewing problems – stitch formations, damage along the seam line puckering, Testing for sewability and tailorability, Sewing Machinery, Use of components and trims 4. Alternative methods of joining materials: Welding and adhesives, Moulding 5. Pressing Technology 6. Production Technology 7. Warehousing	15
IV	Engineering & Quality Control, Production Engineering and Principles of Quality Control	05

Texts / References	**References** 1. Cooklin, G. (2006). *Introduction to Clothing Manufacture* (2nd ed.). Wiley-Blackwell. 2. Carr, H. and Latham, B. (1944). *The Technology of Clothing Manufacture* (2nd ed.). Willey publication. 3. Chuter, A.J. (1995). *Introduction to Clothing Production Management* (2nd ed.). Wiley publication. 4. Tyler, D.J. (1992). *Materials Management in Clothing Production* (1st ed.). Wiley Blackwell Science. 5. Carr, H. and Latham, B. (1992): *Fashion Design and Product Development* (1st ed.). Wiley Blackwell Science.
Learning Outcomes	By the end of the course, students will be able to: • Acquire knowledge about the role of the garment industry in the Indian economy • Understand the background, structure, and importance of the garment industry in the Indian economy and explore problems and prospects related to the textile and garment industry. • Able to comprehend the textile sector, which will foster the growth of entrepreneurial abilities. • Understand the garment technology, learn about garment retailing, and uses of machines in the garment industry.

Human Development and Family Studies

Course Title	**Methods and Techniques of Assessment in Human Development (HSCMJ819 andHSCMJ820)**			
Category of Course[247]	Major			
Credits[248]& Hours of		Theory	Practical	Cumulative
	Credits	3	2	5

[247] SEC – Skill Enhancement Course; AEC – Ability Enhancement Course; VAC – Value Added Course; MD – Multidisciplinary Course

Teaching	Hours of Teaching (Total)	45	60	105
Course Objectives	• To apprise the students with different methods and techniques of assessment in human development. • To develop skills in psychological test administration, scoring, analysis, interpretation and report writing. • To learn practically about assessment of human growth and development			

Course Content

Units	Course Content	Hr. of Teaching
I	**Developmental assessment, methods and techniques.** Assessment –Concept, functions, characteristics, steps and rationale of assessment. History of tests and measurements. Different methods of child study/ developmental assessment. Techniques of measurement and their significance in measuring different aspects of human development. Role of assessment in intervention.	08
II	**Types of measures & methods** Scientific methods-definition, importance, goals and steps. Essential criteria of Scientific methods -reliability, validity control, item analysis. Use of objective measures and methods. Types of tests – individual and group tests. Projective techniques. Psychometrics, Sociometry. Types of scales –nominal, ordinal, interval and ratio scale	07
III	**Development of tests/ scales** Developmental Assessment from birth to early childhood. Tests for infants andchildren. APGAR scoring of new borns. Physical growth assessment. Anthropometricevaluation of nutritional status. Measurement of intelligence. Assessment ofpersonality, aptitude, attitude and environment. Development of test/scale, steps,guidelines and standardization procedure – various methods of calculation of validityand reliability. Variables- extraneous, confounding, researcher variables andparticipant variables affecting internal validity. Threats to internal validity.	15
IV	**Ethical issues and barriers** Ethical issues in the assessment of human development. Special consideration inassessing young children. Ethical issues and barriers in assessment of infants andyoung children. Assessment of children with special needs. Interpretation and useof assessment information. Trends and challenges in assessment of human behavior.	15
PRACTICAL		
I	• Visit to neonatal unit to observe the neonates and to observe their assessment of APGAR score by pediatricians. • Physical growth assessment and nutritional status of children of different age groups. • Review of available developmental screening and diagnostic tests for infants, toddlers and pre-school children. • Review of available screening and diagnostic tests for school age children and adolescents.	15
II	• Developmental assessment of infants by using Bayley's Scale of Infant • Development (BSID). Interpretation of results and report writing • Administration of psychological tests for measuring cognitive abilities andintelligence.	15
III	• Administration of psychological tests for assessment of social, emotional, language and overall personality assessment of children.	10
IV	• Assessment of home environment using HOME (Home Observation and Measurement of Environment) inventory for different age groups of children/Indian Home Inventory/ Family Environment Scale.	10

[248] 1 Credit (Theory) = 15 Hours; 1 Credit (Practical) = 30 Hours

	Interpretation of results and report writing on home environment.	
V	• Development of scale or check lists on selected areas of development. Standardization of the developed test, scoring and interpretation of results.	10

Texts / References	1. Anastasi A. 1988. *Psychological Testing*. 6th Ed., McMillan Publishing Company, New York. 2. Bailey DB and Worley M. 2003. *Assessing Infants and Preschoolers with Handicaps*. MerrillPublishing Company, Delhi. 3. Gregory RJ. 2004. *Psychological Testing - History, Principles and Applications*. 4th Ed.Pearson Education, Atlantic. 4. Gumbiner J. 2003. *Adolescent Assessment.* John Wiley & Sons, New Jersey. 5. Kumar R. 2014. *Research Methodology - A Step by Step Guide for Beginners*, 4th Ed., SagePublications, New Delhi. 6. Miller LA, Macintire SA and Lovler RL. 2012. *Foundations of Psychological Testing – APractical Approach*. 4th Ed., Sage Publications, New Delhi. 7. Shaughnessy JJ and Zechmeister EB. 2014. *Research Methods in Psychology*. 10th Ed.,McGraw - Hill Publishing Company, New York.
Learning Outcomes	• Understanding of different methods of assessment in human development • Development of psychological skill testing, scoring , analysis etc.

Course Title	**Programme Development for Vulnerable Families (HSCMJ821 andHSCMJ822)**
Category of Course[249]	Major

Credits[250]& Hours of Teaching

	Theory	Practical	Cumulative
Credits	3	1	4
Hours of Teaching (Total)	45	30	75

Course Objectives

- To make the students learn to identify vulnerable population in rural and urban areas.
- To develop an understanding regarding techniques of planning, implementing and evaluating development and programmes and projects for vulnerable families.
- To provide practical knowledge of projects and programmes running for vulnerable,
- SWOT analysis and programme evaluation by using several methods

Course Content

Units	Course Content	Hr. of Teaching
I	**Programmes for vulnerable families** Developmental programmes for vulnerable families. Types of programmes and projects for vulnerable families. Different approaches to develop programmes for families. Inter disciplinary approach to research project management. National and international research projects for vulnerable families. National and International programmes and policies for vulnerable children and families. UNICEF framework for protection, care and support of orphans and vulnerable children. National Plan of Action for protection and care of children	15
II	**Programme development – elements and process** Need assessment of vulnerable families. Development of need based multiple programmes or vulnerable families and children - project proposal, principles of project design, steps, guidelines, process involved, aspects of appraisal, basic considerations, risks and returns in project proposal development. Elements of effective programmes for families. Project sustainability- factors, components and action plan. Scientific values Role of Human Development and Family Studies and professional ethics in development of programmes for vulnerable population. Donors and funding agencies-types, National and International donors funding projects. Role of public and private	15

[249] SEC – Skill Enhancement Course; AEC – Ability Enhancement Course; VAC – Value Added Course; MD – Multidisciplinary Course

[250] 1 Credit (Theory) = 15 Hours; 1 Credit (Practical) = 30 Hours

	donors in funding projects.	
III	**Working with vulnerable families** Working with vulnerable families- need, goals and significance. Developing strategies to support vulnerable children and their families. Ethics in working with vulnerable families. Working with children in vulnerable families- need, goals, and strategies. Family resilience in the face of adversities- concept, risk and protective factors. Strengthening family relations. Including fathers in work with vulnerable families. Implementing the stimulating management techniques- Programme Evaluation and Review Technique (PERT), Critical Path Method (CPM), Line of Balance (LOB), Gantt Chart and SWOT analysis.	15
PRACTICAL		
I	• Review of the national international projects and programmes for vulnerablefamilies. • Discussion on programmes and research projects • Development of need assessment performa • Learning to use selected PRA techniques – – Focus group discussions/ interviews – Transit walk, social mapping and time line. • Programme Evaluation by using- Programme Evaluation and Review Technique (PERT), Critical Path Method (CPM) • SWOT analysis • Development of concept note for research project on vulnerable families	15
II	Interviewing families with need assessment Developing need based programme for vulnerable families Class discussion on developed programme and enhancement.	7
III	• Programme implementation – Working with families and execution of developedprogrammes- home based approach • Working with families and execution of developed programmes- child centredapproach	8

Texts / References	1. Chandra P. 1995. *Project Planning, Analysis, Selection, Implementation and Review*. Tata McGraw, New Delhi. 2. Chaudhary DP. 1992. *Women Welfare and Development*. NIPPCD, New Delhi. 3. Duration (Weeks)Topics Community Science: Human Development and Family Studies 4. Dunst C, Trivette C and Angela D. 1998. *Enabling and Empowering Families: Principlesand guidelines for families.* Brookline Books, Inc. Newton. 5. Golden O, Lopres P and Mills G. 2012. *Economic Security for Extremely Vulnerable Families:Themes and Options for Work-force Development and Asset Strategies.* Urban Institute, University of New Hampshire, New Hampshire. 6. Resource and Development Unit. 2012. *Supporting Vulnerable Families: Self-guided learningpackage.* Community Child Care Unit, Victoria. 7. Mynarska M, Riederer B and Jaschinski I. 2015. *Vulnerability of families with children:Major risks, future challenges and policy recommendations*. Wittgenstein Centre for Demography and Global Human Capital, stockhome 8. https://www.dcya.gov.ie/documents/publications/A_Guide_to_what_Works_in_Family_Support_Serviecs_for_Vunerable_Families.pdf 9. https://www.who.int/maternal_child_adolescent/documents/pdfs/lancet_child_dev_series_paper3.pdf 10. https://www.unicef.org/aids/files/Framework_English.pdf 11. https://www.cambridge.org/working-with-vulnerable-families/children-in-the-midst-offamily-and-domestic-violence
Learning Outcomes	• Learning of identification of vulnerable population and finding out suitable technologies for the solution of their needs

Course Title	**Dynamics of Human Development (HSCMJ823)**
Category of Course[251]	Major

Credits[252]& Hours of Teaching	Theory	Practical	Cumulative
Credits	3	NA	3
Hours of Teaching (Total)	45	NA	45

Course Objectives

- To impart information to students regarding advanced concepts of human development, current trends and issues of development.
- To provide in depth understanding of the developmental concepts and processes in human life span.

Course Content

Units	**Course Content**	**Hr. of Teaching**
I	**Nature vs. Nurture** Human development – basic concepts and issues. Genetic foundation, genetic code, chromosomal abnormalities. Role of epigenesis and canalization in growth and development. Interface between heredity and environment. Genetic research and its influence on child's development. Current research findings on pre-natal development and neo-natal stages – developmental sequence, prenatal environmental influences, developmental threats and DNA methylation.	15
II	**Cognitive development** Brain development- key concepts and process of development. Models of intelligence. Cognitive development during early years - perceptual capacities, attention, memory, imitation, early learning, conditioning and assessment. Role of early deprivation and enrichment in cognition. Information processing. Social cognition, emotional intelligence, metacognition and self regulation and their contribution to human mind and behavior. Gardner's Model of Multiple Intelligence. - Sketching of Accessories: Hats and head gears, Footwear, Bags and purses, Jewellery	10
III	**Psycho-social Issues** Language development and its components - pre-linguistic development, phonology, semantics and bilingualism. Socialization practices and influencing factors. Cultural influence on child outcomes. Exposure to media and technology and role of parents and institutions. Impact of socio-emotional deprivation on different stages of development. Vulnerability and resilience, risk and protective factors. Personality changes and self-perceptions through different stages of development. Integrated view of human development.	10
IV	**Current and classic research trends in human development** Seminal work of Sigmund Freud, Erikson, Piaget, Uri Bronfenbrenner and Margaret Mead. Design and field work of "Six cultures project". Current research trends in physical, intellectual, psycho- social and moral development of children from birthto adolescence.	10

Texts / References

1. Berk EL. 2017. *Development Through the Life Span*. 7th Ed., Pearson Education, Atlantic.
2. Bronfenbrenner V. 1979. *The Ecology of Human Development*. Cambridge, Harvard.
3. Feldman RS. 2017. *Development Across the Life Span.* Pearson, London, England.
4. Garbarino J. 1982. *Children and Families in the Social Environment*. Aldine, New York.
5. Kail R and Cavaraugh JC. 2016. *Human Development - A Life Span View.* Cenage Learning, Boston.
6. Papalia DE and Olds SW. 2008. *Human development*. 11th Ed., McGraw Hill, New York
7. Santrock JW. 2006. Life Span Development. Mc Graw Hill, New York.

[251] SEC – Skill Enhancement Course; AEC – Ability Enhancement Course; VAC – Value Added Course; MD – Multidisciplinary Course

[252] 1 Credit (Theory) = 15 Hours; 1 Credit (Practical) = 30 Hours

Learning Outcomes	• Understanding of advanced concepts of human development, current trends and issues of development • Understanding of the developmental concepts and processes in human life span

Family Resource Management

Course Title	**Family Finance and Personal Financial Management (HSCMJ824 and HSCMJ825)**
Category of Course[253]	Major
Credits[254]& Hours of Teaching	

	Theory	Practical	Cumulative
Credits	3	2	**05**
Hours of Teaching (Total)	45	60	**105**

Course Objectives	• To understand the basics of family finance, • To know about the need of insurance, Tax planning etc. • Understandings of concept of expenses, income, budget etc. • Learning of financial security, goal and importance of insurance

Course Content

Units	Course Content	Hr. of Teaching
I	**Family Finance** • Income: Concept of income, Types of income, Sources of family income. • Family Expenses Meaning, Different items of expenditure, factors affecting expenditure of family. • Budgeting: Objectives,Importances, Types of budgets, Advantages of budget. **Investment:** Meaning,Time value of money, Principals of investment, Types of investment, Bank and post office deposits, Shares, Bonds, Mutual funds.	20
II	**Insurance** • Meaning and advantages of various insurances, • Types of insurance-Life, health, goods. • Tax Planning: Concept of tax, types of taxes. e.g. Direct • and indirect taxes. Methods of tax collection. • Financial goal: Setting financial goals e.g. Paying off debts, buying a home, building emergency fund, saving for • retirement.	15
III	• Spendings reduction: Avoid impulse spending, identify and control expenses, reduce debts, monitor cash flow and maintaining good credit score, preserving health	10

PRACTICAL		
I	• Identify income, expenditure and budget planning for Different income groups.	20
II	• Knowledge of e-banking. • Calculation of income tax.	20
III	• Outreach program on insurance -Life/health field consumers.	20

[253] SEC – Skill Enhancement Course; AEC – Ability Enhancement Course; VAC – Value Added Course; MD – Multidisciplinary Course

[254] 1 Credit (Theory) = 15 Hours; 1 Credit (Practical) = 30 Hours

Texts / References	1. Patni. M., (2015), Ergonomics, Star Publications, 1st Edition, ISBN- 9789381246511. 2. Shrilakshmi,B., Nutrition Science, New Age Publishers Pvt. Ltd, 6th Edition, ISBN-9789386418883.
Learning Outcomes	• Understandings of concept of expenses, income, budget etc. • Learning of financial security, goal and importance of insurance • Understanding of budget, calculation of tax, e- banking procedures and life-insurance and its need.

Course Title	**Interior Designing and Landscaping ((HSCMJ826 and HSCMJ827)**			
Category of Course[255]	Major			
Credits[256]& Hours of Teaching		Theory	Practical	Cumulative
	Credits	3	1	**04**
	Hours of Teaching (Total)	45	30	**75**
Course Objectives	• To know the fundaments of interior designing, uses of colours and design composition • To understand the need, scope, advantages of landscaping • To know about the landscaping trees. • To know about the rooms-its accessories, designing of terrace and garden and field experience of landscape garden.			

Course Content

Units	**Course Content**	**Hr. of Teaching**
I	• Importance of interior design and the importance of good taste. • History of Interior Design. • Objectives of Interior Design and furnishing. • **Colour-** Uses and application of colours. • Uses of colour for residential and commercial purposes. • **Basics of design composition-** Building materials, Sustainable building materials and building services. • Types of walls, floorings and ceiling finishings. • Accessories and their use in interior design.	20
II	**Landscaping** ● Meaning, importance and scope of landscaping, History of gardening in India. Principals and elements of landscaping.	15
III	● Landscaping for different purposes. ● Garden features and advantages. ● Different plant species for landscaping annuals, trees, shrubs, climbers and their uses. ● Bonsai-types and importance	10

PRACTICAL		
I	Study of different accessories for different rooms.	05
II	Room arrangement for different activities(Residential/Commercial)	10
III	• Designing of terrace /front garden. • Visit to landscape garden	15

Texts / References	1. Rao, M. P. (2020),Interior Design: Principles and Practice, Standard Publishers and Distributors pvt.ltd., ISBN-978-8180141560.

[255] SEC – Skill Enhancement Course; AEC – Ability Enhancement Course; VAC – Value Added Course; MD – Multidisciplinary Course

[256] 1 Credit (Theory) = 15 Hours; 1 Credit (Practical) = 30 Hours

	2. Shankaraswamy, J., &Neelavati, R. (2022), Landscaping: an introduction 3. Shrubs in landscaping , Narendra Publishing House. 4. Trees in landscaping , Narendra Publishing House. 5. Palms in landscaping, Narendra Publishing House.
Learning Outcomes	• Understanding of basics of interior design, accessories used in it, concept of colour etc. • Learning of landscaping, it's uses in interior designing • Understanding of arrangement of rooms, front garden designing and landscape garden.

Course Title	**Advertising and Labelling information (HSCMJ828)**			
Category of Course[257]	Major			
Credits[258]& Hours of Teaching		Theory	Practical	Cumulative
	Credits	3	-	3
	Hours of Teaching (Total)	45	-	45
Course Objectives	• To know the basics of advertising- its techniques, script writing etc. • To gain insights of media, labelling information and standard • To understand the preparation of labels for different items.			

Course Content

Units	**Course Content**	**Hr. of Teaching**
I	Advertising - Meaning, types, Importance and Advertisement appeal.	5
II	Evaluation of advertising effectiveness. Techniques of advertising - Media planning, advertising code, choosing content and advertising Research.	5
III	Script - Writing for advertisement using different Audiovisual methods. Print media and video media.	15
IV	Labeling information - Meaning, types and Importance. Labeling standards in India.	10
V	Preparation of labels for different items - Food Items, fabric and electric items	10

Texts / References	1. वैज्ञानिकदृष्टिकोणएवंसिद्धांत, नरेंद्रसिंहयादव,राजस्थानहिंदीग्रंथअकादमी 2. Juan carlos Gaaquez- Abad, franciso J. Martinez- Lopez, Katrijn Gielens (Ed)- (2023). Advances in National brand and private label marketing, Springer 3. Wiedeeman, J-Ed- (2011). Labels and Packaging design: the power of branding at the point S purchase. Taschen
Learning Outcomes	Understanding the meaning, importance and types of advertisement, techniques of advertising, script writing and label preparation.

[257] SEC – Skill Enhancement Course; AEC – Ability Enhancement Course; VAC – Value Added Course; MD – Multidisciplinary Course

[258] 1 Credit (Theory) = 15 Hours; 1 Credit (Practical) = 30 Hours

4- Year U.G Degree (Honours with Research)
****Students should choose any one paper according to their selected branch in VII[th] and VIII[th] Semester**

Foods and Nutrition

Course Title	**Research Methodology and Scientific Writing (HSCMJ7R1)**
Category of Course[259]	**Major**

Credits[260]& Hours of Teaching		Theory	Practical	Cumulative
	Credits	4	NA	4
	Hours of Teaching (Total)	60	NA	60

Course Objectives	• To address the issue in selecting a research problem. • To understand the tools and techniques needed for completing research • To learn about writing scientifically

Course Content

Units	Course Content	Hr. of Teaching
I	**RESEARCH METHODS** **Science, scientific methods, scientific approach: Role** of statistics and research in Home Science discipline: Objectives of research: Explanation, control and prediction.	10
II	**Types of Research:** Historical, survey, experimental, case study, social research, participative research. Definition and Identification of a Research Problem, Selection of research problem, Justification, Theory, hypothesis, basic assumptions, limitations and delimitations of the problem. Types of variables	10
III	**Theory of probability:** Population and sample, Probability sampling: systematic random sampling, two stages and multi stage sampling, cluster sampling, Non-Probability sampling: purposive, quota and volunteer sampling/snowball sampling. Basic Principles of Research Design and hypothesises: Purposes of research design; Fundamental, applied and action exploratory and descriptive experimental, survey and case study, ex-post facto, Longitudinal and cross sectional	15
IV	**Qualitative Research Methods:** Theory and design in qualitative research, Definition and types of qualitative research, Methods and techniques of data collection, Informal group discussions, Interviews; Key informants, in-depth interviews, Observations	15
V	**Critical analysis of research.**	10

Texts / References	1. Bandarkar, P.L. and Wilkinson, T.S. (200): Methodology and Techniques of Social Research, Himalaya Publishing House, Mimbai. 2. Bhatnagar, G.L. (1990): Research Methods and Measurements in Behavioural and Soxial Sciences, Agri. Cole Publishing Academy, New Delhi. 3. Dooley, D. (1995): Strategies for interpreting Qualitative Data; Saga Publications, Claifornia. 4. Gay, L.R. (1981, 2nd Ed.): Educational Research, Charles, E. Merill, Columbus, Ohio. 5. Long, J.S. (Ed.) (1988): Common Problems Proper Solutions: Avoiding Errors in Quantitative Research Beverly Hills, Sage Publications, California. 6. Mukherjee, R. (1989): The Quality of lIfe: Valuation in Social Research, Saga Publications, New Delhi. 7. Stranss, A. and Corbin, J. (1990): Basis of Qualitative Research: Grounded Theory Procedures and Techniques, Saga Publications, California.
Learning Outcomes	Understanding of statistical techniques, learning of various statistical test used to approve hypotheses and uses of computer in research

[259] SEC – Skill Enhancement Course; AEC – Ability Enhancement Course; VAC – Value Added Course; MD – Multidisciplinary Course

[260] 1 Credit (Theory) = 15 Hours; 1 Credit (Practical) = 30 Hours

Course Title	**Food Safety and Microbiology (HSCMJ7R2 and HSCMJ7R3)**
Category of Course[261]	Major

Credits[262]& Hours of Teaching		Theory	Practical	Cumulative
	Credits	3	2	05
	Hours of Teaching (Total)	45	60	105

Course Objectives	• To provide fundamental concept of the microorganism associated with food and their characteristics. • To providethe concept of preservation and microbiological safety in various food operations.

Course Content

Units	Course Content	Hr. of Teaching
I	Introduction to Food Microbiology • Definition and scope of Microbiology • History of Microorganism in food- Food Preservation, spoilage Infections and Legislations	5
II	Microorganism in Food • Taxonomy, Role and Significance of microorganisms in food-Food Borne Bacteria, Food Borne Moulds, Food Borne Yeasts, Viruses and Parasite • Factors affecting growth of Microorganism–Intrinsic Parameters, Extrinsic Parameters, Bacterial Growth Curve • Food Borne Diseases: Origin and symptoms - Types- Food Borne Infections, Intoxications and Toxic infection	10
III	Cultivation of Microorganism Repair, detection and sampling of microorganism, Methods of sampling and detection- a. Conventional Methods of isolation-Pure culture methods (Standard Plate Count), Membrane filter technique, Most probable number, Direct microscopic count, electronic counter, dye reduction test b. Rapid Methods of isolation-Physical Methods: Biosensors, Flow Cytometry, Microcalorimetry. Biological/ Immunological Methods: Fluorescent Antibody, Radioimmunoassay, ELISA, Gel Diffusion. Molecular GeneticMethods- Polymerase Chain Reaction, Chemical Methods: Thermo-stable Nuclease, Adenosine Triphosphate Measurement, Bioassay	15
IV	Food Safety and Quality Control 1. Concept of Food Safety Management, GHP and GMP 2. HACCP. ISO 22000 3. Food Laws, Regulations and Standards Control of Microorganism in Foods: Principles and methods of preservation, Physical Methods of Food Preservation- Dehydration,Freezing, Cool Storage, Heat Treatment, Irradiation, Chemical Methods, Biopreservatives esp. Bacteriocins, Introduction to Hurdle concept and Non Thermal Methods	15

Practical

Units	Course Content	Hr. of Teaching
I	• Understanding Morphology and Structural Features of Various Microorganism: Preparing different types of media. • Learning of different instruments used in microbiology laboratory	20

[261] SEC – Skill Enhancement Course; AEC – Ability Enhancement Course; VAC – Value Added Course; MD – Multidisciplinary Course

[262] 1 Credit (Theory) = 15 Hours; 1 Credit (Practical) = 30 Hours

II	• Staining of bacteria: Gram's Staining, acid-fast spore, capsule and Flagellar Staining, Motility of bacteria, Staining of yeast and molds. • HACCP plan for a food process	20
III	• Microbiological analysis for- Water (Most Probable Number), Milk (Methylene Blue Reduction Test), Curd and probiotic count, adulteration test for microorganism detection.	20

Texts / References	1. Jay, B. J., Loessner,J. M., Golden, A. D.Modern Food Microbiology.SeventhEdition.Food Science Text Series. 2. Frazier, W.C.&Westhoff, D.C.(2014). Food Microbiology. Fifth Edition. TMH Publication, New Delhi. 3. Garbutt, J. (1997). Essentials of Food Microbiology. Arnold London. 4. Mathur, P. (2018). Food Safety and Quality Control. 1st Edition. Orient Blackswan Private Ltd. India. 5. Ravishashankar, R. &Jamuna, B. (2015). MicrobialFood Safety and Food Preservation. CRC Press, Boca Raton.
Learning Outcomes	• Develop understanding of important genera of microorganism associated with food and their characteristics, their growth pattern and parameters. • Develop learning about various preservation and control techniques in various food operations.

Course Title	**Applied Food Science (HSCMJ7R4 and HSCMJ7R5)**			
Category of Course[263]	**Major**			
Credits[264]& Hours of Teaching		Theory (T)	Practical (P)	Cumulative
	Credits	3	2	**05**
	Hours of Teaching (Total)	45	60	**105**
Course Objectives	• The goal of the course is to give students a systematic understanding of the chemistry of food ingredients such as proteins, fats, and carbohydrates as well as pigments. • Students will also gain insight into the additives that are important to the processed food industry.			

Course Content

Units	Course Content	Hr. of Teaching
I	**Properties of food**- physical, chemical and functional, Protein Structure and properties, factors affecting properties and its interaction with other food constituents- Denaturation, Coagulation.	05
II	**Carbohydrate**: Structure and properties, factors affecting properties and its interaction with other food **a. Sugar-** Structure and properties, their application in food system, crystallization, caramelization, Maillard reaction and its industrial application, factors affecting properties and its interaction with other food constituents- Sweetness, preservation, appearance, freezing point, fermentation **b. Starches-** Structure and properties, factors affecting properties and its interaction with other food constituents- Starch gelatinization, Dextrinization, Functional properties- Thickening property, binding properties. Introduction to polysaccharides, Resistant starch, Genetically Modified Starch, Non-starch polysaccharide, dietary fibre	15
III	• **Lipids**: Structure and properties, factors affecting properties and its interaction with other food constituents- Rancidity, emulsion, Role of Food lipids in flavour.	10
IV	• **Food pigments, colorants and additives:** Pigments in animal and plant tissues,	10

[263] SEC – Skill Enhancement Course; AEC – Ability Enhancement Course; VAC – Value Added Course; MD – Multidisciplinary Course

[264] 1 Credit (Theory) = 15 Hours; 1 Credit (Practical) = 30 Hours

	Food colours; Types and properties, regulatory aspects, safety issues.	
V	• **Food adulteration**: Its types and contaminant & Detection **Beverages:** Harvesting, processing and by-products; Coffee, tea, cocoa, alcoholic beverages.	05
PRACTICAL		
I.	• Preparation and preservation of Jam and Jellies and pickles • Drying and dehydration of fruits and vegetables	20
II	• Spray drying of Milk • Preparation of fermented products • Sensory evaluation of food items	20
III	• Identification of food packaging materials • Determination of quality of eggs • Quality analysis of water from different sources	20

Texts / References	1. B. Srilakshmi - Food Science, New Age International Publishers, 8th edition 2. Shakuntala, M. N., Shadaksharaswamy, M. (1998). Foods, Facts and principles, new age international publishers, New Delhi. 3. BIS standards for food products and analysis manual. 4. Manuals of methods of analysis of various food products, FSSAI, 2016
Learning Outcomes	• To provide learning of chemistry of components like proteins, carbohydrates and lipids. • Students will learn about food additives that are relevant to processed food industry.

Course Title	**Social and health issues in Society (HSCMJ7R6)**
Category of Course[265]	Major

Credits[266] & Hour of Teaching

	Theory	Practical	Cumulative
Credits	2	--	2
Hour of Teaching (Total)	30	--	30

Course Objectives	• To cultivate a positive outlook on health and well-being among students • To increase students understanding of National development policies of Govt. and Non-Govt. organization

Course Content

Units	Course Content	Hr. of Teaching
I	Health & well-being • Mental health & wellbeing • Physical • Emotional • Social	05
II	Policies to improve health in different age group by Government & Non - governmental organization with recent trends • Health care system in India • Disabilities	05
III	Policies regarding societal issues in different stages of life of human by Government & Non - governmental organization • Child protection acts • Gender Issues- Women empowerment, Gender Gap, Triple Talaq , Sexual Harassment at Workplace • Poverty related issues	10

[265] SEC – Skill Enhancement Course; AEC – Ability Enhancement Course; VAC – Value Added Course; MD – Multidisciplinary Course

[266] 1 Credit (Theory) = 15 Hours; 1 Credit (Practical) = 30 Hours

IV	Role of traditional media and modern media in development communication- • Communication technology • Gender in extension (Issues & prospects)	10

Texts / References	1. Park, K. (2019). Preventive and social medicine.Banarsidas Bhanot Publishers. Edition- 27, ISBN-9789382219194. 2. Dhama,O.P., &Bhatnagar,O.P.(1987). Extension and communication for development. Oxford & IBH Publishing Co .Edition- 2nd,ISBN – 9786459990314. 3. Ahuja,R. (2000). Bhartiya Samaj. Rawat Publications. Edition- 2007, ISBN - 8170336392. 4. Srivastava,D.N. AsamanyaManovigyan. Sahitya Prakashan Agra. Edition- 13th.India YearBook (2024) Publications Division, Ministry of Information and Broadcasting, Government of India.
Learning Outcomes	• Students will develop skills to critically evaluate and analyze health and well-being policies, understanding their effectiveness for various age groups and disabilities. • They will gain insights into the impact of legal frameworks like the Child Protection Act and societal policies on development and integration. • Students will assess the roles of traditional and modern media in health communication and explore how gender issues influence extension services, proposing strategies for improved gender equity.

Course Title	**Research Methodology and Scientific Writing (HSCMN7R1)**			
Category of Course[267]	Minor			
Credits[268]& Hours of Teaching		Theory	Practical	Cumulative
	Credits	4	NA	4
	Hours of Teaching (Total)	60	NA	60
Course Objectives	• To address the issue in selecting a research problem. • To understand the tools and techniques needed for completing research • To learn about writing scientifically			

Course Content

Units	**Course Content**	**Hr. of Teaching**
I	**RESEARCH METHODS** **Science, scientific methods, scientific approach: Role** of statistics and research in Home Science discipline: Objectives of research: Explanation, control and prediction.	10
II	**Types of Research:** Historical, survey, experimental, case study, social research, participative research. Definition and Identification of a Research Problem, Selection of research problem, Justification, Theory, hypothesis, basic assumptions, limitations and delimitations of the problem. Types of variables	10
III	**Theory of probability:** Population and sample, Probability sampling: systematic random sampling, two stages and multi stage sampling, cluster sampling, Non-Probability sampling: purposive, quota and volunteer sampling/snowball sampling. Basic Principles of Research Design and hypothesises: Purposes of research design; Fundamental, applied and action exploratory and descriptive experimental, survey and case study, ex-post facto, Longitudinal and cross sectional	15
IV	**Qualitative Research Methods:** Theory and design in qualitative research, Definition and types of qualitative research, Methods and techniques of data collection, Informal group discussions, Interviews; Key informants, in-depth interviews, Observations	15
V	**Critical analysis of research.**	10

[267] SEC – Skill Enhancement Course; AEC – Ability Enhancement Course; VAC – Value Added Course; MD – Multidisciplinary Course

[268] 1 Credit (Theory) = 15 Hours; 1 Credit (Practical) = 30 Hours

Texts / References	1. Bandarkar, P.L. and Wilkinson, T.S. (200): Methodology and Techniques of Social Research, Himalaya Publishing House, Mimbai. 2. Bhatnagar, G.L. (1990): Research Methods and Measurements in Behavioural and Soxial Sciences, Agri. Cole Publishing Academy, New Delhi. 3. Dooley, D. (1995): Strategies for interpreting Qualitative Data; Saga Publications, Claifornia. 4. Gay, L.R. (1981, 2nd Ed.): Educational Research, Charles, E. Merill, Columbus, Ohio. 5. Long, J.S. (Ed.) (1988): Common Problems Proper Solutions: Avoiding Errors in Quantitative Research Beverly Hills, Sage Publications, California. 6. Mukherjee, R. (1989): The Quality of lIfe: Valuation in Social Research, Saga Publications, New Delhi. 7. Stranss, A. and Corbin, J. (1990): Basis of Qualitative Research: Grounded Theory Procedures and Techniques, Saga Publications, California.
Learning Outcomes	Understanding of statistical techniques, learning of various statistical test used to approve hypotheses and uses of computer in research

Extension and Communication

Course Title	**Participatory Programme Management (HSCMJ7R7 and HSCMJ7R8)**
Category of Course[269]	Major
Credits[270]& Hours of Teaching	

	Theory	Practical	Cumulative
Credits	3	2	5
Hours of Teaching (Total)	45	60	105

Course Objectives	• To understand the key concepts and skills in effective programme designing and evaluation • To demonstrate the ability to develop, implement, and constructively evaluate program and evaluation plans. • To develop tools for monitoring and evaluation of extension programmes • To develop skill in designing an extension programme (Home Science Based) to bring change in knowledge, skill and attitude
Course Content	

Units	Course Content	Hr. of Teaching
I	• Overview to PPM - Concept, Meaning and Importance. • Types of Participation in Development. • Advantages and disadvantages of participation by different stakeholders • Programme designing in extension– Meaning of programme planning, principles of programme building process, steps involved in programme building process, programme development cycle, planning models and frameworks, planning and developing teaching methods, precautions used in programme building	13
II	• Role of Government and Non-Profit Techniques of participatory planning - RRA, PRA, PLA and their application in extension. • Approaches of participatory planning - cooperative, democratic, bottom up and down. • Situation analysis, Needs and Objectives– Types of needs, methods of identifying needs • Objectives- types, levels and characteristics	8
III	• Participatory planning – Engaging the community and other stakeholders, organisations and committees • Role of officials, non-officials, groups and agencies in programme building	7

[269] SEC – Skill Enhancement Course; AEC – Ability Enhancement Course; VAC – Value Added Course; MD – Multidisciplinary Course

[270] 1 Credit (Theory) = 15 Hours; 1 Credit (Practical) = 30 Hours

	process for extension work. • Utilisation of local infrastructure	
IV	• Programme budgeting, marketing and strategic planning • Sources of budget • Management of budget, • Marketing strategies, steps.	8
V	• Monitoring and Evaluations–Approaches to monitoring, principles, indicators • Evaluation -meaning, purpose, elements, steps, criteria for evaluation, types of evaluation, methods of evaluation, Challenges and issues in monitoring and evaluation • Ethical issues in monitoring and evaluation. • Documentation and follow up – Need for documentation, methods, meaning and need for follow up, methods	9
PRACTICAL		
I	○ Identification of the background information of the community ○ Identification of community needs using participatory methods (any four) a) Social mapping b) Transect walk c) Focus group discussion d) Matrix raking e) Seasonal calendar f) Chapati diagram	20
II	○ Planning a two/three days programme on one of the selected needs ○ Collection of subject matter /content for the designed programme and their presentation ○ Preparation of teaching aids ○ Implementation of the planned programme	28
III	○ Evaluation of the programme (Designing questionnaire / tool for pre post test ○ Report writing	12

Texts / References

1. Sharma,FL, Shri Ram, (2013)Extension Teaching Methods,Agrotech Publishing company, Udaipur
2. Dangi, KL and Santhosh Devi Samota, (2013) Agrotech Publishing Academy, Udaipur
3. Mikkelsen, Britha,(2002), Methods for development work and research.New Delhi:Sage Publications
4. Dale R, (2004) Evaluating Development programmes and projects.New Delhi: Sage Publications
5. Reddy,A(1998) Extension education,Sreelakshmipress,Bapatala
6. Gopal lal Jain,(1997) Rural development,Mangaldeep publications,Jaipur
7. Subah Singh Yadav,Ramkumar, Rural Development and poverty alleviation,Pinter Publishers,Jaipur
8. Misganaw, Seraw,(2011) Extension programme planning and evaluation.LAP Lambert Academic Publishing,

Learning Outcomes	Students will be able to - • To demonstrate the ability to develop, implement and constructively evaluate programme and evaluation plans • To invent tools for monitoring and evaluation of extension programmes • To examine the strategies and approaches in monitoring and evaluating the extension programme

Course Title	**Development Communication (HSCMJ7R9 and HSCMJ7R10)**			
Category of Course[271]	Major			
Credits[272]& Hours of Teaching		Theory	Practical	Cumulative
	Credits	3	2	5

[271] SEC – Skill Enhancement Course; AEC – Ability Enhancement Course; VAC – Value Added Course; MD – Multidisciplinary Course

[272] 1 Credit (Theory) = 15 Hours; 1 Credit (Practical) = 30 Hours

	Hours of Teaching (Total)	45	60	105
Course Objectives	• To familiarize students with global perspective of development communication issues • To impart analytical skills with regard to the process of development communication • To understand the role and use of media in attaining sustainable development goals. • To analyze the indicators of development • To design media for development			

Course Content

Units	Course Content	Hr. of Teaching
I	**Concept : Development and Communication** Communication process – concept, elements and their characteristics, communication competence and empathy, communication effectiveness and credibility, feedback in communication, social networks , Barriers in communication, Message – Meaning, dimensions of a message, characteristics of a good message, Message treatment and effectiveness, distortion of message. Concept of Development as a goal, development as a process, Indicators of Development-Human, development Index, gender empowerment measure, human poverty index etc.	10
II	**Development Communication** Definition, prerequisites of development communication, communication links in development communication, development effort, role and significance of development communication, communication links in development, Models of development communication; independent model, Dependency model, Basic needs model, New paradigm of development, approaches to development communication; Diffusion and Extension approach to development communication, planned Strategies for development communication.	10
III	**National and international perspectives of development communication** National and international perspectives; Evolution of development communication concept; Government and non-government initiatives; Government and nongovernment organisations - FAO, UNDP, WHO, UNICEF, CARE and strategies. National projects of development communication - SITE, Jhabnaetc, case studies on development communication	10
IV	**Media and Development Communication** Understanding the role of traditional and modern media in development communication, Development Journalism- roles and responsibilities of a development reporter, ethics in, reporting, specialized skills required and issues in development reporting News reporting: definition of news, ingredients and qualities of news, news value, types of news reports, structure of news, ICTs: scope in development communication	5
V	**Participatory development communication** Participatory approaches in development communication, planning a Development Communication Campaign, Implementation of Development Communication Project, role of NGOs in development communication, need for information and communication policy for development, Development support communication, Challenges in a participatory development communication, participatory communication and civil society. **Research perspectives of development communication** Emerging issues; Measurable and variables of development communication; Existing research projects; Research lag and supporting organizations, Use of Information technology for development communication research.	10

PRACTICAL

I	• Analysis of development indicators - national and international perspectives • Critical analysis of selected development initiatives	20
II	• Analysis of media for development communication • Designing media for development communication	20
III	• Evaluate strategies used by development agencies for implementation of	20

	development programmes	

Texts / References	1. Mody, Bella (1991), Designing messages for development communication- An audience participation based approach, Sage, Delhi. 2. Melkote, R. Srinivas and Steeves, H. Leslie (2015), Communication for Development in the third world.Theory and practice of empowerment, Sage, New Delhi. 3. Narula, Uma (2014). Handbook of Communication- Models, Perspectives, Strategies, Atlantic, New Delhi. 4. Sen, Amartya (2000). Development as Freedom, Oxford University Press, New Delhi. 5. *Mefalopulos, Paolo. Development communication sourcebook* : *broadening the boundaries of communication/. Paolo Mefalopulos* 6. *Development Communication- A resourse manual fotteaching , Asian Mass Communication Research Centre 39 Newton Road , Singapore.* 7. Servaes, J. (Ed.) (2008). Communication for Development and Social Change, Sage, New Delhi. Sinha, 8. Dipankar. (2013), Development Communication- Contexts for the twenty-first century, Orient Black Swan, New Delhi
Learning Outcomes	• Understand the process of development communication in various national and international organizations • Raise awareness among students about global and local development challenges. • Plan and disseminate communication media on development issues • Encourage ethical and socially responsible communication policies. • Students will learn how to create clear and impactful messages for development projects. • Students will understand how to use different media, like radio and social media, to spread important information.

Course Title	**Textile Testing and Quality Control (HSCMJ7R11 and HSCMJ7R12)**
Category of Course[273]	Major

Credits[274] & Hours of Teaching

	Theory	Practical	Cumulative
Credits	3	2	5
Hours of Teaching (Total)	45	60	105

Course Objectives

- To educate the students about the techniques used to analyse textile fibre, yarns and fabrics for end-use performance.
- To make the student help in acquiring knowledge and understanding of various structural properties of textiles and relate them to end use fabric performance and product.
- To familiarize the students about the different testing equipment, their underlying principles, the international accepted standards, test methods and language of Measurement.
- To expedite the students to analyse and interpret the results and predict the general textile testing.

Units	**Course Content**	**Hr. of Teaching**
I	Introduction to Textile Testing; Concept and Scope, Application areas, Use of Statistics in Data Management, Sampling Procedures	05
II	Total Quality Management (TQM) approach in the field of Textiles & Clothing	05
III	Standardization; Standards for Fabric Performance, Organizations for Standardization (National and International), Quality Control of Textile products, Quality Standards as applicable to various types of Textiles (Garments, yardage, knits, woven, carpets, processing, dyeing)	10
IV	Properties of textiles at different stages: processing and their principles of measurement • Fibres – length, fineness, evenness • Yarn – strength, evenness, openness, load, elongation, crimp • Fabrics – strength, elongation, shrinkage, thickness, cover, air permeability, crease recovery, weight, comfort, stiffness, flammability, repellency, colour fastness • Garment Finishing – colour fastness, shrinkage • Concept of Fabric faults as related to stages of manufacture and the remedies.	15
V	Concept of Statistical Quality Control; Sampling, Test methods used, Tolerance limits, CV%	10

PRACTICAL

Units	**Course Content**	**Hr. of Teaching**
I	Physical Testing of Textiles using appropriate standardized procedures • Fibres – length, diameter, fineness • Yarn – count, heaviness, twist, crimp, strength • Fabric – thread count, thickness, air porosity, abrasion, strength (Tensile, Tear, Bursting) water vapour permeability, cover, stiffness, drapability, crease recovery, pilling, abrasion	10
II	Chemical Testing	20

[273] SEC – Skill Enhancement Course; AEC – Ability Enhancement Course; VAC – Value Added Course; MD – Multidisciplinary Course

[274] 1 Credit (Theory) = 15 Hours; 1 Credit (Practical) = 30 Hours

	• Identification of fibres • Binary Fabrics, blend composition • Shrinkage, water, oil repellency • Sensitivity to various reagents • Colour fastness	
III	MechanicTesting • Seam Strength • Identification of fabric weave • Threat count	15
IV	Inspection of Final Garment	15

Texts / References	1. Booth, J.E. (1968) *Principles of Textile Testing* (3rd ed.) London: Newnes-Butterworth 2. Collier, B. J., & Epps, H. H. (1998). *Textile testing and analysis*. Upper Saddle River, NJ: Prentice HallSkinkle, J. H. (1949). *Textile testing*. New York: Chemical Publishing Co., Inc. 3. Grover, E. B., Grover, E. B., & Hamby, D. S. (2011). *Handbook of textile testing and quality control*. Wiley India Pvt Ltd 4. Bureau of Indian Standards. (1986) Manual of BIS and ISI standards related to textiles in India. **https://www.bis.gov.in/ministry-of-textile** **5.** American Society for Testing and Materials (1898). Annual book of ASTM standards. ASTM International. https://www.astm.org/products-services/standards-and-publications/standards/textile-standards.html
Learning Outcomes	By the end of the course, students will be able to: • Learn different techniques involved in fibre, yarn and fabric preparation • Understand about the fabric performances • Acquire efficiency over different testing methods of textiles.

Course Title	**Draping, Pattern Making and Grading (HSCMJ7R13 and HSCMJ7R14)**
Category of Course[275]	Major
Credits[276]& Hour of Teaching	

	Theory	Practical	Cumulative
Credits	3	2	5
Hour of Teaching (Total)	45	60	105

Course Objectives	• To enable the students to make pattern from sketch/photograph • To enable the students to obtain perfect fit and harmony between the fabric and design of the garment • To develop an understanding of a sample pattern using industrial sample room procedure • To develop an understanding of the use of design elements in the process of range development

Units	**Course Content**	**Hr. of Teaching**
I	Introduction to draping and silhouette of the individual- Dress form, Elements of fabric – woven, knitted.	05
II	Development of the Ladies and Kids block and garments by Flat pattern and draping.	05
III	Development of pattern with variation in • One-piece dresses	10

[275] SEC – Skill Enhancement Course; AEC – Ability Enhancement Course; VAC – Value Added Course; MD – Multidisciplinary Course

[276] 1 Credit (Theory) = 15 Hours; 1 Credit (Practical) = 30 Hours

	• Two-piece dresses • Dart less dresses (Incorporating various collars, sleeves, yokes, necklines, pockets and plackets etc.)	
IV	Draping of bodice block and skirt block and their variation, Draping of asymmetrical designs and preparing patterns. Drafting	10
V	Pattern markings, Pattern envelope and Guide sheet.	15
PRACTICAL		
I	Developing draping Pattern for garments Introduction to grading terminology and methodology; track or stack method, Grading standard size blocks to various sizes	18
II	Procedure for grading blocks to various sizes • Children – bodice block, sleeve block, skirt & shorts block • Women – bodice block, sleeve block, skirt & short block	20
III	Preparation of Portfolio • Two patterns with complete sets of markings • Designing and preparing pattern envelope (front and back) • Markers for three different fabric width and designs (stripes, plaids) • Guide sheet • Three accompanying pattern promotional items.	22

Texts / References	1. Crawform, C.A. (2018). The Art of Fashion Draping (5th ed.). New York: Bloomsbury Academic. 2. Stringer, P.C. (1992). Pattern Drafting for Dressmaking (1st ed.). B T Batsford Ltd. 3. Hillhouse, M.S. and Mansfield, E.A. (1948). Dress Design, Draping and Flat Pattern Making (1st ed.). London: Houghton Mifflin Company. 4. Shelden, M.G. (1974). Design through Draping (2nd ed.) USA: Burgers Publishing Company. 5. Brockman, H.L. (1965). Theory of Fashion Design (1st ed.). New York: John Wiley and Sons. 6. Strickland, G. (1956). A Tailoring Manual (3rd ed.). New York: Macmillan Company. 7. Pepin H. (1942). Modern Pattern Design (2nd ed.). New York: Funk & Wagnalls. 8. Cooklin, G., Hayes, S. G., McLoughlin, J., & Fairclough, D. (2011). Garment Technology for Fashion Designers (2nd ed.). John Wiley & Sons. 9. Ireland. P.J. (1996), *Fashion Design Illustration: Men* (1st ed.). Batsford Ltd.
Learning Outcomes	By the end of the course, students will develop understanding about: • The principles of draping and get to know about the various tools and equipment used for draping. • The cutting and sketching of pattern, draping procedure of dresses, sample preparation and grading of the material.

Human Development and Family Studies

Course Title	**Gender issues in Human Development and Relationships (HSCMJ7R15 and HSCMJ7R16)**
Category of Course[277]	Major
Credits[278]& Hours of Teaching	

	Theory	Practical	Cumulative
Credits	3	2	5

[277] SEC – Skill Enhancement Course; AEC – Ability Enhancement Course; VAC – Value Added Course; MD – Multidisciplinary Course

[278] 1 Credit (Theory) = 15 Hours; 1 Credit (Practical) = 30 Hours

	Hours of Teaching (Total)	45	60	105
Course Objectives	• To orient the students regarding the gender issues in human development and family relationships. • To impart experiences regarding gender issues, family practices and biases prevalent in Indian Society. • To understand about gender analysis, orientation and role of mass media, • To familiarize with NGO, and other organization			

Course Content

Units	Course Content	Hr. of Teaching
I	**Gender perspectives and theories** Concept of gender- biological and socio-cultural connotations.Historical perspectives. Gender differences in human development.Gender theories- Gender Orientationtheory of Sandra Bem. Gender Schema theory, theory of Ego Development andGender. Gender Stratification theory by Blumberg. Gender Identity Formation theory.	10
II	**Gender discrimination, gap and parity** Gender equality and development.Gender inequalities in human development– dimensions, causes and consequences.Gender discrimination indicators- globalgender gaps.Gender Development Index, Global Gender Gap Index and GenderParity Index. Demographic challenges to family ecology- gender role socialization.	10
III	**Gender violence and empowerment** Gender violence- dowry harassment and deaths, suicides, prostitution, sexualharassment and exploitation and prevention. Family violence, amniocentesis, femalefeticide, infanticide, eve teasing. Gender empowerment strategies- working towardsfamily solidarity and social well-being. Gender main streaming- concept, policy ofUnited Nations, objectives, requirements and principles. Empowering lives of women by controlling – patriarchy system, women's sexuality, fertility, labour, lack ofvisibility. Gender budgeting.	15
IV	**Changing trends in status of women** Status of women in India. Various plans and policies designed for achieving genderequality. Changing trends in gender role orientation- early civilization, preindependence,post independent India, contemporary times, socio economic impacton the family and society, cultural impact on the family. Gender role portrayal inmass media.Gender stereotyping in schools. Gender issues at workplace.	10
PRACTICAL		
I	Gender analysis of mass media: Print media and E-media and report writing Study of adopted socialization practices for children of both genders and report writing	20
II	Case studies of three generations on dynamics of gender orientation, Gender roles and responsibilities, report presentation and discussion Views of adolescents on their gender role orientation- designing questions survey through questionnaire, report presentation	20
III	Case studies on changing trends of roles and responsibilities of women and men report writing Visits to women welfare Govt. organizations/ agencies/ NGOs,presentation of report and class discussion	20

Texts / References	1. Banddarage A. 1997. Women Population and Global Crisis - A Political and EconomicalAnalysis.Zed books, London. 2. Barnett RC, Biner L and Baruch GK. 1987. Gender Stress. The Free Press, New York. 3. Chanana K. 1989. Gender and the Household Domain.Sage Publications, New Delhi. 4. apadia S and Gala J. 2015. Gender Across Cultures: Sex and Socialization in Childhood. Sage Publications, New Delhi. 5. Kumar CS. 2017. Gender Socialization and The Making of Gender in The Indian Context. Sage Publications. New Delhi. 6. Menon L. 1997. Gender Issues and Social Dynamics.Kanishka Publishers and

	Distributors, New Delhi. 7. Sudha DK. 2000. Gender Roles. A.P.H. Publishing Corporation, New Delhi.
Learning Outcomes	• Learning of gender roles, orientation and issues • Understanding of role of several organizations

Course Title	**Family Ecology, Cultural Diversity and Therapy (HSCMJ7R17 and HSCMJ7R18)**
Category of Course[279]	Major
Credits[280]& Hours of Teaching	

	Theory	Practical	Cumulative
Credits	3	2	5
Hours of Teaching (Total)	45	60	105

Course Objectives	• To orient the students regarding family as an institution. • To impart knowledge about family transitions and impact of social change and Development • To sensitize the students, regarding the theories and issues pertaining to cultural difference in family studies. • To orient the students regarding various methods and techniques of family therapy. • To know about conflict resolution • To learn role-playing • To gain knowledge of Genogram construction

Course Content

Units	Course Content	Hr. of Teaching
I	**Families in India and Family relationships** Families in India - Types of traditional and modern family structures based on different dimensions (Marriage type, nature of residence, nature of authority, nature of relations among the family members, nature of kin composition, single parent families, unrelated families etc.). Families in rural, tribal, and agrarian community – status of women, children, elderly, and men in these families. Family as a social system. Socialization within the family. Models of parenting. Parent child relationships. Family cohesion, conflict and family disorganization – impact on children. Effect of childbirth on marital life. Child abuse. Family interactions and delinquency. Improving family communication and interpersonal relations.	10
II	**Family under transition, Family stressors and resilience** Family transitions. Change and continuity over life cycle. Impact of social change on family and changing family patterns in India. Religion and family. Family as an institution under stress. Family crisis. Poverty and children. Stressors and family relations - with special reference to family disruption, sickness, divorce, substance abuse and disability. Family's adaptation to stress. Family resilience and protective factors for promotion of family resilience Intergenerational family dynamics in management of family conflicts and negative patterns.	15
III	**Culture, family and diversities in family life and challenges**	10

[279] SEC – Skill Enhancement Course; AEC – Ability Enhancement Course; VAC – Value Added Course; MD – Multidisciplinary Course

[280] 1 Credit (Theory) = 15 Hours; 1 Credit (Practical) = 30 Hours

	Culture- definition, components and characteristics of culture. Agents of cultural influences- school, family, community and other social groups. Cultural factors and impact on families. Elements of India's diverse culture – religion, philosophy, cuisine, language, fine arts, dance, music. Diversities in family life – ethnic, linguistic, regional, etc. Effect of urbanization, secularization, westernization, technological advancement, globalization and other such developments on families in general and agrarian in particular. Challenges before families across cultures. Legal provisions – emerging cultural trends. Research trends in cross-cultural family studies, methodological issues.	
IV	**Family therapy – orientation, types and theoretical perspectives** Family Therapy – concept, need, significance, areas, scope, goals and application of marriage and family therapies. Evolution of family therapy. Early models and basic techniques of family therapy- group process and communications analysis. Theoretical developments in marital and family therapy. Approaches in family therapy - Social Learning approach, Psychoanalytic, Behavioural, Systems approach. Social Constructionism theory. Attachment theory. Classic schools of family therapy- Bowenian Family Systems therapy, Strategic, Structured, Communication and Experiential therapies, Psychodynamic Therapy, Cognitive- Behaviour family therapy and integrated family therapy. Contemporary marital therapies. Family therapy in the 21st century and its application to multicultural, single parent and disorganized families, solution focused therapy, narrative therapy and integrative models. Application of family therapy in depression, substance abuse, schizophrenia and eating disorders.	10
PRACTICAL		
I	Conflict Resolution Role-plays - Create role-playing exercises that involve family conflicts and resolutions. Students can practice mediating conflicts and developing strategies for effective communication and resolution.	10
II	Comparative Analysis Project-Students choose two families—Both from different cultures. They analyze and compare aspects such as family roles, marriage customs, child-rearing practices, and conflict resolution strategies.	10
III	Role-Playing Difficult Scenarios-Create role-playing exercises involving challenging family scenarios, such as conflict resolution, crisis management, or working with resistant clients. Students can take on different roles, including therapist, client, and family members.	10
IV	Genogram Construction-Have students create genograms of a family of their choice (real or fictional), incorporating family relationships, patterns, and histories. Students can then analyze the genogram using different theoretical lenses	14
V	Cultural Competency Training-Conduct training sessions on cultural competence, focusing on how to address and incorporate cultural differences in family therapy. This could include case studies or role-plays that highlight cultural nuances Interviews with Families in Transition-Have students conduct interviews with families who have experienced or are experiencing significant transitions (e.g., migration, loss of a family member, economic changes). Students should focus on how these transitions have impacted family dynamics and resilience strategies used.	16

Texts / References

1. Ballard SM and Taylor AC. 2012. *Family Life Education with Diverse Populations*. Sage Publications, Los Angeles.
2. Brislin RW. 1990. *Applied Cross Cultural Psychology*. Sage Publications, New Delhi
3. Carson DK, Carson CK and Chowdhury A. 2007. *Indian Families at the Crossroads*. Gyan Publishing House, New Delhi.
4. Ratra A, Kaur P, Chhikara S, Varma T and Chawla P. 2006. *Marriage and Family-InDiverse and Changing Scenario.* Deep & Deep Publications Pvt. Ltd, New Delhi
5. Carr A. 2008. *Family Therapy – Concepts, Process and Practice.* 2nd Ed., John Wiley & Sons Ltd, Chichester.
6. Carson DK, Carson CK, Chowdhury A. 2007. *Indian Families at The Crossroads*. Gyan Publishing House, New Delhi.

Learning Outcomes	• Understanding of family as an institution, learning of family transition, cultural differences in family studies and techniques applied in family therapy. • Students can practice mediating conflicts and developing strategies for effective communication and resolution. • Students can then analyze the Genogram using different theoretical lenses

Family Resource Management

Course Title	**Consumer Product Safety and Legislation (HSCMJ7R19 and HSCMJ7R20)**			
Category of Course[281]	Major			
Credits[282]& Hours of Teaching		Theory	Practical	Cumulative
	Credits	3	2	**05**
	Hours of Teaching (Total)	45	60	**105**
Course Objectives	• To know about the basics of consumer safety. • To know about the consumer rights • To aware about the different acts related to safety and liabilities, redressal and complaints of consumers • To impart field related knowledge of consumer safety and product hazards and redressal.			

Course Content

Units	Course Content	Hr. of Teaching
I	•**Introduction-**Meaning, Definition, scope and Importance. •**Product related Hazards-**Physical hazards, Health hazards and Environment hazards. •**Production formation and Labeling** Brand Labels, Information Labels Descriptive Labels and grade labels. •**Product Liability** Meaning, Liability of manufacture trader, importance	15
II	**Provision of the product Safey &liabilities under various Laws-** •Consumer protection ACT, 2019(CPA) •Sale of goods ACT,1930(SGA) •Indian contract ACT, 1872 •Bureau of Indian Standard ACT,2016(BIS) •Consumer protection (Direct Selling) Rules,2021 •Consumer protection (Ecommerce Rules, 2020) •Food safety and standard Act,2006 (FASSAI) •Medical Devices Rules, (2017) •Motor Vehicle ACT,1940(MVA)	20
III	**Mechanism of consumer redressal**-Time limit for complaint filling, Burden of proving fault/defect, Noncompliance with the regulatory standards, non-issue of adequate information on labels.	05
IV	**Redressal of consumer complaints**-Rectification of defects, return of price paid, compensation for the damage and mental agony, recall of the product.	05

PRACTICAL		
I	Project work on requirements of product safety education to consumers and its implementation.	20
II	Survey of consumer product-hazards and redressal.	20
III	Market analysis on different safety measures used in types of food products	20

Texts /	1. Banddarage A. 1997. Women Population and Global Crisis - A Political and

[281] SEC – Skill Enhancement Course; AEC – Ability Enhancement Course; VAC – Value Added Course; MD – Multidisciplinary Course

[282] 1 Credit (Theory) = 15 Hours; 1 Credit (Practical) = 30 Hour

References	EconomicalAnalysis.Zed books, London. 2. Barnett RC, Biner L and Baruch GK. 1987. Gender Stress. The Free Press, New York. 3. Chanana K. 1989. Gender and the Household Domain.Sage Publications, New Delhi. 4. Kapadia S and Gala J. 2015. Gender Across Cultures: Sex and Socialization in Childhood. Sage Publications, New Delhi. 5. Kumar CS. 2017. Gender Socialization and The Making of Gender in The Indian Context. Sage Publications. New Delhi. 6. Menon L. 1997. Gender Issues and Social Dynamics.Kanishka Publishers and Distributors, New Delhi. 7. Sudha DK. 2000. Gender Roles. A.P.H. Publishing Corporation, New Delhi.
Learning Outcomes	• Understanding of consumer rights, safety, liabilities, redressal and complaints • Understanding of consumer safety education, product hazards and handling of problems.

Course Title	**Ergonomics and Appropriate Technology (HSCMJ7R21 and HSCMJ7R22)**
Category of Course[283]	Major
Credits[284]& Hours of Teaching	

	Theory	Practical	Cumulative
Credits	3	2	**05**
Hours of Teaching (Total)	45	60	**105**

Course Objectives	• To impart the fundamental knowledge, scope and importance of Ergonomics. • To provide the understandings of hazards, and tools of Ergonomics • To gain information about anthropometry and ergonomics • To gain knowledge of employee satisfaction in work environment • To understand the relationship between man, machine and environment

Course Content

Units	**Course Content**	**Hr. of Teaching**
I	• **Definition and meaning of ergonomics.** • Scope of ergonomics - In work spaces, sports, leisure and healthy, safety. • **Types of ergonomics:** Physical ergonomics, Cognitive ergonomics, Organisation ergonomics	10
II	• **Ergonomics Hazards and injuries-** • Ergonomics hazards - Repetitive movements, Manual handling, Workplace design. Ergonomics Injuries - Repetitive stress injuries (RSI), Repetitive motion injuries (RMIs), Cumulative Trauma Disorder (CTDs)	10
III	• **Importance of ergonomics -** Efficiency of work, Physical efficiency, Training efficiency. • **Benefits of ergonomics in workplace-** • Benefits regarding- production cost, Productivity, quality, employee engagement, safety culture.	10
IV	• **Ergonomic process and tools-** Physical assessment, Employee injury history, Benefits of ergonomics assessments • **Ergonomic assessment tools-** NIOSH Lifting equation (National institute for occupational safety and health), RULA (Rapid upper limb assessment), HAV (Hand arm vibration calculator)	10
V	• **Anthropometry-** Definition, meaning and types Elements of anthropometry- Height, weight, BMI (Body mass index) Body circumferences (waist, hip, limbs)	05
PRACTICAL		

[283] SEC – Skill Enhancement Course; AEC – Ability Enhancement Course; VAC – Value Added Course; MD – Multidisciplinary Course

[284] 1 Credit (Theory) = 15 Hours; 1 Credit (Practical) = 30 Hours

I	Survey on finding out different sources of satisfaction of employee needs in the work environment.	30
II	To know the relationship between man, machine and environment.	15
III	Application of ergonomics to improve productivity and safety in different field	15

Texts / References	1. Patni. M., (2015), Ergonomics, Star Publications, 1st Edition, ISBN- 9789381246511. 2. Shrilakshmi,B., Nutrition Science, New Age Publishers Pvt. Ltd, 6th Edition, ISBN-9789386418883.
Learning Outcomes	• Learning of fundaments of Ergonomics, different types of hazards, ergonomics in workplaces, assessment and anthropometry • Understanding of employee satisfaction in workplace, and the relationship between man, machine and environment

Semester -VIII
Common papers for all branches of Home Science

Course Title	**Statistics and Computer Application (HSCMJ8R1 and HSCMJ8R2)**
Category of Course[285]	Major
Credits[286]& Hours of Teaching	

	Theory	Practical	Cumulative
Credits	3	1	4
Hours of Teaching (Total)	45	30	75

Course Objectives	• To enable the students to develop knowledge in statistical tools and computer applications. • To understand the meaning of correlation, regression analysis for estimation and prediction purposes. • To discuss about the needs of various statistical test in Home Science discipline. • To teach the students how to organize, analyze, interpret and present the research data effectively. • To demonstrate the understanding of descriptive statistics by practical application of quantitative reasoning and data visualization • To demonstrate the use of correlation, regression analysis and association for estimation and prediction purposes.

Course Content

Units	Course Content	Hr. of Teaching
I	Introduction to Statistics - Definition, importance and scope of statistics, Descriptive and Inferential statistics. Data Management; Raw data, ungrouped frequency distribution, grouped frequency distribution, relative frequency table, cumulative frequency tables, how to convert raw data to the form of a frequency distribution, Graphs; histogram, frequency polygon, frequency curve, ogives. Scales of measurement-nominal, ordinal, interval and ratio scales. Coding of data.	8
II	Measures of central tendency; Definition, arithmetic mean; simple and weighted arithmetic mean, median, mode, geometric mean, their uses, merits and demerits, Partition values – quartiles and percentiles, Measures of dispersion; Definition, Absolute and relative measures of dispersion; range, variance, standard deviation, standard error, coefficient of variation.	10

[285] SEC – Skill Enhancement Course; AEC – Ability Enhancement Course; VAC – Value Added Course; MD – Multidisciplinary Course

[286] 1 Credit (Theory) = 15 Hours; 1 Credit (Practical) = 30 Hours

III	Normal Distribution and its applications, Probability- classical approach, random variable- discrete and continuous random variables, Normal random variable, characteristics and properties of a normal curve, standard normal distribution, converting raw scores into standard normalized scores, standard normal curve.	6
IV	Correlation, Regression and Association of Attributes, Linear correlation- meaning and types of correlation, scatter diagram, Karl Pearson's coefficient of correlation, Spearman's Rank correlation coefficient, Linear Regression and Prediction: Concept of regression lines and regression equations, use of regression lines, role of coefficient of alienation in prediction.	8
V	Testing of Hypotheses; Definition, concepts of statistical hypothesis-simple and composite, null hypothesis, alternative hypothesis, test of a statistical hypothesis, critical region, Type I error, Type II error, significance level, confidence level. Parametric test- Testing of hypothesis concerning the mean of a population, testing the equality of means of two populations, Testing of hypothesis concerning the proportion of a population, testing the equality of proportions of two populations, chi-square test, F test, ANOVA concepts, ANOVA-single factor, Non parametric; chi-square test- testing goodness of fit, independence of attributes. Computer; importance and uses in research & statistics, Basic features of Microsoft word and Excel, Statistical analysis using Excel sheet and SPSS, tabular & graphical representation of data using computer, frequency distribution; Histogram, pie diagram, scatter diagram graphs using Excel.	13
PRACTICAL		
I	Preparation of different types of tables with research data on computer. Graphical representation of research data; Different types of statistical graphs and their uses in statistics, Line graph; types and different uses, pie diagram, scatter diagram etc. Preparation of Frequency distribution curves and graphs- histogram, frequency polygon and ogives through computer.	10
II	Discussing and solving practical problems of Statistics -Related to central tendency; mean, median, mode, partition values, dispersion; standard deviation, mean deviation, concept of Skewness and kurtosis and their measures etc., and hypothesis and hypothesis testing; Correlation, chi-square, t-test, Z - test, ANOVA.	10
III	Basic Statistical tools in computer for research and data analysis; MS-word, MS-Excel, SPSS etc. Learn about SPSS software and Solving above given statistical problems using Excel sheet and SPSS.	10

Texts / References	1. Kothari, C. R. (2014). *Research Methodology – methods and techniques*, 3rd edition, New Delhi: New age International Publishers 2. Gupta, S. C., & Kapoor, V. K. (2020). Fundamentals of mathematical statistics. New Delhi: Sultan Chand & Sons. 3. Gupta, S. P. (2001). Statistical Methods, New Delhi: Sultan Chand & Sons. 4. Gupta, S. P. (2001). Advanced Practical Statistics. New Delhi: S. Chand and Company Ltd., 5. Landau, S. (2019). A handbook of statistical analyses using SPSS. London: Chapman & Hall. 6. Singh, V. P. (2009). Simplified MS Office 2007. New Delhi: Computech Publications Limited. 7. Wackerly, D., Mendenhall, W., & Scheaffer, R. L. (2008). Mathematical statistics with applications. USA: Thomson Learning
Learning Outcomes	By the end of course the students will be able to; • Discuss the significance of statistics in the discipline of Home Science. • Describes the basic concepts of statistical inferences and test of significance. • Apply the appropriate statistical techniques for analysis and interpretation of data. • Understand working on a computer system and assess of MS- WORD, MS-EXCEL. • Analyze Research data through various test as chi-square, mean, median, mode, standard deviations, t-test etc. and present result through graphical presentation and tabulation using computer

Course Title	**Project/Dissertation (HSCDS8R1)**
Category of Course[287]	Dissertation
Credits[288]& Hours of Teaching	

	Theory	Practical	Cumulative
Credits	-	12	12
Hours of Teaching (Total)	-	360	360

Course Objectives (not more than 100 words)	NA
Course Content	The course content be divided into minimum 3 Units to maximum 5 units along with defined hour of teaching for each unit.

Units	**Course Content**	**Hr. of Teaching**
I	NA	
II	NA	
III	NA	
IV	NA	
V	NA	

Texts / References	NA
Learning Outcomes (not more than 100 words)	NA

Course Title	**Statistics and Computer Application (HSCMN8R1 and HSCMN8R2)**
Category of Course[289]	Minor
Credits[290]& Hours of Teaching	

	Theory	Practical	Cumulative
Credits	3	1	4
Hours of Teaching (Total)	45	30	75

Course Objectives	• To enable the students to develop knowledge in statistical tools and computer applications. • To understand the meaning of correlation, regression analysis for estimation and prediction purposes. • To discuss about the needs of various statistical test in Home Science discipline. • To teach the students how to organize, analyze, interpret and present the research data effectively. • To demonstrate the understanding of descriptive statistics by practical application of quantitative reasoning and data visualization • To demonstrate the use of correlation, regression analysis and association for estimation and prediction purposes.

[287] SEC – Skill Enhancement Course; AEC – Ability Enhancement Course; VAC – Value Added Course; MD – Multidisciplinary Course

[288] 1 Credit (Theory) = 15 Hours; 1 Credit (Practical) = 30 Hours

[289] SEC – Skill Enhancement Course; AEC – Ability Enhancement Course; VAC – Value Added Course; MD – Multidisciplinary Course

[290] 1 Credit (Theory) = 15 Hours; 1 Credit (Practical) = 30 Hours

Course Content

Units	Course Content	Hr. of Teaching
I	Introduction to Statistics - Definition, importance and scope of statistics, Descriptive and Inferential statistics. Data Management; Raw data, ungrouped frequency distribution, grouped frequency distribution, relative frequency table, cumulative frequency tables, how to convert raw data to the form of a frequency distribution, Graphs; histogram, frequency polygon, frequency curve, ogives. Scales of measurement-nominal, ordinal, interval and ratio scales. Coding of data.	8
II	Measures of central tendency; Definition, arithmetic mean; simple and weighted arithmetic mean, median, mode, geometric mean, their uses, merits and demerits, Partition values – quartiles and percentiles, Measures of dispersion; Definition, Absolute and relative measures of dispersion; range, variance, standard deviation, standard error, coefficient of variation.	10
III	Normal Distribution and its applications, Probability- classical approach, random variable- discrete and continuous random variables, Normal random variable, characteristics and properties of a normal curve, standard normal distribution, converting raw scores into standard normalized scores, standard normal curve.	6
IV	Correlation, Regression and Association of Attributes, Linear correlation- meaning and types of correlation, scatter diagram, Karl Pearson's coefficient of correlation, Spearman's Rank correlation coefficient, Linear Regression and Prediction: Concept of regression lines and regression equations, use of regression lines, role of coefficient of alienation in prediction.	8
V	Testing of Hypotheses; Definition, concepts of statistical hypothesis-simple and composite, null hypothesis, alternative hypothesis, test of a statistical hypothesis, critical region, Type I error, Type II error, significance level, confidence level. Parametric test- Testing of hypothesis concerning the mean of a population, testing the equality of means of two populations, Testing of hypothesis concerning the proportion of a population, testing the equality of proportions of two populations, chi-square test, F test, ANOVA concepts, ANOVA-single factor, Non parametric; chi-square test-testing goodness of fit, independence of attributes. Computer; importance and uses in research & statistics, Basic features of Microsoft word and Excel, Statistical analysis using Excel sheet and SPSS, tabular & graphical representation of data using computer, frequency distribution; Histogram, pie diagram, scatter diagram graphs using Excel.	13
PRACTICAL		
I	Preparation of different types of tables with research data on computer.Graphical representation of research data; Different types of statistical graphs and their uses in statistics, Line graph; types and different uses, pie diagram, scatter diagram etc. Preparation of Frequency distribution curves and graphs-histogram, frequency polygon and ogives through computer.	10
II	Discussing and solving practical problems of Statistics -Related to central tendency; mean, median, mode, partition values, dispersion; standard deviation, mean deviation, concept of Skewness and kurtosis and their measures etc., and hypothesis and hypothesis testing; Correlation, chi-square, t-test, Z - test, ANOVA.	10
III	Basic Statistical tools in computer for research and data analysis; MS-word, MS-Excel, SPSS etc.Learn about SPSS software and Solving above given statistical problems using Excel sheet and SPSS.	10

Texts / References

1. Kothari, C. R. (2014). *Research Methodology – methods and techniques*, 3rd edition, New Delhi: New age International Publishers
2. Gupta, S. C., & Kapoor, V. K. (2020). Fundamentals of mathematical statistics. New Delhi: Sultan Chand & Sons.
3. Gupta, S. P. (2001). Statistical Methods, New Delhi: Sultan Chand & Sons.
4. Gupta, S. P. (2001). Advanced Practical Statistics. New Delhi: S. Chand and Company Ltd.,
5. Landau, S. (2019). A handbook of statistical analyses using SPSS. London: Chapman & Hall.
6. Singh, V. P. (2009). Simplified MS Office 2007. New Delhi: Computech

BANARAS HINDU UNIVERSITY

Department of Mathematics

Faculty of Science

SYLLABI

B.Sc. (Hons.) Programme

In

Mathematics

DEPARTMENT OF MATHEMATICS
BANARAS HINDU UNIVERSITY, VARANASI-221005
Syllabus
NEP Course Structure for Four Year Undergraduate Mathematics Program

Ist Year

Semester –I			
Course Code	**Course Description**	**Title**	**Credits**
MATMJ11	MAT-Major (4)	Calculus	4
MATMN11	MAT-Minor*(4)	Calculus	4
MATSE11	MAT-Skill Enhancement#(SE) (3)	Ethics in Academia and Mathematical Exploration	3
MATMD11	Multidisciplinary**(MD) (3)	Basic Mathematics-I	3
VA1+VA2+AE1 (2+2+2)		From the Pool of VA and AE Courses	6
		Total credit	20

Semester –II			
Course Code	**Course Description**	**Title**	**Credits**
MATMJ21	MAT-Major (4)	Algebra	4
MATMN21	MAT-Minor* (4)	Algebra	4
MATSE21	MAT-Skill Enhancement#(SE) (3)	LaTeX Typesetting for Beginners	3
MATMD21	Multidisciplinary**(MD) (3)	Basic Mathematics-II	3
VA3+VA4+AE2 (2+2+2)		From the Pool of VA and AE Courses	6
		Total credit	20

IInd Year

Semester –III			
Course Code	**Course Description**	**Title**	**Credits**
MATMJ31	MAT-Major (8)	Linear Algebra	4
MATMJ32		Analysis	4
MATMV31	MAT-Minor(VOC)* (4)	Python for Mathematical Applications	4
MATSE31	MAT-Skill Enhancement#(SE)(3)	Sage Math for Beginners	3
MATMD31	Multidisciplinary**(MD) (3)	Basic Mathematics-III	3
Ability Enhancement (AE3) (2)		From the Pool AE Courses	2
		Total credit	20

Semester –IV			
Course Code	**Course Description**	**Title**	**Credits**
MATMJ41	MAT-Major (14)	Calculus of several variables	4
MATMJ42		Vector and Tensor Analysis	3
MATMJ43		Differential Equations	4
MATMJ44		Mechanics	3
MATMN41	MAT-Minor* (4)	Differential Equations	4
Ability Enhancement (AE3) (2)		From the Pool AE Courses	2
		Total credit	20

IIIrd Year

Semester –V			
Course Code	**Course Description**	**Title**	**Credits**
MATMJ51	MAT-Major (14)	Abstract Algebra	4
MATMJ52		Metric Spaces	3
MATMJ53		Analytic Geometry	3
MATMJ54		Numerical Analysis	3+1(p)
MATMV51	MAT-Minor(Voc)* (4)	Optimization Techniques	4
MAT-IN-51	Internship(2)	Internship to be done during vacation	2
		Total credit	**20**

Semester –VI			
Course Code	**Course Description**	**Title**	**Credits**
MATMJ61	MAT-Major (16)	Measure and integration	3
MATMJ62		Complex Analysis	3
MATMJ63		Differential Geometry	4
MATMJ64		Number Theory	3
		Optional (opt any one)	
MATMJ65		Linear Programming and Applications	3
MATMJ66		Special Theory of Relativity	3
MATMJ67		Space Dynamics	3
MATMJ68		Discrete Mathematics	3
MATMJ69		Mathematical Modelling	3
MATMJ610		Dynamical System	3
MATMJ611		Data Structures	2+1P
MATMJ612		Analytical Visualization	1+2P
MATMJ613		Graph Theory	3
MATMJ614		Vedic Mathematics	3
MATMV61	MAT-Minor (Voc)* (4)	Formal Languages and Automata Theory	4
		Total credit	**20**

IVth Year

Semester –VII			
Course Code	**Course Description**	**Title**	**Credits**
MATMJ71	MAT-Major (16)	Topology	4
MATMJ72		Advanced Algebra	4
MATMJ73		Functional Analysis	4
MATMJ74		Differentiable Manifolds	4
MATMN71	MAT-Minor A*(4)	Topology	4
		Total credit	**20**

Semester –VIII (Category-1: For Mathematics Honours only)			
Course Code	**Course Description**	**Title**	**Credits**
MATMJ81	MAT-Major (16) **(opt any four papers)**	Geometric Topology	4X4=16
MATMJ82		Fourier Analysis	
MATMJ83		Nonlinear Programming	
MATMJ84		Quadratic Programming	
MATMJ85		Fluid Dynamics	
MATMJ86		Numerical Analysis	
MATMJ87		Mathematical Modeling	
MATMJ88		Numerical Solution of Partial Differential Equations	
MATMJ89		Riemannian Manifolds	
MATMJ810		Information and Coding Theory	
MATMJ811		Algebraic Geometry	
MAT-Minor A*(4)	Any one of the above		4
		Total credit	**20**

Semester –VIII (Category-2: For Mathematics Honours only)			
Course Code	**Course Description**	**Title**	**Credits**
MATMJ8R1	MAT-Major (4) **(opt any onepaper)**	Geometric Topology	4
MATMJ8R2		Fourier Analysis	
MATMJ8R3		Nonlinear Programming	
MATMJ8R4		Quadratic Programming	
MATMJ8R5		Fluid Dynamics	
MATMJ8R6		Numerical Analysis	
MATMJ8R7		Mathematical Modeling	
MATMJ8R8		Numerical Solution of Partial Differential Equations	
MATMJ8R9		Riemannian Manifolds	
MATMJ8R10		Information and Coding Theory	
MATMJ8R11		Algebraic Geometry	
MAT-Minor A*(4)	Any one of the above		4
Dissertation (12)	MAT-DS-8R1	Research Dissertation	12
		Total credit	**20**

Course Title	**MATMJ11/MATMN11: Calculus**

Credits &Hours of Teaching

	Theory	Practical	Cumulative
Credits	4	0	4
Hours of Teaching (Total)	60	0	60

Course Objectives (not more than 100 words)

This course aims to provide a rigorous understanding of sequences andvarious tests for the convergence of series. It delves into the foundational concepts of limit and continuity, including the algebra of limits, continuous functions, and uniform continuity. Students will study differentiability and essential theorems such as the Intermediate Value Theorem, Mean Value Theorem, and Taylor's Theorem. Additionally, the course covers curvature, asymptotes, and the tracing of plane curves, integrating these concepts with practical applications in integral calculus and the geometry of curves.

Units	**Course Content**	**Teaching Hrs**
I	Series: Sequences and their limits. Theorems on limits. Convergent and divergent sequences. Monotone Sequences. Subsequences and the Bolzano-Weierstrass Theorem.	12
II	Series: The Cauchy Criterion. Convergent, Divergent, and Oscillatory series, Comparison test, D'Alembert's ratio test. Raabe's test. Cauchy's nth root test.	12
III	Limit and Continuity: Limits of functions, Algebra of limits. Continuity and uniform continuity of functions, Intermediate value theorem. Differentiability. Chain rule of differentiation.	12
IV	Darboux's theorem, Rolle's theorem, and Mean value theorems. Leibnitz theorem. Taylor's and Maclaurin's theorems. Maxima and Minima of functions. Nowhere differentiable functions.	12
V	Curvature. Asymptotes. Concavity and Convexity: Point of Inflexion, Singular Points. Tracing of plane curves (Cartesian and polar). Definite Integral as the limit of sum.	12

Texts / References

1. T.M. Apostol: Calculus, Vol I, John Wiley and Sons, Inc., New York, 1967.
2. R.G. Bartle; D.R. Sherbert: Introduction to Real Analysis, John Wiley and Sons, Inc., New York, 2011.
3. S.R. Ghorpade; B.V. Limaye: A Course in Calculus and Real Analysis, 2nd Edition, Springer, 2018.
4. Amber Habib, Calculus, Cambridge University Press, 2024.
5. G. Prasad: Differential Calculus, Pothishala Pvt. Ltd. Allahabad, 2000.
6. G. Prasad: Integral Calculus, Pothishala Pvt. Ltd. Allahabad, 2000.
7. A.N. Singh:The Theory and Construction of Non-differentiable Functions, Lucknow University Studies No. I, Newul Kishore Press, Lucknow, 1935.
8. N. Saran: Calculus, Pothishala Pvt. Ltd. Allahabad, 1963.
9. W.F. Trench: Introduction to Real Analysis, Pearson Education, 2003.

Learning Outcomes (not more than 100 words)

Upon completing this course, students can rigorously analyze sequences and series, determining their limits and convergence using various theorems and tests. They will understand and apply the concepts of limits, continuity, and differentiability to functions, utilizing key theorems such as Intermediate and Mean Value Theorems. Students will also learn to evaluate curvature, identify asymptotes, and trace plane curves. Additionally, they will develop the ability to apply integral calculus in understanding the geometric properties of curves and solve related mathematical problems.

Course Title	**MATSE11: Ethics in Academia and Mathematical Exploration**			
Credits &Hours of Teaching		Theory	Practical	Cumulative
	Credits	3	0	3
	Hours of Teaching (Total)	45	0	45
Course Objectives (not more than 100 words)	The objective of this course is to equip students with a robust understanding of ethical practices in higher education and academic research. Simultaneously, it aims to deepen their appreciation for key mathematical concepts and theorems. Students will engage in discussions about the implications of ethical decision-making in research, while also exploring various mathematical topics, such as irrational numbers, logarithms, and the Fibonacci sequence. By the end of the course, students will be able to apply ethical reasoning to academic challenges and recognize the beauty and significance of mathematics in real-world contexts.			

Units	**Course Content**	**Teaching Hrs**
I	Ethics in Higher Education and Academic Research. Ethics of Publication. Ethical Practices in Science Outreach. Ethical Issues Associated with Gender-Bias.	15
II	Six proofs of the infinity of primes. Binomial coefficients are (almost) never powers. Representing numbers as sums of two squares. Three applications of Euler's formula. Sets, functions, and the continuum hypothesis. In praise of inequalities.	15
III	Some irrational numbers. The golden mean and other roots. e: The queen of growth and decay. Logarithms. Infinite series: Fractals and the myth of forever. Fibonacci Numbers.	15

Texts / References	1. A. Ghosh, A.K. Singhvi, K. Muralidhar (Editors) Ethics in Science Education, Research and Governance, INSA, 2019. 2. M. Aigner and M. Ziegler: Proofs from THEBOOK, Springer, 2001. 3. A. Khare and A. Lachowska, Beautiful, Simple, Exact, Crazy: Mathematics in the Real World, Yale University Press, 2015. 4. J. Matousek, Thirty-three Miniatures: Mathematical and Algorithmic Applications of Linear Algebra, American Mathematical Society, 1991.
Learning Outcomes (not more than 100 words)	Upon completing this course, students will have a comprehensive understanding of the ethical frameworks governing higher education and academic research. They will critically analyze issues such as publication ethics, gender bias, and science outreach practices. Additionally, students will explore fundamental mathematical concepts, including the infinity of primes, binomial coefficients, and Euler's formula. They will develop the ability to connect ethical considerations with mathematical principles, fostering a holistic view of the interconnectedness between ethics and the pursuit of knowledge in both academia and mathematics.

Course Title	**MATMD11: Basic Mathematics-I**			
Credits &Hours of Teaching		Theory	Practical	Cumulative
	Credits	3	0	3
	Hours of Teaching (Total)	45	0	45
Course Objectives (not more than 100 words)	This course aims to comprehensively understand matrix theory, linear algebra, and difference equations. Students will learn to perform matrix operations, solve linear systems, and analyze sequences and their limits. The course also covers applying mathematical concepts to real-world problems, including pharmacokinetics and interpreting rates of change in various contexts.			

Units	**Course Content**	**Teaching Hrs**
I	Matrices, matrix addition, and multiplication. Determinants. Elementary row and column operations, Echelon form, rank of a matrix. The inverse of a matrix. Solution of a system of linear equations using matrices and determinants.	15
II	Geometric and Arithmetic Sequences, Monotone Sequences, Limit of a Sequence, Discrete Difference Equations, Linear Difference Equation with Constant Coefficients, Introduction to Pharmacokinetics.	15
III	Limit of a Function, Limit Properties, Right and Left Limits, Continuity, Intermediate Value Theorem, Average Rate of Change, Estimating Rates of Change for Data, Velocity, Examples of Rates of Change.	15

Texts / References	1. Erin N. Bodine, Suzanne Lenhart, and Louis J. Gross, Mathematics for the Life Sciences, Princeton University Press, 2014. 2. Robert G. Bartle and Donald R. Sherbert, Introduction to Real Analysis, John Wiley and Sons, Inc., New York, 2011.
Learning Outcomes (not more than 100 words)	By the end of the course, students will be able to solve systems of linear equations using matrix methods and understand and apply matrix operations, determinants, and inverses. They will also be proficient in determining the rank of matrices and solving linear difference equations. Additionally, students will be able to analyze sequences and series, apply limits and continuity concepts, and interpret rates of change in various contexts, including pharmacokinetics.

Course Title	**MATMD11: Basic Mathematics-I**			
Credits &Hours of Teaching		Theory	Practical	Cumulative
	Credits	3	0	3
	Hours of Teaching (Total)	45	0	45
Course Objectives (not more than 100 words)	This course aims to comprehensively understand matrix theory, linear algebra, and difference equations. Students will learn to perform matrix operations, solve linear systems, and analyze sequences and their limits. The course also covers applying mathematical concepts to real-world problems, including pharmacokinetics and interpreting rates of change in various contexts.			

Units	**Course Content**	**Teaching Hrs**
I	Matrices, matrix addition, and multiplication. Determinants. Elementary row and column operations, Echelon form, rank of a matrix. The inverse of a matrix. Solution of a system of linear equations using matrices and determinants.	15
II	Geometric and Arithmetic Sequences, Monotone Sequences, Limit of a Sequence, Discrete Difference Equations, Linear Difference Equation with Constant Coefficients, Introduction to Pharmacokinetics.	15
III	Limit of a Function, Limit Properties, Right and Left Limits, Continuity, Intermediate Value Theorem, Average Rate of Change, Estimating Rates of Change for Data, Velocity, Examples of Rates of Change.	15

Texts / References	1. Erin N. Bodine, Suzanne Lenhart, and Louis J. Gross, Mathematics for the Life Sciences, Princeton University Press, 2014. 2. Robert G. Bartle and Donald R. Sherbert, Introduction to Real Analysis, John Wiley and Sons, Inc., New York, 2011.
Learning Outcomes (not more than 100 words)	By the end of the course, students will be able to solve systems of linear equations using matrix methods and understand and apply matrix operations, determinants, and inverses. They will also be proficient in determining the rank of matrices and solving linear difference equations. Additionally, students will be able to analyze sequences and series, apply limits and continuity concepts, and interpret rates of change in various contexts, including pharmacokinetics.

Course Title	**MATMJ21: Algebra**

Credits &Hours of Teaching

	Theory	Practical	Cumulative
Credits	4	0	4
Hours of Teaching (Total)	60	0	60

Course Objectives (not more than 100 words)

This course aims to comprehensively understand real and complex numbers, including their roots and geometrical representations. Students will explore polynomials, their roots, the Fundamental Theorem of Algebra, and the relationships between roots and coefficients. The course covers Newton's method for integral roots, equivalence relations, and the division algorithm in $\mathbb{Z}$, including divisibility and the Euclidean algorithm. Students will learn about the Fundamental Theorem of Arithmetic, modular arithmetic, and basic congruence properties. The course also introduces group theory, covering basic properties, symmetries, dihedral groups, orders, subgroups, cyclic groups, and their classifications.

Units	**Course Content**	**Teaching Hrs**
I	Real and complex numbers, roots of complex numbers, the nth roots of unity, and geometrical representation.	12
II	Polynomials, roots of polynomial, Fundamental theorem of algebra, Relations between the roots and the coefficients, imaginary roots, integral and rational roots; Newton's method for integral roots.	12
III	Relation, equivalence relation, and equivalence class. Division algorithm in $\mathbb{Z}$, Divisibility, and the Euclidean algorithm, Fundamental theorem of arithmetic, Modular arithmetic, and basic properties of congruence.	12
IV	Groups, Basic properties of groups, Symmetries of a square, Dihedral group, Order of a group, Order of an element, Subgroups, Centre of a group, Centralizer of an element.	12
V	Cyclic groups and properties, Generators of a cyclic group, Classification of subgroups of cyclic groups.	12

Texts / References

1. W.S. Burnside, and A.W. Panton, The Theory of Equations, Vol. 1. Eleventh Edition,Dover Publications, Inc., 1979.
2. David M. Burton. Elementary Number Theory, 7th Edition, McGraw-Hill Education, 2011.
3. Leonard Eugene Dickson, First Course in the Theory of Equations. John Wiley & Sons, Inc., 2009.
4. I.N. Herstein, Topics in Algebra John Wiley and Sons, 2nd edition, 2004.
5. D.S. Malik, J.M. Mordeson and M.K. Sen, Fundamentals of Abstract Algebra, The McGraw-Hill Companies, Inc., 1997.

Learning Outcomes (not more than 100 words)

Upon completing this course, students can analyze and solve problems involving real and complex numbers, roots of polynomials, and the nth roots of unity. They will understand and apply the Fundamental Theorem of Algebra and Newton's method. Students will gain proficiency in equivalence relations, divisibility, the Euclidean algorithm, and modular arithmetic. Additionally, they will develop a solid foundation in group theory, including understanding the properties of groups, dihedral groups, subgroups, cyclic groups, and the classification of subgroups of cyclic groups.

Course Title	**MATSE21: LaTeX Typesetting for Beginners**

Credits &Hours of Teaching

	Theory	Practical	Cumulative
Credits	2	1	3
Hours of Teaching (Total)	30	20	50

Course Objectives (not more than 100 words)

This course will equip students with the foundational skills to create professional-quality documents using LaTeX. By the end of the course, students will be proficient in formatting text, structuring documents, incorporating mathematical content, managing bibliographies, and customizing layouts. The course also introduces advanced topics like creating custom commands and using LaTeX for presentations, preparing students to handle various document types.

Units	Course Content	**Teaching Hrs**
I	Introduction to LaTeX: Overview of LaTeX and its uses, Installing LaTeX (MikTeX/TeX Live) and an editor (TeXworks/Overleaf), Creating your first LaTeX document, Document structure: preamble, document body, and sections, Compiling LaTeX documents (PDF output)Text Formatting: Basic text formatting (bold, italics, underline, Fonts and sizes, Paragraph formatting (alignment, spacing, indentation, Lists: itemized, enumerated, and description lists, Special characters and symbols. Document Structure and Sections: Creating titles, sections, subsections, and chapters, Table of contents, lists of figures, and tables; page styles: headers, footers, and page numbers; Cross-referencing within the document.	10
II	Working with Mathematical Content: Basic mathematical symbols and equations, Display vs. inline math, Aligning equations, Common math environments (e.g., equation, align), Numbering and referencing equations. Tables and Figures: Creating tables: basic and complex tables, Adding captions and labels to tables, Inserting images and figures, Image formats and sizing, Positioning images within the text, Wrapping text around images	10
III	Bibliography and Citations: Introduction to referencing and bibliographies, Using BibTeX and Biber for bibliography management, Creating a bibliography: thebibliography environment vs. bib file, Common citation styles (APA, IEEE, etc.), Managing citations and references. Advanced Topics in LaTeX: Customizing document classes (e.g., article, report, book), Adding footnotes and endnotes, Creating custom commands and environments, Introduction to LaTeX packages, Presentation with LaTeX: Introduction to Beamer. Final Project and Review: Review all topics covered, Work on a final project (e.g., create a formatted document with text, equations, figures, and references), and Troubleshoot common LaTeX issues.	10

Texts / References

1. *Donald E. Knuth, The TEXbook, Addison-Wesley Publishing Company, 1991.*
2. Leslie Lamport, A Document Preparation System, Addison-Wesley Publishing Company, 1994.
3. Michael Spivak, The Joy of TeX: A Gourmet Guide to Typesetting with the AMSTeX, American Mathematical Society,1990.

Learning Outcomes (not more than 100 words)

Students can Create and compile LaTeX documents with structured content after completing this course.Format text, lists, and paragraphs, and manage document sections.Incorporate and format mathematical equations, tables, and figures.Manage references and bibliographies using BibTeX and Biber.Customize document layouts and styles and use LaTeX for presentations.Troubleshoot common issues and complete a final project demonstrating their LaTeX skills.

Course Title	**MATMD21: Basic Mathematics-II**			
Credits &Hours of Teaching		Theory	Practical	Cumulative
	Credits	3	0	3
	Hours of Teaching (Total)	45	0	45
Course Objectives (not more than 100 words)	This course aims to develop students' understanding of derivatives and their applications. Students will learn to compute derivatives of various functions, including exponential, trigonometric, and logarithmic. The course will cover techniques for finding maxima and minima, optimization problems, and the role of derivatives in analyzing function behavior. Key objectives include mastering differentiation rules, applying the Mean Value Theorem, and solving real-world problems using derivative concepts.			

Units	**Course Content**	**Teaching Hrs**
I	Concept of a Derivative, Limit Definition of a Derivative of a Function, Derivatives of Exponential Functions, Derivatives of Trigonometric Functions, Derivatives and Continuity, Derivatives of Logarithmic Functions.	15
II	The Chain Rule for the Composition of Functions, Quotient and Reciprocal Rules, Exponential Models, Higher Derivatives.	15
III	Maxima and Minima, First Derivative Test, Mean Value Theorem, Concavity, Optimization Problems.	15

Texts / References	1. Erin N. Bodine, Suzanne Lenhart, and Louis J. Gross, Mathematics for the Life Sciences, Princeton University Press, 2014. 2. William F. Trench, Introduction to Real Analysis, Pearson Education, 2003. 3. George B. Thomas, Ross L.Finney, Calculus and Analytic Geometry, 1998.
Learning Outcomes (not more than 100 words)	By the end of the course, students will be proficient in calculating derivatives using various rules and techniques, including the limit definition, chain rule, and rules for exponential, trigonometric, and logarithmic functions. They cananalyze functions for maxima, minima, and concavity, apply the Mean Value Theorem, and solve optimization problems. Additionally, students will understand how derivatives relate to function continuity and will be able to interpret and apply higher derivatives and exponential models.

Course Title	**MATMJ31: Linear Algebra**			
Credits &Hours of Teaching		Theory	Practical	Cumulative
	Credits	4	0	4
	Hours of Teaching (Total)	60	0	60
Course Objectives (not more than 100 words)	This course aims to provide a foundational understanding of linear algebra, focusing on vector spaces, subspaces, and linear transformations. Students will explore concepts such as bases, dimension, rank, nullity, and the properties of matrices. The course covers systems of linear equations, inner product spaces, orthogonality, orthogonal and unitary transformations, and the spectral properties of matrices. Additionally, students will learn about invariant subspaces, eigenvalues, eigenvectors, the Cayley-Hamilton Theorem, and various canonical forms. The course will also introduce bilinear forms, matrix representations, and quadratic forms with applications to the classification of curves and surfaces.			

Units	**Course Content**	**Teaching Hrs**
I	Vector spaces, Subspaces, Span, Bases, Dimension, sum and quotient of Vector spaces, Maps of vector spaces, Linear transformations, Isomorphism, Rank and nullity, Dual space, Transpose, and annihilator.	12
II	Matrix of a linear Transformation, similar matrices, change of basis, Rank of Matrix, Normal form, System of linear equations and their solutions.	12
III	Inner product spaces and theirproperties, orthogonality, and orthonormalization, Orthogonal complement Adjoint of a linear transformation.	12
IV	Orthogonal and Unitary transformations. Hermitian and skew Hermitian matrices. Invariant subspaces, Eigenvalues and eigenvectors, Characteristic polynomial, Cayley-Hamilton Theorem.	12
V	Diagonalization and triangularization, Cyclic Subspaces, Nilpotent transformations, Canonical Forms. Bilinear form, matrix representation, Quadratic forms, and application to classification of curves and surfaces.	12

Texts / References	1. Artin, M. : Algebra, Prentice-Hall, 1994. 2. Herstein, I. N. : Topics in Algebra, Wiley Eastern, 1987. 3. Hoffman, K. and Kunze, R. : Linear Algebra, Prentice-Hall, 1972. 4. Halmos, P. R. : Finite-Dimensional Vector Spaces, Springer-Verlag, 1993. 5. Kwak, Jin Ho; Hong, Sungpyo Linear algebra. Second edition. Birkhäuser Boston, Inc., Boston, MA, 2004.
Learning Outcomes (not more than 100 words)	Upon completing this course, students can analyze and manipulate vector spaces and subspaces, determine linear dependence and independence, and understand bases and dimensions. They will be proficient in linear transformations, isomorphisms, and matrix representations, including similar matrices and change of basis. Students will solve systems of linear equations, work with inner product spaces, and apply concepts of orthogonality and orthonormalization. They will understand eigenvalues, eigenvectors, and the Cayley-Hamilton Theorem and perform diagonalization and triangularization. Additionally, students will apply bilinear and quadratic forms to classify curves and surfaces.

Course Title	**MATMJ32: Analysis**			
Credits &Hours of Teaching		Theory	Practical	Cumulative
	Credits	4	0	4
	Hours of Teaching (Total)	60	0	60
Course Objectives (not more than 100 words)	This course aims to provide an in-depth understanding of the real numbers, their algebraic and order properties, and the completeness property of $\mathbb{R}$. Students will explore sequences, focusing on limit superior and limit inferior, and study convergence theorems. The course covers series, including alternating and absolutely convergent series, with tests by Dirichlet and Abel. Additionally, the course thoroughly examines the Riemann Integral, integrability criteria, and the fundamental and mean value theorems of integral calculus. Students will also study improper integrals, convergence tests, and the application of integrals as functions of a parameter.			

Units	**Course Content**	**Teaching Hrs**
I	The Real numbers: The Algebraic and Order Properties of $\mathbb{R}$. Absolute Value and Real Line.	12
II	The Completeness Property of $\mathbb{R}$. Applications of the Supremum Property. Limit superior and limit inferior of sequences. Monotone convergence theorem.	12
III	Alternating series, absolute convergent series. Dirichlet's and Abel's test. Riemann Integral, Integrability of continuous and monotonic Functions.	12
IV	Fundamental theorem of integral calculus, Mean Value theorems of integral calculus.	12
V	Improper integrals and their convergence. Comparison test, Beta and Gamma functions, Abel's and Dirichlet's test, Integral as a function of a parameter and its applications.	12

Texts / References	1. T. M. Apostol, Mathematical Analysis, Narosa Publishing House, New Delhi, 1985. 2. Richard Dedekind, What Are Numbers and What Should They Be? (A Classic Work) (Revised, edited and translated by H. Pogorzelski, W. Ryan and W. Snyder, Research Institute for Mathematics, Orono, Maine, 1995. 3. R. R. Goldberg, Real Analysis, Oxford & IBH Publishing Company, New Delhi, 1970. 4. S. Lang, Undergraduate Analysis, Springer-Verlag, New York, 1983. 5. W. Rudin, Principles of Mathematical Analysis, McGraw-Hill, 2023.
Learning Outcomes (not more than 100 words)	Upon completing this course, students will be able to understand and apply the algebraic and order properties of $\mathbb{R}$, as well as the completeness and supremum properties. They will analyze sequences using limit superior and inferior, and apply the monotone convergence theorem. Students will evaluate alternating and absolutely convergent series using Dirichlet's and Abel's tests. They will comprehend the Riemann Integral and its integrability criteria, apply integral calculus's fundamental and mean value theorems, and determine the convergence of improper integrals using various tests. Additionally, students will apply integrals as functions of a parameter to solve practical problems.

Course Title	**MATMV31: Python for Mathematical Applications**

Credits &Hours of Teaching

	Theory	Practical	Cumulative
Credits	3	1	4
Hours of Teaching (Total)	45	20	65

Course Objectives (not more than 100 words)

This course aims to provide students with a comprehensive introduction to Python programming. It covers fundamental concepts such as literals, variables, identifiers, data types, and control structures for managing program flow. Students will gain practical experience with Python's core data structures, including lists, tuples, dictionaries, and sets. The course also delves into using functions, focusing on creating reusable code through value-returning and non-value-returning functions, understanding parameter passing, return values, and variable scope.

Units	Course Content	**Teaching Hrs**
I	Fundamental concepts: Literals, variables and identifiers, strings, operators, expressions and data types, Control structures	15
II	Boolean expressions, selection control, iterative control Lists: List structures, Lists, (sequences), iterating over lists; Changing, adding, removing elements, Tuples,	15
III	Dictionaries and sets Functions: Program routines, calling value-returning functions, calling non value-returning functions, parameter passing, return values, variable scope.	15

Texts / References

1. Eric Matthes, Python Crash Course A Hands on, Project based Introduction to Programming, 2016, William Pollock, No Starch Press, Inc.
2. Mark Lutz, Learning Python,O'reilly,2009.
3. S.Sridhar, J. Indumathi, V.M. Hariharan, Python Programming, Pearson, 2023.

Learning Outcomes (not more than 100 words)

By the end of this course, students will Understand and apply fundamental Python programming concepts, including data types, variables, and operators. Use control structures such as loops and conditional statements to manage program flow effectively. Manipulate and operate on Python's core data structures, including lists, tuples, dictionaries, and sets. Develop and utilize functions to create modular, reusable code with an understanding of parameter passing and scope. Write Python programs that demonstrate problem-solving skills and effective use of Python's features.

Course Title	**MATSE31: Sage Math for Beginners**			
Credits &Hours of Teaching		Theory	Practical	Cumulative
	Credits	2	1	3
	Hours of Teaching (Total)	30	20	50
Course Objectives (not more than 100 words)	This course introduces students to SageMath, a versatile open-source mathematics software system. The course covers the essential features of SageMath, enabling students to perform arithmetic, algebra, calculus, and linear algebra operations, as well as create and analyze graphs. By the end of the course, students will be capable of using SageMath for various mathematical applications, from basic computations to solving complex problems in fields like number theory and discrete mathematics.			

Units	Course Content	**Teaching Hrs**
I	Introduction to SageMath: Overview of SageMath: What is it and why use it?, Installing SageMath (locally or using SageMathCell/CoCalc)., Introduction to the SageMath interface and basic commands., Creating and running SageMath notebooks. Arithmetic operations and basic functions. Algebra with SageMath: Working with symbolic expressions and variables. Simplifying expressions, expanding, and factoring. Solving algebraic equations (linear, quadratic, polynomial). Working with systems of equations. Introduction to matrices and basic matrix operations. Functions and Graphing: Defining and evaluating functions in SageMath. Plotting functions: basic plots, multiple plots, and customizing plots. Exploring more complex graphs: polar plots, parametric plots, and 3D plots. Applications: modeling real-world phenomena with functions and graphs.	10
II	Calculus with SageMath: Limits and continuity. Differentiation: finding derivatives and applying differentiation rules. Integration: definite and indefinite integrals. Series and summation. Applications: solving calculus problems using SageMath. Number Theory and Discrete Mathematics: Introduction to number theory: primes, gcd, lcm, and modular arithmetic. Working with integers, rationals, and modular forms. Basic combinatorics: permutations, combinations, and binomial coefficients. Applications in cryptography and coding theory.	10
III	Linear Algebra in SageMath: Introduction to vectors and vector spaces. Matrix operations: addition, multiplication, and inversion. Solving linear systems using matrix methods. Eigenvalues and eigenvectors. Applications: solving linear algebra problems using SageMath. Advanced Topics in SageMath. Introduction to SageMath packages and libraries (e.g., NumPy, SciPy). Polynomial algebra and advanced algebraic structures. Basic differential equations: solving ODEs and PDEs. Introduction to statistics and probability using SageMath. Applications: using SageMath in research and complex problem-solving.Final Project and Review: Review of all topics covered. Working on a final project (e.g., solving a real-world problem using SageMath). Troubleshooting common issues in SageMath. Course feedback and further learning resources.	10

Texts / References	1. Gregory V. Bard, *SageMath for Undergraduates* (online version), 2010. 2. Paul Zimmermann, Computational Mathematics with SageMath, SIAM,2019.
Learning Outcomes (not more than 100 words)	Upon completing this course, students can: Navigate the SageMath interface and perform basic arithmetic and algebraic operations. Utilize SageMath for graphing functions, performing calculus operations, and solving linear algebra problems. Apply SageMath in areas such as number theory, combinatorics, and cryptography. Use SageMath packages for advanced mathematical computations, including differential equations and statistics. Complete a final project demonstrating the practical application of SageMath to a real-world problem.

Course Title	**MATMD31: Basic Mathematics-III**			
Credits &Hours of Teaching		Theory	Practical	Cumulative
	Credits	3	0	3
	Hours of Teaching (Total)	45	0	45
Course Objectives (not more than 100 words)	This course aims to thoroughly understand integration techniques and their applications, including finding areas, volumes, and average values. Students will learn to use substitution and integration by parts to evaluate integrals. The course will also introduce differential equations, focusing on methods such as the separation of variables, and apply these concepts to population dynamics and stability models. Key objectives include mastering integration techniques, applying them to real-world problems, and understanding differential equations and their practical implications.			

Units	**Course Content**	**Teaching Hrs**
I	Definition of an Integral, Antiderivatives, Fundamental Theorem of Calculus, Antiderivatives and Integrals, Average Values. Substitution Method, Integration by Parts. Definite Integral and its applications.	15
II	The Area between Two Curves, The Volume of a Solid of Revolution,Density Functions	15
III	Introduction to Differential Equations, Separation of Variables Method, Models of Limited Population Growth, Equilibria and Stability, Homeostasis	15

Texts / References	1. Erin N. Bodine, Suzanne Lenhart, and Louis J. Gross, Mathematics for the Life Sciences, Princeton University Press, 2014. 2. William F. Trench, Introduction to Real Analysis, Pearson Education, 2003. 3. George B. Thomas, Ross L. Finney, Calculus and Analytic Geometry, 1998.
Learning Outcomes (not more than 100 words)	By the end of the course, students will be able to compute and interpret integrals and antiderivatives and apply the Fundamental Theorem of Calculus. They will use methods such as substitution and integration by parts to solve integrals and analyze applications, including the area between curves, volumes of solids of revolution, and density functions. Students will also understand and solve differential equations using the separation of variables method and apply these concepts to population growth, equilibria, and homeostasis models.

Course Title	**MATMJ41: Calculus of Several Variables**			
Credits &Hours of Teaching		Theory	Practical	Cumulative
	Credits	4	0	4
	Hours of Teaching (Total)	60	0	60
Course Objectives (not more than 100 words)	This course aims to provide a comprehensive understanding of calculus in Euclidean n-space. Students will explore Euclidean norms, distances, and tangent spaces and delve into the concepts of open sets and functions from $\mathbb{R}^n$ to $\mathbb{R}^m$. The course covers limits, continuity, partial and directional derivatives, gradients, and the Jacobian matrix. Students will learn about the Mean Value Theorem, Euler's Theorem, and the Inverse and Implicit Function Theorems. The course also includes second differentials, Taylor series, extrema, Lagrange multipliers, and integration techniques.			

Units	**Course Content**	**Teaching Hrs**
I	Euclidean n-space $\mathbb{R}^n$. Euclidean norm and Euclidean distance. Tangent spaces in $\mathbb{R}^n$. Open sets in $\mathbb{R}^n$.	12
II	Functions from $\mathbb{R}^n$ to $\mathbb{R}^m$. Limit of sequences in $\mathbb{R}^m$. Limit and continuity of functions from $\mathbb{R}^n$ to $\mathbb{R}^m$. Partial derivatives and directional derivatives. Gradient of a function. Derivatives of functions between Euclidean space spaces.	12
III	First differential and Jacobian matrix. Change of Variables. Chain Rule. Mean Value Theorem. Euler's Theorem. Inverse Function Theorem and Implicit Function Theorem (Constant Rank Theorem optional).	12
IV	Hessian matrix, Second differentials and Taylor Series. Maxima, Minima and Saddles. Lagrange Multipliers.	12
V	Integration: Fubini's Theorem. Applications to area, surface area and volume. Beta and Gamma functions. Dirichlet's theorem, Liouville's theorem.	12

Texts / References	1. T.M. Apostol: Mathematical Analysis, Narosa Publishing House, New Delhi, 1985. 2. W. Rudin: Principle of Mathematical Analysis (Thrid edition) McGraw-Hill Kogakusha, 1976, International Student Edition. 3. J.R. Munkres: Analysis on manifolds. Addison-Wesley Publishing Company, Advanced Book Program, Redwood City,CA, 1991. 4. C.H. Edwards: Advanced Calculus of Several Variables, Academic Press, 1973. 5. T. M. Apostol: Calculus, Volume 2, 2nd. Ed., Wiley India, 2007. 6. J.J. Callahan: Advanced Calculus - A Geometric View, Springer, 2010. 7. R. Courant; F. John: Introduction to Calculus and Analysis, Volume 2, John Wiley and Sons, 1974. 8. J. Cooper: A MATLAB Companion for Multivariable Calculus, Harcourt/Academic Press 2001. 9. J.R. Magnus; H. Neudecker: Matrix differential calculus with applications in statistics and econometrics. John Wiley and Sons,Third Ed. 2007. 10. M. Spivak: Calculus on manifolds. A modern approach to classical theorems of advanced calculus. W. A. Benjamin, Inc., New York-Amsterdam, 1965.
Learning Outcomes (not more than 100 words)	Upon completing this course, students can analyze Euclidean n-space, compute Euclidean norms, and understand tangent spaces. They will evaluate the limits and continuity of multivariable functions and calculate partial and directional derivatives. Students will apply the chain rule, the Mean Value Theorem, Euler's Theorem, and the Inverse and Implicit Function Theorems. They will determine maxima, minima, and saddle points using second differentials and Taylor series and solve optimization problems with Lagrange multipliers. Additionally, students will apply Fubini's Theorem, evaluate Beta and Gamma functions, and use Green's, Stokes', and Gauss' theorems for line and surface integrals.

Course Title	**MATMJ42: Vector and Tensor Analysis**

Credits &Hours of Teaching

	Theory	Practical	Cumulative
Credits	3	0	3
Hours of Teaching (Total)	45	0	45

Course Objectives (not more than 100 words)

This course aims to provide a comprehensive understanding of differential operators and vector integration, focusing on gradient, divergence, and curl, as well as the Helmholtz decomposition. Students will explore line, surface, and volume integrals and apply integral theorems such as Green's theorem, Gauss's divergence theorem, and Stokes' theorem. The course covers curvilinear coordinates, including orthogonal systems, and extends these concepts to tensor analysis. Students will learn about contravariant and covariant tensors, coordinate transformations, physical laws, and the metric tensor, Christoffel symbols, geodesics, and the gradient, divergence, and curl in tensor form.

Units	**Course Content**	**Teaching Hrs**
I	Differential operators: The concept of Gradient, Divergence, and Curl. Helmholtz decomposition.	9
II	Vector Integration: Line, surface, and volume integrals. Integral Theorems: Green's theorem in the plane, Gauss divergence theorems, Stokes' theorem, Green's formulas, and application of these theorems/formulas.	9
III	Curvilinear Coordinates: Curvilinear and orthogonal curvilinear coordinate systems and unit vectors. Arc lengths. Volume elements. Gradient, Divergence, and Curl in curvilinear coordinate systems. Some special orthogonal curvilinear coordinate systems.	9
IV	Tensor Analysis: Contra variant and covariant tensors, mixed tensors, coordinate transformation, and physical laws. Contraction, symmetric, and skew-symmetric tensors. metric tensor, length, and angle between two curves.	9
V	Christoffel symbols. Transformation laws of Christoffel symbols. Geodesics. Gradient, Divergence and Curl in tensor form, Derivation.	9

Texts / References

1. H. Guo: What are tensors exactly?, World Scienti_c, 2021.
2. D.C. Kay: Tensor Analysis, Schaum's Outline Series, McGraw Hill 1988.
3. R.S. Mishra: A Course in Tensors with Applications to Reimannian Geometry, Pothishala Pvt. Ltd, Allahabad.
4. M.R. Spiegel: Vector Analysis, Schaum's Outline Series, McGraw Hill, 1959.

Learning Outcomes (not more than 100 words)

Upon completing this course, students can understand and apply the concepts of gradient, divergence, and curl and perform Helmholtz decomposition. They will evaluate line, surface, and volume integrals and apply integral theorems such as Green's, Gauss's, and Stokes' theorems. Students will master curvilinear coordinates, including orthogonal systems, and calculate arc lengths and volume elements. They will extend their understanding of tensor analysis by working with contravariant and covariant tensors, coordinate transformations, and the metric tensor. Additionally, students will understand Christoffel symbols and geodesics and express gradient, divergence, and curl in tensor form.

Course Title	**MATMJ43/ MATMN41: Differential Equations**

Credits &Hours of Teaching

	Theory	Practical	Cumulative
Credits	4	0	4
Hours of Teaching (Total)	60	0	60

Course Objectives (not more than 100 words)

This course aims to provide a thorough understanding of both ordinary differential equations (ODEs) and partial differential equations (PDEs). Students will explore linear differential equations of the first order, higher-degree equations solvable for x, y, z, singular solutions, and envelopes. The course covers linear differential equations with constant coefficients, homogeneous equations, and the method of variation of parameters. Additionally, students will study second-order linear differential equations with variable coefficients and series solutions. For PDEs, the course includes the formation and classification of linear first-order PDEs, Lagrange's method, Charpit's method for non-linear first-order PDEs, and higher-order linear PDEs with constant and variable coefficients.

Units	**Course Content**	**Teaching Hrs**
I	Differential Equations: Linear differential equations of first order. First order higher degree equations solvable for x, y, z. Singular solution and envelopes.	15
II	Linear differential equations with constant coefficients, homogeneous linear differential equations.	15
III	Qualitative behaviour of solutions. Method of variation of parameters, linear differential equations of second order with variable coefficients, series solution.	15
IV	Partial Differential Equations: Formation of partial differential equations, Linear partial differential equations of first order and its classifications, Lagrange's method.	15
V	Non-linear PDE of first order: Charpit's method. Linear partial differential equation of second and higher order of homogeneous and non-homogeneous forms with constant coefficients, Linear partial differential equations reducible to equations with constant coefficients.	15

Texts / References

1. E.A. Coddington: An Introduction to Ordinary Differential Equations, Prentice Hall of India, 1961.
2. M. Braun: Differential equations and their applications. Springer-Verlag, New York, 1993.
3. B. Rai; D.P. Choudhary; H.I. Freedman: Ordinary Differential Equations, Narosa Publications, New Delhi, 2002.
4. S G Deo, V Raghavendra, Rasmita Kar, V LakshmikanthamTextbook of Ordinary Differential Equations, McGraw Hill Education (India) Private Limited, 2017.
5. G.F. Simmons, Differential equations with Applications and Historical notes, CRC Press.
6. I.N. Sneddon: Elements of Partial Differential Equations, McGraw-Hill Book Company, 1988.

Learning Outcomes (not more than 100 words)

Upon completing this course, students can solve linear differential equations of the first order and higher-degree equations solvable for x, y, z. They will identify singular solutions and envelopes, handle linear differential equations with constant coefficients, and solve homogeneous equations. Students will understand the qualitative behavior of solutions and apply the method of variation of parameters. They will solve second-order linear differential equations with variable coefficients using series solutions. For PDEs, students will form and classify linear first-order PDEs, apply Lagrange's method, solve non-linear first-order PDEs using Charpit's method, and tackle higher-order linear PDEs with constant and variable coefficients.

Course Title	**MATMJ44: Mechanics**			
Credits &Hours of Teaching		Theory	Practical	Cumulative
	Credits	3	0	3
	Hours of Teaching (Total)	45	0	45
Course Objectives (not more than 100 words)	This course aims to provide a solid foundation in the mathematical analysis of forces and couples applied to particles and rigid bodies in static and dynamic states. Students will learn the concepts of vector addition and multiplication, differentiation of vector functions, and their applications in mechanics. The course covers the equilibrium of forces in 2D and 3D, the principle of virtual work, and Poinsot's central axis. It also explores the dynamics of a particle in two dimensions: central orbits, Kepler's laws, and constrained motion. Additionally, students will study the rigid body, moment and product of inertia, principle axes, and equi-momental systems.			

Units	**Course Content**	**Teaching Hrs**
I	Laws of vectors in two-dimension(2D): Application to mechanics, Concurrent forces in a plane, System of parallel forces, Coplanar forces, Theory of couples, Resultant Force and couple, Moment of a force about a point and about a line, Moment of a couple, Varignon's theorem.	9
II	Equilibrium of forces in 2D: Reduction and analytical conditions for the equilibrium of a system of forces acting on a particle and a rigid body, Different forms of the equilibrium conditions; Virtual displacement and virtual work, Principle of virtual work, Deduction of necessary and sufficient conditions for the equilibrium of a system of forces acting on a particle or different points of a rigid body. Application of Hooke's law related to virtual work.	9
III	Dynamics of a particle in 2D: Velocity, acceleration, angular velocity, linear momentum, angular momentum, relative velocity and acceleration, Expressions for velocity and acceleration for the cases of rectilinear and planar motions in Cartesian system, polar system and intrinsic system; Rectilinear motion: simple harmonic motion(SHM), Periodic motion, Amplitude, Time period, Frequency, Phase and epoch	9
IV	Central orbit and Kepler's laws of motion: Equation of central orbit in polar and pedal form, Motion under inverse square law, Particle moving along elliptic, parabolic, hyperbolic and other polar curves, Kepler's laws of planetary motion and related problems; Constrained motion on smooth vertical curves: Upward and downward motion along inner smooth surface of a vertical circle (SHM about the vertex), Upward and downward motion along inner smooth surface of a vertical cycloid (SHM about the vertex between two cusps), Time period of SHM and time taken to reach different heights of the cycloid.	9
V	Forces in 3D: Concept of axis of a couple, Reduction of forces and analytic conditions of equilibrium in 3D, Dyname and components of dyname, Poinsot's central axis; Definition of a rigid body, Moment of inertia(M.I.) and product of inertia(P.I.), Theorem of parallel axes, Moment of inertia and product of inertia of some symmetrical bodies: Rod, Rectangular plate, Circular ring and disc, Hollow and solid spheres, Principle axes and principal moments, M.I. and P.I. about an inclined lines.	9

Texts / References	1. J.L. Synge; B.A. Griffith: Principle of Mechanics, McGraw Hill, 1949. 2. F. Chorlton: Textbook of Dynamics, CBS Publishers, India, 2nd Edition, 2002. 3. S.L. Loney: An Elementary Treatise on Statics, G.K. Publishers, India, 2016. 4. S.L. Loney: An Elementary Treatise on Dynamics of Particle and of Rigid Body, AITS Publishers, India, 1998. 5. A.S. Ramsey: Dynamics (Part I & II), .CBS Publishers, India, 2002 6. R.C. Hibbelar: Engineering Mechanics-Statics and Dynamics, Prentice Hall Publishers, 13th Edition, 2012. 7. H. Goldstein: Classical mechanics, Addison-Wesley Series in Physics, Addiso-Wesley Publishing Co., 2nd Edition, 1980.
Learning Outcomes (not more than 100 words)	Upon completing this course, students will be able to understand and apply concepts of vectors to physical problems and analyze forces in equilibrium. They will comprehend the necessary conditions for equilibrium in two and three dimensions and apply the principle of virtual work. Students will understand particle dynamics, including velocity, acceleration, and motions in various coordinate systems. They will solve problems related to central orbits and Kepler's laws and recognize the dynamics of constrained motion. Students will also calculate moments and products of inertia and feel the concepts of principle axes, momental ellipse and ellipsoid, and equi-momental systems.

Course Title	**MATMJ51: Abstract Algebra**			
Credits &Hours of Teaching		Theory	Practical	Cumulative
	Credits	4	0	4
	Hours of Teaching (Total)	60	0	60
Course Objectives (not more than 100 words)	This course comprehensively introduces abstract algebra, covering fundamental concepts such as homomorphisms, isomorphisms, and group theory. Students will explore subgroups, group generation, and the center of a group, as well as Lagrange's theorem and its applications, including Euler's theorem and Fermat's theorem. The course will cover normal subgroups, quotient groups, and the fundamental theorems of homomorphism and isomorphism. Students will also study symmetric groups, permutations, and group actions. The course includes exploring rings, subrings, ideals, quotient rings, and polynomial rings, focusing on integral domains, division rings, and fields.			

Units	**Course Content**	**Teaching Hrs**
I	Homomorphism, Isomorphism. Subgroup, group generated by a subset, center of a group, coset, Lagrange theorem applications: Euler's theorem, Fermat and Wilson Theorem.	15
II	Product of groups, Normal subgroup, quotient group, Fundamental theorem of homomorphism, first and second isomorphism theorems, Commutator and abelianization.	15
III	Symmetric group, cycles, transpositions, even and odd permutations, Alternating group and normal subgroups of S_n.	15
IV	Group action: regular and conjugations, orbits, isotropy, class equation, conjugacy class, groups of order p^2. Rings, definitions, and examples of subrings, rings of Gaussian integers, matrix rings, quaternions, Ideals, and quotient rings, Homomorphisms.	15
V	Integral domain, division rings, Communicative rings and fields. Field of fractions, Polynomial rings, division algorithm, Ideals of a polynomial ring over a field. Algebra of Reals, Complex numbers, Quaternions and Octonians.	15

Texts / References	1. I.N. Herstein: Topics in Algebra, Wiley Eastern Ltd, New Delhi, 1975. 2. M. Artin: Algebra, Prentice Hall, Inc., Englewood Cliffs, NJ, 1991. 3. J.B. Fraleigh: Algebra, Narosa, 1998. 4. R. Lal: Algebra vol 1, Springer, 2020.
Learning Outcomes (not more than 100 words)	Upon completing this course, students can understand and apply the concepts of homomorphisms, isomorphisms, and subgroup structures, including Lagrange's theorem and its applications. They will analyze symmetric groups, permutations, and group actions and utilize concepts such as orbits and conjugacy classes. Students will explore ring theory, including the definitions and properties of subrings, ideals, and quotient rings. They will understand and work with integral domains, division rings, commutative rings, fields, and polynomial rings and apply the division algorithm and concepts related to the field of fractions.

Course Title	MATMJ52: Metric Spaces			
Credits &Hours of Teaching		Theory	Practical	Cumulative
	Credits	3	0	3
	Hours of Teaching (Total)	45	0	45
Course Objectives (not more than 100 words)	This course aims to understand metric spaces and functional analysis deeply. Students will explore the fundamental concepts of metric spaces, including neighborhoods, limit points, open and closed sets, and completeness. The course will cover compactness, Cantor's intersection theorem, and the construction of real numbers as the completion of rationals. Students will also study sequences and series of functions, focusing on pointwise and uniform convergence, Cauchy's criterion, and various tests for uniform convergence. Additionally, the course includes the study of uniform convergence about continuity, Riemann-Stieltjes integration, differentiation, and approximation theorems.			

Units	Course Content	Teaching Hrs
I	Definition of a Metric Space: Metric, examples, and basic properties.Open and Closed Sets: Definitions, examples, and properties within metric spaces. Neighborhoods and Convergence: Understanding neighborhoods, limit points, and convergent sequences. Topology induced by a metric. Interior, Closure, and Boundary: Definitions and their significance in metric spaces.	15
II	The subspace of a metric space. Completeness. Compactness: Heine-Borel Theorem.Compactness and sequential compactness.Connectedness: Connected and disconnected sets.Path-connected spaces.	15
III	Cantor's intersection theorem.Construction of real numbers as the completion of the incomplete metric space of rationals. Dense subsets. Separable metric spaces. Continuous functions. Uniform continuity, Isometry, and homeomorphism. Equivalent metrics.	15

Texts / References	1. E.T. Copson: Metric Spaces, Cambridge University Press, 1968. 2. S. Kumaresan: Topology of Metric Spaces, Narosa Publishing House, New Delhi, 2005. 3. W. Rudin: Principles of Mathematical Analysis, McGraw-Hill, 1976. 4. B.K. Tyagi: First Course in Metric Spaces, Cambridge University Press, 2010. 5. Irving Kaplansky, Set Theory and Metric Spaces,AMS Chelsea Publishing, 1972. 6. Mícheál Ó Searcóid, Metric Spaces, Springer, 2006. 7. Athanase Papadopoulos, Metric Spaces, Convexity and Nonpositive Curvature: Second Edition,European Mathematical Society, 2014.
Learning Outcomes (not more than 100 words)	Upon completing this course, students will be able to understand and apply concepts related to metric spaces, including neighborhoods, limit points, and the notions of open and closed sets. They will analyze completeness, compactness, and Cantor's intersection theorem and construct real numbers as the completion of rationals. Students will explore dense subsets, separable metric spaces, and continuous functions. They will analyze sequences and series of functions for pointwise and uniform convergence, apply Cauchy's criterion, and utilize convergence tests. Students will understand the relationship between uniform convergence, continuity, and Riemann-Stieltjes integration and apply approximation theorems and equicontinuity concepts.

Course Title	**MATMJ53: Analytic Geometry**

Credits &Hours of Teaching

	Theory	Practical	Cumulative
Credits	4	0	4
Hours of Teaching (Total)	60	0	60

Course Objectives (not more than 100 words)

This course offers a detailed exploration of polar coordinates and their applications and the study of geometric entities in three-dimensional space. Students will learn to work with polar equations for lines, circles, and conics and understand the equations for chords, tangents, and normals. The course covers the analysis of planes and straight lines in $\mathbb{R}^3$ using vector methods and the properties of spheres, including plane sections, circles, and tangent planes. Students will also study cones and cylinders, including their equations and conditions of tangency, and explore conoids, including central conoids and paraboloids, emphasizing tangent planes, normals, and the classification of quadrics.

Units	**Course Content**	**Teaching Hrs**
I	Polar coordinators, Polar Equation: Distance between two points. Polar equation of a straightline. Polar equation of a circle. Polar equation of a conic. Equations ofchord, tangent, normal, chord of contact of a conic.	12
II	Plane and straight line: Plane and straight line in $\mathbb{R}^3$ by using vectormethod.	12
III	Sphere: Equation of a sphere. Plane section of sphere. Equations of circle.Sphere passing through a given circle. Equation of tangent plane. Angle ofintersection of two sphere.	12
IV	Cone and Cylinder: Cone with vertex as origin. Condition for the generalequation of second degree to represent a cone. Equation of Right circularcone. Equation of tangent plane to a cone. Condition of tangency. Reciprocalcone. Enveloping cylinder, Right circular cylinder.	12
V	Conicoids: Central conicoids. Paraboloids. Equation of tangent plane andnormal to a conicoid. Condition of tangency. Cone through six normals. Planesections of conicoids. Enveloping cone and enveloping cylinder.Classification of quadrics.	12

Texts / References

1. R.J.T. Bell: An Elementary Treatise on Co-ordinate geometry of three dimensions, Macmillan India Ltd., New Delhi, 1994.
2. M.M. Tripathi: Coordinate Geometry: Polar Coordinates Approach, Narosa Publishing House, New Delhi, 2005.
3. M.M. Tripathi: A Course on Geometry in Euclidean 3-space,
4. P. Balasubramanyam; K.G. Subramanyam; G.R. Venkatraman: Coordinate geometry of two and three dimensions, Tata McGraw-Hill, New Delhi, 1994.

Learning Outcomes (not more than 100 words)

Upon completing this course, students can derive and analyze polar equations for lines, circles, and conics and understand the equations for associated geometric features such as chords and tangents. Using vector methods, they will work with planes and straight lines in three-dimensional space. Students will understand and apply the equations for spheres, including plane sections and tangent planes, and analyze intersections of spheres. They will study cones and cylinders, including conditions for tangency and equations of enveloping surfaces. Additionally, students will explore conicoids, including paraboloids, classify quadrics, and understand tangent planes, normals, and other geometric properties.

Course Title	**MATMJ54: Numerical Analysis**			
Credits &Hours of Teaching		Theory	Practical	Cumulative
	Credits	3	1	4
	Hours of Teaching (Total)	45	15	60
Course Objectives (not more than 100 words)	This course focuses on numerical methods and their applications in solving mathematical problems. Students will learn techniques for computing errors and solving nonlinear equations using Bisection, Regula-Falsi, Secant, and Newton-Raphson methods, along with fixed-point iteration and the convergence rate. The course covers the solution of polynomial roots using the Birge-Vieta method, linear systems using Gauss elimination and iterative methods, and eigenvalue computation through the Power method. Students will also explore finite differences and interpolation techniques, including Newton's forward and backward methods, Lagrange interpolation, and divided difference interpolation. Key numerical integration methods, including the Trapezoidal, Simpson, Boole, and Weddle's rules, will be covered. The course concludes with methods for solving ordinary differential equations, including Euler's method, Modified Euler's method, Runge-Kutta methods, and Predictor-Corrector methods.			

Units	**Course Content**	**Teaching Hrs**
I	Errors and their computations; Numerical solutions of nonlinear equations:Bisection method, Regula-Falsi, Secant method, Newton-Raphson, fixed pointiteration, Rate of convergence of iterative methods;	9
II	Roots of Polynomials: Birge-Vieta method; System of linear equations: Gauss elimination method, Gauss-Jordan method, Jacobi iterative method, Gauss-Seidal iterative method; Eigen value computation: Power method; Finite differences;	9
III	Interpolation: Newton's forward and backward interpolation, Lagrange's interpolation, Newton's divided difference interpolation; Numerical differentiation;	9
IV	Numerical integration: Trapezoidal rule, Simpson's one-third rule, Simpson'sthree-eighth rule, Boole's rule and Weddle's rule; Errors in quadratureformulae;	9
V	Numerical solution to ordinary differential equations of firstorder: Euler's method, Modified Euler's method, Runge-Kutta second andfourth order, Implicit Runge-Kutta second order; Predictor Correctormethods: Milne Simpson method, Adams-Bashforth method.	9

Texts / References	1. M.K. Jain; S.R.K. Iyengar; R.K. Jain: Numerical Methods for Scientific and Engineering Computation, New Age International, New Delhi, 1984. 2. C.F. Gerald; P.O. Wheatley: Applied Numerical Analysis, Pearson Education, 1970. 3. S.D. Conte; C. de Boor: Elementary Numerical Analysis, McGraw-Hill,1972. 4. C.E. Froberg: Introduction to Numerical Analysis, Addition-Wesley, 1965. 5. M.J. Maron, Numerical Analysis A Practical Approach, Macmillan Publishing Company Inc., New York, 1982. 6. S.S. Sastry: Introductory Methods of Numerical Analysis, PHI Learning Private Limited, New Delhi,1979.
Learning Outcomes (not more than 100 words)	Upon completing this course, students will be proficient in various numerical techniques for solving mathematical problems. They can compute and assess errors and apply methods for solving nonlinear equations, including iterative techniques and convergence analysis. Students will gain expertise in solving systems of linear equations and computing eigenvalues. They will understand and apply interpolation techniques and numerical differentiation and accurately perform numerical integration using multiple quadrature rules. Additionally, students will be skilled in solving ordinary differential equations using various methods, including Euler's, Runge-Kutta, and Predictor-Corrector methods.

Course Title	MATMV51: Optimization Techniques			
Credits &Hours of Teaching		Theory	Practical	Cumulative
	Credits	4	0	4
	Hours of Teaching (Total)	60	0	60
Course Objectives (not more than 100 words)	This course aims to equip students with fundamental and advanced techniques in optimization, focusing on linear programming (LP), duality, and both constrained and unconstrained optimization. Students will learn model formulation, graphical methods, and the Simplex Method for LP problems while exploring duality and specialized algorithms like the transportation problem. Key methods such as steepest descent and conjugate gradients will be covered for unconstrained optimization alongside necessary and sufficient optimality conditions. In constrained optimization, the focus will be on KKT conditions and Lagrangian functions, with practical applications across industries			

Units	Course Content	Teaching Hrs
I	Real life Applications and Model Formulation of Linear Programming problems, Graphical Methods, convex set, extreme points, Canonical and Standard Form, Slack, Surplus and artificial Variables, basic feasible solution, The Simplex Method, Two-Phase Method, Big-M Method.	15
II	Duality in Linear Programming, dual simplex method, Transportation Problem, North-West Corner Method, Least Cost Method, Vogel's Approximation Method, MODI method, assignment problem, Hungarian Method.	15
III	Unconstrained Optimization, local and global minimizers, first and second-order necessary optimality conditions, second-order sufficient optimality condition, steepest descent method, the conjugate gradient method.	15
IV	Constrained Optimization, feasible directions, descent directions, Lagrangian function, Fritz-John optimality conditions, constraint qualifications, Karush-Kuhn-Tucker optimality conditions, convex functions and properties, sufficient optimality conditions, applications.	15

Texts / References	1. D.G. Luenberger; Y. Ye: Linear and Nonlinear Programming, Springer,2008. 2. DG. Luenberger: Optimization by Vector Space Methods, Wiley-Interscience, 1997. 3. S.S. Rao: Engineering Optimization: Theory and Practice,Newage Publishers, 2013.
Learning Outcomes (not more than 100 words)	By the end of the course, students will: Formulate and solve linear programming problems using graphical and simplex methods.Understand the concepts of duality and sensitivity analysis in LP. Apply transportation and assignment problem techniques. Utilize optimization algorithms like the steepest descent and conjugate gradient methods for unconstrained problems. Derive andinterpret optimality conditions (KKT, Lagrangian) in constrained problems. Analyze convexity and apply sufficient conditions to optimization models in real-world applications.

Course Title	**MATMJ61: Measure and Integration**			
Credits &Hours of Teaching		Theory	Practical	Cumulative
	Credits	4	0	4
	Hours of Teaching (Total)	60	0	60
Course Objectives (not more than 100 words)	This course provides an in-depth exploration of measure theory and integration, focusing on developing and applying measures and outer measures. Students will study the extension and uniqueness of measures and the completion of measures with a detailed look at Lebesgue outer measure and its properties. The course covers measurable sets and functions, Borel and Lebesgue measurability, and the integration of non-negative functions, including convergence theorems and comparisons between Riemann and Lebesgue integrals. Students will also explore signed measures, the Hahn and Jordan decomposition theorems, the Radon-Nikodym theorem, and Lebesgue-Stieltjes integrals, with applications to product measures, Fubini's theorem, and measures on locally compact spaces.			

Units	**Course Content**	**Teaching Hrs**
I	Measures and outer measures. Measure induced by an outer measure, Extension of a measure. Uniqueness of Extension, Completion of a measure. Lebesgue outer measure. Measurable sets.	12
II	Non-Lebesgue measurable sets. Regularity. Measurable functions. Borel and Lebesgue measurability. Integration of non-negative functions. The general integral. Convergence theorems. Mode in Convergence, Riemann and Lebesgue integrals.	12
III	Signed measure. Hahn and Jordan decomposition theorems. Absolutelycontinuous and singular measures.	12
IV	Radon-Nikodym theorem. Labesgue decomposition. Riesz representation theorem. Extension theorem (Carathedory). Lebesgue-Stieltjes integral.	12
V	Product measures. Fubini's theorem. Baire sets. Baire measure. Continuous functions with compact support. Regularity of measures on locally compact spaces. Integration of continuous functions with compact support. Reisz-Markoff theorem.	12

Texts / References	1. H.L.Royden: Real Analysis, 4th Edition, Macmillan, 1993. 2. P.R. Halmos: Measure Theory, Van Nostrand, 1950. 3. G. de Barra: Measure Theory and Integration, Wiley Eastern, 1981. 4. E. Hewitt; K. Stromberg: Real and Abstract Analysis, Springer, 1969. 5. R. G. Bartle: The Elements of Integration, John Wiley, 1966. 6. I.K. Rana: An Introduction to Measure and Integration, Narosa Publishing House, 1997.
Learning Outcomes (not more than 100 words)	Upon completing this course, students can understand and apply concepts related to measures and outer measures, including their extensions, uniqueness, and completion. They will identify and work with measurable sets and functions and understand the differences between Borel and Lebesgue measurability. Students will be proficient in integrating non-negative functions, using convergence theorems, and comparing Riemann and Lebesgue integrals. They will also analyze signed measures, apply the Hahn and Jordan decomposition theorems, and use the Radon-Nikodym theorem. Additionally, students can work with the Lebesgue-Stieltjes integral, product measures, Fubini's theorem, and measures on locally compact spaces.

Course Title	**MATMJ62: Complex Analysis**			
Credits &Hours of Teaching		Theory	Practical	Cumulative
	Credits	4	0	4
	Hours of Teaching (Total)	60	0	60
Course Objectives (not more than 100 words)	This course delves into the theory and applications of complex analysis, exploring the fundamental concepts of the complex plane, including open sets, domains, and regions. Students will study stereographic projections, linear transformations, and Möbius transformations, focusing on their geometric properties and conformal mappings. Key topics include the limits, continuity, differentiability, and analyticity of complex functions governed by the Cauchy-Riemann equations. The course covers complex integration, including line integrals, Cauchy's theorems, and the Cauchy integral formula. Students will also explore series expansions, including Taylor and Laurent series, and investigate singularities, branch points, and multi-valued functions.			

Units	**Course Content**	**Teaching Hrs**
I	The complex plane and open set, domain, and region in a complex plane. Stereographic projection. Linear transformations, the transformation $w = 1/z$, Möbius transformations and its geometric properties, Conformal mappings.	12
II	Schwarz' theorem, Riemann mapping theorem and its applications.Functions of complex variables and their mapping properties. Elementary functions: the exponential, logarithmic, and trigonometric functions. Limits, continuity, differentiability, and analyticity of functions of a complex variable. The Cauchy-Riemann equations and sufficient conditions for differentiability and analyticity. Harmonic functions.	12
III	Complex integration: Line integration, Green's theorem, antiderivative theorem, Cauchy's theorem(weak form), Cauchy-Goursat's theorem, Cauchy's integral formula, Cauchy's inequality, Liouville theorem, fundamental theorem of algebra, maximum modulus theorem.	12
IV	Sequences, series and their convergence, power series, radius of convergence, Taylor and Laurent series.	12
V	Integration and differentiation of power series, Absolute and uniform convergence of power series. Branch point, branch cut, branches of a multi-valued function, analyticity of the branches of $Logz, z^a$. Singularities and their classification, Weierstrass-Casorati's theorem.	12

Texts / References	1. T. Apostol, Mathematical Analysis, Addison-Wesley, Reading, MA, 1967. 2. L.V. Ahlfors, Complex analysis, McGraw-Hill International Editions, New Delhi, 1979. 3. J.E. Brown, R.V. Churchill, Complex Variables and Applications, McGraw-Hill, 2004. 4. J.B. Conway, Functions of one complex variable, Springer-Verlag, 1978. 5. T.W. Gamelin, Complex analysis, Springer, 2001. 6. R.E. Greene, S.G. Krantz, Function Theory of One Complex Variable, John Wiley and Sons, Inc., 1997. 7. S. Ponnusamy, Foundations of Functional Analysis, Narosa Publishing House, 2005. 8. S. Ponnusamy, H. Silverman, Complex variables with applications, Birkhäuser, 2006. 9. W. Rudin, Real and Complex Analysis, Third ed., McGraw-Hill, New York, 1987.
Learning Outcomes (not more than 100 words)	Upon completing this course, students can understand and apply concepts related to the complex plane, including open sets, domains, and stereographic projections. They will analyze linear and Möbius transformations, their geometric properties, and conformal mappings. Students will master the limits, continuity, differentiability, and analyticity of complex functions using the Cauchy-Riemann equations. They will be proficient in complex integration, including applying Cauchy's theorems and integral formulas. Students will also be able to work with power series, determine their radius of convergence, and understand branch points and singularities.

Course Title	**MATMJ63: Differential Geometry**			
Credits &Hours of Teaching		Theory	Practical	Cumulative
	Credits	4	0	4
	Hours of Teaching (Total)	60	0	60
Course Objectives (not more than 100 words)	This course thoroughly examines differential geometry, focusing on curves and surfaces in $\mathbb{R}^2$ and $\mathbb{R}^3$. Students will explore fundamental concepts such as arc length, curvature, and the Frenet-Serret apparatus for curves, including the rotation index and various theorems related to curves. For surfaces, the course covers essential topics such as the First and Second Fundamental Forms, normal curvature, geodesic curvature, and key theorems, including Gauss's Theorema Egregium and the Gauss-Bonnet Formula. Emphasis is placed on understanding the intrinsic and extrinsic properties of surfaces, isometries, and geodesics.			

Units	**Course Content**	**Teaching Hrs**
I	Curves in $\mathbb{R}^2$ and $\mathbb{R}^3$: Basic Definitions and Examples. Arc Length. Curvature and the Frenet-Serret Apparatus. The Fundamental Existence and Uniqueness Theorem for Curves. Bishop frames.	12
II	Non-Unit Speed Curves. The Rotation Index of a Plane Curve, Convex Curves, The Isoperimetric Inequality, Mukhopadhyay Theorem (The Four-Vertex Theorem). Fenchel's Theorem, The Fary-Milnor Theorem.	12
III	Surfaces in $\mathbb{R}^3$: Basic Definitions and Examples. The First Fundamental Form. Arc length of curves on surfaces. Normal curvature. Geodesic curvature. Gauss and Weingarten Formulas.	12
IV	Geodesics, Parallel Vector Fields Along a Curve, and Parallelism. The Second Fundamental Form and the Weingarten Map, Principal, Gaussian, and Mean Curvatures. Casorati curvature.	12
V	Isometries of surfaces, Gauss's Theorema Egregium, The Fundamental Theorem of Surfaces, Surfaces of Constant Gaussian Curvature. Exponential map, Gauss Lemma, Geodesic Coordinates. The Gauss-Bonnet Formula and the Gauss-Bonnet Theorem (description only).	12

Texts / References	1. Christian Bär, Elementary Differential Geometry, Cambridge University Press, 2010. 2. M. P. do Carmo, Differential geometry of curves and surfaces, Prentice Hall 1976. 3. A. Gray, Differential Geometry of Curves and Surfaces, CRC Press, 1998. 4. R. S. Millman and G. D. Parkar, Elements of Differential Geometry, Prentice Hall 1977. 5. S. Montiel and A. Ros, Curves and Surfaces, American Mathematical Society, 2005. 6. S. Mukhopadhyay, Parametric Coefficients in the Differential Geometry of Curves, Calcutta Unversity Press, 1910. 7. B. O'Neill, Elementary Differential Geometry, Elsevier 2006. 8. John Oprea, Differential Geometry and its applications, Prentice Hall 1997. 9. A. Pressley, Elementary Differential Geometry, Springer 2010. 10. John A. Thorpe, Elementary Topics in Differential Geometry, Springer, 1979. 11. V. A. Toponogov, Differential geometry of curves and surfaces – A concise guide, Birkhäuser, 2006.
Learning Outcomes (not more than 100 words)	Upon completing this course, students will understand differential geometry deeply, focusing on studying curves and surfaces in $\mathbb{R}^2$ and $\mathbb{R}^3$. They can compute and interpret key geometric properties such as arc length, curvature, and the Frenet-Serret apparatus for curves. Students will also master the rotation index of plane curves and apply various theorems, including Mukhopadhyay's Four-Vertex Theorem, Fenchel's Theorem, and the Fary-Milnor Theorem. In studying surfaces, they will learn to analyze the intrinsic properties using the First and Second Fundamental Forms, normal and geodesic curvatures, and apply Gauss and Weingarten formulas. Additionally, students will understand isometries, Gauss's Theorema Egregium, and the Gauss-Bonnet Formula, equipping them with the tools to explore surface curvature and geometric properties in depth.

Course Title	**MATMJ64: Number Theory**

Credits &Hours of Teaching

	Theory	Practical	Cumulative
Credits	3	0	3
Hours of Teaching (Total)	45	0	45

Course Objectives (not more than 100 words)

This course aims to introduce fundamental concepts in number theory, including divisibility, prime numbers, GCD, LCM, and unique factorization. Students will explore Euclidean algorithms, congruences, and modular arithmetic. The course will cover solving Diophantine equations, quadratic residues, Gaussian integers, and prime number distribution. Advanced topics include the Riemann Zeta function, prime number theorems, and applications in cryptography and coding.

Units	**Course Content**	**Teaching Hrs**
I	Divisibility, prime numbers, greatest common divisor (GCD), least common multiple (LCM). Fundamental Theorem of Arithmetic: Unique factorization in integers. Euclidean Algorithm: Computing GCD, extended Euclidean algorithm.	9
II	Congruences and Modular Arithmetic: Definitions, properties. Linear Congruences: Solvability, algorithms. Chinese Remainder Theorem: Statement and applications. Diophantine Equations Linear Diophantine Equations: Solving equations of the form $ax + by = c$.	9
III	Fermat's Last Theorem: Historical context, basic proof ideas. Pell's Equation: Methods of solving, applications. Quadratic Residues and Quadratic Reciprocity Quadratic	9
IV	Residues: Definitions, properties. Quadratic Reciprocity: Statements, applications. Gaussian Integers: Definition, properties. Prime Numbers Prime Number Distribution: Sieve methods, prime number theorem. Dirichlet's Theorem: Arithmetic progressions, primes in progressions.	9
V	Goldbach's Conjecture: Statement, historical context. Analytic Number Theory Riemann Zeta Function: Definition, analytic continuation. Prime Number Theorems: Statements and elementary proofs. Distribution of Primes: Asymptotic behavior, twin primes conjecture. RSA algorithm, applications of number theory in cryptography. Error-correcting codes, applications of number theory in coding.	9

Texts / References

1. David M. Burton, Elementary Number Theory, Wm. C. Brown Publishers, Dubuque, Iowa 1989.
2. K. Ireland, and M. Rosen, A Classical Introduction to Modern Number Theory, GTM Vol. 84, Springer-Verlag, 1972.
3. G. A. Jones, and J. M. Jones, Elementary Number Theory, Springer-Verlag, 1998.
4. W. Sierpinski, Elementary Theory of Numbers, North-Holland, Ireland, 1988.
5. Niven, S.H. Zuckerman, and L.H. Montgomery, An Introduction to the Theory of Numbers, John Wiley, 1991.
6. H. B. Mann, Addition Theorems, Krieger, 1976.
7. Melvyn B. Nathanson, Additive Number Theory: Inverse Problems and the Geometry of Subsets, Springer-Verlag, 1996.

Learning Outcomes (not more than 100 words)

Upon completion, students will be proficient in the foundational principles of number theory and their applications. They will understand and apply the Euclidean algorithm, solve linear Diophantine equations, and work with modular arithmetic. Students will also grasp advanced concepts such as the distribution of primes, the RSA algorithm, and using number theory in cryptography and error-correcting codes.

Course Title	MATMJ65: Linear Programming and Applications			
Credits &Hours of Teaching		Theory	Practical	Cumulative
	Credits	3	0	3
	Hours of Teaching (Total)	45	0	45
Course Objectives (not more than 100 words)	This course provides a comprehensive introduction to linear programming and its applications. Students will learn to formulate and solve linear programming problems using graphical methods, the Simplex Method, and its variants, including the Two-Phase and Big-M Methods. The course covers key concepts in linear programming theory, such as canonical and standard forms, slack, surplus variables, basic feasible solutions, and issues like degeneracy and unbounded solutions. Students will explore duality in linear programming, including the formulation and solution of dual problems and the dual simplex method. The course also addresses specialized problems, such as transportation and assignment problems, with the North-West Corner Method, Least Cost Method, Vogel's Approximation Method, and the Hungarian Method.			

Units	Course Content	Teaching Hrs
I	Linear Programming: Applications and Model Formulation, Graphical SolutionMethods, The Simplex Method, Two-Phase Method, Big-M Method, Some Complications and Their Resolution, Different types of Linear Programming Solutions.	9
II	Theory of Simplex Method: Canonical and Standard Form of LP Problem, Slack, Surplus and artificial Variables, basic solution, degenerate solution, Reduction of Feasible Solution to a Basic Feasible Solution, Improving a Basic Feasible Solution, Alternative Optimal Solutions, Unbounded Solution, Optimality Condition, Unrestricted Variables, Degeneracy and its Resolution.	9
III	Duality in Linear Programming, Formulation of Dual Linear Programming Problem, Standard Results on Duality, dual simplex method, revised simplex method, Integer Linear Programming.	9
IV	Transportation Problem: Mathematical Model of Transportation Problem, North-West Corner Method, Least Cost Method, Vogel's Approximation Method, Test for Optimality by MODI method, Variations in Transportation Problem, Maximization Transportation Problem.	9
V	Assignment Problem: Mathematical Models of Assignment Problem, Hungarian Method for Solving Assignment Problem.	9

Texts / References	1. Ferris, M. C., Mangasarian, O. L., & Wright, S. J., Linear programming with MATLAB. Society for Industrial and Applied Mathematics., 2007. 2. Kwon, R. H., Introduction to linear optimization and extensions with MATLAB. CRC Press, 2013. 3. Ploskas, N., and Samaras, N., Linear programming using MATLAB (Vol. 127). Switzerland: Springer, 2017. 4. Mishra, S. K., and Ram, B., Introduction to linear programming with MATLAB. CRC Press, 2017.
Learning Outcomes (not more than 100 words)	Upon completing this course, students can effectively formulate and solve linear programming problems using various methods, including graphical solutions and the Simplex Method. They will understand and apply the theory behind canonical and standard forms, slack and surplus variables, and handle issues such as degeneracy and unbounded solutions. Students will be adept at formulating and solving dual linear programming problems, utilizing dual and revised simplex methods. Additionally, they will solve transportation and assignment problems using specific methods and criteria for optimality.

Course Title	MATMJ66: Special Theory of Relativity			
Credits &Hours of Teaching		Theory	Practical	Cumulative
	Credits	3	0	3
	Hours of Teaching (Total)	45	0	45
Course Objectives (not more than 100 words)	The course aims to deepen students' understanding of the foundations and implications of the special theory of relativity. It will review Newtonian mechanics, introduce concepts such as inertial frames, the Michelson-Morley experiment, and Lorentz transformations, and explore the relativistic treatment of space and time. The course also covers relativistic kinematics, the geometric representation of space-time, and the relationship between mass and energy. Additionally, it examines the relativistic formulations of mechanics and electromagnetism, including Maxwell's equations and their transformations.			

Units	Course Content	Teaching Hrs
I	Review of Newtonian mechanics: Inertial frames. Speed of light and Gallilean relativity. Michelson-Morley experiment. Lorentz-Fitzgerold contraction hypothesis. Relative character of space and time. Postulates of special theory of relativity. Lorentz transformation equations and its geometrical interpretation. Group properties of Lorentz transformations.	9
II	Relativistic kinematics: Composition of parallel velocities. Length contraction. Time dilation. Transformation equations for components of velocity and acceleration of a particle and Lorentz contraction factor.	9
III	Geometrical representation of space-time: Four dimensional Minkowskian space-time of special relativity. Time-like, light-like and space-like intervals. Null cone, Proper time. World line of a particle. Four vectors and tensors in Minkowiskian space-time.	9
IV	Relativistic mechanics – Variation of mass with velocity. Equivalence of mass and energy. Transformation equations for mass momentum and energy. Energy-momentum four vector. Relativistic force and Transformation equations for its components. Relativistic Lagrangian and Hamiltonian. Relativistic equations of motion of a particle.	9
V	Energy momentum tensor of a continuous material distribution. Electromagnetism - Maxwell's equations in vacuo. Transformation equations for the densities of electric charge and current. Propagation of electric and magnetic field strengths. Transformation equations for electromagnetic four potential vector. Transformation equations for electric and magnetic field strengths. Gauge transformation. Lorentz invariance of Maxwell's equations. Maxwell's equations in tensor form. Lorentz force on a charged particle. Energy momentum tensor of an electromagnetic field.	9

Texts / References	1. C. Moller, The Theory of Relativity, Oxford Clarendon Press, 1952. 2. P. G. Bergmann, Introduction to the Theory of Relativity, Prentice Hall of India, 1969. 3. J. L. Anderson, Principles of Relativity Physics, Academic Press, 1967. 4. W. Rindler, Essential Relativity, Van Nostrand Reinhold Company, 1969. 5. V. A. Ugarov, Special Theory of Relativity, Mir Publishers, 1979. 6. R. Resnick, Introduction to Special Relativity, Wiley Eastern Pvt. Ltd. 1972. 7. J. L. Synge, Relativity: The Special Theory, North-Holland Publishing Company, 1956. 8. W. G. Dixon, Special Relativity: The Foundation of Macroscopic Physics, Camb. Uni. Press, 1982.
Learning Outcomes (not more than 100 words)	By the end of the course, students will be able to explain the key concepts of special relativity, including time dilation, length contraction, and the relativistic transformation of velocities and accelerations. They will understand the geometric representation of space-time and the role of four vectors and tensors. Students can also derive and apply the transformation equations for physical quantities in electromagnetism and mechanics, comprehend the energy-momentum tensor, and appreciate the Lorentz invariance of physical laws.

Course Title	MATMJ67: Space dynamics			
Credits &Hours of Teaching		Theory	Practical	Cumulative
	Credits	3	0	3
	Hours of Teaching (Total)	45	0	45
Course Objectives (not more than 100 words)	The course comprehensively introduces celestial mechanics and its relevance in aerospace engineering. It covers Kepler's laws, orbital mechanics, the two-body problem, and orbital maneuvers and perturbation theory. The curriculum extends to special cases like the restricted three-body problem, attitude dynamics and control, spacecraft dynamics, and mission design. It also explores advanced topics and emerging trends in space dynamics, complemented by practical laboratory sessions using simulation tools.			

Units	Course Content	Teaching Hrs
I	Introduction to Celestial Mechanics Overview of space dynamics and its importance in aerospace engineering Kepler's laws of planetary motion Two-body problem: orbit determination, orbital elements. Orbital Mechanics Keplerian orbits: elliptical, circular, parabolic, hyperbolic Orbital parameters and their significance Orbital maneuvers: Hohmann transfer, inclination change, rendezvous maneuvers.	9
II	Perturbation Theory Effects of perturbations: gravitational, atmospheric, solar radiation pressure Perturbation analysis: secular effects, periodic effects Methods of orbit determination considering perturbations.	9
III	Orbital Mechanics in Special Cases Restricted three-body problem: Lagrange points, stability regions Orbital resonance and its implications.	9
IV	Attitude Dynamics and Control Attitude representation: Euler angles, quaternion Attitude dynamics: equations of motion, torque analysis Attitude control systems: control strategies, stabilization techniques. Spacecraft Dynamics Spacecraft kinematics and dynamics Equations of motion for a rigid body in space Spacecraft stability and control: stability criteria, control actuators.	9
V	Space Mission Design Mission requirements and objectives Mission analysis: trajectory optimization, launch window determination Case studies: interplanetary missions, satellite constellations . Advanced Topics and Emerging Trends Advanced topics in space dynamics: chaotic motion, libration points Emerging trends in space dynamics research Laboratory Sessions and Projects Simulation of orbital mechanics using software tools (e.g., MATLAB, STK)	9

Texts / References	1. H.D. Curtis: "Orbital Mechanics for Engineering Students." Butterworth-Heinemann, 3rd edition, 2013. 2. D.A. Vallado: "Fundamentals of Astrodynamics and Applications." Microcosm Press, 4th edition, 2013. 3. J.E. Prussing: and Bruce A. Conway. "Orbital Mechanics." Oxford University Press, 1993.
Learning Outcomes (not more than 100 words)	By the end of the course, students will understand the fundamental principles of celestial mechanics, including the determination of orbits and orbital elements. They can analyze and execute orbital maneuvers, account for perturbations, and understand attitude dynamics and control strategies. Students will develop the skills to design space missions, including trajectory optimization and stability analysis. They will also gain practical experience in simulating orbital mechanics using software tools and be familiar with advanced concepts and current research trends in space dynamics.

Course Title	**MATMJ68: Discrete Mathematics**

Credits &Hours of Teaching

	Theory	Practical	Cumulative
Credits	3	0	3
Hours of Teaching (Total)	45	0	45

Course Objectives (not more than 100 words)

The course aims to introduce students to key concepts in discrete mathematics, focusing on counting techniques, lattice theory, and Boolean algebra. It covers the structure and properties of lattices, including duality and distributive properties, and explores Boolean functions and their applications to switching circuits. Additionally, the course introduces graph theory, including studying different types of graphs, paths, circuits, and matrix representations, focusing on Eulerian paths, planar graphs, and trees.

Units	**Course Content**	**Teaching Hrs**
I	Counting techniques. Lattices as partially ordered sets and as algebraic systems.	9
II	Duality, Distributive, complemented and complete lattices.	9
III	Boolean algebras and their basic properties. Boolean functions and expressions. Application of Boolean algebra to switching circuits (using AND, OR and NOT gates).	9
IV	Graphs and Planar Graphs: Graphs, Multi-graphs, Weighted Graphs, Directed graphs. Paths and circuits.	9
V	Matrix representation of graphs. Eulerian paths and circuits. Planar graphs. Euler's formula. Trees and spanning trees.	9

Texts / References

1. J.P. Tremblay; R. Manohar: Discrete Mathematical Structures with Applications to Computer Science, Tata McGraw Hill, New Delhi, 2001.
2. C.L. Liu: Elements of Discrete Mathematics, 2nd Edition, Tata McGraw-Hill, International Edition, 1986.
3. K.H. Rosen: Discrete Mathematics and its Applications, 8th Edition, Tata McGraw-Hill, 2021.
4. S. Wiitala: Discrete Mathematics: A Unified Approach, McGraw-Hill Book Co., 1987.
5. N. Deo: Graph Theory with Applications to Engineering and Computer Science, Prentice-Hall of India.
6. V.K. Balakrishnan: Introductory Discrete Mathematics, Dover, 1996.

Learning Outcomes (not more than 100 words)

By the end of the course, students will be able to apply counting techniques and understand the fundamental concepts of lattice theory, including Boolean algebra and their applications in digital circuits. They will also gain proficiency in graph theory, classifying and analyzing different types of graphs, identifying Eulerian paths and circuits, applying Euler's formula to planar graphs, and understanding the properties and applications of trees and spanning trees.

Course Title	MATMJ69: Mathematical Modeling			
Credits &Hours of Teaching		Theory	Practical	Cumulative
	Credits	3	0	3
	Hours of Teaching (Total)	45	0	45
Course Objectives (not more than 100 words)	The course aims to provide an understanding of differential equations and their role in modeling dynamic systems. It covers the concepts of fixed points, stability analysis, and bifurcations. Students will learn the principles of mathematical modeling, including the system approach, formulation, and analysis of models. The course includes discrete and continuous-time models, such as cell growth, logistic, and prey-predator models, and introductory epidemic models like SIS and SIR.			

Units	Course Content	Teaching Hrs
I	System of differential equations; Fixed points and their stability;Basic idea of bifurcations.	9
II	Introduction to modeling: Elementary mathematical models and General modeling ideas.	9
III	Role of mathematics in problem-solving; Concepts of mathematical modeling; system approach; formulation, Analysis of models.	9
IV	Discrete and Continuous-time models: cell growth model, logistic model, prey-predator model.	9
V	Introduction to infectious diseases: Simple epidemic models such as SIS, SIR, etc.	9

Texts / References	1. J.N. Kapur:Mathematical Model in Biology and Medicine, East-West Press Pvt. Ltd. 2. S.H. Strogat: Nonlinear dynamics and chaos with student solutions manual: With applications to physics, biology, chemistry, and engineering. CRC Press; 2018. 3. C.L. Dyne: Principles of Mathematical Modeling, Academic Press, 2004. 4. D.N.P. Murthy; N.W. Page; E. Y. Rodin: Mathematical Modelling: A Tool for Problem Solving in Engineering, Physical, Biological and Social Sciences, Pergamon 1990.
Learning Outcomes (not more than 100 words)	By the end of the course, students will be able to analyze the stability of fixed points and understand bifurcation concepts. They will develop skills in constructing and analyzing mathematical models for various real-world systems, including biological and ecological processes. Students will gain experience with discrete and continuous-time models, apply them to problems such as population dynamics and disease spread, and appreciate the role of mathematics in problem-solving and decision-making.

Course Title	MATMJ610: Dynamical Systems			
Credits &Hours of Teaching		Theory	Practical	Cumulative
	Credits	3	0	3
	Hours of Teaching (Total)	45	0	45
Course Objectives (not more than 100 words)	The course introduces the fundamental concepts of linear and non-linear dynamical systems. Topics include autonomous and non-autonomous systems, diagonalization, Jordan canonical forms, stability analysis, and the treatment of non-homogeneous systems. It also covers solutions to initial value problems, existence and uniqueness theorems, linearization, and the classification of critical points in phase space. The course explores applications of dynamical systems in various fields such as physics, biology, economics, and engineering.			

Units	Course Content	Teaching Hrs
I	Linear dynamical systems: preliminary concepts, autonomous and non-autonomous systems, diagonalization.	9
II	Fundamental theorem of linear systems.	9
III	Jordan canonical forms, stable, unstable, and center subspaces, nonhomogeneous linear systems.	9
IV	Non-linear dynamical systems: solutions to initial value problem, existence and uniqueness of solutions, linearization, phase space, classification of critical points.	9
V	Applications of Dynamical Systems. Applications in physics (e.g., pendulum, chaotic systems). Applications in biology (e.g., population dynamics). Applications in economics and engineering.	9

Texts / References	1. L. Perko: Differential equations and dynamical systems, Springer-Verlag, 2001. 2. F. Verhulst: Non-linear Differential Equations and Dynamical Systems, Springer, 1990.
Learning	Students will gain a solid understanding of the theory and analysis of linear and non-linear

Outcomes (not more than 100 words)	dynamical systems. They will learn to classify critical points, analyze the stability of systems, and apply mathematical techniques like diagonalization and linearization. Students will also develop the skills to solve initial value problems and explore practical applications in diverse areas, such as modeling population dynamics, analyzing chaotic systems, and solving engineering problems.
Course Title	**MATMJ611: Data Structures**

Credits &Hours of Teaching

	Theory	Practical	Cumulative
Credits	2	1	3
Hours of Teaching (Total)	30	30	60

Course Objectives (not more than 100 words)	This course comprehensively introduces fundamental data structures and algorithms in C programming. Students will learn about basic constructs such as arrays, strings, structures, and linked lists (including singly, circular, doubly, and circular doubly linked lists). The course covers stacks and queues, including their array and linked representations, operations, and evaluation of arithmetic expressions using Polish notations. Topics include hashing techniques, hash tables, hash functions, collision resolution methods, and their applications. Students will also explore trees (binary trees, binary search trees, AVL trees, red-black trees, multi-way search trees, heaps), and graphs, including graph terminology, traversal algorithms (BFS and DFS), topological sorting, minimum spanning trees, and shortest path algorithms.

Units	**Course Content**	**Teaching Hrs**
I	C Fundamentals, Arrays, Strings, Structures, Linked Lists (Singly Linked Lists, Circular Linked Lists, Doubly Linked Lists, Circular Doubly Linked Lists).	6
II	Stacks, Array Representation of Stacks, Operations on a Stack, Linked Representation of Stacks, Operations on a Linked Stack, Evaluation of arithmetic expressions: Polish Notations, Queues, Array Representation of Queues, Linked Representation of Queues, Types of Queues (Circular Queues, Deques, Priority Queues).	6
III	Hashing and Collision: Motivation of Hashing, Hash Tables, Hash Functions, Different Hash Functions, Collision Resolution by Open Addressing, Collision Resolution by Chaining, Pros and Cons of Hashing, Applications of Hashing.	6
IV	Trees: Basic Terminology, Types of Trees, Creating a Binary Tree from a General Tree, Traversing a Binary Tree, Efficient Binary Trees (Binary Search Trees, AVL Trees, Red-black Trees), Multi-way Search Trees, Heaps. Graphs: Graph Terminology, Applications of Graphs.	6
V	Matrix Representation of Graphs, Graph Traversal Algorithms (Breadth-First Search (BFS) Algorithm and Depth-First Search (DFS) Algorithm), Topological Sorting, Minimum Spanning Trees (MST), MST Algorithms, Shortest Path Algorithms.	6

Texts / References	1. B.S. Gottfried: Schaum's Outline Programming with C, McGraw Hill, 1996. 2. T.H. Cormen: Charles E. Leiserson, Ronald L. Rivest, Clifford Stein, Introduction to Algorithms, 3rd Edition, The MIT Press, 2009. 3. A.M. Tenenbaum; Y. Langsam; M.J. Augenstein: Data Structures Using C, Pearson Education India, 2019. 4. D.B. West: Introduction to Graph Theory, 2nd Edition, Prentice Hall, 2000. 5. 5. Reema Thareja, Data Structures Using C, 2nd Edition, Oxford,2014.
Learning Outcomes (not more than 100 words)	By the end of this course, students will be proficient in implementing and using fundamental data structures such as arrays, strings, structures, linked lists, stacks, and queues. They will understand and apply various stack and queue operations, hashing techniques, and collision resolution methods. Students will also be skilled in working with different types of trees, including binary and balanced trees like AVL, red-black trees, multi-way search trees, and heaps. Additionally, they will master graph algorithms, including traversal (BFS and DFS), topological sorting, minimum spanning trees, and shortest path algorithms, and understand their applications.

Course Title	**MATMJ612: Analytical Visualization**

Credits &Hours of Teaching

	Theory	Practical	Cumulative
Credits	1	2	3
Hours of Teaching (Total)	15	60	75

Course Objectives (not more than 100 words)

This course introduces fundamental mathematical and geometric concepts, including elementary and special functions (such as the Heaviside and delta functions), asymptotes, curvature in 2D and 3D, and extrema. It covers Roll's Theorem, the Mean-Value Theorem, fixed-point theorems, fractals, and the Fibonacci sequence. Students will explore geometry topics like conic sections, spheres, cones, cylinders, and curves in $\mathbb{R}^3$ and study differential equations, including rotation of vectors, Kepler's laws, simple harmonic motion, and transforms (Laplace and Fourier). Mechanics topics include moment of inertia and angular momentum.

Units	**Course Content**	**Teaching Hrs**
I	Elementary and Special functions (Step-side, Heaviside, delta, jump function), Asymptotes, Curvature (2D, 3D), Maxima-Minima, Tangent, and Normal, Roll's Theorem. Mean-Value theorem. Fixed Point Theorem, Fractals, Fibonacci sequence.	3
II	Convergence of sequence, Golden Ratio. Geometry: Conic Section, Sphere, Cone, Cylinder, Coincides, Right circular cylinder, Cardroid, Curve and surface in R3, Geodesics of Hyperbolic space, Sphere, Meshing. Differential Equation: Rotation of Vectors, Kepler's Law, S.H.M., ODE and its phase portrait, Bessel and Legendre functions, Laplace Transform, Fourier Transform, Fourier Series, PDE and Phase-Portrait. Mechanics: Moment of inertia, Compound Pendulum, Angular Momentum.	3
III	Basic course of simulation using MATLAB: MATLAB programming, Overview of MATLAB environment, commands and operations, Variables and data types, Scripts and functions, Basic plotting, Loops and execution control (if-else, switch-case, loops), Functions and their creation, Debugging and error handling, File input and output.	3
IV	Vectors and Matrices: Creating and manipulating vectors and matrices, Matrix operations (addition, subtraction, multiplication), Solving linear equations, Eigenvalues and Eigenvector, MATLAB function f-zero in a single variable, Fixed-point iteration in a single variable, Newton-Raphson in single variable and multiple variables, MATLAB function f-solve in single and multiple variables.	3
V	Advanced Plotting and Visualization: 2D and 3D plotting, customizing plots (labels, legends, titles, color map), Specialized plots (histograms, bar charts, scatter plots), Creating multiple plots in one figure (subplot, tiled layout), Plotting functions and data, Exporting and Printing Plots.	3

Texts / References

1. R. Pratap: Getting started with MATLAB: A Quick introduction for Scientists and Engineers, Oxford University Press Inc., 2002.
2. S. Attaway: A Practical Introduction to Programming and Problem Solving, Elsevier India Pvt Ltd-New Delhi, 2009.
3. B.H. Hahn; D.T. Valenttine: Essential MATLAB For Engineers and Scientists Fourth Edition, Elsevier, 2010.

Learning Outcomes (not more than 100 words)

By the end of this course, students will be proficient in mathematical and geometric concepts such as curvature, extrema, asymptotes, and differential equations. They will understand and apply fixed-point theorems, fractals, and sequences like Fibonacci. Students will be skilled in analyzing geometric shapes, differential equations, and transforms, including Laplace and Fourier. Additionally, they will gain hands-on experience with MATLAB, including programming basics, vector and matrix operations, solving equations, and advanced plotting techniques. They caneffectively create, manipulate, and visualize mathematical data and functions using MATLAB tools.

Course Title	**MATMJ613: Graph Theory**

Credits &Hours of Teaching

	Theory	Practical	Cumulative
Credits	3	0	3
Hours of Teaching (Total)	45	0	45

Course Objectives (not more than 100 words)

This course aims to present a comprehensive understanding of advanced topics in graph theory. Students will learn to do calculations in graph and will understand the areas such as networks, the underlying algebra in graph theory and developing algorithms which are efficient. The course also is also intended to introduce students to various topics which are often omitted from a first course on graph theory. Students will also be exposed to real world problems which are being/have been solved by the help of graph theory.

Units	**Course Content**	**Teaching Hrs**
I	The Introduction: Graphs, Degree of a vertex, Paths and Cycles, Connectivity, Examples of Graphs such as bipartite graphs, Planar and non planar graphs, Contraction, Minor, Trees and Forests, distances	9
II	Matching Covering and Packing: Matching, in a graph and matching in a bipartite graph. Assignment problems, Covering and Packing, Covering by paths and cycles, Tutte's theorem	9
III	Coloring: Edge and vertex colorings, 4 and 5 colorable graphs, List coloring, Perfect graphs. Flows: Flow in a network, group valued flows, Tutte's flow conjecture, k-Flows, Supply and demand problems	9
IV	Extremal graph theory: Minors, Hadwigers Conjecture, Regularity, Szemeredi's Regularity Lemma, Using the regularity lemma, partitions using paths and cycles. Ramsey Theory: Ramser Numbers, Induced Ramsey Theorem, Ramsey property and connectivity, Sperner's Lemma	9
V	Random Graphs: Definition, Existence and expectation, probabilistic methods, properties of almost all graphs, Threshold function.	9

Texts / References

1. R Diestel: Graph Theory GTM 173 IV ed., Springer 2012.
2. J A Bondy, USR Murty: Graph Theory, GTM 244, Springer, 2008.
3. Douglas West: Introduction to graph theory, Pearson, 2000.

Learning Outcomes (not more than 100 words)

By the end of the course, students will have a good understanding of complexity and algorithms. They will also be able to relate and model the relational real world problem in terms graphs. The subject graph theory, like number theory has its own flavor and the students will be able to appreciate and understand this on completion of this course. This course will be very useful for both the areas which are referred to pure and applied Mathematics. On completion of this course students may be easily inducted into research in graph theory.

Course Title	**MATMJ614: Vedic Mathematics**

Credits &Hours of Teaching

	Theory	Practical	Cumulative
Credits	3	0	3
Hours of Teaching (Total)	45	0	45

Course Objectives (not more than 100 words)

This course offers an in-depth exploration of Vedic Mathematics, highlighting its historical significance and foundational principles. Students will engage with the system's distinctive sutras and sub-sutras, learning to apply them to various arithmetic operations, algebraic, geometric, and contributions of Indian Mathematician. The curriculum emphasizes rapid calculation approach, covering multiplication, squaring, cubing, square root, cube root, multiplication and division factorization and solution of equations.

Units	**Course Content**	**Teaching Hrs**
I	Multiplication in arithmetic: *Nikhilam* sutra, *Antyayordasake'pi* sutra Multiplication: *Urdhvatiryak* Concept of *bijanka*, and Verification of all the operations by *Bijanka*, Square in arithmetic by Yavadunam, *Ekadhikena* sutra, *Dwandvayoga* sutra, Cube in arithmetic by sutras *Nikhilam* and *Anurupyena* sutra, Square root of four or -five-digit numbers Cube root Applications of Meru-prastar in higher order powers.	9
II	Decimal and fraction, division by Nikhilam sutram, division of 1/19, 1/29 by Ekadhikenpurven sutram, division by Paravartya sutram, division by Anurupeyana sutram, division of polynomials, factors of general second-degree equation by Lopsthapanabhyam sutram.	9
III	Multiplication of linear, quadratic, and cubic polynomials in one variable. (*Urdhvatiryak sutra*), Division of polynomials by Sutra-*Paravartya Yojayet*, Solution of particular types of linear equations in one variable, Factors of the quadratic and Cubic Expressions, Solutions of simultaneous linear in two variables.	9
IV	A brief introduction to the four Shulva sutras, Baudhayan triplets for the angle of a right-angled triangle, Addition and subtraction of Baudhayan triplets, Concept, definition, and properties of six trigonometric functions based on Baudhayan triplets. Formulation of Identities, Heights and distance by Baudhayan.	9
V	Introduction of Sutras and sub-sutras by Swami Bharati Krishna Tirtha ji, Contributions of Aryabhata, Life and contributions of Bhaskara II.Kaparekar Numbers, Life and contributions of Ramanujan.	9

Texts / References

1. S.B. Krishna Tirtha, Vedic Mathematics, Motilal Banarasi Das, 1965.
2. Vedic Ganita: Vihangam Drishti-I, Shiksha Sanskriti Utthan Nyasa, New Delhi.
3. V.B. Datta; A.N. Singh: History of Hindu Mathematics A Source Book Parts I and II, 1935.
4. V.G. Unkalkar: Magical World of Mathematics (Vedic Mathematics) Vandana Publishers Banglore, 2017.
5. V.G. Unkalkar: Excel With Vedic Mathematics, Vandana Publishers Banglore, 2019.

Learning Outcomes (not more than 100 words)

By the end of the course, students will be proficient in applying Vedic Mathematics for high-speed calculations, such as addition, subtraction, and multiplication. They will master techniques for squaring and cubing numbers, working with decimals and fractions, and solving equations. Students will gain skills in mental arithmetic and a deeper understanding of Vedic mathematical concepts.

Course Title	MATMV61: Formal Languages and Automata Theory			
Credits &Hours of Teaching		Theory	Practical	Cumulative
	Credits	3	1	4
	Hours of Teaching (Total)	45	30	75
Course Objectives (not more than 100 words)	This course aims to provide a deep understanding of the theoretical foundations of computer science, focusing on formal languages, automata, and computability. Students will explore the Chomsky hierarchy, learn to design and analyze various types of automata and understand the computational limits defined by Turing machines. The course also covers complexity theory, emphasizing the practical applications of formal languages and automata in software engineering, compiler design, and network protocols.			

Units	Course Content	Teaching Hrs
I	Introduction: Alphabet, languages and grammars, productions and derivation, Language generated by a grammar, Chomsky hierarchy. Regular languages and finite automata: Deterministic and non-deterministic finite automata, acceptance of language by finite automata, properties of regular languages, equivalence and minimization of finite automata, Moore and Mealy machines, regular expressions, regular grammars, Pumping lemma.	9
II	Context-free and context-sensitive languages: Context-free grammars (CFGs) and languages (CFLs), parse trees, ambiguity in CFG, Chomsky and Greibach normal forms, Pumping lemma for CFLs, closure properties of CFLs, Pushdown automata; Context-sensitive grammars and languages, linear bounded automata.Recursively enumerable	9
III	languages and Turing machines: The basic model for Turing machines, configurations and acceptance, Turing-recognizable (recursively enumerable) and Turing-decidable (recursive) languages, unrestricted grammars, universal Turing machines, halting problem.	9
IV	Regular Languages, Context-Free Languages, Context-Sensitive Languages, Recursively Enumerable Languages, Linear Bounded Automata, Examples and Applications of Chomsky Hierarchy, Advanced Topics in Automata Theory, Minimization of Finite Automata, Myhill-Nerode Theorem, Introduction to Quantum Automata, Automata in Real-World Applications: Compilers, Parsing, Network Protocols.	9
V	Computability and Complexity, Introduction to Complexity Classes: P, NP, and NP-Complete, Reductions and Cook-Levin Theorem, Time Complexity and Space Complexity, The Role of Automata in Complexity Theory, Applications and Case Studies, Applications of Automata and Formal Languages in Software Engineering, Case Studies: Lexical Analysis, Compiler Design, Model Checking, Current Research Trends in Formal Languages and Automata Theory	9

Texts / References	1. D.C. Kozen: Automata and Computability, Undergraduate Texts in Computer Science, Springer, 1997. 2. J.E. Hopcroft; R. Motwani; J.D. Ullman, Introduction to Automata Theory, Languages, and Computation, third edition, Prentice Hall, 2007. 3. H.R. Lewis; C.H. Papadimitriou: Elements of the Theory of Computation, second edition, Prentice Hall, 1998. 4. M. Sipser: Introduction to the Theory of Computation, third edition, Course Technology, 2005. 5. P. Linz: An Introduction to Formal Languages and Automata, Narosa, 2007. 6. D.I.A. Cohen: Introduction to Computer Theory, second edition, Wiley, 1991.
Learning Outcomes (not more than 100 words)	Upon completing this course, students will be able toanalyze and classify languages using the Chomsky hierarchy; Design and minimize finite automata, pushdown automata, and Turing machines; Apply formal language concepts to solve real-world problems in software engineering and computational theory; Understand and explain key concepts in computability, complexity theory, and their implications for computer science; Explore advanced topics in automata theory and current research trends.

Course Title	**MATMJ71/MATMN71: Topology**			
Credits &Hours of Teaching		Theory	Practical	Cumulative
	Credits	4	0	4
	Hours of Teaching (Total)	60	0	60
Course Objectives (not more than 100 words)	This course introduces fundamental concepts in topology, covering basic notions such as open and closed sets, closure, interior, and limit points. Students will explore continuous maps, homeomorphisms, and different types of maps, including open and closed maps. The course will examine quotient topology and identification spaces, including the Möbius strip, projective plane, torus, and Klein bottle. Key topics include connectedness, locally connected spaces, components, path connectedness, compactness, and separation axioms (T_0, T_1, T_2, T_3). Students will study Urysohn's lemma, Tietze's extension theorem, Urysohn's embedding, metrization theorem, countability axioms, compactifications, and paracompactness. Additionally, the course covers the homotopy of maps and paths, the fundamental group, covering spaces and transformations, simply connectedness, the universal cover, and Van Kampen's theorem.			

Units	**Course Content**	**Teaching Hrs**
I	Open sets. Neighborhoods. Interior,Exterior, and Boundary. Limit points and Derived set. Closed sets and Closure. Bases and Subbases.	12
II	Continuous Mappings. Homeomorphism. Induced and coinduced topologies. Subspace topology, Product topology, and Quotient topology. Identification Spaces (Cone, Möbius Strip, Projective plane, Torus, Klein bottle etc.).	12
III	Separable spaces, Lindelöf spaces, First countable spaces and Second countable spaces. Cantor-Bendixson Theorem. Compactness, Compactifications and Paracompactness.	12
IV	Separation axioms: Hausdorff space, Regular spaces, Completely regular spaces,Tychonoff spaces, Normal spaces, T_4 space.Urysohn's lemma, Tietze's extension theorem, Urysohn's embedding and Metrization theorem.Connectedness, Locally Connected Spaces, Components, Path connectedness andLocally path connectedness.	12
V	Homotopy of maps and paths, Fundamental group, Covering Spaces, Covering transformations, Simply Connectedness, Universal Cover, Van Kampen Theorem.	12

Texts / References	1. M.A. Armstrong:Basic Topology, Springer Verlag, 1983. 2. M.H. Cho: Discovering modern general topology, Kyung Moon Publishers, Korea, 2001. 3. F.H. Croom: Principles of Topology, Kyung Moon Publishers, Korea 1996. 4. J. Dugundji: Topology, Prentice-Hall. 1966. 5. J.L. Kelly:General Topology, van Nostrand, Reinhold Co., New York, 1995. 6. J.R. Munkres: Topology Prentice Hall of India, 2000. 7. B.L. Sharma: Sansthiti I - Sāmānya Sansthiti (Topology I - General Topology), Uttar Pradesh Hindi Sansthan, Hindi Granth Academy Division, Lucknow, 1980. 8. R. Vaidyanathaswamy:Treatise on set topology, Indian mathematical society, 1947.
Learning Outcomes (not more than 100 words)	By the end of this course, students will be able to understand and apply fundamental topological concepts, including open and closed sets, continuity, and homeomorphisms. They will grasp quotient topology and identification spaces, such as the Möbius strip and Klein bottle. Students will analyze connectedness, compactness, and separation axioms and apply Urysohn's lemma, Tietze's extension theorem, and metrization theorems. They will also explore countability axioms, compactifications, and paracompactness. In algebraic topology, students will understand homotopy, the fundamental group, covering spaces, and covering transformations, and will apply Van Kampen's theorem to compute fundamental groups.

Course Title	**MATMJ72: Advanced Algebra**

Credits &Hours of Teaching

	Theory	Practical	Cumulative
Credits	4	0	4
Hours of Teaching (Total)	60	0	60

Course Objectives (not more than 100 words)

This course aims to provide an in-depth exploration of group theory and ring theory. Students will learn about isomorphism theorems, symmetric and alternating groups, dihedral groups, matrix groups, and isometry groups of $\mathbb{R}^2$and $\mathbb{R}^3$. The course covers direct products, indecomposable groups, group actions, stabilizer subgroups, orbit decomposition, and the class equation. Key concepts include Sylow subgroups, Sylow's theorems, p-groups, and their applications. In ring theory, topics include rings, subrings, homomorphisms, ideals, quotient rings, integral domains, polynomial rings, field of fractions, division rings, fields, and subfields. Students will explore field extensions, factorization of polynomials, splitting fields, separable extensions, automorphisms, normal extensions, Galois theory, finite fields, cyclic Galois groups, the fundamental theorem of algebra, cyclotomic extensions, and solvability by radicals.

Units	**Course Content**	**Teaching Hrs**
I	Isomorphism theorems for groups, Symmetric groups, Alternating groups, Dihedral groups, Matrix groups, Isometry groups of $\mathbb{R}^2$ and $\mathbb{R}^3$, Internal and External direct product and their relationship, Indecomposable groups.	12
II	Action of a group G on a set, Stabilizer subgroups and orbit decomposition, Class equation of an action, Sylow subgroups, Sylow's Theorem I, II and III, p-groups, Examples and applications, Groups of order p q, Direct and inverse images of Sylow subgroups.	12
III	Rings, Examples and properties, Subrings, Homomorphism, Ideals and Quotient rings, Integral domain, Polynomial rings, Field of fraction, Division rings, Fields, subfields. Characteristic of a ring and field, Prime subfields, Field extensions, Finite extensions, Algebraic and transcendental extensions.	12
IV	Factorization of polynomials in extension fields. Splitting fields. Separable extensions, Perfect fields. Automorphisms of fields, Normal extensions, normal closures, Galois extensions, Fundamental theorem of Galois theory, Computation of Galois groups of polynomials.	12
V	Primitive element, Finite fields, Subfields of finite fields, Cyclic Galois groups, fundamental theorem of algebra. Cyclotomic extensions and polynomials, Cyclic extensions, Solvability by radicals.	12

Texts / References

1. D.S Dummit; R. Foote: Abstract Algebra, Wiley, 2003.
2. J. Gallian: Contemporary Abstract Algebra, Narosa, 1998.
3. R. Lal: Algebra vol 1 and 2, Springer, 2022.
4. J.B. Fraleigh: A first course in Abstract Algebra, Pearson, 2002.

Learning Outcomes (not more than 100 words)

By the end of this course, students will be proficient in group theory, including isomorphism theorems, symmetric, alternating, and dihedral groups, matrix groups, and group actions. They will understand stabilizer subgroups, orbit decomposition, Sylow subgroups, and Sylow's theorems. In ring theory, students will be adept at working with rings, subrings, ideals, quotient rings, polynomial rings, and fields. They will grasp concepts of field extensions, factorization of polynomials, separable and normal extensions, automorphisms, and Galois theory. Additionally, students will analyze finite fields, cyclic Galois groups, cyclotomic extensions, and the solvability of polynomials by radicals.

Course Title	MATMJ73: Functional Analysis			
Credits &Hours of Teaching		Theory	Practical	Cumulative
	Credits	4	0	4
	Hours of Teaching (Total)	60	0	60
Course Objectives (not more than 100 words)	This course aims to provide a thorough understanding of normed linear and Banach spaces, completeness of □□ space. Students will explore bounded linear transformations, normed linear spaces, and fundamental theorems like the open mapping, closed graph, and uniform boundedness principle. The course will also address the Hahn-Banach theorem, dual spaces, separability, reflexive spaces, weak convergence, and compact operators. Additionally, it will delve into inner product spaces, Hilbert spaces, orthonormal sets, and essential theorems and operators in Hilbert spaces, including the Riesz representation theorem and self-adjoint operators.			

Units	Course Content	Teaching Hrs
I	Normed linear spaces and Banach spaces.The □□-space as Banach spaces	12
II	Bounded linear transformations. □(□, □)as a normed linear space. Open mapping and closed graph theorems. Uniform boundedness principle and its consequences. Hahn-Banach theorem and its application	12
III	Dual spaces with examples. Separability. Reflexive spaces. Weak convergence. Compact operators.	12
IV	Inner product spaces, Hilbert spaces. Orthonormal sets. Bessel's inequality. Complete orthonormal sets and Parseval's identity. Structure of Hilbert spaces. Projection theorem.	12
V	Riesz representation theorem. Riesz-Fischer theorem. Adjoint of an operator on a Hilbert space. Reflexivity of Hilbert spaces. Self-adjoint operators. Positive, projection, normal, and unitary operators.	12

Texts / References	1. H.L. Royden: Real Analysis, Macmillan, 4th Edition, 1993. 2. G.F. Simmons: Introduction to Topology and Modern Analysis, McGraw-Hill, 1963. 3. G. Bachman; L. Narici: Functional Analysis, Academic Press, 1966. 4. A.E. Taylor: Introduction to Functional Analysis, John Wiley, 1958. 5. B.V. Limaye: Functional Analysis, Wiley Eastern. 6. N. Dunford; J.T. Schwartz: Linear Operators, Part-I, Interscience, 1958. 7. R.E. Edwards: Functional Analysis, Holt Rinehart and Winston, 1965. 8. C. Goffman; G. Pedrick: First Course in Functional Analysis, Prentice- Hall of India, 1987. 9. K.K. Jha: Functional Analysis and Its Applications, Students' Friend, 1986. 10. Erwin Kreyszig, Introductory Functional Analysis with Applications,John Wiley and Sons,1978. 11. Rajendra Bhatia, Notes on Functional Analysis, Hindustan Book Agency (Springer), 2009.
Learning Outcomes (not more than 100 words)	By the end of this course, students will understand and work with normed linear spaces, Banach spaces, and □□-spaces, applying key inequalities and concepts of convergence. They will handle bounded linear transformations and normed linear spaces, utilizing the open mapping, closed graph, and uniform boundedness theorems. Students will apply the Hahn-Banach theorem, understand dual and reflexive spaces, and analyze weak convergence and compact operators. They will gain proficiency in inner product spaces, Hilbert spaces, orthonormal sets, and essential theorems such as Riesz representation and Riesz-Fischer. Additionally, students will work with various operators in Hilbert spaces, including self-adjoint operators.

Course Title	**MATMJ74: Differentiable Manifolds**			
Credits &Hours of Teaching		Theory	Practical	Cumulative
	Credits	4	0	4
	Hours of Teaching (Total)	60	0	60
Course Objectives (not more than 100 words)	This course aims to provide a rigorous introduction to the concepts of differentiable manifolds and related topics in differential geometry. Students will explore the theory of differentiable maps, tangent spaces, vector fields, and integral curves. The course covers advanced topics like submanifolds, distributions, integrability, tensor calculus, and connections, including the Koszul connection. Additionally, the course delves into the geometry of Lie groups, Lie algebras, and fibre bundles, offering insights into their applications in physics and mathematics.			

Units	**Course Content**	**Teaching Hrs**
I	Differentiable manifolds - Definitions and examples. Differentiable maps. Jacobian matrix. Tangent spaces. Vector fields. Integral curves.	15
II	Submanifolds. Distributions and integrability. 1-parameter group of transformations. Tensors and forms.	15
III	The Koszul connection. Covariant, Lie and Exterior derivatives. Geodesics and curvature.	15
IV	Lie Groups and Lie Algebra. Fibre bundles	15

Texts / References	1. R.L.Bishop; R.J.Crittenden:GeometryofManifolds,AcademicPress,1964. 2. S.S.Chern;W.H.Chen; K.S.Lam:LecturesonDifferentialGeometry,WorldScientific,2000. 3. N.J.Hicks:NotesonDifferentialGeometry,VonNostrand,1965. 4. J.M.Lee:Introduction toSmoothManifolds,Springer,2006. 5. Y.Matsushima: DifferentiableManifolds, Dekker,1972. 6. M.Spivak: AComprehensiveIntroductiontoDifferential GeometryVol 13ed., PublishorPerish,1999. 7. F.Warner:FoundationsofDifferentiableManifoldsandLieGroups,Springer,1983.
Learning Outcomes (not more than 100 words)	Upon completion of this course, students will be able to:understand and apply the fundamental concepts of differentiable manifolds and tangent spaces; analyze and compute the Jacobian matrix, vector fields, and integral curves; apply the theory of connections, including the Koszul connection, to study geodesics and curvature; grasp the structure and properties of Lie groups, Lie algebras, and fibre bundles; use tensor calculus and differential forms to solve complex problems in differential geometry.

Course Title	**MATMJ81/MATMJ8R1: Geometric Topology**

Credits &Hours of Teaching

	Theory	Practical	Cumulative
Credits	4	0	4
Hours of Teaching (Total)	60	0	60

Course Objectives (not more than 100 words)

This course introduces advanced topics in topology, focusing on simplicial complexes, including n-simplices, simplicial maps, and triangulations. Students will explore affinely and geometrically independent points, and the geometric carrier and realizations of simplicial complexes. The course covers singular simplices, chains, cycles, and boundaries, leading to understanding singular homology and its axioms. Students will compute the homology of various surfaces like spheres, projective planes, tori, Möbius strips, and Klein bottles. The course also addresses the classification of closed surfaces, Euler characteristics, and surface groups. Additionally, students will examine the classification problem in 3-manifolds, including Poincaré's theorem, loop and sphere theorems, prime decompositions, and the study of Seifert fibered spaces and hyperbolic manifolds.

Units	**Course Content**	**Teaching Hrs**
I	Affinely and geometrically independent points, n-Simplex, Simplicial complex in dimension n, simplicial maps, geometric carrier and realizations, link and star of a simplex, Triangulaons. Examples and computations of Triangulaonsrepresennng Topological objects.	12
II	Singular simplices, chains, cycles and boundaries. Group of chains and boundaries, Singular Homology. Discussion of various axioms. Computation of Homology of surfaces such as Sphere, Projective plane, Torus, Mobius strip, Cylinder, Klein bottle.	12
III	Orientable double cover. Euler Characteristics, closed surfaces as quotients of 4g-gon. Discussion of classifications of closed surfaces. Surface groups and presentation. Two dimensional geometries.	12
IV	Discussion of Classification problem in Topology with an Overview of Poincare Theorem and Geometrization in dimension 3. Non availability of strong invariants in dimension 3. Various examples of 3-manifolds. Loop theorem, sphere theorem.	12
V	Prime decomposition, irreducibility. Torus decompositions. JSJ, Seifert fibered spaces and Hyperbolic Manifolds. Non solvability of word problem: Manifolds of dimension 4 and more.	12

Texts / References

1. A. Hatcher: Algebraic Topology, Cambridge Univ Press, 2002.
2. A. Hatcher: Basic, Topology of 3 –manifolds.
3. J. Hempel: 3-Manifolds. Annals of Math Studies 86. Princeton University Press, 1976.
4. V.V. Prasolov; A.B. Sossinsky: Knots, Links, Braids and 3-Manifolds, AMS, 1997.
5. J.R. Munkres: Elements of Algebraic Topology, CRC Press, 1984.

Learning Outcomes (not more than 100 words)

By the end of this course, students will be proficient in working with simplicial complexes, including computing triangulations and understanding simplicial maps and geometric realizations. They will master concepts such as singular simplices, chains, cycles, and boundaries, and will be able to compute and analyze singular homology for surfaces like spheres and tori. Students will also understand the classification of closed surfaces, Euler characteristics, and surface groups. Additionally, they will be familiar with key results in 3-manifold topology, including the Poincaré theorem, prime decompositions, and the study of hyperbolic and Seifert fibered spaces.

Course Title	**MATMJ82/MATMJ8R2: Fourier Analysis**

Credits &Hours of Teaching

	Theory	Practical	Cumulative
Credits	4	0	4
Hours of Teaching (Total)	60	0	60

Course Objectives (not more than 100 words)

This course explores fundamental aspects of Fourier series and transforms. Students will study the uniqueness of Fourier series, convolutions, and summability methods such as Cesaro and Abel. Key topics include Fejer's theorem, the Poisson kernel, and the Dirichlet problem in the unit disc. The course will address mean square convergence and provide continuous functions with divergent Fourier series examples. In distributions, students will learn about the calculus of distributions, Schwartz class functions, and the Fourier transforms of rapidly decreasing functions. They will also cover the Riemann-Lebesgue lemma, the Fourier inversion theorem, and the Fourier transforms of Gaussians and tempered distributions.

Units	**Course Content**	**Teaching Hrs**
I	Basic Properties of Fourier Series: Uniqueness of Fourier Series,Convolutions, Cesaro and Abel Summability, Fejer's theorem.	12
II	Poisson Kernel and Dirichlet problem in the unit disc. Mean square Convergence, Example of Continuous functions with divergent Fourier series.	12
III	Distributions and Fourier Transforms: Calculus of Distributions, Schwartz class of rapidly decreasing functions.	12
IV	Fourier transforms of rapidly decreasing functions, Riemann Lebesgue lemma, Fourier Inversion Theorem, Fourier transforms of Gaussians.	12
V	Tempered Distributions: Fourier transforms of tempered distributions, Convolutions.	12

Texts / References

1. R.S. Strichartz: A Guide to Distributions and Fourier Transforms, CRC Press, 1994.
2. E.M. Stein; R. Shakarchi: Fourier Analysis: An Introduction, Princeton University Press, 2003.
3. I. Richards; H. Youn: Theory of Distributions: A Nontechnical Introduction, Cambridge University Press, 1990.
4. R.S. Pathak: A Course in Distribution Theory and Applications, Narosa, 2001.
5. G. H. Hardy, Divergent Series, Oxford University Press, 1973.
6. A. Zygmund, Trigonometric Series, Cambridge University Press, 2002.

Learning Outcomes (not more than 100 words)

By the end of this course, students will be proficient in analyzing and applying the Fourier series, including understanding uniqueness, convolutions, and various summability methods. They will be able to use Fejer's theorem and the Poisson kernel and solve the Dirichlet problem in the unit disc. Students will also grasp mean square convergence and handle examples of continuous functions with divergent Fourier series. In distribution theory, they will understand the calculus of distributions, the Schwartz class, and Fourier transforms of rapidly decreasing functions. They will apply the Riemann-Lebesgue lemma and the Fourier inversion theorem and handle Fourier transforms of Gaussians and tempered distributions.

Course Title	**MATMJ83/MATMJ8R3: Nonlinear Programming**

Credits &Hours of Teaching

	Theory	Practical	Cumulative
Credits	4	0	4
Hours of Teaching (Total)	60	0	60

Course Objectives (not more than 100 words)

This course provides a comprehensive introduction to convex analysis and optimization techniques. Students will study convex sets, convex combinations, Carathéodory's theorem, convex hulls, separation theorems, and convex functions, including their epigraphs and lower level sets. Key topics include the continuity of convex functions, differentiable and twice differentiable convex functions, and generalized convexity. The course covers unconstrained optimization methods, such as first and second order necessary conditions, line search techniques, and methods including the golden section, Fibonacci, quadratic and cubic interpolation, steepest descent, Newton's method, conjugate gradient, and quasi-Newton methods. In constrained optimization, students will explore local, global, and isolated minimizers, feasible and descent directions, Lagrangian functions, Fritz-John and Karush-Kuhn-Tucker conditions, convex programming, duality, and saddle points.

Units	**Course Content**	**Teaching Hrs**
I	Convex analysis: convex set, convex combination, Caratheodory's theorem, convex hull, Separation theorems, convex functions, epigraphs, lower level sets, continuity of convex functions.	12
II	Alternative theorems, differentiable and twice differentiable convex functions, generalized convexity.	12
III	Unconstrained Optimization: local and global minimizers, first and second order necessary optimality conditions, second order sufficient optimality condition, unimodal functions, line search, golden section method.	12
IV	Fibonacci Method, Quadratic Interpolation Methods, Cubic Interpolation Method, the steepest descent method, the Newton method, the conjugate gradient method, Quasi-Newton method.	12
V	Constrained Optimization: local, global and isolated minimizers, feasible directions, descent directions, Lagrangian function, Fritz-John optimality conditions, constraint qualifications, Karush-Kuhn-Tucker optimality conditions, convex programming, second order optimality conditions, duality, saddle points.	12

Texts / References

1. O.L. Mangasarian:Nonlinear programming. Society for Industrial and Applied Mathematics, 1994.
2. J. Nocedal;S.J. Wright:Numerical optimization. New York, NY: Springer New York, 1999.
3. S.P. Boyd;L. Vandenberghe:Convex optimization. Cambridge University Press, 2004.
4. S.K. Mishra; B. Ram: Introduction to unconstrained optimization with R. Springer Nature, 2019
5. E.K. Chong; W.S. Lu;S.H. Zak: An Introduction to Optimization: With Applications to Machine Learning. John Wiley and Sons, 2023

Learning Outcomes (not more than 100 words)

By the end of this course, students will be able to analyze and apply concepts from convex analysis, including convex sets, functions, and separation theorems. They will understand the continuity of convex functions and generalized convexity. In unconstrained optimization, students will solve problems using various methods such as line search, quadratic and cubic interpolation, and gradient-based techniques including steepest descent, Newton's method, and conjugate gradient methods. For constrained optimization, students will apply Lagrangian methods, Fritz-John and Karush-Kuhn-Tucker conditions, and handle duality and saddle points, addressing both convex and general programming problems.

Course Title	**MATMJ84/MATMJ8R4: Quadratic Programming**

Credits &Hours of Teaching

	Theory	Practical	Cumulative
Credits	4	0	4
Hours of Teaching (Total)	60	0	60

Course Objectives (not more than 100 words)

This course focuses on quadratic programming problems, including unconstrained and constrained cases with equality and inequality constraints. Students will study quadratic cost functions, convex quadratic functions, and concepts related to local and global minimizers. The course covers existence and uniqueness theorems, KKT systems, and min-max dual and saddle point problems. Students will analyze the properties of solution sets, solution map continuity, and apply Farka's Lemma. The course also addresses duality in constrained quadratic programming, numerical algorithms, nonconvex quadratic programming, and applications in portfolio optimization and affine variational inequalities.

Units	**Course Content**	**Teaching Hrs**
I	Unconstrained quadratic programming problems, Quadratic cost functions, Convex quadratic functions, Local and Global minimizers, Existence and Uniqueness theorems.	12
II	Quadratic Programming problems with equality constraints, Optimality, Existence and Uniqueness, KKT systems, Min-max, Dual and saddle point problems, Properties of the solution sets of quadratic.	12
III	Programming problems, Continuity of the solution map, Quadratic programming problems with inequality constraints.	12
IV	Farka's Lemma, Optimality, Existence and Uniqueness of solution, Duality for constrained quadratic programming problems, Algorithms for numerical solutions of quadratic programming problems.	12
V	Nonconvex quadratic programming problems, Applications to Portfolio optimization and Affine Variational inequalities.	12

Texts / References

1. Z. Dostal: Optimal Quadratic Programming Algorithms, Springer, New York, 2009.
2. M.J. Best: Quadratic Programming with Computer Programs, CRC, 2017.
3. G.M. Lee; N.N. Tam; N.D. Yen: Quadratic Programming and Affine Variational Inequalities, Springer, New York, 2005.

Learning Outcomes (not more than 100 words)

By the end of this course, students will be able to solve unconstrained and constrained quadratic programming problems, including those with equality and inequality constraints. They will understand quadratic cost functions, convexity, and optimality conditions and be able to apply KKT systems, min-max duality, and saddle point concepts. Students will analyze solutions' existence, uniqueness, and continuity, and utilize Farka's Lemma. They will also be proficient in duality theory and numerical algorithms for solving quadratic programming problems, and they will apply these techniques to real-world scenarios such as portfolio optimization and affine variational inequalities.

Course Title	MATMJ85/MATMJ8R5: Fluid Dynamics

Credits &Hours of Teaching

	Theory	Practical	Cumulative
Credits	4	0	4
Hours of Teaching (Total)	60	0	60

Course Objectives (not more than 100 words)

This course aims to comprehensively understand fluid dynamics and its mathematical foundations. Key objectives include exploring fundamental concepts such as the equation of continuity, boundary surfaces, and the nature of fluid flow through various geometries. Students will study irrotational and rotational motions, vortex lines, and key theorems like Euler's Equation of Motion and Bernoulli's Theorem. Additionally, the course covers stress components in real fluids, principal stresses, and the transformation of stress components. Practical applications include analyzing flows between flat plates, through pipes, and between rotating cylinders.

Units	Course Content	Teaching Hrs
I	Equation of continuity, Boundary surfaces, path lines and streamlines, Irrotational and rotational motions, Vortex lines, Euler's Equation of motion, Bernoulli's theorem, Impulsive actions, Motion in two-dimensions.	12
II	Conjugate functions, Source, sink, doublets and their images, conformal mapping. Stress components in real fluid, Equilibrium equation in terms of stress components, Transformation of stress components.	12
III	Principal stresses, Nature of strains, Transformation of rates of strain, Relationship between stress and rate of strain.	12
IV	Navier-Stokes equation of motion. Buckingham Π-theorem, Flow between parallel flat plates, Couette and plane Poiseuille flows.	12
V	Flow through a pipe, Hagen Poiseuille flow, flow between two co-axially cylinders and two concentric rotating cylinders,Unsteady motion of a flat plate.	12

Texts / References

1. W.H. Besant; A.S. Ramsey: A Treatise on Hydrodynamics, CBS Publishers and Distributors,Delhi, 1988.
2. S.W. Yuan: Foundations of Fluid Dynamics, Prentice-Hall of India, 1988.
3. F. Charlton: A Text Book of Fluid Dynamics, CBC, 1985.

Learning Outcomes (not more than 100 words)

Upon completion of the course, students will be able to apply fluid dynamics principles to analyze and solve problems involving fluid flow, including calculating stress components and understanding the behavior of fluids under various conditions. They will master conjugate functions, source and sink dynamics, and conformal mapping. Students will be proficient in applying the Navier-Stokes equation, Buckingham Π-theorem, and analyzing flows in different geometries like pipes and rotating cylinders. They can also perform calculations related to unsteady motion and boundary conditions.

Course Title	**MATMJ86/MATMJ8R6: Numerical Analysis**			
Credits &Hours of Teaching		Theory	Practical	Cumulative
	Credits	4	0	4
	Hours of Teaching (Total)	60	0	60
Course Objectives (not more than 100 words)	This course aims to equip students with a comprehensive understanding of integral equations and matrix computations, and their application in numerical methods for differential equations. Key objectives include mastering Fredholm and Volterra integral equations, converting initial and boundary value problems into integral equations, and solving them using numerical methods like Newton-Cotes, Lagrange interpolation, and Chebyshev polynomials. Students will also learn techniques for solving systems of linear equations, matrix inversion, and factorization. The course covers numerical methods for first-order and second-order differential equations, boundary value problems, and introduces the Finite Element Method for solving boundary value problems.			

Units	**Course Content**	**Teaching Hrs**
I	Integral equations: Fredholm and Volterra equations of first and second types. Conversions of initial and boundary value problems into integral equations, numerical solutions of integral equations using Newton-Cotes, Lagrange`s linear interpolation and Chebyshev polynomial.	12
II	Matrix Computations: System of linear equations, Conditioning of Matrices, Matrix inversion method, Matrix factorization, Tridiagonal systems.	12
III	Numerical solutions of system of simultaneous first order differential equations and second order initial value problems (IVP) by Euler and Runge-Kutta (IV order) explicit methods.	12
IV	Numerical solutions of second order boundary value problems (BVP) of first, second and third types by shooting method and finite difference methods.	12
V	Finite Element method: Introduction, Methods of approximation: Rayleigh-Ritz Method, Gelarkin Method and its application for solution of BVP.	12

Texts / References	1. M.K. Jain; S.R.K. Iyenger; R.K. Jain: Numerical Methods for Scientific and Engineering Computations, New Age Publications, 2003. 2. M.K. Jain: Numerical Solution of Differential Equations, 2nd edition, Wiley-Eastern. 3. D.V. Griffiths; I.M. Smith: Numerical Methods for Engineers, Oxford University Press, 1993. 4. S.S. Sastry: Introductory Methods of Numerical Analysis. 5. C.F. Gerald; P.O. Wheatley: Applied Numerical Analysis, Addison- Wesley, 1998. 6. S. Gupta: Text Book on Calculas of Variation, Prentice-Hall of India, 2002. 7. N. Kumar: An Elementary Course on Variational Problems in Calculus, Narosa Publishing House,New Delhi, 2004.
Learning Outcomes (not more than 100 words)	Upon completion, students will proficiently solve Fredholm and Volterra integral equations and convert boundary and initial value problems into integral equations. They will effectively use numerical methods, such as Euler and Runge-Kutta methods, to solve differential equations. Students will gain expertise in matrix computations, including matrix inversion and factorization. They will also be able to solve boundary value problems using shooting and finite difference methods and apply the Finite Element Method, including Rayleigh-Ritz and Galerkin methods, to solve complex boundary value problems.

Course Title	**MATMJ87/MATMJ8R7: Mathematical Modeling**

Credits &Hours of Teaching

	Theory	Practical	Cumulative
Credits	4	0	4
Hours of Teaching (Total)	60	0	60

Course Objectives (not more than 100 words)

This course is designed to introduce students to the fundamental principles and techniques of mathematical modeling, focusing on applications in biology, ecology, and epidemiology. Students will explore the role of mathematics in problem-solving and the modeling process, including the development of elementary mathematical models. The course covers modeling with ordinary differential equations (ODEs) and difference equations, examining concepts such as stability, eigenvalues, and fixed points. By the end of the course, students will be able to apply these mathematical tools to analyze real-world problems in population dynamics and related fields.

Units	**Course Content**	**Teaching Hrs**
I	Introduction to Mathematical Modeling: modeling process, Elementary mathematical models; Role of mathematics in problem solving.	12
II	Single species population model: The exponential model, logistic model, harvesting model, and its critical value.	12
III	Modeling with Ordinary Differential Equations: Overview of basic concepts in ODE and stability ofsolutions: steady state and their local and global stability; Some applications in Epidemiology and ecology.	12
IV	Modeling with Difference Equations: Overview of basic concepts concerning matrices.	12
V	Eigenvalues andEigenvectors; Fixed points, stability, and iterative processes;Applications to population growth	12

Texts / References

1. J.N. Kapur: Mathematical Modeling, Wiley Eastern, 1988.
2. D.N. Burghes: Mathematical Modeling in the Social Management and Life Science, Ellie Herwood and John Wiley, 1980.
3. F. Charlton: Ordinary Differential and Difference Equations, Van Nostrand, 1965.

Learning Outcomes (not more than 100 words)

By the end of this course, students willUnderstand the process of mathematical modeling and its application in solving real-world problems.Develop and analyze models using ordinary differential equations, focusing on stability and steady-state solutions.Apply difference equations, including matrices, eigenvalues, and eigenvectors, to model population dynamics.Gain insight into the stability and iterative processes of mathematical models.Utilize mathematical models to explore and predict outcomes in epidemiology and ecology.

Course Title	**MATMJ88/MATMJ8R8: Numerical Solutions of Partial Differential Equations**

Credits &Hours of Teaching

	Theory	Practical	Cumulative
Credits	3	1	4
Hours of Teaching (Total)	45	30	75

Course Objectives (not more than 100 words)

This course aims to equip students with the knowledge and skills required to numerically solve partial differential equations (PDEs). It covers the numerical solutions of parabolic, hyperbolic, and elliptic PDEs in various coordinate systems and dimensions, emphasizing explicit and implicit schemes. Students will learn about convergence, stability analysis, and advanced methods like alternating direction implicit (ADI) techniques. Additionally, the course introduces the finite element method,focusing on linear, triangular, and rectangular elements. By the end of the course, students will be able to apply these numerical methods to solve complex boundary value problems.

Units	**Course Content**	**Teaching Hrs**
I	Numerical solutions of parabolic PDE in one space: two and three levels explicit and implicit differenceschemes. Convergence and stability analysis.	9
II	Numerical solution of parabolic PDE of second order in two space dimension: implicit methods, alternatingdirection implicit (ADI) methods. Nonlinear initial BVP.	9
III	Difference schemes for parabolic PDE in spherical and cylindrical coordinate systems in one dimension.	9
IV	Numerical solution of hyperbolic PDE in one and two space dimension: explicit and implicit schemes. ADImethods. Difference schemes for first order equations.	9
V	Numerical solutions of elliptic equations, approximations of Laplace and biharmonic operators. Solutions ofDirichlet, Neuman and mixed type problems.Finite element method: Linear, triangular elements, and rectangular elements.	9

Texts / References

1. M.K. Jain; S.R.K. Iyenger; R.K. Jain: Computational Methods for Partial Differential Equations,Wiley Eastern, 1994.
2. M.K. Jain: Numerical Solution of Differential Equations, 2nd edition, Wiley Eastern.
3. S.S. Sastry: Introductory Methods of Numerical Analysis, , Prentice-Hall of India, 2002.
4. D.V. Griffiths; I.M. Smith: Numerical Methods of Engineers, Oxford University Press, 1993.
5. C.F. General; P.O. Wheatley: Applied Numerical Analysis, Addison- Wesley, 1998.

Learning Outcomes (not more than 100 words)

Upon completing this course, students will:Understand and implement numerical methods for solving parabolic, hyperbolic, and elliptic PDEs in different coordinate systems.Analyze the convergence and stability of explicit and implicit difference schemes.Apply advanced techniques like ADI methods to multi-dimensional PDE problems.Solve boundary value problems using appropriate numerical methods, including Dirichlet, Neumann, and mixed-type problems.Utilize the finite element method for solving PDEs, focusing on linear, triangular, and rectangular elements, and understand their application to real-world problems.

Course Title	MATMJ89/MATMJ8R9: Riemannian Manifolds			
Credits &Hours of Teaching		Theory	Practical	Cumulative
	Credits	4	0	4
	Hours of Teaching (Total)	60	0	60
Course Objectives (not more than 100 words)	This course introduces students to the fundamental concepts of Riemannian geometry, focusing on Riemannian metrics, connections, and the geometry of curved spaces. The course covers essential topics such as geodesics, curvature tensors, and Jacobi fields. Students will explore theorems like Hopf-Rinow, Hadamard's, and Cartan's and study complete manifolds and real space forms. Additionally, the course examines the fundamental equations governing Riemannian submanifolds.			

Units	Course Content	Teaching Hrs
I	Riemannian Metrics. Riemannian connection. Fundamental Theorem of Riemannian Geometry. Geodesics.	20
II	Curvature - Riemann curvature, Sectional curvature, Ricci curvature, scalar curvature. Kulkarni-Nomizu tensor fields. Conformal curvature tensor field.	20
III	Jacobi Fields. Complete manifolds, Hopf-Rinow Theorem, The Theorem of Hadamard. Real space forms, Theorem of Cartan on thedetermination ofthe metric by means of the curvature. Fundamental equations for Riemannian submanifolds.	20

Texts / References	1. S.S. Chern; W.H. Chen; K.S. Lam: Lectures on Differential Geometry, World Scientific, 2000. 2. M.P. do Carmo: Riemannian Geometry, Birkhauser, 1992. 3. N.J. Hicks: Notes on Differential Geometry, Von Nostrand, 1965. 4. P. Petersen: Riemannian Geometry, Springer 2006. 5. J. Jost: Riemannian Geometry and Geometric Analysis (6ed. Springer, 2011).
Learning Outcomes (not more than 100 words)	By the end of this course, students will; understand and apply the concepts of Riemannian metrics, connections, and the fundamental theorem of Riemannian geometry; analyze geodesics and study various curvature forms, including Riemann, sectional, Ricci, and scalar curvatures; utilize theorems like Hopf-Rinow and Hadamard to explore the properties of complete manifolds; grasp the significance of Jacobi fields in understanding the behavior of geodesics; apply the fundamental equations of Riemannian submanifolds to solve geometric problems.

Course Title	**MATMJ810/MATMJ8R10: Information and Coding Theory**

Credits &Hours of Teaching

	Theory	Practical	Cumulative
Credits	4	0	4
Hours of Teaching (Total)	60	0	60

Course Objectives (not more than 100 words)

This course aims to provide a comprehensive understanding of Shannon's information theory, including source and channel coding fundamentals. Students will explore concepts like uniquely decodable and instantaneous codes, entropy, and mutual information alongside key inequalities and coding techniques such as Huffman and Shannon-Fano coding. The course also delves into error-correcting codes, covering topics like Hamming distance, linear codes, decoding rules, and bounds. Advanced topics include perfect codes, the Hamming and Golay codes, and MDS codes.

Units	Course Content	Teaching Hrs
I	Overview of Shannon theory, Source coding and Channel coding, Uniquely decodable codes, Instantaneous codes, Kraft's and McMillan's inequality, Binary Huffman codes, Average wordlength of Huffman codes, extensions of sources	12
II	Information and entropy, properties of the entropy function, entropy and average word length, Shannon-Fano coding, Shannon's first theorem, Binary symmetric channel, system entropies, Mutual Information and channel capacity	12
III	Error correcting codes: maximum likelihood decoding, Hamming distance and distance of a code, minimum distance decoding rule, Linear codes, minimum distance of linear codes, Hamming weight, Bases for linear codes, Generator matrix and parity-check matrix, equivalence of linear codes, (Slepian) standard array and syndrome decoding	12
IV	Hamming's sphere-packing bound, the Gilbert-Varshamov bound. Perfect codes, The Hamming codes and the Golay codes, Singleton bound and MDS codes, Hadamard matrices and codes.	12

Texts / References

1. G.A. Jones; J.M. Jones: information and Coding Theory: Springer, 2000.
2. S. Ling; C.Xing: Coding Theory, Cambridge University Press, 2004.
3. J.H.V. Lint: Introduction to Coding Theory, Springer, 1982.

Learning Outcomes (not more than 100 words)

By the end of the course, students will understand the principles of Shannon theory, source and channel coding, and the mathematical foundation of entropy; analyze and construct optimal coding schemes, including Huffman and Shannon-Fano codes; apply concepts like mutual information and channel capacity to evaluate communication systems;gain proficiency in error-correcting codes, including linear codes, decoding methods, and bounds. develop the ability to design and evaluate advanced codes, such as Hamming, Golay, and MDS codes, for reliable data transmission.

Course Title	**MATMJ811/MATMJ8R11: Algebraic Geometry**

Credits &Hours of Teaching

	Theory	Practical	Cumulative
Credits	3	0	3
Hours of Teaching (Total)	45	0	45

Course Objectives (not more than 100 words)

This course aims to introduce the students to the topic of algebraic geometry. This course, as the name suggests is a fusion of Algebra and geometry. The students would have already had familiarity with algebra and geometry and in this course they will see how the two subjects of Mathematics come together to help each other.

Units	**Course Content**	**Teaching Hrs**
I	Introduction and Overview, Affine Space, Affine plane curve, Projective space, projective space curve, their properties using set theoretic operations, Examples.	9
II	Affine algebraic sets, Algebraic sets in terms of zeros of polynomials, Projective Algebraic sets, Zariski Topology, irreducible space, Noetherian space, affine Variety and quasi affine variety, Dimension, Krull dimension	9
III	Interlude to field theory, extension, irreducible and minimal polynomial, Algebraically closed field,, Ring extension, integral element, module finiteness, integrally closed extension.	9
IV	Weak nullstellensatz, Hilbert's Nullstellensatz and their proof, Transcendence base, Polynomial map	9
V	Rational functions, Coordinate ring, valuations, completion, topological field, Tangent space, Derivations	9

Texts / References

1. D Mumford: The red book of varieties and schemes, Springer, 1999.
2. J S Milne: Algebraic Geometry, Web version, 2023.
3. S S Abhyankar: Algebraic Geometry for Scientists and Engineers, AMS, 2011.
4. Igor R. Shafarevich: Basic Algebraic Geometry 1, Springer, 1994.

Learning Outcomes (not more than 100 words)

After completion of this course the students will have a detailed account of foundation of Algebraic Geometry. The student will also be able to appreciate that the problems of geometry have also been approached via other methods which are different from polynomial approaches. After attending this course a student will be in a better position to approach the advanced topics in Algebraic geometry.

BANARAS HINDU UNIVERSITY

Department of Molecular and Human Genetics

Faculty of Science

SYLLABI

B.Sc. Programme

In

Molecular and Human Genetics

BANARAS HINDU UNIVERSITY
(Detailed Syllabus of different Courses under NEP 2020)

Department of Molecular and Human Genetics

Faculty of Science, BHU

Course Title	**Basics of Human Genome: MHGMD3I**
Category of Course[291]	MD-Sem-III
Credits[292]& Hour of Teaching	

	Theory	Practical	Cumulative
Credits	3		3
Hour of Teaching (Total)	45		45

Course Objectives (not more than 100 words)	The students will be introduced to the Human genome project (HGP) which was an international scientific research project which was successfully completed in the year 2003 by sequencing the entire human genome of 3.3 billion base pairs. The HGP led to the growth of bioinformatics, disease gene mapping as well as personalized medicine.
Course Content	The course content be divided into minimum 3 Units to maximum 5 units along with defined hour of teaching for each unit.

Units	Course Content	Hr. of Teaching
I	The Genome project I.1History, organization and goals of human genome project	10
II	Organization of human genome II.1Mitochondrial genome II.2Oganisation of nuclear genome II.3 Variation and size of genes	15
III	Gene families III.1. Multigene families – Classical gene families, families with large conserved domains, families with small conserved domains III.2. Gene superfamilies III.3. Gene families in clusters III.4. Pseudogenes III.5. Repetitive DNA and transposable elements	15
IV	IV.1.Disease and genomics	5

Texts / References	**Recommended Books** 1.Strachan and Read (2011). Human Molecular Genetics 4th Ed. Wiley 2. Pasternak (2000). An Introduction to Molecular Human Genetics.Fritzgerald 3.Sudbery (2002). Human Molecular Genetics. Prentice Hall 4. Lewin et al. (2009). Lewin's Genes X. Jones & Bartlett Learning, 2009 5.Brown (2007). Genomes. Bios 6.Dale &Schartz (2003). From Genes to Genomes. Wiley 7.Hawley and Mori (1999). The Human Genome. Academic
Learning Outcomes (not more than 100 words)	This course is designed to provide the students resources needed to enhance student learning in genomics and personalized medicine. It will also provide them the importance of Human Genome Project and its possible applications.

[291] SEC – Skill Enhancement Course; AEC – Ability Enhancement Course; VAC – Value Added Course; MD – Multidisciplinary Course

[292] 1 Credit (Theory) = 15 Hours; 1 Credit (Practical) = 30 Hours

BANARAS HINDU UNIVERSITY

Department of Physics

Faculty of Science

SYLLABI

B.Sc. (Hons.) Programme

In

Physics

NEP Curriculum for Physics Department (Updated on 14-09-2024)

Semester	Courses	Credits
I	PHYMJ11: Mechanics & General Properties of Matter	3
	PHYMJ12: Physics Laboratory- 1	1
	PHYMD11: Physics in Everyday Life **(max. intake 100)**	3
	PHYSE11: Mathematical Problem Solving Skills **(max. intake 100)**	3
	Minor same as major PHYMJ11, PHYMJ12	3+1
	VA (To be offered by the University)	2+2
	AE (To be offered by the University)	2
	Total Credits	**20**
II	PHYMJ21: Thermal Physics	3
	PHYMJ22: Physics Laboratory -2	1
	PHYMD21: Indian Contributions in Physical Sciences: Ancient to Modern **(max. intake 100)**	3
	PHYSE21: Energy Conversion and Storage for Sustainable Development **(max. intake 50)**	2
	PHYSE22: Skill Course Laboratory-1	1
	Minor same as major PHYMJ21, PHYMJ22	3+1
	VA (To be offered by the University)	2+2
	AE (To be offered by the University)	2
	Total Credits	**20**
III	PHYMJ31: Wave & Wave Optics	3
	PHYMJ32: Physics of Semiconductors and Devices	3
	PHYMJ33: Physics Laboratory -3	2
	PHYMD31: Historical Developments of Physical Science **(max. intake 100)**	3
	PHYSE31: Computational Physics: Programming and Data Analysis **(max. intake 50)**	2
	PHYSE32: Skill Course Laboratory-2	1
	PHYMV31: Applied Electronics and Fiber Optics*	3
	PHYMV32: Minor Vocational Laboratory-1	1
	AE (To be offered by the University)	2
	** Students may opt any four credit course from Online SWAYAM courses approved by the Department.*	
	Total Credits	**20**
IV	PHYMJ41: Electromagnetic theory & Special Theory of Relativity	4
	PHYMJ42: Mathematical Physics-I	3
	PHYMJ43: Computational Physics	3
	PHYMJ44: Physics Laboratory -4	2
	PHYMJ45: Computer Laboratory	2
	PHY-Minor (same as major : PHYMJ41*	4
	AE (To be offered by the University)	2
	** Students may opt any four credit course from Online SWAYAM courses approved by the Department.*	
	Total Credits	**20**

V	PHYMJ51: Quantum Mechanics-I	4
	PHYMJ52: Classical Mechanics-I	3
	PHYMJ53:Statistical Mechanics-I	3
	PHYMJ54: Physics Laboratory -5	4
	PHYIN51: (Internship): [Students can do internship after first to fourth semester during summer vacation]	2
	PHYMV51: Hands-on Training on Tooling, Welding, Electronics, Instrumentation, and Machine shop.*	3
	PHYMV52: Minor Vocational Laboratory	1
	** Students may opt any four credit course from Online SWAYAM courses approved by the Department.*	
	Total Credits	**20**
VI	***Any four elective theory courses (3 credit each) from the courses PHYMJ61(T) to PHYMJ67***	4x3
	PHYMJ61: Electronic circuits and Analysis	
	PHYMJ62: Solid State Physics	
	PHYMJ63: Atomic, Molecular and Laser Physics	
	PHYMJ64: Nuclear & Particle physics	
	PHYMJ65: Soft Matter Physics	
	PHYMJ66: Space Physics	
	PHYMJ67: Physics Laboratory -6	4
	PHYMV61: Artificial Intelligence and Machine learning*	3+1
	** Students may opt any four credit course from Online SWAYAM courses approved by the Department.*	
	Total Credits	**20**
VII-H	***Any four elective theory courses (3 credit each) form the list***	4x3
	PHYMJ71: Classical Mechanics-II	
	PHYMJ72: Mathematical Physics-II	
	PHYMJ73: Quantum Mechanics-II	
	PHYMJ74: Advanced Topics in Integrated Circuits, Digital Systems, Embedded Architectures, and Antenna	
	PHYMJ75: Nano Science and Technology	
	PHYMJ76: Advanced Molecular Spectroscopy	
	PHYMJ77: Nuclear Models and Reactions	
	PHYMJ78: Plasma Astrophysics and Physics of Interstellar Medium	
	PHYMJ79: Physics Laboratory- A OR PHYMJ710:Physics Laboratory-B	3
	PHYMJ711: Physics Laboratory-C	1
	PHY-Minor [PHYMN71 to PHYMN78] [Any one from the major elective courses from PHYMJ71 to PHYMJ78 + one unit of lab (1)]*	3+1
	** Students may opt any four credit course from Online SWAYAM courses approved by the Department.*	
	Total Credits	**20**

VIII-H	***Any Four elective theory courses (3 credit each)***	4x3
	PHYMJ81: Statistical Mechanics-II	
	PHYMJ82: Electrodynamics and Plasma Physics	
	PHYMJ83: Advanced Topics in Quantum Mechanics	
	PHYMJ84: Advanced Photonics and Optical Communication	
	PHYMJ85: Advanced Topics in Condensed Matter Physics	
	PHYMJ86: Spectroscopic Techniques for Materials Characterization	
	PHYMJ87: Particle Physics	
	PHYMJ88: Astrophysics of Stars and Galaxies	
	PHYMJ89: Physics Laboratory –A OR PHYMJ810: Physics Laboratory-B	3
	PHYMJ811: Physics Laboratory-C	1
	PHY-Minor [PHYMN71 to PHYMJ78] [Any one from the major elective courses from PHYMJ81 to PHYMJ88 + one unit of lab(1)]*	3+1
	** Students may opt any four credit course from Online SWAYAM courses approved by the Department.*	
	Total Credits	**20**
	Note: (1) **In Semester VII,** half of the students will perform Physics **Lab. A** experiments (3 credits) and other half will perform Physics **Lab. B** experiment (3 credits). (2) **In Semester VIII,** remaining half of the students will perform Physics **Lab. B** experiments (3 credits) and other half will perform Physics **Lab. A** experiment (3 credits).	
	Research Students	
VII-R	***Same as VII-H*** [PHYMJ7R1 to PHYMJ7R8]	
VIII-R	PHYDS8R1: Dissertation	12
	PHYMJSR1: Research Methodologies	2
	PHYMJ8R2: Research Techniques	2
	PHY-Minor [PHYMN8R1 to PHYMN8R8] [Any one from the major elective courses (3)+one unit of lab(1)] as offered in the VIII Sem. (Hons.)*	3+1
	** Students may opt any four credit course from Online SWAYAM courses approved by the Department.*	
	Total Credits	**20**

Remarks:

(1) Students may earn upto 40% of credits from online platform SWAYAM. The SWAYAM courses will be decided by the Department from time to time.
(2) Electives may be changed from time to time by the Department.

BANARAS HINDU UNIVERSITY
(Detailed Syllabus of different Courses under NEP 2020)

Department of PHYSICS **Faculty of SCIENCE**

Course Title	**PHYMJ11: Mechanics & General Properties of Matter**			
Category of Course	**Major** / Minor / Minor (Vocational) / SEC / AEC / VAC / MD/Internship/Dissertation (Tick any one of the above)			
Credits & Hour of Teaching		**Theory**	**Practical**	**Cumulative**
	Credits	3	00	3
	Hour of Teaching (Total)	45	00	45
Course Objectives	This course aims to provide a foundational understanding of mechanics and the general properties of matter. Topics include the motion of particles under various forces, inertial and non-inertial frames of reference, dynamics of particle systems, and principles of gravitation. Additionally, students will explore damped and forced oscillations, elastic properties of materials, and fluid dynamics. Through theoretical and practical approaches, the course will enhance students' analytical skills and understanding of physical principles governing natural phenomena.			
Course Content	The course content be divided into minimum 3 Units to maximum 5 units along with defined hour of teaching for each unit.			
Units	**Course Content**			**Hr. of Teaching**
I	**Fundamentals:** Motion of a particle under an external force, conservative and non-conservative forces, work done by a non-conservative force, law of conservation of energy. **Frames of references:** Inertial and non-inertial frames, Transformation equations (Inclined and Rotating frames), Centrifugal and Coriolis force, Effect of centrifugal and Coriolis force due to earth rotation. **Gravitation**: Motion of a particle under gravitational force, inertial and gravitational mass, gravitational potential, and fields due to a spherical shell and a solid sphere.			12
II	**System of particles**: Dynamics of a system of particles subject to external forces, Centre of mass, laboratory frame and centre of mass frame, conservation of linear and angular momenta; elastic and inelastic collision in one and two dimensions.			10
III	**Damped and Forced Oscillation**: Simple and compound pendulum, Damped oscillator, Energy and Q-factor, Forced oscillations (one degree of freedom), condition of resonance; Ballistic Galvanometer.			7
IV	**Elastic properties:** Modulus of rigidity, Poisson ratio, relation between elastic constants, twisting couple of cylinders (hollow and solid), statical and dynamical methods for determination of modulus of rigidity, Bending of beams.			9
V	**Fluid Dynamics**: Bernoulli's theorem, equation of continuity, streamline and turbulent flow (Reynolds number), surface tension and surface energy, viscosity and Poiseuille's equation.			7
Texts / References	1. Physics Part –1: Resnick and Halliday 2. Mechanics: D. S. Mathur 3. Mechanics: J. C. Upadhyay 4. Mechanics: H. S. Hans and S. P. Puri 5. A Treatise on General Properties of Matter: Sengupta and Chatterjee			
Learning Outcomes	Upon completing this course, students will be able to • Analyze particle motion under various forces, including work done by non-conservative forces and energy conservation principles. • Understand and differentiate between inertial and non-inertial frames of reference, including the effects of centrifugal and Coriolis forces. • Describe the dynamics of particle systems, center of mass, and conservation laws, and solve problems involving collisions. • Comprehend gravitational forces, potentials, and fields in different contexts.			

<table>
<tr><td></td><td colspan="4">• Examine damped and forced oscillations, resonance conditions, and applications like the ballistic galvanometer.
• Evaluate the elastic properties of materials and the bending of beams using various methods.
• Apply fluid dynamics principles to real-world problems involving flow, surface tension, and viscosity.</td></tr>
<tr><td>Course Title</td><td colspan="4">PHYMJ12: Physics Laboratory-1</td></tr>
<tr><td>Category of Course</td><td colspan="4">Major / Minor / Minor (Vocational) / SEC / AEC / VAC / MD/Internship/Dissertation
(Tick any one of the above)</td></tr>
<tr><td rowspan="3">Credits & Hour of Teaching</td><td></td><td>Theory</td><td>Practical</td><td>Cumulative</td></tr>
<tr><td>Credits</td><td>0</td><td>01</td><td>01</td></tr>
<tr><td>Hour of Teaching (Total)</td><td>0</td><td>30</td><td>30</td></tr>
<tr><td></td><td colspan="4">Group I
1. To determine the Stefan’s constant.
2. To study the forward/reverse characteristics of the PN junction diode
3. To determine the modulus of rigidity of a wire using Maxwell's needle method.
4. To study series resonant L. C. R. circuits.
5. To determine the Young’s modulus of the material of a metallic bar by bending of beam method.
6. To determine the acceleration due to gravity using the compound pendulum.

Group II
1. To determine the focal length of a combination of lenses
2. To determine the modulus of rigidity using Bartron’s apparatus.
3. To determine the viscosity of liquid using Poiseuille’s method.
4. To determine the thermal conductivity of a bad conductor using Lee's disc method
5. To study the variation of the magnetic field along the axis of the Helmholtz Galvanometer and to determine the reduction factor.
6. To determine the resistance per unit length and an unknown resistance using C. F. Bridge.

*In Semester I, half of the students will do the experiments of Group I and the other half will do the experiments of Group II. In Semester II, the students will exchange their groups. Additions and deletions in the list of experiments may be made from time to time by the department.</td></tr>
</table>

Course Title	**PHYMD11: Physics in Everyday Life**			
Category of Course	Major / Minor / Minor (Vocational) / SEC / AEC / VAC / **MD**/Internship/Dissertation (Tick any one of the above)			
Credits & Hour of Teaching		**Theory**	**Practical**	**Cumulative**
	Credits	03	0	03
	Hour of Teaching (Total)	45	0	45
Course Objectives	This course tries to explain the Physics behind the things that we experience in our day-to-day life. Every module will be taught in 6-7 lectures and the whole course will be covered in about 45 lectures.			
Course Content	The course content be divided into minimum 3 Units to maximum 5 units along with defined hour of teaching for each unit.			

Units	**Course Content**	**Hr. of Teaching**
I	**Motion and Fluids -** Skating and effect of forces, Use of Ramps in day-to-day life, Seesaw and Merry-go-round, Bumping Cars at the Mall, Roller Coasters, Bicycles, Launch of Spacecrafts, Orbits, Switching orbits. Air pressure, Gas (hot air) Balloons, Buoyancy, Water distribution from Overhead Tank, Using hoses for cleaning and gardening, Flow of blood in veins, Aerodynamics of balls (cricket and golf), Airplanes.	13
II	**Heat** Celsius, Kelvin and Fahrenheit, Thermometer, Heat transfer (conduction, convection and radiation), Solid, Liquid and Gas (example of water and concept of Latent Heat), Pressure cooking, Staying warm in extreme colds, Air conditioner.	08
III	**Electricity, Electronics and Magnetism** Static electricity, Current and Voltage, Series and Parallel circuits, AC and DC, Power distribution, Transformer, Wiring in homes, Flash light and batteries, Magnets (temporary and permanent), Compass.	08
IV	**Electromagnetic Waves** Cell phones, Satellite communication, Microwave heating, Light, Sun light, Rising and setting Sun, Polarizing Sun glasses, Car Windshield, LED bulbs, LASERs, Magnifying glass, Camera, CCD detectors.	08
V	**Miscellaneous** Elasticity, Springs, Steel Bridges, Pendulum clocks, Electronic clocks, Sound and Music (Violin), Energy – Mass conversion, Atom and Hydrogen bomb, Energy generation in Sun / Stars.	08

Texts / References	1. How things work, Louis A. Bloomfield, J. Wiley & Sons. 2. Physics for entertainment, Y. Perelman, Create space Independent Publishers. 3. General physics and its application to industry and everyday life, Ervin S. Ferry, J. Wiley & Sons.
Learning Outcomes	At the end of this course, a student will develop insight into Physics that works behind the day-to-day working of things we use. This may be walking, using electricity, watering plants, cell phones and other electronic and electrical devices, etc. The course is developed focusing students that do not have Physics as their major subject.

Course Title	**PHYSE11: Mathematical Problem Solving Skills**			
Category of Course	Major / Minor / Minor (Vocational) / **SEC** / AEC / VAC / MD/Internship/Dissertation (Tick any one of the above)			
Credits & Hour of Teaching		**Theory**	**Practical**	**Cumulative**
	Credits	3	0	3
	Hour of Teaching (Total)	45	0	45
Course Objectives	The course is designed to train the science students with mathematical skills in order to attempt diverse problems in science discipline. The topics covered are: Functions and their Taylor series, Numerical methods to find the roots, Ordinary differential equations and their applications, Fourier theorem, Vector calculus and elementary probability concepts.			
Course Content	The course content be divided into minimum 3 Units to maximum 5 units along with defined hour of teaching for each unit.			

Units	**Course Content**	**Hr. of Teaching**
I	**Functions:** Linear, quadratic, trigonometric, exponential and logarithmic functions, visualization and graph plotting; graphical method to find the roots; functions of more than one variables, partial derivatives, maxima and minima.	10
II	**Taylor series:** Taylor series for elementary functions (e.g., exponential, trigonometric), applications of Taylor series. **Numerical methods:** Roots of transcendental equations using Bi-section and Newton-Raphson methods.	10
III	**Differential equations:** Techniques for solving first-order ODEs: integrating factors; Introduction to higher order and partial differential equations.	10
IV	**Vector Calculus:** Vectors in two and three dimensions, concept of Gradient, Divergence and Curl with examples.	06
V	**Probability theory:** Concepts of probability, probability density functions, normalization, mean and variance, examples of Gaussian and Maxwell's distribution of speeds.	09

Texts / References	1. Advanced Engineering Mathematics: E. Kreyszig 2. Applied Mathematics for Engineers and Physicists: L. A. Pipes and L. R. Harvill 3. Mathematical Physics with Applications, Problems and Solutions: V. Balakrishnan 4. Mathematical Methods for Physicists: G. B. Arfken and H. J. Weber
Learning Outcomes	The students will be equipped with soft skills in mathematical sciences which are prerequisite for most of the courses in science discipline.

Course Title	**PHYMJ21: Thermal Physics**			
Category of Course	**Major** / Minor / Minor (Vocational) / SEC / AEC / VAC / MD/Internship/Dissertation (Tick any one of the above)			
Credits & Hour of Teaching		**Theory**	**Practical**	**Cumulative**
	Credits	3	0	3
	Hour of Teaching (Total)	45	0	45
Course Objectives	This course is designed at an introductory level, containing the topics of basic thermodynamics and the kinetic theory of gases and due to its importance in physics, the thermodynamics of radiation is included in a separate unit. Special emphasis is laid on the concept of entropy. The essential mathematical apparatus of thermodynamic functions, the Clausius-Clapeyron equation and applications form an integral part of thermodynamics. The kinetic theory of gases contains elementary treatment of transport phenomena, and the van der Waals equation of state. A proper grounding in the thermodynamic method is an essential prerequisite, among others, for the courses on statistical mechanics, and hence for the other core courses of physics.			
Course Content	The course content be divided into minimum 3 Units to maximum 5 units along with defined hour of teaching for each unit.			

Units	**Course Content**	**Hr. of Teaching**
I	**Thermodynamics:** Brief revision of the Zeroth law and the First law of thermodynamics, quasistatic, reversible and irreversible processes, work done in isothermal and adiabatic processes, Carnot's cycle and Carnot's theorem, the Second law of thermodynamics, The thermodynamic temperature scale.	08
II	**Entropy:** Entropy as a thermodynamic variable, Entropy change in reversible and irreversible processes. Entropy and disorder, Principle of increase of entropy, Entropy and unavailable energy, Entropy of ideal gases, S-T diagram.	08
III	**Thermodynamic functions and Applications**: Internal energy, Enthalpy, Helmholtz free energy, and Gibbs free energy, Maxwell thermodynamical relations and their applications, TdS equations, Criteria of equilibrium of a system, Clausius-Clapeyron equations, Applications to sublimation, vaporization, and freezing processes. The Third law of thermodynamics, Nernst heat theorem.	08
IV	**Kinetic Theory of Gases:** Maxwell's speed distribution (without derivation), Mean free path, transport phenomena (viscosity and thermal conductivity), Real gases, Andrews curves, van der Waals equation of state, Critical constants, Virial coefficients. Elementary ideas of Phase transition, Coexistence of phases, Triple point. Joule effect (free expansion), Joule-Thomson effect (Thermodynamic analysis), Inversion temperature, Liquefaction of gases.	12
V	**Radiation:** The blackbody radiation, Kirchhoff's law, The Blackbody spectrum, Wien's displacement law, Stefan-Boltzmann law, Radiation pressure, Rayleigh-Jeans law, Planck's quantum theory of radiation.	9

Texts / References

1. Heat and Thermodynamics: M. W. Zemansky and R. H. Dittman.
2. Heat and Thermodynamics: Brij Lal and N. Subrahmanyam.
3. Thermodynamics, Kinetic Theory, and Statistical Thermodynamics: F. W. Sears and G. L. Salinger
4. Basic Thermodynamics: Evelyn Guha
5. A Treatise on Heat: M. N. Saha and B. N. Srivastava.

<table>
<tr><td>Learning Outcomes</td><td colspan="4">The learning outcomes include:
1. Learning the thermodynamic method and using the method to understand many important physical phenomena.
2. The skills for solving problems in other allied areas of science, especially chemistry, using the methods of thermodynamics.
3. Appreciation of the origins of quantum physics from the thermodynamics of radiation.</td></tr>
<tr><td>Course Title</td><td colspan="4">PHYMJ22: Physics Laboratory-2</td></tr>
<tr><td>Category of Course</td><td colspan="4">Major / Minor / Minor (Vocational) / SEC / AEC / VAC / MD/Internship/Dissertation
(Tick any one of the above)</td></tr>
<tr><td rowspan="3">Credits & Hour of Teaching</td><td></td><td>Theory</td><td>Practical</td><td>Cumulative</td></tr>
<tr><td>Credits</td><td>0</td><td>01</td><td>01</td></tr>
<tr><td>Hour of Teaching (Total)</td><td>0</td><td>30</td><td>30</td></tr>
<tr><td></td><td colspan="4">Group I
1. To determine the Stefan’s constant.
2. To study the forward/reverse characteristics of the PN junction diode
3. To determine the modulus of rigidity of a wire using Maxwell's needle method.
4. To study series resonant L. C. R. circuits.
5. To determine the Young’s modulus of the material of a metallic bar by bending of beam method.
6. To determine the acceleration due to gravity using the compound pendulum.
Group II
1. To determine the focal length of a combination of lenses
2. To determine the modulus of rigidity using Bartron’s apparatus.
3. To determine the viscosity of liquid using Poiseuille’s method.
4. To determine the thermal conductivity of a bad conductor using Lee's disc method
5. To study the variation of the magnetic field along the axis of the Helmholtz Galvanometer and to determine the reduction factor.
6. To determine the resistance per unit length and an unknown resistance using C. F. Bridge.

*In Semester I, half of the students will do the experiments of Group I and the other half will dothe experiments of Group II. In Semester II, the students will exchange their groups. Additions and deletions in the list of experiments may be made from time to time by the department.</td></tr>
</table>

Course Title	**PHYMD21: Indian Contributions in Physical Sciences: Ancient to Modern**			
Category of Course	Major / Minor / Minor (Vocational) / SEC / AEC / VAC / **MD**/Internship/Dissertation (Tick any one of the above)			
Credits & Hour of Teaching		**Theory**	**Practical**	**Cumulative**
	Credits	03	0	03
	Hour of Teaching (Total)	45	0	45
Course Objectives	This course will give students a broad overview of the contributions of Indian scientists to physics, mathematics and astronomy down the ages. The beginnings in the Harappan culture and the Vedic texts will be followed by a survey of classical Hindu science, beginning with Aryabhata. The influence of Indian science on the world will be highlighted. The return of scientific knowledge in the colonial period will then be discussed. Finally the achievements of noted Indian physicists will be highlighted, including the colonial period as well as postcolonial developments and the contemporary period.			
Course Content	The course content be divided into minimum 3 Units to maximum 5 units along with defined hour of teaching for each unit.			

Units	**Course Content**	**Hr. of Teaching**
I	**Beginnings of Indian Science:** Harappan astronomy and technology, physics and astronomy in the Vedas: *Shatapatha Brahmana* and *Taittiriya Samhita*, *Sulba Sutras*: Baudhayana and growth of geometry, decimal system, Bakshali manuscript and invention of the zero, concept of large and small numbers and scales; *Shankhya* and *Vaisheshik Shastras*, *Bhagavata Purana*.	08
II	**Golden period of Hindu Science:** Aryabhata and the heliocentric hypothesis, Varahamihira, Brahmagupta, Sridhara and Bhaskara, *Surya siddhanta*, Jain science, Kerala school of mathematics, *Sawai* Jai Singh and late Hindu astronomy, Indian calendars and eras.	09
III	**Exchanges between India and the world:** The *Yavanajataka* and *Romaka Siddhanta,* Al-Biruni, influence of Indian science on Islamic and Western science, Pingala and Fibonacci, colonial science: James Rennell and cartography, Great Trigonometric Survey, Radhanath Sikdar, pioneers in science teaching: John Tytler, Eugene Lafont, Charles Racine, and their noted students, Indian pioneers: Mahendra Lal Sarkar, Ardashir Cursetjee, Ashutosh Mukherjee, Ramchundra Lall and Srinivasa Ramanujan.	08
IV	**Indian contributions to modern physics:** Highlights of the work of J.C. Bose, D.M. Bose, M.N. Saha, S.N. Bose, C.V. Raman, K.S. Krishnan, A.P.J. Abdul Kalam, S.K. Mitra, H.J. Bhabha, V. A. Sarabhai, S. Chandrasekhar, A.K. Raychaudhuri, N.S. Kapany, Harish-Chandra, S. Pancharatnam, E.C.G. Sudarshan, Jogesh Pati, M.L. Mehta, D.N. Verma, T.V. Ramakrishnan, Ashoke Sen.	20

Texts / References	1. Chattopadhyaya, Debiprasad (1986). *"History of science and technology in ancient India: the beginnings."* Firma KLM Pvt. Ltd.. 2. D.M. Bose, S.N. Sen, B.V. Subbarayappa (Eds.), "*A Concise History of Science in India*" (Orient Blackswan, Hyderabad, 1967). 3. Subbarayappa, B.V. (1989), "*Indian astronomy: an historical perspective*", in *Cosmic Perspectives* edited by Biswas etc., pp. 25–41, Cambridge University Press. 4. Indian National Science Academy (2001), *Pursuit and promotion of science: The Indian Experience*, Indian National Science Academy. 5. Teresi, Dick *et al* (2002), *Lost Discoveries: The Ancient Roots of Modern Science-from the Babylonians to the Maya*, Simon & Schuster. 6. F. Günergun and Dhruv Raina, "*Science between Europe and Asia*", (Springer, 2010). 7. Rajesh Kocchar, "*Science and the British Empire*" (Routlege India, 2024).
Learning Outcomes	At the end of the course, students should have a comprehensive understanding of the role of Indian physicists and mathematicians, not just in the ancient world, but also in the contemporary world, in furthering the cause of science. The course should generate pride in the achievements of these Indian thinkers and highlight the very many fundamental achievements of Indians down the ages. It is expected that these examples will provide inspiration to youngsters to chart their own way forward.

Course Title	**PHYSE21: Energy Conversion and Storage for Sustainable Development**			
Category of Course	Major / Minor / Minor (Vocational) / **SEC** / AEC / VAC / MD/Internship/Dissertation (Tick any one of the above)			
Credits & Hour of Teaching		**Theory**	**Practical**	**Cumulative**
	Credits	02	0	02
	Hour of Teaching (Total)	30	0	30
Course Objectives	The aim of this course is to provide students with practical skills and knowledge related to energy conversion and storage technologies for sustainable development. It covers various aspects of energy generation, conversion, storage, and utilization, focusing on renewable and sustainable energy sources.			
Course Content	The course content be divided into minimum 3 Units to maximum 5 units along with defined hour of teaching for each unit.			

Units	**Course Content**	**Hr. of Teaching**
I	**Introduction to Energy Conservation and Storage:** Introduction to energy conservation technologies. Overview of energy storage systems, Importance of sustainable development and renewable energy.	06
II	**Energy Conversion Technologies:** Photovoltaic systems and solar panels, Wind turbines and wind energy conversion systems, Bioenergy technologies, Hydropower technologies, and Geothermal power generation. **Energy Storage Technologies:** Basics of secondary batteries, electrodes for secondary batteries, battery technologies and applications, Hydrogen storage and Fuel cells, Pumped hydro storage, Thermal energy storage systems, Compressed air energy storage, Grid integration of renewable energy systems, Energy system modeling and analysis.	14
III	**Policies and Regulations:** Government policies and incentives for renewable energy, Environmental regulations and standards.	04
IV	**Future Trends and Challenges:** Emerging technologies in energy conversion and storage, Current challenges and research opportunities. Global energy transition and its impact on sustainable development.	06

Texts / References	1. Hydrogen as a Future Energy Carrier, A. Zuttel, A. Borgschulte and L. Schlapbach, Willey 2008, 2. Energy Storage and Conversion Systems, A. Kuperman and A. Lampasi, MDPI 2023 3. Energy for Sustainable Development: Demand, Supply, Conversion and Management, Md. Hasanuzzaman, Nasrudin Abd Rahim, Elsevier Science 2019 4. Government Policies and Regulations for renewable energy (Internet Resources)
Learning Outcomes	After completion of this course, the students will get practical skills and knowledge related to energy conversion and storage technologies for sustainable development. Students will have an idea of various aspects of energy generation and its conversion, storage, and utilization, focusing on renewable and sustainable energy sources. After doing practical assignments, laboratory exercises, group projects, and presentations, students will have a better understanding of the importance of energy conversion and storage for sustainable development.

Course Title	**PHYSE22: Skill Course Laboratory**			
Category of Course	Major / Minor / Minor (Vocational) / **SEC** / AEC / VAC / MD/Internship/Dissertation (Tick any one of the above)			
Credits & Hour of Teaching		**Theory**	**Practical**	**Cumulative**
	Credits	0	01	01
	Hour of Teaching (Total)	0	30	30
Course Objectives	The aims of this course are to provide students with practical skills and knowledge related to energy conversion and storage technologies for sustainable development. It covers various aspects of energy generation, conversion, storage, and utilization, focusing on renewable and sustainable energy sources.			
	Experiments			**Hr. of Teaching**
	1. Experiments on energy conversion devices: Photovoltaic cell characteristics. 2. Experiment on hydrogen production by electrolysis method. 3. Fabrication of rechargeable cell and its characterization. 4. Experiment on rechargeable battery: packaging and testing. 5. Development and characterization of fuel cells. 6. Hands on laboratory exercise and simulations.			30

Course Title	**PHYMJ31: Wave & Wave Optics**			
Category of Course	**Major** / Minor / Minor (Vocational) / SEC / AEC / VAC / MD/Internship/Dissertation (Tick any one of the above)			
Credits & Hour of Teaching		**Theory**	**Practical**	**Cumulative**
	Credits	03	0	03
	Hour of Teaching (Total)	45	0	45
Course Objectives	• To develop the concept of oscillation, waves and their representation. • Differential equation of waves and plane waves propagation in 3-Dimentions. • Elementary ideas of e.m. theory of light; wave-particle duality. • Idea of coherence; temporal and spatial coherence. • Theory of interference and classification of Interference • Concept of diffraction: Fresnel's diffraction and Fraunhofer diffraction with examples • Concept of un-polarized and polarized light; different types of polarizations • The Jones matrix representation of polarizations • Huygen's theory of double refraction • Production and detection of different polarized light • Retardation plates; optical activity • Dichroism and selective absorption. • Some Optical Instruments and idea about human eye.			
Course Content	The course content be divided into minimum 3 Units to maximum 5 units along with defined hour of teaching for each unit.			
Units	**Course Content**			**Hr. of Teaching**
I	**Oscillation & Waves:** Oscillation and concept of phase. Difference between oscillation and waves, characteristics of waves (energy, intensity, and their representation in terms of amplitude), progressive waves, Differential equation of wave motion, Plane waves in 3-Dimentions, superposition of waves, stationary waves, Concept of wave-fronts, phase velocity and group velocity.			4
II	**Wave optics:** **Nature of light:** Elementary ideas of e.m. theory of light, wave-particle duality. Characteristics of a light wave. Fresnel reflection and transmission coefficient. Basic idea about: coherence, coherence length, coherence time, bandwidth, mono-chromaticity, and temporal and spatial coherence.			4

III	**Interference:** Superposition of light waves, Theory of interference, Classification of Interference: division of wave-front and division of amplitude. Young's double slit experiments, Conditions for sustained interference, Fresnel Biprism, Stoke's treatment of reflection and refraction of waves. Lloyd's single mirror experiment. Interference in parallel and wedge shaped films, Colour of thin films. Newton's rings. Michelson interferometer and their applications. Multiple beam interference in parallel film and Fabry-Perot interferometer.	14
IV	**Diffraction:** Fresnel's diffraction, Zone plates: positive and negative zone plate, Diffraction due to circular aperture and opaque circular disc, Diffraction due to thin and thick wire, basic idea about Cornu's spiral, Fraunhofer diffraction due to single slit, double slits and plane transmission grating, concept of missing orders, Resolving power of grating. **Optical Instruments:** Basic idea human eye, field of view, eye-piece, spectrometer, telescope, microscope. Resolving power of telescope and Microscope, Basic idea about Mercury-, sodium lamp and laser light.	13
V	**Polarization:** Unpolarized and Polarized light, Brewster's law, Malus' law, Plane polarized-, elliptically polarized- and circularly polarized light. Elementary idea of Matrix representation of polarizations: The Jones matrix. Production of polarized light by reflection, refraction and scattering. Polarization by double refraction and Huygen's theory, Nicol prism, Retardation plates, Production and detection of Plane-, circularly- and elliptically polarized light. Optical activity and Fresnel's theory, Bi-quartz polarimeter. Dichroism and selective absorption.	10
Texts / References	1. Physical Optics: B. K. Mathur and T. P. Pandya. 2. Optics: Ajoy Ghatak (McGraw Hill Publication) 3. Fundamental of Optics: Francis Jenkins and Harvey White (McGraw Hill) 4. Introduction to Modern Optics: G. R. Fowels. (Dover Series) 5. Optics: E. Hecht (Addition Wesley) 6. A textbook of Optics: N. Subrahmanyam, Brijlal and M. N. Avadhanulu. 7. Geometrical and Physical Optics: Longhurst. (McGraw Hill Publication).	
Learning Outcomes	1. Oscillation, waves and their representation; plane waves propagation in 3-Dimentions. 2. Elementary ideas of e.m. theory of light and wave-particle duality. 3. Idea of coherence; temporal and spatial coherence. 4. Theory of interference and different types of Interference 5. Concept of diffraction: Fresnel's diffraction and Fraunhofer diffraction for different cases. 6. Concept of un-polarized and polarized light; different types of polarizations. The Jones matrix representation of polarizations. 7. Huygen's theory of double refraction; Production and detection of different polarized light. 8. Retardation plates; optical activity; Dichroism and selective absorption. 9. Some important Optical Instruments and idea about human eye.	

Course Title	**PHYMJ32: Physics of semiconductors and Devices**			
Category of Course	**Major** / Minor / Minor (Vocational) / SEC / AEC / VAC / MD/Internship/Dissertation (Tick any one of the above)			
Credits & Hour of Teaching		**Theory**	**Practical**	**Cumulative**
	Credits	03	0	03
	Hour of Teaching (Total)	45	0	45
Course Objectives	**Objective:** This course aims to provide a comprehensive understanding of the physical principles underlying semiconductor materials and their applications in various electronic devices. Students will learn about the formation of energy bands, the distinction between different types of materials, and the operational principles of crucial semiconductor devices. The course will also cover the design and analysis of electronic circuits, emphasizing practical applications and the latest advancements in semiconductor technology.			
Course Content	The course content be divided into minimum 3 Units to maximum 5 units along with defined hour of teaching for each unit.			

Units	Course Content	Hr. of Teaching
I	**Physics of Semiconductors:** Physical basis for band formation in solids and difference between metal, insulator and semiconductor. Intrinsic and extrinsic semiconductors, Fermi-Dirac distribution, Fermi level, Concept of effective mass, density of states. Thermal generation and recombination of electron hole pairs. Einstein's relation between mobility and diffusion. Drift and diffusion currents.	10
II	**P-N junction and Zener diode:** Depletion width and potential barrier, Diode equation, junction capacitance, I-V characteristics. Application of P-N junction diode as Rectifiers, ripple factor, Passive filters, rectification efficiency and percentage regulation. Clipping and clamping circuits, Zener diode and voltage regulation, tunnel diode.	10
III	**Electronic Devices:** Concepts of Homo- and Hetero-junction devices, Transistor circuits, Input and Output characteristics in CB, CC and CE configurations, Early effect, α and β parameters; DC load line, Operating point, Biasing and bias-stabilization. CE amplifier and frequency response.	10
IV	**Field effect transistors:** I-V Characteristics of JFET and MOSFET, FET biasing, FET as an amplifier. Silicon controlled rectifier (SCR), I-V Characteristics, phase controlled rectifier. Uni-junction transistor (UJT), I-V Characteristics, relaxation oscillator.	08
V	**Operational amplifier and Opto-Electronic Devices:** Block diagram, characteristics parameters, inverting and non-inverting amplifier. Solar cells – I-V characteristics, fill factor and efficiency, LED, LCD and flexible display devices.	07

Texts / References	1. Electronic Devices : T. L. Floyd 2. Device and Circuits : J. Millman and C. Halkias. 3. A Text Book of Electronics: Kakani and Bhandari. 4. Electronic Fundamental and Applications: D. Chatopadhyay and P.C. Rakshit. 5. Solid State Electronic Devices: Ben G. Streetman and Sanjay Kumar Banerjee. 6. Electronic Principles: Albert Malvino and David J. Bates
Learning Outcomes	1. Understand the physical basis for band formation in solids and differentiate between metals, insulators, and semiconductors. 2. Explain the concepts of intrinsic and extrinsic semiconductors, including Fermi levels and the effective mass of charge carriers. 3. Analyze the operation of P-N junction diodes, including their I-V characteristics and applications in rectification and voltage regulation. 4. Design and analyze circuits involving transistors (CB, CC, CE configurations) and understand their input/output characteristics. 5. Understand the operation and applications of field-effect transistors (JFET and MOSFET) and other semiconductor devices like SCR and UJT. 6. Apply knowledge of operational amplifiers in various configurations and analyze their performance parameters. 7. Explore the characteristics and efficiency of solar cells, LEDs, LCDs, and flexible display devices.

Course Title	**PHYMJ33: Physics Laboratory-3**			
Category of Course	**Major** / Minor / Minor (Vocational) / SEC / AEC / VAC / MD/Internship/Dissertation (Tick any one of the above)			
Credits & Hour of Teaching		**Theory**	**Practical**	**Cumulative**
	Credits	0	02	02
	Hour of Teaching (Total)	0	60	60
	Experiments			
	Group-I			
	1. Newton's Ring (Determination of wavelength of monochromatic source) 2. Diffraction grating (Determination of wavelength of monochromatic source using spectrometer) 3. Determination of specific rotation of cane sugar (polarimeter) 4. Anderson's bridge (determination of self inductance) 5. Phase shift measurement (C-R; L-R; L-C-R) 6. Planck's Constant (using different filters) 7. Polarization using Wave-plate			
	Group-II			
	1. Fresnel's biprism (Determination of wavelength of monochromatic source) 2. Resolving power of grating 3. Diffraction by thin wire (measurement of thickness) 4. To determine Mutual inductance of a pair of coils 5. Input and output characteristics of P-N-P transistor 6. Fourier analysis (square, triangle and half wave) 7. Measurement of Energy band gap of a semiconductor (P-N Diode)			
	Extra			
	1. Malus' Law (polarization) 2. Lloyd's Mirror Experiment			

Course Title	**PHYMD31: Historical Developments of Physical Science**			
Category of Course	Major / Minor / Minor (Vocational) / SEC / AEC / VAC / **MD**/Internship/Dissertation (Tick any one of the above)			
Credits & Hour of Teaching		**Theory**	**Practical**	**Cumulative**
	Credits	03	0	03
	Hour of Teaching (Total)	45	0	45
Course Objectives	Students will be introduced to the development of physical sciences through the ages, from the very first civilisations, down to the contemporary areas of interest. The story of the great discoveries in physical science and mathematics, and the movements they engendered, will be explained to the students. The way in which initial ideas are supplanted by news ones due to new thinking or new experimental data, and the interplay between theoretical ideas and experimental work are to be covered.			
Course Content	The course content be divided into minimum 3 Units to maximum 5 units along with defined hour of teaching for each unit.			
Units	**Course Content**			**Hr. of Teaching**
I	**Beginnings of Physical Science in the Ancient World**: Neolithic period, early developments in ancient Egypt, Chaldaea, Iran, India and China, Greek science: Pythagoras, Thales, Empedocles, Plato, Aristotle, Ptolemy and Aristarchus of Samos, doctrine of four elements, atomism in Greece and India, motion paradox of Zeno, Lucretius and Pliny, Archimedes, Eratosthenes, invention of the zero, development of trigonometry in India, Julian calendar, John Philoponus.			08
II	**Physical Science in the Mediaeval World:** dark ages in Europe and India, the Venerable Bede, Roger Bacon, Albertus Magnus, Ockham's razor, Buridan's theory of impetus, Gregorian calendar, Islamic science: al-Biruni, al-Kindi, Nasiruddin Tusi, al-Khwarizmi, Omar Khayyam, ibn Haytham, ibn Sina, Fibonacci and 'Arabic' numerals.			07

III	**The Renaissance and Classical Physics:** Francis Bacon, Leonardo da Vinci, Copernicus, Galileo and Bruno, Stevinus, Descartes, Tycho Brahe and Kepler, Snell's Law, invention of the telescope and microscope, the Newtonian revolution, mechanics developments: Hooke, Leibnitz, Laplace, Lagrange, Euler and d'Alembert, the Enlightenment, electricity and magnetism: Gilbert, Coulomb, Arago, Ampére, Faraday and the Maxwellian synthesis, Edison and Tesla, Crookes tubes and cathode ray phenomena, fluorescence and the photo-electric effect; Huygens, Young and wave propagation, gas laws, thermal conduction and discovery of the laws of thermodynamics, Carnot cycle, atomic theory and the kinetic theory of gases.	15
IV	**Twentieth Century and Contemporary Physics:** relativity: special and general theories, radioactivity and atomic structure, discovery of the nucleus, old quantum theory: Planck, Einstein, Bohr and Compton, quantum mechanics: wave and matrix forms, Dirac synthesis; quantum statistics: Bose-Einstein and Fermi-Dirac distributions, invention of quantum field theory; discovery of superconductivity and superfluidity; invention of the transistor and the electronics revolution; development of nuclear energy: Manhattan project and nuclear reactors; cosmic rays, giant particle accelerators and discovery of elementary particles: the Standard Model; cosmology and the Big Bang model, discovery of the cosmic microwave background and its fluctuations, presence of dark matter.	15
Texts / References	1. *The Oxford Handbook of the History of Physics* (Edited by Jed Z. Buchwald and Robert Fox, Oxford University Press 2013,) 2. H. Floris Cohen, *How Modern Science Came into the World* (Amsterdam: Amsterdam University Press, 2010). 3. Steven Shapin, *The Scientific Revolution* (Chicago: University of Chicago Press, 1996). 4. H.F. Cohen, *The Scientific Revolution: A Historiographical Inquiry* (Chicago: University of Chicago Press, 1994). 5. Károly Simonyi, *A Cultural History of Physics* (Translated by David Kramer)(CRC Press, 2012) 6. Kuhn, T.S. 1972. *The Structure of Scientific Revolutions*. Chicago: Univ. of Chicago Press. 7. Needham, J. 1956. *Science and Civilization.* Cambridge: Cambridge Univ. Press.	
Learning Outcomes	Students should emerge with a clear idea of how science arises as an organic growth in civilization and that it is an international enterprise involving all humankind. They will understand the rich interplay between conceptualization and experimental data which has given us the science of today. Above all, they should emerge with an understanding of science as a creative and evolving field of human endeavour.	

Course Title	**PHYSE31: Computational Physics: Programming and Data Analysis**			
Category of Course	Major / Minor / Minor (Vocational) / **SEC** / AEC / VAC / MD/Internship/Dissertation (Tick any one of the above)			
Credits & Hour of Teaching		**Theory**	**Practical**	**Cumulative**
	Credits	02	0	02
	Hour of Teaching (Total)	30	0	30
Course Objectives	This course provides a balanced mix of python programming fundamentals, scientific computing, and practical data analysis skills, preparing students for more advanced courses or real-world applications.			
Course Content	The course content is divided into 3 units along with defined hour of teaching for each unit.			
Units	**Course Content**			**Hr. of Teaching**
I	**Introduction to Python Programming** Introduction to Python: Why Python?, Setting up the environment: Anaconda, Jupyter Notebook, Python syntax, variables, and data types, Basic operations and expressions; Conditional statements: if, elif, else; Loops: for, while; Functions: defining, calling, and scope; Lists, tuples, and sets; Dictionaries: key-value pairs; Strings: operations and methods; Working with files: reading from and writing to files, SciPy for scientific computing			15

II	**Data Handling & Manipulation** Overview of Python libraries for data analysis: NumPy, Pandas, Matplotlib, Seaborn, Installing and importing libraries, Introduction to NumPy arrays, Array operations: indexing, slicing, and reshaping, Mathematical operations and statistical functions, Working with multi-dimensional arrays, Introduction to Pandas: Series and Data Frames, Importing and exporting data (CSV, Excel, etc.), Data Frame operations: filtering, sorting, and grouping, Handling missing data and data cleaning	08
III	**Data Analysis & Visualization** Exploratory data analysis, Descriptive statistics and summary functions, Data visualization with Matplotlib and Seaborn: line plots, bar charts, histograms, etc., Customizing plots: titles, labels, legends, and colours, Working with time series data, Correlation and covariance, Merging, joining, and concatenating data, Pivot tables and cross-tabulation	07
Texts / References	*"Python for Data Analysis"* by Wes McKinney *"Automate the Boring Stuff with Python"* by Al Sweigart Documentations: Python, NumPy, Scipy, Matplotlib, Seaborn, Pandas	
Learning Outcomes	By course end, students will write Python code, manipulate data using NumPy and Pandas, and conduct exploratory data analysis with visualization tools like Matplotlib. They will also learn to perform scientific computing using SciPy.	

Course Title	**PHYSE32: Skill Course Laboratory-2**			
Category of Course	Major / Minor / Minor (Vocational) / **SEC** / AEC / VAC / MD/Internship/Dissertation (Tick any one of the above)			
Credits & Hour of Teaching		**Theory**	**Practical**	**Cumulative**
	Credits	00	01	01
	Hours of Teaching	00	30	30
Course Objectives	This course provides a balanced mix of python programming fundamentals, scientific computing, and practical data analysis skills, preparing students for more advanced courses or real-world applications.			

Units	**Experiments**	**Hours of Teaching**
I	**Python Exercises** 1. Basic Syntax & Data Types: Input name and date of birth. Calculate the age based on the date of birth and print it with the name. 2. Conditionals: Check if a number is even/odd and divisible by 4. 3. Loops: Print all prime numbers between 1 and 100. 4. Functions: Find the GCD of two numbers using a function. 5. Lists: Return unique elements from a list. 6. List Comprehensions: Filter even numbers from a list. 7. Dictionaries: Count word occurrences in a sentence. 8. File I/O: Read numbers from a file, write even numbers to a new file. 9. Error Handling: Handle invalid file input or data in the I/O program. 10. Analyse the given data using pandas. **Physics problems (any five)** 1. Write a Python program to simulate projectile motion (with or without air resistance). Students should calculate and plot the trajectory of the projectile. 2. Solve the equation of motion for a simple harmonic oscillator using the SciPy. 3. Write a Python program to fit experimental data (e.g., decay curves, oscillatory motion) to a theoretical model using least-squares fitting and plot it using the Matplotlib or Seaborn. 4. Simulate wave propagation in a string using the wave equation. Implement and visualize standing and traveling waves. 5. Model radioactive decay using random number generators to simulate the decay of particles over time. Plot the number of particles as a function of time and compare	30

	it to the theoretical exponential decay. 6. Simulate the forces between multiple charged particles based on Coulomb's law. Visualize the motion of charged particle in the resulting force. 7. Given an initial angular velocity, angular acceleration, and time, calculate and plot the angular displacement and angular velocity as functions of time. 8. Given data for stress and strain, write a Python script to plot the stress-strain curve and calculate the elastic region's slope (Young's Modulus). 9. Write a Python program to compute and plot the pressure and velocity at different points in the pipe. 10. Write a Python program to calculate and simulate the fringe positions in Young's double-slit experiment.	
References	Python exercises on based on the course "Computational Physics: Programming and Data Analysis" and most of the physics problems are based on the courses taught in previous and current semesters.	
Learning outcomes	By course end, students will write Python code, manipulate data using NumPy and Pandas, and conduct exploratory data analysis with visualization tools like Matplotlib. They will also learn to perform scientific computing using SciPy.	

Course Title	**PHYMV31: Applied Electronics and Fiber Optics**			
Category of Course	Major / Minor / **Minor (Vocational)** / SEC / AEC / VAC / MD/Internship/Dissertation (Tick any one of the above)			
Credits & Hours of Teaching		**Theory**	**Practical**	**Cumulative**
	Credits	3	0	03
	Hours of Teaching	45	0	45
Course Objective	This course aims to provide students with a foundational understanding of essential electronic components, measurement tools, and the principles of fiber optic communication. Students will gain practical skills in using electronic instruments, understanding semiconductor devices, and exploring optical fiber technologies for communication applications.			
Course Content	The course content is divided into 3 units along with defined hour of teaching for each unit.			
Unit	**Course Content**			**Hours of Teaching**
I	**Electronics measurement tools:** Conversion of Galvanometer to Voltameter/ Ammeter and their uses. Multimeters and their types, features and components. Practical applications of multimeters in electrical troubleshooting. Safety precautions when using a multimeter. LCR meter, Signal measurement by CRO and DSO. Calibration techniques of electronic instruments and error analysis.			15
II	**Basic electronic components:** Active and passive electronic components, transformer, basic of semiconductors, working principle of semiconductor diodes, applications of diodes in rectification, reverse current protection and switching, Zener diodes and voltage regulation. Bipolar Junction Transistor (BJT) and their applications, Operation of n-p-n and p-n-p transistors, Biasing of BJT. Introduction to LED, Photodiode, FET, JFET, MOSFET, CMOS and VMOS.			15
III	**Fiber optics communication:** Basic concepts of optical fibers and their structure. Types of optical fibers (single-mode and multi-mode). Signal propagation and losses in optical fibers. Laser and its application in communication. Study of optical fiber tools (OTDR, OSA, Power meter, Stripper, Splicer, fiber coupler and detectors)			15
References	1. A Course in Electrical and Electronic Measurements and Instrumentation, by A. K. Sawhney and Puneet 2. Electronics Fundamentals: Circuits, Devices, and Applications: Thomas L. Floyd and David M. Buchla 3. Optical Fiber Communications Principles and Practice by John M. Senior			

Learning outcomes	By the end of this course, students will be able to proficiently use electronic measurement tools, analyze and troubleshoot circuits, understand the operation of semiconductor devices, and apply knowledge of fiber optics in communication systems. They will also demonstrate the ability to work with optical fiber equipment and perform error analysis in electronic measurements.

Course Title	**PHYMV32: Minor Vocational Laboratory-1**			
Category of Course	Major / Minor / **Minor (Vocational)** / SEC / AEC / VAC / MD/Internship/Dissertation (Tick any one of the above)			
Credits & Hours of Teaching		**Theory**	**Practical**	**Cumulative**
	Credits	0	01	01
	Hours of Teaching	0	30	30
Course Objective	This course aims to provide students with a foundational understanding of essential electronic components, measurement tools, and the principles of fiber optic communication. Students will gain practical skills in using electronic instruments, understanding semiconductor devices, and exploring optical fiber technologies for communication applications.			
Course Content	The course content is divided into 3 units along with defined hour of teaching for each unit.			
Unit	**Experiments**			**Hours of Teaching**
	<u>Experiments in Applied Electronics and Fiber Optics</u> 1. Conversion of Galvanometer to Voltmeter and Ammeter 2. Construction and Response Analysis of a Parallel Resonance Circuit Using Soldering Techniques. 3. Design of a Regulated Power Supply using Zener Diode. 4. Estimation of Gain and Bandwidth in RC-Coupled Common Emitter (CE) Amplifier. 5. Study of Bending Loss and Splicing Loss in Single-Mode and Multi-Mode Optical Fiber. 6. Study of Electrical and Optical Characteristics of Light Emitting Diodes (LEDs) and PIN Photo detector.			30

SEMESTER-IV

Course Title	**PHYMJ41: Electromagnetic Theory & Special Theory of Relativity**			
Category of Course	**Major** / Minor / Minor (Vocational) / SEC / AEC / VAC / MD/Internship/Dissertation (Tick any one of the above)			
Credits & Hour of Teaching		**Theory**	**Practical**	**Cumulative**
	Credits	4	0	4
	Hour of Teaching (Total)	60	0	60
Course Objectives	The course is designed for students to prepare them for a major in Physics. The students will have the opportunity to learn the following: 1. Mathematical concepts of gradient, divergence and curl and their applications. 2. Basics of Electrodynamics including displacement current. 3. Maxwell's equations in differential form. 4. Energy and momentum conservation in electrodynamics. 5. Solving the Maxwell's equations for EM waves in free space, and conducting and dielectric media. 6. Michelson-Morley experiment and postulates of special theory of relativity. 7. Applications of special theory of relativity including relativistic energy-momentum relation.			
Course Content	The course content be divided into minimum 3 Units to maximum 5 units along with defined hour of teaching for each unit.			
Units	**Course Content**			**Hr. of Teaching**
I	**Vector Calculus:** Concept of gradient, divergence and curl operators; Gradient,			06

	Gauss divergence, Stokes theorem and related problems.	
II	**Electrodynamics**: Concept and charge and current densities, Electrostatics, Coulomb and Gauss Law(Divergence and curl of electrostatic field), Magnetostatics, Ampere's law(Divergence and curl of magnetostatic field); Electrodynamics: Concept of electromotive force and electric field, Faraday's law of electromagnetic induction, Generalized Ampere's law and the concept of Displacement current and its significance, Equation of continuity, Maxwell's equations in differential and integral form, Maxwell's equation in a dielectric medium and boundary conditions, Scalar and vector potentials, Gauge transformations, Coulomb and Lorentz Gauges, Poynting theorem and energy conservation (qualitative idea of momentum conservation).	22
III	**EM wave propagation**: EM wave equation and their solutions; Polarization of EM wave; Propagation of plane EM waves in different media: free space, dielectrics and conductors; Laws of reflection, transmission at normal and oblique incidence in linear media and conducting media (Fresnel's equations), total internal reflection and Brewster angle, Elementary idea on waveguides.	20
IV	**Relativity:** Michelson-Morley experiment, Postulates of special theory of relativity, Lorentz transformation and physical significance of Lorentz invariance, Length contraction, time dilation, Concept of simultaneity, Relativistic velocity transformation relations, mass energy relation, Concept of zero rest mass of photon, Relativistic relation between energy and momentum.	12
Texts / References	1. Introduction to Electrodynamics (3rd Edition): David J. Griffiths. 2. EM Waves and Fields: P. Lorrain and O. Corson. 3. Elements of Electromagnetics: Mathew N. O. Sadiku 4. Introduction to Special Relativity: Robert Resnick	
Learning Outcomes	The students will learn the following: 1. The tools of vector calculus and their use in electrostatics and magnetostatics problems. 2. How to solve boundary value problems in electrostatics and magnetostatics. 3. The concept of scalar and vector potentials and gauge transformations. 4. Concepts of charge, energy and momentum conservation in electrodynamics. 5. Maxwell's equations in differential form and their application to wave propagation in media. 6. The postulates of special theory of relativity and their consequences.	

Course Title	**PHYMJ42: Mathematical Physics-I**			
Category of Course	**Major** / Minor / Minor (Vocational) / SEC / AEC / VAC / MD/Internship/Dissertation (Tick any one of the above)			
Credits & Hour of Teaching		**Theory**	**Practical**	**Cumulative**
	Credits	3	0	3
	Hour of Teaching (Total)	45	0	45
Course Objectives	This is the first of the two courses on Mathematical Physics at the Undergraduate level. This course contains the very essential basic mathematical methods necessary for all the other courses in Physics and hence is an essential prerequisite for almost all the courses in physics. In order to able to make progress in understanding physics a minimum facility is required in the mathematical methods.			
Course Content	The course content be divided into minimum 3 Units to maximum 5 units along with defined hour of teaching for each unit.			

Units	**Course Content**	**Hr. of Teaching**
I	**Curvilinear Coordinates:** Orthogonal curvilinear coordinates, differential operators (without derivations), concept of a metric, spherical and cylindrical coordinates and their unit vectors.	09
II	**Tensors:** Introduction to tensors, cartesian, covariant, contravariant and mixed tensors, contractions and direct products. Examples: symmetric, anti-symmetric, isotropic, and pseudo tensors.	09
III	**Matrices:** Orthogonal, Hermitian, and unitary matrices, inverse of a matrix, (orthogonal) similarity transformations, eigen value problems and diagonalization of matrices (Examples of non-degenerate and degenerate cases).	09
IV	**Differential Equations:** Brief revision of first order and second order linear differential equations with constant coefficients, Second order homogeneous differential equations and their series solutions (examples: Harmonic oscillator and Bessel equations), singular points, linear independence of two solutions, Wronskian integral method for a second solution.	09
V	**Special Functions:** Legendre polynomials, spherical harmonics, Hermite and Laguerre polynomials, generating functions, recurrence relations, Rodrigues' formulae, orthonormality conditions, Gamma function, Dirac delta function.	09

Texts / References	• Mathematical Methods for Physicists: G.B. Arfken and H.J. Weber • Advanced Engineering Mathematics: Erwin Kreyszig • Applied Mathematics for Engineers and Physicists: L.A. Pipes and L.R. Harvill • Mathematical Physics: P. K. Chattopadhyay • Theory and Problems of Vector Analysis (Schaum's Outline Series): M.R. Spiegel • Theory and Problems of Advanced Calculus (Schaum's Outline Series): M.R. Spiegel
Learning Outcomes	This course will help acquire the mathematical skills necessary for solving problems in physics. In order to grasp the concepts of physics problem-solving is an absolute must. This course is a first step in that direction.

Course Title	**PHYMJ43: Computational Physics**			
Category of Course	**Major** / Minor / Minor (Vocational) / SEC / AEC / VAC / MD/Internship/Dissertation (Tick any one of the above)			
Credits & Hour of Teaching		**Theory**	**Practical**	**Cumulative**
	Credits	03	0	03
	Hour of Teaching (Total)	45	0	45
Course Objectives	The objective of this course is to enable the student to apply numerical methods and techniques, using computers, in order to solve physics-related problems. Students will use the programming language of their choice on Linux workstations. The emphasis of the course is on applying computational methods to address physical problems that defy analytical solutions.			
Course Content	The course content be divided into minimum 3 Units to maximum 5 units along with defined hour of teaching for each unit.			

Units	**Course Content**	**Hr. of Teaching**
I	**Introduction to Computers and Programming:** 1. Computer architecture overview 2. Programming Languages: Compiled (Fortran, C) vs. interpreted languages (python) 3. Representation on a computer: Integer representation, floating-point representation, Machine precision 4. Errors in Computation 5. Programming and visualization	10
II	**Numerical Methods:** 1. Data Analysis (Random Variables, Random number Generator, Moment calculations) 2. Polynomial data fitting 3. Root finding 4. Numerical Differentiation and Interpolation 5. Numerical Integration 6. Differential Equations 7. Partial differential Equations 8. Random Processes: Monte Carlo Integration, Random Walk, Metropolis algorithm 9. Linear Algebra: Eigen value Problems 10. Optimization Techniques	20
III	**Applications:** 1. Harmonic Oscillator 2. Random variables and Central limit theorem 3. Central force field problems 4. Ising Model 5. Wave Equations 6. Bayesian Inferences	15

Texts / References	1. Computational Physics by Mark Newman (Create Space Independent Publishing Platform) 2. Computational Physics by Jos Thijssen (Cambridge University Press) 3. Computational Physics: Problem Solving with Python by Rubin H. Landau, Manuel J. Paez, and Cristian Bordeian (Wiley) 4. Computational Methods for Physics, Joel Franklin, Cambridge University Press 5. Numerical Methods in Physics with Python, Alex Gezerlis, (Cambridge University Press)
Learning Outcomes	On completion of this course, students should be able to: 1- Use Linux 2- Using programming methods to 3- Address a given problem utilizing one or multiple computational methods. 4- Independently coding the algorithms, analyzing and presenting the obtained results in a scientific manner. Students will learn to effectively tackle complex problems using computational methods, ensuring robust and reliable solutions tailored to the specific problem at hand.

Course Title	**PHYMJ44: Physics Laboratory-4**			
Category of Course	**Major** / Minor / Minor (Vocational) / SEC / AEC / VAC / MD/Internship/Dissertation (Tick any one of the above)			
Credits & Hour of Teaching		**Theory**	**Practical**	**Cumulative**
	Credits	0	02	02
	Hour of Teaching (Total)	0	60	60
	Group-I			
	1. Newton's Ring (Determination of wavelength of monochromatic source) 2. Diffraction grating (Determination of wavelength of monochromatic source using spectrometer) 3. Determination of specific rotation of cane sugar (polarimeter) 4. Anderson's bridge (determination of self inductance) 5. Phase shift measurement (C-R; L-R; L-C-R) 6. Planck's Constant (using different filters) 7. Polarization using Wave-plate			
	Group-II			
	1. Fresnel's biprism (Determination of wavelength of monochromatic source) 2. Resolving power of grating 3. Diffraction by thin wire (measurement of thickness) 4. To determine Mutual inductance of a pair of coils 5. Input and output characteristics of P-N-P transistor 6. Fourier analysis (square, triangle and half wave) 7. Measurement of Energy band gap of a semiconductor (P-N Diode)			
	Extra			
	1. Malus' Law (polarization) 2. Lloyd's Mirror Experiment			

Course Title	**PHYMJ45: Computer Laboratory**			
Category of Course	**Major** / Minor / Minor (Vocational) / SEC / AEC / VAC / MD/Internship/Dissertation (Tick any one of the above)			
Credits & Hour of Teaching		**Theory**	**Practical**	**Cumulative**
	Credits	0	02	02
	Hour of Teaching (Total)	0	60	60
	Experiments			
	1. Polynomial data fitting 2. Root finding 3. Differential Equations 4. Numerical Integration 5. Linear Algebra: Eigen value Problems 6. Optimization Techniques			

SEMESTER-V

Course Title	**PHYMJ51: Quantum Mechanics-I**			
Category of Course	**Major** / Minor / Minor (Vocational) / SEC / AEC / VAC / MD/Internship/Dissertation (Tick any one of the above)			
Credits & Hour of Teaching		**Theory**	**Practical**	**Cumulative**
	Credits	04	0	04
	Hour of Teaching (Total)	60	0	60
Course Objectives	The course is designed at the introductory level for the students who have basic understanding of key concepts of modern physics. The students will learn the following: 1. Inadequacy of classical mechanics in sub-atomic world and new ideas behind the origin of quantum mechanics. 2. Properties of wave-function and basics of wave mechanics. 3. How to solve the Schrodinger equation for barrier, potential well and harmonic oscillator problems 4. How to describe the states and observables in quantum mechanics. 5. Applications of Schrodinger equation to angular momentum and Hydrogen atom problems.			
Course Content	The course content be divided into minimum 3 Units to maximum 5 units along with defined hour of teaching for each unit.			

Units	**Course Content**	**Hr. of Teaching**
I	**Birth of Quantum Mechanics:** Brief discussions on photoelectric effect, Compton effect and hydrogen spectra. de Broglie hypothesis, wave-particle duality, double slit experiment, uncertainty principle, Schrödinger equation, Wave function, Normalization, Probability current density and conservation of probability, Statistical interpretation.	12
II	**Wave mechanics:** Time independent Schrödinger equation, stationary states, general solution of time dependent Schrödinger equation, problems of infinite square well, free particle, wave packet, group velocity and phase velocity, finite square well and finite barrier, tunneling, delta function well, harmonic oscillator.	18
III	**Formalism:** Postulates of quantum mechanics, observables, Hermitian operators, eigenvalues and eigen function, uncertainty principle (including time and energy), commuting observables and compatibility, Momentum and energy operators, Expectation values, Ehrenfest theorem, Harmonic oscillator by operator method; Schrodinger and Heisenberg pictures; Spin and Statistics, Exchange symmetry; Time dependent Perturbation theory, Transition probability and Fermi's Golden rule.	18
IV	**Schrödinger equation in 3-dimension:** Hydrogen atom, Angular momentum operators and their eigen functions, electron spin, Stern-Gerlach experiment.	12

Texts / References	1. Quantum Mechanics: D. J. Griffiths 2. Quantum Physics: S. Gasiorowicz 3. Quantum Mechanics: B. H. Bransden and C. J. Joachain 4. Quantum Physics of Atoms, Molecules, Nuclei and Solids: R. M. Eisberg and R. Resnick 5. Quantum Mechanics: Ghatak and Loknathan
Learning Outcomes	The students will have the opportunity to grasp the conceptual basis and formalism of Quantum Mechanics. The course will prepare them to acquire the necessary skills for solving problems in atomic and molecular physics, nuclear physics and solid-state physics

Course Title	**PHYMJ52: Classical Mechanics-I**			
Category of Course	**Major** / Minor / Minor (Vocational) / SEC / AEC / VAC / MD/Internship/Dissertation (Tick any one of the above)			
Credits & Hour of Teaching		**Theory**	**Practical**	**Cumulative**
	Credits	03	0	03
	Hour of Teaching (Total)	45	0	45
Course Objectives	The objectives of this course are (i) to emphasis the understanding of classical systems using Lagrangian and Hamiltonian approach, (ii) to find the solution of a classical system through the equations of motions obtain from Lagrangian and Hamiltonian and to learn usefulness and applications of Poisson Bracket and Canonical transformation.			
Course Content	The course content be divided into minimum 3 Units to maximum 5 units along with defined hour of teaching for each unit.			

Units	**Course Content**	**Hr. of Teaching**
I	**Lagrangian formulation:** System of particles, Constraints, Degrees of freedom, Generalized coordinates, Virtual displacement, D'Alemberts principle and Lagrange's equation, Velocity dependent potential of electro-magnetic field. Variational principle, Hamilton's principle, Euler-Lagrange's equation, Lagrangian for simple systems, Lagrangian for a relativistic particle, Cyclic coordinates, symmetries and conservation laws. Advantages of Lagrangian: electro-mechanical analogies, Raleigh Dissipation function, Lagrange's undetermined multipliers, Lagrange's equation for non-holonomic systems, Virial theorem, Principle of mechanical similarity.	21
II	**Hamiltonian formulation:** Legendre transformations and Hamilton's equations of motion, Hamiltonian for simple systems, for a charge particle in Electro-magnetic field, Poisson Brackets, Jacobi Identity. Point transformation.	11
III	**Small oscillation** Theory of small oscillations, Eigenvalue equations, normal modes of oscillation and examples, Vibrational modes of linear triatomic molecules	05
IV	**Central force problem:** Two body central force problem, reduction to the equivalent one body problem, Differential equation for the orbit and integrable power law potentials, Classification of orbits, Condition for stable circular orbit, Kepler problems, scattering problem in central force field.	08

Texts / References	1. Classical Mechanics: H. Goldstein. 2. Mechanics: L . D. Landau and E. M. Lifshitz 3. Classical Dynamics, D T Greenwood. 4. Introduction to Classical Mechanics: R. G. Takwale and Puranik. 5. Classical Mechanics of Particles and Rigid Bodies: K. C. Gupta. 6. Introduction to Classical Mechanics: N. C. Rana and P. Joag
Learning Outcomes	Learning outcomes are : The students will be able (i) to construct Lagrangian and Hamiltonian of classical systems, (ii) to obtain the equations of motion from Lagrangian and Hamiltonian, (iii) to find the solution of classical system by solving equations of motion, (iv) to learn about canonical transformation and Poisson brackets and use those in understanding classical system and (v) to find the normal modes of oscillations in coupled systems.

Course Title	PHYMJ53: Statistical Mechanics-I			
Category of Course	**Major** / Minor / Minor (Vocational) / SEC / AEC / VAC / MD/Internship/Dissertation (Tick any one of the above)			
Credits & Hour of Teaching		**Theory**	**Practical**	**Cumulative**
	Credits	03	0	03
	Hour of Teaching (Total)	45	0	45
Course Objectives	The objectives of the Statistical Mechanics I course are to equip the students with relevant elementary concepts like probability theory, the formulation of ensemble theory with simple examples, and quantum statistical mechanics and its applications.			
Course Content	The course content be divided into minimum 3 Units to maximum 5 units along with defined hour of teaching for each unit.			

Units	Course Content	Hr. of Teaching
I	**Elementary Probability Theory:** Random walk problem, Probability distributions, moments of distributions (mean and dispersion) Central limit theorem, examples and related problems.	08
II	**Basic concepts of statistical physics and applications:** Phase space, Density of states, Liouville's theorem, Ergodicity, Postulates of statistical mechanics, microstates and macrostates, microcanonical ensembles, relation between statistical and thermodynamic parameters, classical ideal gas, Gibbs paradox. Canonical ensemble, Partition function, thermodynamic functions, fluctuations, Examples: classical ideal gas, Harmonic oscillator, Langevin paramagnetism, statistical equivalence. Grand canonical ensemble (elementary discussion), fluctuation and statistical equivalence.	27
III	**Quantum Statistics:** Introductory idea on quantum statistical mechanics, exchange symmetry, counting, distributions and their classical limit. Examples: Black-body radiation (Planck's formula), conduction electrons in metals and its specific heat.	10

Texts / References	1. Fundamentals of Statistical and Thermal Physics: Frederick Reif (McGrawHill). 2. Statistical Mechanics: R.K.Pathria (Elsevier). 3. Statistical Mechanics: Kerson Huang (Wiley). 4. Statistical Physics of Particles: M.Kardar (Cambridge University press).
Learning Outcomes	After completing this course, the students are expected to acquire basic analytical skills in the field of equilibrium statistical physics, which would be essentially required in advanced courses in the field.

Course Title	**PHYMJ54: Physics Laboratory-5**			
Category of Course	**Major** / Minor / Minor (Vocational) / SEC / AEC / VAC / MD/Internship/Dissertation (Tick any one of the above)			
Credits & Hour of Teaching		**Theory**	**Practical**	**Cumulative**
	Credits	0	04	04
	Hour of Teaching (Total)	0	120	120
	Experiments			
	Group-I			
	1. Magnetic susceptibility measurement. 2. Measurement of Cauchy's constants. 3. Measurement of Hall coefficient and carrier density. 4. Geiger-Műller counter characteristics. 5. Design of Zener regulated power supply. 6. SCR characteristics and its use as a phase control rectifier. 7. Experiment on negative feedback. 8. Characteristics of FET and its application as amplifier. 9. Experiments on operational amplifier.			
	Group-II			
	1. Characteristics of MOSFET and its application as an amplifier. 2. Characteristics of UJT and its application as a relaxation oscillator. 3. Positive feedback- Hartley and phase shift oscillator. 4. Wave shaping circuits. 5. Amplitude modulation and demodulation characteristics. 6. Wavelength (and difference) using Michelson Interferometer. 7. To determine the Rydberg constant using CDS. 8. Speed of sound in a liquid using Ultrasonics. 9. e/m measurement using Magnetron/Thompson method.			
	Optional			
	1. Absorption and Emission spectra. 2. Hysteresis loop. 3. Speed of Light. 4. Experiments on multi-vibrators.			

PHYIN51: (Internship): [Students can do internship after first to fourth semester during summer vacation]

Course Title	**PHYMV51: Hands-on Training on Tooling, Welding, Electronics, Instrumentation, and Machine shop**.			
Category of Course	Major / Minor / **Minor (Vocational)** / SEC / AEC / VAC / MD/Internship/Dissertation (Tick any one of the above)			
Credits & Hour of Teaching		**Theory**	**Practical**	**Cumulative**
	Credits	3	0	3
	Hour of Teaching (Total)	45	0	45
Course Objectives	This course will introduce the students to machining and instrumentation fundamentals. The student will develop a basic understanding of the operation, set-up, and applications of machine tools and precision measuring tools. They will learn the concepts of measurement science and sensors. Emphasis will be placed on Machine shop safety, housekeeping, and preventive maintenance of instruments.			
Course Content	The course content be divided into minimum 3 Units to maximum 5 units along with a defined hour of teaching for each unit.			

Units	**Course Content**	**Hr. of Teaching**
I	**Types of tool** Basic Hand tools (hammers, hacksaw, file, torsion tools, etc.), Semi-precision measurement tools, Precision measurement tools (Vernier calipers, micrometer, etc.), Power tools (drills, saw, grinders, sander, etc.), Hydraulic and Pneumatic tools, Health and safety practices, Hands-on training and DIY projects.	5
II	**Basic Electronics** Study of different electronic components: Resistance, capacitance, inductor, diode, LED display devices, transistor, electromagnetic relay, Integrated Circuits; Elementary printed circuit board design, fabrication, and testing; Soldering / De-soldering practice; Study of electronic test and measuring equipment: Multimeter, Oscilloscope, Function generator, Power Supply; Troubleshooting practice and DIY projects.	13
III	**Forging and Welding** Introduction to forging tools, furnaces, and forging machines; Introduction to and practice of different welding processes; Introduction to gas cutting and its application; Making welded joints using different welding processes; Hands-on training and DIY projects.	6
IV	**Instrumentation** Overview of instrumentation and its role in various industries; Introduction to sensors (temperature, pressure, strain, displacement, and more) and transducers; Signal conditioning and its importance. Amplification, filtering, and linearization techniques. Noise reduction and grounding techniques; Basics of data acquisition systems. Analog-to-digital conversion (ADC) techniques. Digital-to-analog conversion (DAC) techniques; Introduction to vacuum instrumentation; Demonstration and DIY projects.	16
V	**Machine shop** Introduction to machine tools - lathes, drilling machines, shaping machines, planning machines, slotting machines, milling machines, grinding machines; Demonstration on the lathe.	5
Texts / References	1. Workshop Technology Vol. I & II, by Raghuwanshi B.S., Dhanpath Rai & Sons. 2. Mechanical Workshop Practiceby John K.C., PHI 2010. 3. Machine Tool Practices (What's New in Trades & Technology) by Kibbe R, Meyer R, Stenerson J, and Curran K, Pearson 2019 4. Additional reading material/handout's will be provided in class.	

Learning Outcomes	**Theory Learning outcomes** • Develop a basic understanding of the operation, set-up, and applications of machine tools and precision measuring tools. • Define basic electronics like active and passive components including resistors, capacitors, inductors, and color coding of capacitors and resistors. • Compare different kinds of diodes – switch and rectifier, transistors – amplifier and switch, and logic gates. • Outline the functions of electronic circuits. • They will learn the concepts of measurement science and sensors. • Develop an understanding of essential parts of lathe, shaping, and milling machines and various accessories and attachments used. **Practical Learning Outcome** • Identify a variety of hand tools and power tools and describe their purpose, application, and how they can be operated in a safe and proper manner. • Handle different kinds of electronic parts or components and connectors and their specifications. • Illustrate working on hand soldering equipment with various level soldering techniques • Demonstrate soldering/de-soldering of resistors, capacitors, and ICs in PCBs. • Demonstrate welding tee joints.

Course Title	**PHYMV52: Minor Vocational Laboratory**			
Category of Course	Major / Minor / **Minor (Vocational)** / SEC / AEC / VAC / MD/Internship/Dissertation (Tick any one of the above)			
Credits & Hour of Teaching		**Theory**	**Practical**	**Cumulative**
	Credits	0	01	01
	Hour of Teaching (Total)	0	30	30
	Experiments			
	Any five experiments 1. Measurements with Multimeter, Clampmeter, and Wattmeter. 2. Make Car battery jumper cables. 3. Solder wires together, alligator clips, and connectors. 4. Soldering/de-soldering of resistors, capacitors, and ICs in PCBs. 5. Assembling BNC cables. 6. Spot weld wire to wire. 7. Welding of tee joints. 8. Temperature sensor using thermocouples. Experiments will be added or deleted periodically			

SEMESTER-VI

Course Title	**PHYMJ61: Electronic Circuits and Analysis**			
Category of Course	**Major** / Minor / Minor (Vocational) / SEC / AEC / VAC / MD/Internship/Dissertation (Tick any one of the above)			
Credits & Hour of Teaching		**Theory**	**Practical**	**Cumulative**
	Credits	03	0	03
	Hour of Teaching (Total)	45	0	45
Course Objectives	This course provides a thorough understanding of analog and digital circuits including their analysis techniques. Students will learn key principles, such as Thevenin and Norton theorems, nodal and mesh analysis, and two-port network parameters. They will analyze transistor amplifiers, AC and transient circuits, and design oscillators and feedback amplifiers. In digital circuits, students will explore Boolean algebra, logic gates, and combinational and sequential circuits, including adders, multiplexers, and counters. By the end of the course, students will be adept at designing and analyzing a variety of analog and digital circuits, preparing them for advanced studies.			
Course Content	The course content be divided into minimum 3 Units to maximum 5 units along with defined hour of teaching for each unit.			
Units	**Course Content**			**Hr. of Teaching**
I	Superposition, Thevenin, Norton and Maximum Power Transfer Theorems, Network elements, Network graphs, Nodal and Mesh analysis. Two-port network parameters: Z, Y, and h parameters.			08
II	Hybrid parameter model of transistor, analysis of transistor amplifier (with and without RS and RL) using h- parameters, AC circuit analysis, Transient analysis, Zero and Poles, Bode Plots, Simplified hybrid model. Single stage amplifier in CE, CB and CC modes. RC coupled CE amplifier and its frequency response.			09
III	Tuned voltage amplifiers. Power amplifier and its classification, distortion, and efficiency, push-pull amplifier, Feedback in amplifiers, positive and negative feedback, the effect of negative feedback on the characteristics of different types of amplifiers, voltage, and current series feedback circuits. Barkhausen criterion of oscillations, tuned collector oscillator, Hartley / Colpitt oscillator, phase shift oscillator. Need and types of modulation, amplitude modulation, analysis of A.M. wave, Transistor based A.M. modulator Circuit, demodulator circuit.			12
IV	Boolean algebra, fundamental logic gates, NAND and NOR gates as universal gates, X-OR & X-NOR gates. Simplification of Boolean expressions using SOP and K-maps.			08
V	Half and full adders and subtractors, multiplexers, demultiplexers, encoder-decoder, counters, and shift registers.			08
Texts / References	1. Electronics Fundamental and Application: Chattopadhyay and Rakshit. 2. Principle of Digital Electronics: Malvino and Leach. 3. A Text Book of Electronics: Kakani and Bhandari. 4. Electronic Devices: T.L. Floyd. 5. Integrated Electronics: Millman and Halkias. 5.Digital Systems Principles and Applications: Ronald J. Tocci			
Learning Outcomes	Upon completing this course, students will be able to: 1. Apply superposition, Thevenin, and Norton theorems to analyze electrical circuits. 2. Perform nodal and mesh analysis, and understand two-port network parameters. 3. Analyze transistor amplifiers and AC circuits using hybrid parameters. 4. Design and evaluate single-stage, tuned, and power amplifiers, understanding feedback effects. 5. Implement oscillators and modulation techniques in circuit designs. 6. Use Boolean algebra to simplify logic expressions and design combinational and sequential circuits, including adders, multiplexers, and counters.			

Course Title	**PHYMJ62: Solid State Physics**			
Category of Course	**Major** / Minor / Minor (Vocational) / SEC / AEC / VAC / MD/Internship/Dissertation (Tick any one of the above)			
Credits & Hour of Teaching		**Theory**	**Practical**	**Cumulative**
	Credits	03	0	03
	Hour of Teaching (Total)	45	0	45
Course Objectives	• Concept of space lattice, Bravais lattices and their properties. • Diffraction of x-rays by crystals; reciprocal lattice • Structure factors, extinction conditions, and its significance. • Concept of density of states; theory of specific heat of solids • Vibrations of chain lattices and dispersion relation of phonon • Concept and theory of free electron gas, Fermi energy, Fermi surface • Density of states and degeneracy; dimensionality effect. • Motion of electrons in electric and magnetic field; Hall effect; ideas of quantum Hall effect, and superconductivity • Electrons in periodic potential; idea of energy bands • Origin of magnetism, Quantum theory of dia- and paramagnetism • Heisenberg model; ordering of spins: ferromagnetism, anti-ferromagnetism Spin waves, dispersion relation of magnons; magnetic interactions.			
Course Content	The course content be divided into minimum 3 Units to maximum 5 units along with defined hour of teaching for each unit.			

Units	**Course Content**	**Hr. of Teaching**
I	**Structure and Symmetry:** Space lattice, Bravais lattices, Miller indices for direction and planes, Common crystal structures: NaCl, CsCl, ZnS and Diamond, Close packed structures. External symmetry elements and concept of point groups of crystals, Internal symmetry elements. Elementary idea of quasicrystals and amorphous materials. Diffraction of x-rays, Laue equations and Braggs law, reciprocal lattice, Brillouin Zones and Ewald construction, atomic scattering and structure factors. Intensity of Bragg scattering from a unit cell and extinction conditions. Elementary idea of bonding in solids, Lennard Jones potential.	14
II	**Lattice Vibrations:** Vibrational modes of continuous medium, Density of states, Einstein's and Debye's theory of specific heat, Vibrations of one dimensional monoatomic and diatomic chain lattice, Phonons, elastic constants.	09
III	**Electronic Properties:** Theory of free electron gas, Drude model and its drawbacks; Sommerfeld model and theory of electrical conductivity, Concept of Fermi energy, Fermi surface, Fermi temperature etc. Density of states and degeneracy, and its dimensionality effect. Heat capacity of electron gas, motion of electrons in electric and magnetic field and Hall effect, elementary ideas of quantum Hall effect, Cyclotron resonance and magneto resistance, De Haas von Alfen effect. CMR and GMR, and basic idea of superconductivity. Electrons in periodic potential, Bloch theorem, Kronig-Penny model, idea of energy bands: metals, insulators and semiconductors.	14
IV	**Magnetic Properties:** Origin of magnetism, Langevin's theory, Quantum theory of paramagnetism, Curie-Brillouin law, Weiss Molecular theory, Heisenberg model, ordering of spins, ferromagnetism, Anti-ferromagnetism, spin waves, dispersion relation of magnons, ferromagnetic domains. Magnetic interactions.	08

Texts / References	1. Crystalloraphy for Solid State Physics: A. R. Verma and O.N. Srivastava. 2. Solid State Physics: Gelard Burns (Academic Press) 3. Solids State Physics: C. Kittel. 4. Solids State Physics: Ashcroft and Mermin. 5. Solids State Physics: A J Decker.

	6. Solid State Physics ---An Introduction to principles of Materials Science: H. Ibach & H. Luth (Springer) 7. Magnetism in solids: Stephan Brandell (Oxford University Press) 8. Quasicrystal: A prima: C. Janot (Academic Press).
Learning Outcomes	In this paper student will learn the space lattice, Bravais lattices and their properties; X-ray diffraction and reciprocal lattice Importance of Structure factors; theory of specific heat of solids concept of phonon; theory of free electron gas, Fermi energy, Fermi surface; dimensionality effect of density of states. Hall effect; ideas of quantum Hall effect, and superconductivity; idea of energy bands; Quantum theory of magnetism; ordering of spins; Spin waves, dispersion relation of magnons; magnetic interactions.

Course Title	**PHYMJ63: Atomic, Molecular and Laser Physics**			
Category of Course	**Major** / Minor / Minor (Vocational) / SEC / AEC / VAC / MD/Internship/Dissertation (Tick any one of the above)			
Credits & Hour of Teaching		**Theory**	**Practical**	**Cumulative**
	Credits	03	0	03
	Hour of Teaching (Total)	45	0	45
Course Objectives	The objective of the proposed course is to make the students aware about the developments in the field of atomic, molecular Physics and Lasers. The course will also develop an understanding about the interpretations of atomic and molecular spectra and associated theoretical framework. In addition to this, the course will focus on the understanding of LASER and its applications in various fields.			
Course Content	The course content be divided into minimum 3 Units to maximum 5 units along with defined hour of teaching for each unit.			

Units	**Course Content**	**Hr. of Teaching**
I	**Atomic Physics:** Brief review of Bohr and Sommerfeld model of atom. Effect of finite nuclear mass in relation to Rydberg constant. Idea of discrete energy levels and electron spin: Franck – Hertz and Stern – Gerlach experiments Significance of four quantum numbers and concept of atomic orbitals.	10
II	**One valence electron atom:** Orbital magnetic dipole moment, Orbital, spin and total angular momenta, Larmor precession, Vector model of atom, Electronic configuration and atomic states, Spin-orbit interaction and fine structure, Intensity of spectral lines, General selection rules, Lamb shift and Retherford experiment, Hyperfine structure of lines **Two valence electron atoms** LS and JJ coupling schemes and resulting spectra. Spectroscopic terms of equivalent and non-equivalent electrons, Idea of normal and inverted doublet.	15
III	**Atom - field Interactions** Dipole transitions, Zeeman Effect and Paschen-Bach effect and Stark Effects	06
IV	**Molecular Spectra:** Elementary idea of molecular spectra, Electronic, rotational, vibrational and Raman spectra of diatomic molecules	08
V	**Lasers:** Einstein coefficients, Threshold condition for LASER action, Rate equation for three level laser system, Characteristics of laser radiation. Ruby Laser, He-Ne and Nd-YAG Laser.	06

Texts / References	1. Introduction to Atomic Spectra: H E White, McGraw Book Company, Inc. 2. Fundamentals of molecular spectroscopy: Banwell, C.N. and McCash, E.M., Tata McGraw Hill, (2007). 3. Quantum Physics of Atoms, Molecules, Solids, Nuclei and Particles: by Robert Martin Eisberg and Robert Resnick

	4. Physics of atoms and molecules B. Bransden 5. Molecular Structure and Spectroscopy: G. Aruldhas 6. Lasers: Fundamentals and Applications by A. Ghatak and K. Thyagarajan
Learning Outcomes	The students in this course will learn about the developments in the field of atomic, molecular physics and lasers. They will learn about various theoretical and experimental works which has led to the understanding of modern spectroscopy. This course will also allow them to learn about origins of the spectral lines of atoms and molecules in the absence and presence of external fields. The laser portion of the syllabus aims to develop the understanding of Physics behind the Laser action.

Course Title	**PHYMJ64: Nuclear & Particle physics**			
Category of Course	**Major** / Minor / Minor (Vocational) / SEC / AEC / VAC / MD/Internship/Dissertation (Tick any one of the above)			
Credits & Hour of Teaching		**Theory**	**Practical**	**Cumulative**
	Credits	3	0	3
	Hour of Teaching (Total)	45	0	45
Course Objectives	The aim of the course is to provide basics as well as advanced knowledge of the subject. Under this course student will be provided depth knowledge of the following topics: 1. Knowledge of important fundamental properties of nuclei, such as mass, binding energy, separation energy, size, spin, parity, deformation, quadrupole moment, magnetic dipole moment will be covered. 2. Properties of nuclear force, such as, strength, range, saturation, spin dependence, charge independence are covered. 3. Nuclear models: Liquid Drop Model, and Bethe-Weizsaecker formula, Fermi gas model, Shell model. 4. Knowledge of nuclear decay processes (Alpha, Beta and Gamma-ray),Decay laws and radioactivity, Half-life and Mean life, 5. Fundamental Interactions of elementary particles, Classification of elementary particle, Quarks model, Quantum numbers (charge, spin, parity, isospin, strangeness, color). 6. Knowledge of idea of accelerator and its applications in Science, Working principle of Van de Graaff and Linear accelerators, Cyclotron. 7. Knowledge of working of detectors: GM Counter, Ionization Chamber			
Course Content	The course content be divided into minimum 3 Units to maximum 5 units along with defined hour of teaching for each unit.			
Units	**Course Content**			**Hr. of Teaching**
I	**Introduction of Nucleus:** ***Properties of Nuclei:*** Mass, Charge, Size, Constituent of nuclei, Binding energy, Separation energy, Chart of Nuclei; Spin and Parity, Magnetic Dipole Moment. ***Properties of Nuclear Force:*** Saturation, Strong, Short range, Spin dependence, charge independence. ***Models:*** Liquid Drop Model, Bethe-Weizsaecker Mass formula, Stability of nuclei, Basic idea of Shell model.			12
II	**Nuclear Decay Processes:** ***Basics of nuclear decay:*** Types of nuclear decay, Decay laws and radioactivity, Half-life and Mean life time. ***Alpha decay:*** Energy spectrum, Q-value, Gamow's theory of alpha decay. ***Beta decay:*** Types of beta decay and Q-value, Energy spectrum, Neutrino hypothesis, Beta decay selection rule, Fermi and Gamow-Teller transitions. ***Gamma decay:*** Basic idea of gamma decay and selection rules for gamma transitions, internal conversion.			12
III	**Elementary Particles**: Fundamental Interactions, Classification of elementary particle, discrete symmetries; quark model, quantum numbers (charge, spin); Isospin and hypercharge, multiplets, Eight-fold way for mesons and baryons; Color hypothesis; Qualitative ideas of symmetry breaking and unification.			15

IV	**Accelerators and Detectors:** ***Accelerators:*** Basics idea of working of Van de Graaff and Linear accelerators; Cyclotron and Synchrotron. ***Detectors:*** GM Counter, Ionization Chamber.	06
Texts / References	1. Concepts of Nuclear Physics: B L Cohen 2. Introductory Nuclear Physics: S.S.M. Wong 3. Nuclear Physics: V. Devanathan 4. Nuclear Physics: S. N. Ghoshal 5. Nuclear Physics: H. S. Hans 6. Introduction to Nuclear Physics: H.A.Enge	
Learning Outcomes	After passing this course student will be able to attempt problems related to following topics in nuclear physics: 1. Estimation of Mass, Charge, Size and binding energy of the nuclei. 2. Determination of spin and parity of the nuclear levels. 3. Calculation of Q-value, calculation of half-life, radioactivity, determining of spin 4. Estimation of beta gamma and alpha decay, and its half-life. 5. Applications and working knowledge of accelerators 6. Working knowledge of nuclear detectors and radiation measurement.	

Course Title	**PHYMJ65: Soft Matter Physics**			
Category of Course	**Major** / Minor / Minor (Vocational) / SEC / AEC / VAC / MD/Internship/Dissertation (Tick any one of the above)			
Credits & Hour of Teaching		**Theory**	**Practical**	**Cumulative**
	Credits	3	0	03
	Hour of Teaching (Total)	45	0	45
Course Objectives	The objective of the course is to offer a comprehensive overview of the phenomena and concepts that define soft matter. Students will explore the principles of physics to grasp how simple components contribute to the complex behaviors observed in soft materials and living systems. The emphasis of the course will be on introducing tools for understanding and characterizing the properties of soft matter systems mainly: polymers, colloids, and liquid crystals.			
Course Content	The course content be divided into minimum 3 Units to maximum 5 units along with defined hour of teaching for each unit.			
Units	**Course Content**			**Hr. of Teaching**
I	**Introduction to interactions, structure and phase transition in soft matter:** Intermolecular forces, Concepts of broken symmetry, rigidity, and long-wavelength fluctuations. Order parameter, structure factor, density correlation functions, Basics of phase transition (1st and 2nd order), gas-liquid transition.			10
II	**Soft Matter Systems:** ***Liquid crystals:*** Introduction, liquid crystal phases and transitions, Distorted nematic ordering, response to electric and magnetic fields, Topological defects. ***Polymers:*** Model systems and chain statistics, polymers in solvents and melts, coil-globule transition, visco-elasticity, gelation. ***Colloids:*** Stability of colloidal systems, Poisson-Boltzmann theory, DLVO theory, Depletion interactions, Electro-kinetic effects.			7+7+7=21
III	**Diffusion processes:** Fick's laws, Diffusion Equation, Random walks, Brownian motion, Langevin and Fokker-Plank equations			8
IV	**Elasticity in soft matter:** Classical theory, stress tensor, generalized elasticity, elastic-free energies for nematics, smectics, membranes, rubber elasticity in polymers			6

Texts / References	1. Soft Matter Physics by Masao Doi, Oxford University Press, 2013, ISBN: 978-0-19-965295-2. 2. Soft Condensed Matter by Richard A.L. Jones, Science Press, 2008, ISBN: 978-7-03-022126-1. 3. Principles of Condensed Matter Physics by P. M. Chaikin and T. C. Lubensky, Cambridge University Press, 1995, ISBN: 9780511813467. 4. Theory of Simple Liquids: with Applications to Soft Matter by Hansen and McDonald, Academic Press, 2013, ISBN: 978-0123870322
Learning Outcomes	On completion of this course, students should be able to: 1- Understand soft matter with focus on a few specific classes of materials 2- Explain the physics that govern the structures and properties of soft matter 3- Working knowledge of simple models used to explain the properties of soft matter. Student will be able to identify common instances of soft matter systems in everyday life and explain the physics behind them.

Course Title	**PHYMJ66: Space Physics**			
Category of Course	**Major** / Minor / Minor (Vocational) / SEC / AEC / VAC / MD/Internship/Dissertation (Tick any one of the above)			
Credits & Hour of Teaching		**Theory**	**Practical**	**Cumulative**
	Credits	03	0	03
	Hour of Teaching (Total)	45	0	45
Course Objectives	• To know the basic and fundamentals of Space Physics and Astrophysics. • To learn fundamentals of Sun, Planets, Stars and Galaxies processes. • To know the recent developments of Space and Astrophysics mainly, the Indian Space Program. • To generate interest of students to participate and join Indian Space Research Organization (ISRO) for higher studies and research. • To supply trained students to different space and astrophysics institutes for advance research.			
Course Content	The course content be divided into minimum 3 Units to maximum 5 units along with defined hour of teaching for each unit.			

Units	**Course Content**	**Hr. of Teaching**
I	**Positional Astronomy:** Astronomical Coordinate Systems, measurement of astronomical parameters (mass, radius, time, distance, luminosity measurements), Solar and Sidereal day, Optical telescopes and designs. Detection method of radio-wave, X-ray, gamma-ray, gravitational wave.	08
II	**The Sun:** Structure of the Sun: Solar interior, solar atmosphere; Solar structures, Sun spots and their properties, Prominences, Solar Flares; CME, Solar cycle, Solar magnetic field; Solar Wind: Properties of solar wind, Magnetic field frozen into solar wind, Heliosphere.	08
III	**The Planets and Earth:** Defining planets; Terrestrial planets, Giant planets; Minor objects: Kuiper belt objects, asteroids, meteoroids; Planetary formation, Planetary structure and generation of magnetic fields, Exoplanet. Earth's Interior, magnetic field, atmosphere: composition, constituents; Ionosphere: Its structure & formation; Aurora Borealis; Magnetosphere: Its structure, Magnetopause, Magnetotail.	10
IV	**The Stars & Galaxies:** The Hertzsprung-Russell (H-R) diagram; Star-birth; The main sequence; Nuclear reactions; Stellar evolution, Post-main sequence; Stellar remnants: white dwarfs, neutron stars, black holes. Hubbles's classification of galaxies, Spiral and elliptical galaxies, Milky way galaxy, galaxy clusters and cosmological origin.	12
V	**Recent developments in Space and Astronomy:** Satellite launching vehicles, Indian Satellite missions: history, recent and future missions, Astrobiology, multi messenger astronomy, Space Situational Awareness.	07

Texts / References	1. Astrophysics of the Sun: Harold Zirin, Cambridge University Press, Cambridge, U.K. 2. Solar Astrophysics: Peter V. Foukal, Wiley-VchVerlag GmbH & Co. UK. 3. Fundamental Astronomy: H. Karttunen, P. Kroger, H. Oja, M. Poutanen, K.J. Donner, Springer Verlag, New Yerk 4. An Introduction to Modern Astrophysics: W. Carroll & D. A. Ostlie, Addison Wesley 5. Introduction to Space Physics: Ed. M.G. Kevilson& C.T. Russell, Cambridge Univ. Press, UK. 6. The Physics of Atmosphere: John Houghton, Cambridge University Press, U.K 7. Theoretical Astrophysics, Volumes I, II & III, T. Padmanabhan, Cambridge University Press. 8. Space Science, K.S. Krishnaswamy, New Age International Publications, 2017 9. Astrophysics for Physicists, Cambridge University Press, 2010 10. Astrophysics, Stars and Galaxies, K.D. Abhyankar, Universities Press, 2018
Learning Outcomes	The students will learn basic and fundamentals of Space Physics and Astrophysics which will help them to initiate their advance studies and research in different institutes of Space Science mainly, Indian Space Research Organization (ISRO) laboratories. Since Indian space research program needs trained students with basic knowledge of Sun, planes, stars, galexies, etc, this course will help them to join these advance laboratories to strengthen the Indian Space Program.

Course Title	**PHYMJ67: Physics Laboratory-6**			
Category of Course	**Major** / Minor / Minor (Vocational) / SEC / AEC / VAC / MD/Internship/Dissertation (Tick any one of the above)			
Credits & Hour of Teaching		**Theory**	**Practical**	**Cumulative**
	Credits	0	04	04
	Hour of Teaching (Total)	0	120	120
	Experiments			
	Group-I			
	1. Magnetic susceptibility measurement. 2. Measurement of Cauchy's constants. 3. Measurement of Hall coefficient and carrier density. 4. Geiger-Müller counter characteristics. 5. Design of Zener regulated power supply. 6. SCR characteristics and its use as a phase control rectifier. 7. Experiment on negative feedback. 8. Characteristics of FET and its application as amplifier. 9. Experiments on operational amplifier.			
	Group-II			
	1. Characteristics of MOSFET and its application as an amplifier. 2. Characteristics of UJT and its application as a relaxation oscillator. 3. Positive feedback- Hartley and phase shift oscillator. 4. Wave shaping circuits. 5. Amplitude modulation and demodulation characteristics. 6. Wavelength (and difference) using Michelson Interferometer. 7. To determine the Rydberg constant using CDS. 8. Speed of sound in a liquid using Ultrasonics. 9. e/m measurement using Magnetron/Thompson method.			
	Optional			
	1. Absorption and Emission spectra. 2. Hysteresis loop. 3. Speed of Light. 4. Experiments on multi-vibrators.			

Course Title	**PHYMV61: Artificial Intelligence and Machine Learning**			
Category of Course	Major / Minor / **Minor (Vocational)** / SEC / AEC / VAC / MD/Internship/Dissertation (Tick any one of the above)			
Credits & Hours of Teaching		**Theory**	**Practical**	**Cumulative**
	Credits	3	1	4
	Hours of Teaching	45	30	75
Course Objective	This 45-hour basic course on Artificial Intelligence (AI) using Python is designed to provide learners basics concepts and practical applications of AI. Through hands-on projects and exercises, students will develop their AI skills and its application to real-world problems.			
Course Content	The course content is divided into 5 units along with defined hour of teaching for each unit.			
Unit	**Content**			**Hours of Teaching**
I	**Introduction to Artificial Intelligence** Definition and history of AI, Different AI applications and use cases, Overview of AI subfields (Machine Learning, Natural Language Processing, Computer Vision, etc.), Essential Mathematics for AI			5
II	**Python for AI** Introduction to Jupyter Lab for interactive coding, Python basics and data structures, Working with libraries: NumPy, SciPy, and Pandas. Plotting Tools: Matplotlib and Seaborn			12
III	**Machine Learning Fundamentals** Understanding supervised, unsupervised, and reinforcement learning, Regression and classification algorithms, Evaluating model performance, Introduction to Scikit-learn library, Building and training ML models, Feature selection and engineering techniques, deep learning			12
IV	**Natural Language Processing (NLP)** Basics of NLP and its applications, Text preprocessing and tokenization, Building NLP models with NLTK or SpaCy, Large Language Models, Prompt engineering for ChatGPT			10
V	**Computer Vision and Image Processing** Introduction to Computer Vision and image processing, Working with Open CV library, Building a simple image recognition application			6
References	"Artificial Intelligence: A Modern Approach" by Stuart Russell and Peter Norvig "Pattern Recognition and Machine Learning" by Christopher M. Bishop "Deep Learning" by Ian Goodfellow, Yoshua Bengio, and Aaron Courville "Hands-On Machine Learning with Scikit-Learn, Keras, and TensorFlow" by AurélienGéron "Machine Learning Yearning" by Andrew Ng "The Elements of Statistical Learning" by Trevor Hastie, Robert Tibshirani, and Jerome Friedman "Reinforcement Learning: An Introduction" by Richard S. Sutton and Andrew G. Barto			
Learning outcomes	Students will master AI/ML concepts, algorithms, and practical implementation of AI/machine learning. They'll develop thinking for real-world problem-solving and AI considerations.			

SEMESTER-VII

<table>
<tr><td>Course Title</td><td colspan="4">PHYMJ71: Classical Mechanics-II</td></tr>
<tr><td>Category of Course</td><td colspan="4">Major / Minor / Minor (Vocational) / SEC / AEC / VAC / MD/Internship/Dissertation
(Tick any one of the above)</td></tr>
<tr><td rowspan="3">Credits & Hour of Teaching</td><td></td><td>Theory</td><td>Practical</td><td>Cumulative</td></tr>
<tr><td>Credits</td><td>3</td><td>0</td><td>3</td></tr>
<tr><td>Hour of Teaching (Total)</td><td>45</td><td>0</td><td>45</td></tr>
<tr><td>Course Objectives</td><td colspan="4">The objective of this course is to (i) provide exposure to advanced topics in classical mechanics, with an emphasis on developing analytical skills to solve problems, (ii) understand the rigid body dynamics following Lagrangian or Hamiltonian formalism, (iii) understand small oscillation theory,(iv) get familiar with analytical and numerical concepts in nonlinear dynamics, chaos, and fractals and (v) apply Lagrangian and Hamiltonian formalism to continuous systems and identify symmetry and conserved quantities.</td></tr>
<tr><td>Course Content</td><td colspan="4">The course content be divided into minimum 3 Units to maximum 5 units along with defined hour of teaching for each unit.</td></tr>
<tr><td>Units</td><td colspan="3">Course Content</td><td>Hr. of Teaching</td></tr>
<tr><td>I</td><td colspan="3">Rigid body dynamics:
Degrees of freedom of a free rigid body, Angular momentum and kinetic energy of a rigid body, Moment of inertia tensor, Eigen values of inertia tensor, principal moments of inertia, products of inertia, The kinematics of rigid body motion, Euler angles, infinitesimal rotations, rigid body equations of motion, Spherical top, Symmetric, Precession of equinoxes and of satellite orbits</td><td>18</td></tr>
<tr><td>II</td><td colspan="3">Canonical transformation:
Generating functionals, Applications. Hamilton-Jacobi Theory and solution of Kepler’s problem. Action angle variables, Solutions for periodic systems.</td><td>05</td></tr>
<tr><td>III</td><td colspan="3">Non-linear dynamics:
Non-linear equation of motions; phase diagram, logistic maps, flows, Limit cycles. Bifurcations, fixed points and attractors, Lyapunov exponent. Simple examples like Duffing and van der Pol oscillators, Basic idea of chaotic solutions, fractal dimensions, Poincare section and KAM theorem.</td><td>15</td></tr>
<tr><td>IV</td><td colspan="3">Lagrangian and Hamiltonian for continuous systems:
Transition from discrete to continuous system. Lagrangian density, Principle of least action, Euler-Lagrangian equation for continuous systems, Lagrangian for vibrational string. Hamiltonian density, Equations of motion. Noether’s theorem and conserve quantities.</td><td>07</td></tr>
<tr><td></td><td colspan="3"></td><td></td></tr>
<tr><td>Texts / References</td><td colspan="4">1. Classical Mechanics: H. Goldstein.
2. Nonlinear dynamics and chaos by Steven Strogatz
3. Introduction to Classical Mechanics: N. C. Rana and P. Joag
4) Chaos and nonlinear dynamics: An introduction for scientists and engineers by Robert Hilborn
5) Chaos: Introduction to dynamical systems by K. T. Alligood, T. D. Sauer and J. A. Yorke
6) Chaos in dynamical systems by Edward Ott
7. Introduction to the Modeling and Analysis of Complex systems: Hiroki Sayama</td></tr>
<tr><td>Learning Outcomes</td><td colspan="4">After completing the Classical Mechanics II course, the students are expected to acquire analytical skills to tackle problems related to rigid body dynamics, coupled oscillations within the framework of small oscillation theory, nonlinear dynamics (phase portrait, fixed point, stability analysis, Lyapunov exponent), and the application of Hamiltonian formalism to continuous fields, including simplifying equations of motion by finding symmetries and conservations.</td></tr>
</table>

Course Title	**PHYMJ72: Mathematical Physics-II**			
Category of Course	**Major** / Minor / Minor (Vocational) / SEC / AEC / VAC / MD/Internship/Dissertation (Tick any one of the above)			
Credits & Hour of Teaching		**Theory**	**Practical**	**Cumulative**
	Credits	3	0	3
	Hour of Teaching (Total)	45	0	45
Course Objectives	This is the second and advanced course on Mathematical Physics at the Undergraduate level. This course contains the mathematical methods essential for all the advanced level courses in Physics and hence is also a prerequisite for all the courses in physics. In order to be able to make progress in understanding physics a minimum facility is required in the mathematical methods.			
Course Content	The course content be divided into minimum 3 Units to maximum 5 units along with defined hour of teaching for each unit.			

Units	**Course Content**	**Hr. of Teaching**
I	**Theory of Functions of a Complex Variable:** Analyticity and Cauchy-Riemann Conditions, Cauchy's integral theorem and formula, Taylor series and Laurent series expansion, Zeros and singular points, Multivalued functions, Branch Points and Cuts, Riemann Sheets and surfaces, Residues, Residue theorem, Jordan's Lemma, evaluation of definite integrals, Cauchy principal value, dispersion relations (Kramers-Kroenig relations).	18
II	**Integral Transforms:** **Fourier Transform:** Fourier Integral, Sine, Cosine and Complex transforms with examples, Fourier Inverse Transform. Definition, Properties and Representations of Dirac Delta Function, Properties of Fourier Transforms, Transforms of derivatives, Parseval's Theorem, Convolution Theorem, Momentum representation, Transfer Functions, Applications to Partial differential equations.	09
III	**Integral Transforms:** **Laplace transform:** Definition, Properties and examples of Laplace Transforms, Inverse Transform, Convolution theorem and its applications, transforms of derivatives, Laplace transform method of solving differential equations (Ordinary and Partial differential equations), Differentiation and Integration of transforms, Inverse Transform by Bromwich integral.	09
IV	**Group Theory:** Concept of a group (additive and multiplicative), Matrix representation of a group, homomorphism, isomorphism, reducible and irreducible representations of a group, Examples of SO(2), SO(3), and SU(2) groups. Introduction to Lie groups, generators, and algebras, example of angular momentum. Elementary ideas of discrete groups, examples.	09

Texts / References	1. Mathematical Methods for Physicists (6/e): G.B. Arfken and H.J. Weber 2. Applied Mathematics for Engineers and Physicists: L.A. Pipes and L.R. Harvill 3. Complex Variables and Applications: J.W. Brown and R.V. Churchill 4. Complex Variables (Schaum's Outline Series): M.R. Spiegel 5. Fourier and Laplace Transforms: R.J. Beerends, H.G. ter Morsche, J.C. van den Berg, and E.M. van de Vrie 6. Fourier Transforms: I.N. Sneddon 7. Group Theory and Its Application to Physical Problems: M. Hamermesh 8. Group Theory and Its Application to the Quantum Mechanics of Atomic Spectra: E.P. Wigner
Learning Outcomes	Upon successful completion the students will have learnt the applications of 1. Complex analysis for solving certain classes of problems in physics. 2. Integral transform methods for solving differential equations and the momentum representation for problems in quantum mechanics and optics. 3. An elementary introduction to the powerful methods of generalized functions. 4. The section on the Group Theory is meant to be a broad and elementary exposure to the important concepts of Group Theory. Learning outcomes include the appreciation of group theory as a powerful mathematical tool to treat symmetries in Physical systems, that could provide invaluable clues to possible physical theories, eg., The Standard Model.

Course Title	**PHYMJ73: Quantum Mechanics-II**			
Category of Course	**Major** / Minor / Minor (Vocational) / SEC / AEC / VAC / MD/Internship/Dissertation (Tick any one of the above)			
Credits & Hour of Teaching		**Theory**	**Practical**	**Cumulative**
	Credits	3	0	3
	Hour of Teaching (Total)	45	0	45
Course Objectives	The course is designed at the intermediate level for the students who have already taken and introductory course in Quantum Mechanics. The students will learn the following: 1. Mathematical formalism of linear vector spaces. 2. Matrix representation of states and observables. 3. Symmetries and conservation laws in quantum mechanics and application to angular momenta. 4. Green's function for Schrodinger equation and elementary treatment of scattering problems in quantum mechanics. 5. Time independent and time dependent perturbation theory. 6. Variational and other approximate methods.			
Course Content	The course content be divided into minimum 3 Units to maximum 5 units along with defined hour of teaching for each unit.			
Units	**Course Content**			**Hr. of Teaching**
I	**Linear Vector Space and Representation Theory:** Linear vector space and Hilbert space, Dirac Bra - Ket notation, Representations: operator and matrix methods, Matrix representation of Observables and states, Determination of eigenvalues and eigenstate for observables using matrix representations, Schwartz inequality and Gram-Schmidt orthogonalization, Measurement, observables and uncertainty relations, Change of basis and unitary transformations, Coordinate and momentum representations.			12
II	**Theory of Angular Momentum:** Symmetry, invariance and conservation laws, relation between rotation and angular momentum, commutation rules, Matrix representations, addition of angular momenta and Clebsch-Gordan coefficients.			11
III	**Scattering Theory:** Differential and total Scattering cross-sections laws, Green Function, Born approximation, validity and simple applications, partial waves and phase shifts.			10
IV	**Approximation Methods:** Time-independent Perturbation theory (non-degenerate and degenerate), Zeeman effect (Normal), Degenerate perturbation theory, Stark effect; Variational method and applications to helium atom and simple cases.			12
Texts / References	1. Modern Quantum Mechanics: J.J. Sakurai. 2. Quantum Mechanics: L. I. Schiff. 3. Introduction to Quantum Mechanics: C.J. Joachain and B.H. Bransden. 4. Introduction of Quantum Mechanics: D.J. Griffiths. 5. Principles of Quantum Mechanics: P.A.M.Dirac. 6. Quantum Mechanics: P.M. Mathews and K. *Venkatesan* 7. Modern Quantum Mechanics: R. Shanker 8. Quantum Mechanics: L. Ballantine			
Learning Outcomes	The students will have the opportunity to learn the matrix mechanic formalism and its application to angular momenta. The course will also prepare them to use approximate methods like perturbation theory, variational principle etc. for various problems in physics.			

Course Title	**PHYMJ74: Advanced Topics in Integrated Circuits, Digital Systems, Embedded Architectures, and Antenna**			
Category of Course	**Major** / Minor / Minor (Vocational) / SEC / AEC / VAC / MD/Internship/Dissertation (Tick any one of the above)			
Credits & Hour of Teaching		**Theory**	**Practical**	**Cumulative**
	Credits	03	0	03
	Hour of Teaching (Total)	45	0	45
Course Objectives	This course aims to provide understanding of the principles and applications of integrated circuits, digital systems, embedded architectures, and antenna design. Students will explore semiconductor surfaces, MOS capacitors, and the fabrication of integrated circuits, including operational amplifiers, timers, and phase-locked loops. Additionally, the course covers digital logic gates, microprocessors, and microcontroller architectures, along with foundational antenna theory and design.			
Course Content	The course content be divided into minimum 3 Units to maximum 5 units along with defined hour of teaching for each unit.			

Units	**Course Content**	**Hr. of Teaching**
I	**Integrated Circuits and Fabrication:** Semiconductor surfaces and Metal/Semiconductor Contact, MOS (Capacitor, Accumulation, Depletion and Inversion). Fabrication of ICs (Planar, Monolithic, Active and Passive Including MOS).	6
II	**Timer (IC-555):** Internal Structure (Block Diagram) Operation, Astable, Monostable and Applications. **Op-Amp (IC-741):** Internal Structure (Block Diagram) Slew Rate, Frequency Response and Compensation, Applications (Linear and Non- Linear).	8
III	**Phase Locked Loops (IC-565):** Internal Structure (Block) Diagram) Application as Frequency	4
IV	**Digital Systems and Embedded Architectures**: FSK and FM Demodulation, TTL, MOS and CMOS Gates, Parallel Binary adder/subtractor, BCD Addition/ Subtraction, Encoder, Decoder, MUX, DE-MUX, Flip-Flops, Shift Resister, Counter, Memory Concept, RAM, ROM, EEPROM and Flash.	15
V	**Microprocessor:** ALU, control unit, registers, etc., Instruction set architecture (ISA) and addressing modes. **Microcontroller Architecture:** On-chip peripherals and their functions (timers, counters, UART, ADC, etc.), Comparison of microcontroller architecture with microprocessors. **Antenna:** Basics of Radiowave propagation, Radiation from short electric doublet. Monopole and Dipole Antenna, Antenna parameters, Antenna Arrays.	12

Texts / References	**Reference Books:** 1. Integrated Electronics: Millman and Halkias. 2. Physics of Semiconductors Devices: Sze. 3. Op-Amps and Linear Integrated Circuits: Gayakwad. 4. Digital Fundamental: Floyed. 5. Electronic Communication Systems: Kennedy 6. Linear Integrated Circuits: Choudhary and Jain. 7. Digital Electronics: Jain.
Learning Outcomes	After going through this course, students will be able to: (i) Analyze semiconductor surfaces and metal/semiconductor contacts. (ii) Understand MOS capacitor operations and IC fabrication processes. (iii) Apply knowledge of operational amplifiers, timers, and phase-locked loops in practical circuits. (iv) Design and analyze digital systems, including adders, subtractors, and memory units. (v) Understand microprocessor and microcontroller architectures and their applications. (vi) Explain the principles of radio wave propagation and design various types of antennas.

Course Title	**PHYMJ75: NANO SCIENCE AND TECHNOLOGY**			
Category of Course	**Major** / Minor / Minor (Vocational) / SEC / AEC / VAC / MD/Internship/Dissertation (Tick any one of the above)			
Credits & Hour of Teaching		**Theory**	**Practical**	**Cumulative**
	Credits	03	0	03
	Hour of Teaching (Total)	45	0	45
Course Objectives	In modern era Nanoscience and Nanotechnology has becoming very important even in everyday life. In this course: • Different synthesis and characterization protocol for nanoparticles will be introduced. • Synthesis of different types of Carbon nanostructures including C60, carbon nanotubes, Graphene, 2D materials beyond graphene etc. and their physical properties. • Different quantum nanostructures---their preparations and characterization will be discussed. Different analytical techniques for nanostructures such as XRD, TEM, SPM (STM an SFM); XPS, Raman, IR, UV-vis, PL etc. will be taught.			
Course Content	The course content be divided into minimum 3 Units to maximum 5 units along with defined hour of teaching for each unit.			

Units	**Course Content**	**Hr. of Teaching**
I	**Nanoparticles: Synthesis and Properties:** Method of Synthesis: RF Plasma, Chemical Methods, Pulsed Laser Methods, Biological Methods: Synthesis using micro-organisms, Metal Nanoclusters, Magic Numbers, Modeling of Nanoparticles, Bulk to Nano Transitions.	05
II	**Carbon Nanostructures:** Nature of Carbon Clusters, Discovery and structure of C_{60}, Superconductivity in C60, Carbon Nanotubes: Synthesis, Structure, Electrical and Mechanical Properties. Graphene: Discovery, Synthesis and Structural Characterization through TEM, Elementary Concept of its applications. Other 2D materials: synthesis and properties.	11
III	**Quantum Wells, Wires and Dots:** Preparation of Quantum Nanostructures (wells, wires and dots), Size Effects, Conduction Electrons and Dimensionality, Properties dependent on Density of States.	09
IV	**Analytical Techniques for Nano Structures:** Scanning Probe Microscopes (SPM): STM and SFM Diffraction Techniques: XRD, TEM Spectroscopic Techniques: XPS, IR, Raman, UV-Vis, PL	16
V	**Bulk Nanostructure Materials:** Methods of Synthesis, Solid Disorders Nanostructures, Mechanical Properties, Nanostructure Multilayers, Metal Nanocluster, Composite Glasses, Porous Silicon.	04

Texts / References	1. Introduction to Nanotechnology: Poole and Owners 2. Quantum Dots :Jacak, Hawrylak and Wojs 3. Handbook of Nanostructured Materials and Nanotechnology :Nalva (editor) 4. Nano Technology/ Principles and Practices: S.K. Kulkarni 5. Carbon Nanotubes: SilvanaFiorito 6. Nano technology: Richard Booker and Earl Boysen
Learning Outcomes	In this course, different synthesis and characterization protocol for nanoparticles have been introduced. Synthesis of different types of Carbon nanostructures including C60, carbon nanotubes, Graphene, 2D materials beyond graphene, etc. and their physical properties have been discussed. Different quantum nanostructures---their preparations and characterization are discussed. Different analytical techniques for nanostructures such as XRD, TEM, SPM (STM an SFM); XPS, Raman, IR, UV-vis, PL etc. have been taught.

Course Title	**PHYMJ76: Advanced Molecular Spectroscopy**			
Category of Course	**Major** / Minor / Minor (Vocational) / SEC / AEC / VAC / MD/Internship/Dissertation (Tick any one of the above)			
Credits & Hour of Teaching		**Theory**	**Practical**	**Cumulative**
	Credits	03	0	03
	Hour of Teaching (Total)	45	0	45
Course Objectives	In this course, the fundamental principles of the different forms of spectroscopy will be elaborated in a unified way from both theoretical and experimental viewpoints. Topics covered here deals with the observation and interpretation of radiation absorbed or emitted by molecules. This information can lead into the knowledge of structure and dynamical properties of the molecule. The course will enable the student to get an understanding on the Molecular spectra (rotational, vibrational and electronic spectra).			
Course Content	The course content be divided into minimum 3 Units to maximum 5 units along with defined hour of teaching for each unit.			

Units	**Course Content**	**Hr. of Teaching**
I	**Rotational spectra:** Rotational symmetry of molecules; rotational spectra of linear, symmetric top, spherical and asymmetric top molecules; rotational selection rules for linear molecules; effect of nuclear spin on the rotational spectra.	10
II	**Vibrational Spectra:** Vibrational spectra of a diatomic molecule as a harmonic and anharmonic oscillator; vibrational-rotational (IR and Raman) spectra of linear and symmetric top molecules.	10
III	**Electronic Spectra:** Electronic transitions; Basics of Absorption, Fluorescence and Phosphorescence; Jablonski diagram; A brief discussion of molecular states; The Franck-Condon principle; Dissociation energy. Vibronic interaction and Herzberg Teller theory for absorption spectrum.	10
IV	**Molecular Symmetries and Group Theory:** Symmetry properties of molecule: symmetry element, symmetry operation and point group, character table, Group theory: representation of a group, Matrix Representations of symmetry elements of a Point Group; Reducible and irreducible Representations; Character Tables for C_{2v} and C_{3v} point groups; Normal modes of vibration and their distribution into symmetry species of the molecule.	15

Texts / References	Chemical Applications of Group Theory: F.A. Cotton; Fundamentals of Molecular Spectroscopy : C.N. Banwell; Introduction to Molecular Spectroscopy : G.M. Barrow; Modern Spectroscopy : J.M. Hollas; Molecular spectra and Molecular structure Vol. I and II: G. Hertzberg; Molecular Structure and Spectroscopy: G. Aruldhas:
Learning Outcomes	Spectroscopy is the study of the interaction of electromagnetic (EM) radiation with matter. EM radiation covers a wide range of frequencies from gamma rays to radio frequencies. Depending on the frequency of radiation interacting with the matter, one can have different forms of spectroscopy. The structural and dynamic aspects of spectroscopy are fundamental to physics, chemistry and biology. Thus, this course will provide a thorough conceptual understanding for these branches of science.

Course Title	**PHYMJ77: Nuclear Models and Reactions**			
Category of Course	**Major** / Minor / Minor (Vocational) / SEC / AEC / VAC / MD/Internship/Dissertation (Tick any one of the above)			
Credits & Hour of Teaching		**Theory**	**Practical**	**Cumulative**
	Credits	03	0	03
	Hour of Teaching (Total)	45	0	45
Course Objectives	In this course, the fundamental properties of nuclei and related phenomena will be elaborated. Theoretical concept of nuclear reaction and excitations will be explained. Shell model, Collective models, will be taught for taking up research in nuclear physics course.			
Course Content	The course content be divided into minimum 3 Units to maximum 5 units along with defined hour of teaching for each unit.			

Units	**Course Content**	**Hr. of Teaching**
I	**Nuclear Models:** ***Shell Model:*** Properties of Single particle states, Energy, spin and parities, Population of excited states in nuclei, Qualitative discussion and estimates of reduced transition rates, Magnetic moments and Schmidt Lines. ***Collective Model:*** Bohr's Collective model for even-even spherical, collective vibrational and rotational excitations.	18
II	**Nuclear Force and Nuclear Reactions:** ***Nuclear Force:*** Deuteron problem, Tensor force, S and D states, Neutron-Proton and proton-proton scattering, Effective range theory, Spin-dependence of nuclear forces, Charge independence and charge symmetry of nuclear forces, Isospin formalism. ***Nuclear Reactions:*** Basic idea of direct reaction and compound nuclear reactions, Expressions for scattering and reaction cross sections in terms of partial wave amplitudes, Resonances reactions and derivation of Breit-Wigner single level formula for compound nucleus theory and its applications.	15
III	**Experimental Techniques:** ***Detectors:*** Outline of interaction of particles and gamma-rays with matter, Gas filled counters, Scintillation (NaI detector), Semi conductor detectors (HPGe and Silicon Surface Barrier Detector) ***Accelerators:*** Linear accelerator, Introduction of Modern Colliders, LHC and RHIC, Storage ring.	12

Texts / References	1. Atomic and Nuclear Physics Vol. II: Ghoshal. 2. Nuclear Structure: Preston and Bhaduri. 3. Nuclear Structure: M. K. Pal. 4. Introductory Nuclear Physics: Wong. 5. Nuclear Theory: Elton. 6. Nuclear Interactions: de Benedetti. 7. Nucleon-nucleon Interaction: Brown and Jackson. 8. Nuclear Structure: M.K.Pal.
Learning Outcomes	The course is design to provide a thorough knowledge of concept of nuclear physics. Student after learning this course will be able to take higher research in nuclear physics, radiation physics

Course Title	**PHYMJ78: Plasma Astrophysics and Physics of Interstellar Medium**			
Category of Course	**Major** / Minor / Minor (Vocational) / SEC / AEC / VAC / MD/Internship/Dissertation (Tick any one of the above)			
Credits & Hour of Teaching		**Theory**	**Practical**	**Cumulative**
	Credits	3	0	3
	Hour of Teaching (Total)	45	0	45
Course Objectives	This course will provide a detailed knowledge of Plasma Astrophysics and Physics of Interstellar Medium.			
Course Content	The course content be divided into minimum 3 Units to maximum 5 units along with defined hour of teaching for each unit.			

Units	**Course Content**	**Hr. of Teaching**
I	**Overall structure of Plasma Physics and Astrophysics**, Classification of Celestial Objects, Typical examples of Celestial Objects, Magnetized and nonmagnetized plasma, theory of turbulence	07
II	**Fundamental processes in Hydrostatic and Magnetostatic Objects**, Dynamo theory, Magneto-hydrodynamic waves and instabilities, Magneto-convection, Magneto-buoyancy, Parker instability, Theory of Magnetic reconnection, Fractal Nature of Current Sheet, Fundamental processes in Gravitational Objects	18
III	**Atomic and Radiation Physics of Plasmas**, Theory of Radiative Transfer, Nonlinear steepening and Shocks, Particle Acceleration, Cosmic Rays	08
IV	**The Interstellar objects**, mass budget of Interstellar medium (ISM), Physics and Chemistry of ISM, Gas Cooling/heating, Interstellar Polycyclic Aromatic Hydrocarbon Molecules, HII regions, Photodissociation Regions, Molecular clouds, Interstellar Shocks	12

Texts / References

1. Plasma Astrophysics, T. Tajima and Kazunari Shibata, Westview Press, 2002
2. Plasma Astrophysics, Claudio Chiuderi and Marco Velli, Springer, 2015
3. The Physics and Chemistry of the Interstellar Medium, A.G.G. M. Tielens, 2010
4. Cosmical Magnetic Fields, E.N. Parker, Clarendon Press, Oxford, Cambridge University Press , 1979
5. An introduction to the atomic and radiation physics of plasmas, Cambridge University Press, 2018
6. Physics of solar system plasmas, Thomas E. Cravens, Cambridge University Press, 2004
7. Physics and Chemistry of the Interstellar Medium, Sun Kwok, 2007
8. Lectures in Magnetohydrodynamics, D.D. Schnack, Springer, 2009
9. Modern Fluid Dynamics for Physics and Astrophysics, Springer, 2016
10. Astrophysics for Physicists, ArnabRaiChoudhuri, Cambridge University Press, 2010
11. Plasma Physics for Astrophysics, Russell M. Kulsrud, Princeton University Press, 2005
12. Lectures on Astrophysics, Steven Weinberg, Cambridge University Press, 2020
13. Theoretical Astrophysics (volumes I, II, III), T. Padmanabhan, Cambridge University Press, 2002
14. Atomic Astrophysics and Spectroscopy, Anil K. Pradhan and Sultana N. Nahar, Cambridge University Press, 2011
15. Plasma Astrophysics: Kinetic Processes in Solar and Stellar Coronae, Arnold O. Benz, Springer, 2014

Learning Outcomes	After attending this course the students will have an idea of astrophysical plasma and interstellar environments where this plasma is present. The students will also learn about radiative transfer in interstellar environments.

Course Title	**PHYMJ79: Physics Laboratory-A**			
Category of Course	**Major** / Minor / Minor (Vocational) / SEC / AEC / VAC / MD/Internship/Dissertation (Tick any one of the above)			
Credits & Hour of Teaching		**Theory**	**Practical**	**Cumulative**
	Credits	0	03	03
	Hour of Teaching (Total)	0	90	90
	1. Determine the ratio e/m for an electron by measuring the normal Zeeman splitting of the yellow line of neon using a Spectrometer. 2. Determine the Lande-g factor for a given sample (DPPH) using the electron spin resonance spectrometer. 3. In Fabry-Perot Interferometer setup, determine the wavelength of source, determine the gap between Fabry-Perot etalon at different micrometer reading and find the finesse. 4. Determine the resistivity of a given semiconductor at different temperatures using Four-probe method and calculate the energy band gap of the semiconductor. 5. Determine the first excitation potential energy of Argon atom using Franck Hertz experiment. 6. In the Experiment of Faraday Effect show that magnetic rotation follows the $\cos^2$ law of intensity and determine the value of Verdict constant. 7. Study the Kerr effect in Lithium Niobate crystal. 8. Record the emission spectrum of the given lamp and fluorescence spectrum of the dye solution using a Spectrometer. Determine the red shift and quantum yield of Dye.			

OR

Course Title	**PHYMJ710: Physics Laboratory-B**			
Category of Course	**Major** / Minor / Minor (Vocational) / SEC / AEC / VAC / MD/Internship/Dissertation (Tick any one of the above)			
Credits & Hour of Teaching		**Theory**	**Practical**	**Cumulative**
	Credits	0	03	03
	Hour of Teaching (Total)	0	90	90
	1. Design of CE Amplifier 2. Experiment with Differential Amplifier 3. Experiment with Operational Amplifier 4. Transmission Line Trainer 5. Combinational Logic 6. Design of a Regulated Power Supply 7. Multivibrators using CE Amplifier 8. Experiment with Timer (IC-555) 9. Application of Operational Amplifier 10. Counter and Shift Register			

Course Title	**PHYMJ711: Physics Laboratory-C**			
Category of Course	**Major** / Minor / Minor (Vocational) / SEC / AEC / VAC / MD/Internship/Dissertation (Tick any one of the above)			
Credits & Hour of Teaching		**Theory**	**Practical**	**Cumulative**
	Credits	0	01	01
	Hour of Teaching (Total)	0	30	30
	1. Matrix Algebra 2. Bisection method for finding roots 3. Newton - Raphson method for finding roots 4. Simpson - 1/3 rule of Integration 5. Least-squares fit			

SEMESTER-VIII

Course Title	**PHYMJ81: Statistical Mechanics-II**			
Category of Course	**Major** / Minor / Minor (Vocational) / SEC / AEC / VAC / MD/Internship/Dissertation (Tick any one of the above)			
Credits & Hour of Teaching		**Theory**	**Practical**	**Cumulative**
	Credits	3	0	3
	Hour of Teaching (Total)	45	0	45
Course Objectives	The objectives of the Statistical Mechanics II course are to equip the students with relevant advanced topics like quantum statistical mechanics, weakly interacting systems, and an introduction to phase transition phenomena.			
Course Content	The course content be divided into minimum 3 Units to maximum 5 units along with defined hour of teaching for each unit.			
Units	**Course Content**			**Hr. of Teaching**
I	**Quantum Statistical Mechanics:** Postulates and density matrix, Ensembles in an ideal gas, Partition function, Thermodynamic functions, distributions Ideal Fermi gas, Concept of Fermi energy, Grand Partition function, equation of state and thermodynamics, Examples: white dwarf star. Ideal Bose gas, Grand Partition function, equation of state and thermodynamics, Bose-Einstein condensation, concept of macroscopic state and superfluidity.			26
II	**Interacting systems:** Cluster expansion for an ideal gas, equation of state, Virial expansion and Virial coefficients.			07
III	**Phase transitions:** Ising model in one-dimension, Equivalence with other models, Peierls argument, mean field theory (Bragg-Williams and Bethe-Peierls), Exact solution of Ising modelin1-dimension, Spin-spin correlation function, Heisenberg model (introductory), Landau theory and critical exponents.			12
Texts / References	1. Statistical Mechanics: R. K. Pathria (Elsevier). 2. Statistical Mechanics: Kerson Huang (Wiley). 3. Statistical Mechanics: L. D. Landau and E.M. Lifshitz (Pergamon). 4. Equilibrium Statistical Physics: M. Plischke and B. Bergersen (World Scientific). 5. A Modern course in Statistical Physics: L.E.Reichl (John-Wiley).			
Learning Outcomes	After completing this course, the students are expected to acquire advanced analytical skills in the field of statistical physics which would be of great use in pursuing higher studies and research.			

Course Title	**PHYMJ82: Electrodynamics and Plasma Physics**			
Category of Course	**Major** / Minor / Minor (Vocational) / SEC / AEC / VAC / MD/Internship/Dissertation (Tick any one of the above)			
Credits & Hour of Teaching		**Theory**	**Practical**	**Cumulative**
	Credits	3	0	3
	Hour of Teaching (Total)	45	0	45
Course Objectives	The course is designed at advanced level students. The students will have the opportunity to learn the following: 1. Accelerated charges and electromagnetic radiation. 2. To calculate the energy loss in the form of Bremsstrahlung, Synchrotron and Cerenkov radiation. 3. Motion of charged particles in electric and magnetic fields. 4. Concepts of field strength tensor and Maxwell's equation in four vector notation. 5. Elementary ideas of Debye shielding and plasma confinement. 6. Application of plasma physics to MHD and wave propagation in a plasma.			
Course Content	The course content be divided into minimum 3 Units to maximum 5 units along with defined hour of teaching for each unit.			

Units	**Course Content**	**Hr. of Teaching**
I	**Electromagnetic Radiation:** Radiation by moving charges, Wave Equation for Scalar and Vector Potentials, Retarded and Lienard Wie'chert Potentials, Electric and Magnetic field due to a uniformly moving charge and an accelerated charge, Linear and circular Acceleration and Angular Distribution of radiated Power, Elementary idea of Bremsstrahlung, Synchrotron Radiation and Cerenkov radiation.	10
II	**Dynamics of Charged Particles in E and B Fields:** Motion of Charged Particles in electromagnetic Field: Uniform E and B Fields, Non-uniform Fields Diffusion Across Magnetic Fields, Time Varying E and B Fields.	8
III	**Electrodynamics in Four vector notation:** Four vectors and tensors, Electromagnetic field Tensor in Four dimensions and Maxwell's Equations, Dual Field Tensor, Covariance of Maxwell's equations.	5
IV	**Basics in Plasma Physics:** Elementary Concepts: Plasma Oscillations, Debye Shielding, Plasma Parameters, Magneto-plasma, Plasma Confinement, First, Second, and Third Adiabatic Invariants (Pinch Effect, Magnetic Mirrors), Formation of Van Allen radiation belt.	8
V	**MHD and waves in Plasma:** Fundamental magneto-hydrodynamics (MHD) equations, MHD Waves: Magneto-sonic and Alfven Waves, Magneto-convection. Phase Velocity, Group Velocity, Cut-offs, Resonance for Electromagnetic Wave Propagating Parallel and Perpendicular to the Magnetic Field.	14

Texts / References	1. Classical Electrodynamics: J.D. Jackson. 2. Classical Electricity and Magnetism: W.K.H. Panofsky and M. Phillips. 3. Fundamentals of Plasma Physics: J. A. Bittencourt. 4. Principles of plasma physics: N. A. Krall, A. W. Trivelpiece 5. Introduction to Plasma Physics and Controlled Fusion: F.F. Chen.
Learning Outcomes	The students will learn the following: 1. To calculate the electric and magnetic fields due to accelerated charges. 2. To write electrodynamics in relativistic four vector and tensor form. 3. The electromagnetic wave propagation in a plasma and calculate Debye shielding etc. 4. Fluid dynamics approach to plasma and related phenomena.

Course Title	**PHYMJ83: Advanced Topics in Quantum Mechanics**			
Category of Course	**Major** / Minor / Minor (Vocational) / SEC / AEC / VAC / MD/Internship/Dissertation (Tick any one of the above)			
Credits & Hour of Teaching		**Theory**	**Practical**	**Cumulative**
	Credits	3	0	3
	Hour of Teaching (Total)	45	0	45
Course Objectives	The course is designed for advanced learners who have already taken one or more courses in Quantum Mechanics. The course contents are of advanced nature and usually covered at elementary level or remain untouched in a regular Quantum Mechanics course. The students will have the opportunity to learn the following: 1. Semi-classical theory of radiation and selections rules. 2. WKB method and its applications. 3. Berry-Pancharatnam phase and its applications. 4. Concepts of Entanglement and quantum information. 5. The basics of relativistic quantum mechanics.			
Course Content	The course content be divided into minimum 3 Units to maximum 5 units along with defined hour of teaching for each unit.			

Units	**Course Content**	**Hr. of Teaching**
I	**Approximation Methods:** Semi-classical theory of radiation**:** dipole approximation, selection rules, atomic transitions; WKB method, Bohr-Sommerfeld quantization; application to spherically symmetric potentials; tunneling amplitudes (optional); Adiabatic approximation: Berry-Pancharatnam phase, (Ehernberg-Siday) Aharonov-Bohm effect.	18
II	**Foundations of Quantum Information Theory:** Postulates of quantum mechanics; concepts of quantum superposition and qubits, Bloch sphere representation; quantum measurement; unitary operators and quantum gates, quantum circuits and their representation; entanglement and its properties, von-Neumann entropy and its properties; teleportation, quantum dense coding, quantum algorithms.	16
III	**Relativistic Wave-equations:** Klein-Gordon equation and its limitations; Dirac equation, probability current density; negative energy solutions, Feynman-Stuckelberg interpretation; spinor solutions for a free particle; Dirac equation in four vector notations, coupling with electromagnetic field.	11

Texts / References	1. A Text-book of Quantum Mechanics: P.M. Mathews and K. *Venkatesan* 2. Principles of Quantum Mechanic: R. Shankar 3. Modern Quantum Mechanics: J.J. Sakurai 4. Quantum Computation and Quantum Information: M. A. Nielsen and I. L. Chuang 5. Quantum Information : An Introduction : M. Hayashi 6. Relativistic Quantum Mechanics: J.D. Bjorken and S.D. Drell
Learning Outcomes	The students will learn the advanced level topics which are frequently used in research. This course is also a forerunner for advanced level courses on Quantum Information Theory, Many body Physics and Particle Physics.

Course Title	**PHYMJ84: Advanced Photonics and Optical Communication**			
Category of Course	**Major** / Minor / Minor (Vocational) / SEC / AEC / VAC / MD/Internship/Dissertation (Tick any one of the above)			
Credits & Hour of Teaching		**Theory**	**Practical**	**Cumulative**
	Credits	03	0	03
	Hour of Teaching (Total)	45	0	45
Course Objectives	Introduction to Photonics and Optical Communication," provides a comprehensive overview of photonics, emphasizing its interdisciplinary nature and historical developments in optical communication. Key topics include light-matter interactions, wave propagation, and the use of semiconductor materials in photonics. The course covers photonic crystals, band gap engineering, integrated optics, and waveguide devices, with a focus on silicon photonics. It also explores photonic sensors, surface plasmon resonance sensing, and optical networks, including Wavelength Division Multiplexing. Practical exercises with Optical Time Domain Reflectometer (OTDR) will enhance understanding of fiber characterization, attenuation measurement, and fault localization.			
Course Content	The course content be divided into minimum 3 Units to maximum 5 units along with defined hour of teaching for each unit.			

Units	**Course Content**	**Hr. of Teaching**
I	**Introduction to Photonics and Optical Communication:** Overview of photonics and its interdisciplinary nature, Basics of light-matter interactions and wave propagation, Historical developments in optical communication. **Optical Materials and Devices:** Semiconductor materials for photonics (laser diodes, LEDs, photodetectors), Optical amplifiers (EDFA, Raman amplifiers), Photonic modulators and switches.	06
II	**Photonic Crystals and Band gap Engineering:** Introduction to photonic crystals and periodic structures. Photonic band gap engineering and applications, Photonic crystal fibers and waveguides. **Integrated Optics and Waveguide Devices:** Basics of integrated optics and waveguide theory, On-chip integrated optical components (AWGs, MMI couplers, etc.), Silicon photonics and its applications.	14
III	**Photonic Sensors and Sensing Techniques:** Principles of photonic sensors and transducers, Fiber optic sensors (temperature, pressure, strain, etc.), Biosensors and biomedical applications. **Surface Plasmon Resonance (SPR) Sensing:** Introduction to SPR and surface plasmons, SPR sensing principles and applications, Biochemical and environmental sensing using SPR.	09
IV	**Optical Networks and Optical Fiber Waveguides:** Fundamentals of optical networks and architectures, Wavelength Division Multiplexing (WDM) and Dense WDM (DWDM), Optical fiber waveguide modes and propagation. **Optical Time Domain Reflectometer (OTDR) and Fiber Characterization:** Principles and operation of OTDR, Fiber characterization, attenuation measurement, and fault localization, Practical exercises with OTDR equipment	16

Texts / References	**Reference Books:** 1. Introduction to Fiber Optics" by A. Ghatak and K. Thyagarajan 2. Fiber Optics and Optoelectronics" by R. K. Shevgaonkar 3. Optical Fiber Communications" by Gerd Keiser 4. Fiber Optic Communications: Principles and Practice" by Rajiv Ramaswami and Kumar N. Sivarajan 5. Understanding Fiber Optics" by Jeff Hecht

<table>
<tr><td>Learning Outcomes</td><td colspan="4">Upon completing this course, students will be able to:
1. Identify key historical developments in optical communication.
2. Understand the fundamentals of photonics and optical communication.
3. Analyze semiconductor materials and devices used in photonics.
4. Apply concepts of photonic crystals and bandgap engineering.
5. Design and evaluate integrated optics and waveguide devices.
6. Utilize photonic sensors and surface plasmon resonance techniques.
7. Understand the architecture and components of optical networks.
8. Operate Optical Time Domain Reflectometer (OTDR) for fiber characterization and fault localization.</td></tr>
<tr><td>Course Title</td><td colspan="4">PHYMJ85: Advanced Topics in Condensed Matter Physics</td></tr>
<tr><td>Category of Course</td><td colspan="4">Major / Minor / Minor (Vocational) / SEC / AEC / VAC / MD/Internship/Dissertation
(Tick any one of the above)</td></tr>
<tr><td rowspan="3">Credits & Hour of Teaching</td><td></td><td>Theory</td><td>Practical</td><td>Cumulative</td></tr>
<tr><td>Credits</td><td>3</td><td>0</td><td>3</td></tr>
<tr><td>Hour of Teaching (Total)</td><td>45</td><td>0</td><td>45</td></tr>
<tr><td>Course Objectives</td><td colspan="4">Condensed matter physics explores how numerous particles organize at a macroscopic level, leading to diverse physical phenomena. Interactions between these particles often give rise to emergent properties. Phase transitions and quantum effects play crucial roles in elucidating different material phases. This course covers significant advancements from the past century, highlighting their impact on our comprehension of solid-state physics. Additionally, students will gain insights into how recent developments continually enhance our understanding in this field.</td></tr>
<tr><td>Course Content</td><td colspan="4">The course content be divided into minimum 3 Units to maximum 5 units along with defined hour of teaching for each unit.</td></tr>
<tr><td>Units</td><td colspan="3">Course Content</td><td>Hr. of Teaching</td></tr>
<tr><td>I</td><td colspan="3">Semiclassical transport theory: Semiclassical Wave Packets, Wave-Packet Dynamics in Bloch Bands, Dynamics in uniform magnetic fields, Quantum Oscillations, The Boltzmann Transport Equation, Thermal Transport and Thermoelectric Effects.</td><td>12</td></tr>
<tr><td>II</td><td colspan="3">Fundamentals of the many-electron system: Hartree-Fock theory, screening. Thomas-Fermi theory.</td><td>08</td></tr>
<tr><td>III</td><td colspan="3">Superconductors: Basic phenomenology and thermodynamics of superconductors, London-theory, Ginzburg-Landau theory, coherence length and penetration depth, type-I and type-II superconductor, lower and upper critical field, the Josephson junction, Cooper’s problem, BCS theory.</td><td>12</td></tr>
<tr><td>IV</td><td colspan="3">Quantum Hall Effect: Landau levels, Integer quantum hall effect.</td><td>05</td></tr>
<tr><td>V</td><td colspan="3">Magnetism: Spin-spin interaction, Heisenberg model (ferromagnetism and anti-ferromagnetism), Holstein–Primakoff theory, spin-wave excitation.</td><td>08</td></tr>
<tr><td></td><td colspan="3"></td><td></td></tr>
<tr><td>Texts / References</td><td colspan="4">1. N. Ashcroft and N. Mermin, Solid State Physics.
2. Charles Kittel , Introduction to Solid State Physics.
3. Charles Kittel, Quantum Theory of Solids.
4. S. M. Girvin, K. Yang, Modern Condensed Matter Physics.
5. Michael Tinkham, Introduction to Superconductivity.</td></tr>
<tr><td>Learning Outcomes</td><td colspan="4">Students will learn basic ideas of
1. Transport properties of matter and how experiments and theory are related.
2. How to deal with simple many-electron problem.
3. Theoretical developments of superconductivity phenomena.
4. Hall-effect and topological systems.
5. Quantum spin systems.</td></tr>
</table>

Course Title	**PHYMJ86: Spectroscopic Techniques for Materials Characterization**			
Category of Course	**Major** / Minor / Minor (Vocational) / SEC / AEC / VAC / MD/Internship/Dissertation (Tick any one of the above)			
Credits & Hour of Teaching		**Theory**	**Practical**	**Cumulative**
	Credits	03	0	03
	Hour of Teaching (Total)	45	0	45
Course Objectives	The objectives of the proposed course are to make the students aware about the basics of various types of spectroscopic techniques, the understanding about the experimental set ups and help them to gain more insights about the obtained results. The proposed course content aims to help students in developing their understanding about the practical applications of a number of spectroscopic techniques.			
Course Content	The course content be divided into minimum 3 Units to maximum 5 units along with defined hour of teaching for each unit.			

Units	**Course Content**	**Hr. of Teaching**
I	**Optical/Absorption Spectroscopy:** Introduction of UV Visible Spectroscopy, Different Types of Transitions, Principles of UV Visible Spectroscopy, Instrumentation of UV Visible Spectroscopy and Source of Light, The Beer-Lambert Law (and deviations from it), Empirical rules for calculating absorption maxima, Shifts in absorption maxima, Applications of UV-Visible Spectroscopy in nano, and bio materials.	11
II	**Fluorescence spectroscopy** Introduction to fluorescence: Electronic transition, Energy of electronic transition, Selection rules, The Franck Condon principle, Jablonski diagram, Instrumentation for Fluorescence Spectroscopy, Solvent and Environmental Effects, Time-Domain Lifetime Measurements, Fluorescence Quenching, Fluorescence Anisotropy, Excited state phenomena: Energy Transfer and Proton Transfer, Applications of Fluorescence spectroscopy in nano, and bio materials.	11
III	**IR Spectroscopy** Basic idea of molecular vibrations, Instrumentation and working principle and IR and FT-IR spectrometers, Various IR sources, Detectors, and Monochromators, Applications of IR spectroscopy in chemical identification and materials characterization.	8
IV	**Raman Spectroscopy** Basic idea of Rotational, vibrational and electronic Raman Spectroscopy, Effect of polarisation on Raman spectra, Instrumentation for Raman Spectroscopy, Principle of Surface-Enhanced Raman Spectroscopy (SERS), Surface selection rules, SERS substrates, Applications of Raman spectroscopy in nanomaterials, biomaterials, medicine, and forensic science	10
V	**Spectroscopic calculations using Density Functional Theory:** Structure optimization, Deducing IR, Raman, and electronic transitions	5

Texts / References	1. C. N. Banwell and E. M. McCash, Fundamentals of Molecular Spectroscopy, McGraw Hill 2. Principles of Fluorescence Spectroscopy by J R Lakowicz (Springer publication). 3. Optical Spectroscopy: Fundamentals And Advanced Applications by EmilRoduner, Katharina Kress, Patricia B. C. Forbes, TjaartKrüger 4. J. R. Ferraro, K. Nakamoto and C. W. Brown, Introductory Raman Spectroscopy, Academic Press, San Diego, 2003 5. J. Laane, Ed., Frontiers of Molecular spectroscopy, Elsevier, 2009 6. Ira N. Levine Quantum Chemistry, 7e, Pearson 7. Peter Atkins, and Ronald Friedman, Molecular Quantum Mechanics, OXFORD
Learning Outcomes	The students in this course will learn about the fundamentals and advancements in the area of Optical/Absorption Spectroscopy, Fluorescence spectroscopy, IR Spectroscopy, and Raman Spectroscopy. The students will also learn about the physics behind the associated experimental techniques and their use in the characterization of materials. This course will also help students to learn about the advancements in the area of the spectroscopic techniques for the characterization of advanced materials.

Course Title	**PHYMJ87: Particle Physics**			
Category of Course	**Major** / Minor / Minor (Vocational) / SEC / AEC / VAC / MD/Internship/Dissertation (Tick any one of the above)			
Credits & Hour of Teaching		**Theory**	**Practical**	**Cumulative**
	Credits	03	0	03
	Hour of Teaching (Total)	45	0	45
Course Objectives	1. To explain the basic constituents of particles and to describe the symmetries and conservation laws. 2. To explain the kinematics of scattering and decay processes and applications. 3. To explain the fundamental interactions and the ideas of unification. 4. To introduce particle accelerators, particle detectors and sub detectors. 5. To describe the purpose, components, and function of a typical colliding beam machine. 6. How to use the curvature of a charge track to determine the momentum of a particle. 7. To discuss basic concepts in making inference from observation data and discuss associated errors.			
Course Content	The course content be divided into minimum 3 Units to maximum 5 units along with defined hour of teaching for each unit.			

Units	**Course Content**	**Hr. of Teaching**
I	**Relativistic Kinematics:** Four-vectors and Lorentz transformations; Lorentz covariance; Mandelstam variables, kinematics of decays and cross section; deep inelastic scattering, parton model, Bjorken scaling.	12
II	**QED and Electroweak theory:** Brief introduction to QED and Feynman rules (without derivation), gauge invariance, cross section calculations (e.g. electron-muon scattering); Weak interactions and weak decays; Fermi's theory of weak interactions; Ideas of spontaneous symmetry breaking, Higgs mechanism and electro-weak unification.	15
III	**High-Energy Experiments:** Particle accelerators: Linear and circular accelerators, general concept of designing a high energy experiment, coverage and option.; Passage of charged particles through matter, Energy loss curve - Bethe Bloch equation Particle detection: Gaseous and semiconductor detectors; tracking and Calorimetry, shower generation; a general purpose detector. Data analysis: Simulation, calibration, track reconstruction, reconstruction of events, Error analysis.	18

Texts / References	1. Introduction to High Energy Physics: D. H. Perkins 2. An introductory course of Particle Physics: P. B. Pal 3. Introduction to Elementary Particles: D. J. Griffiths 4. Modern Particle Physics: M. Thomson 5. Techniques for nuclear and particle physics experiments: W. R. Leo 6. Experimental Techniques in High Energy Nuclear and Particle physics: T. Ferbel 7. Radiation detection and measurement: G. F. Knoll
Learning Outcomes	Students will have achieved the ability to 1. Understand and apply relativistic kinematics in the decay process. 2. Use the quark model for understanding the properties of hadrons e.g. neutrons and protons. 3. Compare and contrast different types of particle accelerators and particle detectors and sub detectors. 4. Understand interactions of radiation with matter. 5. Analyze and connect measurement results to a physical problem.

Course Title	**PHYMJ88: Astrophysics of Stars and Galaxies**			
Category of Course	**Major** / Minor / Minor (Vocational) / SEC / AEC / VAC / MD/Internship/Dissertation (Tick any one of the above)			
Credits & Hour of Teaching		**Theory**	**Practical**	**Cumulative**
	Credits	03	0	03
	Hour of Teaching (Total)	45	0	45
Course Objectives	This course will provide a detailed knowledge of Stellar Astronomy. Starting from Stellar Structure equations to Star Formation and Evolution will be addressed in depth. The course also aims to briefly introduce Galaxies and Astronomy at large scales.			
Course Content	The course content be divided into minimum 3 Units to maximum 5 units along with defined hour of teaching for each unit.			

Units	**Course Content**	**Hr. of Teaching**
I	**Interiors of Stars** – Hydrostatic Equilibrium, The Virial Theorem, Equation of state, Stellar Energy Sources, Energy Transport including theory of radiative transport, convective transport, Schwarzschild criterion and Thermodynamics, Properties of stellar material , Opacity, Solar interior and Sun's atmosphere, Stellar Model Building	8
II	**The Interstellar Medium and Star Formation** - Interstellar Dust and Gas, The Formation of Protostars, Jeans Criterion, Fragmentation of Collapsing Clouds, Physics of Shock Waves, Pre-Main-Sequence Evolution, Hayashi Phase (Hayashi Line), Nucleosynthesis, Main Sequence and Post-Main-Sequence Stellar Evolution, Evolution on the Main Sequence, Late Stages of Stellar Evolution, Binary Stars, Stellar Clusters	10
III	**Post-Main-Sequence Evolution of Massive Stars** – The Classification of Supernovae, Core-Collapse Supernovae, Gamma-Ray Bursts, Cosmic Rays,	05
IV	**The Degenerate Remnants of Stars –** The Discovery of Sirius B, White Dwarfs, The Physics of Degenerate Matter, The Chandrasekhar Limit, The Cooling of White Dwarfs, Supernova, Neutron Stars, Density and Equation of State, Models, Pulsars, Pulsar Glitch, Black Holes, Area Theorem, Hawking radiation, Mass-Luminosity relation	14
V	**The Milky Way, The Nature of Galaxies** – The Hubble Sequence, Spirals and Irregular Galaxies, Spiral Structure, Elliptical Galaxies, Galactic Evolution, Expanding universe, Interactions of Galaxies, The Formation of Galaxies, Rotation curve for galaxies, Dark Matter, Dark Energy, Gravitational Waves	08

Texts / References	1. An Introduction to Modern Astrophysics, BW Carroll & DA Ostlie, Pearson 2. Introduction to Stellar Astrophysics Volumes I, II and III, Erika Bohm-Vitense, Cambridge University Press 3. An Introduction to the Theory of Stellar Structure and Evolution, D. Prialnik, Cambridge University Press 4. The Physical Universe, F. Shu, University Science Books 5. Theoretical Astrophysics, Volumes I, II and III, T. Padmanabhan, Cambridge University Press
Learning Outcomes	After taking the course, the student will develop an understanding of formation and evolution of stars. The student will also gain insight into the basics of galaxies, its formation and classification.

Course Title	**PHYMJ89: Physics Laboratory-A**			
Category of Course	**Major** / Minor / Minor (Vocational) / SEC / AEC / VAC / MD/Internship/Dissertation (Tick any one of the above)			
Credits & Hour of Teaching		**Theory**	**Practical**	**Cumulative**
	Credits	0	03	03
	Hour of Teaching (Total)	0	90	90
	1. Determine the ratio e/m for an electron by measuring the normal Zeeman splitting of the yellow line of neon using a Spectrometer. 2. Determine the Lande g factor for a given sample (DPPH) using the electron spin resonance spectrometer. 3. In Fabry-Perot Interferometer setup, determine the wavelength of source, determine the gap between Fabry-Perot etalon at different micrometer reading and find the finesse. 4. Determine the resistivity of a given semiconductor at different temperatures using Four-probe method and calculate the energy band gap of the semiconductor. 5. Determine the first excitation potential energy of Argon atom using Franck Hertz experiment. 6. In the Experiment of Faraday Effect show that magnetic rotation follows the $\cos^2$ law of intensity and determine the value of Verdict constant. 7. Study the Kerr effect in Lithium Niobate crystal. 8. Record the emission spectrum of the given lamp and fluorescence spectrum of the dye solution using a Spectrometer. Determine the red shift and quantum yield of Dye.			

OR

Course Title	**PHYMJ810: Physics Laboratory-B**			
Category of Course	**Major** / Minor / Minor (Vocational) / SEC / AEC / VAC / MD/Internship/Dissertation (Tick any one of the above)			
Credits & Hour of Teaching		**Theory**	**Practical**	**Cumulative**
	Credits	0	03	03
	Hour of Teaching (Total)	0	90	90
	1. Design of CE Amplifier 2. Experiment with Differential Amplifier 3. Experiment with Operational Amplifier 4. Transmission Line Trainer 5. Combinational Logic 6. Design of a Regulated Power Supply 7. Multivibrators using CE Amplifier 8. Experiment with Timer (IC-555) 9. Application of Operational Amplifier 10. Counter and Shift Register			

Course Title	**PHYMJ811: Physics Laboratory-C**			
Category of Course	**Major** / Minor / Minor (Vocational) / SEC / AEC / VAC / MD/Internship/Dissertation (Tick any one of the above)			
Credits & Hour of Teaching		**Theory**	**Practical**	**Cumulative**
	Credits	0	01	01
	Hour of Teaching (Total)	0	30	30
	1. Euler method and Modified Euler Methods for solving ODEs 2. Runge-Kutta Method for solving ODEs 3. Differential Coefficient 4. Lagrange Interpolation 5. Gaussian Quadrature 6. Jacobi method of Matrix diagonalization 7. Monte-Carlo Integration			

PHYDS8R1: Dissertation (12 credits)

SEMESTER (VIII)-R

Course Title	**PHYMJ8R1: Research Methodologies**			
Category of Course	**Major** / Minor / Minor (Vocational) / SEC / AEC / VAC / MD/Internship/Dissertation (Tick any one of the above)			
Credits & Hour of Teaching		**Theory**	**Practical**	**Cumulative**
	Credits	02	0	02
	Hour of Teaching (Total)	30	0	30
Course Objectives	This course will introduce the students to the concept of research, how to formulate a research problem, design a research project, read and evaluate research articles, and how to prepare reports, articles and presentations.			
Course Content	The course content be divided into minimum 3 Units to maximum 5 units along with defined hour of teaching for each unit.			

Units	**Course Content**	**Hr. of Teaching**
I	**Introduction** Definition of research, Types of research, Experimental, theoretical and interdisciplinary research; Experimental lab protocol: Lab Record or Log Book, Lab-safety, Lab waste management; Intellectual Property Rights: citation and assignation of proper credit. Ethical issues in research – data falsification, plagiarism and other forms of scientific misconduct.	7
II	**Literature search and review** Importance of conducting literature review, Information sources: libraries, databases, search engines and keywords, styles of referencing, making case studies.	4
III	**Critical scientific reading** Types of research articles- primary, secondary and special articles; Structure of a research article: abstract, introduction, methodology, results and discussion, conclusion, references, appendices; How to read a journal research article, interpreting tables and graphs.	6
IV	**Research design** Objectives of research; Research problem formulation: research questions, problem definition, formulation of hypothesis and its testing; Perseverance and time management, confirmatory/consistency tests.	5
V	**Writing in Physics** How to write a research paper, where and how to submit research papers to journals, journal and article metrics; guidelines for writing thesis/dissertation/report; Writing research proposals and progress reports.	8

Texts / References	1. RESEARCH METHODOLOGY by S. Rajasekar, P. Philominathan, V. Chinnathambihttps://arxiv.org/abs/physics/0601009 2. Research Method for Science by Michael. P. Marder (Cambridge University Press) https://doi.org/10.1017/CBO9781139035118 3. Research Methodology and Scientific Writing by. C.G. Thomas (Springer) https://doi.org/10.1007/978-3-030-64865-7
Learning Outcomes	The students should be able to • demonstrate knowledge of research process (reading, evaluating, and developing) • perform literature reviews using databases (print and online). • read, evaluate, and present a journal paper. • identify, explain and compare the key elements of a research proposal. • explain the rationale for research ethics. • to identify laboratory hazards and implement safe lab practices. • tailor presentations for target audience.

Course Title	**PHYMJ8R2: Research Techniques**			
Category of Course	**Major** / Minor / Minor (Vocational) / SEC / AEC / VAC / MD/Internship/Dissertation (Tick any one of the above)			
Credits & Hour of Teaching		**Theory**	**Practical**	**Cumulative**
	Credits	02	0	02
	Hour of Teaching (Total)	30	0	30
Course Objectives	This course will introduce the students to the different types of data analysis, as well as to different kinds of theoretical and experimental research techniques.			
Course Content	The course content be divided into minimum 3 Units to maximum 5 units along with defined hour of teaching for each unit.			

Units	**Course Content**	**Hr. of Teaching**
I	**Data types and data collection techniques** Digital and analog data, data filtration, outliers.	2
II	**Data analysis** Quantitative and qualitative methods of data analyses, Representing data: tables, charts, 2D and 3D graphs, polar plots; Curve fitting (Regression Analysis); Least square Fit to a Straight line, error estimation of the fitted parameters, limitations of the least square method, Goodness of a fit Error Analysis: Instrumental and Statistical Uncertainties, Propagation of Errors, Application of Error Equations, Statistical Fluctuations: confidence levels.	6
III	**Introduction to theoretical research techniques** Deciding the accuracy level of a calculation, iterative methods, use of computer algebra, numerical computation and simulation, consistency checks, application to DFT, MD, quantum field theoretic calculations	10
IV	**Introduction to experimental research techniques** X-ray diffraction, Optical Microscopy, Scanning Electron Microscopy, Transmission electron Microscopy, Fluorescence Spectroscopy, Raman spectroscopy, X-ray photoelectron spectroscopy, observing multi-messengers from the Universe, particle detection and identification.	10
V	**Methods in scientific thinking** Scientific thinking and objectivity, Correspondence principle, Occam's razor, Eliminating social, economic and religious bias in scientific thinking, the importance of reproducibility in science.	2

Texts / References	Research Ethics for Scientists: A Companion for Students by C. Neal Stewart Jr.
Learning Outcomes	The students should be able to • represent data efficiently for maximum impact • Develop an understanding of techniques in theoretical and experimental research.

BANARAS HINDU UNIVERSITY

Department of Statistics

Faculty of Science

SYLLABI

B.Sc. (Hons.) Programme

In

Statistics

COURSE STRUCTURE FOR 4-YEAR UG STATISTICS, NEP-2020 Department of Statistics, Banaras Hindu University		
Semester-I		
Course Code	**Title**	**Credits**
STAMJ11	Descriptive Statistics	3
STAMJ12	Practical based on STAMJ11	1
STAMN11	Descriptive Statistics	3
STAMN12	Practical based on STAMN11	1
STAMD11	Elementary Statistics	2
STAMD12	Practical based on STAMD11	1
STASE11	Data analysis using Excel	1
STASE12	Practical based on STASE11	2
VA11	(Offered by the University/Institute)	2
VA12	(Offered by the University/Institute)	2
AE11	(Offered by the University/Institute)	2
	Total	**20**
Semester-II		
STAMJ21	Introduction to Probability Theory	3
STAMJ22	Practical based on STAMJ21	1
STAMN21	Introduction to Probability Theory	3
STAMN22	Practical based on STAMN21	1
STAMD21	Inferential Statistics	2
STAMD22	Practical based on STAMD21	1
STASE21	Data analysis using SPSS	1
STASE22	Practical based on STASE21	2
VA21	(Offered by the University/Institute)	2
VA22	(Offered by the University/Institute)	2
AE21	(Offered by the University/Institute)	2
	Total	**20**

Semester-III		
STAMJ31	Basics of Probability Distributions	3
STAMJ32	Sampling Distributions	3
STAMJ33	Practical based on STAMJ31, STAMJ32	2
STAMV31	Connecting Data with Probability Models	3
STAMV32	Practical based on STAMN31	1
STAMD31	Basics of Sample Surveys and Design of Experiment	2
STAMD32	Practical based on STAMD31	1
STASE31	Data analysis using R	1
STASE32	Practical based onSTASE31	2
AE31	(Offered by the University/Institute)	2
	Total	**20**

Semester-IV		
STAMJ41	Statistical Inference I	3
STAMJ42	Sample Surveys and Design of Experiment	4
STAMJ43	Applied Statistics	4
STAMJ44	Practical based on STAMJ41,	1
STAMJ45	Practical based on STAMJ42 and STAMJ43	2
STAMN41	Statistical Inference I	3
STAMN42	Practical based onSTAMN41	1
AE41	(Offered by the University/Institute)	2
	Total	**20**
Semester-V		
Course Code	**Title**	**Credits**
STAMJ51	Operations Research	4
STAMJ52	Numerical Methods	3
STAMJ53	Statistical Inference II	4
STAMJ54	Practical based on STAMJ51, STAMJ52 and STAMJ53	3
STAIN51	Internship	2
STAMV51	Structure and Visualization of Data	3
STAMV52	Practical based on STAMV51	1
	Total	**20**
Semester-VI		
STAMJ61	Stochastic Processes	3
STAMJ62	Statistical Process Control and Reliability	3
STAMJ63	Econometrics and Actuarial Statistics	4
STAMJ64	Official and Vital Statistics	3
STAMJ65	Practical based on STAMJ61, STAMJ62, and STAMJ64	3
STAMV61	Data-Driven Decision Making	3
STAMV62	Practical based on STAMV61	1
	Total	**20**

Semester-VII		
STAMJ71	Linear Models & Regression Analysis	3
STAMJ72	Measure & Probability Theory	3
STAMJ73	Survey Sampling	3
STAMJ74	Advanced Statistical Inference	4
STAMJ75	Practical based on STAMJ71	1
STAMJ76	Practical based on STAMJ73 and STAMJ74	2
STAMN71	Linear Models & Regression Analysis	3
STAMN72	Practical based on STAMN71	1
	Total	**20**
Semester-VIII (for Honours Students)		
STAMJ81	Design and Analysis of Experiments	3
STAMJ82	Multivariate Analysis	3
STAMJ83	Bayesian Inference	3
STAMJ84	Statistical Aspects of Machine Learning	3
STAMJ85	Practical based on STAMJ81	1
STAMJ86	Practical based on STAMJ82, STAMJ83, STAMJ84	3
STAMN81	Design and Analysis of Experiments	3
STAMN82	Practical based on STAMN81	1
	Total	**20**

Semester-VIII (for Honours with Research Students)		
Major Elective theory Courses		
STAMJ8R1	Distribution Theory	3
STAMJ8R2	Technical Demography	3
STAMJ8R3	Bayesian Inference	3
STAMJ8R4	Advanced Theory of Sample Surveys	3
STAMJ8R5	Statistical Process and Quality Control	3
Student may opt any ONE course among the above list of major elective courses with 3 credits		
STAMJ8R6	Practical based on Elective STAMJ8R1 to STAMJ8R5	1
STADS8R1	Project/Dissertation	12
STAMN8R1	Same as the Major Elective opted	3
STAMN8R2	Practical based on STAMN8R1	1
	Total	**20**

Note: Practical will based on the different software and programming languages.

Semester I

Course Title: STAMJ11: Descriptive Statistics

Category of Course: Major

Credits &Hours of Teaching

	Theory	Practical	Cumulative
Credits	**3**	**1**	**4**
Hours of Teaching (Total)	**45**	**30**	**75**

Course Objectives

1. To understand the concept of basic statistics, types of data, collection methods, variables and their types.
2. To know the summarization and representation of numerical data through diagrams and graphs, frequency distribution.
3. To understand central value and dispersion of data and their different measurements and describing nature of frequency curve.
4. To aware about bivariate data and their relation/functional relation through different measures.

Course Content: The course content be divided into minimum 3 Units to maximum 5 units along with defined Hours of teaching for each unit.

Units	Course Content	Hours of Teaching
I	Origin of Statistics & its application area, Data and its sources: primary and secondary. Data collection methods: designing a questionnaire and schedule. Scales of measurements. Types of variable: discrete variable, continuous variable, qualitative variable, quantitative variable. Construction and properties of tables. Distribution of variables. Discrete distribution, continuous distribution, cumulative distribution.	10
II	Graphical summarization of data: histogram, frequency polygon, frequency curve, ogives, stem-and-leaf plot, box plot, bar chart, multiple bar chart, stack bar plot, pie chart, line chart, diagrammatic and graphical representation of grouped data, frequency and cumulative frequency distribution and their applications.	10
III	Concept of central tendency and its measures, partition values, dispersion and relative dispersion, moments, Sheppard's correction for moments, skewness, kurtosis and their measures. Bivariate data: Scatter diagram, measurement of covariation, standardized covariation (product moment correlation coefficient) with assumptions and its properties, Spearman's correlation, point biserial correlation, biserial correlation, coefficient of determination.	10
IV	Theory of attributes: Independence and Association of attributes, various measures of association for two-way classified data.	5
V	Regression: purpose and scope, simple linear regression and concept of error, principle of least square and fitting of linear regression. Properties of regression equations, properties of regression coefficients, predicted and residual variances.	10

Texts / References:

1. Chattamvelli, R., & Shanmugam, R. (2023). *Descriptive statistics for scientists and engineers*. Springer.
2. Holcomb, Z. (2016). *Fundamentals of descriptive statistics*. Routledge.
3. Kore, B. G., & Dixit, P. G. (2022). Descriptive Statistics-I. *Nirali Prakashan, Pune*.
4. Goon A.M., Gupta A.K. and Das Gupta B. (2014): Fundamental of Statistics, Vol. I (5^{th} edition), World Press, Calcutta.
5. Mood A.M., Greybill, F.A. and Boes D.C. (1974): Introduction to the Theory of Statistics, McGraw Hill.
6. Freund, R. J., & Wilson, W. J. (2003). Statistical Methods, Elsevier.
7. Croxton F.E., Cowden D.J. and Karlin S. (1973) Applied General Statistics.

Learning Outcomes: Upon completing this course, students will achieve the following learning outcomes:

1. Students will learn data types and tools: become familiar with both quantitative and qualitative data, and the statistical tools available for their analysis.
2. They will learn to tabulate and present them into diagrams and graphs and interpret data.
3. Understand Statistical Measures: Comprehend various measures of central tendency, dispersion, skewness, kurtosis, and the properties of moments.
4. Explore Linear Correlation: Determine linear correlations between two variables using different measures, and study their properties.
5. Apply the least squares method to fit curves and regression lines, and understand their basic properties
6. Compute Measures of Association: Learn to calculate different measures of association within the theory of attributes.

Course Title	STAMJ12: Practical Based on STAMJ11

Paper will be based on numerical problems on different units of Paper STAMJ11

Unit	Hours of Practical
Unit I&II	5
Unit III	10
Unit IV&V	15

Course Title:	STAMN11: Descriptive Statistics

Category of Course: Minor

Credits &Hours of Teaching

	Theory	Practical	Cumulative
Credits	**3**	**1**	**4**
Hours of Teaching (Total)	**45**	**30**	**75**

Course Objectives

1. To understand the concept of basic statistics, types of data, collection methods, variables and their types.
2. To know the summarization and representation of numerical data through diagrams and graphs, frequency distribution.
3. To understand central value and dispersion of data and their different measurements and describing nature of frequency curve.
4. To aware about bivariate data and their relation/functional relation through different measures.

Course Content: The course content be divided into minimum 3 Units to maximum 5 units along with defined Hours of teaching for each unit.

Units	Course Content	Hours of Teaching
I	Origin of Statistics & its application area, Data and its sources: primary and secondary. Data collection methods: designing a questionnaire and schedule. Scales of measurements. Types of variable: discrete variable, continuous variable, qualitative variable, quantitative variable. Construction and properties of tables. Distribution of variables. Discrete distribution, continuous distribution, cumulative distribution.	10
II	Graphical summarization of data: histogram, frequency polygon, frequency curve, ogives, stem-and-leaf plot, box plot, bar chart, multiple bar chart, stack bar plot, pie chart, line chart, diagrammatic and graphical representation of grouped data, frequency and cumulative frequency distribution and their applications.	10
III	Concept of central tendency and its measures, partition values, dispersion and relative dispersion, moments, Sheppard's correction for moments, skewness, kurtosis and their measures. Bivariate data: Scatter diagram, measurement of covariation, standardized covariation (product moment correlation coefficient) with assumptions and its properties, Spearman's correlation, point biserial correlation, biserial correlation, coefficient of determination.	10
IV	Theory of attributes: Independence and Association of attributes, various measures of association for two way classified data.	5
V	Regression: purpose and scope, simple linear regression and concept of error, principle of least square and fitting of linear regression. Properties of regression equations, properties of regression coefficients, predicted and residual variances.	10

Texts / References:

1. Chattamvelli, R., & Shanmugam, R. (2023). *Descriptive statistics for scientists and engineers*. Springer.
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3. Kore, B. G., & Dixit, P. G. (2022). Descriptive Statistics-I. *Nirali Prakashan, Pune*.
4. Goon A.M., Gupta A.K. and Das Gupta B. (2014): Fundamental of Statistics, Vol. I (5th edition), World Press, Calcutta.
5. Mood A.M., Greybill, F.A. and Boes D.C. (1974): Introduction to the Theory of Statistics, McGraw Hill.
6. Freund, R. J., & Wilson, W. J. (2003). Statistical Methods, Elsevier.
7. Croxton F.E., Cowden D.J. and Karlin S. (1973) Applied General Statistics.

Learning Outcomes: Upon completing this course, students will achieve the following learning outcomes:

1. Students will learn data types and tools: become familiar with both quantitative and qualitative data, and the statistical tools available for their analysis.
2. They will learn to tabulate and present them into diagrams and graphs and interpret data.
3. Understand Statistical Measures: Comprehend various measures of central tendency, dispersion, skewness, kurtosis, and the properties of moments.
4. Explore Linear Correlation: Determine linear correlations between two variables using different measures, and study their properties.
5. Apply the least squares method to fit curves and regression lines, and understand their basic properties
6. Compute Measures of Association: Learn to calculate different measures of association within the theory of attributes.

Course Title	**STAMN12: Practical Based on STAMN11**

Paper will be based on numerical problems on different units of Paper STAMN11

Unit	**Hours of Practical**
Unit I&II	5
Unit III	10
Unit IV&V	15

Course TitleSTAMD11:Elementary Statistics

Category of Course: MD

Credits & Hours of Teaching:

	Theory	**Practical**	**Cumulative**
Credits	**2**	**1**	**3**
Hours of Teaching (Total)	**30**	**30**	**60**

Course Objectives:

1. To understand data and its type.
2. To develop idea of graphical representation of data
3. To convert data to single point and its distance
4. To understand bivariate relation

Course Content: The course content be divided into minimum 3 Units to maximum 5 units along with defined Hours of teaching for each unit.

Units	**Course Content**	**Hours of Teaching**
I	Data Types and Measurement Scales: Understanding different data types (nominal, ordinal, interval, ratio), Identifying appropriate measurement scales for variables, Implications of measurement scales on descriptive statistics.	5
II	Data Visualization for Descriptive Statistics: Diagrammatic and Graphical representation of data (bar plots, histograms, box plots), Interpreting visual representations of data distributions, using summary statistics in conjunction with graphs. Introduction to Exploratory Data Analysis (EDA): Overview of EDA and its importance in data analysis, The EDA process and its key components, Understanding the role of EDA in decision-making.	5
III	Measures of Central Tendency: Mean median, and mode, weighted mean and its application,	10

	selecting appropriate measures for different data distributions. Measures of Dispersion: Range and interquartile range, Quantiles and percentiles, Variance and standard deviation, Coefficient of variation, Skewness and kurtosis. Summary statistics and data distributions.	
IV	Exploring Relationships and Dependencies: Cross-tabulation and contingency tables, Scatter plots and measures of correlation coefficients (Pearson, Spearman), Interpreting relationships and dependencies between variables. Regression Analysis: Simple and multiple linear regression, interpreting regression coefficients and making predictions	10

Texts / References

1. Chattamvelli, R., & Shanmugam, R. (2023). *Descriptive statistics for scientists and engineers*. Springer.
2. Holcomb, Z. (2016). *Fundamentals of descriptive statistics*. Routledge.
3. Kore, B. G., & Dixit, P. G. (2022). Descriptive Statistics-I. *Nirali Prakashan, Pune*.
4. Goon A.M., Gupta A.K. and Das Gupta B. (2014): Fundamental of Statistics, Vol. I (5^{th} edition), World Press, Calcutta.
5. Mood A.M., Greybill, F.A. and Boes D.C. (1974): Introduction to the Theory of Statistics, McGraw Hill.
6. Freund, R. J., & Wilson, W. J. (2003). Statistical Methods, Elsevier.
7. Croxton F.E., Cowden D.J. and Karlin S. (1973) Applied General Statistics.

Learning Outcomes:

1. Student will learn types of variable, nature and scale of measurement.
2. Enhance the understanding data structure and hidden facts in data through diagrams.
3. Student will be capable to know the summary statistics and its utility.
4. Student will be capable to know the idea of relationship between variables and prediction.

Course Title	**STAMD12: Practical Based on STAMD11**

Paper will be based on numerical problems on different units of Paper STADMD11

Unit	**Hours of Practical**
Unit I&II	10
Unit III	10
Unit IV	10

Course Title: STASE11: Data analysis using Excel

Category of Course: SEC

Credits &Hours of Teaching

	Theory	**Practical**	**Cumulative**
Credits	**1**	**2**	**3**
Hours of Teaching (Total)	**15**	**60**	**75**

Course Objectives:

1. To understand basics of EXCEL and their functions.
2. To know about data mining, including data importation and organization of data.
3. To understand the statistical analysis using EXCEL.

Course Content: The course content is divided into minimum 3 Units to maximum 5 units along with defined Hours of teaching for each unit.

Units	Course Content	Hours of Teaching
I	How to use variables; enter data, copy and paste cells, and format text in Excel. Auto sum, fill, sort, filter, find, replace, and conditional formatting functions to your data. Create tables and pivot tables for data handling. Manipulate data with new variables, if statements, and other operators. Use freeze and name functions for data analysis.	5
II	Create frequency distributions and graphs for your data. Decorate and export your graphs to other applications. Compute descriptive statistics, correlation, regression, and probability with Excel functions. Interpret the results for decision making.	5
III	Test hypotheses with t tests, chi-square tests, ANOVA, and other methods. Rank and calculate percentiles for your data. Import and export data from different sources to Excel. Link and consolidate data across workbooks and worksheets. Analyze data from multiple sources.	5

Texts / References

1. Bill Jelen, and Michael Alexander (2021): Microsoft Excel 2019 Pivot Table Data Crunching (Business Skills), Microsoft Publication.
2. Wayne L. Winston (2014): Marketing Analytics: Data-Driven Techniques with Microsoft Excel 1st Edition, Wiley Publication.
3. Gordon S. Linoff(2015): Data Analysis Using SQL and Excel 2nd Edition, Wiley Publication.

Learning Outcomes: Students will learn to:

1. EXCEL tasks such as data entry, formatting, and creating formulas.
2. Essential data analysis techniques including sorting, filtering, pivot tables, different charts and graphs.
3. Organization of data for applying different statistical tests using EXCEL.

Course Title	**STASE12: Practical Based on STASE11**

Paper will be based on numerical problems on different units of Paper STASE11

Unit	Hours of Practical
Unit I	20
Unit II	20
Unit III	20

Note: Syllabus of Course code STAVA11, STAVA12 and STAAE11 will be framed at faculty level

Semester-II

Course Title: STAMJ21: Introduction to Probability Theory

Category of Course: Major

Credits & Hours of Teaching

	Theory	Practical	Cumulative
Credits	**3**	**1**	**4**
Hours of Teaching (Total)	**45**	**30**	**75**

Course Objectives:

1. To understand fundamental knowledge of probability theory and its computation.
2. To explore characteristics of random variables and its probability distribution.
3. To understand expectation, moments and different generating functions.
4. Additionally, it provides insight into key theoretical distributions and their basic properties

Course Content: The course content be divided into minimum 3 Units to maximum 5 units along with defined Hours of teaching for each unit.

Units	Course Content	Hours of Teaching
I	Review of combinatorial analysis. Random experiment: Trial, sample point, sample space, elementary events, events, equally likely, disjoint events, mutually exclusive events and exhaustive events. Classical and relative frequency approach to probability, axiomatic approach to probability, merits and demerits of these approaches, properties of probability. Conditional probability and independence, total and compound probability theorems, partition of sample	15

	space, Bayes theorem and its applications	
II	Random Variable: Concept of discrete random variable, distribution function, probability mass function, joint probability mass function of several discrete random variables, marginal and conditional probability mass functions. Continuous random variable, probability density function, joint density function of two continuous variables, marginal and conditional probability density functions.	10
III	Expectation of random variables and its properties, conditional expectation, moments in terms of expectation, conditional expectations.	5
IV	Moments and cumulants, moment generating function, cumulant generating function, probability generating functions, Probability inequalities (Markov's and Chebychev's).	10
V	Basic idea and properties of some theoretical probability distributions: Binomial, Poisson and Normal distributions.	5

Texts / References

1. Ross, S. M. (2010). A first course in probability (Vol. 2). New York: Macmillan.8th edition
2. Feller, W. (1991). An introduction to probability theory and its applications, Volume 2. John Wiley & Sons.
3. Bhat B.R., Srivenkataramana T. and Rao Madhava K.S. (1996): Statistics, A Beginner's Text, Vol. I and II, New Age International (P) Ltd.
4. Snedecor's G.W. and Cochran W.G. (1989): Statistical Methods, Iowa State University Press. 8th edition
5. Mood A.M., Greybill F.A. and Bose D.C. (2017): Introduction to the Theory of Statistics, McGraw Hill. 3rd edition
6. Spiegel M.R. (1992): Theory and problem of Statistics, Schaum's Publishing Series.2nd edition
7. Goon A.M., Gupta M.K. and Das Gupta B. (2013): Fundamental of Statistics, Vol. I, World Press, Calcutta
8. Meyer P.L. (1970): Introductory Probability and Statistical Applications, Addision Wesley. 2nd edition
9. Parzen E. (1992): Modern Probability Theory and its Applications, Wiley Eastern.
10. Hogg R.V. and Craig A.T. (2019): Introduction to mathematical Statistics, Amerind Publishing Co. 8th edition
11. Hoel P.G. (1984): Introduction to Mathematical Statistics, Asia Publication. 5th edition
12. Rohtagi, V.K. (2015) An Introduction to Probability Theory and Mathematical Statistics, John Wiley and Sons. 3rd edition.

Learning Outcomes: Students will be able to:

(1) Acquire a strong understanding of elementary probability theory and its applications.
(2) Comprehend the axiomatic foundation of modern probability theory and recognize the role of random variables in analyzing random phenomena.
(3) Understand the laws of probability and effectively use Bayes' theorem
(4) Characterize probability models and functions of random variables for both single and multiple random variables.
(5) Evaluate and apply expectation, moments and characteristic functions, and grasp concepts related to inequalities and probabilistic limits.
(6) Gain a thorough understanding of some standard univariate distributions and someproperties.

Course Title	STAMJ22: Practical Based on STAMJ21

Paper will be based on numerical problems on different units of Paper STAMJ21

Unit	Hours of Practical
I&II	10
III	6
IV&V	14

Course Title: STAMN21: Introduction to Probability Theory

Category of Course: Minor

Credits & Hours of Teaching

	Theory	Practical	Cumulative
Credits	**3**	**1**	**4**
Hours of Teaching (Total)	**45**	**30**	**75**

Course Objectives:

1. To understand fundamental knowledge of probability theory and its computation.
2. To explore characteristics of random variables and its probability distribution.
3. To understand expectation, moments and different generating functions.
4. Additionally, it provides insight into key theoretical distributions and their basic properties

Course Content: The course content be divided into minimum 3 Units to maximum 5 units along with defined Hours of teaching for each unit.

Units	Course Content	Hours of Teaching
I	Review of combinatorial analysis. Random experiment: Trial, sample point, sample space, elementary events, events, equally likely, disjoint events, mutually exclusive events and exhaustive events. Classical and relative frequency approach to probability, axiomatic approach to probability, merits and demerits of these approaches, properties of probability. Conditional probability and independence, total and compound probability theorems, partition of sample space, Bayes theorem and its applications	15
II	Random Variable: Concept of discrete random variable, distribution function, probability mass function, joint probability mass function of several discrete random variables, marginal and conditional probability mass functions. Continuous random variable, probability density function, joint density function of two continuous variables, marginal and conditional probability density functions.	10
III	Expectation of random variables and its properties, conditional expectation, moments in terms of expectation, conditional expectations.	5
IV	Moments and cumulants, moment generating function, cumulant generating function, probability generating functions, Probability inequalities (Markov's and Chebychev's).	10
V	Basic idea and properties of some theoretical probability distributions: Binomial, Poisson and Normal distributions.	5

Texts / References

1. Ross, S. M. (2010). A first course in probability (Vol. 2). New York: Macmillan.8th edition
2. Feller, W. (1991). An introduction to probability theory and its applications, Volume 2. John Wiley & Sons.
3. Bhat B.R., Srivenkataramana T. and Rao Madhava K.S. (1996): Statistics, A Beginner's Text, Vol. I and II, New Age International (P) Ltd.
4. Snedecor's G.W. and Cochran W.G. (1989): Statistical Methods, Iowa State University Press. 8th edition
5. Mood A.M., Greybill F.A. and Bose D.C. (2017): Introduction to the Theory of Statistics, McGraw Hill. 3rd edition
6. Spiegel M.R. (1992): Theory and problem of Statistics, Schaum's Publishing Series.2nd edition
7. Goon A.M., Gupta M.K. and Das Gupta B. (2013): Fundamental of Statistics, Vol. I, World Press, Calcutta
8. Meyer P.L. (1970): Introductory Probability and Statistical Applications, Addision Wesley. 2nd edition
9. Parzen E. (1992): Modern Probability Theory and its Applications, Wiley Eastern.
10. Hogg R.V. and Craig A.T. (2019): Introduction to mathematical Statistics, Amerind Publishing Co. 8th edition
11. Hoel P.G. (1984): Introduction to Mathematical Statistics, Asia Publication. 5th edition
12. Rohtagi, V.K. (2015) An Introduction to Probability Theory and Mathematical Statistics, John Wiley and Sons. 3rd edition.

Learning Outcomes: Students will be able to:

(1) Acquire a strong understanding of elementary probability theory and its applications.
(2) Comprehend the axiomatic foundation of modern probability theory and recognize the role of random variables in analyzing random phenomena.
(3) Understand the laws of probability and effectively use Bayes' theorem
(4) Characterize probability models and functions of random variables for both single and multiple random variables.
(5) Evaluate and apply expectation, moments and characteristic functions, and grasp concepts related to inequalities and probabilistic limits.
(6) Gain a thorough understanding of some standard univariate distributions and someproperties.

Course Title	**STAMN22: Practical Based on STAMN21**

Paper will be based on numerical problems on different units of Paper STAMN21

Unit	**Hours of Practical**
I&II	10
III	6
IV&V	14

Course Title: STAMD21: Inferential Statistics

Category of Course: MD

Credits & Hours of Teaching:

	Theory	**Practical**	**Cumulative**
Credits	**2**	**1**	**3**
Hours of Teaching (Total)	**30**	**30**	**60**

Course Objectives:

1. To understand the measurement of uncertainty.
2. To understand the estimation process:
   (i) Point estimation
   (ii) Interval estimation
   (iii) Hypothesis testing
3. To understand non parametric hypothesis tests

Course Content: The course content be divided into minimum 3 Units to maximum 5 units along with defined Hours of teaching for each unit.

Units	**Course Content**	**Hours of Teaching**
I	Overview of statistical methods and their applications. Probability and Probability Distributions: Fundamentals of probability theory, Discrete and continuous probability distributions, Binomial, Poisson and Normal distribution and its properties, Sampling distributions standard error and Central Limit Theorem.	10
II	Statistical Inference-Estimation; Point estimation and interval estimation, Confidence intervals for population parameters, Sample size determination for estimation.	5
III	Hypothesis Testing: Introduction to hypothesis testing, Z-test, One-sample and two-sample t-tests, Categorical Data Analysis: Chi-square test of independence of attributes, Chi-square test of goodness-of-fit, Chi-square test for contingency tables, Log-linear models for categorical data analysis, Interpreting and reporting results for categorical data.	10
IV	Nonparametric Methods: Wilcoxon signed-rank test, Mann-Whitney U test, Kruskal-Wallis test, Interpreting nonparametric test results.	5

Texts / References

1. Cheryl Ann Willard**,** Statistical Methods, (2020): An Introduction to Basic Statistical Concepts and Analysis, Taylor and Francis Group, 2020**.**
2. Goon A.M., Gupta A.K. and Das Gupta B. (1999): Fundamental of Statistics, Vol. I, World Press, Calcutta.
3. Mood A.M., Greybill, F.A. and Bose D.C. (1974): Introduction to the Theory of Statistics, McGraw Hill.
4. Goon A.M., Gupta A.K. and Das Gupta B. (1999): Fundamental of Statistics, Vol. II, World Press, Calcutta.

Learning Outcomes: Students will learn to:

1. Estimate unknown parameters of different models on the basis of data and its fitting.
2. Validate the known parameter value on the basis of model and data.

3. To use different statistical tests for validation/comparison of quantitative and qualitative data for known distribution.
4. To use different statistical tests for validation/comparison of quantitative and qualitative data for unknown distribution.

STAMD22: Practical Based on STAMD21

Paper will be based on numerical problems on different units of Paper STAMD21

Unit	Hours of Practical
I	4
II&III	20
IV	6

Course Title: STASE21: Data analysis using SPSS

Category of Course: SEC

Credits & Hours of Teaching

	Theory	Practical	Cumulative
Credits	**1**	**2**	**3**
Hours of Teaching (Total)	**15**	**60**	**75**

Course Objectives:

1. To understand basics of SPSS and their different functions.
2. To know about data mining, including data importation and organization of data through SPSS.
3. To understand the statistical analysis using SPSS.
4. To strengthen students' ability to analyze and interpret data using a range of statistical techniques

Course Content: The course content be divided into minimum 3 Units to maximum 5 units along with defined Hours of teaching for each unit.

Units	Course Content	Hours of Teaching
I	How to use SPSS interface, terms, and data formats? Import and export data from different sources. Navigate data editor and variable view. Data types and measurement levels. Data Entry and Manipulation, Recode and transform variables. Merge and append datasets. Descriptive Statistics: central tendency, variability, etc. Frequency distributions and histograms. Cross-tabulate variables and make contingency tables. Function for descriptive analysis.	5
II	Data Visualization: Create and customize charts and graphs. Add data labels and annotations. Export charts and graphs from SPSS. Transform variables (standardize, normalize, etc.). Create new variables in SPSS. Compute and recode variables. Run frequency analysis and descriptive statistics on specific variables.	5
III	Parametric Tests: Independent and paired t-tests, one-way ANOVA, etc. Nonparametric Tests: chi-square test, Mann-Whitney U test, Wilcoxon signed-rank test, Kruskal-Wallis test, etc. Correlation and Regression: Pearson's and Spearman's correlation coefficients, simple and multiple linear regression analysis. Check assumptions and interpret results of regression analysis. Generate scatter plots and regression output.	5

Texts / References

1. Kenneth Stehlik-Barry, Anthony J. Babinec (2017): Data Analysis with IBM SPSS Statistics, Packt Publishing.
2. Andy Field (2020): Discovering Statistics Using IBM SPSS Statistics, Sage Publication Ltd.
3. Julie Pallant (2013): SPSS Survival Manual: A Step by Step Guide to Data Analysis Using IBM SPSS 5th Edition.
4. George, D., & Mallery, P. (2019). *IBM SPSS statistics 26 step by step: A simple guide and reference*. Routledge.
5. Leech, N. L., Barrett, K. C., & Morgan, G. A. (2014). *IBM SPSS for intermediate statistics: Use and interpretation*. Routledge.
6. Cleophas, T. J., &Zwinderman, A. H. (2016). *SPSS for Starters and 2nd Levelers* (pp. 35-40). Cham, Switzerland: Springer.

Learning Outcomes: Students will learn to:

1. SPSS tasks such as data entry, formatting, and creating formulas.
2. Essential data analysis techniques including sorting, recoding and computing, filtering, different charts and graphs.
3. Organization of data for applying different parametric and non parametric statistical tests using SPSS.

Course Title	**STASE22: Practical Based on STASE21**

Paper will be based on numerical problems of Paper STADSE21

Unit	**Hours of Practical**
I	30
II	20
III	10

Note: Syllabus of Course code STAVA21, STAVA22 and STAAE21 will be framed at faculty level

Semester III

Course Title: STAMJ31: Basics of Probability Distributions

Category of Course: Major

Credits & Hours of Teaching

	Theory	**Practical**	**Cumulative**
Credits	**3**	**1**	**4**
Hours of Teaching (Total)	**45**	**30**	**75**

Course Objectives:

1. This course is designed to introduce various discrete and continuous probability distributions along with their properties and real-life applications.
2. This course will also introduce the theoretical development of the distribution of function of one/two-dimensional random variable.
3. The students will also have idea about bivariate data and associated numerical measures.
4. To understand the idea and application of bivariate probability distribution.

Course Content: The course content be divided into minimum 3 Units to maximum 5 units along with defined Hours of teaching for each unit.

Units	**Course Content**	**Hours of Teaching**
I	Standard discrete and continuous distributions: binomial, Poisson, geometric, negative binomial, hypergeometric, uniform, normal, beta, exponential, and gamma distributions.	15
II	Moment generating function, probability generating function of above distributions, bivariate normal distributions with properties and their applications. Additive property and applications of above distributions	10
III	Distribution of function of univariate and bivariate random variables using moment generating function, distribution function and linear transformation method.	5
IV	Correlation and Regression of bivariate continuous random variables. Regression functions and their properties	10
V	Bivariate normal distribution: Marginal distribution, conditional distribution and simple problems based on bivariate normal distribution.	5

Texts / References

1. Mukhopadhyay, P. (1996): Mathematical Statistics, New Central Book Agency.
2. Hoel P.G. (1971): Introduction to Mathematical Statistics, Asia Publishing House.
3. Goon A.M., Gupta A.K. and Das Gupta B. (2014): Fundamental of Statistics, Vol. I (5^{th} edition), World Press, Calcutta.
4. Mood A.M., Greybill, F.A. and Boes D.C. (1974): Introduction to the Theory of Statistics, McGraw Hill.
5. Forbes, C., Evans, M., Hastings, N., & Peacock, B. (2011). *Statistical distributions* (1st ed.). John Wiley & Sons.
6. Hogg, R. V., McKean, J. W., & Craig, A. T. (2021). *Introduction to mathematical statistics* (8th ed.). Pearson Education India.
7. Feller, W., & Morse, P. M. (1958). *An introduction to probability theory and its applications*.
8. Rohatgi, V.K. and Saleh, A.K.M.E. (2001): An Introduction to Probability and Statistics, Second Edition, John Wiley & Sons.

Learning Outcomes: Students will be able to:

1. Express the features of discrete and continuous random variables.
2. know about the different characterizations of discrete probability distribution
3. know about the different characterizations of the continuous probability distribution
4. define different generating function for probability distributions
5. describe bivariate data numerically and graphically.
6. have some idea about bivariate probability distribution and its applications.

Course Title: STAMJ32: Sampling Distributions

Category of Course: Major

Credits & Hours of Teaching

	Theory	**Practical**	**Cumulative**
Credits	**3**	**1**	**4**
Hours of Teaching (Total)	**45**	**30**	**75**

Course Objectives:

1. To understand idea of population and sample
2. To understand concept of sampling distribution
3. To derive sampling distributions of function of random sample
4. To understand order statistics.

Course Content: The course content be divided into minimum 3 Units to maximum 5 units along with defined Hours of teaching for each unit.

Units	**Course Content**	**Hours of Teaching**
I	Concept of population and their types, simple random sample from a distribution, statistic and its sampling distribution, standard error, Construction of sampling distribution of statistic; derivation of distribution of sample mean, sample variance and sample proportions	15
II	Derivation of some more sampling distributions viz. Chi-square distribution, t-distribution, F-distribution, Z-distribution and their properties with applications.	15
III	Order statistics: Definition and distributions of different order statistics viz. smallest, largest, r^{th} etc. Joint distribution of order statistics and distribution of Range and median along with their applications.	15

Texts / References

1. B Mood A.M., Greybill F.A. and Bose D.C. (1974): Introduction to the Theory of Statistics, McGraw Hill.
2. Freund J.E. (2001) : Mathematical Statistics, Prentice hall of India.
3. Hoges J.L. and Lehmann E.L. (1964): Basic Concepts of Probability and Statistics, Holden Day.
4. Snedecor G.W. and Cochran W.G. (1989): Statistical Methods, 8th edition, Iowa State University Press.
5. Mukhopadhyay P. (1996): Mathematical Statistics, NCBA.
6. Wackerly, D. D., Mendenhall III, W., & Scheaffer, R. L. (2014). *Mathematical Statistics with Applications* (8th ed.). Duxbury Press.

Learning Outcomes: Upon completing this course, students will achieve the following learning outcomes:

1. Concept of types of population and methods of drawing the random sample.
2. Construction of sampling distributions of sample-based statistic viz., mean and proportions.
3. Properties and applications of ordered random variables.
4. Idea about distribution of order statistics and function of order statistics.
5. Theory and applications of some standard sampling distributions.

Course Title	**STAMJ33: Practical Based on STAMJ31 & STAMJ32**

Paper will be based on numerical problems of Paper STAMJ31 & STAMJ32 as per following distribution

Paper and Unit	Number of Practical
Paper STAMJ31Unit I to V	30
Paper STAMJ32Unit I to III	30

Course Title: STAMV31: Connecting Data with Probability Models

Category of Course: MV

Credits & Hours of Teaching

	Theory	Practical	Cumulative
Credits	3	1	4
Hours of Teaching (Total)	**45**	**30**	**75**

Course Objectives

1. To make a solid understanding of applications of discrete and continuous probability distributions.
2. To understand the concept of sampling distributions and the Central Limit Theorems for applications.
3. Apply probability models to classification and prediction tasks.
4. Explore advanced probability models and their applications.

Course Content: The course content be divided into minimum 3 Units to maximum 5 units along with defined Hours of teaching for each unit.

Units	**Course Content**	**Hours of Teaching**
I	Statistical approach of probability. Conditional probability and its application based on data. Idea of probability distributions viz Bernoulli, Binomial, Poisson, Geometric, negative binomial normal, uniform and other continuous distributions and their properties.	15
II	Fitting of distributions on random data sets. Basic idea of inference. Population, Sample, parameter, estimator, estimate, methods of estimation. Probability distribution of functions of sample data. Concept of sampling distribution.	10
III	Idea of central limit theorem and introduction to hypothesis testing and construction of confidence intervals. Confusion matrix and types of errors in hypothesis testing. Level of significance, critical region.	10
IV	Idea of small and large sample tests. Data based application of Z test, t test, paired t test, chi square test, Idea of transition probability Advanced	10

Texts / References

1. David Spiegelhalter (2020). Art of Statistics, Learning from data. A Pelican Book.
2. Debra A. Perkowski, Michael Perkowski, UMO University of Missouri, (2006). Data and Probability Connections. Pearson Publication.
3. Wackerly, D. D., Mendenhall III, W., & Scheaffer, R. L. (2007). *Mathematical Statistics with Applications* (7th ed.). Duxbury Press.
4. Hogg, R. V., McKean, J. W., & Craig, A. T. (2012). *Introduction to Mathematical Statistics* (7th ed.). Pearson Education.

Learning Outcomes: Students will be able to:

1. Applications and utility of Probability models and their real-life applications.
2. Statistical concepts and sampling distributions of statistic.
3. How to apply probability models for decision making in real life problems.
4. Learn some advanced probability models and their applications.

Course Title	**STAMV32: Practical Based on STAMV31**

Paper will be based on numerical problems of different units of Paper STAMV31

Unit	**Hours of Practical**
I	4
II	10
III	6
IV	10

Course Title: STAMD31: Basics of Sample Surveys and Design of Experiment

Category of Course: MD

Credits & Hours of Teaching

	Theory	Practical	Cumulative
Credits	**2**	**1**	**3**
Hours of Teaching (Total)	**30**	**30**	**60**

Course Objectives:

1. To explain the concepts of population, sample, census, sampling and non- sampling error
2. To understand concept of probability and non probability sampling
3. To plan, design and conduct experiments.
4. To understand the concepts of ANOVA and basic designs

Course Content: The course content be divided into minimum 3 Units to maximum 5 units along with defined Hours of teaching for each unit.

Units	Course Content	Hours of Teaching
I	Concept of population and sample, need for sampling, complete enumeration versus sampling. Basic concepts in sampling, sampling and Non-sampling errors.	5
II	Concept of probability and non-probability sampling and their applications: Simple random sampling with and without replacement, Stratified random sampling, proportional and optimum allocation, Systematic sampling (when population size (N) is an integer multiple of sampling size (n)).	10
III	Analysis of Variance (ANOVA); One-way ANOVA and post hoc tests, Two-way ANOVA, Assumptions and limitations of ANOVA, Interpreting ANOVA results and performing follow-up analyses.	5
IV	Experimental Design: Principles of experimental design, Completely Randomized Design (CRD), and Randomized Block Design (RBD). Randomized controlled trials, Factorial designs and interaction effects, interpreting experimental design results.	10

Texts / References

1. Cochran, W. G. (1977). *Sampling Techniques* (3rd ed.). John Wiley and Sons, New York.
2. Sukhatme, P. V., Sukhatme, B. V., Sukhatme, S., & Asok, C. (1998). *Sampling Theory of Surveys with Applications* (4th ed.). Indian Society of Agricultural Statistics, New Delhi.
3. Goon, A. M., Gupta, M. K., & Das Gupta, B. (2014). *Fundamentals of Statistics*, Vol. II (5th ed.). World Press, Calcutta.
4. Lohr, S. L. (2021). *Sampling: Design and Analysis* (3rd ed.). Brooks/Cole, Cengage Learning.
5. Lehtonen, R., &Veijanen, A. (2012). *Survey Sampling: Theory and Methods*. Springer.
6. Dean, A., & Voss, D. (2023). *Design and Analysis of Experiments* (7th ed.). Springer.

Learning Outcomes: Students will learn to:

1. Distinguish between probability and non-probability sampling.
2. Understand the process of selecting sampling units under different sampling schemes.
3. To know about basic principles of design and to conduct the experiments under basic designs.
4. They learn about complex designs like factorial designs and its applications.

Course Title	**STAMD32: Practical Based on STAMD31**

Paper will be based on numerical problems of Paper STAMD31

Unit	**Hours of Practical**
I	6
II	6
III	8
IV	10

Course Title: STASE31: Data analysis using R

Category of Course: SEC

Credits & Hours of Teaching

	Theory	**Practical**	**Cumulative**
Credits	**1**	**2**	**3**
Hours of Teaching (Total)	**15**	**60**	**75**

Course Objectives

1. To understand the overview of R and R-studio and their applications.
2. To know about data manipulation, data import and export selecting columns and filtering rows, sorting data, and summarizing data with basic descriptive statistics.
3. To understand Data visualization, basic plots.
4. To write and use R functions for statistical analysis.

Course Content: The course content be divided into minimum 3 Units to maximum 5 units along with defined Hours of teaching for each unit.

Units	**Course Content**	**Hours of Teaching**
I	Introduction to R: Overview of R and its uses in data analysis, Installing R and R Studio, Introduction to R packages. Basic R syntax and data structures: Using R as a calculator: arithmetic operations, vectors and matrices, data frames for tabular data, indexing and subsetting data structures. Data manipulation: selecting columns and filtering rows, sorting data, adding and modifying variables, summarizing data with basic descriptive statistics.	5
II	Data import and export: reading data from csv and excel files, exporting data to different formats, handling missing values during data import. Data visualization: Basic plots (scatter plots, bar plots, line plots), customizing plot aesthetics (labels, titles, colors), adding multiple plots on one canvas. Control structures and functions: conditional statements (if-else), loops (for, while).	5
III	Writing and using functions: Applying functions to data, basic statistical analysis, descriptive statistics (mean, median, standard deviation), hypothesis tests (t-tests, chi-square tests), correlation analysis, basic regression models.	5

Texts / References

1. John Chambers, Software for Data Analysis: Programming with R, Springer, 2008.
2. Phil Spector, Data Manipulation with R, Springer, 2008.
3. Hadley Wickham, Advanced R, Chapman & Hall/CRC The R Series, 2014
4. W.H. Press, S.A. Teukolsky, W.T. Vellering and B.P. Flannery, Numerical Recipes in C, Second edition, Cambridge University Press, 1993.

Learning Outcomes: Upon completing this course, students will achieve the following learning outcomes:

1. Install and proficiently use R programming language in R and R Studio and their Mathematical operations.
2. Data visualization, Import, export, data manipulation, functions.
3. Define, calculate, and apply probability and probability distributions to solve diverse problems.
4. Conduct and interpret various hypothesis tests to facilitate decision-making processes.
5. Analyze, interpret, and understand data and their analysis using R.

Course Title	STASE32: Practical Based on STASE31

Paper will be based on numerical problems of Paper STASE31

Unit	Hours of Practical
I	20
II	20
III	20

Note: Syllabus of Course code STAAE31 will be framed at faculty level

Semester IV

Course Title: STAMJ41: Statistical Inference-I

Category of Course: Major

Credits& Hours of Teaching

	Theory	Practical	Cumulative
Credits	**3**	**1**	**4**
Hours of Teaching (Total)	**45**	**30**	**75**

Course Objectives

1. The objective of this course is to introduce the idea about parametric inferential procedures.
2. To introduce the concept of point and interval estimation of the parameter
3. To understand the concept of testing of a hypothesis and its applications in real scenario.
4. To introduce the concept and theoretical development of small & large sample parametric test.
5. To introduce the concept and theoretical development of non- parametric test.

Course Content: The course content be divided into minimum 3 Units to maximum 5 units along with defined Hours of teaching for each unit.

Units	Course Content	Hours of Teaching
I	Elementary idea of point estimation of parameters, properties of good estimator: unbiasedness, consistency, efficiency, & sufficiency with simple illustrative examples. Idea of Confidence interval estimation	10
II	Concepts of statistical hypotheses: null and alternative hypothesis, critical region, two types of errors, level of significance, p-value and power of a test. One and two tailed tests. Statement of Law of Large Numbers and Central Limit Theorem.	10
III	Small Sample tests: t-test for single Mean, difference of Means and Paired t-test. chi-square test for Goodness of fit and independence of attributes. F-test for Equality of variances.	10
IV	Large sample Tests: Large sample tests for single mean and difference of two means. Confidence intervals for mean(s). Large sample test for single proportion, difference of proportions, Standard deviation(s) and Correlation coefficient(s).	10
V	Non-parametric tests- Definition, advantages and disadvantages, Sign, Run, Median tests, Spearman's rank correlation test, Wilcoxon Mann-Whitney test, Kolmogorov Smirnov - one sample and two sample tests.	5

Text book/ References:

1. Mood A.M., Greybill F.A. and Boes D.C. (1974) : Introduction to the Theory of Statistics, McGraw Hill.
2. Freund J.E. (2001) : Mathematical Statistics, Prentice hall of India.
3. Goon A.M., Gupta M.K. and Das Gupta B. (2014) : Fundamental of Statistics, Vol. I ()5th edition), World press, Calcutta.
4. Rohatgi, V.K. and Saleh, A.K.M.E. (2001): An Introduction to Probability and Statistics, Second Edition, John Wiley & Sons.
5. Rao C.R. (1973): Linear Statistical Inference and its Applications, Revised edition, Weley Eastern.
6. Hoges J.L. and Lehmann E.L. (1964): Basic Concepts of Probability and Statistics, Holden Day.
7. Snedecor G.W. and Cochran W.G. (1989) : Statistical Methods (8th edition), Iowa State University Press.
8. Sheskin, D. J. (2020). *Handbook of parametric and nonparametric statistical procedures*. Chapman and hall/CRC, Fifth Edition
9. Roussas, G. G. (2015). *An introduction to probability and statistical inference*. Elsevier, Second Edition
10. Almudevar, A. (2021). *Theory of statistical inference*. Chapman and Hall/CRC, First Edition
11. Wasserman, L. (2013). All of statistics: A concise course in statistical inference, Second Edition

Learning Outcomes: After completing this course, the students will be able to understand the followings;

1. About the point and interval estimation of the parameter(s)
2. Various properties of a good estimators and their theoretical development.
3. Concept of large sample, law for large number and related theorem.
4. Concept of small and large sample parametric test.
5. Concept and application of various non-parametric test.

Course Title: STAMJ42: Sample Surveys and Design of Experiment

Category of Course: Major

Credits& Hours of Teaching

	Theory	Practical	Cumulative
Credits	**4**	**1**	**5**
Hours of Teaching (Total)	**60**	**30**	**90**

Course Objectives:

This course is designed

1. To provide the concept of sampling and related terminologies.
2. To introduce the concept of various probability and non-probability sampling techniques and their comparisons.
3. To introduce the concept of one way and two-way ANOVA.
4. To describe the need and applications of design of experiments and related principles.
5. To understand the layout and analysis of various types of designs viz. CRD, RBD and LSD.
6. To understand the layout and analysis of factorial designs.

Course Content: The course content be divided into minimum 3 Units to maximum 5 units along with defined Hours of teaching for each unit.

Units	Course Content	Hours of Teaching
I	Concept of population and sample, need for sampling, complete enumeration versus sampling, Basic concepts in sampling, sampling and non-sampling errors. Acquaintance with the working (questionnaires, sampling design, methods followed in field investigation, principal findings, etc.) of NSSO and other agencies undertaking sample surveys.	10
II	Concept of probability and non-probability sampling. Simple random sampling with and without replacement, estimation of population mean, population proportions and their standard errors. Stratified random sampling, proportional and optimum allocation, comparison with simple random sampling for fixed sample size.	15
III	Systematic sampling (when population size (N) is an integer multiple of sampling size (n)). Estimation of population mean and standard error of this estimate, comparison with simple random sampling.	10
IV	Elementary idea of cluster sampling. Use of auxiliary information, ratio, product and regression methods of estimation.	10
V	Analysis of variance for one way and two-way classifications (with one observation per cell), need for design of experiments, basic principles of experimental design: randomization, replication and local control, complete analysis and layout of completely randomized design, randomized block design and Latin square design. Factorial experiments: 2^2 and2^3 factorial experiments.	15

Texts / References:

1. Sampath S. (2005): Sampling Theory and Methods, Narosa Publishing House, New Delhi.
2. Cochran W.G. (1977): Sampling Techniques, John Wiley and Sons, New York.
3. Sukhatme P.V., Sukhatme B.V., Sukhatme S. and Asok C. (1998): Sampling Theory of Surveys with Applications (4th ed.)., Indian Society of Agricultural Statistics, New Delhi.
4. Goon A.M., Gupta M.K. and Das Gupta B. (2014): Fundamentals of Statistics, Vol. II, world Press, Calcutta.
5. Sampath S. (2000): Sampling Theory and Methods, Narosa Publishing House, New Delhi.
6. Des Raj (2000): Sample Survey Theory, Narosa Publishing House, New Delhi.
7. Murthy M.N. (1967): Sampling Theory and Methods, Statistical Publishing Society, Calcutta.
8. Kish L (1965): Survey Sampling, John Wiley and Sons, New York.
9. Hansen M.H., Hurwitz W.N. and Madow W.G. (1975) : Sample Survey Method and Theory, Vol. I, Methods and Applications, Vol. II, New York and London, Wiley Publication.
10. Cochran W.G. and Cox G.M. (1957) : Experimental Design, John Wiley and Sons.
11. Das, M. N. and Giri J. (1986) : Design and Analysis of Experiments, Springer Verlag.
12. Kempthorne O. (1965) : The Design and Analysis of Experiments, Wiley Eastern
13. Singh, R., & Mangat, N. S. (2013). Elements of survey sampling (Vol. 15).

Learning Outcomes:

After completing this course, the students will understand the followings;

1. Concept of population and different methods of selecting random sample
2. Concept and idea about probability and non-probability sampling techniques along with their realistic applications.
3. About different types of methods of estimation through the use of auxiliary information.
4. Concept and meaning of one way and two-way ANOVA.
5. The importance of design of experiment and associated principle
6. Analysis and layout of different types of designs.

Course Title: STAMJ43: Applied Statistics

Category of Course: Major

Credits & Hours of Teaching

	Theory	Practical	Cumulative
Credits	**4**	**1**	**5**
Hours of Teaching (Total)	**60**	**30**	**90**

Course Objectives: This course is design to

1. Understand time series analysis and its components: stationary/non-stationary, moving averages, trends, seasonality, cycles, and randomness.
2. Learn classical decomposition and differencing approach for time series models.
3. Introduction to time series models like AR, MA, ARMA, and ARIMA.
4. Study index numbers, price/quantity relatives, composition, and different methods (Laspeyres, Paasche, Marshall-Edgeworth, Fisher, chain base).
5. Understand consumer demand theory, the law of demand, price elasticity, demand curve estimation, and forms of demand functions.
6. Analyse income distributions, Pareto and lognormal distributions, Lorenz curve, and Gini coefficient.

Course Content: The course content be divided into minimum 3 Units to maximum 5 units along with defined Hours of teaching for each unit.

Units	Course Content	Hours of Teaching
I	Time Series Analysis: A realization of stochastic process, nature of time series data, Stationary and non-stationary time series, moving averages, different components: secular trend, seasonal, cyclic and random	15
II	Classical decomposition model, Differencing approach, time series models: Introduction to some time series models such as AR, MA and ARMA, ARIMA model	8
III	Index Numbers: Price relatives and quantity or volume relatives, Link and chain relatives' composition of index numbers; Laspeyre's, Paasche's, Marshal Edgeworth's and Fisher's index numbers; chain base index number, tests for index number, cost of living index number.	15
IV	Theory and analysis of consumer's demand, law of demand, price elasticity of demand, estimation of demand curves, forms of demand functions, Engel's curve, income elasticity of demand	15
V	Analysis of income and allied distributions: Pareto distribution, graphical test, fitting of Pareto law, illustration, lognormal distribution and properties, Lorenz curve, Gini's coefficient	7

Texts / References:

1. Brockwell, P. J., & Davis, R. A. (2009). *Time Series: Theory and Methods*. Germany: Springer New York.
2. Brockwell, P. J., & Davis, R. A. (2013). *Introduction to Time Series and Forecasting*. Germany: Springer.
3. Chatfield, C. (2003). *The Analysis of Time Series: An Introduction* (6th ed.). Chapman and Hall/CRC.
4. Mukhopadhyay, P. (1994). *Applied Statistics*. New Central Book Agency Pvt. Ltd., Calcutta.
5. Goon, A. M., Gupta, M. K., & Das Gupta, B. (2008). *Fundamentals of Statistics*, Vol. II. World Press, Calcutta.
6. Mankiw, N. G. (2021). *Principles of Economics* (9th ed.). Cengage Learning.
7. Sen, A. (1973). *On Economic Inequality*. Oxford University Press.
8. Cowell, F. A. (2000). *Measuring Inequality*. Oxford University Press

Learning Outcomes: After completing this course student will able to :

1. Analyze and model time series data.
2. Apply classical decomposition and differencing approaches on time series data.
3. Utilize the concept of AR, MA, ARMA, and ARIMA models.
4. Construct and interpret various index numbers.
5. Understand the consumer demand theory and estimation of demand functions.
6. Capable to analyze and fit income distributions using Pareto and lognormal distributions, and calculate Lorenz

curve and Gini coefficient.

Course Title	**STAMJ44: Practical Based on STAMJ41**

Paper will be based on numerical problems of Paper STAMJ41

Paper and Unit	Number of Practical
I	2
II	4
III, IV & V	24

Course Title	**STAMJ45: Practical Based on STAMJ42 &STAMJ43**

Paper will be based on numerical problems of Paper STAMJ42 &STAMJ43

Paper STAMJ42 Unit I to V	30
Paper STAMJ43 Unit I to V	30

Course Title: STAMN41: Statistical Inference-I

Category of Course: Minor

Credits& Hours of Teaching

	Theory	**Practical**	**Cumulative**
Credits	**3**	**1**	**4**
Hours of Teaching (Total)	**45**	**30**	**75**

Course Objectives

1. The objective of this course is to introduce the idea about parametric inferential procedures.
2. To introduce the concept of point and interval estimation of the parameter
3. To understand the concept of testing of a hypothesis and its applications in real scenario.
4. To introduce the concept and theoretical development of small & large sample parametric test.
5. To introduce the concept and theoretical development of non- parametric test.

Course Content: The course content be divided into minimum 3 Units to maximum 5 units along with defined Hours of teaching for each unit.

Units	**Course Content**	**Hours of Teaching**
I	Elementary idea of point estimation of parameters, properties of good estimator: unbiasedness, consistency, efficiency, & sufficiency with simple illustrative examples. Idea of Confidence interval estimation	10
II	Concepts of statistical hypotheses: null and alternative hypothesis, critical region, two types of errors, level of significance, p-value and power of a test. One and two tailed tests. Statement of Law of Large Numbers and Central Limit Theorem.	10
III	Small Sample tests: t-test for single Mean, difference of Means and Paired t-test. chi-square test for Goodness of fit and independence of attributes. F-test for Equality of variances.	10
IV	Large sample Tests: Large sample tests for single mean and difference of two means. Confidence intervals for mean(s). Large sample test for single proportion, difference of proportions, Standard deviation(s) and Correlation coefficient(s).	10
V	Non-parametric tests- Definition, advantages and disadvantages, Sign, Run, Median tests, Spearman's rank correlation test, Wilcoxon Mann-Whitney test, Kolmogorov Smirnov - one sample and two sample tests.	5

Text book/ References:

1. Mood A.M., Greybill F.A. and Boes D.C. (1974) : Introduction to the Theory of Statistics, McGraw Hill.
2. Freund J.E. (2001) : Mathematical Statistics, Prentice hall of India.
3. Goon A.M., Gupta M.K. and Das Gupta B. (2014) : Fundamental of Statistics, Vol. I ()5th edition), World press, Calcutta.
4. Rohatgi, V.K. and Saleh, A.K.M.E. (2001): An Introduction to Probability and Statistics, Second Edition, John Wiley & Sons.
5. Rao C.R. (1973): Linear Statistical Inference and its Applications, Revised edition, Weley Eastern.
6. Hoges J.L. and Lehmann E.L. (1964): Basic Concepts of Probability and Statistics, Holden Day.
7. Snedecor G.W. and Cochran W.G. (1989) : Statistical Methods (8th edition), Iowa State University Press.
8. Sheskin, D. J. (2020). *Handbook of parametric and nonparametric statistical procedures*. Chapman and hall/CRC, Fifth Edition
9. Roussas, G. G. (2015). *An introduction to probability and statistical inference*. Elsevier, Second Edition
10. Almudevar, A. (2021). *Theory of statistical inference*. Chapman and Hall/CRC, First Edition
11. Wasserman, L. (2013). All of statistics: A concise course in statistical inference, Second Edition

Learning Outcomes:

After completing this course, the students will be able to understand the followings;

1. About the point and interval estimation of the parameter(s)
2. Various properties of a good estimators and their theoretical development.
3. Concept of large sample, law for large number and related theorem.
4. Concept of small and large sample parametric test.
5. Concept and application of various non-parametric test.

Course Title	**STAMN42: Practical Based on STAMN41**

Paper will be based on numerical problems of Paper STAMN41

Unit	Number of Practical
I	2
II	4
III, IV &V	24

Semester V

Course Title: STAMJ51: Operations Research

Category of Course: Major

Credits& Hours of Teaching

	Theory	**Practical**	**Cumulative**
Credits	**4**	**1**	**5**
Hours of Teaching (Total)	**60**	**30**	**90**

Course Objectives:

1. To understand optimization problems.
2. To develop linear programming problems (LPP) for real life situations.
3. To solve the LPP through different techniques under large number of decision variables and constraints.
4. To discuss the management of inventory problems.
5. To understand networking and project management.

Course Content: The course content be divided into minimum 3 Units to maximum 5 units along with defined Hours of teaching for each unit.

Units	**Course Content**	**Hours of Teaching**
I	Definitions and scope of operation research, different types of models in operations research – their construction and general method of solution.	7
II	Elements of linear programming problem (LPP): Canonical and standard forms, formulation of LPP, graphical method to solve two variable LPP, solution of LPP using simplex procedure, use of artificial variables in LPP, generation of extreme point solutions, principle of duality in LPP, statement and proof of duality theorem, simple problems based on duality theorem.	15
III	Transportation problem (TP): different methods of finding initial feasible solution of a TP, UV method of finding optimal solution of a TP, Problems of degeneracy, and special cases of TP. Assignment problem: Hungarian method to find optimal assignment, special cases of assignment problem.	15
IV	Inventory Control: Definitions of various costs involved in inventory control. Deterministic Economic Lot Size problems with and without shortages.	8
V	Theory of games: Two person zero-sum games, pure and mixed strategies, saddle point, maximin-minimax principle of rectangular games, games without saddle point, dominance and modified dominance property to reduce the game matrix and solution to rectangular game with mixed strategy, graphical solution of 2xN and Mx2 games, reduction of game problems to a LPP. Theory of Network – PERT, CPM.	15

Texts / References:

1. Taha, H. (2019). Operations Research: An Introduction, Pearson Education, 10th edition.
2. Hadley, G: (2002): Linear Programming, Narosa Publications.
3. Hillier, F.A and Lieberman, G.J. (2010): Introduction to Operations Research Concepts and cases, 9th Edition.
4. Gass S.I. (2011): Linear Programming- Methods and Applications, 5th edition, Dover Publications Inc.
5. McKinsey J.C.C. (2003): Introduction to the Theory and Games, Dover Publications Inc.
6. KantiSwaroop, Gupta P.K. and Singh M.M. (2007). Operations Research, 13th Edition, Sultan Chand and Sons.

Learning Outcomes:

After completing this course, a student will be able to:

1. Convert real life problem into LPP.
2. Utilize different approaches to solve the optimization problems.
3. Manage the problems of transportation, assignment, game for optimization purposes.
4. The management of inventory problems.
5. Learn project management and review techniques.

Course Title: STAMJ52: Numerical Methods

Category of Course: Major

Credits & Hours of Teaching

	Theory	Practical	Cumulative
Credits	**3**	**1**	**4**
Hours of Teaching (Total)	**45**	**30**	**75**

Course Objectives:

1. To understand differencing methods to fit a polynomial.
2. To understand interpolation, extrapolation for missing or future observation.
3. Techniques of evaluating integral numerically.
4. Techniques for summation of mathematical series.
5. Solving deferential equations as well as linear and transcendental equations numerically.

Course Content: The course content be divided into minimum 3 Units to maximum 5 units along with defined Hours of teaching for each unit.

Units	Course Content	Hours of Teaching
I	What is numerical analysis? Calculus of Finite differences. Operators: Δ, ∇, δ, E and D and their relationships. factorial polynomials, separation of symbols, differences of zero. Taylor's series.	5
II	Interpolation and polynomial approximation Weierstarss theorem, extrapolation, Newton-Gregory's forward and backward interpolation formulae for equally-spaced arguments, divided differences and their properties, Newton's formula for divided difference, Lagrange's formula for unequal intervals, central difference formula due to Gauss, Stirling, Bessel, Laplace and Everett, remainder terms in interpolation formula. error analysis.	10
III	Inverse interpolation: Different methods of inverse interpolation. Numerical differentiation: Three-point formulae and five-point formulae Numerical Integration: General Quadrature formula: Trapezoidal rule, Simpson's one-third and three-eight rules, Weddle's rule, Newton-Cotes formula. Truncation error in the numerical integration formulae.	10
IV	Summation of series: Series whose general term is (i) the first difference of a function (ii) in geometric progression and (iii) a product of two functions. Difference equation: Linear difference equations (homogeneous and non-homogeneous) with constant coefficients.	10
V	Numerical solutions of differential equations: Euler's method, Milne's method, Picard's method and Runge-Kutta method. Method of solving linear and transcendental equations: Regula-falsi, bisection method, fixed-point iteration method, Newton-Raphson method, error analysis	10

Texts / References:

1. Scarborough, J. B. (2020). *Numerical Mathematical Analysis* (6th ed.). Oxford University Press and Oxford Book Co.
2. Freeman, H. (1961). *Finite Differences for Actuarial Students* (6th ed.). Cambridge University Press.
3. Atkinson, K., & Han, W. (2003). *Elementary Numerical Analysis* (3rd ed.). John Wiley & Sons, Inc.
4. Pettofrezzo, A. J. (2012). *Introductory Numerical Analysis*. United States: Dover Publications.
5. Hildebrand, F. B. (1987). *Introduction to Numerical Analysis*. India: Dover Publications.
6. Spiegel, M. R. (1971). *Schaum's outline of theory and problems of calculus of finite differences and difference equations*. United Kingdom: McGraw-Hill Education.
7. Conte, S. D., & de Boor, C. (1981). *Elementary Numerical Analysis: An Algorithmic Approach* (3rd ed.). McGraw-Hill.

Learning Outcomes: After completing this course a student will learn to:

1. To fit the polynomials of different degree using differencing operators.
2. Interpolating and extrapolating the missing or future observations by Newton's, Langranze's and other techniques.
3. Apply quadrature formula for evaluation of integrals numerically.
4. Apply the methods of solving differential equations as well as linear and transcendental equations numerically.

Course Title: STAMJ53: Statistical Inference -II

Category of Course: Major

Credits & Hours of Teaching

	Theory	**Practical**	**Cumulative**
Credits	**4**	**1**	**5**
Hours of Teaching (Total)	**60**	**30**	**90**

Course Objectives:

1. To introduce the concept and properties of a good estimator and their illustrations.
2. To understand the meaning of lower bound, complete family of distributions.
3. To introduce the idea about construction of minimum variance unbiased estimators through the use of sufficient statistics and their uniqueness.
4. To illustrate various methods of point estimation of parameters along with their illustration.
5. To illustrate various methods of interval estimation of parameters along with their illustration.
6. To discuss the concept and importance of testing of hypothesis problem in detail.
7. Elementary idea about the decision theoretic approach and Bayes estimation.

Course Content: The course content be divided into minimum 3 Units to maximum 5 units along with defined Hours of teaching for each unit.

Units	**Course Content**	**Hours of Teaching**
I	Properties of point estimators: unbiasedness, consistency of estimators and sufficient conditions for consistency, relative efficiency of an estimator, asymptotic efficiency, Cramer-Rao lower bound, sufficiency, factorization theorem (without proof), concept of complete sufficient statistics, minimum variance unbiased estimator, Rao-Blackwell and Lehmann-Scheffe Theorems.	15
II	Methods of point estimation : moments, maximum likelihood, minimum chi-square, least square with examples, CAN and BAN estimators, point estimates of location and scale parameters, regression coefficient, correlation coefficient and other useful parameters.	15
III	General method for constructing confidence intervals, shortest confidence intervals, confidence intervals for the parameters of univariate normal, two independent normal distributions and exponential distributions. error in the numerical integration formulae.	10
IV	Testing of statistical hypotheses, critical region, size and power of a test, most powerful test, randomized and non randomized test, Neyman Pearson lemma and its applications, Uniformly most powerful test, unbiased test, uniformly most powerful unbiased test, Likelihood ratio test, statement of its properties and applications.	15
V	Elementary idea about decision theory: Loss function, risk function, estimation and testing viewed as decision problems. Bayes rule.	5

Texts / References:

1. Casella, G., & Berger, R. L. (2022). *Statistical Inference* (3rd ed.). Brooks/Cole, Cengage Learning.
2. Mukhopadhyay, N. (2020). *Probability and statistical inference*. CRC Press.
3. Kale, B.K. (1999): A First Course on Parametric Inference, Narosa Publishing House.
4. Rohatgi, V.K. (1988): An Introduction to Probability and Mathematical Statistics, Wiley Eastern, New Delhi.
5. Lehmann, E.L. (1986): Theory of Point Estimation, Student Edition.
6. Lehmann, E.L.(1986): Testing Statistical Hypotheses, Student Editions.
7. Rao, C.R. (1973): Linear Statistical Inference and its Applications, Wiley Eastern.
8. Ferguson, T.S. (1967): Mathematical Statistics, Academic Press.
9. Zacks, S. (1971): Theory of Statistical Inference, Wiley, New York.
10. Sheskin, D. J. (2020). *Handbook of parametric and nonparametric statistical procedures*. Chapman and hall/CRC, Fifth Edition
11. Roussas, G. G. (2015). *An introduction to probability and statistical inference*. Elsevier, Second Edition
12. Almudevar, A. (2021). *Theory of statistical inference*. Chapman and Hall/CRC, First Edition
13. Wasserman, L. (2013). All of statistics: A concise course in statistical inference, Second Edition

Learning Outcomes:

After completing this course, the students will be able to:

1. Know that how the best estimators for the parameter(s) in any parametric family of distributions are chosen.
2. Obtain the lower bound to the variance of unbiased estimators, complete sufficient statistics for the parameter.
3. Construct the MVUE and UMVUE.
4. Grasp various methods of point and interval estimation of parameters.
5. Conceptualize the testing of hypothesis problem and related test.
6. Understand decision theoretic approach and related estimation procedure.

Course Title	**STAMJ54: Practical Based on STAMJ51, STAMJ52 & STAMJ53**

Paper will be based on numerical problems of Paper STAMJ51, STAMJ52 & STAMJ53

Paper& Unit	**Hours of Practical**
Paper STAMJ51unit I to V	**30**
Paper STAMJ52 unit I to V	**30**
Paper STAMJ53 unit I to V	**30**

Course Title	**STAIN51: Internship**

The student will do summer internship work either in campus or outside of the campus.

Internship Credit	**Duration**
2	**Summer Vocation**

Course Title: STAMV51: Structure and Visualization of Data

Category of Course: Minor (Vocational)

Credits & Hours of Teaching

	Theory	**Practical**	**Cumulative**
Credits	**3**	**1**	**4**
Hours of Teaching (Total)	**45**	**30**	**75**

Course Objectives

1. Understand the principles of data structure and organization.
2. Learn and apply key data visualization techniques.
3. Develop proficiency in using visualization tools.
4. Analyze data to extract meaningful insights and communicate findings.

Course Content: The course content be divided into minimum 3 Units to maximum 5 units along with defined Hours of teaching for each unit.

Units	**Course Content**	**Hours of Teaching**
I	Overview of data. scales of measurement, types variables. Data collection methods, and preparing data. Sources of data (surveys, web scraping, databases).Data structures: Arrays, lists, tables, and databases Data types and formats (CSV,SQL).Data normalization and schema design case studies of effective and ineffective visualizations.	15
II	Data cleaning exercise using Excel. Basic chart types: Bar, error bars, line, pie, and scatter plots. Explore advanced visualization methods. Heatmaps, histograms, box plots.	10
III	Numerical descriptors and their roles in data analysis for univariate and bivariate data. Measures of Inequalities	5
IV	Time series analysis basics, Plotting trends, seasonality, and anomalies, Tools for time series data visualization.	10
V	Explore visualization techniques for large datasets. Key performance indicators (KPIs) and business metrics, Creating executive dashboards Communicating insights to stakeholders.	5

Texts / References:

1. Healy, K(2018). Data Visualization: A Practical Introduction". Princeton University Press.
2. Wilke, C.O. (2019). Fundamentals of Data Visualization: A Primer on Making Informative and Compelling Figures. Shroff/O'Reilly Publication.
3. Ranganathan, K. (2023). Impactful Data Visualization: Hide and Seek with Graphs.

Learning Outcomes:

Students will be able to:

1. Understand the importance and purpose of data visualization.
2. Learn methods for collecting and preparing data.
3. Explore how data is organized and structured.
4. Get familiar with basic tools for data descriptions.

Course Title | **STAMV52: Practical Based on STAMV51**

Paper will be based on numerical problems of Paper STAMV51

Unit	Hours of Practical
I	**2**
II	**4**
III	**10**
IV	**8**
V	**6**

Semester VI

Course Title: STAMJ61: Stochastic Processes

Category of Course: Major

Credits& Hours of Teaching

	Theory	Practical	Cumulative
Credits	3	1	4
Hours of Teaching (Total)	45	30	75

Course Objectives:

This course is designed to introduce:

1. To understand stochastic processes
2. To analyze discrete time Markov chains
3. To understand Continuous-time Markov chains
4. To understand Various counting processes and their applications & analysis.

Course Content: The course content be divided into minimum 3 Units to maximum 5 units along with defined Hours of teaching for each unit.

Units	Course Content	Hours of Teaching
I	Introduction to stochastic processes: Definition and examples of stochastic process, Classification of SPs according to state space and time domain. Types of stochastic processes: independent process, Bernoulli process, processes with independent increments, processes with stationary increments, Markov processes, counting processes, second-order processes, Gaussian processes, martingales, Brownian motion. Stationary process: weakly stationary and strongly stationary processes. Elementary problems and applications.	8
II	Markov chains: definition and examples of Markov chain (MC), transition probability matrix, order of Markov chain, Markov chain as graphs, higher transition probabilities, classification of states, basic limit theorem of Markov chain. Finite state Markov chains, Chapman-Kolmogorov equations, calculation of n-step transition probability and its limit. Classification of states, aperiodic & irreducible MC, recurrent & transient MC, concept of total probability with recursion, absorption probability, mean hitting time, mean return time, stationary distribution. Random walk and gambler's ruin problem.	13
III	Discrete state space continuous time MC: Kolmogorov forward and backward equations, jump probability, transition probability, generator matrix and its stationary distribution. Statistical inference in MC and Markov processes.	11
IV	Counting processes: Poisson process and related inter-arrival time distribution, superposition and decomposition of Poisson process, nonhomogeneous Poisson process. birth and death process, queuing model as a case of counting process.	13

Texts / References:

1. Papoulis, A., &Unnikrishna Pillai, S. (2002). Probability, Random Variables, and Stochastic Processes (4th ed.). Tata McGraw-Hill.
2. Ross, S. M. (2023). Introduction to Probability and Statistics for Engineers and Scientists (5th ed.). Academic

Press.
3. Basu, A. K. (2005). Introduction to Stochastic Processes. Narosa Publishing.
4. Karlin, S., & Taylor, H. M. (1975). A First Course in Stochastic Processes, Vol. 1. Academic Press.
5. Castaneda, L. B., Arunachalam, A., & Dharmaraja, S. (2016). Introduction to Probability and Stochastic Processes with Applications. Wiley, Asian Edition.
6. Bharat, B. R. (2000). Stochastic Models: Analysis and Applications. New Age International, India.
7. Feller, W. (1968). Introduction to Probability and Its Applications, Vol. 1. Wiley Eastern.
8. Ross, S. M. (1996). Stochastic Processes. Wiley.

Learning Outcomes

Students will be able to:

1. Define and classify various types of stochastic processes, including independent, Bernoulli, Markov, and Gaussian processes, and understand their properties such as stationary increments and martingales.
2. Comprehend the definition, transition probability matrix, and classification of states in Markov chains, and apply key concepts such as the Chapman-Kolmogorov equations, higher transition probabilities, and the basic limit theorem to practical problems.
3. Conceptualize discrete state space continuous time Markov chains, including Kolmogorov equations, jump probabilities, generator matrices, and their stationary distributions, and perform statistical inference on these processes.
4. Understand counting processes like the Poisson process, its inter-arrival time distribution, superposition and decomposition, and nonhomogeneous Poisson processes, and analyze birth and death processes and queuing models as specific cases of counting processes.

Course Title: STAMJ62: Statistical Process Control and Reliability

Category of Course: Major

Credits& Hours of Teaching

	Theory	Practical	Cumulative
Credits	**3**	**1**	**4**
Hours of Teaching (Total)	**45**	**30**	**75**

Course Objectives

1. To introduce the fundamental problem-solving tool in Statistical Process Control (SPC), known as control charts
2. To determine whether a process is in control or if special causes of variation need to be addressed.
3. To discuss and demonstrate practical applications of basic control charts for variables and attributes, showing how they enable organizations to maintain and improve their processes.
4. To introduce the concepts of life testing experiments and reliability analysis.
5. To discuss estimation procedures for various life-time distributions in the presence of censored data.
6. To discuss various system configurations.

Course Content: The course content be divided into minimum 3 Units to maximum 5 units along with defined Hours of teaching for each unit.

Units	Course Content	Hours of Teaching
I	Statistical process and product control: Quality of a product, need for quality control, basic concept of process control, process capability and product control, general theory of control charts, causes of variation in quality, control limits, sub-grouping summary of out-of-control criteria.	8
II	Charts for attributes: p-chart, np-chart, c-chart, Charts for variables: R-chart, σ-charts. x-bar chart.	14
III	Life testing and reliability theory: Basic concepts of life testing experiments, reliability, hazard function, mean time to system failure and their inter-relationship. System reliability concepts: Parallel, series, series-parallel, parallel-series, bridge and k-out of- n systems. Concept of Redundancy and Preventive maintenance	8
IV	Elementary notion of censored data, type I and type II censoring schemes. Point and interval estimation procedures: exponential, Weibull, gamma, lognormal. UMVUE of reliability function and reliability hypothesis testing for exponential distribution. Stress-strength reliability and its estimation for the exponential distribution.	15

Texts / References:

1. Montgomery, D. C. (2019). *Introduction to Statistical Quality Control* (8th ed.). Wiley.
2. Chakraborti, S., & Graham, M. A. (2019). *Nonparametric Statistical Process Control*. Wiley.
3. Mitra, A. (2021). *Fundamentals of quality control and improvement* (5th ed.). Wiley.
4. Wetherill, G. B., & Brown, D. W. (2013). *Statistical Process Control: Theory and Practice*. United States: Springer US.
5. Gross A. j. and Clark, V.A. (1975): Survival Distribution: Reliability applications in the Biomedical Sciences, John Wiley and Sons.
6. Elandt – Johnson, R.E. Johnson N. L.: Survival Models and Data Analysis, John Wiley and Sons.
7. Gertsbakh, I. B. (2000). Reliability theory: with applications to preventive maintenance. Springer Science & Business Media.
8. Balagurusamy E. (2017). Reliability Engineering, McGraw Hill Education India

Learning Outcomes

After study of this course students should be able to do the following:

1. Understand chance and assignable causes of variability in a process
2. Explain the statistical basis of the Shewhart control chart, including choice of sample size, control limits, and sampling interval
3. Know how to design variables control charts such as X-bar and R charts, and attribute control charts such as p, np, c, u-charts.
4. Understand basic concepts of life testing experiments, reliability, and hazard function.
5. Learn about different censoring schemes such as Type I and Type II, and their applications
6. Know the different life-time distributions and related estimation problems.

Course Title: STAMJ63: Econometrics and Actuarial Statistics

Category of Course: Major

Credits & Hours of Teaching

	Theory	Practical	Cumulative
Credits	**4**	**NIL**	**4**
Hours of Teaching (Total)	**60**	**NIL**	**60**

Course Objectives:

This course is designed to:

1. Understand econometric models and estimation techniques.
2. Address heteroscedasticity, autocorrelation, and multicollinearity.
3. Apply actuarial concepts in insurance and utility theory.
4. Calculate interest rates and annuities.

Course Content: The course content be divided into minimum 3 Units to maximum 5 units along with defined Hours of teaching for each unit.

Units	Course Content	Hours of Teaching
I	Nature of econometrics, the general linear model (GLM) and its extensions, ordinary least squares (OLS) estimation and prediction, generalized least squares (GLS) estimation and prediction, heteroscedastic disturbances, pure and mixed estimation.	13
II	Autocorrelation, its consequences and tests. Multicollinearity problem, its implications and tools for handling the problem, ridge regression. Instrumental variable estimation, errors in variables.	12
III	Expected value principle, utility and utility function, insurance and utility theory, mutually advantageous situation for insurance, survival function, time-until-death for a person, future life time, curtate future lifetime, force of mortality, relation of life table function to the survival function, Life table examples, deterministic survivorship group.	10
IV	Nominal and effective rates of interest and discount, force of interest and discount, compound interest, accumulation factor, insurance payable at the moment of death and at end of the year of death, concept of annuities, continuous and discrete life annuities, concept of premiums, continuous and discrete premiums.	10

Texts / References:

1. Promislow, S. D. (2014). *Fundamentals of Actuarial Mathematics* (3rd ed.). Wiley.
2. Deshmukh, S. R. (2009). *Actuarial Statistics: An Introduction Using R* (3rd ed.).
3. Borowiak, D. S., & Shapiro, A. F. (2014). *Financial and Actuarial Statistics: An Introduction* (2nd ed.). CRC Press.
4. Wooldridge, Jeffrey M. (2023). *Introductory Econometrics: A Modern Approach* (8th ed.). Cengage Learning.
5. Hayashi, F. (2000). *Econometrics*. Princeton University Press.
6. Greene, W. H. (2023). *Econometric Analysis* (8th ed.). Pearson.
7. Asteriou, D., & Hall, S. G. (2023). *Applied Econometrics* (5th ed.). Palgrave Macmillan.
8. Davidson, R., & MacKinnon, J. G. (2004). *Econometric Theory and Methods* (5th ed.). Oxford University Press.
9. Lo, A. W., &MacKinlay, A. C. (1999). *The Econometrics of Financial Markets*. Princeton University Press.

Learning Outcomes:

1. Grasp the nature of econometrics and the application of general linear models (GLM), including ordinary least squares (OLS) and generalized least squares (GLS) for estimation and prediction.
2. Identify and manage problems such as heteroscedasticity, autocorrelation, and multicollinearity, employing techniques like ridge regression and instrumental variable estimation.
3. Comprehend the expected value principle, utility functions, and the application of insurance and utility theory, including the analysis of survival functions and life tables.
4. Master concepts of nominal and effective interest rates, force of interest, compound interest, and various types of annuities, as well as the computation of premiums for continuous and discrete life insurance products.

Course Title: STAMJ64: Official and Vital Statistics

Category of Course: Major

Credits & Hours of Teaching

	Theory	Practical	Cumulative
Credits	**3**	**1**	**4**
Hours of Teaching (Total)	**45**	**30**	**75**

Course Objectives:

1. To understand the official statistics, sources of different data required regarding economy, agriculture, demography, environment, social and cultural situations in a particular country.
2. To understand vital statistics and their sources, trends and measures.
3. To aware about population projections methods, family welfare programs and labour force statistics.

Course Content: The course content be divided into minimum 3 Units to maximum 5 units along with defined Hours of teaching for each unit.

Units	Course Content	Hours of Teaching
I	Introduction to Indian and International statistical systems. role, function and activities of central and state statistical organizations, organization of large-scale sample surveys, role of national sample survey organization general and special data dissemination systems.	10
II	System of collection of agricultural statistics, crop forecasting and estimation, productivity, fragmentation of holdings, support prices, buffer stocks, impact of irrigation projects. Statistics related to industries, foreign trade, balance of payment, cost of living, inflation, educational and other social statistics.	10
III	Some basic demographic concepts. Components of population change. Historical trends in population situation in the world. Brief description of Demographic transition theory. Sources of Demographic Data: Population census; Uses and limitations; Indian Censuses, Vital registration system, National Sample Surveys, Sample Registration System, Demographic Health Surveys (DHS) and other sample surveys.	10
IV	Measurement of Mortality and Life Table: Crude death rate, Standardized death rates, Age-specific death rates, Infant Mortality rate, Death rate by cause, Complete life table and its main features, Uses of life table. Maternal Mortality rate	5
V	Basic terms and concepts used in the study of fertility. Measurement of Fertility: Crude birth rate, general fertility rate, age specific birth rate, total fertility rate, gross reproduction rate, net reproduction rate. Concepts of population projections; population estimates and forecasts uses of population projections. Mathematical methods of measuring population projection. Population growth in developed and developing countries, evaluation and performance of family welfare programmes, projections of labour force and manpower.	10

Texts / References:

1. Basic Statistics Relating to the Indian Economy (CSO), 1990.
2. Guide to Official Statistics (CSO) 1999.
3. Statistical System in India (CSO), 1995.
4. Principles and accommodation of National Population Censuses, UNESCO.
5. Panse, V.G.: Estimation of Crop Yields (FAO).
6. Family Welfare Yearbook, Annual Publication of D/o Family Welfare.
7. Monthly Statistics of Foreign Trade in India, DGCIS, Calcutta and other Govt. Publications.
8. Ram Kumar (1986): Technical Demography, Wiley Eastern Ltd.
9. Benjamin, B. (1969): Demographic Analysis, George, Allen and Unwin.
10. Cox, P.R. (1970): Demography, Cambridge University Press.
11. Spiegelman, M. (1969): Introduction to Demographic Analysis, Harvard University Press.
12. Pathak, K. B. and Ram, F.(1992) Techniques of Demographic Analysis, Himalaya Publication House.

Learning Outcomes: Upon completing this course, students will achieve the following learning outcomes:

1. Students will learn national and international statistical systems for official statistics.
2. They will learn to different sources of demographic data like census, vital registration systems, sample surveys.
3. They will learn to measures of fertility, mortality and life-table techniques.
4. Students will learn different population projection methods and their applications.

Course Title	STAMJ65: Practical Based on STAMJ61, STAMJ62 &STAMJ64

Paper will be based on numerical problems of Paper STAMJ61, STAMJ62 &STAMJ64

Paper and Unit	Hours of Practical
Paper STAMJ61 Unit I to IV	30
Paper STAMJ62 Unit I to IV	30
Paper STAMJ64 Unit I to V	30

Semester VII

Course Title: STAMJ71: Linear Models & Regression Analysis

Category of Course: Major

Credits& Hours of Teaching

	Theory	Practical	Cumulative
Credits	**3**	**1**	**4**
Hours of Teaching (Total)	**45**	**30**	**75**

Course Objectives:

1. To understand the concepts of liner models and estimation of parameters.
2. To learn g-inverse of a matrix and its application in estimation.
3. Explain the applications of linear model in analysis of variance.
4. To understand multiple comparison tests in comparison of means.
5. To explore the idea of simple and multiple regression, residual analysis and detection of outliers.
6. To understand the assumptions of regression analysis.

Course Content: The course content be divided into minimum 3 Units to maximum 5 units along with defined Hours of teaching for each unit.

Units	Course Content	Hours of Teaching
I	Gauss-Markov linear models, estimable functions, error and estimation space, normal equations and least square estimators, estimation of error variance, estimation with correlated observations, properties of least square estimators, generalized inverse of a matrix and solution of normal equations, variances and covariances of least square estimators.	15
II	One way and two-way classifications, fixed, random and mixed effects models. Analysis of variance (two-way classification only), Multiple comparison tests due to Tukey, Scheffe and Student-Newmann-Keuls.	5
III	Simple linear regression, multiple regression, fit of polynomials and use of orthogonal polynomials. Residuals and their plots as tests for departure from assumptions such as fitness of the model, normality, homogeneity of variances and detection of outliers and Remedies	15
IV	Multicollinearity, ridge regression, subset selection of explanatory variables, Mallow-Cp Statistics and its applications.	10

Texts / References:

1. Goon, A.M., Gupta, M.K. and Das Gupta, B. (1967): An Outline of Statistical Theory, Vol. 2, The World Press Pvt. Ltd., Calcutta.
2. Rao, C.R. (1973); Linear Statistical Inference and its Application, Wiley Eastern.
3. Graybill, I.A. (1961): An Introduction to Linear Statistical Models, Vol. 1, McGraw Hill Book Co. Inc.
4. Draper, N.R. and Smith H. (2014); Applied Regression Analysis, 4th Ed. Wiley.
5. Weisberg, S. (2005): Applied Linear Regression, 3rd Ed. Wiley.
6. Cook, R.D. and Weisherg, S. (2007): Residuals and Inference in Regression, 2nd Ed. Chapman and Hall

Learning Outcomes: Students will learn

1. The estimation techniques and calculation of parameters of linear models.
2. The concepts and applications of Fixed effects, random effects and mixed effects models.
3. Properties of least square method f estimation of parameters of linear models.
4. simple and multiple regression analysis, and computation of R^2 and adjusted R^2
5. Residual analysis and methods of obtaining residuals, computation of outliers.
6. Diagnosis of multicollinearity, applications of ridge regression and Mallow-Cp Statistics.

Course Title: STAMJ72: Measure & Probability Theory

Category of Course: Major

Credits& Hours of Teaching

	Theory	Practical	Cumulative
Credits	**3**	**Nil**	**3**
Hours of Teaching (Total)	**45**	**Nil**	**45**

Course Objectives

1. To understand the concepts of classes of sets, field, sigma field, limit s of sequence of sets.
2. To learn probability measure and its properties.
3. Understand measurable function, different convergence theorems.
4. To understand characteristic function and different mode of convergence of sequence of random variables and their applications.
5. To explore the idea of Law of large numbers, CLT and their applications.

Course Content: The course content be divided into minimum 3 Units to maximum 5 units along with defined Hours of teaching for each unit.

Units	Course Content	Hours of Teaching
I	Classes of sets, fields, sigma field, minimal sigma field, Borel sigma field, sequence of sets, limsup and liminf of a sequence of sets, measure, probability measure, properties of measure, Caratheodory extension theorem, Lebesgue and Lebesgue - Steiltzes measures.	15
II	Inverse function and their properties, measurable functions, random variables, sequence of random variables, Integration of a measurable function with respect to a measure, monotone convergence theorem, Fatou's lemma, dominated convergence theorem.	10
III	Characteristic function, uniqueness theorem, Levy's continuity theorem, Convergence in distribution, Convergence in probability, almost sure convergence.	10
IV	Borel-Cantelli lemma, independence of random variables, weak law and strong law of large numbers for the sequences of independently and identically distributed and non- i.i.d. random variables; Central limit theorem due Lindeberg- Levy for i.i.d. random variables, Liapounav's CLT for sequence of non- i.i.d. random variables.	10

Texts / References

1. Robert, A. (1972): Real Analysis and Probability, Academic press.
2. Billingsley, P. (2008): Probability and Measure, Third edition, Wiley.
3. Dudley, R.M. (2002): Real Analysis and Probability; Cambridge Studies in Advanced Mathematics.
4. Kingman, J.F.C. and Taylor, S.J. (2011): Introduction to Measure and Probability, Cambridge University Press.
5. Basu, A. K. (2012): Measure Theory And Probability: Second Edition, Prentice Hall India Learning Private Limited.
6. Athreya, K. B. and Lahiri, S. N. (2010): Measure Theory and Probability Theory Springer- Verlag New York Inc.

Learning Outcomes: Students will learn

1. Field, Sigma field, minimal field and Sigma field, Borel field and their properties, probability measure and their characterizations.
2. Integration of measurable function with respect to a measure.
3. Properties of different modes of convergence.
4. Different modes of convergence and examples of convergence of sequence of random variables
5. Continuity theorem and inversion theorem of characteristics function and their applications.
6. Laws of large numbers and different types of CLT and their applications.

Course Title: STAMJ73: Survey Sampling

Category of Course: Major

Credits & Hours of Teaching

	Theory	Practical	Cumulative
Credits	**3**	**1**	**4**
Hours of Teaching (Total)	**45**	**30**	**75**

Course Objectives

1. To explain the concepts of fixed population vs super-population, and method of SRS and stratified sampling.
2. How to use auxiliary information in estimation
3. To explain the concept of unequal probability sampling
4. How to deal with non-response in surveys.

Course Content: The course content be divided into minimum 3 Units to maximum 5 units along with defined Hours of teaching for each unit.

Units	Course Content	Hours of Teaching
I	Fixed population and super-population approaches. Distinct features of finite population sampling, Probability sampling design and estimators along with basic statistical properties. Review of some important results in SRSWOR and SRSWR. Estimation of population mean/Total in stratified population, Allocation problem in stratified random sampling in case of fixed cost and also for specified precision. Expression for variance of stratified sample mean in case of fixed cost, Post stratification, Double sampling with post stratification, Deep stratification, Controlled sampling.	11
II	Ratio, product and regression methods of estimation. Estimation of population mean, evaluation of bias and variance/MSE to the first order of approximation, comparison with simple random sampling. Double sampling scheme, Some double sampling estimators for mean using auxiliary character (Ratio, regression and product) method of estimation, Some unbiased ratio type estimators for population mean.	11
III	Unequal probability sampling: PPSWR/WOR methods (including Lahiri's scheme) and Des Raj estimator, Murthy estimator (for n=2). Horvitz Thompson Estimator of finite population total/mean, Expression for Variance (HTE) and its unbiased estimator, Issue of non-negative variance estimation, IIPS Scheme of sampling due to Midzuno-Sen.	13
IV	Concept of cluster sampling, two stage sampling, Non-sampling error with special reference to non-response problems.	10

Texts / References

1. Cassel, C.M., Sarndal, C.E. and Wretman (1977): Foundation of Inference in Survey Sampling, Wiley Inter Science, New York.
2. Hansen, M. H., Hurwitz, W. N., & Madow, W. G. (1953). Sample survey methods and theory.
3. Singh, R., & Mangat, N. S. (2013). Elements of survey sampling (Vol. 15).
4. Springer Science & Business Media.
5. Murthy, M.N. (1977): Sampling Theory and Methods. Statistical Publication Society, Calcutta.
6. Mukhopadhyay, P. (1996): Inferential Problems in Survey Sampling, New Age International (P).
7. Sampath S. (2000) : Sampling Theory and Methods, Narosa Publishing House, New Delhi.
8. Sukhatme P.V., Sukhatme B.V., Sukhatme S. and Asok C. (1998): Sampling Theory of Surveys with Applications (4th ed.)., Indian Society of Agricultural Statistics, New Delhi.
9. Goon A.M., Gupta M.K. and Das Gupta B. (2014): Fundamentals of Statistics, Vol. II, world Press, Calcutta.
10. Cochran, W.G.: Sampling Techniques (3rd edition. 1977), Wiley.
11. Singh D. and Chaudhary, F.S. (1986): Theory and Analysis of Sample Survey Designs, New Age International Publishers.
12. Singh, S. (2003) : Advanced sampling theory with applications. Springer-Science +Business Media, B.V.
13. Wu, C. and Thompson, M. E. (2020) : Sampling theory and practice. Springer.

Learning Outcomes: Upon completing this course, students will achieve the following learning outcomes

1. To select sampling units under probability and non-probability sampling procedures.
2. Constructing improved estimators using auxiliary information.
3. Student will be able to differentiate between the situations of equal probability and PPS sampling methods
4. How to tackle non-response problems in surveys.

Course Title: STAMJ74: Advanced Statistical Inference

Category of Course: Major

Credits & Hours of Teaching

	Theory	Practical	Cumulative
Credits	**4**	**1**	**5**
Hours of Teaching (Total)	**60**	**30**	**90**

Course Objectives

1. To understand Extend Cramer-Rao inequality and bounds.
2. To understand properties different statistics.
3. To understand maximum asymptotic properties of estimators.
4. To explore advanced inferential procedures.

Course Content: The course content be divided into minimum 3 Units to maximum 5 units along with defined Hours of teaching for each unit.

Units	Course Content	Hours of Teaching
I	Extension of Cramer-Rao inequality for multi-parameter case, Bhattacharya bounds.	10
II	Ideas of sufficient, minimal complete-sufficient statistics, sufficiency when the range of variable depends on a parameter, minimum variance unbiased estimators, Rao-Blackwell, Lehman-Scheffe and Basu theorem.	15
III	MLE and its asymptotic properties, Interval estimation by confidence sets, Neyman theory, uniformly most accurate intervals.	15
IV	Neyman-Pearson lemma, generalized Neyman-Pearson lemma, monotone likelihood ratio families, UMP tests for one and two sided alternatives, admissibility and unbiasedness of tests, type A and type A1 tests, similar tests, tests having Neyman structure, likelihood ratio test (LRT) asymptotic distribution of LRT statistic.	20

Texts / References

1. Kale, B.K. (1999): A First Course on Parametric Inference, Narosa Publishing House.
2. Rohatgi, V.K. (1988): An Introduction to Probability and Mathematical Statistics, Wiley Eastern, New Delhi.
3. Lehmann, E.L. (1986): Theory of Point Estimation, Student Edition.
4. Lehmann, E.L.(1986): Testing Statistical Hypotheses, Student Editions.
5. Zacks, S. (1971): Theory of Statistical Inference, Wiley, New York.
6. Sheskin, D. J. (2020). Handbook of parametric and nonparametric statistical procedures. Chapman and hall/CRC, Fifth Edition
7. Roussas, G. G. (2015). An introduction to probability and statistical inference. Elsevier, Second Edition
8. Almudevar, A. (2021). Theory of statistical inference. Chapman and Hall/CRC, First Edition
9. Wasserman, L. (2013). All of statistics: A concise course in statistical inference, Second Edition
10. Casella, G., & Berger, R. L. (2022). Statistical Inference (3rd ed.). Brooks/Cole, Cengage Learning.
11. Mukhopadhyay, N. (2020). Probability and statistical inference. CRC Press.
12. Niewiadomska-Bugaj, M., &Bartoszynski, R. (2020). Probability and statistical inference. John Wiley & Sons.
13. Silvey, S. D. (2017). Statistical inference. Routledge.

Learning Outcomes:

1. Proficiency in extending Cramer-Rao inequality to compute the lower bound of the covariance matrix of unbiased estimators and understanding the Bhattacharya bound which provides tighter variance bounds where Cramer-Rao bounds may not be sufficient.
2. Ability to identify and apply sufficient, minimal complete-sufficient statistics, derive and utilize minimum variance unbiased estimators.
3. Understanding of MLE and its asymptotic properties.
4. Skill in constructing and interpreting confidence intervals using Neyman theory.
5. Capability to apply Neyman-Pearson lemma and generalized lemma for hypothesis testing.
6. Expertise in conducting UMP tests, evaluating test admissibility and unbiasedness, and performing LRT with an understanding of their asymptotic distributions.

Course Title	STAMJ75: Practical Based on STAMJ71

Paper will be based on numerical problems of Paper STAMJ71, STAMJ73, STAMJ74 as per following distribution

Unit	Number of Practical
I	4
II	10
III	10
IV	6

Course Title	STAMJ76: Practical Based on STAMJ73& STAMJ74

Paper will be based on numerical problems of Paper STAMJ73& STAMJ74 as per following distribution

Paper STAMJ73 Unit I to III	30
Paper STAMJ74 Unit I to III	30

Course Title: STAMN71: Linear Models & Regression Analysis

Category of Course: Minor

Credits& Hours of Teaching

	Theory	Practical	Cumulative
Credits	**3**	**1**	**4**
Hours of Teaching (Total)	**45**	**30**	**75**

Course Objectives:

1. To understand the concepts of liner models and estimation of parameters.
2. To learn g-inverse of a matrix and its application in estimation.
3. Explain the applications of linear model in analysis of variance.
4. To understand multiple comparison tests in comparison of means.
5. To explore the idea of simple and multiple regression, residual analysis and detection of outliers.
6. To understand the assumptions of regression analysis.

Course Content: The course content be divided into minimum 3 Units to maximum 5 units along with defined Hours of teaching for each unit.

Units	Course Content	Hours of Teaching
I	Gauss-Markov linear models, estimable functions, error and estimation space, normal equations and least square estimators, estimation of error variance, estimation with correlated observations, properties of least square estimators, generalized inverse of a matrix and solution of normal equations, variances and covariances of least square estimators.	15
II	One way and two-way classifications, fixed, random and mixed effects models. Analysis of variance (two-way classification only), Multiple comparison tests due to Tukey, Scheffe and Student-Newmann-Keuls.	5
III	Simple linear regression, multiple regression, fit of polynomials and use of orthogonal polynomials. Residuals and their plots as tests for departure from assumptions such as fitness of the model, normality, homogeneity of variances and detection of outliers and Remedies	15
IV	Multicollinearity, ridge regression, subset selection of explanatory variables, Mallow-Cp Statistics and its applications.	10

Texts / References:

1. Goon, A.M., Gupta, M.K. and Das Gupta, B. (1967): An Outline of Statistical Theory, Vol. 2, The World Press Pvt. Ltd., Calcutta.
2. Rao, C.R. (1973); Linear Statistical Inference and its Application, Wiley Eastern.
3. Graybill, I.A. (1961): An Introduction to Linear Statistical Models, Vol. 1, McGraw Hill Book Co. Inc.
4. Draper, N.R. and Smith H. (2014); Applied Regression Analysis, 4th Ed. Wiley.
5. Weisberg, S. (2005): Applied Linear Regression, 3rd Ed. Wiley.
6. Cook, R.D. and Weisberg, S. (2007): Residuals and Inference in Regression, 2nd Ed. Chapman and Hall

Learning Outcomes: Students will learn

1. the estimation techniques and calculation of parameters of linear models.

2. the concepts and applications of Fixed effects, random effects and mixed effects models.
3. properties of least square method f estimation of parameters of linear models.
4. simple and multiple regression analysis, and computation of R^2 and adjusted R^2
5. residual analysis and methods of obtaining residuals, computation of outliers.
6. diagnosis of multicollinearity, applications of ridge regression and Mallow-Cp Statistics.

Course Title: STAMN72: Practical Based on STAMN71

Paper will be based on numerical problems of Paper STAMN71

Unit	Hours of Practical
I	4
II	10
III	10
IV	6

Semester VIII

Course Title: STAMJ81: Design and Analysis of Experiments

Category of Course: Major

Credits& Hours of Teaching

	Theory	Practical	Cumulative
Credits	**3**	**1**	**4**
Hours of Teaching (Total)	**45**	**30**	**75**

Course Objectives

1. To understand the concepts of basic designs and analysis in the case of missing observations.
2. To learn Analysis of Covariance (ANCOVA) for CRD and RBD under one concomitant variable.
3. Understand the concept of Incomplete Block Designs, BIBD and PBIBD.
4. To understand factorial experiments and analysis, nested designs and fractional factorial.
5. To explore the idea Split plot and Strip Plot designs.
6. To understand application response area, clinical trials, RCT.

Course Content: The course content be divided into minimum 3 Units to maximum 5 units along with defined Hours of teaching for each unit.

Units	Course Content	Hours of Teaching
I	Review of linear estimation and basic designs, missing plot technique: General theory and applications, Analysis of Co-variance for CRD and RBD.	10
II	Incomplete block design: Balanced incomplete block designs, simple lattice designs, Two-associate partially balanced incomplete block designs: association scheme and intra block analysis, group divisible designs.	10
III	General factorial experiments, factorial effects; estimates and testing the significance of factorial effects; study of 2^n and 3^r factorial experiments in randomized blocks; complete and partial confounding, construction of symmetrical confounded factorial experiments, fractional replications for symmetrical factorials, split plot and strip-plot experiments.	15
IV	Application areas: Response surface experiments; first order designs, and orthogonal designs; clinical trials, treatment-control designs; model variation and use of transformation; Tukey's test for additivity.	10

Texts / References

1. Dean, A., & Voss, D. (2023). *Design and Analysis of Experiments* (7th ed.). Springer.
2. Montgomery, C. D. (2023). *Design and Analysis of Experiment* (9th ed.). Wiley, New York.
3. Myers, R. H. (2016). *Response Surface Methodology* (4th ed.). John Wiley & Sons.
4. Dey, A. (1986). *Theory of Block Designs.* Wiley Eastern.
5. Das, M., & Giri, N. (1979). *Design and Analysis of Experiments*. Wiley Eastern.
6. Joshi, D. D. (1987). *Linear Estimation and Design of Experiments*. Wiley Eastern.
7. Giri, N. (1986). *Analysis of Variance*. South Asian Publishers.

Learning Outcomes: Students will learn

1. Basic fundamentals of designs, complete block designs their layout and analysis under missing observations.
2. Incomplete block designs their types, analysis and applications.
3. properties of different convergence theorems.
4. 2^n, 3^n factorial experiments and their analysis, obtain confounded effects under different replications.
5. Applications of Split plot (Nested designs), Strip-plot designs.
6. Treatment control designs and Randomized control trails with applications.

Course Title: STAMJ82: Multivariate Analysis

Category of Course: Major

Credits & Hours of Teaching

	Theory	Practical	Cumulative
Credits	**3**	**1**	**4**
Hours of Teaching (Total)	**45**	**30**	**75**

Course Objectives

1. To understand the basic concepts of vector space and matrices.
2. To impart knowledge about multivariate normal and its derived distributions.
3. Estimation and hypothesis testing for the parameters of multivariate normal populations.
4. To understand different dimension reduction methods.

Course Content: The course content be divided into minimum 3 Units to maximum 5 units along with defined Hours of teaching for each unit.

Units	Course Content	Hours of Teaching
I	Overview of multivariate data, multivariate normal distribution and its properties. Random sampling from multivariate normal distribution. Maximum likelihood estimators of parameters, distribution of sample mean vector, testing of mean vector for one and two sample problems.	15
II	Wishart matrix – its distribution and properties, distribution of sample generalized variance, testing of equality of covariance matrices. Overview of multiple and partial correlation coefficients, null and non-null distribution of multiple correlation coefficients.	8
III	Hotelling's T^2 statistic – its distribution and properties, applications in testing of mean vector for one and more multivariate normal population and on equality of components of mean vector in two multivariate normal populations. Mahalanobis D^2 statistic and its distribution.	7
IV	Discrimination & classification, procedure of classification based on several multivariate populations with emphasis on multivariate normal populations, probability of misclassification, idea of sample discriminant function.	8
V	Idea of Principal components analysis, Canonical correlation analysis with their applications.	7

Texts / References

1. Johnson, R. A., & Wichern, D. W. (2015). *Applied Multivariate Statistical Analysis* (6th ed.). Pearson.
2. Anderson, T. W. (2003). *An Introduction to Multivariate Statistical Analysis* (3rd ed.). Wiley.
3. Morrison, D. F. (2004). *Multivariate Statistical Methods* (4th ed.). Brooks/Cole.
4. Muirhead, R. J. (1982). *Aspects of Multivariate Statistical Theory*. Wiley.
5. Carroll, J. D., & Green, P. E. (2002). *Analyzing Multivariate Data*. Cengage Learning.
6. Hair, J. F., Black, W. C., Anderson, R. E., & Tatham, R. L. (2006). *Multivariate Data Analysis* (7th ed.). Pearson.

Learning Outcomes: After completing this course a student will have knowledge of

1. Applications of multivariate normal distribution.
2. Sampling distributions of estimators of parameters of MVN distribution.
3. Comparison of MVN populations.
4. Classification of observations in two or more populations.
5. Various dimension reduction techniques like Principal Component Analysis, Factor Analysis and Canonical Correlation Analysis.

Course Title: STAMJ83: Bayesian Inference

Category of Course: Major

Credits & Hours of Teaching

	Theory	Practical	Cumulative
Credits	**3**	**1**	**4**
Hours of Teaching (Total)	**45**	**30**	**75**

Course Objectives

1. Provide an overview of statistical decision theory.
2. To equip students with fundamentals of Bayesian theory.
3. Develop skills in Bayesian inference.
4. Introduce basic Bayesian computation techniques and their practical applications.

Course Content: The course content be divided into minimum 3 Units to maximum 5 units along with defined Hours of teaching for each unit.

Units	Course Content	Hours of Teaching
I	An overview of Statistical Decision Theory, decision problem and 2-person game, loss functions, risk functions, decision rules and utilty functions. Concept of admissibility, minimaxity and completeness, Bayes rules, admissibility of Bayes rules.	14
II	Different types of informative and non-informative prior distributions: conjugate priors, Jeffreys' priors, maximum entropy priors, invariant priors. Summarizing posterior distributions and the posterior as an average of the prior and data.	12
III	Bayes point and interval estimation, comparisons with likelihood based inferences; inferences for standard parameter models. Concepts of prior odds, posterior odds, Bayes factors. Bayes testing for simple and composite hypotheses. Lindley';s paradox, Bayesian model checking and comparison, Predictive distribution. Brief Idea of point and interval prediction.	14
IV	Elementary idea of Bayesian computation.	5

Texts / References

1. Berger, J.O. (1985): Statistical Decision Theory and Bayesian Analysis, Springer Verlag.
2. Robert, C.P. and Casella, G. (2004): Monte Carlo Statistical Methods, Springer Verlag.
3. Leonard, T., & Hsu, J. S. (2001). Bayesian methods: an analysis for statisticians and interdisciplinary researchers (Vol. 5). Cambridge University Press.
4. Bernardo, J. M., & Smith, A. F. (2000). Bayesian theory. John Wiley & Sons.
5. Robert, C. P. (2007). The Bayesian choice: from decision-theoretic foundations to computational implementation (Vol. 2). New York: Springer.
6. Gamerman, D., & Lopes, H. F. (2006). Markov chain Monte Carlo: stochastic simulation for Bayesian inference. Chapman and Hall/CRC.
7. Box, G.P. and Tiao, G.C(1992): Bayesian Inference in Statistical Analysis, Addison-Wesley.
8. Gelman, A., Carlin, J. B., Stern, H. S., & Rubin, D. B. (1995). Bayesian data analysis. Chapman and Hall/CRC.
9. Bansal, A.K. (2007). Bayesian Parametric Inference. Alpha Science International Ltd.
10. Sinha, S.K. (1998). Bayesian Estimation. New Age International Pvt. Ltd.

Learning Outcomes: Upon completing this course, students will achieve the following learning outcomes

1. Key concepts, including decision problems, loss functions, risk functions, and utility functions.
2. Develop knowledge of prior, posterior distributions and prior elicitation.
3. Parameter estimation under different loss functions and testing of hypothesis.
4. Conduct Bayes estimation for the real-world problems and compare these methods with likelihood-based inferences.

Course Title: STAMJ84: Statistical Aspects of Machine Learning

Category of Course: Major

Credits & Hours of Teaching

	Theory	Practical	Cumulative
Credits	**3**	**1**	**4**
Hours of Teaching (Total)	**45**	**30**	**75**

Course Objectives

This course is designed to introduce:

1. Proficiency in python for machine learning regarding statistical modeling
2. Apply supervised and unsupervised learning techniques for multivariate analysis
3. Perform data preprocessing and exploratory statistical analysis
4. Understand and implement neural networks

Course Content: The course content be divided into minimum 3 Units to maximum 5 units along with defined Hours of teaching for each unit.

Units	Course Content	Hours of Teaching
I	Introduction to Python, Overview of machine learning concepts and applications: Supervised, unsupervised, and reinforcement learning. Types of learning algorithms: regression, classification, and clustering.	5
II	Data Preprocessing and Visualization: Data cleaning and handling missing values. Feature scaling and normalization. Handling categorical variables. Exploratory data analysis and visualization using Python libraries (e.g., Pandas, Matplotlib, Seaborn).	8
III	Regression Analysis: Linear regression and multiple linear regression. Polynomial regression and feature transformation. Regularization techniques (L1, L2). Evaluation metrics for regression models. Classification Methods: Logistic regression and probabilistic models. Naive Bayes classifiers. Decision trees and ensemble methods (random forests, boosting). Support vector machines for classification. Performance evaluation and metrics for classification models.	12
IV	Unsupervised Learning Techniques: Clustering algorithms (K-means, hierarchical clustering). Dimensionality reduction techniques (PCA, t-SNE). Evaluation and validation of clustering results.	10
V	Introduction to Neural Networks: Basics of artificial neural networks (ANNs). Activation functions and training algorithms. Feedforward neural networks. Backpropagation algorithm.	10

Texts / References

1. Hastie, T., Tibshirani, R., & Friedman, J. H. (2009). *The Elements of Statistical Learning: Data Mining, Inference, and Prediction* (2nd ed.). Springer.
2. Géron, A. (2019). *Hands-On Machine Learning with Scikit-Learn, Keras, &TensorFlow: Concepts, Tools, and Techniques for Building Intelligent Systems* (2nd ed.). O'Reilly Media.
3. Müller, A. C., & Guido, S. (2016). *Introduction to Machine Learning with Python: A Guide for Data Scientists*. O'Reilly Media.
4. Raschka, S. (2017). *Python Machine Learning: Machine Learning in Python: A Practical Introduction with Scikit-learn* (2nd ed.). Packt Publishing.
5. Aurélien, G. (2017). *Deep Learning with Python.* Packt Publishing.
6. Chollet, F. (2018). *Deep Learning with Keras*. Manning Publications.
7. Liu, J., Tang, X., & Liu, H. (2019). *Practical Machine Learning: A Python-Based Guide*. O'Reilly Media
8. John M. Zelle, Python Programming: An Introduction to Computer Science, 2004.
9. Chun W. J. (2010), Core Python Programming, Pearson.
10. Murphy, K. P. (2012). Machine learning: A probabilistic perspective. MIT Press.
11. Goodfellow, I., Bengio, Y., &Courville, A. (2016). Deep learning. MIT Press.

Learning Outcomes: Students will be able to

1. Develop a strong foundation in Python programming and its libraries for machine learning, including data preprocessing, visualization, and handling various data types.
2. Implement and evaluate machine learning algorithms for regression, classification, and clustering, understanding their applications and limitations.
3. Conduct data cleaning, feature scaling, normalization, and exploratory data analysis using Python tools like Pandas, Matplotlib, and Seaborn.
4. Grasp the basics of artificial neural networks, including activation functions, training algorithms, and

backpropagation, and apply them to real-world problems.

Course Title: STAMJ85: Practical Based on STAMJ81

Paper will be based on numerical problems of Paper STAMJ81

Paper & Unit	Hours of Practical
I	4
II	6
III&IV	20

Course Title: STAMJ86: Practical Based on STAMJ82, STAMJ83& STAMJ84.

Paper will be based on numerical problems of Paper STAMJ82, STAMJ83& STAMJ84

Paper & Unit	Hours of Practical
STAMJ82 Unit I to V	30
STAMJ83 Unit I to IV	30
STAMJ84 Unit I to V	30

Course Title: STAMN81: Design and Analysis of Experiments

Category of Course: Minor

Credits& Hours of Teaching

	Theory	Practical	Cumulative
Credits	**3**	**1**	**4**
Hours of Teaching (Total)	**45**	**30**	**75**

Course Objectives

1. To understand the concepts of basic designs and analysis in the case of missing observations.
2. To learn Analysis of Covariance (ANCOVA) for CRD and RBD under one concomitant variable.
3. Understand the concept of Incomplete Block Designs, BIBD and PBIBD.
4. To understand factorial experiments and analysis, nested designs and fractional factorial.
5. To explore the idea Split plot and Strip Plot designs.
6. To understand application response area, clinical trials, RCT.

Course Content: The course content be divided into minimum 3 Units to maximum 5 units along with defined Hours of teaching for each unit.

Units	Course Content	Hours of Teaching
I	Review of linear estimation and basic designs, missing plot technique: General theory and applications, Analysis of Co-variance for CRD and RBD.	10
II	Incomplete block design: Balanced incomplete block designs, simple lattice designs, Two-associate partially balanced incomplete block designs: association scheme and intra block analysis, group divisible designs.	10
III	General factorial experiments, factorial effects; estimates and testing the significance of factorial effects; study of 2^n and 3^r factorial experiments in randomized blocks; complete and partial confounding, construction of symmetrical confounded factorial experiments, fractional replications for symmetrical factorials, split plot and strip-plot experiments.	15
IV	Application areas: Response surface experiments; first order designs, and orthogonal designs; clinical trials, treatment-control designs; model variation and use of transformation; Tukey's test for additivity.	10

Texts / References

1. Dean, A., & Voss, D. (2023). *Design and Analysis of Experiments* (7th ed.). Springer.
2. Montgomery, C. D. (2023). *Design and Analysis of Experiment* (9th ed.). Wiley, New York.
3. Myers, R. H. (2016). *Response Surface Methodology* (4th ed.). John Wiley & Sons.
4. Dey, A. (1986). *Theory of Block Designs.* Wiley Eastern.
5. Das, M., & Giri, N. (1979). *Design and Analysis of Experiments*. Wiley Eastern.
6. Joshi, D. D. (1987). *Linear Estimation and Design of Experiments*. Wiley Eastern.
7. Giri, N. (1986). *Analysis of Variance*. South Asian Publishers.

Learning Outcomes: Students will learn

1. Basic fundamentals of different designs.
2. Incomplete block designs their types, analysis and applications.
3. properties of different convergence theorems.

4. 2^n , 3^n factorial experiments and their analysis,
5. Applications of designs.

Course Title: STAMN82: Practical Based on STAMN81

Paper will be based on numerical problems of Paper STAMN81

Unit	Hours of Practical
I	4
II	6
III &IV	20

Semester VIIIR

Course Title: STAMJ8R1: Distribution Theory

Category of Course: Major

Credits & Hours of Teaching

	Theory	Practical	Cumulative
Credits	**3**	**1**	**4**
Hours of Teaching (Total)	**45**	**30**	**75**

Course Objectives

1. To introduce the concept univariate and bivariate probability distributions.
2. To develop various distributions through various approaches.
3. To develop concept of mixture and truncated probability distributions.
4. To understand different probability-inequalities.
5. To understand non-central sampling distributions.
6. To conceptualize order statistics and their functions.

Course Content: The course content be divided into minimum 3 Units to maximum 5 units along with defined Hours of teaching for each unit.

Units	Course Content	Hours of Teaching
I	Brief review of basic distribution theory, joint, marginal conditional pmf and pdf, standard discrete and continuous distributions, bivariate normal, bivariate exponential, multivariate normal and multinomial distributions, functions of random variables and their distributions using Jacobian of transformation and other tools.	15
II	Compound, truncated and mixture distributions, multiple and partial correlations, linear and multiple regressions. Markov, Holder, Jensen, Liapunov inequalities.	10
III	Sampling distributions, non-central chi-square, t and F distributions and their properties. Distributions of quadratic forms under normality and related distribution theory.	10
IV	Order statistics, their distributions and properties, joint and marginal distributions of order statistics, moments of order statistics and recurrence relations, extreme values and their asymptotic distributions with applications. approximating distributions Δ-Method & its applications, approximating distributions of sample moments, transformations of statistics.	10

Texts / References

1. Dudewicz, E.J. and Mishra, S.N. (1988): Modern Mathematics Statistics, Wiley International students edition.
2. Rohatagi, V.K. (1984): An introduction to Probability Theory and Mathematical Statistics, Wiley Eastern.
3. Rao, C.R. (1973); Linear Statistical Inference and its Applications, Wiley Eastern.
4. Pitman, J. (1993): Probability, Narosa Publishing House.
5. Jonson, S. and Kotz, S. (1972): Distribution in Statistics Vol. I-II & III, Houghton and Mifflin.
6. Mukhopadhyay, P. (1996): Mathematical Statistics, NCBA.
7. Ferguson, T.S. (1967): Mathematical Statistics, Academic Press.
8. Forbes, C., Evans, M., Hastings, N., & Peacock, B. (2011). *Statistical distributions* (1st ed.). John Wiley & Sons.
9. Hogg, R. V., McKean, J. W., & Craig, A. T. (2021). *Introduction to mathematical statistics* (8th ed.). Pearson Education India.
10. Feller, W., & Morse, P. M. (1958). *An introduction to probability theory and its applications*.

Learning Outcomes: After completing this course, the students will learn the followings;

1. Development of univariate and bivariate probability distributions through various approaches.
2. Different transformation techniques for obtaining the distribution of function one or more random variables.
3. Importance of mixture and truncated probability distributions.

4. To understand the applicability of different probability inequalities and their development.
5. Development of non-central sampling distributions viz., chi, t and F.
6. Importance of order statistics, distribution of different order statistics and related functions.
7. Moments of order statistics and their asymptotic distributions.

Course Title: STAMJ8R2: Technical Demography

Category of Course: Major

Credits & Hours of Teaching

	Theory	Practical	Cumulative
Credits	**3**	**1**	**3**
Hours of Teaching (Total)	**45**	**30**	**75**

Course Objectives

1. To understand the difference between demography and Population studies and sources of collecting demographic data.
2. To understand quality of data and concept of population transition theory.
3. Understand the concept of measures of fertility, models of reproduction and different types of birth interval data.
4. To understand concepts of mortality its measure, Life table types and its construction methods
5. To explore the idea of migration, migration models and its measures.
6. To understand population projections, nuptiality and its measure.

Course Content: The course content be divided into minimum 3 Units to maximum 5 units along with defined Hours of teaching for each unit.

Units	Course Content	Hours of Teaching
I	Coverage and content errors in demographic data, Chandrasekharan—Deming formula to check completeness of registration data, adjustment of age data- use of Whipple, Myer and UN indices. Population transition theory.	10
II	Measures of fertility; stochastic models for reproduction, distributions of time of birth, inter-live birth intervals and of number of births (for both homogeneous and homogeneous groups of women), estimation of parameters; estimation of parity progression from open birth interval data.	10
III	Measures of Mortality; construction of abridged life tables, infant mortality rate and its adjustments, model life table.Stable and quasi-stable populations, intrinsic growth rate. Models of population growth and their filling to population data.	10
IV	Internal migration and its measurement, migration models, concept of international migration.Methods for population projection, component method of population projection, Nuptiality and its measurements.	15

Texts / References

1. Kumar, R. (1986): Technical Demography, Wiley Eastern Ltd.
2. Benjamin, B. (1969): Demographic Analysis, George, Allen and Unwin.
3. Chiang, C.L. (1968): Introduction to Stochastic Progression.
4. Cox, P.R. (1970): Demography, Cambridge University Press.
5. Keyfitz, N. (1977): Introduction to the Mathematics of Population-with Revisions, Addison-Wesley, London.
6. Spiegelman, M. (1969): Introduction to Demographic Analysis, Harvard University Press.
7. Wolfenden, H.H. (1954): Population Statistics and Their Compilation, Am Actuarial Society.

Learning Outcomes: Students will learn

1. Basics of demography and its sources and quality of demographic data.
2. Fertility models, stochastic models, reproduction modeling, PPR and birth intervals data.
3. Various measures of mortality and life table techniques.
4. Population growth, projections, and migration.

Course Title: STAMJ83:Bayesian Inference

Category of Course: Major

Credits & Hours of Teaching

	Theory	Practical	Cumulative
Credits	**3**	**1**	**4**
Hours of Teaching (Total)	**45**	**30**	**75**

Course Objectives

1. Provide an overview of statistical decision theory.
2. To equip students with fundamentals of Bayesian theory.
3. Develop skills in Bayes point and interval estimation and in performing Bayesian hypothesis testing.
4. Introduce basic Bayesian computation techniques and their practical applications.

Course Content: The course content be divided into minimum 3 Units to maximum 5 units along with defined Hours of teaching for each unit.

Units	Course Content	Hours of Teaching
I	An overview of Statistical Decision Theory, decision problem and 2-person game, loss functions, risk functions, decision rules and utilty functions. Concept of admissibility, minimaxity and completeness, Bayes rules, admissibility of Bayes rules.	14
II	Different types of informative and non-informative prior distributions: conjugate priors, Jeffreys' priors, maximum entropy priors, invariant priors. Summarizing posterior distributions and the posterior as an average of the prior and data.	12
III	Bayes point and interval estimation, comparisons with likelihood based inferences; inferences for standard parameter models. Concepts of prior odds, posterior odds, Bayes factors. Bayes testing for simple and composite hypotheses. Lindley';s paradox, Bayesian model checking and comparison, Predictive distribution. Brief Idea of point and interval prediction.	14
IV	Elementary idea of Bayesian computation.	5

Texts / References

1. Berger, J.O. (1985): Statistical Decision Theory and Bayesian Analysis, Springer Verlag.
2. Robert, C.P. and Casella, G. (2004): Monte Carlo Statistical Methods, Springer Verlag.
3. Leonard, T., & Hsu, J. S. (2001). Bayesian methods: an analysis for statisticians and interdisciplinary researchers (Vol. 5). Cambridge University Press.
4. Bernardo, J. M., & Smith, A. F. (2000). Bayesian theory. John Wiley & Sons.
5. Robert, C. P. (2007). The Bayesian choice: from decision-theoretic foundations to computational implementation (Vol. 2). New York: Springer.
6. Gamerman, D., & Lopes, H. F. (2006). Markov chain Monte Carlo: stochastic simulation forBayesian inference. Chapman and Hall/CRC.
7. Box, G.P. and Tiao, G.C(1992): Bayesian Inference in Statistical Analysis, Addison-Wesley.
8. Gelman, A., Carlin, J. B., Stern, H. S., & Rubin, D. B. (1995). Bayesian data analysis. Chapman and Hall/CRC.
9. Bansal, A.K. (2007). Bayesian Parametric Inference. Alpha Science International Ltd.
10. Sinha, S.K. (1998). Bayesian Estimation. New Age International Pvt. Ltd.

Learning Outcomes: Upon completing this course, students will achieve the following learning outcomes

1. Key concepts, including decision problems, loss functions, risk functions, and utility functions.
2. Develop knowledge of prior, posterior distributions and prior elicitation.
3. Parameter estimation under different loss functions and testing of hypothesis.
4. Conduct Bayes estimation for the real-world problems and compare these methods with likelihood-based inferences.

Course Title: STAMJ8R4 :Advanced Theory of Sample Surveys

Category of Course: Major

Credits & Hours of Teaching

	Theory	Practical	Cumulative
Credits	3	1	4
Hours of Teaching (Total)	45	30	75

Course Objectives

1. To explain the concepts of errors in sample surveys
2. To explain the of RRT
3. To understand the problem of small area estimation

Course Content: The course content be divided into minimum 3 Units to maximum 5 units along with defined Hours of teaching for each unit.

Units	Course Content	Hours of Teaching
I	Non–Sampling Errors:Different kinds of non – sampling errors. Frame imperfections. Estimation in the presence of frame imperfections. Non–Response:Sources of non – response; unit and item non – response and their measures; Dealing with non – response : call backs and follow – ups; sub-sampling of non – respondents; imputation techniques for unit and item non – response.	11
II	Measurement Errors:Nature of measurement errors; models of measurement errors for estimating population parameters. Interpenetrating sub-samples.	11
III	Randomized Response Technique:Warner's model; related and unrelated questionnaire models; use of binary responses.	13
IV	Issues in Small Area Estimation:Preliminaries; background of domain estimation; basic estimation methods for domains; direct estimators; synthetic estimators; generalized regression estimators.	10

Texts / References

1. Cassel, C.M., Sarndal, C.E. and Wretman (2013): Foundation of Inference in Survey Sampling, 2nd Ed., Wiley Inter Science, New York.
2. Murthy, M.N. (1977): Sampling Theory and Methods. Statistical Publication Society, Calcutta.
3. Mukhopadhyay, P. (1996): Inferential Problems in Survey Sampling, New Age International (P).
4. Sukhatme, P.V., Sukhatme, B.V., Sukhatme, S. and Asok, C. (1984): Sampling Theory of Surveys with Applications, Iowa State University Press and Indian Society of Agricultural Statistics.
5. Cochran, W.G.: Sampling Techniques (3rd edition. 1977), Wiley.
6. Singh D. and Chaudhary, F.S. (1986): Theory and Analysis of Sample Survey Designs, New Age International Publishers.
7. Chaudhuri, A. and R. Mukherjee (1988): Randomised response: theory and techniques, New York, Marcel Deckker Inc.
8. Singh, S. (2003) : Advanced sampling theory with applications. Springer-Science +Business Media, B.V.
9. Wu, C. and Thompson, M. E. (2020) : Sampling theory and practice. Springer.

Learning Outcomes: Upon completing this course, students will achieve the following learning outcomes

5. How to tackle different types of errors in real life situations.
6. How to collect the information when it is of sensitive nature
7. How to get the estimates under the situation of small area.

Course Title: STAMJ8R5 :Statistical Process and Quality Control

Category of Course: Major

Credits& Hours of Teaching

	Theory	Practical	Cumulative
Credits	**3**	**1**	**4**
Hours of Teaching (Total)	**45**	**30**	**75**

Course Objectives

1. To introduce the fundamental problem-solving tool in Statistical Process Control (SPC), known as control charts
2. To determine whether a process is in control or if special causes of variation need to be addressed.
3. To discuss and demonstrate practical applications of basic control charts for variables and attributes, showing how they enable organizations to maintain and improve their processes.
4. To introduce single-, double-, and sequential-sampling plans as quality assurance tools.
5. To introduce various capability indices to estimate the process capability.
6. To discuss the use of the 2^{k-p} system of fractional factorial designs.

Course Content: The course content be divided into minimum 3 Units to maximum 5 units along with defined Hours of teaching for each unit.

Units	Course Content	Hours of Teaching
I	Basic concepts of process monitoring and control; process capability and process optimization.	6
II	General theory and review of control charts for attribute and variable data; O.C. and A.R.L. of control charts; control by gauging; moving average and exponentially weighted moving average charts; Cu-Sum charts using V-masks and decision intervals; Economic	16

	design of X-bar chart.	
III	Acceptance sampling plans for attributes inspection; single and double sampling plans and their properties; plans for inspection by variables for one-sided and two sided specification. Mil Std. and IS plans; continuous sampling plans of Dodge type and Wald-Wolfowitz type an d then properties. Sequential sampling plan and its properties; Bayesian sampling plans.	9
IV	Capability indices Cp, Cpk and Cpm; estimation, confidence intervals and tests of hypotheses relating to capability indices for normally distributed characteristics.	7
V	Use of design of experiments in SPC; factorial experiments, fractional factorial designs; construction of such designs and analysis of data.Multivariate quality control; use of control ellipsoid and of utility functions.	7

Texts / References

1. Montgomery, D.C. (2019): Introduction to Statistical Quality Control; 8th edition, Wiley.
2. Chakraborti, S. and Graham, M. A. (2019) Nonparametric Statistical Process Control, Wiley
3. Mitra, A. (2021). Fundamentals of quality control and improvement. 5th edition, Wiley
4. Wetherill, G. B., Brown, D. W. (2013). Statistical Process Control: Theory and Practice. United States: Springer US.
5. Oakland, J., Oakland, R. J. (2018). Statistical Process Control. United Kingdom: Taylor & Francis.
6. Aslam, M., Saghir, A., Ahmad, L. (2020). Introduction to Statistical Process Control. United Kingdom: Wiley.

Learning Outcomes: After careful study of this course students should be able to do the following

1. Understand chance and assignable causes of variability in a process
2. Explain the statistical basis of the Shewhart control chart, including choice of sample size, control limits, and sampling interval
3. Know how to design variables control charts such as $\bar{X}$ and R charts, EWMA and CUSUM charts, and attribute control charts such as p, np, c, u-charts.
4. Calculate and properly interpret process capability ratios, for example, $\boldsymbol{C_p}$., $\boldsymbol{C_{pk}}$ and $\boldsymbol{C_{pm}}$.
5. Understand the role of acceptance sampling in modern quality control systems and to know how single-, double-, and sequential-sampling plans are used.
6. Know how to use the 2^{k-p} system of fractional factorial designs.

Course Title: STAMJ8R6: Practical Based on STAMJ8R1, STAMJ8R3, STAMJ8R4 and STAMJ8R5 (student will opt any one)

Paper and Unit	Hours of practical
STAMJ8R all units	**30**
STAMJ8R2 all units	**30**
STAMJ8R3 all units	**30**
STAMJ8R4 all units	**30**
STAMJ8R5 all units	**30**

Course Title: STADS8R1: Project/Dissertation

Student will complete a project/ Dissertation on a topic as decided by the department. The mode of and area of dissertation will be different for each student. The dissertation will be of 12 credits.

Course Title: STAMN8R1: Elective paper

Any one out of STAMJ8R1 STAMJ8R2, STAMJ8R3, STAMJ8R4 and STAMJ8R5) Syllabus and credit will be same as mentioned against the papers.

Course Title: STAMN8R2: Practical paper

Any one out of STAMJ8R1 STAMJ8R2, STAMJ8R3, STAMJ8R4 and STAMJ8R5) Syllabus and credit will be same as mentioned against the papers.

Practical based on the elective paper out of STAMJ8R1 STAMJ8R2, STAMJ8R3, STAMJ8R4 and STAMJ8R5

BANARAS HINDU UNIVERSITY

Department of Zoology

Faculty of Science

SYLLABI

B.Sc. (Hons.) Programme

In

Zoology

NEP COURSE STRUCTURE FOR 4-YEAR UG ZOOLOGY
Department of Zoology, Banaras Hindu University

Semester –I		
Course Code	**Title**	**Credits**
ZOOMJ11	Animal Diversity and Animal Form & Function	3
ZOOMJ12	Lab. exercises based on course ZOOMJ11	1
ZOOMN11	Animal Diversity and Animal Form & Function	3
ZOOMN12	Lab. exercises based on course ZOOMN11	1
ZOOMD11	Animal Biology	3
ZOOSE11	Applied Zoology	2
ZOOSE12	Lab. exercises based on course ZOOSE11	1
AE11	Offered by Institute/University	2
VA11	Offered by Institute/University	2
VA12	Offered by Institute/University	2
	Total	**20**
Semester –II		
ZOOMJ21	Fundamentals of Cell Biology and Biochemistry	3
ZOOMJ22	Lab. exercises based on course ZOOMJ21	1
ZOOMN21	Fundamentals of Cell Biology and Elementary Biochemistry	3
ZOOMN22	Lab. Exercises based on course ZOOMN21	1
ZOOMD21	Hormones and Diseases	3
ZOOSE21	Food, Preservatives and Adulterants	2
ZOOSE22	Lab. exercises based on course ZOOSE21	1
AE21	Offered by Institute/University	2
VA21	Offered by Institute/University	2
VA22	Offered by Institute/University	2
	Total	**20**
Semester –III		
ZOOMJ31	Basic Genetics	3
ZOOMJ32	Economic Zoology	3
ZOOMJ33	Lab. exercises based on course ZOOMJ31 & ZOOMJ32	2
ZOOMV31	Economic Zoology	3
ZOOMV32	Lab. exercises based on course ZOOMV31	1
ZOOMD31	Archaeozoology	3
ZOOSE31	Microscopy and Histology & Histochemistry	2
ZOOSE32	Lab. exercises based on course ZOOSE31	1
AE31	Offered by Institute/University	2
	Total	**20**

Semester –IV		
ZOOMJ41	Fundamental Endocrinology	3
ZOOMJ42	Developmental Biology	3
ZOOMJ43	Evolution	2
ZOOMJ44	Systematics and Taxonomy	2
ZOOMJ45	Lab. exercises based on course ZOOMJ41 & ZOOMJ42	2
ZOOMJ46	Lab. exercises based on course ZOOMJ43 & ZOOMJ44	2
ZOOMN41	Fundamental Endocrinology	3
ZOOMN42	Lab. exercises based on course ZOOMN41	1
AE41	Offered by Institute/University	2
	Total	**20**
Semester –V		
ZOOMJ51	Functional Anatomy of Non-chordates	3
ZOOMJ52	Animal Behaviour	2
ZOOMJ53	Immunology	3
ZOOMJ54	Biology of Infectious Diseases	2
ZOOMJ55	Lab. exercises based on course ZOOMJ51 & ZOOMJ52	2
ZOOMJ56	Lab. exercises based on course ZOOMJ53 & ZOOMJ54	2
ZOOIN57	Internship	2
ZOOMN51	Aquaculture	3
ZOOMN52	Lab. exercises based on course ZOOMN51	1
	Total	**20**
Semester –VI		
ZOOMJ61	Functional Anatomy of Chordates	3
ZOOMJ62	Environmental Biology	3
ZOOMJ63	Cell Biology	3
ZOOMJ64	Mammalian Physiology	3
ZOOMJ65	Lab. exercises based on course ZOOMJ61 & ZOOMJ62	2
ZOOMJ66	Lab. exercises based on course ZOOMJ63 & ZOOMJ64	2
ZOOMV61	Clinical Biochemistry	3
ZOOMV62	Lab. exercises based on course ZOOMV61	1
	Total	**20**

Semester –VII		
ZOOMJ71	Biochemistry and Molecular Biology	3
ZOOMJ72	Molecular Genetics	3
ZOOMJ73	Molecular Endocrinology	3
ZOOMJ74	Bioinformatics and Biostatistics	3
ZOOMJ75	Lab. exercises based on course ZOOMJ71 & ZOOMJ72	2
ZOOMJ76	Lab. exercises based on course ZOOMJ73 & ZOOMJ74	2
ZOOMN71	Structure and Functions of Biomolecules	3
ZOOMN72	Lab. exercises based on course ZOOMN71	1
	Total	**20**
Semester –VIII (Honours)		
ZOOMJ81	Biotechniques	3
ZOOMJ82	Neurobiology	3
ZOOMJ83	Chronobiology	3
ZOOMJ84	Entomology and Fish Biology	3
ZOOMJ85	Lab. exercises based on course ZOOMJ81	1
ZOOMJ86	Lab. exercises based on course ZOOMJ82 & ZOOMJ83	2
ZOOMJ87	Lab. exercises based on course ZOOMJ84	1
ZOOMN81	Biotechniques	3
ZOOMN82	Lab. exercises based on course ZOOMN81	1
	Total	**20**
Semester –VIII (Honours with Research)		
ZOOMJ8R1	Biotechniques	3
ZOOMJ8R2	Lab. exercises based on course ZOOMJ8R1	1
ZOOMN8R1	Biotechniques	3
ZOOMN8R2	Lab. exercises based on course ZOOMN8R1	1
ZOODS8R3	Dissertation	12
	Total	**20**

Note: Students may have the option to take Offline as well as Online courses. However, students may take up to the 40% of the credits from Online courses in each category. Further, the capping of 40% may be relaxed to 60% for Courses in "Others" category to enable them to credit more interesting courses. Students will have to pay the fees for Online courses.

MJ – Major Course; MN – Minor Course; MV – Minor (Vocational); MD – Multidisciplinary Course; SE – Skill Enhancement Course; AE – Ability Enhancement Course; VA – Value Added Course; IN – Internship; DS – Dissertation

Credit (Theory) = 15 Hours; 1 Credit (Practical) = 30 Hours

BANARAS HINDU UNIVERSITY
(Detailed Syllabus of different Courses under NEP 2020)

Department of Zoology
Faculty of Science

Course Title	**ZOOMJ11: Animal Diversity and Animal Form & Function**
Category of Course	**Major** / ~~Minor / Minor (Vocational) / SEC / AEC / VAC / MD/Internship/Dissertation~~ (Tick any one of the above)

Credits & Hour of Teaching	Theory	Practical	Cumulative
Credits	3		3
Hour of Teaching (Total)	45		45

Course Objectives (not more than 100 words)	• Explore the origin and evolutionary connections between various phyla. • Examine the general characteristics of animals from protozoa to chordates. • Determine the taxonomic positions of hemichordates and protochordates. • Compare the structures and functions of animal physiological systems. • Investigate the adaptive modifications of animals in relation to their environments.
Course Content	The course content be divided into minimum 3 Units to maximum 5 units along with defined hour of teaching for each unit.

Units	Course Content	Hr. of Teaching
I	1. Criteria for classification of multicellular animals 1.1 Symmetry 1.2 Early development: Spiral and radial cleavage Origin of germ layers Protostomes (protostome subgroups) and Deuterostomes 1.3 Body cavities: acoelomates, pseudocoelomates, coelomates (schizo- and enterocoelomates) 1.4 Segmentation, metamerism and tagmatization 1.5 Homology and Analogy	3
II	2. Non-Chordates: General characters and classification of the following up to classes with examples showing distinctive features 2.1 Protozoa 2.2 Porifera 2.3 Cnidaria 2.4 Ctenophora 2.5 Platyhelminthes 2.6 Nematoda 2.7 Annelida 2.8 Arthropoda 2.9 Mollusca 2.10 Echinodermata	8
III	3. Hemichordates: General characters and classification up to sub-classes 4.Chordates: General characters and classification of the following up to sub-classes/ orders with examples showing distinctive/adaptive features 4.1 Protochordates: Urochordates, Cephalochordates 4.2 Cyclostomes 4.3 Pisces 4.4 Amphibians 4.5 Reptiles 4.6 Aves 4.7 Mammals	11
IV	5. Modes and Types of Feeding, Digestion and Excretion 5.1 Feeding mechanisms: suspension, deposit, cropping and sucking (herbivorous) and raptorial (carnivorous) 5.2 Intracellular and extracellular digestion: food vacuole and gastrovascular cavity 5.3 Open tubular: Metanephridia 5.4 Closed saccular: Malpighian tubules and vertebrate kidney	12

	6. Respiratory Organs and Pattern of Circulation 6.1 Structure and function of gills, trachea and vertebrate lungs 6.2 Pattern of circulation: Open and closed systems	
V	7. Nervous system, Receptors and Sense organ 7.1 Patterns of the nervous system in non-chordates 7.2 Organization of the nervous system in vertebrates 7.3 Phonoreception in mammals 7.4Photoreception in mammals 8. Reproduction 8.1 Types of asexual reproduction: fission, regeneration and parthenogenesis 8.2 Sexual reproduction: primary sex organs and their functions	11

Texts / References	1. Hickman, Keen, Larson and Eisenhour: Animal Diversity (9th ed., 2021, Mc Graw Hill) 2. Miller & Harley: Zoology (10th ed. 2016, McGraw Hill) 3. Campbell & Reece: Biology (7th ed. 2005, Pearson) 4. Mader: Biology (9th ed. 2007, Brown) 5. Kotpal: Modern textbook of Zoology: Invertebrates (11th ed. 2016 Rastogi) 6. Kotpal: Modern textbook of Zoology: Vertebrates (4th ed. 2016 Rastogi)
Learning Outcomes (not more than 100 words)	1. Students will develop a fundamental understanding of animal kingdom classification. 2. The ability to identify general characteristics of various phyla and classes, along with suitable examples in relation to phylogeny, will be acquired by students. 3. Understanding of the specialized structures and functions of various animal body parts will be gained. 4. Students will explore comparative and evolutionary perspectives of animal physiology.

Course Title	**ZOOMJ12: Lab. exercises based on course ZOOMJ11**
Category of Course	**Major** / ~~Minor / Minor (Vocational) / SEC / AEC / VAC / MD/Internship/Dissertation~~ (Tick any one of the above)

Credits & Hour of Teaching	Theory	Practical	Cumulative
Credits		1	1
Hour of Teaching (Total)		30	30

Course Objectives (not more than 100 words)	• To identify various phylum of animal kingdom based on their external features. • To study the adaptive features found in animals of various phyla. • To recognize morphological features and locate various organ systems in different animals. • To learn basic dissection skills required for anatomical understanding.
Course Content	The course content be divided into minimum 3 Units to maximum 5 units along with defined hour of teaching for each unit.

Units	Course Content	Hr. of Teaching
I	*Part A: Animal Diversity* 1. Study of transverse sections/chart of the following: *Sycon* (as an example of Parazoa to show its structure, spicules and canal system), *Hydra* (as an example of diploblastic animal), *Fasciola* (as an example of a triploblastic acoelomate animal), *Ascaris* (as an example of triploblastic pseudocoelomate animal), *Hirudinaria (*as an example of triploblastic schizocoelomate animal), Frog (as an example of triploblastic enterocoelomate animal). 2. Study of salient features and classification up to classes of the following non-chordates with special emphasis on their adaptive characters: *Amoeba, Euglena, Plasmodium, Paramecium, Euplectella, Physalia, Corallium, Hormiphora, Taenia, Ascaris (*male and female), *Nereis* (including heteronereid stage), *Hirudinaria, Bonellia, Chiton, Mytilus,* Octopus*, Limulus, Eupagurus, Sacculina, Asterias, Echinus, Holothuria.*	8
II	3. Mounting of *Obelia* colony 4. Salient features and classification up to Orders of the following with special emphasis on their adaptive characters: *Balanoglossus, Herdmania,* Amphioxus *Lamprey, Trygon,* Lung Fish, *Uraeotyphlus, Alytes, Hyla, Chameleon,* Tortoise, poisonous and non-poisonous snakes, Duck, Kiwi, Duck-billed Platypus, *Macropus,* Mole, *Lemur*	7
III	*Part B: Animal Form & Function* 5.1. Dissection and mounting of cephalic appendages and Hastate plate of *Palaemon* 5.2. Dissection of the digestive system of Palaemon or *Periplaneta americana* 5.3. Dissection of afferent branchial arteries of *Mystus*	8
IV	6.1 Dissection of the nervous system of *Palaemon* 6.2 Permanent slide preparation of gemmules of sponges 6.3 Study of the following through permanent slides/museum specimens: Conjugation in *Paramecium*, Trochophore larva, Zoea larvae, Pluteus larvae, Tornaria, Ammocoetes and Tadpole (frog); Axolotl	7

Texts / References	1. Lal: Practical Zoology- Invertebrates (12th ed., Rastogi Publications) 2. Lal: Practical Zoology- Vertebrates (12th ed., Rastogi Publications) 3. Verma: A manual of Practical Zoology - Chordates (11th ed., S Chand publications)
Learning Outcomes (not more than 100 words)	1. Students will be able to identify animals belonging to various phyla based on their external morphology and adaptive features. 2. Students will be able to understand the structural organization and anatomical variability of different organ systems.

Course Title	**ZOOMN11: Animal Diversity and Animal Form & Function**
Category of Course	~~Major /~~ **Minor** / ~~Minor (Vocational) / SEC / AEC / VAC / MD/Internship/Dissertation~~ (Tick any one of the above)

Credits & Hour of Teaching		Theory	Practical	Cumulative
	Credits	3		3
	Hour of Teaching (Total)	45		45

Course Objectives (not more than 100 words)	• Explore the origin and evolutionary relationships between different phyla. • Examine the general characteristics of animals from protozoa to chordates. • Analyze the taxonomic position of hemichordates and protochordates. • Compare the structures and functions of animal physiological systems. • Investigate the adaptive modifications in different animals in relation to their environment.
Course Content	The course content be divided into minimum 3 Units to maximum 5 units along with defined hour of teaching for each unit.

Units	Course Content	Hr. of Teaching
I	1. Criteria for classification of multicellular animals 1.1 Symmetry 1.2 Early development: Spiral and radial cleavage Origin of germ layers Protostomes (protostome subgroups) and Deuterostomes 1.3 Body cavities: acoelomates, pseudocoelomates, coelomates (schizo- and enterocoelomates) 1.4 Segmentation, metamerism and tagmatization 1.5 Homology and Analogy	3
II	2. Non-Chordates: General characters and classification of the following up to classes with examples showing distinctive features 2.1 Protozoa 2.2 Porifera 2.3 Cnidaria 2.4 Ctenophora 2.5 Platyhelminthes 2.6 Nematoda 2.7 Annelida 2.8 Arthropoda 2.9 Mollusca 2.10 Echinodermata	8
III	3. Hemichordates: General characters and classification up to sub-class 4.Chordates: General characters and classification of the following up to sub-classes/ orders with examples showing distinctive/adaptive features 4.1 Protochordates: Urochordates, Cephalochordates 4.2 Cyclostomes 4.3 Pisces 4.4 Amphibians 4.5 Reptiles 4.6 Aves 4.7 Mammals	11
IV	5. Modes and Types of Feeding, Digestion and Excretion 5.1 Feeding mechanisms: suspension, deposit, cropping and sucking (herbivorous) and raptorial (carnivorous) 5.2 Intracellular and extracellular digestion: food vacuole and gastrovascular cavity 5.3 Open tubular: Metanephridia 5.4 Closed saccular: Malpighian tubules and vertebrate kidney 6. Respiratory Organs and Pattern of Circulation 6.1 Structure and function of gills, trachea and vertebrate lungs 6.2 Pattern of circulation: Open and closed systems	12
V	7. Nervous system, Receptors and Sense organ 7.1 Patterns of the nervous system in non-chordates 7.2 Organization of the nervous system in vertebrates 7.3 Phonoreception in mammals	11

	7.4 Photoreception in mammals 8. Reproduction 8.1 Types of asexual reproduction: fission, regeneration and parthenogenesis 8.2 Sexual reproduction: primary sex organs and their functions	

Texts / References	1. Hickman, Keen, Larson and Eisenhour: Animal Diversity(9^{th} ed., 2021, Mc Graw Hill) 2. Miller & Harley: Zoology (10^{th} ed. 2016, McGraw Hill) 3. Campbell & Reece: Biology (7th ed. 2005, Pearson) 4. Mader: Biology (9th ed. 2007, Brown) 5. Kotpal: Modern textbook of Zoology: Invertebrates (11^{th} ed. 2016 Rastogi) 6. Kotpal: Modern textbook of Zoology: Vertebrates (4^{th} ed. 2016 Rastogi)
Learning Outcomes (not more than 100 words)	1. Students will gain a fundamental understanding of animal kingdom classification. 2. They will be able to identify the general characteristics of various phyla and classes, with suitable examples related to phylogeny. 3. An understanding of the specialized structures and functions of various animal body parts will be acquired. 4. Students will develop insights into the comparative and evolutionary aspects of animal physiology.

Course Title	**ZOOMN12: Lab. exercises based on course ZOOMN11**
Category of Course	~~Major /~~ **Minor** / ~~Minor (Vocational) / SEC / AEC / VAC / MD/Internship/Dissertation~~ (Tick any one of the above)

Credits & Hour of Teaching	Theory	Practical	Cumulative
Credits		1	1
Hour of Teaching (Total)		30	30

Course Objectives (not more than 100 words)	• To identify various phylum of animal kingdom based on their external features. • To study the adaptive features found in animals of various phyla. • To recognize morphological features and locate various organ systems in different animals. • To learn basic dissection skills required for anatomical understanding.
Course Content	The course content be divided into minimum 3 Units to maximum 5 units along with defined hour of teaching for each unit.

Units	Course Content	Hr. of Teaching
I	*Part A: Animal Diversity* 1. Study of transverse sections/chart of the following: *Sycon* (as an example of Parazoa to show its structure, spicules and canal system), *Hydra* (as an example of diploblastic animal), *Fasciola* (as an example of a triploblastic acoelomate animal), *Ascaris* (as an example of triploblastic pseudocoelomate animal), *Hirudinaria (*as an example of triploblastic schizocoelomate animal), Frog (as an example of triploblastic enterocoelomate animal). 2. Study of salient features and classification up to classes of the following non-chordates with special emphasis on their adaptive characters: *Amoeba, Euglena, Plasmodium, Paramecium, Euplectella, Physalia, Corallium, Hormiphora, Taenia, Ascaris (*male and female), *Nereis* (including heteronereid stage), *Hirudinaria, Bonellia, Chiton, Mytilus,* Octopus*, Limulus, Eupagurus, Sacculina, Asterias, Echinus, Holothuria.*	8
II	3. Mounting of *Obelia* colony 4. Salient features and classification up to Orders of the following with special emphasis on their adaptive characters: *Balanoglossus, Herdmania,* Amphioxus *Lamprey, Trygon,* Lung Fish, *Uraeotyphlus, Alytes, Hyla, Chameleon,* Tortoise, poisonous and non-poisonous snakes, Duck, Kiwi, Duck-billed Platypus, *Macropus,* Mole, *Lemur*	7
III	*Part B: Animal Form & Function* 5.1. Dissection and mounting of cephalic appendages and Hastate plate of *Palaemon* 5.2. Dissection of the digestive system of Palaemon or *Periplaneta americana* 5.3. Dissection of afferent branchial arteries of *Mystus*	8
IV	6.1 Dissection of the nervous system of *Palaemon* 6.2 Permanent slide preparation of gemmules of sponges 6.3 Study of the following through permanent slides/museum specimens: Conjugation in *Paramecium*, Trochophore larva, Zoea larvae, Pluteus larvae, Tornaria, Ammocoetes and Tadpole (frog); Axolotl	7

Texts / References	1. Lal: Practical Zoology- Invertebrates (12th ed., Rastogi Publications) 2. Lal: Practical Zoology- Vertebrates (12th ed., Rastogi Publications) 3. Verma: A manual of Practical Zoology - Chordates (11th ed., S Chand publications)
Learning Outcomes (not more than 100 words)	1. Students will be able to identify animals belonging to various phyla based on their external morphology and adaptive features. 2. Students will be able to understand the structural organization and anatomical variability of different organ systems.

Course Title	**ZOOMD11: Animal Biology**
Category of Course	~~Major / Minor / Minor (Vocational) / SEC / AEC / VAC~~ / **MD**/~~Internship/Dissertation~~ (Tick any one of the above)

Credits & Hour of Teaching	Theory	Practical	Cumulative
Credits	3		3
Hour of Teaching (Total)	45		45

Course Objectives (not more than 100 words)	• Investigate the origin and evolutionary relationships between different phyla. • Delve into the basic units of life, biomolecules, and their functional organization. • Examine the flow of genetic information, genes, and related diseases. • Analyze the structures and functions of animal physiological systems.
Course Content	The course content be divided into minimum 3 Units to maximum 5 units along with defined hour of teaching for each unit.

Units	Course Content	Hr. of Teaching
I	1. Properties and origin of life 2. Diversity of evolution of animal systems 2.1 Classification of major groups of living system 2.2 Concept and evidence of organic evolution 2.3 Theory of natural selection – industrial melanism	3 8
II	3. Cell – the unit of life 3.1 Organization of cell 3.2 Cell multiplication	8
III	4. Biomolecules 4.1 Sugars, fats and proteins 4.2 Enzymes - biological catalysts 4.3 Production of energy in biological system	8
IV	5. Inheritance of biological characters 5.1 Laws of Inheritance 5.2 Nature of hereditary material and flow of genetic information 5.3 Genes and diseases – sickle cell anemia, Down syndrome	8
V	6. Physiology of 6.1 Digestion 6.2 Breathing 6.3 Blood circulation 6.4 Urine formation 6.5 Endocrine glands	10

Texts / References	1. Biology for class XI & XII NCERT Textbooks 2. Verma et al, Cell Biology, Genetics, Molecular Biology, Evolution and Ecology (2008, S Chand) 3. Cain et al, Discover Biology (4th Edition, W. W. Norton & Company)
Learning Outcomes (not more than 100 words)	• Students will understand the origin and evolutionary relationship between different phyla and the basic units of life, biomolecules, and their functional organization. • They will able to connect the information on inheritance, genes and diseases. • They will understand the structures and functions of animal physiological systems.

Course Title	**ZOOSE11: Applied Zoology**
Category of Course	~~Major / Minor / Minor (Vocational) /~~ **SEC** ~~/ AEC / VAC / MD/Internship/Dissertation~~ (Tick any one of the above)

Credits & Hour of Teaching

	Theory	Practical	Cumulative
Credits	2		2
Hour of Teaching (Total)	30		30

Course Objectives (not more than 100 words)

- To learn the basic culture methods of various economically important animals.
- To learn the concept of aquaculture, bee products, silk production and animal husbandry.
- To gain knowledge in the field of pest management and transgenic animals.

Course Content: The course content be divided into minimum 3 Units to maximum 5 units along with defined hour of teaching for each unit.

Units	Course Content	Hr. of Teaching
I	1. Pisciculture 1.1 Aquaculture resources in India 1.2 Fin fish culture	2
II	2. Economically important insects 2.1 Sericulture 2.1.1 Types, Life cycle and Rearing of Silkworms 2.1.2 Harvesting and processing of cocoons 2.1.3 Diseases and their control 2.2 Apiculture 2.2.1 Species, Life cycle and organization of bee colony 2.2.2 Bee products and their uses 2.2.3 Diseases and their control 2.3 Lac culture 2.3.1 Lac insect, Life cycle and its host plants 2.3.2 Lac production and its uses 2.3.3 Diseases and their control	14
III	3. Pests and their management 3.1 Cultural methods 3.2 Chemical methods 3.3 Biological methods	4
IV	4. Animal husbandry and Transgenic animals 4.1. Dairy 4.1.1 Breeds of Bovine 4.1.2 Techniques of dairy management 4.1.3 Milk and milk products 4.2 Poultry 4.2.1 Types of Breeds 4.2.2 Reproductive system and egg formation (Hen model) 4.2.3 Nutritional value of egg and chicken 4.3 Transgenic animals	10

Texts / References

1. Shukla and Upadhyaya: Economic Zoology (Rastogi Publishers)
2. Omkar: Industrial Entomology (Springer Publisher, 2017)
3. Omkar: Pests and Their Management (Springer Publisher, 2018)

Learning Outcomes (not more than 100 words)

1. Students will gain insight into aquaculture systems, including breeding and post-harvest techniques.
2. They will explore the concepts of beekeeping, silkworm rearing, and the associated pests and diseases.
3. Understanding of various types of animal husbandry and their management practices will be developed.

Course Title	**ZOOSE12: Lab. exercises based on course ZOOSE11**
Category of Course	~~Major / Minor / Minor (Vocational)~~ / **SEC** /~~ AEC / VAC / MD/Internship/Dissertation~~ (Tick any one of the above)

Credits & Hour of Teaching

	Theory	Practical	Cumulative
Credits		1	1
Hour of Teaching (Total)		30	30

Course Objectives (not more than 100 words)

- Learn about the features of various economically important animals.
- Study the life cycle of economically significant insects and their applications.
- Identify adulterations in milk and evaluate the quality of eggs.

Course Content

The course content be divided into minimum 3 Units to maximum 5 units along with defined hour of teaching for each unit.

Units	Course Content	Hr. of Teaching
I	**1.** Dairy 1.1 External morphology and nomenclature of dairy animals. 1.2 Different types of cattle sheds and schedule of day-to-day operation of the dairy farm. 1.3 Determination of the specific gravity of milk by using a mercury lactometer.	8
II	2. Poultry 2.1 External morphology of poultry birds (model) 2.2 Test for fertilized and unfertilized eggs (Light test, Cracking test). 2.3 Test for egg quality (Floating test, cracking test).	6
III	3. Fishery 3.1. External morphology of fish. 3.2 Identification of two major carps – *Labeo rohita* and *Catla catla*.	6
IV	4. Economically important insects 4.1 Honey Bee i. Castes and life cycle (model/chart). ii. Mounting of the sting apparatus. iii. Whole mount preparation of the 3 pairs of legs. 4.2 Silkworm i. Life cycle of mulberry silkworm, *Bombyx mori* ii. Life cycle of tasar silkworm, *Antheraea mylitta*.	**10**

Learning Outcomes (not more than 100 words)

1. Students will understand the external morphology and management of various poultry, dairy breeds and quality of eggs and milk.
2. Students will understand life cycle of economically important insects.

Course Title	**ZOOMJ21: Fundamental of Cell Biology and Biochemistry**
Category of Course	**Major /** ~~Minor / Minor (Vocational) / SEC / AEC / VAC / MD/Internship/Dissertation~~ (Tick any one of the above)

Credits & Hour of Teaching		Theory	Practical	Cumulative
	Credits	3		3
	Hour of Teaching (Total)	45		45

Course Objectives (not more than 100 words)	*Fundamentals of Cell Biology:* • This core Zoology course provides a comprehensive understanding of eukaryotic animal cells, including their organelles and cytoskeleton. • It covers mitochondrial organization, cellular bioenergetics, and homeostasis, enabling students to grasp both simple and complex cellular processes. *Elementary Biochemistry:* • This course underpins advances in medicine, veterinary medicine, agriculture, and biotechnology. • It covers how cells operate through interconnected chemical reactions, the role of macromolecules (proteins, carbohydrates, lipids, and nucleic acids) in cellular functions, and applications in product develop • ent and healthcare advancements.
Course Content	The course content be divided into minimum 3 Units to maximum 5 units along with defined hour of teaching for each unit.

Units	Course Content	Hr. of Teaching
I	1. The Cell 1.1 Pro and Eukaryotic Cell 1.2 Methods in Cell Biology: Idea of microscopy and cell fractionation 2. Organization of cell 2.1 Structure and function of plasma membrane: Lipid bilayer, Cortical cytoskeleton, Membrane proteins, Active and passive transport. 2.2 Introduction to endomembrane system 2.2.1 Endoplasmic reticulum: Forms and Co-translational transport, 2.2.2 Golgi complex: Protein sorting, retrograde pathway 2.2.3 Lysosome and peroxisome 2.3 Introduction to cytoskeleton: Microtubules, Microfilaments and Intermediate filaments 2.4 Mitochondria 2.4.1 Mitochondrial genome and Endo-symbiotic hypothesis 2.4.2 Structure and Functions: Membrane proteins, Chemiosmotic process 2.5 Nuclear envelope and nuclear pore complex 2.6 Nucleolus and Biogenesis of ribosome 2.7 Interphase chromatin, Chromosomes 2.8 Higher order chromatin organization, heterochromatin and euchromatin, chromosome bands 2.9 Polytene and lamp brush chromosomes as models of gene regulation	13
II	3. Cell reproduction 3.1 Basic features of cell cycle 3.2 Cell Cycle checkpoints and their regulation (Restriction point, Cyclins, Cdks and APC) 3.3 Mitosis: Microtubule complex and spindle assembly 3.4 Process and phases of meiosis and its significance 4. Elementary knowledge of cell transformation and cancer 5. Introduction to the cellular basis of immunity	10
III	Elementary Biochemistry Introduction: 1.1 Scope and Importance of Biochemistry 1.2 Principle of biomolecular organization, configuration and conformation 1.3 Water as a biological solvent	2
IV	Proteins and Enzymes	9

	2.1 Functions and Diversity of Proteins 2.2 Properties of peptide bond 2.3 Structural organization of proteins 2.4 General properties of enzymes 2.5 Major classes of enzymes 2.6 Mechanism of enzyme action (ES complex and lowering of activation energy and Concept of chemical catalysis) 2.7 Introduction to enzyme kinetics	
V	Carbohydrates and Lipids 3.1 Classification of carbohydrates 3.2 Structure and conformation of monosaccharides 3.3 Oligosaccharides (disaccharides) and polysaccharides 3.4 Biological significance and classification of lipids 3.5 Fatty acids: Types and nomenclature Nucleic acids 4.1 Bases, nucleosides and nucleotides 4.2 DNA structure: DNA double helix (Watson and Crick model) 4.3 Basic mechanism of DNA replication (Prokaryotes) 4.4 Transcriptional unit and basic concept of transcription (Prokaryotes) 4.5 Genetic code and basic mechanism of translation (Prokaryotes) 4.6 Introduction to recombinant DNA techniques and their applications	11
Texts / References	*Fundamental of Cell Biology* 1. Alberts et al, Molecular Biology of the Cell (7th Edition, Garland) 2. Karp: Cell and Molecular Biology (9th Edition, John Wiley) 3. Lodish et al: Molecular Cell Biology (9th Edition, Freeman) 4. Plopper et al, Lewin's Cells (3rd Edition, Jones and Bartlett) *Elementary Biochemistry* 1. Berg, Tymoczko, Stryer; Biochemistry (7th ed. 2012, Freeman) 2. Conn, Stumpf, Bruening; Principles of Biochemistry (5th ed. 1987, Wiley	
Learning Outcomes (not more than 100 words)	1. The students shall have a thorough understanding of the chemical components of the cell, their structure, and functions. 2. Gain insight into the chemical reactions and interactions between the macromolecules regulating cellular machinery. 3. Use the knowledge gained in making scientific breakthroughs in disease biology and transform global health care. 4. Useful for a career in biomedical research, forensic science, and pharmaceutics.	

Course Title	**ZOOMJ22: Lab. exercises based on course ZOOMJ21**
Category of Course	**Major** / ~~Minor / Minor (Vocational) / SEC / AEC / VAC / MD/Internship/Dissertation~~ (Tick any one of the above)

Credits & Hour of Teaching	Theory	Practical	Cumulative
Credits		1	1
Hour of Teaching (Total)		30	30

Course Objectives (not more than 100 words)	• The practical course aims to develop students' proficiency in basic laboratory techniques, scientific experimentation, hypothesis testing, and data interpretation while fostering good lab practices and independent problem-solving skills. • Students will master microscopy and staining techniques to analyze eukaryotic cells and their organelles. • Practical skills in cell biology will be developed through techniques like centrifugation, staining, and observing mitosis. • Students will perform biochemical tests to understand fundamental biochemical processes.
Course Content	The course content be divided into minimum 3 Units to maximum 5 units along with defined hour of teaching for each unit.

Units	Course Content-	Hr. of Teaching
I	*Part A: Fundamentals of Cell Biology* 1. Drawing of the ultrastructure of the cell and different organelles (from photographs provided). 2. Familiarizationwiththestudent'slightmicroscopeandstereobinocularmicroscope. 3. Application of centrifuge – separation of sperm from other testicular cells by low-speed centrifugation. 4. Diversity of eukaryotic cells – methylene blue staining of buccal epithelium, sperm, neurons, striated muscle cells; Leishman staining of mammalian blood cells. 5. Permeability of plasma membrane – effect of isotonic, hypotonic and hypertonic solutions on mammalian RBC. 6. Staining of mitochondria with Janus green in the buccal epithelium. 7. Mitosis in onion root tip.	15
II	*Part B: Elementary Biochemistry* 1. Preparation of models of amino acids, dipeptides and nucleotides. 2. Ninhydrin test for α-amino acids. 3. Benedict's test for reducing sugars. 4. Iodine test for starch. 5. Determination of acid value of oil.	15

Texts / References	
Learning Outcomes (not more than 100 words)	• The students must be able to perform experiments independently and become proficient in basic lab techniques. • Gain in-depth understanding of biochemical principles, data interpretations and logical conclusions.

Course Title	**ZOOMN21: Fundamental of Cell Biology & Elementary Biochemistry**
Category of Course	~~Major /~~ **Minor** / ~~Minor (Vocational) / SEC / AEC / VAC / MD/Internship/Dissertation~~ (Tick any one of the above)

Credits & Hour of Teaching		Theory	Practical	Cumulative
	Credits	3	1	3
	Hour of Teaching (Total)	45	30	45

Course Objectives (not more than 100 words)	*Fundamentals of Cell Biology:* • This core Zoology course provides a comprehensive understanding of eukaryotic animal cells, including their organelles and cytoskeleton. • It covers mitochondrial organization, cellular bioenergetics, and homeostasis, enabling students to grasp both simple and complex cellular processes. *Elementary Biochemistry:* • This course underpins advances in medicine, veterinary medicine, agriculture, and biotechnology. • It covers how cells operate through interconnected chemical reactions, the role of macromolecules (proteins, carbohydrates, lipids, and nucleic acids) in cellular functions, and applications in product development and healthcare advancements.
Course Content	The course content be divided into minimum 3 Units to maximum 5 units along with defined hour of teaching for each unit.

Units	Course Content-	Hr. of Teaching
I	1. The Cell 1.1 Pro and Eukaryotic Cell 1.2 Methods in Cell Biology: Idea of microscopy and cell fractionation 2. Organization of cell 2.1 Structure and function of plasma membrane: Lipid bilayer, Cortical cytoskeleton, Membrane proteins, Active and passive transport. 2.2 Introduction to endomembrane system 2.2.1 Endoplasmic reticulum: Forms and Co-translational transport, 2.2.3 Golgi complex: Protein sorting, retrograde pathway 2.2.3 Lysosome and peroxisome 2.3 Introduction to cytoskeleton: Microtubules, Microfilaments and Intermediate filaments 2.4 Mitochondria 2.4.1 Mitochondrial genome and Endo-symbiotic hypothesis 2.4.2 Structure and Functions: Membrane proteins, Chemiosmotic process 2.5 Nuclear envelope and nuclear pore complex 2.6 Nucleolus and Biogenesis of ribosome 2.7 Interphase chromatin, Chromosomes 2.8 Higher order chromatin organization, heterochromatin and euchromatin, chromosome bands 2.9 Polytene and lamp brush chromosomes as models of gene regulation	13
II	3. Cell reproduction 3.1 Basic features of cell cycle 3.2 Cell Cycle checkpoints and their regulation (Restriction point, Cyclins, Cdks and APC) 3.3 Mitosis: Microtubule complex and spindle assembly 2.4 Process and phases of meiosis and its significance 3. Elementary knowledge of cell transformation and cancer 4. Introduction to the cellular basis of immunity	10
III	Elementary Biochemistry Introduction: 1.1 Scope and Importance of Biochemistry 1.2 Principle of biomolecular organization, configuration and conformation 1.3 Water as a biological solvent	2
IV	Proteins and Enzymes 2.1 Functions and Diversity of Proteins	9

	2.2 Properties of peptide bond 2.3 Structural organization of proteins 2.4 General properties of enzymes 2.5 Major classes of enzymes 2.6 Mechanism of enzyme action (ES complex and lowering of activation energy and Concept of chemical catalysis) 2.7 Introduction to enzyme kinetics	
V	Carbohydrates and Lipids 3.1 Classification of carbohydrates 3.2 Structure and conformation of monosaccharides 3.3 Oligosaccharides (disaccharides) and polysaccharides 3.4 Biological significance and classification of lipids 3.5 Fatty acids: Types and nomenclature Nucleic acids 4.1 Bases, nucleosides and nucleotides 4.2 DNA structure: DNA double helix (Watson and Crick model) 4.3 Basic mechanism of DNA replication (Prokaryotes) 4.4 Transcriptional unit and basic concept of transcription (Prokaryotes) 4.5 Genetic code and basic mechanism of translation (Prokaryotes) 4.6 Introduction to recombinant DNA techniques and their applications	13

Texts / References	*Fundamental of Cell Biology* 5. Alberts et al, Molecular Biology of the Cell (7th Edition, Garland) 6. Karp: Cell and Molecular Biology (9th Edition, John Wiley) 7. Lodish et al: Molecular Cell Biology (9th Edition, Freeman) 8. Plopper et al, Lewin's Cells (3rd Edition, Jones and Bartlett) *Elementary Biochemistry* 3. Berg, Tymoczko, Stryer; Biochemistry (7th ed. 2012, Freeman) 4. Conn, Stumpf, Bruening; Principles of Biochemistry (5th ed. 1987, Wiley
Learning Outcomes (not more than 100 words)	1. The students shall have a thorough understanding of the chemical components of the cell, their structure and functions. 2. Gain insight into the chemical reactions and interactions between the macromolecules regulating cellular machinery. 3. Use the knowledge gained in making scientific breakthrough in disease biology and transform global health care. 4. Useful for career in biomedical research, forensic science and pharmaceutics.

Course Title	**ZOOMN22: Lab. exercises based on course ZOOMN21**
Category of Course	~~Major /~~ **Minor** / ~~Minor (Vocational) / SEC / AEC / VAC / MD/Internship/Dissertation~~ (Tick any one of the above)

Credits & Hour of Teaching

	Theory	Practical	Cumulative
Credits-**Section B**		1	1
Hour of Teaching (Total)		30	30

Course Objectives (not more than 100 words)

- The practical course aims to develop students' proficiency in basic laboratory techniques, scientific experimentation, hypothesis testing, and data interpretation while fostering good lab practices and independent problem-solving skills.
- Students will master microscopy and staining techniques to analyze eukaryotic cells and their organelles.
- Practical skills in cell biology will be developed through techniques like centrifugation, staining, and observing mitosis.
- Students will perform biochemical tests and prepare molecular models to understand fundamental biochemical processes.

Course Content: The course content be divided into minimum 3 Units to maximum 5 units along with defined hour of teaching for each unit.

Units	Course Content	Hr. of Teaching
I	**Part A: Fundamentals of Cell Biology** 1. Drawing of the ultra structure of the cell and different organelles (from photographs provided). 2. Familiarizationwiththestudent'slightmicroscopeandstereobinocularmicroscope. 3. Application of centrifuge – separation of sperm from other testicular cells by low-speed centrifugation. 4. Diversity of eukaryotic cells – methylene blue staining of buccal epithelium, sperm, neurons, striated muscle cells; Leishman staining of mammalian blood cells. 5. Permeability of plasma membrane – effect of isotonic, hypotonic and hypertonic solutions on mammalian RBC. 6. Staining of mitochondria with Janus green in the buccal epithelium. 7. Mitosis in onion root tip.	15
II	**Part B: Elementary Biochemistry** 1. Preparation of models of amino acids, dipeptides and nucleotides. 2. Ninhydrin test for α-amino acids. 3. Benedict's test for reducing sugars. 4. Iodine test for starch. 5. Determination of acid value of oil.	15

Texts / References

Learning Outcomes (not more than 100 words)

- The students must be able to perform experiments independently and become proficient in basic lab techniques.
- Gain an in-depth understanding of biochemical principles, data interpretations, and logical conclusions.

Course Title	**ZOOMD21: Hormones and Diseases**
Category of Course	~~Major / Minor / Minor (Vocational) / SEC / AEC / VAC /~~ **MD**/~~Internship/Dissertation~~ (Tick any one of the above)

Credits & Hour of Teaching		Theory	Practical	Cumulative
	Credits	3		3
	Hour of Teaching (Total)	45		45

Course Objectives (not more than 100 words)	• To define and classify hormones, neurohormones, neurotransmitters, and pheromones, and describe their characteristics. • To study the structure, biological functions, and regulation of the hypothalamus, pituitary gland, pineal gland, thyroid and parathyroid glands, adrenal glands, endocrine pancreas, and gonads. • To identify and explain hormonal dysfunctions such as diabetes insipidus, dwarfism, gigantism, acromegaly, goiter, tetany, Addison's disease, Cushing's syndrome, and diabetes mellitus.
Course Content	The course content be divided into minimum 3 Units to maximum 5 units along with defined hour of teaching for each unit.

Units	Course Content	Hr. of Teaching
I	Scope of Endocrinology Pituitary gland General organization and hormones Diseases: dwarfism, gigantism, acromegaly, diabetes insipidus Pineal gland General organization and hormone Sleep disorders, and jet lag	10
II	Thyroid gland General organization and hormones Diseases: goiter, myxoedema, cretinism, graves disease, Hashimoto disease Parathyroid gland General organization and hormones Diseases: bone diseases, tetany	9
III	Endocrine pancreas General organization and hormones Disease: diabetes mellitus, obesity	8
IV	Adrenal gland General organization and hormones Diseases: Addison's disease, Cushing's syndrome ,hirsutism	8
V	Testis General organization and hormones Diseases: Male infertility, Impotency, Cryptorchidism, Varicocele Ovary General organization and hormones Diseases: female infertility, polycystic ovary disease, hyperandrogenism,	10

Texts / References	1. Hadley, M.C.: Endocrinology, Prentice Hall, International Edition, 2000 2. Wilson and Foster, Williams Text Book of Endocrinology 10th edition, W.B. Saunders Company Philadelphia, 2005
Learning Outcomes (not more than 100 words)	Upon completing this course, students will be able to: 1. Understand and describe Chemical Messengers including hormones, neurohormones, neurotransmitters, and pheromones. 2. Distinguish between endocrine, paracrine, and autocrine modes of hormone delivery. 3. Analyze the Structure and Function of different Endocrine Glands: 4. Identify and analyze hormonal dysfunctions

Course Title	**ZOOSE21: Food, Preservatives and Adulterants**
Category of Course	~~Major / Minor / Minor (Vocational)~~ / **SEC** / ~~AEC / VAC / MD/Internship/Dissertation~~ (Tick any one of the above)

Credits & Hour of Teaching	Theory	Practical	Cumulative
Credits	2		2
Hour of Teaching (Total)	30		30

Course Objectives (not more than 100 words)	• To understand the chemistry, classification, and physico-chemical properties of key food constituents, including carbohydrates, proteins, lipids, minerals, and vitamins. • To explore the chemistry, classification, and detection methods of natural, permitted, and non-permitted preservatives. • To learn about adulteration, its types, causes, and measures, as well as modern analytical techniques for adulterant screening. • To gain knowledge of analytical methods for determining key properties and contaminants in food products, including fats, oils, dairy products, and fermented products. • To understand the detection of pesticide residues in various food items. • To study legislative regulations and safety guidelines for food products.
Course Content	The course content be divided into minimum 3 Units to maximum 5 units along with defined hour of teaching for each unit.

Units	Course Content	Hr. of Teaching
I	1. Chemistry, classification and physico-chemical properties of food constituents 1.1. Carbohydrate 1.2. Protein 1.3. Lipid 1.4. Minerals and Vitamins 2. Chemistry, classification and physico-chemical properties of preservatives 3. Natural, permitted and non- permitted preservatives 3.1 Methods of detection	8
II	1. Adulteration and Deterioration: Introduction, types of adulteration/substitution 2. Causes and Measure of adulteration 1.1. Sampling Procedures 1.2. Identification of substances of natural origin, pesticide residues, phototoxin and microbial contamination 1.3. Adulterant screening using modern analytical techniques	6
III	1. Determination of acid value, ester value, saponification value, iodine value, peroxide value, rancidity, moisture, ash, volatile matter, heavy metals, density, and viscosity 2. General Analytical methods for milk, milk constituents and adulterations	4
IV	1. General Analytical methods for ice cream, milk powder, butter, margarine, cheese and adulterations 2. Determination of adulteration in fats and oils	4
V	1. Analysis of fermentation products like wine, spirits, beer and vinegar 2. Determination of pesticide residues in grain, fruits, vegetables and other food items 3. Legislative regulations of food products and safety guidelines	8

Texts / References	1. Food Additives and Contaminants: Sources, Effects and Control" Editors: Alan M. Branen, P. Michael Davidson, Seppo Salminen, and John H. Thorngate Publisher: CRC Press. Edition: 2nd Edition, 2001. 2. Food Analysis "Editor: Suzanne Nielsen Publisher: Springer Edition: 5th Edition, 2017.
Learning Outcomes (not more than 100 words)	1. Students will be able to identify and describe the chemical composition and properties of major food constituents. 2. They will understand the role and detection of various preservatives in food. 3. They will recognize different types of adulteration and apply methods to detect them. Students will acquire skills in analyzing food products for quality and safety. 4. They will comprehend food legislation and safety standards.

Course Title	**ZOOSE22: Lab. exercises based on course ZOOSE21**
Category of Course	~~Major / Minor / Minor (Vocational) /~~ **SEC** / ~~AEC / VAC / MD/Internship/Dissertation~~ (Tick any one of the above)

Credits & Hour of Teaching	Theory	Practical	Cumulative
Credits		1	1
Hour of Teaching (Total)		30	30

Course Objectives (not more than 100 words)	• To develop practical skills in analyzing the chemical composition of food constituents. • To identify and analyze adulterants and contaminants. • To perform quality analysis of dairy products and to assess rancidity in fats and oils. • To analyze fermentation products for chemical composition. • To ensure compliance with food safety regulations.
Course Content	The course content be divided into minimum 3 Units to maximum 5 units along with defined hour of teaching for each unit.

Units	Course Content	Hr. of Teaching
I	Carbohydrate Analysis 1. Determination of reducing sugars using Fehling's test and Benedict's test. 2. Quantitative analysis of total sugars using the phenol-sulfuric acid method.	6
II	Protein Analysis 1. Quantitative estimation of proteins using the Kjeldahl method for nitrogen determination. 2. Protein content analysis using the Bradford or Lowry method	6
III	Lipid Analysis 1. Determination of fat content in food samples using Soxhlet extraction. 2. Measurement of acid value, saponification value, and iodine value of fats and oils.	4
IV	Quality Analysis of Dairy Products 1. Determination of fat content in milk using the Gerber method. 2. Detection of adulteration in milk using the lactometer and fat test	6
V	Rancidity Testing in Fats and Oils 1. Measurement of peroxide value to assess oxidative rancidity. 2. Detection of rancidity by determining the free fatty acid content. Food Safety and Regulatory Compliance 3. Analysis of food labels for compliance with nutritional labeling regulations. 4. Practical exercise in reading and interpreting food safety guidelines and regulations.	8

Texts / References	1. Food Additives and Contaminants: Sources, Effects and Control" Editors: Alan M. Branen, P. Michael Davidson, Seppo Salminen, and John H. Thorngate Publisher: CRC Press. Edition: 2nd Edition, 2001. 2. Food Analysis" Editor: Suzanne Nielsen Publisher: Springer Edition: 5th Edition, 2017.
Learning Outcomes (not more than 100 words)	1. Students will be able to analyze the chemical composition of food constituents. 2. They will identify and quantify preservatives and detect adulterants and contaminants. 3. They will perform quality assessments of dairy products and determine rancidity in fats and oils. 4. Students will analyze fermentation products and understand food safety compliance.

Course Title	**ZOOMJ31: Basic Genetics**
Category of Course	**Major** / ~~Minor / Minor (Vocational) / SEC / AEC / VAC / MD/Internship/Dissertation~~ (Tick any one of the above)

Credits & Hour of Teaching		Theory	Practical	Cumulative
	Credits	3		3
	Hour of Teaching (Total)	45		45

Course Objectives (not more than 100 words)	• The course aims to give students a fundamental understanding of the principles and complexities of heredity and variation. • Apart from basic Mendelian genetics this course will highlight extension of Mendelian Genetics and cytoplasmic inheritance. • Students will learn how genetic information is passed on in eukaryotes and prokaryotes, how genes interact and work together in a complex manner in biological system and their molecular basis. • Students will learn about the significant role played by chromosomes in determining sex and various chromosomal anomalies that can severely affect normal human development with specific examples.
Course Content	The course content be divided into minimum 3 Units to maximum 5 units along with defined hour of teaching for each unit.

Units	Course Content	Hr. of Teaching
I	1. Elements of heredity and variation 1.1 Mendel's laws of inheritance 1.2 Chromosomal basis of inheritance 1.3 Application of laws of probability to Mendelian inheritance: product rule, sum rule, binomial expansion 1.4 Chi-square test and its application	7
	2. Extension of Mendelism 2.1 Dominance relationships 2.2 Multiple allelism 2.3 Lethal alleles 2.4 Pleiotropy 2.5 Penetrance and expressivity 2.6 Phenocopy 2.7 Sex-influenced and Sex-limited traits 2.8 Epistasis	7
II	3. Basic introduction to quantitative inheritance	2
	4. Cytoplasmic Inheritance 4.1 Maternal effect 4.2 Extranuclear Inheritance 4.3 Infective Inheritance	6
	5. Linkage and crossing-over 5.1 Two - point test cross in Drosophila 5.2 Cytological demonstration of crossing over in Drosophila	4
	6. Sex chromosomes and sex-linkage 6.1 Sex chromosome systems: XX/XO, XX/XY, ZZ/ZW and haploidy/diploidy types 6.2 Sex-linkage	2
III	7. Mutation and Mutagenesis 7.1 Structural and numerical alterations of chromosomes; meiotic consequences in structural heterozygotes 7.2 Gene Mutation 7.2.1 Spontaneous and induced mutations 7.2.2 Molecular basis of mutation 7.2.3 Detection of mutation (Ames' test and C*l*B technique in Drosophila)	8
	8. Human Genetics 8.1 Pedigree analysis 8.2 Karyotype, banding and nomenclature of chromosome subdivisions 8.3 Genetic disorders	8

	8.3.1 Chromosomal aneuploidy (Down, Turner and Klinefelter syndromes) 8.3.2 Chromosome translocation (chronic myeloid leukemia) and deletion ("cry of cat" syndrome) 8.3.3 Gene mutation (cystic fibrosis) 9. Genetic Counseling	1
Texts / References	*Books Recommended* 1. Snustad and Simmons: Principles of Genetics (2019, 7th ed. John Wiley) 2. Hartl and Jones: Essential Genetics- A Genomic Perspective (2009, Jones and Bartlet) 3. Pierce: Genetics - A Conceptual Approach (2012, Freeman) *Suggested Readings* 1. Griffith et al.: An Introduction to Genetic Analysis (Freeman 11th ed, 2015) 2. Brooker: Genetics - Analysis and Principles (2012, 4th ed McGraw Hill) 3. Russell: Genetics (2010, Benjamin Cummings) 4. Gersen & Keagle: The Principles of Clinical Cytogenetics (2005, Humana) 5. Hawley & Walker: Advanced Genetic Analysis (2003, Blackwell)	
Learning Outcomes (not more than 100 words)	• Upon successfully completing the course, the students will have a comprehensive understanding of genetic principles and mode of transmission of genetic traits. • This knowledge will prepare students for advanced studies and careers in genetics, biology, and related fields.	

Course Title	**ZOOMJ32: Economic Zoology**
Category of Course	**Major**~~/ Minor / Minor (Vocational) / SEC / AEC / VAC / MD/Internship/Dissertation~~ (Tick any one of the above)

Credits & Hour of Teaching		Theory	Practical	Cumulative
	Credits	3		3
	Hour of Teaching (Total)	45		45

Course Objectives (not more than 100 words)	• Understand the economic significance of various animals. • Explore the concepts of aquaculture, apiculture, sericulture, and animal husbandry. • Acquire knowledge in animal production and the processing of animal products.
Course Content	The course content be divided into minimum 3 Units to maximum 5 units along with defined hour of teaching for each unit.

Units	Course Content	Hr. of Teaching
I	1. Aquaculture 1.1 Prawn culture 1.2 Pearl Culture 1.3 Fish Culture 1.4 Fish by-products & common fish diseases	12
II	2. Sericulture 2.1 Types of silk 2.2 Silkworms and their host plants 2.3 Mulberry silkworm culture 2.4 Diseases and their control	8
III	3. Apiculture 3.1 Species of honey bees in India 3.2 Life history of *Apis* 3.3 Methods of Beekeeping 3.4 Bee products and their uses 3.5 Diseases and their control	8
IV	4. Lac culture 4.1 Lac insect and its life cycle 4.2 Cultivation of lac insect host plants, processing and uses of lac 4.3 Diseases and their control	5
V	5. Dairy and Poultry 5.1 Introduction to common dairy animals 5.2 Techniques of dairy management 5.3 Milk and milk products 5.4 Cattle diseases 5.5 Types of poultry breeds 5.6 Poultry rearing method 5.7 Poultry diseases	12

Texts / References	1. Shukla and Upadhyaya: Economic Zoology (Rastogi Publishers) 2. Omkar: Industrial Entomology (Springer Publisher) 3. Jabde: Text Book of Applied Zoology: Vermiculture, Apiculture, Sericulture, Lac culture.
Learning Outcomes (not more than 100 words)	1. Students will gain knowledge of aquaculture systems, including breeding and post-harvest techniques. 2. Honeybee and silkworm rearing, along with the diseases affecting them, will be explored. 3. Understanding the types of poultry and dairy breeds, along with their management practices, will be emphasized.

Course Title	**ZOOMJ33: Lab. exercises based on course ZOOMJ31 & ZOOMJ32**
Category of Course	**Major** ~~/ Minor / Minor (Vocational) / SEC / AEC / VAC / MD/Internship/Dissertation~~ (Tick any one of the above)

Credits & Hour of Teaching	Theory	Practical	Cumulative
Credits		2	2
Hour of Teaching (Total)		60	60

Course Objectives (not more than 100 words)	• Understand the law of segregation and genetic traits in humans. • Master various techniques using Drosophila. • Study the external features of economically important animals. • Perform dissections on key parts of economically significant insects. • Identify adulterations in milk and assess the quality of eggs.
Course Content	The course content be divided into minimum 3 Units to maximum 5 units along with defined hour of teaching for each unit.

Units	Course Content	Hr. of Teaching
I	*Part - A: Basic Genetics* 1. Application of probability in the law of segregation with coin tossing. 2. Frequency of the following genetic traits in humans: widow's peak, attached ear lobe, dimple in the chin, hypertrichosis, color blindness, PTC tasting. 3. Study of mode of inheritance of the following traits by pedigree charts – attached ear lobe, widow's peak. 4. Familiarization with techniques of handling Drosophila, identifying males and females;Observing wild type and mutant (white eye, wingless) flies and setting up cultures. 5. Demonstration of the law of segregation using monohybrid crosses in Drosophila (using wild type and sepia-eyed flies). 6. Demonstration of lethal alleles using Curly (Cy) mutant in Drosophila. 7. Demonstration of multiple allelism by showing mutants of white eye series in Drosophila. 8. Study of structural chromosome aberrations (dicentric, ring chromosomes, and inversions in polytene chromosomes) from prepared slides/photographs. 9. Study of human karyotypes and numerical alterations (Down syndrome, Klinefelter syndrome and Turner syndrome).	30
II	*Part – B: Economic Zoology* 1. Dairy 1.1 External morphology and nomenclature of dairy animals. 1.2 Different types of cattle sheds and schedule of day-to-day operation of the dairy farm. 1.3 Determination of the specific gravity of milk by using a mercury lactometer. 3. Poultry 2.1 External morphology of poultry birds (model) 2.2 Test for fertilized and unfertilized eggs (Light test, Cracking test). 2.3 Test for egg quality (Floating test, cracking test). 4. Fishery 3.1. External morphology of fish. 3.2 Identification of two major carps – *Labeorohita* and *Catlacatla*. 5. Economically important insects 4.1 Honey Bee i. Castes and life cycle (model/chart). ii. Mounting of the sting apparatus. iii. Whole mount preparation of the 3 pairs of legs. 4.2 Silkworm i. Life cycle of mulberry silkworm, *Bombyx mori* ii. Life cycle of tasar silkworm, *Antheraea mylitta*.	30

Learning Outcomes (not more than 100	1. Students will grasp basic genetic techniques using coin tossing, public surveys, and the Drosophila model. 2. The external morphology and management of various poultry and dairy breeds, along with the quality of eggs and milk, will be studied.

words)	3. Students will explore the life cycles of economically important insects.

Course Title	**ZOOMV31: Economic Zoology**
Category of Course	~~Major / Minor /~~**Minor (Vocational)**~~/ SEC / AEC / VAC / MD/Internship/Dissertation~~ (Tick any one of the above)

Credits & Hour of Teaching		Theory	Practical	Cumulative
	Credits	3		3
	Hour of Teaching (Total)	45		45

Course Objectives (not more than 100 words)	• Understand the economic significance of various animals. • Explore the concepts of aquaculture, apiculture, sericulture, and animal husbandry. • Acquire knowledge in animal production and the processing of animal products.
Course Content	The course content be divided into minimum 3 Units to maximum 5 units along with defined hour of teaching for each unit.

Units	Course Content	Hr. of Teaching
I	1. Aquaculture 1.1 Prawn culture 1.2 Pearl Culture 1.3 Fish Culture 1.4 Fish by-products & common fish diseases	12
II	2. Sericulture 2.1 Types of silkworms and their host plants 2.2 Mulberry silkworm culture 2.3 Diseases and their control	8
III	3. Apiculture 3.1 Species of honey bees in India 3.2 Life history of *Apis* 3.3 Methods of Beekeeping 3.4 Bee products and their uses 3.5 Diseases and their control	8
IV	4. Lac culture 4.1 Lac insect and its life cycle 4.2 Cultivation of lac insect host plants, processing and uses of lac 4.3 Diseases and their control	5
V	5 Dairy and Poultry 5.1 Introduction to common dairy animals 5.2 Techniques of dairy management 5.3 Milk and milk products 5.4 Cattle diseases 5.5 Types of poultry breeds 5.6 Poultry rearing method 5.7 Poultry diseases	12

Texts / References	1. Shukla and Upadhyaya: Economic Zoology (Rastogi Publishers) 2. Omkar: Industrial Entomology (Springer Publisher) 3. Jabde: Text Book of Applied Zoology: Vermiculture, Apiculture, Sericulture, Lac culture.
Learning Outcomes (not more than 100 words)	1. Students will gain knowledge of aquaculture systems, including breeding and post-harvest techniques. 2. Honeybee and silkworm rearing, along with the diseases affecting them, will be explored. 3. Understanding the types of poultry and dairy breeds, along with their management practices, will be emphasized.

Course Title	**ZOOMV32: Lab. Exercises based on course ZOOMV31**
Category of Course	~~Major~~ / ~~Minor~~ **/ Minor (Vocational)** ~~/ SEC / AEC / VAC / MD/Internship/Dissertation~~ (Tick any one of the above)

Credits & Hour of Teaching		Theory	Practical	Cumulative
	Credits		1	1
	Hour of Teaching (Total)		30	30

Course Objectives (not more than 100 words)	• Study the external features of economically important animals. • Perform dissections on key parts of economically significant insects. • Identify milk adulterations and evaluate egg quality.
Course Content	The course content be divided into minimum 3 Units to maximum 5 units along with defined hour of teaching for each unit.

Units	**Course Content**	**Hr. of Teaching**
I	1. Dairy 1.1 External morphology and nomenclature of dairy animals. 1.2 Different types of cattle sheds and schedule of day-to-day operation of the dairy farm. 1.3 Determination of the specific gravity of milk by using a mercury lactometer.	8
I	2. Poultry 2.1 External morphology of poultry birds (model) 2.2 Test for fertilized and unfertilized eggs (Light test, Cracking test). 2.3 Test for egg quality (Floating test, cracking test).	6
III	3. Fishery 3.1. External morphology of fish. 3.2. Identification of two major carps – *Labeo rohita* and *Catla catla*.	6
IV	4. Economically important insects 4.1 Honey Bee i. Castes and life cycle (model/chart). ii. Mounting of the sting apparatus. iii. Whole mount preparation of the 3 pairs of legs. 4.2 Silkworm i. Life cycle of mulberry silkworm, *Bombyx mori* ii. Life cycle of tasar silkworm, *Antheraea mylitta*.	10

Learning Outcomes (not more than 100 words)	1. Students will understand the external morphology and management of various poultry, dairy breeds and quality of eggs and milk. 2. Students will understand life cycle of economically important insects.

Course Title	**ZOOMD31: Archaeozoology**
Category of Course	~~Major / Minor / Minor (Vocational) / SEC / AEC / VAC~~ / **MD**/~~Internship/Dissertation~~ (Tick any one of the above)

Credits & Hour of Teaching	Theory	Practical	Cumulative
Credits	3		3
Hour of Teaching (Total)	45		45

Course Objectives (not more than 100 words)	• The primary objective of this course is to offer a comprehensive understanding of the role of human and animal remains in archaeological contexts and their significance in studying past human societies. • This course, encompasses a diverse curriculum starting from an introduction to archaeozoology, exploring the Bioarchaeological chronology of South Asia, discussing significant civilizations, understanding human origins and archaic humans, to examining the evolution and utility of ancient DNA. • Alongside theoretical knowledge, a 1-credit lab exercise complements the course, emphasizing practical skills such as archaeological site visits, tool identification, dating methods, DNA extraction, and data analysis, thereby providing a holistic educational experience.
Course Content	The course content be divided into minimum 3 Units to maximum 5 units along with defined hour of teaching for each unit.

Units	Course Content	Hr. of Teaching
I	Introduction and Archaeological Chronology of South Asia 1.1 Stone Age 1.2 Early Farming and Domestication 1.3 Bronze Age 1.4 Iron Age	7
II	Civilisations in South Asia 2.1 Sindhu-Saraswati River Valley Civilisation 2.2 Ganga-Valley civilisation	7
III	Origin of Humans 3.1 What changes have made us humans 3.2 Modern Humans and Out-of-Africa 3.3 Understanding the genetics of Peopling of South Asia	10
IV	Archaic Humans 4.1 Neanderthals 4.2 Denisovans 4.3 Genetic Introgression	5
V	Ancient DNA 5.1 Evolution of Ancient DNA Technology 5.2 Use of ancient DNA in understanding animal evolution 5.3 Genetics of Domestication and Lactose Tolerance 5.4 Archaeozoology and Diseases	10

Texts / References	1. Human Evolutionary Genetics (Second Edition): Jobling, Hollox, Hurles, Kivisild and Tyler-Smith. Garland Science, New York. 2. Neanderthal Man: In Search of Lost Genomes Svante Paabo 3. Denisovans: The Archaic Humans of the Paleolithic Period History Titans 4. Who we are and how we got here. DNA and the New Science of the Human Past. David Reich. Oxford University Press 5. Understanding Archaeology. K. Rajan 6. An Oxford Companion to Indian Archaeology. DK Chakrabarti.
Learning Outcomes (not more than 100 words)	1. The course is pivotal for understanding the historical and biological evolution of both humans and animals within the context of South Asia's rich prehistorical timeline. 2. It explores the progression from the Stone Age to the Iron Age, delving into the major civilizations, the origin of humans, archaic humans, and the advancements in ancient DNA technology. 3. This comprehensive study sheds light on the genetic and cultural shifts that have shaped human and animal history. 4. The inclusion of tool identification, and DNA analysis, further enriches this learning experience, fostering a deeper appreciation and understanding of our ancestral past.

Course Title	**ZOOSE31: Microscopy and Histology & Histochemistry**
Category of Course	~~Major / Minor / Minor (Vocational)~~ / **SEC** / ~~AEC / VAC / MD/Internship/Dissertation~~ (Tick any one of the above)

Credits & Hour of Teaching	Theory	Practical	Cumulative
Credits	2		3
Hour of Teaching (Total)	30		30

Course Objectives (not more than 100 words)	• To acquaint students with different types of microscopes, histological and histochemical techniques, and to get hands-on training in handling microscopes and sample preparation of various biological tissues.
Course Content	The course content be divided into minimum 3 Units to maximum 5 units along with defined hour of teaching for each unit.

Units	Course Content	Hr. of Teaching
I	1. Introduction to microscopy: general principles and components, numerical aperture, diffraction, and Optical Resolution	3
II	2. Light Microscopy 2.1 Bright field microscopy 2.1.1 Students microscope 2.1.2 Compound microscope 2.2 Phase contrast microscopy 2.3 Dark field microscopy	5
III	3. Sample preparation for light microscopy 3.1 Cytological technique 3.1.1 Vital Staining (Methylene blue, Gram Staining) 3.1.2 Sample fixation, staining, and mounting 3.1.3 Preparation of permanent slides 3.2 Histological and histochemical techniques 3.2.1 Fixation and fixatives 3.2.2 Tissue processing and microtomy 3.2.3 Principle and method of histological staining- Hematoxylins and eosin 3.2.4 Histochemical techniques to detect carbohydrates, proteins, and lipids	12
IV	4. Fluorescence microscopy 4.1 Epi-fluorescence microscopy 4.1.1 Source of light: halogen lamp and diodes 4.1.2 Excitation and emission spectra of various luorophores 4.1.3 Use of filters and dichroic mirrors 4.2 Confocal microscopy 4.2.1 source of light: lasers and diodes 4.2.2 photomultiplier tubes 4.2.3 conventional filters vs digital filters 4.3 Sample preparation for Fluorescence microscopy 4.3.1 Fluorescent dyes 4.3.2. earning critical steps in immunostaining	10

Texts / References

Microscopy:

1. Karp: Cell and Molecular Biology (2007, Wiley)
2. Pollard & Earnshaw: Cell Biology (2002, Saunders)
3. Fundamentals of Light Microscopy and Electronic Imaging (2012, Douglas B. Murphy and Michael W. Davidson)
4. Ruthman: Methods in Cell Research (1970, Bell & Sons)

Histology:

1. Bancroft's Theory and Practice of Histological Techniques- Suvarna et al., 2018, Elsevier health Sciences, 2018
2. Histochemistry, theoretical and applied (Vol. I, II, III) - Pearse, A. G. Everson (4th ed 1980-1993,

	Churchill- Livingstone)
Learning Outcomes (not more than 100 words)	1. Upon successful completion of the course, students will receive training in preparing various types of samples for different analyses. 2. They will become proficient in using various microscopes to analyze the samples. 3. The course will prepare students for careers in pathology, sample diagnosis, and related fields.

Course Title	**ZOOSE32: Lab. Exercises based on course ZOOSE31**
Category of Course	~~Major / Minor / Minor (Vocational)~~ / **SEC** / ~~AEC / VAC / MD/Internship/Dissertation~~ (Tick any one of the above)

Credits & Hour of Teaching

	Theory	Practical	Cumulative
Credits		1	1
Hour of Teaching (Total)		30	30

Course Objectives (not more than 100 words)	• To acquaint students with different types of microscopes, histological and histochemical techniques and to get hands on training in handling microscope and sample preparation of various biological tissues.
Course Content	The course content be divided into minimum 3 Units to maximum 5 units along with defined hour of teaching for each unit.

Units	Course Content	Hr. of Teaching
I	Students' Microscope and stereo-binocular basic assembly and application	4
II	1. Tissue fixation, paraffin block preparation and sectioning. 2. Histological staining of paraffin sections using Hematoxylin and eosin 3. Histochemical staining for lipids using Sudan Black B, III and IV	12
III	Cytological smear preparation and staining with methylene blue, Janus green and Leishman stain	6
IV	Staining tissues with fluorescent dyes (DAPI, PI) Visualization of DNA, mitochondria and cytoskeleton under microscope using permanent slides.	8

Texts / References	*Microscopy:* 1. Karp: Cell and Molecular Biology (2007, Wiley) 2. Pollard & Earnshaw: Cell Biology (2002, Saunders) 3. Fundamentals of Light Microscopy and Electronic Imaging (2012, Douglas B. Murphy and Michael W. Davidson) 4. Ruthman: Methods in Cell Research (1970, Bell & Sons) *Histology:* 1. Bancroft's Theory and Practice of Histological Techniques- Suvarna et al., 2018, Elsevier health Sciences, 2018 2. Histochemistry, theoretical and applied (Vol. I, II, III) - Pearse, A. G. Everson (4^{th} ed 1980-1993, Churchill- Livingstone)
Learning Outcomes (not more than 100 words)	1. Upon successful completion of the course, students will receive training in preparing various types of samples for different analyses. 2. They will become proficient in using various microscopes to analyze the samples. 3. The course will prepare students for careers in pathology, sample diagnosis, and related fields.

Course Title	**ZOOMJ41: Fundamental Endocrinology**
Category of Course	**Major** / ~~Minor / Minor (Vocational) / SEC / AEC / VAC / MD/Internship/Dissertation~~ (Tick any one of the above)

Credits & Hour of Teaching

	Theory	Practical	Cumulative
Credits	3		3
Hour of Teaching (Total)	45		45

Course Objectives (not more than 100 words)

- To define and classify hormones, neurohormones, neurotransmitters, and pheromones, and describe their characteristics.
- To explain hormone delivery methods: endocrine, paracrine, and autocrine.
- To understand feedback mechanisms in hormone regulation.
- To describe the general mechanisms of action for peptide and steroid hormones.
- To study the structure, biological functions, and regulation of the hypothalamus, pituitary gland, pineal gland, thyroid and parathyroid glands, adrenal glands, endocrine pancreas, and gonads.
- To understand the roles of gastrointestinal hormones like gastrin, CCK, and secretin.
- To identify and explain hormonal dysfunctions such as diabetes insipidus, dwarfism, gigantism, acromegaly, goitre, tetany, Addison's disease, Cushing's syndrome, and diabetes mellitus.

Course Content

The course content be divided into minimum 3 Units to maximum 5 units along with defined hour of teaching for each unit.

Units	Course Content	Hr. of Teaching
I	Introduction to Endocrinology 1.1 Definition, classification and characteristics of chemical messengers (hormones, neurohormones, neurotransmitters and pheromones) 1.2 Hormone delivery: Endocrine, paracrine and autocrine modes Hormone feedback mechanisms 1.3 General mechanism of hormone action (Peptide and Steroid hormones)	10
II	Structure, biological actions and regulation of secretion of 2.1 Hypothalamus and Pituitary gland 2.2 Pineal gland 2.3 Thyroid and Parathyroid gland 2.4 Adrenal gland 2.5 Endocrine pancreas	20
III	Reproductive hormones: 3.1 Structural organization of gonads 3.2 Synthesis, biological action and regulation of secretion of 3.2.1 Estrogen 3.2.2Progesterone 3.2.3Testosterone	6
IV	Gastrointestinal hormones: Gastrin, CCK and Secretin	3
V	Hormonal dysfunctions: 4.1 Diabetes insipidus 4.2 Dwarfism, gigantism, acromegaly 4.3 Goitre 4.4 Tetany 4.5 Addison's disease 4.6 Cushing's syndrome 4.7 Diabetes mellitus (Type I and II)	6

Texts / References

1. Hadley: Endocrinology, Fifth Edition, 2000, Prentice Hall
2. Norris: Vertebrate Endocrinology, Fourth Edition, 2007, Academic Press
3. Goodman: Basic Medical Endocrinology, Fourth Edition, 2009, Elsevier Inc.

Learning Outcomes (not more than 100 words)

Upon completing this course, students will be able to:

1. Understand and Describe Chemical Messengers including hormones, neurohormones, neurotransmitters, and pheromones.
2. Distinguish between endocrine, paracrine, and autocrine modes of hormone delivery.
3. Describe hormone feedback mechanisms and their role in maintaining physiological balance.
4. Understand the general mechanisms of action for peptide and steroid hormones, including receptor interactions and signal transduction pathways.
5. Analyze the Structure and Function of different Endocrine Glands:
6. Identify and Analyze Hormonal Dysfunctions:

Course Title	**ZOOMJ42: Developmental Biology**
Category of Course	**Major** ~~/ Minor / Minor (Vocational) / SEC / AEC / VAC / MD/Internship/Dissertat~~ion (Tick any one of the above):

Credits & Hour of Teaching		Theory	Practical	Cumulative
	Credits	3		3
	Hour of Teaching (Total)	45		45

Course Objectives (not more than 100 words)	• To provide historical background about the key hypothesis and discoveries in the field of embryology • To know about the processes by which a single cell (zygote) formed after the fertilization becomes an embryo and then an adult organism. • To provide knowledge about the crucial developmental processes, including gametogenesis, fertilization, cleavage, and gastrulation • To explain the concept of commitment (specification and determination), competence, differentiation, regeneration. • To understand the role of primary organizer and axis formation in frog by experiments performed by Hans Spemann, Pieter Nieuwkoop, and Gimlich and Gerhart
Course Content	The course content be divided into minimum 3 Units to maximum 5 units along with defined hour of teaching for each unit.

Units	Course Content	Hr. of Teaching
I	1. Historical perspective and scope of developmental biology 1.1 Contributions of several scientists 1.2 Anatomical, Experimental and Genetic Approaches 1.3 Karl Ernst von Baer Principles	3
	2. Gametogenesis 2.1 Spermatogenesis 2.2 Oogenesis	5
II	3. Fertilization 3.1 External fertilization: sea urchin 3.2 Internal fertilization	5
	4. Cleavage 4.1 Patterns and types 4.2 Cleavage in frog and chick embryo	3
III	5. Fate map and gastrulation in frog and chick 5.1 Fate map 5.2 Gastrulation in frog 5.3 Gastrulation in chick	5
	6. Concept of commitment (specification and determination), competence and differentiation 6.1. Autonomous, Conditional, and Syncytial specification 6.2 Induction and Competence 6.3 Definition and types of Differentiation	7
IV	7. Primary organizer and axis formation in frog 7.1 Experiments of Hans Spemann 7.2 Nieuwkoop center 7.3 Experiments of Pieter Nieuwkoop, and Gimlich and Gerhart	7
	8. Extra embryonic membranes	2
V	9. Hormonal control of metamorphosis in frog 10. Concept of regeneration 10.1 Morphallaxis 10.2 Epimorphosis 10.3 Stem cell-mediated regeneration 10.4 Compensatory regeneration	4 4

Texts / References	1. Gilbert: Developmental Biology (8th ed., 2006, Sinauer) 2. Balinsky: An Introduction to Embryology (1981, CBS) 3. Wolpert: Principles of Development (3rd ed., 2007, Oxford) 4. Sastry and Shukla: Developmental Biology (2nd ed., 2021, Rastogi Publications) 5. Verma and Agarwal: Chordate Embryology (2010, S. Chand)

Learning Outcomes (not more than 100 words)	After studying the course, the student will: 1. Comprehensively understand developmental biology from embryo to adult 2. Understand the fundamental concepts of commitment (specification and determination), competence, differentiation, metamorphosis, and regeneration 3. Understand the importance of primary organizer in the embryonic development
Course Title	ZOOMJ43: Evolution
Category of Course	Major / Minor / Minor (Vocational) / SEC / AEC / VAC / MD/Internship/Dissertation (Tick any one of the above):

Credits & Hour of Teaching	Theory	Practical	Cumulative
Credits	2		2
Hour of Teaching (Total)	30		30

Course Objectives (not more than 100 words)	• Studying evolutionary biology aims to understand the processes driving the diversity and adaptation of life on our planet. • Key objectives include exploring the mechanisms of evolution, such as natural selection, genetic drift, and gene flow, and reconstructing the evolutionary relationships among species through phylogenetic analysis. • Students learn to interpret fossil records and molecular data to trace evolutionary history and identify patterns of speciation and extinction. • The field of evolution also examines the role of evolutionary processes in shaping ecological interactions and behaviors.
Course Content	The course content be divided into minimum 3 Units to maximum 5 units along with defined hour of teaching for each unit.

Units	Course Content	Hr. of Teaching
I	1. History of Evolutionary Thoughts 2. Evidence of organic evolution 2.1 Comparative anatomy 2.2 Comparative embryology 2.3 Palaeontology 2.4 Biochemistry and genetics 2.5 Zoogeography 3. Theories of Evolution 3.1 Lamarckism 3.2 Darwinism 3.3 Concept of synthetic theory	01 03 03
II	4. Population Genetics 4.1Gene frequencies in Mendelian populations 4.2 Hardy- Weinberg equilibrium 4.3 Evolutionary forces (Mutation, Selection, Random genetic drift, Migration)	06
III	5. Genetic polymorphism 5.1 Chromosomal 5.2 Allozyme 5.3 DNA polymorphism	03
IV	6. Modes of speciation 7. Isolating mechanisms 8. Evolution at molecular level	02 02 02
V	9. Evolution through ages (Geological columns; Evolution of horse; Evolution of man)	04

Texts / References	1. Futuyma: Evolutionary Biology (2005, Sinauer) 2. Hall and Hallgrimsson: Strickberger's Evolution (2008, Jones and Bartlet) 3. Hartl and Clark: Principles of Population Genetics (1989 & 1997, Sinauer) 4. Moody: Introduction to Evolution (1978, Kalyani). 5. Rastogi: Organic Evolution (2007, Kedarnath & Ramnath).
Learning Outcomes (not more	1. The aspect of evolutionary biology helps to understand the mechanism of evolution of different forms of life on our earth planet. 2. How genetic and ecological factors facilitate the process of speciation and the way organisms adapt to their environments over time could be known by going through the study

than 100 words)	of evolutionary biology. 3. One can learn to construct and analyze evolutionary trees to understand the relationships between species. 4. Its knowledge helps to examine changes in DNA sequences to infer evolutionary relationships among different forms of life.

Course Title	**ZOOMJ44: Systematics and Taxonomy**			
Category of Course	**Major** ~~/ Minor / Minor (Vocational) / SEC / AEC / VAC / MD/Internship/Dissertat~~ion (Tick any one of the above):			
Credits & Hour of Teaching		Theory	Practical	Cumulative
	Credits	2		2
	Hour of Teaching (Total)	30		30
Course Objectives (not more than 100 words)	• The study of Systematics and Taxonomy aims to understand and organize biological diversity by classifying organisms into hierarchical categories based on evolutionary relationships. • This knowledge facilitates the construction of phylogenetic trees, aids in identifying and naming species, and supports accurate communication within the scientific community. • It also enhances research by providing a framework for data organization, informs conservation efforts by identifying endangered species, and integrates insights from various biological disciplines.			
Course Content	The course content be divided into minimum 3 Units to maximum 5 units along with defined hour of teaching for each unit.			

Units	Course Content	Hr. of Teaching
I	Introduction to taxonomy and its relationship with systematics Zoological nomenclature 1. Binominal 2. Trinominal	05
II	Kinds of taxonomic characters 1. Morphological 2. Embryological 3. Behavioural 4. Ecological 5. Numerical	08
III	Kinds of zoological classification 1. Components of classification 2. Linnaean hierarchy	04
IV	Concept of species 1. Typological 2. Nominalistic 3. Biological 4. Evolutionary	06
V	Molecular Taxonomy	03

Texts / References	*Books Recommended* 1. Boolotian and Stiles: College Zoology (1981, Macmillan) 2. Dalela and Sharma: Animal Taxonomy and Museology (1976, Jai Prakash Nath). 3. Kapoor: Theory and Practicals of Animal Taxonomy (1988, Oxford & IBH). 4. Mayr and Ashlock: Principles of Systematic Zoology (1991, McGraw Hill). 5. Roymahoney: Laboratory Techniques in Zoology (1966, Butterworths). 6. Simpson: Principles of Animal Taxonomy (1962, Oxford).
Learning Outcomes (not more than 100 words)	Upon completing this course/module, students will: 1. Understand the core principles of taxonomy and systematics, including their interrelationship in biological classification. 2. Accurately apply zoological nomenclature rules, distinguishing between binomial and trinomial naming systems. 3. Identify and utilize various taxonomic characters in classifying organisms. 4. Evaluate different species concepts (typological, nominalistic, biological, and evolutionary) and their relevance in modern taxonomy, along with the role of molecular techniques in elucidating phylogenetic relationships.

Course Title	**ZOOMJ45: Lab. exercises based on course ZOOMJ41 & ZOOMJ42**
Category of Course	**Major** / ~~Minor / Minor (Vocational) / SEC / AEC / VAC / MD/Internship/Dissertation~~ (Tick any one of the above)

Credits & Hour of Teaching

	Theory	Practical	Cumulative
Credits		2	2
Hour of Teaching (Total)		60	60

Course Objectives (not more than 100 words)

Fundamental Endocrinology:

- This course equips students with proficiency in handling and maintaining laboratory rodents, surveying endocrine glands and sex organs, and conducting vaginal smear analysis to study the estrous cycle.
- It covers surgical techniques like ovariectomy and orchidectomy, histological analysis of endocrine and reproductive organs, and sperm parameter assessment.
- Additionally, students will learn hormone estimation using the ELISA technique.

Developmental Biology:

- Students will learn to identify animal eggs based on yolk distribution, understand meroistic oogenesis, recognize sperm structure, and study embryonic developmental stages in frogs and chicks through models and slides.

Course Content: The course content be divided into minimum 3 Units to maximum 5 units along with defined hour of teaching for each unit.

Units	Course Content	Hr. of Teaching
I	1.1 Handling, sexing, numbering and maintenance of rat/mouse. 1.2 Study of the estrous cycle by vaginal smear preparation.	10
II	2.1 General survey of endocrine glands and accessory sex organs in rat/mouse. 2.2 Demonstration of Ovariectomy and Orchidectomy in rat 2.3 Study of sperm parameters (Sperm count, motility and viability). 2.4 Estimation of any hormone by ELISA (Demonstration only)	10
III	Study of histological slides of the following: 1. Pituitary 2. Thyroid and parathyroid 3. Endocrine, pancreas 4. Adrenal 5. Testis 6. Ovary 7. Uterus 8. Seminal vesicle	10
IV	1. Study of different types of eggs (snail, *Drosophila*, frog, chick and mouse) 2. Demonstration of sperm motility in rat/mice 3. Study of meroistic oogenesis by dissecting and observing ovaries of *Drosophila*	10
V	4. Study of eggs and tadpoles of frogs from collected/preserved material 5. Study of frog development through models 6. Window preparation on hen's egg 7. Demonstration of chick embryonic development, making window preparation of fertilized egg 8. Study of whole mount preparations of chick embryos at 16-18, 24-28, 33-36 and 42-48 hours of development	20

Texts / References

1. Advanced Practical Zoology by PS Verma & PC Srivastava. S. Chand Publishing, 2015

Learning Outcomes (not more than 100 words)

Upon completing this course, students will be able to:

1. Demonstrate proper techniques for handling, sexing, numbering, and maintaining rats/mice.
2. Identify and describe the major endocrine glands and accessory sex organs in rats/mice.
3. Analyze the estrous cycle in rodents through vaginal smear preparation.
4. Understand and observe the procedures for ovariectomy and orchidectomy in rats.
5. Identify and interpret histological slides of various endocrine glands and reproductive organs (pituitary, thyroid, parathyroid, endocrine pancreas, adrenal, testis, ovary, uterus, seminal vesicle).
6. Assess sperm parameters, including count, motility, and viability.
7. Understand the principles of hormone estimation using ELISA and observe its demonstration.

Course Title	**ZOOMJ46: Lab. exercises based on course ZOOMJ43 & ZOOMJ44**
Category of Course	**Major** / ~~Minor / Minor (Vocational) / SEC / AEC / VAC / MD/Internship/Dissertation~~ (Tick any one of the above)

Credits & Hour of Teaching	Theory	Practical	Cumulative
Credits		2	2
Hour of Teaching (Total)		60	60

Course Objectives (not more than 100 words)

Evolution:

- This course explores the processes driving life's diversity and adaptation, focusing on mechanisms like natural selection, genetic drift, and gene flow.
- Students learn to reconstruct evolutionary relationships through phylogenetic analysis, interpret fossil records and molecular data, and trace patterns of speciation and extinction.
- Additionally, the course examines how evolutionary processes shape ecological interactions and behaviors.

Systematics and Taxonomy:

- Students will learn to classify organisms based on evolutionary relationships, aiding in constructing phylogenetic trees, identifying and naming species, and facilitating scientific communication.
- This knowledge also supports research and informs conservation efforts.

Course Content

The course content be divided into minimum 3 Units to maximum 5 units along with defined hour of teaching for each unit.

Units	Course Content	Hr. of Teaching
I	*Part – A: Evolution (Credit 1)* 1. Natural selection – experiment using red and white-eyed Drosophila flies. 2. Isolating mechanism - Demonstration of sexual isolation in Drosophila: *D. bipectinata* and *D. malerkotliana.* 3. Calculation of Hardy-Weinberg equilibrium in human population considering MN and ABO blood group system. 4. Fossils – One representative fossil each from Foraminifera, Trilobita, Ammonites and Echinodermata. 5. Models of chordate fossils – Brontosaurus, Dimetrodon, Archaeopteryx, Dinoceras. 6. Evolution of horse – through models.	30
II	*Part – B: Systematics and Taxonomy (Credit 1)* 1. Identification of five locally available fishes based on their morphological characters. 2. Identification of the following species of Drosophila based on the pattern of their sex combs: *D. melanogaster, D. ananassae, D. bipectinata* and *D. malerkotliana.* 3. Zoological names of some common animals. 4. Preservation of insects. 5. Fixation of freshwater protozoans.	30

Texts / References	
Learning Outcomes (not more than 100 words)	1. Students will conduct natural selection experiments with Drosophila and calculate Hardy-Weinberg equilibrium, demonstrating their understanding of evolutionary processes. 2. The ability to identify and classify organisms, including locally available fishes and different Drosophila species, will be developed through hands-on practice. 3. Practical experience in preserving insects, fixing freshwater protozoans, and recognizing key fossils will enhance their understanding of evolutionary history and taxonomy.

Course Title	**ZOOMN41: Fundamental Endocrinology**
Category of Course	~~Major /~~ **Minor** ~~/ Minor (Vocational) / SEC / AEC / VAC / MD/Internship/Dissertation~~ (Tick any one of the above)

Credits & Hour of Teaching	Theory	Practical	Cumulative
Credits	3		3
Hour of Teaching (Total)	45		45

Course Objectives (not more than 100 words)	• To define and classify hormones, neurohormones, neurotransmitters, and pheromones, and describe their characteristics. • To explain hormone delivery methods: endocrine, paracrine, and autocrine. • To understand feedback mechanisms in hormone regulation. • To describe the general mechanisms of action for peptide and steroid hormones. • To study the structure, biological functions, and regulation of the hypothalamus, pituitary gland, pineal gland, thyroid and parathyroid glands, adrenal glands, endocrine pancreas, and gonads. • To understand the roles of gastrointestinal hormones like gastrin, CCK, and secretin. • To identify and explain hormonal dysfunctions such as diabetes insipidus, dwarfism, gigantism, acromegaly, goitre, tetany, Addison's disease, Cushing's syndrome, and diabetes mellitus.
Course Content	The course content be divided into minimum 3 Units to maximum 5 units along with defined hour of teaching for each unit.

Units	Course Content	Hr. of Teaching
I	Introduction to Endocrinology 1.2 Definition, classification and characteristics of chemical messengers (hormones, neurohormones, neurotransmitters and pheromones) 1.2 Hormone delivery: Endocrine, paracrine and autocrine modes Hormone feedback mechanisms 1.4 General mechanism of hormone action (Peptide and Steroid hormones)	10
II	Structure, biological actions and regulation of secretion of 2.1 Hypothalamus and Pituitary gland 2.2 Pineal gland 2.3 Thyroid and Parathyroid gland 2.4 Adrenal gland 2.5 Endocrine pancreas	20
III	Reproductive hormones: 3.1 Structural organization of gonads 3.2 Synthesis, biological action and regulation of secretion of 3.2.1 Estrogen 3.2.2Progesterone 3.2.3Testosterone	6
IV	Gastrointestinal hormones: Gastrin, CCK and Secretin	3
V	Hormonal dysfunctions: 4.1 Diabetes insipidus 4.2 Dwarfism, gigantism, acromegaly 4.3 Goitre 4.4 Tetany 4.5 Addison's disease 4.6 Cushing's syndrome 4.7 Diabetes mellitus (Type I and II)	6

Texts / References	1. Hadley: Endocrinology, Fifth Edition, 2000, Prentice Hall 2. Norris: Vertebrate Endocrinology, Fourth Edition, 2007, Academic Press 3. Goodman: Basic Medical Endocrinology, Fourth Edition, 2009, Elsevier Inc.
Learning Outcomes (not more than 100 words)	Upon completing this course, students will be able to: 1. Understand and Describe Chemical Messengers including hormones, neurohormones, neurotransmitters, and pheromones. 2. Distinguish between endocrine, paracrine, and autocrine modes of hormone delivery. 3. Describe hormone feedback mechanisms and their role in maintaining physiological balance. 4. Understand the general mechanisms of action for peptide and steroid hormones, including receptor interactions and signal transduction pathways. 5. Analyze the Structure and Function of different Endocrine Glands: 6. Identify and Analyze Hormonal Dysfunctions:

Course Title	**ZOOMN42: Lab. exercises based on course ZOOMN41**
Category of Course	~~Major~~ / **Minor** ~~/ Minor (Vocational) / SEC / AEC / VAC / MD/Internship/Dissertation~~ (Tick any one of the above)

Credits & Hour of Teaching

	Theory	Practical	Cumulative
Credits		1	1
Hour of Teaching (Total)		30	30

Course Objectives (not more than 100 words)	• The course develops skills in handling laboratory rodents, surveying endocrine glands and sex organs, and analyzing vaginal smears to study the estrous cycle. • To understand the surgical techniques and implications of ovariectomy and orchidectomy in rats. • To gain skills in identifying and analyzing histological slides of endocrine glands and reproductive organs, including the pituitary, thyroid, parathyroid, pancreas, adrenal, testis, ovary, uterus, and seminal vesicle. • To measure and assess sperm parameters such as count, motility, and viability. • To observe and comprehend the principles of hormone estimation using the ELISA technique.
Course Content	The course content be divided into minimum 3 Units to maximum 5 units along with defined hour of teaching for each unit.

Units	Course Content	Hr. of Teaching
I	1.1 Handling, sexing, numbering and maintenance of rat/mouse. 1.2 Study of the estrous cycle by vaginal smear preparation.	10
II	2.1 General survey of endocrine glands and accessory sex organs in rat/mouse. 2.2 Demonstration of Ovariectomy and Orchidectomy in rat 2.3 Study of sperm parameters (Sperm count, motility and viability). 2.4 Estimation of any hormone by ELISA (Demonstration only)	10
III	3.1 Study of histological slides of the following: 3.2 Pituitary 3.3 Thyroid and parathyroid 3.4 Endocrine, pancreas, 3.5 Adrenal 3.6 Testis & Ovary 3.7 Uterus 3.8 Seminal vesicle	10

Texts / References	1. Advanced Practical Zoology by PS Verma & PC Srivastava. S. Chand Publishing, 2015
Learning Outcomes (not more than 100 words)	Upon completing this course, students will be able to: 1. Demonstrate proper techniques for handling, sexing, numbering, and maintaining rats/mice. 2. Identify and describe the major endocrine glands and accessory sex organs in rats/mice. 3. Analyze the estrous cycle in rodents through vaginal smear preparation. 4. Understand and observe the procedures for ovariectomy and orchidectomy in rats. 5. Identify and interpret histological slides of various endocrine glands and reproductive organs (pituitary, thyroid, parathyroid, endocrine pancreas, adrenal, testis, ovary, uterus, seminal vesicle). 6. Assess sperm parameters, including count, motility, and viability. 7. Understand the principles of hormone estimation using ELISA and observe its demonstration.

Course Title	**ZOOMJ51: Functional Anatomy of Non-chordates**
Category of Course	**Major** / ~~Minor / Minor (Vocational) / SEC / AEC / VAC / MD/Internship/Dissertation~~ (Tick any one of the above)

Credits & Hour of Teaching	Theory	Practical	Cumulative
Credits	3		3
Hour of Teaching (Total)	45		45

Course Objectives (not more than 100 words)	• The course would help students to understand the characteristic morphological and anatomical features of diverse animal groups. • Will help students to develop basic understanding of structure-function relationships and its adaptive significance in survival in different habitats. • Students will be able to outline the ecological, medicinal and economic significance of various life forms.
Course Content	The course content be divided into minimum 3 Units to maximum 5 units along with defined hour of teaching for each unit.

Units	Course Content	Hr. of Teaching
I	1. Protozoa Study of *Euglena* and *Monocystis* (locomotion, nutrition and reproduction) 2. Organization of Metazoans 2.1 Grades of organization 2.2 Symmetry, Germ layers, diploblastic and triploblastic organization, coelom, metamerism 3. Porifera 3.1 Study of *Leucosolenia* and *Sycon* (structure, skeleton and reproduction) 3.2 Aquaferous system	4 5 3
II	Cnidaria and Ctenophora 4.1 Study of *Obelia* and *Aurelia (*structure and reproduction) 4.2 Salient features of ctenophores and comparison with cnidarians	7
III	5. Platyhelminthes: *Fasciola* and *Taenia* (structure, reproduction, life-cycle and parasitic adaptations) 6. Nemathelminthes: Ascaris- (Structure, reproduction and life-cycle)	5 3
IV	7. Annelida: Nereis- (Structural features and reproduction) 8. Arthropoda 8.1 *Palaemon* (Structural features and reproduction), 8.2 Types of metamorphosis in insects 8.3 Salient features and evolutionary significance of Onychophora	3 4
V	9. Mollusca 9.1 *Unio:* Structural features and reproduction 9.2 Torsion and detorsion in gastropods 10. Echinodermata 10.1 *Asterias*: Structural features and reproduction 10.2 Hydrostatic system	6 5

Texts / References	1.Barnes: Invertebrate Zoology (Recent edition, Holt Saunders International) 2. Marshall: Parker &Hashwell Textbook of Zoology, Vol I (Recent edition, Macmillan) 3. Barnes: The Invertebrates – A Synthesis (Recent edition, Blackwell) 4. Hunter: Life of Invertebrates (Recent edition, Collier Macmillan) 5. Moore: An Introduction to the Invertebrates (2001, Cambridge University Press)
Learning Outcomes (not more than 100 words)	1. The course will empower students to appreciate the diversity in life forms and their ecological, economic and medicinal importance in human life. 2. Will encourage students to critically analyze the organizational complexity and characteristic features of non-chordates making them familiarize with the morphology and anatomy of representatives of various animal phyla.

Course Title	**ZOOMJ52: Animal Behaviour**
Category of Course	**Major** ~~/ Minor / Minor (Vocational) / SEC / AEC / VAC / MD/Internship/Dissertation~~ (Tick any one of the above)

Credits & Hour of Teaching		Theory	Practical	Cumulative
	Credits	2		2
	Hour of Teaching (Total)	30		30

Course Objectives (not more than 100 words)	• To introduce students to the patterns of behaviour and core animal behaviour theories. • To identify some of the mechanisms involved in the production of a behavior by an animal. • To study and understand the ecological and evolutionary perspectives for the diversity of behaviour.
Course Content	The course content be divided into minimum 3 Units to maximum 5 units along with defined hour of teaching for each unit.

Units	Course Content	Hr. of Teaching
I	1. Introduction and Patterns of behaviour	4
II	2. Instinct and learning 2.1 Innate behavior 2.2 Learned behavior and types of learning	4
III	3. Control of behavior 3.1 Neural control 3.2 Hormonal control 3.3 Genetic and environmental control	8
IV	4. Social organization 4.1 Communication: Channels and Functions 4.2 Foraging and antipredator behavior 4.3 Mating system and Parental care 4.4 Group living, altruism and cooperation 4.5 Dispersal and migration 4.6 Coordination and orientation	10
V	5. Biological rhythms	4

Texts / References	1. Lee Alan Dugatkin (2020): Principles of Animal Behavior (4th ed., University of Chicago Press). 2. Drickamer, Vessey & Jakob (2002): Animal Behaviour – Mechanisms, Ecology and Evolution (5th ed., McGraw-Hill). 3. Judith Goodenough, Robert A. Wallace, Betty McGuire (2010): Perspectives on Animal Behavior (3rd ed., John Wiley & Sons). 4. David McFarland (2009) Animal Behaviour: Psychobiology, Ethology and Evolution (3rd ed., Longman Scientific).
Learning Outcomes (not more than 100 words)	1. The student will be able to understand the fundamental concepts of ethology that apply to most of the species. 2. The student will be able to predict the proximate (physiology, cognition, etc) and ultimate (evolution, adaptation) explanations of behaviour. 3. Students will have better analyses and interpretation skills while observing and animal. 4. Students will be able to relate animal behavior with other aspects like animal biodiversity, conservation and ecology.

Course Title	**ZOOMJ53: Immunology**
Category of Course	**Major** / ~~Minor / Minor (Vocational) / SEC / AEC / VAC / MD/Internship/Dissertation~~ (Tick any one of the above):

Credits & Hour of Teaching		Theory	Practical	Cumulative
	Credits	3		3
	Hour of Teaching (Total)	45		45

Course Objectives (not more than 100 words)	• To provide historical perspective along with basic understanding about immunity. • To provide knowledge about immune cells and lymphoid organs • To provide knowledge on properties of antigens, and structure, types, and function of antibodies • To acquire knowledge about complement system and their role in immunity. • To explain the concept of hypersensitivity, auto immunity and immune deficiencies
Course Content	The course content be divided into minimum 3 Units to maximum 5 units along with defined hour of teaching for each unit.

Units	Course Content	Hr. of Teaching
I	1. Introduction to Immunology 1.1 Historical perspective 1.2 Clonal Selection Theory 1.3 Types of Immunity 2. Cells and organs of the immune system 2.1. Hematopoiesis 2.2. Hematopoietic stem cells and progenitor cells 2.3. Types of immune cells: lymphoid and myeloid 2.4. Primary and secondary lymphoid organs and lymphatic system	4 8
II	3. Innate Immunity 4. Humoral Immunity 4.1. Antigen and immunogen 4.2. Hapten 4.3. Adjuvant 4.4. Immunoglobulins: types, structure, function, and diversity 4.5. Structure of B cell receptor 4.6. Antibody-mediated effector functions 4.7. Antigen-Ab reactions for immunological techniques	4 8
III	5. Complement System 5.1 Complement components 5.2 Classical pathway 5.3 Alternative pathway 5.4 Lectin Pathway 6. Cell-mediated Immunity 6.1. Structure of T cell receptor 6.2. Structure and organization of Major Histocompatibility Complex and T cell interaction 6.3. Antigen processing and presentation	3 9
IV	7. General Introduction to Immunological Disorders 7.1 Autoimmunity 7.2 Immunodeficiency 7.3 Hypersensitivity 7.4 Tolerance 8. Concept of vaccination	5 4

Texts / References	1. Janeway'sImmunobiology, 7th ed. 2008, Garland Science Publication. 2. Kubey*et al.*: Immunology, 7th ed. 2013, W.H. Freeman and Company Publication, New York. 3. Roitt and Delvis: Roitt's Essential Immunology, 6th ed. 2006, Blackwell Publication 4. Fundamental Immunology, 6th ed. 2008, Lippincott Williams & Wilkins, Philadelphia 5. Acharya *et al.*: Immunology, 2nd ed. 2011, Kalyani Publishers, Ludhiyana, Punjab
Learning Outcomes (not more than	1. Understand about the immune system that how an intricate system regulates the immune response against a vast variety of pathogen. 2. Understand how immune armaments get formed and mature in our body, what are the organs

100 words)	that are participating in their formation and maturation. 3. Understand the basic structure and function of immunoglobulin generation and their classification as well as their function in immune responses 4. Understand the role of complement system 5. Able to know how MHC molecules and T cells work together and protect from various diseases 6. Know about the different approaches of conception of vaccination. Different method of the vaccine preparation, its characteristic properties, uses, schedule of vaccination of different age groups
Course Title	**ZOOMJ54: Biology of Infectious Disease**
Category of Course	**Major** / ~~Minor / Minor (Vocational) / SEC / AEC / VAC / MD/Internship/Dissertation~~ (Tick any one of the above):

Credits & Hour of Teaching	Theory	Practical	Cumulative
Credits	2		2
Hour of Teaching (Total)	30		30

Course Objectives (not more than 100 words)	• Provide information on infectious agents and types of pathogens. • Educate on parasites, parasitism, vectors, and zoonotic diseases. • Explain pathogenesis and diseases caused by protozoa and helminths.
Course Content	The course content be divided into minimum 3 Units to maximum 5 units along with defined hour of teaching for each unit.

Units	Course Content	Hr. of Teaching
I	1. Introduction to infectious agents 1.1 Animal associations 1.2 Concept of harms 1.3 Signs and symptoms 2. Types of pathogens and diseases 2.1 Viruses- Influenza, Dengue 2.2 Bacteria - Mycobacteria, Salmonella 2.3 Fungi - Candida, Histoplasma 2.4 Parasites- Protozoans and Helminths	2 8
II	3. Pathogenicity and Infection 1.1 Pathogenicity and Infectious Disease 1.2 Virulence 1.3 Exposure and Transmission 4. General concept of parasites and parasitism 4.1 Introduction to parasitology: basic principles and concepts 4.2 Systematics, ecology and evolution 4.3 Vector 4.4 Zoonosis	3 4
III	5. Parasitic protozoans: life cycle, pathogenesis and diseases caused by - 5.1 Entamoeba histolytica 5.2 Plasmodium 5.3 Toxoplasma gondii	4
IV	6. Helminths: life cycle, pathogenesis and diseases caused by - 6.1 *Paragonimus westermani* *6.2 Trichinella spiralis* 7. Dynamics of Host-Parasite interaction: Evasive strategies	3 2

Texts / References	1. Smith, Animal Parasitology 1996. Cambridge University Press. 2. Chandler and Reid, Introduction to Parasitology 1970, Wiley. 3. Marr et al., Molecular Medical Parasitology 2003, Elsevier. 4. Ash and Orihel, Atlas of Human Parasitology. American Society for Clinical Pathology Press 5th edition, 2007. 5. Willey et al. Prescott's Microbiology, McGraw-Hill Higher Education, 9th edition, 2011
Learning Outcomes	• Students will learn about infectious agents, types of pathogens, pathogenicity, and infection. • Also, they will come to know about parasites and parasitism, vector, and zoonotic disease.

(not more than 100 words)	• They will be familiar with pathogenesis and diseases caused by protozoan and helminths.

Course Title	**ZOOMJ55: Lab. exercises based on course ZOOMJ51 & ZOOMJ52**
Category of Course	**Major** / ~~Minor / Minor (Vocational) / SEC / AEC / VAC / MD/Internship/Dissertation~~ (Tick any one of the above)

Credits & Hour of Teaching	Theory	Practical	Cumulative
Credits		2	2
Hour of Teaching (Total)		60	60

Course Objectives (not more than 100 words)	• To impart concepts and knowledge about the morphology, and anatomy of non-chordates through observations of real animals/preserved specimens/models. • To observe the diversity in animals making students understand about their distinguishing features. • To enhance the student's understanding of animal behavior through observations, analyses, and interpretation of several types of animal behavior. • To highlight the adaptive significance of the behavior to the organisms.
Course Content	The course content be divided into minimum 3 Units to maximum 5 units along with defined hour of teaching for each unit.

Units	Course Content	Hr. of Teaching
I	*Part A: Functional Anatomy of Non-chordates (Credit 1)* I. Protozoa to Pseudocoelomates 1. Protozoa: Culturing of *Paramecium* and *Euglena* and observation of their locomotion 2. Porifera 2.1 Study of canal systems (asconoid, syconoid, leuconoid) from prepared slides and models 2.2 Study of the following museum specimens:*Euplectella, Hyalonema, Cliona, Euspongia* 3. Cnidaria 3.1 Study of the following through prepared slides: T.S. of Hydra through ovary and testis, Scyphistoma and Ephyra. 3.2 Study of the following museum specimens: *Physalia, Porpita, Tubipora, Corallium, Gorgonia, Fungia, Millepora.* 4. Ctenophora: Study of the following museum specimens: *Hormiphora, Beroe* 5. Platyhelminthes: Study of the following from slides/specimen: *Dugesia, Polystomum, Schistosoma, Echinococcus, Fasciola, Taenia*, Miracidium, sporocyst, redia, cercaria, metacercaria, Hexacanth bladder worm 6. Nemathelminthes: Study of the following from slide/specimen: *Ascaris* (male and female)	15
II	II. Coelomates 7. Annelida 7.1 Leech 7.1.1 External features 7.1.2 Dissections: Digestive system 7.1.3 Mounting of jaws and salivary glands 7.2. *Nereis*: Permanent stained preparation of parapodium 7.3 Study of the following museum slides/specimens*: Nereis, Aphrodite, Arenicola, Sabella, Acanthobdella, Branchellion, Bonellia* 7.4 Trochophore Larva, T.S. of Leech through crop sac 8. Arthropoda 8.1 Study of the following museum specimens/slides: *Daphnia, Cypris, Cyclops (male and female), Lepas, Balanus, Cancer, Julus, Scolopendra*, Lepisma, Cricket, grasshopper, termite, *Apis*, wasp, butterfly, moth. 8.2 Study of the following larval forms from slides: Nauplius, Zoea and Megalopa. 9. Mollusca: Study of the following museum specimens: *Chiton, Cyprea,*	15

	Patella, Aplysia, Doris, Dentalium, Mytilus, Pecten *Teredo, Sepia, Loligo, Octopus.* 10. Echinodermata 10.1 *Asterias, Echinus, Holothuria, Cucumaria, Clypeaster* (cake urchin) 10.2 Study of the following larval forms from slides: Bipinnaria, Brachiolaria, Auricularia, Ophiopluteus and Echinopluteus.	
III	*Part B: Animal Behaviour (Credit 1)* ***1. Study of habitat selection in the first and third instar larvae of*** **Drosophila melanogaster.** ***2. Habituation in earthworms/mosquito larvae*** 3. Locomotor behaviour of dipteran larvae (Housefly/blowfly/fruit fly): 3.1. Locomotion on different types of substrata (writing paper, plastic sheet and sandpaper 3.2. Effects of light intensity and light quality on the rate of locomotion 4. Study of individual and social behavioural patterns of a troop of monkey 5. Study of interspecific association between cattle and egrets / mixed flock foraging in birds. 6. Study of circadian rhythm by measuring locomotor activity patterns in mice (demonstration). 7. Study of memory and learning in mice through maze-based experiments.	30

Texts / References	1. SS Lal: Practical Zoology- Invertebrates (12th ed., Rastogi Publications) 2. PS Verma: A manual of Practical Zoology-Invertebrates (11th ed., S Chand publications)
Learning Outcomes (not more than 100 words)	1. Students will get familiarized with the morphology and anatomy of representatives of various animal phyla. 2. Museum specimen studies will provide students a comprehensive idea of structural features of non-chordates and the basis of classification. 3. Students will have enhanced Understanding of the types of animal behavior and their importance to the organisms. 4. Students will be able to relate animal behavior with other subjects such as biodiversity, evolutionary biology, ecology, conservation biology and genetic basis of the behavior.

Course Title	**ZOOMJ56: Lab. exercises based on course ZOOMJ53 & ZOOMJ54**		
Category of Course	**Major** / ~~Minor / Minor (Vocational) / SEC / AEC / VAC / MD/Internship/Dissertation~~ (Tick any one of the above)		
Credits & Hour of Teaching		Theory	Practical	Cumulative
	Credits		2	2
	Hour of Teaching (Total)		60	60
Course Objectives (not more than 100 words)	(a) To provide a basic understanding about the use of mice for immunological experiments along with precautions being considered during their handling (b) To learn cell counting by hemocytometer (c) To identify immune cells on the basis of nuclear morphology (d) To learn the staining procedure of the protozoans and helminth parasites		
Course Content	The course content be divided into minimum 3 Units to maximum 5 units along with defined hour of teaching for each unit.		
Units	**Course Content**		**Hr. of Teaching**
I	1. An introduction and acquaintance with necessary precautions in immunological practical and proper handling of the mice. 2. Study of different lymphoid organs, counting and fix the cell number for particular experiments.		10
II	1. To perform retro-orbital bleeding with the help of capillary tubes and preparation of blood film for differential cell count. 2. Separation of peritoneal macrophages and their identification on the basis of non specific esterase staining.		10
III	1. Enumeration of apoptotic cells by trypan blue exclusion test. 2. To study antigen-antibody interaction with the help of Mancini/Ouchterlony method Immunodiffusion).		10
IV	1. Introduction on collection and preservation of specimens, quality control and safety measures. 2. Staining procedure for protozoans and helminth parasites. 3. Study of bacteria by Gram stain. 4. Preparation of thin blood smear: total and differential counting. 5. Identification of protozoan parasites from permanent slides. *Trypanosoma*: epimastigote or trypomastigote form. *Leishmania*: promastigote and amastigote form. *Plasmodium*: sporozoites and signet ring. *Toxoplasma*: tachyzoites and bradyzoites. *Giardia* *Entamoeba:* trophozoites 6. Identification and characterization of helminth parasites from permanent slides Cercaria of *Fasciola.* Eggs of *Schistosoma.* Cyst of *Echinococcusgranulosus.* Microfilarie of *Wuchereria.* 7. Parasite culture (demonstration only)		30
Learning Outcomes (not more than 100 words)	After studying the course, the student will: (a) Learn about mice handling (b) Able to identify and locate primary and secondary lymphoid organs (c) Learn the methods for the isolation and characterization of immune cells, including macrophages (d) Able to perform TC/DC in blood		

<table>
<tr><td>Course Title</td><td colspan="3">ZOOIN57: Internship</td></tr>
<tr><td>Category of Course</td><td colspan="3">Major / ~~Minor / Minor (Vocational) / SEC / AEC / VAC / MD/~~Internship~~/Dissertation~~
(Tick any one of the above)</td></tr>
<tr><td>Credits & Hour of Teaching</td><td colspan="3"><table>
<tr><td></td><td>Theory</td><td>Practical</td><td>Cumulative</td></tr>
<tr><td>Credits</td><td></td><td>2</td><td>2</td></tr>
<tr><td>Hour of Teaching (Total)</td><td></td><td>2 weeks</td><td>2 weeks</td></tr>
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<tr><td>Course Objectives (not more than 100 words)</td><td colspan="3">(a) To provide opportunity for career exploration and to learn new skills in industry/organization/research labs with faculty and researchers in their own or other curriculum.
(b) To provide opportunity to utilize their learned skills in the class room into practice and to enhance their skills in the research environment/field work and benefit from the Mentor/Supervisor and developing a learning network.</td></tr>
<tr><td>Course Content</td><td colspan="3">The course content be divided into minimum 3 Units to maximum 5 units along with defined hour of teaching for each unit.</td></tr>
<tr><td>Units</td><td>Course Content</td><td>Hr. of Teaching</td></tr>
<tr><td>I</td><td>Visit to a research lab/industry related to the curriculum and submission of a report.</td><td>2 weeks</td></tr>
<tr><td>Learning Outcomes (not more than 100 words)</td><td colspan="3">(a) Learn to apply theoretical knowledge into research work/field work in a research lab or industry.
(b) Learn to prepare a scientific report.
(c) Learn to develop/use a method to study an objective and enhance their skill to interact with fellow members/Mentor.</td></tr>
</table>

Course Title	**ZOOMV51: Aquaculture**
Category of Course	~~Major / Minor /~~ **Minor (Vocational)** ~~/ SEC / AEC / VAC / MD/Internship/Dissertation~~ (Tick any one of the above)

Credits & Hour of Teaching	Theory	Practical	Cumulative
Credits	3		3
Hour of Teaching (Total)	45		45

Course Objectives (not more than 100 words)	• Demonstrate the types and practices of aquaculture. • Understand the physicochemical requirements of aquaculture systems. • Learn the nutritional needs of species and their disease management. • Gain knowledge of advanced omics approaches in aquaculture. • Comprehend the socio-economic status of fish farmers.
Course Content	The course content is divided into minimum 3 Units to maximum 5 units along with defined hours of teaching for each unit.

Units	Course Content	Hr. of Teaching
I	1. Overview of aquaculture 1.1 Scope and definition 1.2 Introduction to finfish and shellfish 1.3 Aquaculture systems and methods 2. Water quality and aquatic health 2.1 Physicochemical conditions of pond water 2.2 Causes and effects of water pollution	**10**
II	3. Freshwater Aquaculture 3.1 Fish culture 3.1.1 Carp culture 3.1.2 Ornamental fish culture 3.2 Prawn culture 3.3 Pearl culture 3.4 Integrated fish farming	**10**
III	4. Fish Feed formulation and nutrition 4.1 Supplementary 4.2 Medicinal 4.3 Artificial 5. Fish disease and management 5.1 Microbial 5.2 Parasitic 5.3 Nutritional deficiency	**7**
IV	6. Fish by-products 6.1 Pharmaceuticals 6.2 Enzymatic and biomolecular materials 6.3 Commercial products 7. Preservation methods in aquaculture	**6**
V	8. Aquaculture biotechnology 8.1 Genetic applications in aquaculture 8.2 Cryopreservation of gametes 8.3 Fish genetic resource and conservation 9. Omics approach in fisheries and aquaculture 10. Aquaculture economics in India 10.1 Commerce and trading in aquaculture 10.2 Socio-economic condition of fish farmers in India	**12**

Texts / References	1. Khanna and Singh, Textbook of Fish Biology and Fisheries (2015, Narendra Publishing House) 2. Gopakumar, Singh and Chitranshi, Fifty Years of Fisheries Research in India (2000, Fisheries Division, Indian Council of Agricultural Research) 3. Jhingran, Fish and Fisheries of India (1985, Hindustan Publishing Corporation) 4. Pillay, Aquaculture: Principles and Practices: Fishing News Books (2005, First Indian reprint) 5. Smith, Fish Diseases and Medicine (2019, CRC Press) 6. Mohanty, Advances in Fish Research Vol VII (2019, Narendra Publishing House)

Learning Outcomes (not more than 100 words)	1. Students will learn about different types of aquaculture systems. 2. The importance of physicochemical requirements in aquaculture will be understood. 3. They will become familiar with the nutritional needs of species and approaches to disease management. 4. The advantages of the omics approach in aquaculture will be explored. 5. Awareness of the current socio-economic conditions of fish farmers will be gained.
Course Title	**ZOOMV52: Lab. Exercises based on course ZOOMV51**
Category of Course	Major / Minor / Minor (Vocational) / SEC / AEC / VAC / MD/Internship/Dissertation (Tick any one of the above)

Credits & Hour of Teaching

	Theory	Practical	Cumulative
Credits		1	1
Hour of Teaching (Total)		30	30

Course Objectives (not more than 100 words)	• To learn about commercially important aquatic species. • To gain knowledge of different types of culture methods and fishing gear. • To learn effective water quality management practices for aquaculture.
Course Content	The course content is divided into minimum 3 Units to maximum 5 units along with defined hour of teaching for each unit.

Units	**Course Content**	**Hr. of Teaching**
I	Survey of fish market and identification of locally available fishes of economic importance	7
II	Seasonal analysis of pond water by measuring the following physico-chemical properties: i. Dissolved CO_2 content ii. O_2 content	8
III	Study of fishing nets	3
IV	Determination of protein content in a fresh and preserved fish	7
IV	Visit to fish farm and hatchery	5

Texts / References	1.Khanna and Singh, Textbook of Fish Biology and Fisheries (2015, Narendra Publishing House) 2. Gopakumar, Singh and Chitranshi, Fifty Years of Fisheries Research in India (2000, Fisheries Division, Indian Council of Agricultural Research) 3. Jhingran, Fish and Fisheries of India (1985, Hindustan Publishing Corporation) 4. Pillay, Aquaculture: Principles and Practices: Fishing News Books (2005, First Indian reprint) 5. Smith, Fish Diseases and Medicine (2019, CRC Press) 6. Mohanty, Advances in Fish Research Vol VII (2019, Narendra Publishing House)
Learning Outcomes (not more than 100 words)	Students will be able to understand 1. Commercially important cultivable finfish and shellfish species. 2. Arrangement of different types of ponds and design of an ideal fish farm. 3. The analysis of water quality of a culture pond

Course Title	**ZOOMJ61: Functional Anatomy of Chordates**
Category of Course	**Major** / ~~Minor / Minor (Vocational) / SEC / AEC / VAC / MD/Internship/Dissertation~~ (Tick any one of the above)

Credits & Hour of Teaching		Theory	Practical	Cumulative
	Credits	3		3
	Hour of Teaching (Total)	45		45

Course Objectives (not more than 100 words)	• To comprehend the comparative structures among chordates together with a discussion of the function and evolution of different animal physiological systems. • To provide vertebrate morphology as an integrative discipline bringing together physiology, embryology, behavior, and ecology deploying methods of systematics and paleontology.
Course Content	The course content be divided into minimum 3 Units to maximum 5 units along with defined hour of teaching for each unit.

Units	Course Content	Hr. of Teaching
I	1. Origin of vertebrates 1.1 Fish 1.2 Amphibia 1.3 Reptilia 1.4 Aves 1.5 Mammalia	5
II	2. Integument and its derivatives 2.1 Structure of integument 2.2 Scales, feathers, hair, claws, nails, hoofs, horns, antlers, glands 3. Endoskeleton 3.1 General plan of neurocranium and dermatocranium. 3.2 Jaw suspensorium 3.3 Vertebrae	3 3
III	4. Digestive system 4.1 Modifications in the alimentary canal in relation to feeding habits: length and surface area, internal folds and supplementary diverticulae, ruminants' stomach 4.2 Dentition in mammals 5. Respiratory system 5.1 Aquatic respiration 5.1.1 Cutaneous 5.1.2 Branchial 5.2. Aerial respiration 5.2.1 Accessory respiratory organs in fish 5.2.2 Air-sacs in birds 5.2.3 Lungs	5 6
IV	6. Circulatory system 6.1 Aortic arches 6.2 Portal systems 6.3 Lymphatic system 7. Nervous system 7.1Evolution of the brain (cerebral hemispheres and cerebellum) 7.2 Neuromast organs of lower vertebrates	5 5
V	8. Urinogenital system 8.1 Excretory system 8.1.1 Types and evolution of kidney tubules 8.1.2 Urinary duct and bladder 8.2. Reproductive system 8.2.1 General plan of gonads and urinogenital ducts 8.2.2 Types of uteri	7

Texts / References	1.Kardong: Vertebrates: Comparative Anatomy, Function, Evolution (Recent edition, Mcgraw Hill Education) 2. Kent: Comparative Anatomy of the Vertebrates (Recent edition, Mcgraw Hill Education) 3. Romer & Parsons: The vertebrate Body (6th ed. 1986, Saunders) 4. Jordan and Verma: Chordate Zoology (S. Chand & Company Pvt. Ltd.)

Learning Outcomes (not more than 100 words)	1. The students can directly engage in the discovery of vertebrate form which includes various controversies in concepts that support them in understanding the scientific process. 2. A comprehensive comparative study of morphology, function, and evolution will help students to develop skills in critical thinking and mastery of concepts.

Course Title	**ZOOMJ62: Environmental Biology**
Category of Course	**Major** ~~/ Minor / Minor (Vocational) / SEC / AEC / VAC / MD/Internship/Dissertation~~ (Tick any one of the above)

Credits & Hour of Teaching	Theory	Practical	Cumulative
Credits	3		3
Hour of Teaching (Total)	45		45

Course Objectives (not more than 100 words)	• To understand about the living environment and the relationship between biological organisms and their environment • To study the interactions between humans and the natural environment and address the various environmental challenges, such as climate change, deforestation, air and water pollution, and biodiversity loss
Course Content	The course content be divided into minimum 3 Units to maximum 5 units along with defined hour of teaching for each unit.

Units	Course Content	Hr. of Teaching
I	1. Introduction to environmental biology 1.1 Major ecosystems of the world-t*undra*, *taiga*, temperate deciduous forest, tropical rain forest, *savannah*, grassland and desert with adaptations in flora and fauna 2. Trophic relationship 2.1. Ecological pyramids 2.2. Food chain and Food web	10
II	3. Ecosystem energetics 3.1. Energy flow in ecosystem 3.2. Productivity 4. Population and communities 4.1. Population characteristics: density, natality, mortality and growth curve 4.2. Nature, structure and attributes of biological communities 4.3. Community dynamics: ecological succession, ecotone, edge effect 4.4. Positive and negative interactions	15
III	5. Global environmental changes 5.1. Sources and impact of environmental pollution – air, water and soil 5.2. Green house gases and their effects 5.3. Solid waste management 6. Conservation biology 6.1. Biodiversity: benefits, hotspots, threats and conservation 6.2. Soil and water resources and their conservation 6.3. Introduction to environmental laws and ethics	20

Texts / References	1. Reece et al. (2011): Campbell biology (9th ed.,Pearson, New York) 2. Cunningham and Cunningham (2003): Environmental science (Tata McGraw Hill Publishing Company Limited, New Delhi.) 3. Enger and Smith (2000): Environmental Science (7th ed., McGraw-Hill Higher Education, London) 4. Odum and Barrett (2005): Fundamental of Ecology, Thomson Brooks/Cole, USA 5. Primack (2004): A Primer of Conservation Biology (3rd ed., Sinauer Associates, USA) 6. J. S. Singh (2014): Ecology, Environmental Science and Conservation 7. P. D. Sharma (2007): Ecology and Environment
Learning Outcomes (not more than 100 words)	1. Studying environment biology not only enables students to learn a great deal of environment-related basic knowledge but also can foster a feeling toward the environment and develop skills needed to protect the environment 2. Environmental studies will provide you with the scientific knowledge and tools to measure, monitor, and model the environmental systems and processes, and to assess and mitigate the environmental impacts and risks of human activities and systems.

Course Title	**ZOOMJ63: Cell Biology**
Category of Course	**Major** ~~/ Minor / Minor (Vocational) / SEC / AEC / VAC / MD/Internship/Dissertation~~ (Tick any one of the above)

Credits &Hours of Teaching		Theory	Practical	Cumulative
	Credits	3		3
	Hour of Teaching (Total)	45		45

Course Objectives (not more than 100 words)	• The course aims to provide an in-depth understanding of the organization of eukaryotic cells, principles of membrane transport, functions of different types of transporter proteins, and detailed processes associated with its functions like membrane transport, intracellular transport, signaling mechanisms, and cell reproduction. • Students will learn about the various cellular organizations, mitochondrial organization, cellular bioenergetics, and the structural organization of the cytoskeleton.
Course Content	The course content be divided into minimum 3 Units to maximum 5 units along with defined hour of teaching for each unit.

Units	Course Content	Hr. of Teaching
I	• Eukaryotic Cell 1.1 Membrane Transport 1.1.1 Principles of membrane transport 1.1.2 Types of carrier proteins, channel proteins, and their regulation 1.1.3 Physiological importance of symporters and antiporters (Glucose transport, pH maintenance) 1.1.4 Types of transporters: P-type, F-type, V-type, ABC transporters 1.1.5 Gated channels 1.1.6 Selectively across Ion channels: K^+, Na^+ channels and Aquaporins 1.1.7 Endocytic-exocytic cycle 1.2 Intracellular transport and protein sorting 1.2.1 Types of signal sequences and their role in protein targeting 1.2.2 Passage of proteins through endoplasmic reticulum and membrane topology 1.2.3 Post-translational processing of protein in Endoplasmic reticulum and its significance 1.2.3 Processing and sorting of proteins in Golgi apparatus 1.2.4 Nuclear transport 1.2.5 Mitochondrial transport: TIM23 complex, SAM complex	7 8
II	2. Mitochondria and energy transfer 2.1 Organization of mitochondrial genome 2.2 Fission and Fusion 2.3 Proton pumps of Electron transport chain 2.4 Electrochemical gradient and bioenergetics	4
III	3. Cellular organization 3.1 Cytoskeleton 3.1.1 Structural organization of microfilaments and microtubules: Tread milling and Dynamic instability, actin-binding proteins and motor proteins. 3.1.2 Importance of Intermediate filaments: Keratin, Lamins, Desmin 3.1.3 Microtubular organelles 3.2 Cell-cell interactions 3.2.1 Types of Cell junctions 3.2.2 Properties of Cell adhesion and extracellular matrix 3.3 Cell signaling 3.3.1 Receptors: G-coupled receptors, RTK receptors, Nuclear receptors 3.3.2 Second messenger: cAMP and protein kinases 3.3.3 Overview of major signaling pathways	5 3 5

IV	4. Cell Reproduction 4.1 Cell Division 4.1.1 Experimental evidence of cell cycle events 4.1.2 M-phase: Biorientation, Chromosome movement, Regulation of Mitosis and Cytokinesis 4.1.3 Oncogenes and tumor suppressor genes 4.1.4 Cell transformation: Viral Transformation, Clonal expansion, angiogenesis and Metastasis 4.2 Apoptosis and cell death 4.2.1 Intrinsic and Extrinsic pathway 4.2.2 Bcl2 family	8 3
V	5. Interphase nucleus 5.1 Organization of interphase nucleus: Chromosome domains and territories, 3-C 5.2 Heterochromatin: HP1, Concept of boundary elements 5.3 Histones modifications and associated gene regulation 5.4 Centromere and telomere	5

Recommended Books	1. Alberts et al, Molecular Biology of the Cell (7th Edition, Garland) 2. Karp: Cell and Molecular Biology (9th Edition, John Wiley) 3. Lodish et al: Molecular Cell Biology (9th Edition, Freeman) 4. Plopper et al, Lewin's Cells (3rd Edition, Jones and Bartlett)
Learning Outcomes (not more than 100 words)	1. Upon completing the course, students will have a comprehensive understanding of eukaryotic cells, detailed structures, and the various biological processes associated with eukaryotic cells. 2. Students will be proficient in analyzing and explaining the various processes involved in these cellular functions. 3. Students will be equipped with the necessary skills and insights to comprehend the complexities of eukaryotic cell biology and its significance in the broader field of life sciences.

Course Title	**ZOOMJ65: Lab. exercises based on course ZOOMJ61 & ZOOMJ62**
Category of Course	**Major** / ~~Minor / Minor (Vocational) / SEC / AEC / VAC / MD/Internship/Dissertation~~ (Tick any one of the above)

Credits & Hour of Teaching

	Theory	Practical	Cumulative
Credits		2	2
Hour of Teaching (Total)		60	60

Course Objectives (not more than 100 words)

Functional Anatomy of Chordates

- To understand the comparative structures among chordates together with a discussion of function and evolution of different animal physiological systems through dissections, models and museum specimens.
- To develop skills of dissection and basic laboratory work.

Environmental Biology

- To understand, analyze, and solve environmental problems using scientific methods and ethical principles

Course Content

The course content be divided into minimum 3 Units to maximum 5 units along with defined hour of teaching for each unit.

Units	Course Content	Hr. of Teaching
I	*PART-A: Functional Anatomy of Chordates (Credit 1)* 1. Lower chordates 1.1. Amphioxus 1.1.1 External features 1.1.2 Mounting of the oral hood, velum and pharyngeal wall 1.1.3 Study of the following slides: T.S. through oral hood, midgut diverticulum, pharyngeal region, gonads and post-oral region of the intestine 1.2 Study of the following permanent slides/specimens: *Pyrosoma, Salpa, Doliolum* 2. Vertebrates 2.1 Integument and its derivatives 2.1.1 Mounting of cycloid and ctenoid scales 2.1.2 Mounting of chromatophores of fish 2.1.3 Study of different types of feathers: Contour, filoplume and down feathers 2.2 General anatomy 2.2.1 Vascular system 2.2.1.1 Heart and afferent and efferent branchial vessels of *Mystus*/ *Cirrhinus sp.* 2.2.1.2 Arterial and venous systems of rat 2.2.2 Respiratory system: Accessory respiratory organs of *Heteropneustes/ Channa/Clarius*	15

II	3. Histology: Study of permanent slides of the following tissues and organs of mammals- Tooth, tongue, oesophagus, stomach, intestine, pancreas, liver, spleen, kidney, cartilage, bone 4. Classification and distinctive features of the following 4.1 Cyclostomata: *Petromyzon, Myxine* 4.2 Chondrichthyes: *Scoliodon, Sphyrna, Torpedo, Pristis* 4.3 Osteichthyes: *Protopterus, Exocetus, Hippocampus, Syngnathus, Tetradon, Diodon, Amia, Anabas, Ophiocephalus, Clarias, Heteropneustes, Catla, Labeo,* 4.4 Amphibia: *Ichthyophis, Axolotl larva, Amphiuma*,Proteus, *Pipa,* Rhacophorais, Hyla 4.5 Reptilia: Turtle, *Chameleon, Draco, Uromastix, Varanus, Calotes, Iguana, Mabuya, X Natrix, Naja, Vipera, Alligator* 4.6 Aves: *Apterys, Struthio, Aptenodytes, Francolinus, Tytoalba, Dinopium, Milvus, Corvus, Pavo, Eudynamys, Passer, Psittacula, Anas, Grus* 4.7 Mammalia: *Ornithqorhynchus, Tachyglossus, Macropus, Manis, Erinaceus, Pteropus, Lemur, Loris, Bradypus, Phoca, Lutra, Equus cabalus, Camelus, Capra, Bos*	15
III	*PART-B: Environmental Biology (Credit 1)* 1. Estimation of grasshopper population density by capture-recapture method 2. Estimation of percent frequency, abundance and dominance of producers in grassland by quadrat sampling method 3. Estimation of percent frequency, abundance and dominance of consumers in grassland by quadrat sampling method	15
IV	4. Determination of total hardness of water sample 5. Determination of pH of different water samples by using pH meter. 6. Determination of carbonate and nitrate in soil samples 7. Determination of free CO_2in different samples of pond water	15

Texts / References	*Functional Anatomy of Chordates* 1. Lal: Practical Zoology- Vertebrates (12th ed., Rastogi Publications) 2. Verma: A manual of Practical Zoology-Chordates (11th ed., S Chand publications) *Environmental Biology* 1. Reece et al. (2011): Campbell biology (9th ed.,Pearson, New York) 2. Cunningham and Cunningham (2003): Environmental science (Tata McGraw Hill Publishing Company Limited, New Delhi.) 3. Enger and Smith (2000): Environmental Science (7th ed., McGraw-Hill Higher Education, London) 4. Odum and Barrett (2005): Fundamental of Ecology, Thomson Brooks/Cole, USA 5. Primack (2004): A Primer of Conservation Biology (3rd ed., Sinauer Associates, USA) 6. J. S. Singh (2014): Ecology, Environmental Science and Conservation 7. P. D. Sharma (2007): Ecology and Environment
Learning Outcomes (not more than 100 words)	1. Students will gain familiarity with the anatomy of representative animals. 2. They will understand organ function, evolution, and the placement of organisms within a phylogenetic context. 3. Students will acquire scientific knowledge and tools to measure, monitor, and model environmental systems, assess impacts, and mitigate the risks of human activities.

Course Title	**ZOOMJ66: Lab. exercises based on course ZOOMJ63 & ZOOMJ64**
Category of Course	**Major** / ~~Minor / Minor (Vocational) / SEC / AEC / VAC / MD/Internship/Dissertation~~ (Tick any one of the above)

Credits & Hour of Teaching

	Theory	Practical	Cumulative
Credits-Section B		2	2
Hour of Teaching (Total)		60	60

Course Objectives (not more than 100 words)

- Equip students with hands-on experience in advanced microscopy techniques, including phase contrast, fluorescence, confocal, and electron microscopy.
- Develop proficiency in cell biology practices, such as tissue culture, chromosome analysis, and DNA visualization techniques.
- Enable students to perform essential mammalian physiology procedures, including blood cell counting, hemoglobin determination, and blood pressure measurement.

Course Content: The course content be divided into minimum 3 Units to maximum 5 units along with defined hour of teaching for each unit.

Units	Course Content	Hr. of Teaching
I	*PART-A: Cell Biology (Credit 1)* 1. Use of phase contrast optics by observing the live sperm/paramecium in physiological saline 2. Demonstration of the use of fluorescence microscope (DNA and RNA fluorescence) and familiarity with confocal microscope 3. Familiarity with scanning and transmission electron microscopes (photograph and visit the Department of Metallurgy) 4. Familiarity with tissue culture (visit plant and animal tissue culture labs.) Use of colchicine in arresting anaphase movement (onion root tips) 6. Visualization heterochromatin zed sex chromatin through Barr body 7. Demonstration of chromatin distribution using DAPI staining. 8. Metaphase chromosome preparations from the bone marrow of mouse/rat 9. Meiosis in grass hopper testis 10. Study of permanent slides to understand the following: 10.1. Constitutive heterochromatin(C-band) 10.2. Semiconservative DNA replication (BrdU-labelling) 10.3. Detection of S-phase cells in a random population (autoradiography) 10.4. Transcription in polytene chromosome puffs (autoradiography) 10.5. Chromosome organization (G-banding) 10.6. Premature chromosome condensation 10.7. Actin remodeling in migrating tumor cells 10.8. Prediction of telomere length through FISH.	30
II	*PART-B: Mammalian Physiology (Credit 1)* 1. Counting of red blood corpuscles 2. Counting of white blood corpuscles 3. Determination of hemoglobin content 4. Determination of blood groups 5. Measurement of blood pressure using sphygmomanometer 6. Preparation of casein from milk	30

Texts / References

Learning Outcomes (not more than 100 words)

1. Students will develop the ability to analyze cellular processes through advanced microscopy and experimental techniques, enhancing their understanding of chromosomal and molecular biology.
2. They will gain hands-on experience in essential physiological procedures, enabling them to accurately assess and interpret key mammalian biological functions.

Course Title	**ZOOMV61: Clinical Biochemistry**
Category of Course	~~Major / Minor~~ / **Minor (Vocational)** ~~/ SEC / AEC / VAC / MD/Internship/Dissertation~~ (Tick any one of the above)

Credits & Hour of Teaching	Theory	Practical	Cumulative
Credits	3		3
Hour of Teaching (Total)	45		45

Course Objectives (not more than 100 words)	• Equip students with an understanding of the biochemical basis of various diseases, including enzyme and protein deficiency disorders, and related diagnostic and treatment strategies. • Develop knowledge of the chemistry, composition, and functions of bodily fluids, along with common biomarkers of organ functions. • Provide insights into the mechanisms of drug action, including biotransformation, drug delivery, and the impact of addiction.
Course Content	The course content be divided into minimum 3 Units to maximum 5 units along with defined hour of teaching for each unit.

Units	Course Content	Hr. of Teaching
I	1. Biochemical basis of diseases/disorders, diagnosis and treatment 1.1. Molecular deficiency disorders 1.1.1 Disorders of enzyme deficiency 1.1.2 Disorders of protein deficiency/defects 1.2. Storage and transport associated disorders Biochemistry of Diabetes and Obesity 1.3. Biochemical changes in pregnancy & lactation	10
II	2. Chemistry, composition & functions 2.1 Blood 2.2 Lymph 2.3 CSF 2.4 Ascitic fluid 2.5 Pleural fluid 2.6. Lipid profile	10
III	3. Common biomarkers of organ functions 3.1 Liver 3.2 Kidney 3.3 Thyroid 3.4 Heart	10
IV	4. Immunity and human health 4.1 Autoimmunity 4.2 Immunodeficiency 4.3 Cancer 4.4 Septicemia 4.5 Transplantation	8
V	5. Drugaction 5.1 Mechanisms 5.2 Drug addiction 5.3 Biotransformation of drugs 5.4 Drug delivery, targeting and clinical trials	7

Texts / References	1. Bhagvan: Medical Biochemistry (4th Ed.), Hap, 2004 2. Goodman et al.: The Pharmacological Basis of Therapeutics (7th Ed.), Macmillan Publishers, 1991
Learning Outcomes (not more than 100 words)	Students will develop the ability to i. Learn how biochemical imbalances and abnormalities lead to various diseases. ii. Interpret laboratory results and make informed clinical decisions. iii. A comprehensive understanding of the biochemical basis of human health and disease. iv. Apply biochemical principles to interpret laboratory test results. v. Perform common clinical biochemistry laboratory techniques and procedures. vi. Analyze and interpret biochemical data to make informed clinical decisions.

Course Title	**ZOOMV62: Lab. Exercises based on course ZOOMV61**
Category of Course	~~Major / Minor /~~ **Minor (Vocational)** ~~/ SEC / AEC / VAC / MD/Internship/Dissertation~~ (Tick any one of the above)

Credits & Hour of Teaching	Theory	Practical	Cumulative
Credits		1	1
Hour of Teaching (Total)		30	30

Course Objectives (not more than 100 words)	• Train students in the proper techniques for specimen collection, handling, and storage to ensure accurate biochemical analysis. • Develop proficiency in the estimation of key enzyme activities, including LDH, AST, ALT, and alkaline phosphatase. • Equip students with the skills to measure and interpret serum lipid profiles, glucose, and urea levels.
Course Content	The course content be divided into minimum 3 Units to maximum 5 units along with defined hour of teaching for each unit.

Units	Course Content	Hr. of Teaching
I	1. Specimen collection, handling & storage of sample. 2. Estimation of total activity of following enzymes. i) LDH ii) AST (GOT) iii) ALT (GPT) iv) Alkaline phosphatase 3. Estimation of serum lipid profile i) Serum total cholesterol. ii) Serum HDL cholesterol. 4. Estimations i) Glucose ii) Urea	30

Texts / References	1. Bhagvan: Medical Biochemistry (4th Ed.), Hap, 2004 2. Goodman et al.: The Pharmacological Basis of Therapeutics (7th Ed.), Macmillan Publishers, 1991
Learning Outcomes (not more than 100 words)	• Students will be able to apply best practices in laboratory settings for the preservation of sample integrity during collection and storage. • They will accurately perform and analyze enzyme assays, demonstrating competence in quantifying enzyme activities in clinical samples. • Students will interpret lipid profile data, identifying potential health risks associated with abnormal cholesterol levels. • They will develop critical thinking skills by analyzing glucose and urea levels, drawing correlations to metabolic and renal health.
Course Title	**ZOOMJ71: Biochemistry and Molecular Biology**
Category of Course	**Major** / ~~Minor / Minor (Vocational) / SEC / AEC / VAC / MD/Internship/Dissertation~~ (Tick any one of the above)

Credits & Hour of Teaching	Theory	Practical	Cumulative
Credits	3		3
Hour of Teaching (Total)	45		45

Course Objectives (not more than 100 words)	• The course covers various fundamental and advanced topics in genetics. • The course aims to provide students with a comprehensive understanding of the principles and mechanisms of genetics. • Students will learn how genes are mapped to chromosomes and study various tools to understand their regulation and function. • This course will also assist towards understanding of biological processes like transposition, genetic determination of sex, DNA recombination, damage and repair. • The course starts by exploring genetics in bacteria and progresses to the mammalian genome.
Course Content	The course content be divided into minimum 3 Units to maximum 5 units along with defined hour of teaching for each unit.

Units	Course Content	Hr. of Teaching	
I	1. Proteins: Composition and organization 1.1 Amino acids: Ionization, titration curve, pK and pI 1.2 N-terminal analysis: Sanger and Edman's reactions 1.3 Higher order organization 2. Enzymes 2.1 Kinetics (determination of Km and Vmax using Michaelis-Menten and Lineweaver-Burk plots) 2.2 Acid-base and covalent catalysis 2.3 Concept of regulation of enzyme activity 2.3.1 Inhibition 2.3.2 Allosteric regulation 2.3.3 Role of covalent modifications 2.4 Ribozymes and concept of abzymes	5 7	
II	3. Carbohydrates 3.1. Polysaccharides 3.1.1 Homopolymers 3.1.2 Heteropolymers (peptidoglycans and glycosaminoglycans) 3.2. Catabolism of carbohydrates and ATP production 3.2.1 Glycolysis 3.2.2 Krebs cycle 3.2.3 Electron transport chain and ATP synthesis 4. Lipids: Structural and functional significance 4.1 Triglycerides 4.2 Phospholipids 4.3 Sphingolipids 4.4 Cholesterol	7 3	
III	5. Nucleic acids 5.1 Conformation of DNA (A, B and Z) 5.2 Hoogsteen base pairing-Guanine quadruplex 5.3 Structure of nucleosomes 5.4 Mechanism of DNA replication 5.5 Transcription 5.5.1 Basic mechanism (prokaryotic model) 5.5.2 Transcription initiation complex in eukaryotes 5.5.3 Processing of RNA Pol II Transcript 5.5.4 Mechanism of translation	12	
IV	6. Recombinant DNA and Proteins 6.1 Tools: Restriction enzymes, vectors 6.2 Construction of recombinant DNA 6.3 Production of recombinant protein 6.4 Genome editing	4	

Texts / References	1. Lehninger, Nelson & Cox: Principles of Biochemistry (4th ed, 2007, Worth), 2. Berg, Tymoczko, Stryer; Biochemistry (7th ed. 2012, Freeman)
Learning Outcomes (not more than 100 words)	1. Students will have a sound understanding of the biochemical processes that underpin biological functions at a molecular level and effectively communicate scientific findings relevant to biomolecules ensuring clarity and accuracy. 2. Students will develop the capability to understand biomolecule types, analyze structure-function relationships, interpret biological interactions, describe metabolic pathways, apply laboratory techniques, solve biochemical problems, and communicate scientific ideas.

Course Title	**ZOOMJ72: Molecular Genetics**
Category of Course	**Major** / ~~Minor / Minor (Vocational) / SEC / AEC / VAC / MD/Internship/Dissertation~~ (Tick any one of the above)

Credits & Hour of Teaching	Theory	Practical	Cumulative
Credits	3		3
Hour of Teaching (Total)	45		45

Course Objectives (not more than 100 words)	• The course covers various fundamental and advanced topics in genetics. • The course aims to provide students with a comprehensive understanding of the principles and mechanisms of genetics. • Students will learn how genes are mapped to chromosomes and study various tools to understand their regulation and function. • This course will also assist towards understanding of biological processes like transposition, genetic determination of sex, DNA recombination, damage and repair. • The course starts by exploring genetics in bacteria and progresses to the mammalian genome.
Course Content	The course content be divided into minimum 3 Units to maximum 5 units along with defined hour of teaching for each unit.

Units	Course Content	Hr. of Teaching
I	1. Gene mapping 1.1 Conjugation, transduction and transformation in Bacteria 1.2 Tetrad Analysis in *Neurospora* 1.3 Three-point test cross in *Drosophila* 1.4 Introduction to physical mapping in human 2. Gene expression and gene regulation 2.1 Inducible (*lac)* and repressible (*trp*) operons in *E. coli* 2.2 Regulation of gene activity in eukaryotes 2.2.1 Transcription unit 2.2.2 Initiation of transcription 2.2.3 Transcription factors: repressors, activators 2.2.4 Enhancers and silencers 2.2.5 Concept of epigenetic regulation	6 9
II	3. Transposable elements 3.1 Discovery of transposable elements 3.2 Prokaryotic and eukaryotic elements 3.3 Retroposons 3.4 Mechanisms of transposition 4. Organization of the Human Genome 4.1 Human Genome Project 4.2 Nuclear and Mitochondrial Genome 4.3 Gene families 4.4 LINE& SINE elements 4.5 Single Nucleotide Polymorphism 5. Genetic determination of sex 5.1 Drosophila 5.2 Human	6 6 3
III	6. DNA recombination 6.1 Homologous and non-homologous recombination 6.2 Site-specific recombination 7. DNA damage and repair 7.1 Endogenous and exogenous origin of DNA damage 7.2 Major repair pathways: BER, NER, mismatch repair, NEJ and DSB 8. Human genetic disorders 8.1 Metabolic: Phenylketonuria 8.2 Triplet repeat expansion: Huntington 8.3 Multifactorial: Diabetes mellitus	4 8 3

Texts / References	1. Snustad and Simmons: Principles of Genetics (2019, 7th ed. John Wiley) 2. Pierce: Genetics - A conceptual approach (2012, Freeman) 3. Watson et al.: Molecular biology of the gene (7th ed 2017)

	4. Gardner et al: Principles of Genetics (2006, John Wiley) 5. Griffith et al: An Introduction to Genetic Analysis (Freeman, 2008) 6. Russell: Genetics (2010, Benjamin Cummings) 7. Genome: The Autobiography of a species in 23 chapters: Matt Ridley 2017. Harper Collins
Learning Outcomes (not more than 100 words)	1. Upon successfully completing the ZOB 603 Genetics course, students can understand how the chromosome maps are prepared. 2. They will also learn about the significance of mutations, aiding their understanding of gene regulation and function. 3. This course will provide a foundational understanding of genetics, which is essential for grasping advanced genetic concepts, and will open up several avenues for students in terms of research and employability.

Course Title	**ZOOMJ73: Molecular Endocrinology**
Category of Course	**Major /** ~~Minor / Minor (Vocational) / SEC / AEC / VAC / MD/Internship/Dissertation~~ (Tick any one of the above)

Credits & Hour of Teaching	Theory	Practical	Cumulative
Credits	3		3
Hour of Teaching (Total)	45		45

Course Objectives (not more than 100 words)	• To explain the mechanisms of action of protein and steroid hormones, including signaling pathways and genomic/nongenomic effects. • To understand the organization and functions of the hypothalamo-hypophysial system, including the roles of hypophysiotropic, adenohypophysial, and neurohypophysial hormones. • To explore the epiphysial system, focusing on the pineal gland, biological rhythms, and melatonin's role in photoperiodic measurement. • To describe steroid hormone biosynthesis pathways. • To examine the structure and physiological roles of androgens, estrogen, progesterone, inhibin, mineralocorticoids, glucocorticoids, and catecholamines. • To analyze the regulation and functions of parathormone, calcitonin, vitamin D, insulin, and glucagon in homeostasis.
Course Content	The course content be divided into minimum 3 Units to maximum 5 units along with defined hour of teaching for each unit.

Units	Course Content	Hr. of Teaching
I	Mechanism of hormone action 1.1 Protein hormones: Membrane receptors and signaling pathways (G-proteins, cyclic AMP Signaling cascade, PKC and CaMK signaling pathway), receptor tyrosine kinase pathway 1.2 Steroid hormones: Genomic and nongenomic pathways	10
II	2.1 Hypothalamo-hypophysial System 2.1.1 General organization 2.1.2 Neural control of adenohypophysis: hypophysiotropic hormones and their actions 2.1.3 Adenohypophysial hormones & their physiological roles ▪ Somatotropin and prolactin ▪ Glycoprotein hormones: FSH, LH and TSH ▪ Pro-opiomelanocortin: ACTH, MSH 2.1.4 Neurohypophysial hormones: oxytocin and vasopressin 2.2 Epiphysial System 2.2.1 Pineal, biological clock and calendar 2.2.2 Melatonin and photoperiodic measurement	15
III	Hormonal control of 3.1 Calcium homeostasis 3.2 Glucose homeostasis	6
IV	Adrenal cortex: Control of secretion and physiological role of mineralocorticoid and glucocorticoid hormone Adrenal medulla: Catecholamine biosynthesis, release and physiological role	5
V	Biology of Gonads:	9

	5.1 Gonadal development 5.2 Physiology of the male and female reproductive axis 5.3 Sexual dysfunctions	

Texts / References	1. Hadley: Endocrinology, Fifth Edition, 2000, Prentice Hall 2. Norris: Vertebrate Endocrinology, Fifth Edition, 20012, Academic Press 3. Goodman: Basic Medical Endocrinology, Fifth Edition, 2016, Elsevier Inc. 4. Larson: Williams Textbook of Endocrinology (15th ed 2022, Saunders)
Learning Outcomes (not more than 100 words)	Upon completing this course, students will be able to: 1. Understand signalling mechanisms of protein and steroid hormones. 2. Describe the structure and function of the hypothalamo-hypophysial system. 3. Explain the roles of adenohypophysial hormones. 4. Understand neurohypophysial hormones. 5. Explain the function of the pineal gland and melatonin. 6. Describe steroid hormone biosynthesis. 7. Understand the roles of androgens, estrogens, progesterone, inhibin in gonadal function. 8. Describe the secretion and function of adrenal cortex hormones (mineralocorticoids, glucocorticoids) and adrenal medulla catecholamines. 9. Explain calcium and glucose homeostasis involving parathormone, calcitonin, vitamin D, insulin, and glucagon.
Course Title	**ZOOMJ74: Bioinformatics and Biostatistics**
Category of Course	Major / Minor / Minor (Vocational) / SEC / AEC / VAC / MD/Internship/Dissertation (Tick any one of the above):

Credits & Hour of Teaching	Theory	Practical	Cumulative
Credits	3		3
Hour of Teaching (Total)	45		45

Course Objectives (not more than 100 words)	Bioinformatics: • To provide detailed information about various tools and methodologies to analyze large datasets quickly and efficiently. • To identify pattern and relationship in the data that would be difficult to identify manually • To predict novel targets for developing safe and effective drugs against complex and complicated animal diseases. Biostatistics: • To provide essential tools and methodologies for analyzing data derived from biological, medical, and health-related fields. • To identify health trends, assessing risk factors, and evaluating the effectiveness of treatments and interventions. This information is vital for public health planning and policy-making, aiming to improve population health outcomes.
Course Content	The course content be divided into minimum 3 Units to maximum 5 units along with defined hour of teaching for each unit.

Units	Course Content	Hr. of Teaching
I	Bioinformatics: 1. Introduction of bioinformatics and basics of information technology 1.1 Operating system, web browser, internet protocol (TCP/IP), hypertext, HTML, Web page and uniform resource locators (URL) 2. Introduction to data archiving systems 2.1 FASTA format 2.2 Accession, and GI-Number	4 2

II	3. Basic features of biological data and data 3.1 Types of Biological Data- Primary Databases, Secondary and Composite Databases 3.2 Nucleic acid sequences databases (GenBank, EMBL, DDBJ) 3.3 Genome databases 3.4 Protein sequence, structures and interacting protein databases (Swiss-Prot, TrEMBL, UniProt, PDB) 3.5 Literature databases 4. Introduction to data retrieval systems 4.1 Search engines 4.2 Entrez, sequence retrieval system (SRS) and DBGET / LinkDB	6 2
III	5. Introduction to molecular sequence analysis software packages and tools 5.1 Prediction of motifs and domains (Prosite, ProDom, Pfam, InterPro) 5.2 Sequence (BLAST and Clustal W) and phylogenetic analysis 6. Scope and applications of bioinformatics	4 2
IV	Biostatistics: 1.1. Data collection and classification 1.2. Graphical representation of data 1.1.1. Pie chart 1.1.2. Bar diagram 1.1.3. Histogram 1.1.4. Frequency polygon 1.1.5. cumulative frequency curve	06
V	2.1. Basics of Probability 2.2. Measures of central tendency: Arithmetic Mean, Median, Mode 2.3. Measures of dispersion: Standard deviation and Standard error, Concept of Coefficient of Variation 2.4. Correlation: Types of correlation, Calculation of correlation in continuous data and ordinal data 2.5. Regression: Linear regression and regression equations 2.6. Hypothesis testing: Parametric tests (Paired and unpaired t-test, ANOVA), Non-parametric test (Chi-square test, Mann-Whitney U test)	13

Texts / References	Bioinformatics 1. Barnes & Gray: Bioinformatics for geneticists (2003, Wiley) 2. Lesk: Bioinformatics (5thed 2015, Oxford) 3. Westhead et al: Bioinformatics Instant Notes (Indian ed 2003, Viva Books) 4. Mount, Bioinformatics (2nded 2006, CBS) 5. Hunt and Livesey: Functional Genomics (2006, Oxford) 6. Campbel: Discovering Genomics, Proteomics and Bioinformatics (2006, LPE) 7. A textbook of bioinformatics, Sharma, Munjal and Shanker (2016, Rastogi Publications) **8. Hamid D. Ismail (2022, Chapman and Hall/CRC) Bioinformatics: A Practical Guide to NCBI Databases and Sequence Alignments** Biostatistics: 1. Bruning & Kintz (1977) Computational Handbook of Statistics. Scott 2. Daniel (2000) Biostatistics: A Foundation for Analysis in Health Sciences. John Wiley. 3. Rastogi (2008) Fundamentals of Biostatistics. ANE Books 4. Sharma (2008) Text Book of Biostatistics-I & II. Discovery Publishing 5. Zar (2003) Biostatistical Analysis. Pearson
Learning Outcomes (not more than 100 words)	1. After completing the course, students will develop basic computer skills and become proficient in using genomic, proteomic, and literature databases. 2. They will learn to compare and analyze biological sequences, construct phylogenetic trees, and identify consensus sequences, genes, and open reading frames. 3. Students will also gain the ability to identify protein motifs and domains, and design therapeutic drugs targeting novel disease mechanisms. 4. Students will gain proficiency in collecting, representing, and analyzing research and health-related data, and will be able to effectively communicate these findings to support decision-making in clinical, public health, and research contexts.

Course Title	ZOOMJ75: Lab. exercises based on course ZOOMJ71& ZOOMJ72
Category of Course	Major / Minor / Minor (Vocational) / SEC / AEC / VAC / MD/Internship/Dissertation (Tick any one of the above)

Credits & Hour of Teaching	Theory	Practical	Cumulative
Credits		2	2
Hour of Teaching (Total)		60	60

Course Objectives (not more than 100 words)	• The practical course is designed to give students hands-on training in genetics-based studies. • This will be accomplished through a series of laboratory exercises, including mutant analysis and simulation-based experiments to demonstrate inheritance principles. • Students will engage in various hands-on exercises to better grasp concepts such as sex-linked inheritance and the preparation and analysis of different types of chromosomes.
Course Content	The course content be divided into minimum 3 Units to maximum 5 units along with defined hour of teaching for each unit.

Units	Course Content	Hr. of Teaching
I	*PART-A: Structure and Functions of Biomolecules (Credit 1)* 1. Determination of pK and pI values of glycine 2. Estimation of protein by Biuret method 3. Determination of the activity of enzyme (Urease): a. Effect of [S] and determination of Km and Vmax b. Effect of time 4. Qualitative tests for identification of sugars 5. Qualitative test for DNA & RNA	30
II	*PART-B: Molecular Genetics (Credit 1)* 1. Study of mutants in *Drosophila* (Bar eye, white eye, yellow body, sepia eye, curled wing, dumpy wing, vestigial wing and sepia eye-curled wing and curled wing-ebony body- sepia eye). 2. Simulation of principles of segregation and independent assortment using coloured beads. 3. Application of laws of probability and chi-square test. 4. Study of sex-linkage: reciprocal crosses between red and white-eyed *Drosophila* flies. 5. Study of pattern of inheritance of the traits in human populations: rolling of tongue and interlocking, and of the sex-influenced trait long versus short second finger in relation to the fourth finger (apply Hardy-Weinberg Law). 6. Preparation of polytene chromosome from *Drosophila* larvae. 7. Isolation of Genomic DNA from mouse/rat tissue. 8. Population & Familial analysis of Diabetes.	30

Texts / References	
Learning Outcomes (not more than 100 words)	• The hands-on Molecular Genetics course offers students a unique opportunity to gain practical skills. • By observing genetic mutations in *Drosophila*, students can correlate phenotype with genotype, understand genetic interaction and their molecular basis. • Students will be able to set hands on genetic crosses to understand recessive and dominant, segregation, pattern of inheritance and finally evaluating statistical significance. • Students will acquire comprehensive experience in gathering data from human populations and exploring the intricacies of sex-linked inheritance. • They will also know how to prepare and examine chromosomes for various downstream applications, which will deepen their understanding of the genetic basis of inheritance.

Course Title	**ZOOMJ76: Lab. exercises based on course ZOOMJ73 & ZOOMJ74**
Category of Course	**Major** / ~~Minor / Minor (Vocational) / SEC / AEC / VAC / MD/Internship/Dissertation~~ (Tick any one of the above)

Credits & Hour of Teaching	Theory	Practical	Cumulative
Credits		2	2
Hour of Teaching (Total)		60	60

Course Objectives (not more than 100 words)

Molecular Endocrinology:

- Students will develop skills in handling and maintaining laboratory rats, survey endocrine glands and reproductive organs, and perform surgical ablation of testis and ovary.
- They will study the estrous cycle through vaginal smear analysis, prepare permanent histological slides of endocrine glands, and use ELISA for quantitative hormone assays.

Bioinformatics:

- Students will learn to use and develop tools for curating, comparing, and analyzing biological data, and identify patterns and relationships that are challenging to detect manually.

Biostatistics:

- Students will understand various tools and techniques for analyzing data in biology, medicine, and health contexts.

Course Content

The course content be divided into minimum 3 Units to maximum 5 units along with defined hour of teaching for each unit.

Units	Course Content	Hr. of Teaching
I	*Molecular Endocrinology(Credit 1)* 1.1 Handling, sexing and maintenance of laboratory rat 1.2 Surgical ablation of testis and ovary in rat 1.3 Study of the oestrous cycle of rats by vaginal smear preparation	12
II	2.1 Survey of endocrine glands and reproductive organs in rat 2.2 Preparation of permanent slides of endocrine glands: 1. Pituitary 2. Thyroid 3. Testis 4. Ovary 5. Pancreas 6. Uterus 2.3 Immunohistochemical localization of hormone receptors in reproductive tissues (Demonstration only)	18
III	*Bioinformatics: (Credit 0.5)* 1. Familiarization with computer operations and TCP/IP 2. Data archiving systems: FASTA format, Accession and GI numbers 3. Use of search and meta-search engines (Google, Altavista, Dogpile)	15
III	4. Demonstration of web pages related to biological information: 4.1 NCBI 4.2 ExPasy 5. Hands-on practice with features of the following databases: 5.1 GenBank 5.2 PDB 5.3 PubMed 6. Hands-on practice on following software packages/tools: 6.1 BLAST, 6.2 Clustal-W 6.3 Prosite 6.4 NetPhos 6.5 Rasmol	
IV	*Biostatistics (Credit 0.5)* 1.1. Presentation of data in the form of pie chart, bar diagrams, Histogram, frequency polygon and cumulative frequency curve. 1.2. Use of chi-square test to analyze biological data.	15

	1.3. Calculation of student t-test (paired and unpaired both). 1.4. Applying one-way ANOVA to test differences among more than two	

Texts / References	1. Advanced Practical Zoology by PS Verma & PC Srivastava. S. Chand Publishing, 2015 2. Bruning & Kintz (1977) Computational Handbook of Statistics. Scott 3. Daniel (2000) Biostatistics: A Foundation for Analysis in Health Sciences. John Wiley. 4. Rastogi (2008) Fundamentals of Biostatistics. ANE Books 5. Sharma (2008) Text Book of Biostatistics-I&II. Discovery Publishing 6. Zar (2003) Biostatistical Analysis. Pearson
Learning Outcomes (not more than 100 words)	*Molecular Endocrinology* Students will master the handling of laboratory rats, identify endocrine glands and reproductive organs, and perform testis and ovary ablation. They will analyze the estrous cycle through vaginal smears, prepare histological slides of endocrine organs, and conduct quantitative hormone assays using ELISA. *Bioinformatics* Students will gain skills in computational interpretation of biological data, and analyze biological sequences. They will locate consensus sequences, genes, and open reading frames, and infer evolutionary relationships to identify novel drug targets. *Biostatistics:* Students will practice analyzing collected and experimental data, select and apply appropriate parametric or nonparametric tests, and interpret results for decision-making.

Course Title	**ZOOMN71: Structure and Functions of Biomolecules**
Category of Course	~~Major~~ / **Minor** / ~~Minor (Vocational) / SEC / AEC / VAC / MD/Internship/Dissertation~~ (Tick any one of the above)

	Theory	Practical	Cumulative
Credits	3		3
Hour of Teaching (Total)	45		45

Course Objectives (not more than 100 words)	• The main objective of Structure and Functions of Biomolecules course is to understand the fundamental concepts of biomolecules, including the definition, classification and organization of proteins, enzymes, carbohydrates, lipids, and nucleic acids. • This course emphasized the structural properties of major biomolecules and explain how these structures relate to their functions in biological systems that guide students through the complexities of biomolecular science.
Course Content	The course content be divided into minimum 3 Units to maximum 5 units along with defined hour of teaching for each unit.

Units	Course Content	Hr. of Teaching
I	Proteins and Enzymes: Composition and organization 1.1 Amino acids: Ionization, titration curve, pK and pI 1.2 N-terminal analysis: Sanger and Edman's reactions 1.3 Higher order organization of proteins 1.4 Kinetics (determination of Km and Vmax using Michaelis-Menten and Lineweaver-Burk plots) 1.5 Acid-base and covalent catalysis 1.6 Concept of regulation of enzyme activity 1.6.1 Inhibition 1.6.2 Allosteric regulation 1.6.4 Role of covalent modifications 1.7 Ribozymes and concept of abzymes	15
II	Carbohydrates 2.1. Polysaccharides 2.1.1 Homopolymers 2.1.2 Heteropolymers (peptidoglycans and glycosaminoglycans) 2.2. Catabolism of carbohydrates and ATP production 2.2.1 Glycolysis 2.2.2 Krebs cycle 2.2.3 Electron transport chain and ATP synthesis	8
III	Lipids: Structural and functional significance	5

	3.1 Triglycerides 3.2 Phospholipids 3.3 Sphingolipids 3.4 Cholesterol	
IV	Nucleic acids 4.1 Conformation of DNA (A, B and Z) 4.2 Hoogsteen base pairing-Guanine quadruplex 4.3 Structure of nucleosomes 4.4 Mechanism of DNA replication 4.5 Transcription 4.5.1 Basic mechanism (prokaryotic model) 4.5.2 Transcription initiation complex in eukaryotes 4.5.3 Processing of RNA Pol II Transcript 4.5.4.Mechanism of translation	12
V	Recombinant DNA and Proteins 5.1 Tools: Restriction enzymes, vectors 5.2 Construction of recombinant DNA 5.3 Production of recombinant protein 5.4 Genome editing	5

Texts / References	1. Lehninger, Nelson & Cox: Principles of Biochemistry (4th ed, 2007, Worth), 2. Berg, Tymoczko, Stryer; Biochemistry (7th ed. 2012, Freeman)
Learning Outcomes (not more than 100 words)	1. Upon completion of the course students have a sound understanding of the biochemical processes that underpin biological functions at a molecular level and effectively communicate scientific findings relevant to biomolecules ensuring clarity and accuracy. 2. Students will develop the capability to understand biomolecule types, analyze structure-function relationships, interpret biological interactions, describe metabolic pathways, apply laboratory techniques, solve biochemical problems, and communicate scientific ideas.

Course Title	**ZOOMN72: Lab. exercises based on course ZOOMN71**
Category of Course	**Major** ~~/ Minor / Minor (Vocational) / SEC / AEC / VAC / MD/Internship/Dissertation~~ (Tick any one of the above)

Credits & Hour of Teaching	Theory	Practical	Cumulative
Credits-Section A		1	1
Hour of Teaching (Total)		30	30

Course Objectives (not more than 100 words)	• Develop practical skills in handling biological materials and laboratory equipment. • Enhance understanding of the practical concepts related to the structure and function of biomolecules. • Develop critical thinking and problem-solving skills by evaluating experimental data and understanding the limitations of current biomolecular techniques. • Apply experimental methodologies to investigate the properties of biomolecules. • Develop effective communication skills through lab reports and presentations.
Course Content	The course content be divided into minimum 3 Units to maximum 5 units along with defined hour of teaching for each unit.

Units	Course Content-	Hr. of Teaching
I	1. Determination of pK and pI values of glycine 2. Estimation of protein by Biuret method 3. Determination of the activity of enzyme (Urease): a. Effect of [S] and determination of Km and Vmax b. Effect of time 4. Qualitative tests for identification of sugars 5. Qualitative test for DNA & RNA	30

Texts / References	1. Plummer and Plummer: Introduction to Pract. Biochem. (2001) Tata McGraw Hill 2. Wilson and Walker: Principles of Biochemical and Molecular Biological Techniques (6th ed2006, Cambridge University Press)
Learning Outcomes	Students will be able to- 1. Collect, analyze, interpret, and present experimental data related to biomolecule structure and

(not more than 100 words)	function. 2. Safely and accurately perform standard laboratory techniques related to biomolecule isolation, purification, and analysis. 3. Apply knowledge of biomolecules to drug development, biotechnology etc. 4. Design and conduct independent research projects related to biomolecules.

Course Title	**ZOOMJ81: Biotechniques**
Category of Course	**Major** / ~~Minor / Minor (Vocational) / SEC / AEC / VAC / MD/Internship/Dissertation~~ (Tick any one of the above)

Credits & Hour of Teaching		Theory	Practical	Cumulative
	Credits	3		3
	Hour of Teaching (Total)	45		45

Course Objectives (not more than 100 words)	• To learn basics of instrumentation including principle and applications in the field of Biological Sciences. • Familiarization with cell culture techniques and methodology.
Course Content	The course content be divided into minimum 3 Units to maximum 5 units along with defined hour of teaching for each unit.

Units	Course Content	Hr. of Teaching
I	1. Analytical instruments: Principle and applications& Microscopy 1.1 pH meter 1.2 UV-visible spectrophotometer 1.3 Centrifuge 1.4 Bright field 1.5 Dark field 1.6 Polarized and differential interference contrast microscopy 1.7 Atomic force microscopy 1.8 Fluorescence and Confocal 1.9 Scanning and transmission electron microscopes	15
II	2. Histological Techniques 2.1 Fixation and Fixatives 2.2 Tissue processing and Microtomy 2.3 Principle and methods of histological staining 2.3.1 Hematoxylin and eosin 2.4 Principles of immunohistochemistry	7
III	3. Cell and tissue culture techniques 3.1 Sterilization: laminar flow, media and glassware 3.2 Types of animal cell culture 3.3 Cell viability testing 3.4 Cryopreservation	8
IV	4. Separation techniques 4.1 Chromatography: Principle and Applications 4.1.1 Paper chromatography 4.1.2 Thin layer chromatography 4.1.3 Ion exchange chromatography 4.1.4 Gel-filtration chromatography 4.1.5 HPLC 4. 2 Electrophoresis: Principle and applications of 4.2.1 Agarose gel electrophoresis, native and SDS-PAGE 4.2.2 Western blotting	10
V	5. Radiotracer and Immunoassays techniques: Principle and Applications 5.1 Radioactivity: Nature, measurements and safety aspects 5.2 Imunoassaystechniques 5.2.1 RIA 5.2.2 ELISA	5

Texts / References	1. Boyer: Modern Experimental Biochemistry (1993, Benjamin-Cummings,) 2. Pearse: Histochemistry - Theoretical and applied, Volume I-III (1980-1993, Churchill-

	Living stones) 3. Bancroft: Theroy and Practice of Histological Techniques (2018 Kim S. Suvarna, Christopher Layto, John D. Bancroft) 4. Plummer: An Introduction to Practical Biochemistry (1989, McGraw Hill) 5. Wilson & Walker: Experimental Biochemistry (2006, Cambridge)
Learning Outcomes (not more than 100 words)	Students will be equipped to handle various instruments and learn techniques related to sampling, imaging, data collection, analysis and interpretation in biological samples

Course Title	**ZOOMJ82: Neurobiology**
Category of Course	**Major** / ~~Minor / Minor (Vocational) / SEC / AEC / VAC / MD/Internship/Dissertation~~ (Tick any one of the above)

Credits & Hour of Teaching

	Theory	Practical	Cumulative
Credits	3		3
Hour of Teaching (Total)	45		45

Course Objectives (not more than 100 words)	• The neurobiology course will be able to describe the structure and function of the brain at the sub-cellular and systems level of analysis and explain how molecular and electrical activity in the nervous system contributes to sensation, movement, cognition, and some diseases of the nervous system
Course Content	The course content be divided into minimum 3 Units to maximum 5 units along with defined hour of teaching for each unit.

Units	Course Content	Hr. of Teaching
I	Organization of nervous system 1.1 Brain structure 1.2 Neurons and glia 1.3 Neuronal system: limbic and extrapyramidal 1.4 Blood brain barrier 1.5 Cerebrospinal fluid	10
II	Axonal and synaptic transmission 2.1 Membrane potential, action potential, transmission of nerve impulse 2.2 Types of synapses 2.3 Excitatory and inhibitory post-synaptic potential 2.4 Chemical transmission, neurotransmitters (acetylcholine, catecholamines, serotonin and GABA), neuropeptides	10
III	Learning, memory and Behaviour 3.1 Types and tools 3.2 Molecular mechanisms 3.3 Motivation 3.4 Sleep	10
IV	Brain aging 4.1 Structural alterations 4.2 Functional changes 4.3 Neurogenesis and neuroplasticity 4.4 Neurodegeneration and neuroprotection	5
V	Neuropathology and Brain Imaging 5.1 Strokes 5.2 Epilepsy 5.3 Alzheimer disease 5.4 Huntington disease 5.5 Parkinson disease Brain imaging 5.6 CAT 5.7 PET 5.8 MRI	10

Texts / References	1. Guyton and Hall: Text Book of Medical Physiology (11th Ed 2006, W.B. Saunders) 2. Eric Kandel: Principles of Neural Science (2000, Mc Graw Hill) 3. Allan Siegel (Author), Hreday N. Sapru (Author) Essential Neuroscience (4th Edition 2014 Lippincott Williams and Wilkins)

	4. Mark F. Bear (Author), Barry W. Connors (Author), Michael A. Paradiso (Author)Neuroscience: Exploring the Brain (4th Edition 2015 Wolters Kluwer)
Learning Outcomes (not more than 100 words)	• Students will demonstrate proficiency of the structure and function of the nervous system at various levels of organization. • Students will develop critical thinking skills to formulate scientific questions. • Students will communicate results of scientific investigations effectively to scientific and non-scientific audiences in both the oral and written form.
Course Title	**ZOOMJ83: Chronobiology**
Category of Course	**Major**~~/ Minor / Minor (Vocational) / SEC / AEC / VAC / MD/Internship/Dissertation~~ (Tick any one of the above)

Credits & Hour of Teaching	Theory	Practical	Cumulative
Credits	3		3
Hour of Teaching (Total)	45		45

Course Objectives (not more than 100 words)	• Develop an understanding of the history and scope of chronobiology, including geophysical and biological rhythms. • Study the structure and function of circadian timing systems, focusing on central and peripheral clocks, the roles of sensory receptors, pacemakers, and melatonin. • Evaluate circadian rhythms' impact on homeostasis, disruptions, seasonal affective disorders, and the importance of chronopharmacology, chronomedicine, and chronotherapy.
Course Content	The course content be divided into minimum 3 Units to maximum 5 units along with defined hour of teaching for each unit.

Units	Course Content	Hr. of Teaching
I	1. Introduction to Chronobiology 1.1 History, significant milestones, and scope of the science of chronobiology 1.2 Geophysical and environmental rhythms 1.3 Biological Rhythms: types with examples 1.4 Clock and calendar rhythms	6
II	2. General Features and Characteristics of Rhythms 2.1 Frequency, period, amplitude and phase 2.2 Free running rhythms, phase shifts, phase response curves and phase transition curves 2.3 Photic and non-photic *Zeitgebers* 2.4 Entrainment: parameter and non-parametric, photic and non-photic mechanisms of photic and non-photic entrainment	8
III	3. Photoperiodism and seasonality 3.1 Ultimate and proximate factors 3.2 Type (I &II) seasonal rhythms 3.3 Models of photoperiodic time measurement and photoperiodic history 3.4 Photoperiodic and seasonal responses in animals	4
IV	4. Structural and functional organization of the circadian timing system 4.1 Central and peripheral clocks 4.2 Structural and functional anatomy of the suprachiasmatic nucleus (SCN) 4.3 Sensory receptors, pacemakers, afferent and efferent pathways 4.4 Melatonin: a clock input and clock output 4.5 Molecular transcriptional-translational-post-transitional feedback loops in endogenous time generation (fruit flies, birds, and mammals as examples	10
V	5. Chronobiology in health and disease 5.1 Homeostasis and circadian rhythmicity (regulation of body temperature, sleep, and energy expenditure) 5.2 Circadian disruption (Jet lag and shift work) and lifestyle disorders 5.3 Seasonal affective disorders and depression 5.4 Concept of chrono-pharmacology, chrono-medicine, and chronotherapy 5.5 Light pollution, circadian clock, and biodiversity	8

Texts / References	1. Circadian Physiology: Roberto Refinetti, CRC Press (3rd Ed.) 2016. 2. Chronobiology: Biological Timekeeping; Jay C. Dunlap *et al.*, SinauerAsso.,

	Inc. Publishers, USA, (2005). 3. Introducing Biological Rhythms: Willard L. Koukkari and Robert B. Sothern, Springer (2006).
Learning Outcomes (not more than 100 words)	1. Comprehend the history, milestones, and scope of chronobiology, and distinguish between geophysical, environmental, and biological rhythms. 2. Identify the structure and function of circadian timing systems, including central and peripheral clocks and the role of the SCN and melatonin. 3. Assess the impact of circadian rhythms on health, including the effects of circadian disruption, seasonal affective disorders, and applications in chrono-pharmacology and chronotherapy.
ourse Title	**ZOOMJ84: Entomology and Fish Biology**
Category of Course	**Major /** ~~Minor / Minor (Vocational) / SEC / AEC / VAC / MD/Internship/Dissertation~~ (Tick any one of the above):

Credits & Hour of Teaching	Theory	Practical	Cumulative
Credits	3		4
Hour of Teaching (Total)	45		75

Course Objectives (not more than 100 words)	The purpose of the course is: • To study the diversity and unique morphological features of different insect orders. • To understand the need of various physiological systems in insects. • To learn about the importance of useful and harmful insects. • To give broad introduction to fish distribution, anatomy and physiology. • Familiarization with fish adaptations and their reproductive strategies.
Course Content	The course content be divided into minimum 3 Units to maximum 5 units along with defined hour of teaching for each unit.

Units	Course Content	Hr. of Teaching
I	1.1. Importance and taxonomic richness of insects 1.2. External anatomy 1.2.1. Segmentation and tagmosis 1.2.2. Integument: structure and functions of cuticles, sclerotization	05
II	2. Internal anatomy and physiology 2.1 Nervous system 2.2 Endocrine system and functions of hormones 2.3 Circulatory system: heart and haemolymph 2.4 Respiratory system 2.4.1 Aerial respiration 2.4.2 Aquatic respiration 2.5 Digestive system 2.5.1 Structure of gut 2.5.2 Digestion of food 2.6 Excretory system and waste disposal 2.6.1 Malpighian tubules 2.6.2 Nitrogen excretion 2.7 Reproductive system 2.7.1 Female and male reproductive systems 2.8. Spermatogenesis and oogenesis	07
III	3.1. Sensory system 3.1.1. Tactile mechanoreceptors and position receptors 3.1.2. Compound eye 3.2. Sound and light production in insects 3.3. Insects as friends and foes 3.4. General methods of insect pest management	08
IV	4.1. Natural history and diversity of fishes 4.2. Exotic, larvivorous and weed fishes 4.3. Venomous and poisonous fishes 4.4. Hill stream and Deep-Sea adaptations in fishes 4.5. Migration in fishes	08
V	5.1. Integument – Chromatophores, pigments and scales 5.2. Organs of gas exchange	11

	5.3. Electric organs 5.4. Hydrostatic organs 5.5. Reproductive strategies & Parental care	

Texts / References	*Entomology* 1. Richards & Davies, Imms' General Textbook of Entomology (Vol. I & II), Chapman & Hall, UK 2. Gullan & Cranston, The Insects: An outline of Entomology, Wiley Blackwell, USA 3. Chapman, The Insects: Structure and Function, Cambridge University Press, UK *Fish Biology* 1. Lagler, Bardach, Miller and May Passino: Ichthyology (2003, Wiley) 2. Khanna and Singh: A textbook of Fish Biology and Fisheries (2015, Narendra Publishing House) 3. Fish and Fisheries: Pandey and Shukla (Rastogi Publication) 4. Pillay: Aquaculture: Principles and Practices Fishing News Books (2005, First Indian reprint) 5. Srivastava: A Textbook of Fishery Science and Indian Fisheries (1985, Kitab Mahal) 6. Parihar: Fish Biology and Indian fisheries (1999, Central publishing House Allahabad)
Learning Outcomes (not more than 100 words)	After studying the course, a student will: 1. Learn the vast diversity of insects and their role in environmental engineering. 2. Know the various physiological systems operating in insects. 3. Understand different kinds of beneficial insects, and the measures to control the harmful insects. 4. Become aware of the major research topics in pure and applied entomology. 5. Students will learn about the history, biogeography, physiology and diversity of fish, awell established model system for research.

Course Title	**ZOOMJ85: Lab. exercises based on course ZOOMJ81**
Category of Course	**Major** ~~/ Minor / Minor (Vocational) / SEC / AEC / VAC / MD/Internship/Dissertation~~ (Tick any one of the above)

Credits & Hour of Teaching

	Theory	Practical	Cumulative
Credits		1	1
Hour of Teaching (Total)		30	30

Course Objectives (not more than 100 words)	• To learn basics of instrumentation including principle and applications in the field of Biological Sciences. • Familiarization with cell culture techniques and methodology.
Course Content	The course content be divided into minimum 3 Units to maximum 5 units along with defined hour of teaching for each unit.

Units	Course Content	Hr. of Teaching
I	Direct spectrophotometric detection of proteins and nucleic acids Verification of laws of spectrophotometry Separation of proteins using SDS-PAGE	10
II	Demonstration of DNA gel electrophoresis Demonstration of bright field and phase contrast Demonstration of fluorescence, confocal and electron microscope	10
III	Tissue fixation, paraffin block preparation and sectioning Staining of paraffin section using hematoxylin and eosin stain Visit to any tissue culture lab	10

Texts / References	1. Boyer: Modern Experimental Biochemistry (1993, Benjamin-Cummings,) 2. Pearse: Histochemistry - Theoretical and applied, Volume I-III (1980-1993, Churchill-Livingstones) 3. Bancroft: Theroy and Practice of Histological Techniques (2018 Kim S. Suvarna, Christopher Layto, John D. Bancroft) 4. Plummer: An Introduction to Practical Biochemistry (1989, McGraw Hill) 5. Wilson & Walker: Experimental Biochemistry (2006, Cambridge)
Learning Outcomes (not more than 100 words)	Students will be equipped to handle various instruments and learn techniques related to sampling, imaging, data collection, analysis and interpretation in biological samples
Course Title	**ZOOMJ86: Lab. exercises based on course ZOOMJ82 & ZOOMJ83**
Category of Course	**Major** / ~~Minor / Minor (Vocational) / SEC / AEC / VAC / MD/Internship/Dissertation~~ (Tick any one of the above)

Credits & Hour of Teaching		Theory	Practical	Cumulative
	Credits-Part A		2	2
	Hour of Teaching (Total)		60	60
Course Objectives (not more than 100 words)	• The course aims to introduce students to the scientific concepts underlying the study of neural phenomena; provide an understanding of the principles underlying cellular, molecular, and cognitive neurobiology			
Course Content	The course content be divided into minimum 3 Units to maximum 5 units along with defined hour of teaching for each unit.			

Units	Course Content	Hr. of Teaching
I	*PART-A: Neurobiology* 1. Studies on action potential and measurement of nerve impulse conduction. 2. Studies on spatial learning and memory in rat/mouse model by Morris-Water/ Radial-Arm Maze Tests. 3. Evaluation of mini-mental status examination. 4. a) External morphology of rat brain b) Staining of neuronal cells 5. Spectrophotometric assay of acetylcholine esterase. 6. Demonstration of Primary culture of neurons	30
II	*PART-B: Chronobiology* 1. Measurement of circadian locomotor activity rhythm in insects (demonstration). 2. Measurement of circadian locomotor activity rhythm in mice (demonstration). 3. Measurement of Human circadian rhythm using Actiwatch/Wristband. 4. Calculation of period length, phase shifts, and phase angle difference on pre-recorded data. 5. Construction of a Phase response curve using pre-recorded circadian activity rhythm data. 6. Observation of circadian rhythms in crickets. 7. Study of photoperiodic effects on anxiety using Open Field Test/Elevated Plus maze test 8. Study of re-entrainment of circadian activity rhythms of animals on pre-recorded data.	30

Texts / References	Mark F. Bear (Author), Barry W. Connors (Author), Michael A. Paradiso (Author)Neuroscience: Exploring the Brain (4th Edition 2015 Wolters Kluwer)
Learning Outcomes (not more than 100 words)	Students will engage in laboratory investigations that focus on neuroscience. Students will understand how to construct testable hypotheses and design scientific investigations that contribute to neurobiology.

Course Title	**ZOOMJ87: Lab. exercises based on course ZOOMJ84**
Category of Course	**Major** / ~~Minor / Minor (Vocational) / SEC / AEC / VAC / MD/Internship/Dissertation~~ (Tick any one of the above):

Credits & Hour of Teaching	Theory	Practical	Cumulative
Credits		1	1
Hour of Teaching (Total)		30	30

Course Objectives (not more than 100 words)

The purpose of the course is:

- To explore the variety and distinctive physical characteristics of various insect orders.
- To comprehend the necessity of different physiological systems in insects.
- To give broad introduction to fish distribution, anatomy and physiology.
- Familiarization with fish adaptations and their reproductive strategies.

Course Content

The course content be divided into minimum 3 Units to maximum 5 units along with defined hour of teaching for each unit.

Units	Course Content	Hr. of Teaching
I	1.1. Collection and preservation of insects 1.2. Study of the external morphology of insects	01
II	2.1. Internal anatomy of insects 2.1.1. Alimentary canal 2.1.2. Salivary apparatus: dissection and *in-toto* preparation 2.2. Dissection of frontal ganglion, brain, retrocerebral endocrine glands and recurrent nerve 2.3. Dissection of prothoracic gland 2.4. Dissection of male and female reproductive systems	03
III	3. Study of external morphology and dissection of sting apparatus of honey bee	01
IV	4.1. Classification of the following locally available fishes using key 4.1.1. Carps: *Catla catla*; *Labeo rohita*; *Cirrhina mrigala* 4.1.2. Catfishes:*Heteropneustes fossilis; Clarias batrachus* 4.2. Study of museum specimens of fishes having electric organs, venomous organs and air breathing organs	04
V	5.1. Dissection and display of accessory respiratory organs of *5.1.1. Clarias batrachus* *5.1.2. Heteropneustes fossilis* 5.2. Mounting of respiratory epithelium of accessory respiratory organs of *H. fossilis* 5.3. Study of T.S. of gills, accessory respiratory organs and swim bladder from prepared slides	04

Texts / References

Entomology

1.Richards & Davies, Imms' General Textbook of Entomology (Vol. I & II), Chapman & Hall, UK
2.Gullan & Cranston, The Insects: An outline of Entomology, Wiley Blackwell, USA
3.Chapman, The Insects: Structure and Function, Cambridge University Press, UK

Fish Biology

1. Lagler, Bardach, Miller and May Passino: Ichthyology (2003, Wiley)
2. Khanna and Singh: A textbook of Fish Biology and Fisheries (2015, Narendra Publishing House)
3. Fish and Fisheries: Pandey and Shukla (Rastogi Publication)
4. Pillay: Aquaculture: Principles and Practices Fishing News Books (2005, First Indian reprint)
5. Srivastava: A Textbook of Fishery Science and Indian Fisheries (1985, Kitab Mahal)
6. Parihar: Fish Biology and Indian fisheries (1999, Central publishing House Allahabad)

Learning Outcomes (not more than 100 words)

After studying the course, a student will:

1. Gain knowledge of the different physiological systems present in insects.
2. Learn about various beneficial insects and familiarize with the key research areas in practical entomology.
3. Students will learn about the history, biogeography, physiology and diversity of fish, a well-established model system for research.

Course Title	**ZOOMN81: Biotechniques**
Category of Course	~~Major /~~ **Minor** / ~~Minor (Vocational) / SEC / AEC / VAC / MD/Internship/Dissertation~~ (Tick any one of the above)

Credits & Hour of Teaching	Theory	Practical	Cumulative
Credits	3		3
Hour of Teaching (Total)	45		45

Course Objectives (not more than 100 words)	• To learn basics of instrumentation including principle and applications in the field of Biological Sciences. • Familiarization with cell culture techniques and methodology.
Course Content	The course content be divided into minimum 3 Units to maximum 5 units along with defined hour of teaching for each unit.

Units	Course Content	Hr. of Teaching
I	1. Analytical instruments: Principle and applications& Microscopy 1.1 pH meter 1.2 UV-visible spectrophotometer 1.3 Centrifuge 1.4 Brightfield 1.5 Darkfield 1.6 Polarized and differential interference contrast microscopy 1.7 Atomic force microscopy 1.8 Fluorescence and Confocal 1.9 Scanning and transmission electron microscopes	15
II	2. Histological Techniques 2.1 Fixation and Fixatives 2.2 Tissue processing and Microtomy 2.3 Principle and methods of histological staining 2.3.1 The Haematoxylins and eosin 2.4 Principles of immunohistochemistry	7
III	3. Cell and tissue culture techniques 3.1 Sterilization: laminar flow, media and glassware 3.2 Types of animal cell culture 3.3 Cell viability testing 3.4 Cryopreservation	8
IV	4. Separation techniques 4.1 Chromatography: Principle and Applications 4.1.1 Paper chromatography 4.1.2 Thin layer chromatography 4.1.3 Ion exchange chromatography 4.1.4 Gel-filtration chromatography 4.1.5 HPLC 4. 2 Electrophoresis: Principle and applications of 4.2.1 Agarose gel electrophoresis, native and SDS-PAGE 4.2.2 Western blotting	10
V	5. Radiotracer and Immunoassaystechniques: Principle and Applications 5.1 Radioactivity: Nature, measurements and safety aspects 5.2 Imunoassaystechniques 5.2.1 RIA 5.2.2 ELISA	5

Texts / References	1. Boyer: Modern Experimental Biochemistry (1993, Benjamin-Cummings,) 2. Pearse: Histochemistry - Theoretical and applied, Volume I-III (1980-1993, Churchill-Livingstones) 3. Bancroft: Theory and Practice of Histological Techniques (2018 Kim S. Suvarna, Christopher Layto, John D. Bancroft) 4. Plummer: An Introduction to Practical Biochemistry (1989, McGraw Hill) 5. Wilson & Walker: Experimental Biochemistry (2006, Cambridge)
Learning Outcomes (not more than 100 words)	Students will be equipped to handle various instruments and learn techniques related to sampling, imaging, data collection, analysis and interpretation in biological samples

Course Title	**ZOOMN82: Lab. exercises based on course ZOOMN81**
Category of Course	~~Major~~ / **Minor** / ~~Minor (Vocational) / SEC / AEC / VAC / MD/Internship/Dissertation~~ (Tick any one of the above)

Credits & Hour of Teaching

	Theory	Practical	Cumulative
Credits		1	1
Hour of Teaching (Total)		30	30

Course Objectives (not more than 100 words)	• To learn basics of instrumentation including principle and applications in the field of Biological Sciences. • Familiarization with cell culture techniques and methodology.
Course Content	The course content be divided into minimum 3 Units to maximum 5 units along with defined hour of teaching for each unit.

Units	**Course Content**	**Hr. of Teaching**
I	Direct spectrophotometric detection of proteins and nucleic acids Verification of laws of spectrophotometry Separation of proteins using SDS-PAGE	10
II	Demonstration of DNA gel electrophoresis Demonstration of bright field and phase contrast Demonstration of fluorescence, confocal and electron microscope	10
III	Tissue fixation, paraffin block preparation and sectioning Staining of paraffin section using hematoxylin and eosin stain Visit to any tissue culture lab	10

Texts / References	1. Boyer: Modern Experimental Biochemistry (1993, Benjamin-Cummings,) 2. Pearse: Histochemistry - Theoretical and applied, Volume I-III (1980-1993, Churchill-Livingstones) 3. Bancroft: Theroy and Practice of Histological Techniques (2018 Kim S. Suvarna, Christopher Layto, John D. Bancroft) 4. Plummer: An Introduction to Practical Biochemistry (1989, McGraw Hill) 5. Wilson & Walker: Experimental Biochemistry (2006, Cambridge)
Learning Outcomes (not more than 100 words)	Students will be equipped to handle various instruments and learn techniques related to sampling, imaging, data collection, analysis and interpretation in biological samples

Course Title	**ZOOMJ8R1: Biotechniques**
Category of Course	**Major /** ~~Minor~~ / ~~Minor (Vocational) / SEC / AEC / VAC / MD/Internship/Dissertation~~ (Tick any one of the above)

Credits & Hour of Teaching

	Theory	Practical	Cumulative
Credits	3		3
Hour of Teaching (Total)	45		45

Course Objectives (not more than 100 words)	• To learn basics of instrumentation including principle and applications in the field of Biological Sciences. • Familiarization with cell culture techniques and methodology.
Course Content	The course content be divided into minimum 3 Units to maximum 5 units along with defined hour of teaching for each unit.

Units	Course Content	Hr. of Teaching
I	1. Analytical instruments: Principle and applications& Microscopy 1.1 pH meter 1.2 UV-visible spectrophotometer 1.3 Centrifuge 1.4 Brightfield 1.5 Darkfield 1.6 Polarized and differential interference contrast microscopy 1.7 Atomic force microscopy 1.8 Fluorescence and Confocal 1.9 Scanning and transmission electron microscopes	15
II	2. Histological Techniques 2.1 Fixation and Fixatives 2.2 Tissue processing and Microtomy 2.3 Principle and methods of histological staining 2.3.1 The Haematoxylins and eosin 2.4 Principles of immunohistochemistry	7
III	3. Cell and tissue culture techniques 3.1 Sterilization: laminar flow, media and glassware 3.2 Types of animal cell culture 3.3 Cell viability testing 3.4 Cryopreservation	8
IV	4. Separation techniques 4.1 Chromatography: Principle and Applications 4.1.1 Paper chromatography 4.1.2 Thin layer chromatography 4.1.3 Ion exchange chromatography 4.1.4 Gel-filtration chromatography 4.1.5 HPLC 4. 2 Electrophoresis: Principle and applications of 4.2.1 Agarose gel electrophoresis, native and SDS-PAGE 4.2.2 Western blotting	10
V	5. Radiotracer and Immunoassaystechniques: Principle and Applications 5.1 Radioactivity: Nature, measurements and safety aspects 5.2 Imunoassaystechniques 5.2.1 RIA 5.2.2 ELISA	5

Texts / References	1. Boyer: Modern Experimental Biochemistry (1993, Benjamin-Cummings,) 2. Pearse: Histochemistry - Theoretical and applied, Volume I-III (1980-1993, Churchill-Livingstones) 3. Bancroft: Theroy and Practice of Histological Techniques (2018 Kim S. Suvarna, Christopher Layto, John D. Bancroft) 4. Plummer: An Introduction to Practical Biochemistry (1989, McGraw Hill) 5. Wilson & Walker: Experimental Biochemistry (2006, Cambridge)
Learning Outcomes (not more than 100 words)	Students will be equipped to handle various instruments and learn techniques related to sampling, imaging, data collection, analysis and interpretation in biological samples

Course Title	**ZOOMJ8R2: Lab exercises based on course ZOOMJ8R1**
Category of Course	**Major /** ~~Minor~~ / ~~Minor (Vocational) / SEC / AEC / VAC / MD/Internship/Dissertation~~ (Tick any one of the above)

Credits & Hour of Teaching

	Theory	Practical	Cumulative
Credits		1	1
Hour of Teaching (Total)		30	30

Course Objectives (not more than 100 words)	• To learn basics of instrumentation including principle and applications in the field of Biological Sciences. • Familiarization with cell culture techniques and methodology.
Course Content	The course content be divided into minimum 3 Units to maximum 5 units along with defined hour of teaching for each unit.

Units	Course Content	Hr. of Teaching
I	Direct spectrophotometric detection of proteins and nucleic acids Verification of laws of spectrophotometry Separation of proteins using SDS-PAGE	10
II	Demonstration of DNA gel electrophoresis Demonstration of bright field and phase contrast Demonstration of fluorescence, confocal and electron microscope	10
III	Tissue fixation, paraffin block preparation and sectioning Staining of paraffin section using hematoxylin and eosin stain Visit to any tissue culture lab	10

Texts / References	1. Boyer: Modern Experimental Biochemistry (1993, Benjamin-Cummings,) 2. Pearse: Histochemistry - Theoretical and applied, Volume I-III (1980-1993, Churchill-Livingstones) 3. Bancroft: Theroy and Practice of Histological Techniques (2018 Kim S. Suvarna, Christopher Layto, John D. Bancroft) 4. Plummer: An Introduction to Practical Biochemistry (1989, McGraw Hill) 5. Wilson & Walker: Experimental Biochemistry (2006, Cambridge)
Learning Outcomes (not more than 100 words)	Students will be equipped to handle various instruments and learn techniques related to sampling, imaging, data collection, analysis and interpretation in biological samples

Course Title	**ZOOMN8R1: Biotechniques**
Category of Course	~~Major /~~ **Minor** / ~~Minor (Vocational) / SEC / AEC / VAC / MD/Internship/Dissertation~~ (Tick any one of the above)

Credits & Hour of Teaching	Theory	Practical	Cumulative
Credits	3		3
Hour of Teaching (Total)	45		45

Course Objectives (not more than 100 words)	• To learn basics of instrumentation including principle and applications in the field of Biological Sciences. • Familiarization with cell culture techniques and methodology.
Course Content	The course content be divided into minimum 3 Units to maximum 5 units along with defined hour of teaching for each unit.

Units	Course Content	Hr. of Teaching
I	1. Analytical instruments: Principle and applications& Microscopy 1.1 pH meter 1.2 UV-visible spectrophotometer 1.3 Centrifuge 1.4 Brightfield 1.5 Darkfield 1.6 Polarized and differential interference contrast microscopy 1.7 Atomic force microscopy 1.8 Fluorescence and Confocal 1.9 Scanning and transmission electron microscopes	15
II	2. Histological Techniques 2.1 Fixation and Fixatives 2.2 Tissue processing and Microtomy 2.3 Principle and methods of histological staining 2.3.1 The Haematoxylins and eosin 2.4 Principles of immunohistochemistry	7
III	3. Cell and tissue culture techniques 3.1 Sterilization: laminar flow, media and glassware 3.2 Types of animal cell culture 3.3 Cell viability testing 3.4 Cryopreservation	8
IV	4. Separation techniques 4.1 Chromatography: Principle and Applications 4.1.1 Paper chromatography 4.1.2 Thin layer chromatography 4.1.3 Ion exchange chromatography 4.1.4 Gel-filtration chromatography 4.1.5 HPLC 4. 2 Electrophoresis: Principle and applications of 4.2.1 Agarose gel electrophoresis, native and SDS-PAGE 4.2.2 Western blotting	10
V	5. Radiotracer and Immunoassaystechniques: Principle and Applications 5.1 Radioactivity: Nature, measurements and safety aspects 5.2 Imunoassaystechniques 5.2.1 RIA 5.2.2 ELISA	5

Texts / References	1. Boyer: Modern Experimental Biochemistry (1993, Benjamin-Cummings,) 2. Pearse: Histochemistry - Theoretical and applied, Volume I-III (1980-1993, Churchill-Livingstones) 3. Bancroft: Theroy and Practice of Histological Techniques (2018 Kim S. Suvarna, Christopher Layto, John D. Bancroft) 4. Plummer: An Introduction to Practical Biochemistry (1989, McGraw Hill) 5. Wilson & Walker: Experimental Biochemistry (2006, Cambridge)
Learning Outcomes (not more than 100 words)	Students will be equipped to handle various instruments and learn techniques related to sampling, imaging, data collection, analysis and interpretation in biological samples

Course Title	**ZOOMN8R2: Lab. exercises based on course ZOOMN8R1**
Category of Course	~~Major~~ / **Minor** / ~~Minor (Vocational) / SEC / AEC / VAC / MD/Internship/Dissertation~~ (Tick any one of the above)

Credits & Hour of Teaching

	Theory	Practical	Cumulative
Credits		1	1
Hour of Teaching (Total)		30	30

Course Objectives (not more than 100 words)

- To learn basics of instrumentation including principle and applications in the field of Biological Sciences.
- Familiarization with cell culture techniques and methodology.

Course Content

The course content be divided into minimum 3 Units to maximum 5 units along with defined hour of teaching for each unit.

Units	**Course Content**	**Hr. of Teaching**
I	Direct spectrophotometric detection of proteins and nucleic acids Verification of laws of spectrophotometry Separation of proteins using SDS-PAGE	10
II	Demonstration of DNA gel electrophoresis Demonstration of bright field and phase contrast Demonstration of fluorescence, confocal and electron microscope	10
III	Tissue fixation, paraffin block preparation and sectioning Staining of paraffin section using hematoxylin and eosin stain Visit to any tissue culture lab	10

Texts / References

1. Boyer: Modern Experimental Biochemistry (1993, Benjamin-Cummings,)
2. Pearse: Histochemistry - Theoretical and applied, Volume I-III (1980-1993, Churchill-Livingstones)
3. Bancroft: Theroy and Practice of Histological Techniques (2018 Kim S. Suvarna, Christopher Layto, John D. Bancroft)
4. Plummer: An Introduction to Practical Biochemistry (1989, McGraw Hill)
5. Wilson & Walker: Experimental Biochemistry (2006, Cambridge)

Learning Outcomes (not more than 100 words)

Students will be equipped to handle various instruments and learn techniques related to sampling, imaging, data collection, analysis and interpretation in biological samples

<table>
<tr><td>Course Title</td><td colspan="4">ZOODS8R3: Dissertation</td></tr>
<tr><td>Category of Course</td><td colspan="4"><s>Major / Minor / Minor (Vocational) / SEC / AEC / VAC / MD/Internship</s>/Dissertation
(Tick any one of the above)</td></tr>
<tr><td>Credits & Hour of Teaching</td><td colspan="4"><table>
<tr><td></td><td>Theory</td><td>Practical</td><td>Cumulative</td></tr>
<tr><td>Credits</td><td></td><td>12</td><td>12</td></tr>
<tr><td>Hour of Teaching (Total)</td><td></td><td>360</td><td>360</td></tr>
</table></td></tr>
<tr><td>Course Objectives (not more than 100 words)</td><td colspan="4">
To provide opportunity to utilize their learned skills in the class room into practice and to enhance their skills in the research environment/field work and benefit from the Mentor/Supervisor expertize and developing a learning network.
To provide opportunity to go through the literature/field observation, set up the experiments, obtaining the results and analyzing and interpretation of results and putting together in a scientific write-up.
To provide opportunity to present their experimental/field observation results before the examiners.
</td></tr>
<tr><td>Course Content</td><td colspan="4">The course content be divided into minimum 3 Units to maximum 5 units along with defined hour of teaching for each unit.</td></tr>
<tr><td colspan="5"><table>
<tr><th>Units</th><th>Course Content</th><th>Hr. of Teaching</th></tr>
<tr><td>I</td><td>1. Research projects under the guidance of a faculty member.
2. The student has to select a topic for the dissertation from the Core Course (CC). The dissertation includes laboratory/field-based work followed by the submission of the report and presentation.</td><td>24 hr./week</td></tr>
</table></td></tr>
<tr><td>Texts / References</td><td colspan="4"></td></tr>
<tr><td>Learning Outcomes (not more than 100 words)</td><td colspan="4">Students will be learnt to go through the literature/field observations, asking questions, framing objectives, using appropriate methods to carry out experiments, obtaining results, analyzing, discussing the results and preparing their own presentation.</td></tr>
</table>