Semesterwise distribution of Courses and Credits

**SEMESTER – I**

<table>
<thead>
<tr>
<th>COURSE</th>
<th>TITLE</th>
<th>CREDITS</th>
</tr>
</thead>
<tbody>
<tr>
<td>MPC-101:</td>
<td>MATHEMATICAL PHYSICS</td>
<td>4</td>
</tr>
<tr>
<td>MPC-102:</td>
<td>COMPUTATIONAL PHYSICS</td>
<td>3</td>
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<tr>
<td>MPC-103:</td>
<td>QUANTUM MECHANICS-I</td>
<td>4</td>
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<tr>
<td>MPC-104:</td>
<td>SEMICONDUCTOR DEVICES, INTEGRATED CIRCUITS AND COMMUNICATIONS</td>
<td>3</td>
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<tr>
<td>MPME-101*:</td>
<td>BASIC CONCEPTS IN PHYSICS: SMALL TO LARGE SYSTEMS</td>
<td>3</td>
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<tr>
<td>MPL-101:</td>
<td>ELECTRONICS LABORATORY</td>
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<td>OR</td>
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<tr>
<td>MPL-102:</td>
<td>GENERAL PHYSICS &amp; OPTICS LABORATORY</td>
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<tr>
<td>MPL-103:</td>
<td>COMPUTATIONAL PHYSICS AND PROGRAMMING LABORATORY</td>
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* Not for M.Sc. Physics students

**SEMESTER – II**

<table>
<thead>
<tr>
<th>COURSE</th>
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<tbody>
<tr>
<td>MPC-201:</td>
<td>CLASSICAL ELECTRODYNAMICS AND PLASMA PHYSICS</td>
<td>4</td>
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<tr>
<td>MPC-202:</td>
<td>ATOMIC, MOLECULAR PHYSICS AND LASERS</td>
<td>3</td>
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<tr>
<td>MPC-203:</td>
<td>ELEMENTS OF SOLID STATE PHYSICS</td>
<td>3</td>
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<tr>
<td>MPC-204:</td>
<td>ELEMENTS NUCLEAR PHYSICS</td>
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<tr>
<td>MPME-201:</td>
<td>APPLIED RADIATION PHYSICS</td>
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<tr>
<td>MPL-202:</td>
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<td>MPL-203:</td>
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**SEMESTER - III**

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<tr>
<th>COURSE</th>
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<tr>
<td>MPC–301:</td>
<td>STATISTICAL MECHANICS I</td>
<td>4</td>
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<tr>
<td>MPC–302:</td>
<td>QUANTUM MECHANICS II</td>
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<tr>
<td>MPS–301(A):</td>
<td>ANALOG COMMUNICATION SYSTEMS</td>
<td>4</td>
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<tr>
<td>MPS–301(B):</td>
<td>NUCLEAR PHYSICS: INTERACTIONS &amp; MODELS</td>
<td>4</td>
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<tr>
<td>MPS–301(C):</td>
<td>VIBRATIONAL &amp; ROTATIONAL MOLECULAR SPECTROSCOPY</td>
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<tr>
<td>MPS–301(D):</td>
<td>SOLID STATE PHYSICS: CRYSTALLOGRAPHY AND IMPERFECTIONS IN CRYSTALS</td>
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<tr>
<td>MPME-301:</td>
<td>EXPERIMENTAL TECHNIQUES FOR ANALYTICAL STUDIES</td>
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<tr>
<td>MPE–301:</td>
<td>PLASMA PHYSICS AND SPACE PHYSICS</td>
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<tr>
<td>MPE–302:</td>
<td>LASERS AND LASER APPLICATIONS</td>
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<td>MPE–303:</td>
<td>CHARACTERIZATION OF SOLIDS</td>
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<td>MPE–304:</td>
<td>MOLECULAR BIOPHYSICS</td>
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<td>MPE–305:</td>
<td>METHODS IN THEORETICAL PHYSICS</td>
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<td>MPE–306:</td>
<td>INSTRUMENTATION IN NUCLEAR PHYSICS</td>
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<td>MPE–307:</td>
<td>SOLAR ENERGY, HYDROGEN ENERGY AND OTHER RENEWABLE ENERGIES</td>
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**SEMESTER – IV**

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### SUMMARY OF M.Sc. SYLLABUS IN PHYSICS

<table>
<thead>
<tr>
<th>Semester</th>
<th>No. of Papers</th>
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<td>Total</td>
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### MINOR ELECTIVES:

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<th>SEMESTER:</th>
<th>PAPER NO. AND TITLE</th>
<th>CREDITS</th>
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<tbody>
<tr>
<td>I</td>
<td>MPME-101: BASIC CONCEPTS IN PHYSICS: SMALL TO LARGE SYSTEMS</td>
<td>3</td>
</tr>
<tr>
<td>II</td>
<td>MPME-201: APPLIED RADIATION PHYSICS</td>
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</tr>
<tr>
<td>III</td>
<td>MPME-301: EXPERIMENTAL TECHNIQUES FOR ANALYTICAL STUDIES</td>
<td>3</td>
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</tbody>
</table>
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:

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

Reference Books:
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:

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:
MPC-103: QUANTUM MECHANICS –I

Credit: 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:

MPC-104: SEMICONDUCTOR DEVICES INTEGRATED CIRCUITS AND COMMUNICATIONS

Credit: 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:

Communication:

Reference Books:
1. Integrated Electronics: Millman and Halkias.
5. Electronic Communication Systems: Kennedy
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

Physics of Small Bodies

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 I₂ 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 experiment
11. Compton Effect

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 integration 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:

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:**

**Hydrodynamical Description of Plasma:**
Fundamental equations, Hydromagnetic Waves: Magnetosonic and Alfven Waves, Magnetooconvection 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:**

**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: H₂, C₂, O₂, 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:**

**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
3. Principals of Condensed Matter Physics: P.M. Chaikin and T.C. Lubensky

**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:**

**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 sterility).

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:
2. Introduction to Experimental Nuclear Physics: R.M. Singru.

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 I₂ 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

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 integration 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:

Reference Books:

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 quantizing 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.

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:

Reference Books:
2. Electronics communication: Roddy and Coolen.
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:**

**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

**Vibration-Rotation Energy Levels and Spectra:**

**Reference Books:**
3. Introduction to Molecular Spectroscopy : G.M. Barrow.

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

**Crystallography:**

**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:**

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, Focused ion beam system.

Reference Books: 
1. Spectroscopy Volume 1, 2 and 3: B.P. Straughan and S. Walker.
3. Transmission Electron Microscopy of Metals: Gareth Thomas

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: 

Space Physics: 
Solar Phenomena:
Structure of the Sun, Solar Activity, Prominences, Coronal Heating, Solar Flares.

Solar Wind: 

Magnetosphere: 
Magnetopause, Magnetotail, Magnetic reconnection, Magnetosphere, Plasma flow in the magnetosphere.
Ionosphere:
Structure, Ionospheric Irregularities, Aurora, Borealis, Magnetosphere- Ionosphere coupling.

Reference Books:
2. Introduction to Space Physics: Edited by M. G. Kevilson and C. T. Russell.

MPE-302: LASERS AND LASER APPLICATIONS Credits: 3

Basic Principle and Different Lasers:

Non Linear Processes:

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:

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:
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:
3. Quantum Mechanics of Molecular Conformations: Pullman (Ed.).

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:
2. Introduction to Quantum Mechanics: D.J. Griffiths.
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:**

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

**Credits: 3**

**Solar Energy: Fundamental and Material Aspects:**

**Solar Energy: Different Types of Solar Cells:**

**Hydrogen Energy: Fundamentals, Production and Storage:**

**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
3. Phoptoelectrochemical Solar Cells: Chandra
5. Hydrogen as a Future Energy Carrier : Andreas Zuttel, Andreas Borgschulte and Louis Schlaphbach

**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

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

1. Gamma - Ray Spectroscopy Using NaI (Tl) detector
2. Alpha Spectroscopy 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 Coincidence 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

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\textsubscript{2} molecule
9. Measurement of Band positions and determination of vibrational constants of CN molecule
10. Measurement and analysis of fluorescence spectrum of I\textsubscript{2} vapour
11. Determination of characteristic parameters of an optical fiber
12. Measurement of Raman spectrum of CCl\textsubscript{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 Bismuth crystal as a function of magnetic field

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:

Time Dependent Phenomena:

Reference Books:

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, Shannon-Hartley theorem. Linear block codes, Binary cyclic codes and Convolutions codes.

Digital Signal (Data) Transmission:
Introduction, 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:**

**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:**

**Reference Books:**
1. Nuclear and Particle Physics: W. Burcham and M. Jobes.
2. Quarks and Leptons: Halzen and Martin.

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

**Credits: 4**

**Atomic and Molecular Orbital Theories:**

**Spectroscopy of Diatomic and Poluatomic Molecules:**
Coupling of Electronic and Rotational motion in Diatomic 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.
3. High Resolution Spectroscopy: J.M. Hollas

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; Fibonacci 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 microscopy.

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:

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

Intel 8085:

Intel 8086:

Advanced Microprocessors:

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 level indicator/ controller. DC and stepper motor speed measurements, Waveform generation and frequency measurement.

Reference Books:
5. Microprocessor and Interfacing: D.V. Hall.
MPS-402(B): WEAK INTERACTIONS AND ELECTROWEAK UNIFICATION  

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:  

Reference Books:  
1. Nuclear and Particle Physics: W.E. Burcham and M.Jobes.  
2. Introduction to Elementary Particles: Griffiths.  
3. Quarks and Leptons: Halzen and Martin.  

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

Light Sources, Detectors and Spectroscopic Techniques:  

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:  

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

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, Polaron, 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 Localization 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.

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 (Synchrotron 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°-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:

MPE-402: NANO SCIENCE AND TECHNOLOGY
Credits: 3

Nanoparticles: Synthesis and Properties:

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 Practice: S.K. Kulkarni
5. Carbon Nanotubes: Silvana Fiorito
6. Nanotechlongy: Richard Booker and Earl Boyesen
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:
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:

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:

**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: \( \phi^4 \) theory. Effective action for \( \phi^4 \) 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:**

**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.
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.
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. Berghersen

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:

2. Alpha Spectroscopy 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.
7. To Study the Solid State Nuclear Track Detector.
8. Fission Fragment Energy Loss Measurements from Cf$^{252}$.
11. Compton Scattering: Cross-Section Determination.
13. Identification of particles by visual range in Nuclear Emulsion.

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

PL-401(C): SPECTROSCOPY LABORATORY

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 analkali 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
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

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

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 Bismuth crystal as a function of magnetic field.

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

MPD-401: PROJECT AND DISSERTATION

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