M. Sc. PHYSICS
DEPARTMENT OF PHYSICS
BANARAS HINDU UNIVERSITY

Semesterwise distribution of Courses and Credits

SEMESTER – I

COURSE	TITLE	CREDITS
MPC-101:	MATHEMATICAL PHYSICS	4
MPC-102:	COMPUTATIONAL PHYSICS	3
MPC-103:	QUANTUM MECHANICS-I	4
MPC-104:	SEMICONDUCTOR DEVICES, INTEGRATED CIRCUITS AND COMMUNICATIONS	3
MPME-101*:	BASIC CONCEPTS IN PHYSICS: SMALL TO LARGE SYSTEMS	3
MPL-101:	ELECTRONICS LABORATORY	4
OR		
MPL-102:	GENERAL PHYSICS & OPTICS LABORATORY	4
MPL-103:	COMPUTATIONAL PHYSICS AND PROGRAMMING LABORATORY	2

*** Not for M.Sc. Physics students**

SEMETER – II

MPC-201:	CLASSICAL ELECTRODYNAMICS AND PLASMA PHYSICS	4
MPC-202:	ATOMIC, MOLECULAR PHYSICS AND LASERS	3
MPC-203:	ELEMENTS OF SOLID STATE PHYSICS	3
MPC-204:	ELEMENTS NUCLEAR PHYSICS	3
MPME-201:	APPLIED RADIATION PHYSICS	3
MPL-202:	GENERAL PHYSICS & OPTICS LABORATORY	4
OR		
MPL-201:	ELECTRONICS LABORATORY	4
MPL-203:	COMPUTATIONAL PHYSICS AND PROGRAMMING LABORATORY	2

SEMESTER - III

COURSE	TITLE	CREDITS
MPC–301:	STATISTICAL MECHANICS I	4
MPC–302:	QUANTUM MECHANICS II	3
MPS–301(A):	ANALOG COMMUNICATION SYSTEMS	4
MPS–301(B):	NUCLEAR PHYSICS:INTERACTIONS & MODELS	4
MPS-301(C):	VIBRATIONAL & ROTATIONAL MOLECULAR SPECTROSCOPY	4
MPS-301(D):	SOLID STATE PHYSICS: CRYSTALLOGRAPHY AND IMPERFECTIONS IN CRYSTALS	4
MPME-301:	EXPERIMENTAL TECHNIQUES FOR ANALYTICAL STUDIES	3
MPE-301:	PLASMA PHYSICS AND SPACE PHYSICS	3
MPE-302:	LASERS AND LASER APPLICATIONS	3
MPE–303:	CHARACTERIZATION OF SOLIDS	3
MPE–304:	MOLECULAR BIOPHYSICS	3
MPE–305:	METHODS IN THEORETICAL PHYSICS	3
MPE-306:	INSTRUMENTATION IN NUCLEAR PHYSICS	3
MPE-307:	SOLAR ENERGY, HYDROGEN ENERGY AND OTHER RENEWABLE ENERGIES	3
MPL-301(A):	ELECTRONICS LABORATORY	6
MPL-301(B):	NUCEAR PHYSICS LABORATORY	6
MPL-301(C):	SPECTROSCOPY LABORATORY	6
MPL-301(D):	SOLID STATE PHYSICS LABORATORY	6

SEMESTER – IV

COURSE	TITLE	CREDITS

MPC-401:	**STATISTICAL MECHANICS II**	**3**
MPS-401(A):	**DIGITAL COMMUNICTION SYSTEMS**	**4**
MPS-401(B):	**PARTICLE PHYSICS**	**4**
	MPS-401(C):MOLECULAR ORBITAL THEORY & ELECTRONICS SPECTRA OF MOLECULES	**4**
MPS-401(D):	**SOLID STATE PHYSICS: SOLID SURAFACES & PROPERTIES**	**4**
MPS-402(A):	**MICROPROSCESSORS AND INTERFACING**	**4**
MPS-402(B):	**WEAK INTERACTIONS & ELECTROWEAK UNIFICATION**	**4**
MPS-402(C):	**PRINCIPLES & INSTRUMENTATION IN CONVENTIONAL & LASER SPECTROSCOPY**	**4**
MPS-402(D):	**SOLID STATE PHYSICS: MANY PARTICLE SYSTEMS**	**4**
MPE-401:	**EXPERIMENTAL TECHNIQUES & INSTRUMENTATION IN ATOMIC, MOLECULAR & OPTICAL PHYSICS**	**3**
MPE–402:	**NANOSCIENCE AND TECHNOLOGY**	**3**
MPE-403:	**PHYSICS OF ELECTRONIC MATERIALS & DEVICES**	**3**
MPE-404:	**SATELLITE COMMUNICATION & REMOTE SENING**	**3**
MPE-405:	**QUANTUM FIELD THEORY:PATH INTEGRAL APPROACH**	**3**
MPE-406:	**LIQUID CRYSTAL**	**3**
MPE-407:	**COMPUTATIONAL METHODS IN PHYSICS**	**3**
MPL-401(A):	**ELECTRONICS LABORATORY**	**6**
MPL-401(B):	**NUCLEAR PHYSICS LABORATORY**	**6**
MPL-401(C):	**SPECTROSCOPY LABORATORY**	**6**
MPL-401(D):	**SOLID STATE PHYSICS LABORATORY**	**6**
MPD-401:	**DISSERTATION**	**2**

SUMMARY OF M.Sc. SYLLABUS IN PHYSICS

Semester	No. of Papers			Credits		
	Theory	Practical	Total	Theory	Practical	Total
I	5	2	7	17	6	23
II	5	2	7	16	6	22
III	5	1	6	17	6	23
IV	4	1	5	14	6	20
Dissertation						2
Total	19+ Dissertation	6	25	64	24	90

MINOR ELECTIVES:

SEMESTER:		**PAPER NO. AND TITLE**	**CREDITS**
I	MPME-101:	BASIC CONCEPTS IN PHYSICS: SMALL TO LARGE SYSTEMS	3
II	MPME-201:	APPLIED RADIATION PHYSICS	3
III	MPME-301:	EXPERIMENTAL TECHNIQUES FOR ANALYTICAL STUDIES	3

SEMESTER – I

MPC-101: MATHEMATICAL PHYSICS **Credits: 4**

Theory of Functions of a Complex Variable:
Analyticity and Cauchy-Reimann Conditions, Cauchy's integral theorem and formula, Taylor's series and Laurent's series expansion, Zeros and singular points, Multivalued functions, Branch Points and Cuts, Reimann Sheets and surfaces, Residues, Cauchy's Residue theorem, Jordan's Lemma; Evaluation of definite integrals, Principal Value, Bromwitch contour integrals.

Fourier and Laplace Transforms:
Fourier transform, Sine, Cosine and Complex transforms with examples, Definition, Properties and Representations of Dirac Delta Function, Properties of Fourier Transforms, Transforms of derivatives, Parseval's Theorem, Convolution Theorem, Momentum representation, Applications to Partial differential equations, Discrete Fourier transform, Introduction to Fast Fourier transform, Laplace transform, Properties and examples of Laplace Transform, Convolution theorem and its applications, Laplace transform method of solving differential equations.

Group Theory:
Concept of a group (additive and multiplicative), Matrix representation of a group, Reducible and irreduciable representation of a group,The Great Orthogonality Theorem

Reference Books:

1. Mathematical Methods for Physicists: Arfken.
2. Mathematics for Physicists and Engineers: Pipes.
3. Mathematical Method of Physics Ghatak.
4. Mathematical Methods for Physics: Wyle.
5. Mathematical Methods in Physical Sciences: Boas.
6. Group Theory: Wigner

MPC-102: COMPUTATIONAL PHYSICS AND PROGRAMMING **Credits: 3**

Fortran:
Flow charts, Algorithms, Integer and floating point arithmetic, Precision, Variable types, Arithmetic statements, Input and output statements, Control statements, Executable and non-executable statements, Arrays, Repetitive and logical structures, Subroutines and functions, Operation with files, Operating systems, Creation of executable programs.

Numerical Methods of Analysis:
Solution of algebraic and transcendental equations: Iterative, bisection and Newton-Raphson methods, Solution of simultaneous linear equations: Matrix inversion method, Interpolation: Newton and Lagrange formulas, Numerical differentiation, Numerical Integration, Trapezoidal, Simpson and Gaussian quadrature methods, Least-square curve fitting, Straight line and polynomial fits, Numerical solution of ordinary differential equations: Euler and Runge-Kutta methods.

Simulation:
Generation of uniformly distributed random integers, Statistical tests of randomness, Monte-Carlo evaluation of integrals and error analysis, Non-uniform probability distributions, Importance sampling, Rejection method, Metropolis algorithm, Molecular diffusion and Brownian motion as random walk problems and their Monte-Carlo simulation.

Reference Books:
1. Computational Methods in Physics and Engineering: Wong.
2. Computer Oriented Numerical Methods: Rajaraman.
3. Computer Programming in FORTRAN 77: Rajaraman.
4. Applied Numerical Analysis: Gerald.
5. A Guide to Monte Carlo Simulations in Statistical Physics: Landau and Binder.
6. Numerical Recipes: Teukolsky, Vetterling and Flannery.

MPC-103: QUANTUM MECHANICS –I **Credits: 4**

Linear Vector and Representation Theory:
Linear vector space, Dirac notations of Bra - Ket notation, Matrix representation of Observables and states, Determination of eigenvalues and eigenstate for observables using matrix representations, Change of representation and unitary transformations, Coordinate and momentum representations, Equations of motion in Schroedinger and Heisenberg pictures.

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-Gordon coefficients, Pauli spin matrices.

Green's Functions:
Green's function method of solving inhomogeneous differential equations, Boundary Conditions, Application to One-dimensional problems.

Scattering Theory:
Differential and total Scattering cross-sections laws, partial wave analysis and application to simple cases; Integral form of scattering equation, Born approximation validity and simple applications.

Approximation Methods:
Time-independent Perturbation theory (non-degenerate and degenerate) and applications to fine structure splitting, Zeeman effect (Normal and anomalous), Stark effect, and other simple cases, Variational method and applications to helium atom and simple cases; WKB approximation and applications to simple cases. Time-dependent Perturbation theory, Fermi's Golden rule, Semi-classical theory of interaction of atoms with radiation.

Reference Books:

1. Quantum Mechanics: L.I. Schiff.
2. Modern Quantum Mechanics: J.J. Sakurai.
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.

MPC-104: SEMICONDUCTOR DEVICES INTEGRATED CICUITS AND COMMUNICATIONS **Credits: 3**

Semiconductor Devices:
Metal/Semiconductor Contact, MOS Junction (Accumulation, Depletion and Inversion).

Integrated Circuits:
Fabrication of ICs (Planar, Monolithic, Active and Passive Including MOS).

Op-Amp (IC-741):
Internal Structure (Block Diagram) Slew Rate, Frequency Response and Compensation, Applications (Linear and Non- Linear).

Timer (IC-555):
Internal Structure (Block Diagram) Operation, Astable, Monostable and Applications.

Phase Locked Loops (IC-565):
Internal Structure (Block) Diagram) Application as Frequency Multiplication, Division FSK and FM Demodulation.

Digital ICs:
TTl, MOS and CMOS Gates, Parrallel Binary adder/subtractor, BCD Addition/Subtraction, Encoder, Decoder, MUX, DE-MUX, Flip-Flops, Shift Resister, Counter, Memory Concept, RAM and ROM. Introduction to Microprocessor 8085.

Communication:

Radio Wave Propagation through Ground, Stratosphere and Ionosphere. Radiation from short electric doublet. Monopole and Dipole Antenna, Antenna parameters, Antenna Arrays.

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.

MPME-101: General Concepts in Physics: Large to Small Bodies **Credit 3**

(This minor elective is open for M.Sc. students of other departments only)

Introduction

Historical Development of Physics; Classification of physics in terms of Length scales, Time scales and Energy scales.

Physics of Large Bodies

Evolution of universe and formation of stars. Newton's law of Gravitation; Planetary motion and Kepler's laws; Galilean relativity and concept of inertial frames. Einstein's theory of special relativity.

Physics of Small Bodies

Failure of classical ideas with examples of blackbody spectrum and Photoelectric effect; Heisenberg's Uncertainty Principle; Wave-particle duality. Double-slit experiment, Stern-Gerlach experiment. Concepts of discrete energy levels and spin. Elementary ideas of Schroedinger's Wave mechanics. Relation between Spin and Statistics; Bose-Einstein and Fermi-Dirac statistics, and Maxwell-Boltzmann statistics as classical limit. Elementary Particles (classification, quantum numbers) and Fundamental Interactions (classification, range, strength).

Reference Books:

1. Remarkable Physicists: From Galileo to Yukawa
2. The Feynman Lectures on Physics
3. Concepts of Modern Physics
4. University Physics

MPL-101: ELECTRONICS LABORATORY **Credits: 4**

Students assigned the electronics laboratory work will perform at least eight (08) experiments of the following:

1. Addition, Subtraction and Binary to BCD conversion
2. JK Flip-Flop and up-down counter
3. Transmission Line Experiment
4. Negative Feedback Experiment
5. Multivibrator
6. Differential Amplifier
7. Op-amps and its application
8. IC 555 Timer
9. Design of CE Amplifier
10. Design of Regulated Power Supply
11. Arithmetic Logic Unit
12. Receiver characteristics

Note: Addition and deletion in the list of experiments may be made from time to time by the department.

MPL-102: GENERAL PHYSICS & OPTICS LABORATORY **Credits: 4**

Students assigned the general laboratory work will perform at least eight (08) experiments of the following:

1. Ionization potential of Lithium
2. Zeeman Effect
3. Dissociation Energy of I_2 molecule
4. Hall Effect
5. Four Probe Method
6. Electron Spin Resonance
7. Telexometer
8. Experiment on high intensity monochromator
9. Faraday Effect
10. Frank-Hertz experment
11. Compton Effect
12. Atomic Spectra of two-Electron Systems

Note: Addition and deletion in the list of experiments may be made from time to time by the department.

MPL-103: COMPUTATIONAL PHYSICS & PROGRAMMING LABORATORY **Credits: 2**

Students assigned the computer laboratory work will perform in Semester - I at least four (04) experiments of the following:

1. Jacobi Method of Matrix Diagonalization
2. Solution of transcendental or polynomial equations by the Newton Raphson method
3. Linear curve fitting and calculation of linear correlation coefficient
4. Matrix summation, subtraction and multiplication
5. Matrix inversion and solution of simultaneous equation
6. Lagrange interpolation based on given input data
7. Numerical integration using the Simpson's method
8. Numerical integrationg using the Gaussian quadrature method
9. Solution of first order differential equations using the Rung-Kutta method
10. Numerical first order differentiation of a given function
11. Fast Fourier Transform
12. Monte Carlo integration
13. Use of a package for data generation and graph plotting.
14. Test of randomness for random numbers generators

Note: Addition and deletion in the list of experiments may be made from time to time by the department.

SEMESTER – II

MPC-201: CLASSICAL ELECTRODYNAMICS AND PLASMA PHYSICS **Credits: 4**

Electrodynamics:

Four Potential and Four Field:
Electromagnetic field Tensor in Four dimensions and Maxwell's Equations, Dual Filed Tensor. Wave Equation for Vector and Scalar Potential and Solution, Retarded Potential and Lienard Wiechert Potential.

Acceleration of Charged Particles:
Electric and Magnetic fields due to a Uniformly Moving charge and An Accelerated Charge, Linear and Circular Acceleration and Angular Distribution of Power Radiated, Bremsstrahlung, Synchrotron Radiation and Cerenkov Radiation, Reaction Force of Radiation, Electromagnetic Mass of the Electron.

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.

Plasma Physics:
Elementary Concepts: Plasma Oscillations, Debye Shielding, Plasma Parameters, Magnetoplasma, Plasma Confinement, Firt, Second, and Third Adiabatic Invariants (Pinch Effect, Magnetic Mirrors), Formation of Van Allen Belt.

Hydrodynamical Description of Plasma:
Fundamental equations, Hydromagnetic Waves: Magnetosonic and Alfven Waves, Magnetoconvection and Sun Spots, Bipolar magnetic Regions and Magnetic Buoyancy, Magnetised Winds (Solar Wind).

Wave Phenomena in Magnetoplasma:
Polarisation, Phase Velocity, Group Velocity, Cut-offs, Resonance for Electromagnetic Wave Propagating Parallel and Perpendicular to the Magnetic Field Propagation at Finite Angle.

Reference Books:

1. Classical Electricity and Magnetism: W.K.H. Panofsky and M. Phillips.
2. Plasma Physics: A Bittencourt.
3. Plasma Physics and Controlled Fusion: F.F. Chen.
4. Classical Electrodynamics: J.D. Jackson.

MPC-202: ATOMIC, MOLECULAR PHYSICS AND LASER **Credits: 3**

Atomic Physics:
Dipole selection rules (examples with derivation), Width and shape of spectral lines, Spin-orbit coupling, Lamb shift and Retherford experiment, Hyperfine structure of lines, Normal and specific mass shifts, excitation and ionization processes in electron-atom collisions, experimental determination of collision cross section, Principle of ESR with experimental setup, chemical shift.

Molecular Physics:
Molecular Orbital and Electronic configuration of Diatomic molecules: H_2, C_2, O_2, NO and CN; Vibrational structure and vibrational analysis, Frank Condon Principle, Dissociation Energy, Rotational Raman spectra and influence of nuclear spin.

Lasers:
Requisites for producing laser light, Role of Plane and Confocal cavity resonators, Longitudinal and transverse cavity modes, Mode selection, Q-switching and Mode locking, Generation of Ultra short Pulses.

Reference Books:

1. Physics of Atoms and Molecules: Bransden and Joachain.
2. Lasers - Theory and Applications: K. Thyagrajan and A.K. Ghatak.
3. Introduction to Atomic Spectra: H.E. White.
4. Introduction to Atomic Spectra: HG Kuhn.

MPC-203: ELEMENTS OF SOLID STATE PHYSICS **Credits: 3**

Structure and Symmetry:
Structural description of liquids and solids (amorphous and crystalline), External symmetry elements and concept of point groups, Direct periodic lattices, Basic concept of aperiodicity, Reciprocal lattice and diffraction conditions and its relation with Brillouin zones, Intensity of Bragg scattering from a unit cell and extinction conditions.

Lattice Vibrations:
Interatomic forces and lattice dynamics of crystals with up to two atoms per primitive basis, Quantization of elastic waves.

Electronic Properties of Solids:
Electrons in periodic potential, Band Theory, Tight Binding, Cellular and Pseudo potential methods, Symmetry of energy bands, density of states, Fermi surface, De Haas von Alfen effect, Elementary ideas of quantum Hall effect, Cyclotron resonance and magnetoresistance,

Introduction to superconductivity.

Reference Books:
1. Introduction of Solids: L.V. Azaroff
2. Crystallography Applied to Solid State Physics: A.R. Verma and O.N. Srivastava
3. Principels of Condensed Matter Physics: P.M. Chaikin and T.C. Lubensky
4. Solid State Physics-Structure and Properties of Materials : M.A. Wahab
5. Solid State Physics: N.W. Ashcroft and N.D. Mermin.

MPC-204: ELEMENTS OF NUCLEAR PHYSICS **Credits: 3**

Detectors and Accelerators:
Outline of interaction of charged particles and of Gamma-rays with matter.
Detectors: Gas Filled counters (ionization Chamber), Scintillation counter, Spark Chambers, Cerenkov detectors.
Accelerators: Ion Sources, Synchrotron, Introduction of Modern Colliders (LHC and RHIC), Storage Ring.

Nuclear Reactions:
Discussion of Direct and Compound nuclear reaction mechanisms, expressions for scattering and reaction cross-sections in terms of partial wave amplitudes, Resonances, Discussions and Applications of Breit-Wigner single-level formula, compound nucleus theory.

Nuclear Decay:
Electromagnetic interactions in nuclei, Multipole transitions in nuclei, Parity and angular momentum selection rules, Internal conversion, Fermi theory of beta-decay, Curie plots, Comparative half life, Allowed and forbidden transitions, Detection and properties of neutrino.

2-Body Problem:
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.

Particle Physics: Basic interactions in nature, Elementary particles, Quantum numbers and conservation laws, Concept of isospin, Quarks and colors, Quark model, Eightfold way, Mesons and Baryons, Bound states and resonance states.

Reference Books:
1. Atomic and Nuclear Physics Vol. II: Ghoshal.
2. Nuclear Structure: Preston and Bhaduri.
3. Nuclear Structure: Pal.
4. Introductory Nuclear Physics: Wong.
5. Nuclear Theory: Elton.
6. Nuclear Interactions: de Benedetti.

MPME-201: APPLIED RADIATION PHYSICS **Credits: 3**

(This minor elective is open to M.Sc. students of Physics as well as other Departments)

Basic Nuclear Processes in Radioactive Sources:
Characteristics of nuclear radiations, alpha decay, beta decay, electron capture, gamma emission, annihilation radiation, neutron sources, source activity, radioactivity decay law, decay chains.

Passage of Radiation through Matter:
The cross section, interaction probability in a distance and mean free path, Stopping power of charge particles-Qualitative discussion of the Bethe-Bloch formula, Radiation length, Range of electrons, Interaction of photons, neutrons and charges particles.

Radiation Protection:

Dosimetric Units: The Roentgen, Absorbed dose, Relative Biological effectiveness (RBE), Equivalent dose, Effective Dose, Typical doses from sources (Natural, Environmental & Medical exposures), Radiation shielding and its safety (Gamma-rays, electrons, positrons, charged particles, Neutrons), Ethics of radiations.

Radiation Effects on Biological Systems:
High doses received in a short time, Low-level doses limits, direct ionization of DNA, radiation damage to DNA, Biological effects (Genetic, Somatic, Cancer and sterlity).

General Characteristics of Detectors:
Sensitivity, Detector response, Energy resolution, Response time, Detector efficiency, Dead time, Ionization mechanism and introductory idea about some detectors.

Reference Books:

1. A Primer in Applied Radiation Physics: F.A. Smith.
2. Introduction to Experimental Nuclear Physics: R.M. Singru.
3. Radiation Biophysics: E.L. Alpen.
4. Atom, Radiation and Radiation Protection: J. Turner.

MPL-201: ELECTRONICS LABORATORY **Credits: 4**

Students assigned the electronics laboratory work will perform at least eight (08) experiments of the following:

1. Addition, Subtraction and Binary to BCD conversion
2. JK Flip-Flop and up-down counter
3. Transmission Line Experiment
4. Negative Feedback Experiment
5. Multivibrator
6. Differential Amplifier
7. Op-amps and its application
8. IC 555 Timer
9. Design of CE Amplifier
10. Design of Regulated Power Supply
11. Arithmetic Logic Unit
12. Receiver characteristics

Note: Addition and deletion in the list of experiments may be made from time to time by the department.

MPL-202: GENERAL PHYSICS & OPTICS LABORATORY **Credits: 4**

Students assigned the general laboratory work will perform at least eight (08) experiments of the following:

1. Ionization potential of Lithium
2. Zeeman Effect
3. Dissociation Energy of I_2 molecule
4. Hall Effect
5. Four Probe Method
6. Electron Spin Resonance
7. Telexometer
8. Experiment on high intensity monochromator
9. Faraday Effect and Kerr Effect
10. Frank-Hertz experiment
11. Compton Effect
12. Atomic Spectra of two-Electron Systems

Note: Addition and deletion in the list of experiments may be made from time to time by the department.

MPL-203: COMPUTATIONAL PHYSICS & PROGRAMMING LABORATORY **Credits: 2**

Students assigned the computer laboratory work will perform in Semester – II at least four (04) experiments (other than what they have done in Semester – I) of the following:

1. Jacobi Method of Matrix Diagonalization
2. Solution of transcendental or polynomial equations by the Newton Raphson method
3. Linear curve fitting and calculation of linear correlation coefficient
4. Matrix summation, subtraction and multiplication
5. Matrix inversion and solution of simultaneous equation
6. Lagrange interpolation based on given input data
7. Numerical integration using the Simpson's method
8. Numerical integrationg using the Gaussian quadrature method
9. Solution of first order differential equations using the Rung-Kutta method
10. Numerical first order differentiation of a given function
11. Fast Fourier Transform
12. Monte Carlo integration
13. Use of a package for data generation and graph plotting.
14. Test of randomness for random numbers generators

Note: Addition and deletion in the list of experiments may be made from time to time by the department.

SEMESTER-III

MPC-301: STATISTICAL MECHANICS – I **Credits: 4**

Review:
Canonical and Grand-Canonical ensembles, Partition function, Thermodynamic Functions, Bose Condensation, Correlation in a Fermi gas.

Quantum Statistical Mechanics:
Density matrices, Density matrix in statistical mechanics, Linear Harmonic and anharmonic oscillators, Wigner's function, Perturbation expansion of the density matrix.

Statistical Mechanics of Interacting Systems:
Cluster expansion for a classical gas, Mayer cluster expansion, Equation of state, Radial distribution function, thermodynamic functions in terms of Radial distribution functions.
Quantum cluster expansion, exact treatment of second virial coefficient. Weakly interacting Bose gas, excitation spectrum, super-fluidity in liquid He II, Low temperature behaviour of Bose and Fermi gases, Ising model, mean-field theory in zeroth and first approximations, exact solution in one dimension.

Reference Books:

1. Statistical Mechanics: Parharia.
2. Statistical Mechanics: Haung.
3. Statistical Mechanics: Ma.
4. Statistical Mechanics: Landau and Lifshitz.

MPC-302: QUANTUM MECHANICS – II **Credits: 3**

Identical Particles:
Permutation symmetry, symmetrization postulates, self consistent field approximation, Slater determinant, Hartree Fock method.

Relativistic Quantum Mechanics:
Klein Gordon equation, Dirac equation, negative energy solutions, antiparticles, Dirac hole theory, Feynman interpretation of antiparticles, Gama-matrics and their properties, Convariance of Dirac equation, Charge conjugation, Parity & Time reversal invariance, Bilinear covariants, Plane wave solution, Two component theory of neutrino, Spin & Helicity, Relativistic Hydrogen atom problem.

Field Quantization:
Lagrangian density and equation of motion for field, Symmetries and conservation laws, Noether's theorem, cononical quantization of scalar field, Complex scalar field, electromagnetic field and Dirac field, Problem in quanitizing electromagnetic field, Gupta & Bleuler method, Feynman rules (without derivation), Feynman diagrams.

Reference Books:

1. Relativistic Quantum Mechanics: J.D. Bjorken and S.D. Drell.
2. Relativistic Quantum Fields: J.D. Bjorken and S.D. Drell.
3. A First Book on Quantum Field Theory: Amitabha Lahiri and P.B. Pal.
4. Introduction to QFT: F. Mandle and G. Shaw.
5. Modern Quantum Mechanics: J.J.Sakurai.
6. Principles of Quantum Mechanic: R. Shankar.

MPS-301 (A): ANALOG COMMUNICATION SYSTEMS **Credits: 4**

Microwave Electronics:
Microwave characteristic features & Application, Waveguides and Cavity Resonators, Two cavities Klystron, Reflex Klystron, Semiconductor Gunn diode characteristics. Microwave antenna, Detection of microwave, Dielectric constant measurement, Isolator and circulator, PIN diode modulator, Directional coupler.

Radar Communication:
Basic Radar systems, Radar range equation and performance factor, Radar Cross-section, Pulsed Radar system, Duplexer, Radar Display, Doppler Radar, CWIF Radar, FMCW Radar, Moving Target Indicator (MTI), Blind Speeds.

Analog Signal Transmission:
Introduction, Amplitude, Frequency & phase modulation, AM, FM, Modulating and Demodulating circuits, AM, FM Receivers functioning (BLOCK diagram) and Characteristic Features, Pulse modulation, Sampling processes, PAM, PWM and PPM modulation and demodulation, Quantization processes, Companding and Quantization noise, PCM, Differential PCM and Delta Modulation systems, Comparison of PCM and DM, Time division multiplexing.

Satellite Communication:
Principle of Satellite Communication, Satellite frequency allocation and band spectrum, Satellite orbit, trajectory and its stability, Satellite link design, Elements of Digital Satellite Communication, Multiple Access technique, Antenna system, Transponder, Satellite Applications.

Reference Books:

1. Communication System: Simon Haykin.
2. Electronics communication: Roddy and Coolen.
3. Microwave and Radar Engineering: M. Kulkarni.
4. Digital and analog communication systems : K.San Shanmugam.
5. Satellite Communication: Pratt and Bostiern.
6. Microwave: K.C. Gupta

MPS-301(B): NUCLEAR PHYSICS: INTERACTIONS AND MODELS **Credits: 4**

N-N interaction:
Phenomenological N-N Potentials (Soft core & hard core) and meson theoretical potentials, Polarization in N-N scattering.
Probing charge distribution with electrons, Form factors, Proton form factors, Qualitative ideas on deep inelastic electron-proton scattering, Bjorken scaling and the parton model, Quark structure of the nucleon.

Nuclear Models:
Single particle model of the nucleus, Angular momenta and parities of nuclear ground states, Qualitative discussion and estimates of transition rates, Magnetic moments and Schmidt lines.

Classification of shells, Seniority, Configuration mixing, Pairing Force theory, Simple description of Two-particle shell model spectroscopy.
Deformable liquid drop and nuclear fission, Collective vibrations and excited states, Permanent deformation and collective rotations: Energy levels and electromagnetic properties of even-even and odd-A deformed nuclei, Nilsson model and equilibrium deformation, Coulomb Excitation Studies, Behaviour of Nuclei at high spin, Back-bending.

Reference Books:

1. Atomic and Nuclear Physics Vol. II: Ghoshal.
2. Nuclear Structure: Preston and Bhaduri.
3. Nucleon-nucleon Interaction: Brown and Jackson.
4. Introductory Nuclear Physics: S.S.M. Wong.
5. Nuclear Structure: M.K.Pal.

Credits: 4

MPS-301(C): VIBRATIONAL AND ROTATIONAL MOLECULAR SPECTROSCOPY

Symmetry and Group Theoretical Treatment:
Molecular symmetry and Group Theory, 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, Infrared and Raman Selection rules, Overtone and Combination Bands, Vibrational Potentials with more than one minimum. Qualitative treatment of inversion vibrations and Torsional vibrations.

Vibration-Rotation Energy Levels and Spectra:
Rotational Energy of Spherical, Prolate and Oblate Symmetric Rotors, Rotational Raman and IR Spectra of linear molecules and Determination of their Geometry. Rotation-Vibration Band of a Diatomic Molecule, Parallel and Perpendicular type Bands in Linear and symmetric Rotor Molecules. Qualitative description of Type A, B and C bands in Asymmetric Rotor Molecules.

Reference Books:

1. Chemical Applications of Group Theory : F.A. Cotton.
2. Fundamentals of Molecular Spectroscopy : C.N. Banwell.
3. Introduction to Molecular Spectroscopy : G.M. Barrow.
4. Modern Spectroscopy : J.M. Hollas.

MPS – 301(D): SOLID STATE PHYSICS: CRYSTALLOGRAPHY AND IMPERFECTION IN CRYSTALS **Credits: 4**

Crystallography:
Elementary concepts of space group and its relevance to crystal structure. Principle of Powder diffractometer, Interpretation of powder photographs, Analytical indexing: Ito's methods. Accurate determination of lattice parameters – least-square method. Retvil analysis, Application of powder method.
Interpretation of oscillation photograph, X-ray method of orienting crystals about a crystallographic direction, Bernal chart, Indexing of reflections, Buerger's precession method.
Determination of relative structure amplitudes from measured intensity (Lorentz and Polarization factors), Fourier representation of electron density, The phase problem, Patterson function.

Imperfection of Crystals:
Mechanism of plastic deformation in solids, Stress and strain fields of screw and edge dislocations, Elastic energy of dislocations, Forces between dislocations, Stress needed to operate Frank-Read source, Dislocations in fcc, hcp and bcc lattices, Partial dislocations and stacking faults in close-packed structures.
Experimental method of detecting dislocations and stacking faults, Electron Microscopy: Kinematical theory of diffraction contrast and lattice imaging.

Reference Books:

1. Crystallography for Solid State Physics: Verma and Srivastava.
2. X-ray Crystallography: Azarof.

3. Elementary Dislocation Theory: Weertman and Weertman.
4. Crystal Structure Analysis: Buerge.
5. Electron Microscopy of Thin Crystals: Hirsh.

MPME-301: EXPERIMENTAL TECHNIQUES FOR ANALYTICAL STUDIES Credits: 3

(This minor elective is open to M.Sc. students of Physics as well as other Departments)

Spectroscopic Techniques:
Dispersing devices and detectors: Dispersion and resolution of a prism and a grating spectrometer, Single and double monochromators, Photomultiplier tube, Charge coupled detectors (CCD).

UV and Visible absorption spectroscopy, IR and Raman spectroscopy: Identification of groups, hydrogen bonding and study of conformers, Time–resolved spectroscopy and study of biological samples.

Qualitative and quantitative analysis of trace elements.

Basics of nuclear magnetic resonance (NMR) and electron spin resonance (ESR) spectroscopy, Mössbauer spectroscopy, Microwave spectroscopy, Photoacoustic spectroscopy and their applications.

Laser as a source of radiation and its characteristics, Laser fluorescence and absorption spectroscopy, Multi-photon ionization and separation of isotopes.

Structural Characterization Techniques:
Microstructural characterization, Basics and applications of Scanning electron microscopy (SEM), Biological applications of scanning probe microscopy, Confocal microscopy, Focussed ion beam system.

Reference Books:
1. Spectroscopy Volume 1, 2 and 3: B.P. Straughan and S. Walker.
2. Modern Spectroscopy: J.M. Hollas.
3. Transmission Electron Microscopy of Metals: Gareth Thomas
4. Elements of X-ray Diffraction: Bernard Dennis Cullity.
5. Atomic Force Microscopy/Scanning Tunneling Microscopy: M.T. Bray, Samuel H. Cohen and Marcia L. Lightbody.

MPE-301: PLASMA AND SPACE PHYSICS **Credits: 3**

Plasma Physics:
Trapped Particle Motion:
Collisions, Conductivity, Diffusion along and across magnetic field, convection electric field, Ring current.

Multifluid Theory:
Equation of state, Frozen in Field concept, Stationarity & Equilibria, MHD waves in Dipolar Magnetic Field, Sources of wave energy and instabilities.

Kinetic theory of Plasma:
Boltzmann-Vlasov Equation, Transport Equation, Landau Damping, Collision Damping, Wave Amplification, Role of magnetic field, Wave in Planetary Magnetosphere.

Space Physics:

Solar Phenomena:

Structure of the Sun, Solar Activity, Prominences, Coronal Heating, Solar Flares.

Solar Wind:
Properties, solar wind formations, Interaction of Solar Wind with Magnetized and Unmagnetized Planets.

Magnetophere:
Magnetopause, Magnetotail, Magnetic reconnection, Magnetosphere, Plasma flow in the magnetosphere.

Ionosphere:
Structure, Ionospheric Irregularities, Aurora, Borealis, Magnetosphere- Ionosphere coupling.

Reference Books:

1. Basic Space Plasma Physics: W. Baumjohau and R. A. Treumann.
2. Introduction to Space Physics: Edited by M. G. Kevilson and C. T. Russell.
3. Space Plasma Physics: A.C. Das.
4. Plasma Physics and Introductory Courses: Edited by Rechered Dendy.
5. Introduction of Plasma Physics: R.J. Goldston and P.H. Rutherford.

MPE-302: LASERS AND LASER APPLICATIONS **Credits: 3**

Basic Principle and Different Lasers:
Principle and Working of CO_2 laser and Qualitative Description of Longitudinal and TE laser systems. Threshold condition for Oscillation in Semiconductor Laser. Homostructure and Heterostructure p–n junction lasers, Nd-YAG lasers. Principle of Excimer Laser. Principle and Working of Dye Laser. Free Electron Laser.

Non Linear Processes:
Propagation of Electromagnetic Waves in Nonlinear medium, Self Focusing, Phase matching condition, Fiber Lasers, Stimulated Raman Scattering and Raman Lasers, CARS, Saturation and Two photon Absorptions.

Novel Applications of Laser:
Cooling and Trapping of Atoms, Principles of Doppler and Polarization Gradient Cooling, Qualitative Description of Ion Traps, Optical Traps and Magneto-Optical Traps, Evaporative Cooling and Bose Condensation.

Reference Books:

1. Laser Spectroscopy and Instrumentation : W. Demtroder.
2. Principles of Lasers : O. Svelto.
3. Laser Cooling and Trapping : P.N. Ghosh.
4. Frontiers in Atomic, Molecular and Optical Physics : S.P. Sengupta.

MPE-303: CHARACTERIZATION OF SOLIDS **Credits: 3**

Structural Characterization:
Intense X-ray Sources : Synchrotron Radiation, General theory of X-ray scattering and diffraction, Reciprocal space of perfect and imperfect crystals, X-ray diffraction characterization of imperfections in crystals, Basic concepts of small angle X-ray scattering and its application in evaluation of shape and size of surface particles. Neutron scattering and diffraction with reference to light elements and magnetic structures.

Electronic Characterization:
LEED (Low Energy Electron Diffraction) for Surface Structure, Surface Topography, Elementary Concepts of Scanning and Scanning Tunneling Microscopic Techniques (SEM, STM) X-ray Photoelectron Spectroscopy (XPS/ESCA) for chemical analysis. Methods.RBS (Rutherford Back Scattering) and SIMS (Secondary Ion Mass Spectroscopy). Defect related electronic states characterization by C-V characteristics of electronic junction devices, Temperature stimulated current and capacitance (TSC/TSCAP), Deep Level Transient Spectroscopy (DLTS), Electronic Beam Induced Current (EBIC) and Light Beam Induced Current (LBIC).

Spectroscopic Characterization:
Double Beam IR Spectrometers, Basic Concepts of Raman Spectroscopy in Solids, Sensitive Detectors such as CCD Camera, Concept of Space Group and Point Group, Identification and Analysis of Optic and Acoustic Modes in Solids. Electronic Absorption Study for Band Gap Determination.

Reference Books:

1. Analytical Techniques for Thin Film - Treatise on Material Science and Technology, Vol. 27: K.N. Tu and R. Rosenberg (ed.).
2. Electron Microprobe Analysis: S.J. B. Reed.
3. Topics in Applied Physics, Vol. 4: R. Gomer (ed.).
4. Analysis of High Temperature Materials: O. Van Der Biest (ed.).

MPE-304: MOLECULAR BIOPHYSICS **Credits: 3**

Basic Concepts in Biophysics:

Elementary ideas about the DNA structure, sugar-phosphate backbone, nucleosides and nucleotides, three-dimensional DNA structure, RNA. Proteins: primary, secondary, tertiary and quaternary structures, enzymes and their catalytic activity, DNA and protein folding, DNA denaturation, replication, mutation, intercalation, neurotransmitters, membranes.

DNA and its Role:

Forces stabilizing DNA and protein structure, Theoretical quantum chemical and molecular mechanical methods, Treatment of intermolecular interactions, conformations, hydrogen bonding, stacking and hydrophobic interactions, importance of electrostatic interactions, biomolecular recognition, drug design.

Experimental Techniques:

Application of experimental techniques of light scattering, absorption and fluorescence spectroscopy, Nuclear magnetic resonance, Interaction of UV radiation with DNA, Photodimerization, Photodynamic action.

Reference Books:

1. Essentials of Biophysics: P. Narayanan.
2. Basic Molecular Biology: Price.
3. Quantum Mechanics of Molecular Conformations: Pullman (Ed.).
4. Non-linear Physics of DNA: Yakushevich.
5. Biological Physics: Nelson.

MPE-305: METHODS IN THEORETICAL PHYSICS **Credits: 3**

Path-integral Formalism:
Path-integral formalism in Quantum mechanics, applications to free particle and linear harmonic oscillator; Connection with statistical mechanics.

Foundations in Quantum Mechanics:
Statistical interpretation of Schrodinger's wave functions, Hidden variable and Copenhagen interpretation; EPR paradox and Bell's theorem; Geometrical phase and Aharanov-Bohm effect; Quantum measurement, No-clone theorem, schrodinger's Cat and Quantum Zeno paradox.

General theory of Relativity and Cosmology:
Tensors, metrics and geodesics, dyadics, covariant and contravariant derivatives, Christoffel's symbol and Levi-civita symbol; Einstein's equation and Schwarzchild's solution; Applications in cosmology, Black-holes.

Constraints and Gauge Theory:
Hamilton Method, Constraints (first class and second class); Gauge theory, gauge invariance and related physics.

Reference Books:

1. Techniques and Applications of Path Integration: L.S. Schulman.
2. Introduction to Quantum Mechanics: D.J. Griffiths.
3. Gravitation and Cosmology: S. Weinberg.
4. Classical Dynamics: E.C.G. Sudarshan and N. Mukunda.
5. Lectures on Quantum Mechanics: P.A.M. Dirac.

MPE-306: INSTRUMENTATION IN NUCLEAR AND PARTICLE PHYSICS Credits: 3

Standard Radioactive Sources:
Units, Fast Electron, Heavy Charged Particle, Radiation, Neutron Sources, Biological effects of Radiation, Quantification of Dose Type of Exposure, maximum permissible dose rate.

General Properties of Radiation Detectors:

Simplified detector model, Current and pulse modes of operation, pulse heigh spectra, counting curves and plateaus, energy resolution, detection efficiency, dead time. Device impedances, coaxial cables, Pulse shaping. General characteristics of single & multi-channel methods, spectrum stabilization and computerized spectrum analysis.

Linear and Logic Pulse Functions:
Fast and slow pulses, Linear and logic pulses, instrument standards, Function of pulse processing units, components common to many applications, pulse counting systems, pulse height analysis systems, systems involving pulse timing and pulse shape discrimination.

Background and Detector Shielding:
Sources of background, Background in Gamma ray spectra, Active methods of background reduction, shielding consideration against radiation from an accelerator and radioactive sources.

Counting Statistics and Error Estimation:
Characterization of data, statistical models and applications, error propagation, optimization of counting experiments, and distribution of time intervals.

Reference Books:

1. Radiation Detection and Measurement: G.F. Knoll.
2. Nuclear Physics Techniques: W.R. Leo.
3. Introduction to Nuclear and Particle Physics(2nd Edition): A Das and T. Ferbel.

MPE-307: SCIENCE AND TECHNOLOGY OF SOLAR ENERGY, HYDROGEN AND OTHER RENEWABLE ENERGIES **Credits: 3**

Solar Energy: Fundamental and Material Aspects:
Fundamentals of photovoltaic Energy Conversion Physics and Material Properties, Basic to Photovoltaic Energy Conversion: Optical properties of Solids. Direct and indirect transition semiconductors, interrelationship between absorption coefficients and band gap recombination of carriers.

Solar Energy: Different Types of Solar Cells:
Types of Solar Cells, p-n junction solar cell, Transport Equation, Current Density, Open circuit voltage and short circuit current, Brief description of single crystal silicon and organic and Polymer Solar Cells, Elementary Ideas of Advanced Solar Cells e.g. Tandem Solar cells, Solid Liquid Junction Solar Cells, Nature of Semiconductor, Principles of Photo-electrochemical Solar Cells.

Hydrogen Energy: Fundamentals, Production and Storage:
Relevance in relation to depletion of fossil fuels and environmental considerations. Solar Hydrogen through Photoelectrolysis, Physics of material characteristics for production of Solar Hydrogen. Brief discussion of various storage processes, special features of solid hydrogen storage materials, Structural and electronic characteristics of storage materials. New Storage Modes.

Hydrogen Energy: Safety and Utilization:
Various factors relevant to safety, use of Hydrogen as Fuel, Use in Vehicular transport, Hydrogen for Electricity Generation, Fuel Cells, Various type of Fuel Cells, Applications of Fuel Cell, Elementary concepts of other Hydrogen- Based devices such as Hydride Batteries.

Reference Books:

1. Solar Cell Devices-Physics :Fonash
2. Fundamentals of Solar Cells Photovoltaic Solar Energy :Fahrenbruch & Bube
3. Phoptoelectrochemical Solar Cells: Chandra
4. Hydrogen as an Energy Carrier Technologies Systems Economy : Winter & Nitch (Eds.)
5. Hydrogen as a Future Engery Carrier : Andreas Zuttel, Andreas Borgschulte and Louis Schlapbach

MPL-301(A): Electronics Laboratory **Credits: 6**

Students will be required to perform six (06) experiments of the following:

1. Microwave characteristics and measurements

2. Nonlinear applications of Op amplifier
3. PLL characteristics and its applications
4. PAM, PWM and PPM Modulation and demodulation.
5. PCM / delta modulation and demodulation
6. Fiber optic communication
7. Experiments on MUX, DEMUX, Decoder and shift register
8. Arithmetic operations using microprocessors 8085 / 8086
9. D/A converter interfacing and frequency / temperature measurement with microprocessor 8085 / 8086
10. A/D converter interfacing and AC/DC voltage / current measurement using microprocessor 8085/8086
11. PPI 8251 interfacing with microprocessor for serial communication.
12. Assembly language program on P.C

Note: Addition and deletion in the list of experiments may be made from time to time by the department.

MPL-301(B): Nuclear Physics Laboratory ***Credits: 6***

Students will be required to perform seven (07) experiments of the following:

1. Gamma - Ray Spectroscopy Using NaI (Tl) detector
2. Alpha Sepctroscopy with Surface Barrier Detector
3. Determination of the range and energy of alpha particles using spark counter
4. Study of gamma ray absorption process
5. X-Ray Fluorescence
6. Neutron Activation Analysis Measurement of the Thermal Neutron Flux
7. To Study the Solid State Nuclear Track Detector
8. Fission Fragment Energy Loss Measurements from Cf^{252}
9. Gamma - Gamma Coicidence studies
10. Compton Scattering: Energy Determination
11. Compton Scattering: Cross-Section Determination
12. Determination of energy of mu-mesons in pi-decay using Nuclear Emulsion Technique
13. Identification of particles by visual range in Nuclear Emulsion
14. Study of Rutherford Scattering

Note: Addition and deletion in the list of experiments may be made from time to time by the department.

MPL-301(C): SPECTROSCOPY LABORATORY ***Credits: 6***

Students will be required to perform six (06) experiments of the following:

1. Verification of Hartmann formula for prism spectrogram
2. Measurement of optical spectrum of an alkali atom
3. Determination of metallic component of an inorganic salt
4. Emitter of electric discharge through air in a tube with minute leak
5. Emitter of electric discharge through air in an evacuated tube
6. Measurement of optical spectrum of alkaline earth atoms
7. Measurement of Band positions and determination of vibrational constants of AlO molecule
8. Measurement of Band positions and determination of vibrational constants of N_2 molecule
9. Measurement of Band positions and determination of vibrational constants of CN molecule
10. Measurement and analysis of fluorescence spectrum of I_2 vapour
11. Determination of characteristic parameters of an optical fiber
12. Measurement of Raman spectrum of CCl_4.

Note: Addition and deletion in the list of experiments may be made from time to time by the department.

MPL-301(D): SOLID STATE PHYSICS LABORATORY **Credits: 6**

Students will be required to perform five (05) experiments of the following:

1. Measurement of lattice parameter and indexing of powder photograph
2. Identification of unknown sample using powder diffraction method.
3. To study the ferroelectric transition in TGS crystal and measurement of Curie temperature
4. To measure the superconductivity transition temperature and transition width of a high temperature superconductor
5. Rotation / oscillation photograph and their interpretation
6. To study the modulus of rigidity and internal friction in a metal as a functioning temperature
7. To measure the Cleavage step height of a crystal by multiple Fizeau Fringes
8. To determine magnetoresistance of a Bismrith crystal as a function of magnetic field
9. Synthesis/Fabrication of Cabon Nanotubes by Spray Pysolysis method and its verification through x-ray diffraction.

Note: Addition and deletion in the list of experiments may be made from time to time by the department.

SEMESTER – IV

MPC-401: STATISTICAL MECHANICS – II **Credits: 3**

Critical Phenomena and Phase Transition**:**

Phase transitions and thermodynamic functions. Thermodynamic limit and its importance. Mean field theory, Landau theory. Correlation functions, Ornstein-Zernike theory, Critical behaviour, Critical exponents, Scaling and Universality, Upper and lower critical dimensions. Renormalization group: basic idea, flows, fixed points, Application to 2-d Ising and Potts models.

Time Dependent Phenomena:

Dynamic correlation and response functions. Example of damped harmonic oscillator. Diffusion. Brownian motion and Langevin equations.Correlation and response of damped Brownian oscillator. General properties of correlation and response functions, Linear response theory. Dissipation: The fluctuation-dissipation theorem, The Kubo formula, Fokker-Planck Equation.

Reference Books:

1. Statistical Mechanics: Patheria.
2. Statistical Physics I and II: Kubo, Toda and Ashitsume.
3. Modern Theory of Critical Phenomena: Ma.
4. Statistical Mechanics: Landau and Lifshitz.
5. Lectures on Phase Transitions and Rnormalization Group: Goldenfeild.

MPS-401(A): DIGITAL COMMUNICATION SYSTEMS **Credits: 4**

Signals, Systems and Noise:

Elements of communication systems, Fourier representation of periodic and non-periodic signals, Power spectral density, Impulse and step response of systems, Time and frequency domain analysis of systems, Ideal and Real filters, Noise in communication systems, Representation of narrow band noise, Signal to noise ratio, Noise equivalent band width and noise figure.

Information Theory and Coding:

Introduction, Amount of information, Average information, Shannon's encoding algorithm, Communication channels, Rate of information and capacity of discrete memoryless channels, Shanon-Hartley theorem. Linear block codes, Binary cyclic codes and Convolutions codes.

Digital Signal (Data) Transmission:

Introducation, Base band and pass band data transmission. Base band binary PAM system, Optimum receiver for binary digital modulation schemes, Binary ASK, FSK PSK and differential PSK signaling schemes. Brief idea about M-ary signaling schemes, Serial data communication in computers, USART 8251, MODEM.

Fiber Optic Communication:
Basic optical communication system, wave propagation in optical fiber media, step and graded index fiber, material dispersion and mode propagation, losses in fiber, optical fiber source and detector, optical joints and coupler. Digital optical fiber communication system, First/Second generation system, Data communication network.

Reference Books:

1. Digital and Analog Communication Systems: K. San Shanmugam.
2. Communication Systems: Simon Haykin.
3. Optical Fibre Communication: Kaiser.

MPS-401(B): PARTICLE PHYSICS **Credits: 4**

Particle Phenomenology:
Invariance and conservation laws in relation to particle reactions and decays. Elementary ideas of C, P and T symmetries. Pion-nucleon scattering, isospin analysis and phase shifts, resonances and their quantum numbers, Production and formation experiments, Relativistic kinematics & invariants, Mandelstam variables, Phase space, Decay of one particle into three particles, Dalitz Plot.

Strong Interactions and Symmetries:
Uses of symmetry, space time and internal symmetries, Lie groups generators and Lie algebra, Casimir operators, SU(2) irreducible representation, weight diagram, diagonal generators, SU(3) generators, U and V spin, Raising and Lowering operators, Root diagram, Weight diagram, Dimensionality multiplets of SU(n), Baryons and meson multiplets, Symmetry breaking and Gell-Mann-Okubo mass formula, Decays in terms of Quark Model.

Physics of Quarks and Gluons:
Charm, bottom and top quarks and higher symmetry. Quark-Gluon interaction, Experimental tests of Quantum Chromodynamics. Particle Physics and Thermodynamics in the early Universe. Quark-Gluon Plasma. Stellar evolution and Element Synthesis.

Reference Books:

1. Nuclear and Particle Physics: W. Burcham and M. Jobes.
2. Quarks and Leptons: Halzen and Martin.
3. Unitary symmetry and Elementary Particles: D.B.Lichtenberg.
4. Symmetry Principles in particle Physics: Emmerson.
5. Introduction to High Energy Physics: Perkins.
6. Particles and Nuclei: B. Povh, K. Rith, C. Scholz and F. Zetsche.

MPS-401(C): MOLECULAR ORBITAL THEORY AND ELECTRONIC SPECTRA OF MOLECULES **Credits: 4**

Atomic and Molecular Orbital Theories:
Elementary idea of Atomic Orbitals in Hartree-Fock Theory, Qualitative description of ab-initio methods, LCAO treatment of H_2^+ and H_2 molecules. Molecular charge distribution and Dipole moment. Molecular Electrostatic Potential. Hellman-Feynman Theorem and concept of force. Hybrid Atomic Orbitals in H_2O, CH_4, C_2H_2, and C_2H_4. Concept of lone pairs. Huckel method and its application to Ethylene, Butadiene and Benzene. Changes in molecular geometry on electronic excitation.

Spectroscopy of Diatomic and Poluatomic Molecules:
Coupling of Electrtonic and Rotational motion in Diatomioc Molecules and Rotational structure of $^1\pi$ - $^1\Sigma$ and $^1\Sigma$-$^1\Sigma$ transitions. Vibronic interaction and Herzberg Teller theory for absorption spectrum of benzene vapour.

Single vibronic level spectroscopy and lifetime of vibronic levels in benzene, Quantum yield, Kasha Rule and the concept of nonradiative transitions in molecules. Jablanski diagram and qualitative treatment of small molecule and large molecule limit for nonradiative transitions.

Reference Books:

1. Molecular Orbital Theory: A. Streitweiser.
2. Valence : C.A. Coulson.
3. High Resolution Spectroscopy: J.M. Hollas
4. Laser Spectroscopy and Instrumentation: W. Demtroder.

MPS – 401(D): SOLID STATE PHYSICS: SPECIAL SOLIDS, SURFACES AND PROPERTIES Credits: 4

Aperiodic and Semiperiodic Systems:
Structure and symmetries of liquids, Liquid crystals and amorphous solids. Aperiodic solids and quasicrystals; Fibonaccy sequence, Penrose lattices and their extension to 3-dimensions.

Films and Surface:
Electrical conductivity of thin films, Difference of behaviour of thin films from bulk, Boltzmann Transport equation for a thin film (for diffused scattering), Expression for electrical conductivity.
Elementary concepts of surface crystallography, scanning tunneling and atomic force microcopy.

Magnetic Properties:
Weiss theory of ferromagnetism, Heisenberg model and molecular field theory, Spin waves and magnons, Curie-Weiss law for susceptibility, Ferri and antiferro-magnetic order, Domains and Bloch-wall energy.

Photonic Solids: Fabrication and properties.

Reference Books:

1. Solid State Physics: Kittel.
2. Thin Films: Heavens.
3. Physics of Thin Films: Chopra.
4. Solid State Physics : N.W. Aschroft and N.D. Mermiu

MPS -402(A): MICROPROCESSORS AND INTERFACING **Credits: 4**

Intel 8085:
Internal operation of Intel 8085. Instructions, Opcodes, operands and mnemonics. Constructing machine language codes for instructions, Instruction execution timing diagram. Instruction word size and addressing modes, Instruction set. Stacks subroutines and Interrupts, Machine and assembly language programming.

Intel 8086:
Architecture, Pin description for minimum and maximum modes, Internal operation, Instruction execution timing diagram, Addressing modes. Instruction format for constructing machine language codes for different instructions. Introduction to assembly language. Instruction set and directives, Stacks, Procedures, Macros and interrupts. Flow chart of standard programming structures. I/O interfacing and data transfer scheme.

Advanced Microprosessors:
Multitasking, Architecture and memory management of microprocessor 80286, Brief idea about architecture of microprocessor 80386, 80486 and Pentium, Introduction to Microcontroller.

Microprocessor based Measurement/Control Circuits:
Transducers, D/A and A/D Converters, PPI 8255 Data acquisition and storage, Microprocessor based traffic light controller, Temperature and water label indicator/ controller. DC and steper motor speed measurements, Waveform generation and frequency measurement.

Reference Books:

1. Fundamentals of Microprocessors and Microcomputers: B. Ram.
2. Microprocessor System the 8086 /8088 Family: Liu and Gibson.
3. Microprocessor, Architecture, Programming and Application: R.S. Goonkar.
4. Introduction to Microprocessor: A.P. Mathur.
5. Microprosessor and Interfacing: D.V. Hall.

MPS-402(B): WEAK INTERACTIONS AND ELECTROWEAK UNIFICATION Credits: 4

Weak Interactions:
Leptonic, semileptonic and nonleptonic weak decays. Selection rules, Nuclear Beta decay and form of current-current interaction, Feynman Diagrams, V-A theory, Fermi and G-T selection rules, Parity violation in weak interaction, (Cobalt Sixty Experiment) Neutrino Oscillation and Mixing, Detection of Neutrinos, Decay of Pions and Muons, Calculation of Lifetime for Pions and Muons, Universal Fermi Interaction, Strangeness Oscillations, Regeneration and CP-Violation in Kaon Decay.

Unification of Interactions:
General idea of electro-weak unification, Experimental Evidence of Electro-Weak Unification, Non-Abelian Gauge Field Theory, Spontaneous Symmetry Breaking, Higgs Mechanism, Goldstone Theorem, A Brief Review of Salam-Weinberg-Glashow Model.

Reference Books:

1. Nuclear and Particle Physics: W.E. Burcham and M.Jobes.
2. Introduction to Elementary Particles: Griffths.
3. Quarks and Leptons: Halzen and Martin.
4. Gauge Theory of weak Interactions: Greiner and Muller.

MPS-402 (C): PRINCIPLES AND INSTRUMENTATION IN CONVENTIONAL AND LASER SPECTROSCOPY

Credits: 4

Light Sources, Detectors and Spectroscopic Techniques:
Synchrotron Radiation Source, Dye Laser as a versatile spectroscopic light source, Grating spectrographs and spectrometers based on Czerry-Turner and Ebert mountings. Thermal Detector, Photodiode, Photomultiplier Tube, Channel Electron Multiplier, Charge coupled detector. Principle and Working of a Double Beam infrared spectrophotometer, Raman Spectrometer. Principle and Working of Fourier Transform Spectrometers. Photoacoustic Spectroscopy, Matrix Isolation Spectroscopy.

Non-Conventional Spectroscopic Techniques:
Two-photon spectroscopy, Saturation Spectroscopy, CARS, Experimental techniques of MPI spectroscopy, Optogalvanic spectroscopy and Supersonic Beam Spectroscopy with emphasis on measurement of molecular parameters.

Reference Books:

1. Laser Spectroscopy : W. Demtroder.
2. High Resolution Spectroscopy : J. M. Hollas.
3. Spectrophysics : A. Thorpe.

MPS-402 (D): SOLID STATE PHYSICS: MANY PARTICLE SYSTEMS **Credits: 4**

Interacting Electron Gas:
Hartree and Hartree-Fock Methods, Correlation Energy, Screening, Plasma Oscillations, Dielectric Functions and its Properties, Friedel Oscillations.

Electron-Phonon Interactions:
Interaction of Electron with Acoustic and Optical Phonons, Long Wavelength Limit of Optical Phonons and Crystal Polarization, Polarons, Cooper Pairing due to Phonon, BCS Theory of Superconductivity, Ginzberg-Landau Theory of Superconductivity and Application to type II superconductors, Vortices and Abrikosov Phase.

Optical Properties:
Interactions of Electrons and Phonons with Photons, Direct and Indirect Transitions, Polaritons.

Electron Localiztion in Disordered System:
Electron Localization, Density of States, Mobility Edge, Anderson Model and Mott's Localization, Hopping Conductivity.

Reference Books:

1. Introduction to Solid State Physics: Madelung.
2. Quantum Theory of Solid State: Callaway.
3. Quantum Theory of Solid State: Kittel.

MPE-401: EXPERIMENTAL TECHNIQUES AND INSTRUMENTATION IN ATOMIC, MOLECULAR AND OPTICAL PHYSICS **Credits: 3**

Experimental Techniques:

AES (Auger electron spectroscopy), PES (Photo electron spectroscopy), EELS (Electron energy loss spectroscopy), PIXE (Particle induced x-ray emission), BFS (Beam-foil spectroscopy), TOF (Time-of-flight) spectroscopy, SRS (Synchrootron radiation spectroscopy), technique of coincidence detection, High vacuum generation, Ultra-fast pulse generation and detection.

Instrumentation:

Principle and working of CEM (Channel electron multiplier), MCP (one-and two-dimensional micro-channel plates), PMT (Photo-multiplier tubes), SBD (Surface barrier detectors), Si(Li), HPGe, NaI photon detectors, electrostatic and magnetic charged particle energy analyzers (45^o-parallel plate, and cylindrical mirror analyzer (CMA), TOF-spectrometer, MCA (multi-channel analyzer), TAC (Time-to amplitude converter), CFD (Constant fraction discriminator), ionization pressure gauges (Pirani and Penning).

Reference Books:

1. Electron Spectroscopy: Theory, Techniques and Applications: CR Brundle and AD Baker.
2. Synchrotron Radiation : Techniques and Applications: C. Kunz.
3. Low Energy Electron Spectroscopy: KD Sevier.
4. Radiation Detectors: WH Tait.
5. Advances in Image Pickup and Display, Vol. 1: P. Schagen.

MPE-402: NANO SCIENCE AND TECHNOLOGY **Credits: 3**

Nanoparticles: Synthesis and Properties:

Method of Synthesis: RF Plasma Chemical Methods, Thermolysis, Pulsed Laser Methods, Biological Methods: Synthesis using micro-organisms, Synthesis using Plant Extract, Metal Nanoclusters, Magic Numbers, Modeling of Nanoparticles, Bulk to Nano Transitions.

Carbon Nanostructures:

Nature of Carbon Clusters, Discovery of C_{60}, Structure of C_{60} and its Crystal, Superconductivity in C_{60}, Carbon Nanotubes: Synthesis, Structure, Electrical and Mechanical Properties. Graphene: Discovery, Synthesis and Structural Characterization through TEM, Elementary Concept of its applications.

Quantum Wells, Wires and Dots:

Preparation of Quantum Nanostructures, Size Effects, Conduction Electrons and Dimensionality, Properties Dependent on Density of States.

Analysis Techniques for Nano Structures/ Particles:

Scanning Probe Microscopes (SPM), Diffraction Techniques, Spectroscopic Techniques, Magnetic Measurements

Bulk Nanostructure Materials:

Methods of Synthesis, Solid Disorders Nanostructures, Mechanical Properties, Nanostructure Multilayers, Metal Nanocluster, Composite Glasses, Porous Silicon.

Reference Books:

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: Silvana Fiorito
6. Nanotechlongy: Richard Booker and Earl Boysen

MPE-403: PHYSICS OF ELECTRONIC MATERIALS AND DEVICES **Credits: 3**

Physical Mechanisms:
Crystal structures of Electronic materials (Elemental, III-IV and VI semiconductors), Energy Band consideration in solids in relation to semiconductors, Direct and Indirect bands in semiconductor, Electron/Hole concentration and Fermi energy in intrinsic/Extrinsic semiconductor continuity equation, Carrier mobility in semiconductors, Electron and Hole conductivity in semiconductors, Shallow impurities in semiconductors (Ionization Energies), Deep Impurity states in semiconductors, Carrier Trapping and recombination/generation in semiconductors, Schokley Read theory of recombination, Switching in Electronic Devices.

Devices:

(i) Metal/Semiconductor Junction or (Abrupt P-N Junction), Current-voltage characteristics, C-V measurements, Estimation of Barrier Height and carrier concentration from C-V characteristics, Surface/Interface States, Role of interface States in Junction Diodes.

Field Effect devices, C-V characteristic of MIS diodes (Frequency dependence), Estimation of Interface Trapped charges by capacitance conductance, method CCD (Charge Coupled Devices), MESFET, MOSFET.

(ii) **Microwave Devices:** Tunnel Diode, MIS Tunnel Diode, Degenerate and Non-degenerate semiconductor, MIS Switch Diode, MIM Tunnel diode.
IMPATT Diode.
Characteristics, breakdown Voltage, Avalanche Region and Drift Region, Transferred Electron devices.

(iii) **Photonic Devices:** LED and LASER, Photo detectors, Solar-cells.

Reference Books:

1. Physics of Semiconductor Devices: S.M. Sze.
2. Semiconductor Devices Basic Principles: Jaspreet Singh.
3. Physics and Technology of Semiconductor Devices: A.S. Grove.
4. Metal/Semiconductor Schottky Barrier Junction and their Applications: B.L. Sharma.
5. Metal/Semiconductor Contact: Rhoderick.

MPE-404: SATELLITE COMMUNICATION AND REMOTE SENSING Credits: 3

Principle of Satellite Communication:
General and Technical characteristics, Active and Passive satellites, Modem and Codec.

Communication Satellite Link Design:
General link design equation, Atmospheric and Ionospheric effect on link design, Earth station parameters.

Satellite Analog Communication:
Baseband analog signal, FDM techniques, S/N and C/N ratio in FM in satellite link.

Digital Satellite Transmission:
Advantages, Elements of digital satellite communication, Digital base band signal, Digital modulation Techniques, Digital link Design, TDM, TDMA, some applications of satellite communications.

Concept and Foundations of Remote Sensing:
Electromagnetic Radiation (EMR), interaction of EMR with atmosphere and earth surface, Application area of Remote Sensing.

Characteristics of Remote Sensing Platform & Sensors:
Ground, Air & Space platforms, Return Beam Vidicon, Multi-spectral Scanner, Brief idea of Digital Image Processing.

Microwave Remote Sensing Tools:
Radar Remote Sensing, Microwave Sensing, Lidar (Single and double ended system), (Radar & Lidar): Data Characteristics.

Earth Resource Satellites:
Brief description of Landsat and Indian remote sensing satellites (IRS) Satellites.

Reference Books:

1. Satellite Communication : D.C. Agrawal andA. K. Maini.
2. Satellite Communication: T. Pratt and C. W. Bostiern.
3. Satellite Communication System: M. Richharia.
4. Introduction of Remote Sensing: J.B. Campbell.
5. Manual of Remote Sensing Vol I & II: (Ed. R.N. Colwell).

MPE-405: Quantum Field Theory: Path Integral Approach **Credits: 3**

Path integral quantization and Feynman rules: Scalar and Spinor Fields:
Introduction to Path Integrals, Generating functional for scalar fields, Functional integral, Free particle Green's function, Generating functional for interacting fields: φ^4 theory. Effective action for φ^4 theory. Two point functions, Four point functions, Grassman variable, Fermionic functional integrals and generating functional.

Path Integral Quantization: Gauge Fields:
Propagator and gauge condition in QED. Photon propagator, Propagator for transverse photon. Scattering cross section for some elementary process in QED.

Renormalization:
Divergence in φ^4 theory, Dimensional regularization. Renormalization of φ^4 theory. Divergence in QED. Electron self-energy, Vacuum polarization. WT identities. Anomalous magnetic moment of electron. Renormalization group equations.

Reference Books:

1. An introduction of QFT: M. peskin and D. Schroeder.
2. Quantum Filed Theory: L.H. Ryder.
3. Quantum Field Theory: C. Itzykson and J.B. Zuber.
4. Field Theory: Modern Primer: P. Ramond.
5. Relativistic Quantum Field: J.D. Brojken and S.D. Drell.
6. Introduction to QFT: F. Mandle and G. Shaw.

MPE-406: LIQUID CRYSTALS **Credits: 3**

Introduction:
States of matter, Liquid crystals, Symmetry, structure and order, Mesogenic molecules, Liquid crystals of achiral and chiral molecules, calamitic, disc shape and polymer liquid crystals.

Physical Properties:
Order parameters, measurement by magnetic resonance spectroscopy, Optical anisotropy, refractive index, Dielectric anisotropy, dielectric permittivity, Diamagnetic anisotropy, magnetic susceptibility;, Transport properties, Elastic constants, continuum description.

Statistical Theories of Nematic Order:
Landau-de-Gennes theory, hard particle, Maier saupe- and van der Walls type theories.

Nematic-Smectic A transition:
Phenomenological description, McMillan theory, polymorphism in smectic A Phase.

Chiral liquid crystals:
Chirality in liquid crystals: chiral nematic phase, optical properties, field induced nematic-cholesteric phase change, distortion of structure by magnetic field; Blue phase. Chiral smectic phases, origin of ferroelectricity: Structure, symmetry and ferroelectric ordering in chiral smectic C phase; Antiferroelectric and ferroelectric chiral smectic C phase.

Application of Liquid Crystals.

Reference Books:

1. Liquid Crystals: S. Chandrasekhar.

2. The Physics of Liquid Crystals: P.G. de Gennes and J Prost.
3. Liquid Crystals, Fundamentals: S Singh.

MPE-407: Computational Physics **Credits: 3**

Stochastic Processes
Theory of random walks and simulation of random walks in one, two and three dimensions. Elementary ideas and simulations of self-avoiding walks, additive and multiplicative stochastic processes, Brownian motion and fractional Brownian motion

Percolation theory
Percolation theory and simulation by Hoshen-Kopelman algorithm; Application to simple lattice models in Physics

Simulations of physical models
Elementary ideas of: (a) Time-average and Molecular dynamics: Dynamical equations and physical potentials; Verlet algorithm (b) Ensemble average and Monte Carlo methods; Metropolis algorithm. Introduction to the simulations of: (a) Ising model in magnetism (b) Bak-Tang-Wiesenfeld model in studies of self-organized criticality

Combinatorial optimization problems
Classification of problems; examples of optimization problems: traveling salesman problem (TSP) and satisfiability (k-SAT) problem; heuristic methods of solutions and simulated annealing technique.

References
1. Understanding Molecular Simulation (Academic Press), D. Frenkel & B. Smit
2. Introduction to Percolation Theory (Taylor-Francis), D. Stauffer
3. Equilibrium Statistical Physics (World Scientific), M. Plischke & B. Bergersen
4. Numerical Recipes in C: The Art of Scientific Computing (Cambridge University Press), W.H. Press, B.P. Flannery, S.A. Teukolsky and W.T. Vetterling

MPL-401(A): ELECTRONICS LABORATORY **Credits: 6**

Students will be required to perform six (06) experiments of the following, other than those performed in Semester-III:

1. Microwave characteristics and measurements
2. Nonlinear applications of Op amplifier
3. PLL characteristics and its applications
4. PAM, PWM and PPM Modulation and demodulation.
5. PCM / delta modulation and demodulation
6. Fiber optic communication
7. Experiments on MUX, DEMUX, Decoder and shift register
8. Arithmetic operations using microprocessors 8085 / 8086
9. D/A converter interfacing and frequency / temperature measurement with microprocessor 8085 / 8086
10. A/D converter interfacing and AC/DC voltage / current measurement using microprocessor 8085/8086
11. PPI 8251 interfacing with microprocessor for serial communication.
12. Assembly language program on P.C

Note: Addition and deletion in the list of experiments may be made from time to time by the department.

MPL-401(B): NUCLEAR PHYSICS **Credits: 6**

Students will be required to perform seven (07) experiments of the following, other than those performed in Semester III:

1. Gamma - Ray Spectroscopy Using NaI (Tl) detector.
2. Alpha Spectroscopy with Surface Barrier Detector.
3. Determination of the range and energy of alpha partcles using spark counter.
4. Study of gamma ray absorption process.

5. X-Ray Fluorescence.
6. Neutron Activation Analysis Measurement of the Thermal Neutron Flux.
7. To Study the Solid State Nuclear Track Detector.
8. Fission Fragment Energy Loss Measurements from Cf^{252}.
9. Gamma - Gamma Coicidence studies.
10. Compton Scattering: Energy Determination.
11. Compton Scattering: Cross-Section Determination.
12. Determination of energy of mu-mesons in pi-decay using Nuclear Emulsion Technique.
13. Identification of particles by visual range in Nuclear Emulsion.
14. Study of Rutherford Scattering.

Note: Addition and deletion in the list of experiments may be made from time to time by the department.

PL-401(C): SPECTROSCOPY LABORATORY **Credits: 6**

Students will be required to perform six (06) experiments of the following, other than those performed in Semester III:

1. Verification of Hartmann formula for prism spectrogram
2. Measurement of optical spectrum of an alkali atom
3. Determination of metallic component of an inorganic salt
4. Emmiter of electric discharge through air in a tube with minute leak
5. Emitter of electric discharge through air in an evacuated tube
6. Measurement of optical spectrum of alkaline earth atoms.
7. Measurement of Band positions and determination of vibrational constants of AlO molecule
8. Measurement of Band positions and determination of vibrational constants of N_2 molecule
9. Measurement of Band positions and determination of vibrational constants of CN molecule
10. Measurement and analysis of fluorescence spectrum of I_2 vapour
11. Determination of characteristic parameters of an optical fiber
12. Measurement of Raman spectrum of CCl_4.

Note: Addition and deletion in the list of experiments may be made from time to time by the department.

MPL-401(D): SOLID STATE PHYSICS LABORATORY **Credits: 6**

Students will be required to perform four (04) experiments of the following, other than those performed in Semester III:

1. Measurement of lattice parameter and indexing of powder photograph
2. Identification of unknown sample using powder diffraction method.
3. To study the ferroelectric transition in TGS crystal and measurement of Curie temperature.
4. To measure the superconductivity transition temperature and transition width of a high temperature superconductor.
5. Rotation / oscillation photograph and their interpretation.
6. To study the modulus of rigidity and internal friction in a metal as a functioning temperature.
7. To measure the Cleavage step height of a crystal by multiple Fizeau Fringes.
8. To determine magnetoresistance of a Bismrith crystal as a function of magnetic field.
9. Synthesis/ Fabrication of Carbon Nanotubes by spray paralysis method and its verification through X-ray diffraction.

Note: Addition and deletion in the list of experiments may be made from time to time by the department**.**

MPD-401: PROJECT AND DISSERTATION **Credits: 2**

The dissertation topics will be based on special papers or elective papers and topics of current interest. A departmental committee will distribute the topics.