M.Sc. Physics (I Semester): Mathematical Physics (MPH-L11)

Unit	Content
I	Legendre, Hermite, and Laguerre polynomials and their generating functions. Recurrence relations and special properties of $P_n(x)$ as a solution of Legendre differential equation, Rodrigues formula, orthogonality of $P_n(x)$.
II	Bessel function of the first kind, generating function, recurrence relations, $J_n(x)$ as the solution of Bessel differential equation, Expansion of $J_n(x)$ when n is a half and odd integer.
III	Function of a complex variable, Cauchy Riemann conditions, Cauchy's integral theorem (without proof), Cauchy's integral formula, Cauchy's Residue theorem, singular points.
IV	Integral Transforms: Laplace Transform, First and second shifting theorems, Inverse LT by partial fractions, LT of derivative and integral of a function, Solution of initial value problems by using LT.
V	Fourier Series and Fourier Transform: Fourier series, half range expansion, Arbitrary period, Fourier integral and transforms, FT of delta and Gaussian function.

Text and References Books

Mathematical method for Physics by G. Arfken
Advanced Engineering Mathematics by E.Kreyszig
Special Functions by E.D Rainville
Special Functions by W.W Bell
Functions of a complex variable by R.V.Churchill
Mathematical Method for Physicists and Engineers by K.F.Reily, M.P.Hobson, and S.J.Bence
Mathematical Physics by H.K. Das

M.Sc. Physics (I Semester): Classical Mechanics (MPH-L12)

Unit	Content
I	Preliminaries: Newtonian mechanics of a particle, Mechanics of a system of particles, Constraints; their classification, D'Alembert's principle, Virtual work, generalized coordinates and derivation of Lagrange's equations, Velocity-Dependentpotentials and the Dissipation function, Applications of Lagrangian formulation: Simple Pendulum with rigid support, two connected masses with string passing over a pulley.
II	Variational Principles and Lagrange's Equations: Hamilton's principle, Some techniques of the calculus of variations, Derivation of Lagrange's equation from Hamilton's principle.
III	Two body central force problems: Reduction to the equivalent one-body problem, Motion in a central force field, The Virial theorem, The inverse square law of force, The motion in central force in the Kepler problem.
IV	Hamiltonian equations of motion: Legendre transformations and Hamilton equations of motion, Cyclic coordinates and conservation theorems, Canonical transformation generating functions, Properties, Poisson bracket, Poisson theorem, Relation of Poisson brackets, Hamilton Jacobi method.
V	Small oscillations: Concept of small oscillations, Expression of kinetic energy and potential energy for the problem of small oscillations, Frequency of free vibration, and Normal coordinates.

Text and Reference Books

H. Goldstein: Classical Mechanics
N.C. Rana and P.S. Joag: Classical Mechanics
A. Sommerfield: Mechanics
Percival and D. Richards: Introduction to Dynamics

M.Sc. Physics (I Semester): E.M. Theory & Electrodynamics (MPH-L13)

Unit	Content
I	**Electrostatics:** Electrostatic fields in matter; Dielectrics, Polarization, Field inside a dielectric, Electric displacement. Laplace's and Poisson's Equations, Methods of images, point charge near an infinite conducting plane, Point charge in the presence of a grounded conducting sphere, and Point charge in the presence of charged insulated sphere.
II	**Magneticstatics:** Magnetic vector potential, Magnetostatic fields in Matter: Magnetization, a field of a magnetized object, magnetic field inside matter, linear and nonlinear magnetic media.
III	**Time-Varying Fields:** Maxwell's displacement current, Maxwell's equations, Maxwell's equations in terms of vector and scalar potentials, Poynting theorem, Lienard- Wiechert potentials due to a point charge, Fields of a point charge in motion, Power radiated by an accelerated charge, Larmor's formula and its relativistic generalization.
IV	**Plane Electromagnetic Wave:** Reflection, Refraction of electromagnetic waves at an interface between dielectrics, Fresnel's relation polarization by reflection and total internalreflection, Plain electromagnetic waves in free space, dielectrics, and conducting media.
V	**Plasma:** Definition of plasma, Concept of temperature, Debye shielding, Criteria for plasma, Single-particle motions in E and B fields, Magnetic mirrors and plasma confinement, Plasma as fluid, the fluid equation of motion, Equation of continuity and equation of state, Waves in plasmas, Plasma oscillations, Plasma frequency ωp, Electron plasma waves, ion waves.

Text and Reference Books

Classical Electrodynamics by J.D. Jackson
Foundations of Electromagnetic theory by J.R. Reitz, F.J.Milford and R.W.Christy
Introduction to Electromagnetics by David J. Griffiths
Introduction to Plasma Physics and Controlled Fusion, Vol-1: Plasma Physics by Francis F. Chen Plasma Physics by S.N. Sen.)

M.Sc. Physics (I Semester): Electronic-I (MPH-L14)

Unit	Content
I	**Conduction Mechanism in Semiconductors:** Classification of semiconductors, Direct bandgap, and indirect bandgap semiconductors. The Fermi Level, electron and hole concentrations at equilibrium, the temperature dependence of carrier concentrations, the drift of carriers in electric and magnetic fields; conductivity and mobility, drift and resistance, the effect of temperature and doping on mobility, The Hall effect, Diffusion of carriers in semiconductors; diffusion processes, diffusion and drift of carriers, diffusion, and recombination, The continuity equation.
II	**Semiconductor-diode characteristics:** Qualitative theory of P-N junction, The Contact Potential, Space charge at a junction, Capacitance of p-n junctions, Forward and reverse bias junctions, Reverse bias breakdown, Zener diode, Tunnel diode.
III	**Bipolar Junction Transistors:** Transistor current components, the transistor as an Amplifier, CB, CE, CC configurations, Input-output characteristics, Early Effect, Graphical analysis of the CE configuration, Transistor hybrid model, h parameters, Analysis of a Transistor amplifier circuit using h parameters, Hybrid π model, Ebers-Moll model, Transistor biasing and thermal stabilization.
IV	**Field Effect Transistors:** Construction and characteristics of JFET, transfer characteristic, The FET small-signal model, JFET fixed bias, Self-bias, and voltage divider configurations, JFET source follower (common-Drain) configuration, JFET Common – Gate configuration, Depletion, and enhancement type MOSFETs.
V	**Feedback Amplifiers:** Classification of Amplifiers, Feedback concept, Ways to introduce negative feedback in Amplifiers, Effect of negative feedback, Method of analysis of a feedback amplifier, Voltage-series feedback, Current-series feedback, Voltage-shunt feedback, Current-shunt feedback, Nyquist criterion for stability of feedback amplifiers.

Text and Reference Books

Solid State Electronic Devices by B.G. Streetman
Electronic Devices and Circuit Theory by R.L. Boylested and L. Nashelsky
Integrated Electronics by J. Millman and C.C. Halkias
Introduction to Semiconductor Devices by M. S. Tyagi
Electronic Devices and Circuits by Balbir Kumar and S.B. Jain

M.Sc. Physics (II Semester): Solid-State Physics (MPH-L21)

Unit	Content
I	Crystal Physics and Defects in Crystals: Crystalline solids, unit cell and direct lattice, Bravais lattice in two dimensions (plane lattice) and three-dimensional (space lattice), Closed packed structures.
II	Interaction of X-rays with matter, Absorption of X-rays, X-ray diffraction, The Laue, powder and rotating crystal methods, The reciprocal lattice and its important properties and applications.
III	Crystal imperfections: Point defects, line defects and planer (stacking) faults. Estimation of dislocation density from X-ray diffraction measurements. The observation of imperfections in crystals: electron microscopic techniques.
IV	Electronics Properties of Solids: Electrons in a periodic lattice: Bloch theorem, The Kronig-Penny Model, Effective mass of an electron, Tight-binding approximation, Cellular and pseudopotential methods, Fermi surface: Fermi surface and Brillouin zones, Anomalous skin effect, Cyclotron resonance, de Hass van Alphen effect, Magnetoresistance, Hall effect in semiconductors Superconductivity: Elements of BCS theory, Flux quantization, Meissner effect, Critical temperature, Persistent current.
V	Ferromagnetism: Weiss theory of ferromagnetism, Heisenberg model and molecular field theory, Ferromagnetic domains, The Bloch-wall, Spin waves and magnons, Curie- Weiss law for susceptibility, Ferri and antiferro-magnetic order.

Text and References Books

Verma and Srivastava: Crystallography for Solid State Physics
Azaroff: Introduction to Solids
Omar: Elementary Solid State Physics
Aschroff & Mermin: Solid State Physics
Kittel: Solid State Physics
Chaikin and Lubensky: Principles of Condenced Matter Physics

M.Sc. Physics (II Semester): Statistical Mechanics (MPH-L22)

Unit	Content
I	Foundation of Statistical Mechanics & Ensembles: Phase space, concept of Ensemble, Ensemble average, Liouville's theorem, equation of motion and Liouville's theorem, Canonical Ensemble, Microcanonical Ensemble, Grand Canonical Ensemble, partition functions.
II	Statistical Quantities: Calculation of statistical quantities, Energy and density fluctuations, Entropy of an ideal gas using microcanonical Ensemble, Gibb's paradox, Sackur- Tetrode equation.
III	Postulates of quantum statistical mechanics, Density matrix, Statistics of indistinguishable particles, Maxwell-Boltzmann, Fermi- Dirac and Bose-Einstein Statistics, properties of ideal Bose and Fermi gases, Bose- Einstein condensation.
IV	Cluster expansion for a classical gas, virial equation of state, ising model, mean-field theories of the ising model in three, two and one dimensions, Exact solutions in one-dimension. Landau theory of phase transition, critical indices, scale transformation and dimensional analysis.
V	Fluctuations: Correlation of space-time dependent fluctuations, fluctuations and transport phenomena, Brownian motion, Langevin theory, fluctuation dissipation theorem, The Fokker-Plank equation.

Text and Reference Books

Statistical and Thermal Physics by F. Reif
Statistical Mechanics by K. Huang
Statistical Mechanics by R. K. Pathria
Statistical Mechanics by R. Kubo
Statistical Physics by Landau and Lifshitz
Statistical Mechanics and properties of matter, theory and application by E.S.R. Gopal

M.Sc. Physics (II Semester): Quantum Mechanics (MPH-L23)

Unit	Content
I	Brief introduction to origins of quantum Physics. Wave packets. Dirac notation. Operators, their eigenvalues and eigenfunctions, orthonormality, completeness and closure. Generalized uncertainty principle. Unitary transformations, change of basis. Matrix Representation of operators. Continuous basis, position and momentum representation and their connection. Parity operator.
II	Basic postulates of quantum mechanics. Measurement. Time evolution of system's state. Schrodinger, Heisenberg, and interaction pictures. Density operator. Pure state and mixed state density operators. Discrete and continuous spectra in 1-D. Solution of 1-D harmonic oscillator using algebraic method.
III	Orbital, Spin and total angular momentum operators. Pauli spin matrices, their Commutation relations. Eigenvalues and eigenfunctions of L^2 and L_z. Angular momentum as generator of rotation. Addition of angular momenta. Clebsch-Gordon coeficients. L-S coupling.
IV	Many particle systems, systems of identical particles, exchange degeneracy, symmetrization postulate, construction of symmetric and anti-symmetric wave functions from unsymmetrized functions. The Puli exclusion principle. Introduction to second quantization. Creation and annihilation operators for Fermions and Bosons. Fock states.

Text and References Books

Modern Physics by S.P. Khare.
Quantum Mechanics and Atomic Physics by S.P. Khare.
Quantum Mechanics by S. Gasiorowicz.
A text book of Quantum Mechanics by P.M. Mathews and K. Venkatesan
Introduction to Quantum Mechanics by E. Merzbacher
Quantum Mechanics by L.I. Schiff

M. Sc. Physics (II Semester): Electronics-II (MPH-L24)

Unit	Content
I	Operational Amplifier Basic and Application: Review of Feedback, Linear Circuit, Op- Amp Basic, Inverting and Non-inverting amplifiers, Unity follower, Summing amplifiers, Integrator, Differentiator.
II	Digital Logic Gates: Symbols and truth tables, Classes of digital integrated circuits (Diode logic, DTL, TTL, ECL, MOSFET, CMOS).
III	Digital Electronics and Logic Gate: Binary, Octal, Hexadecimal number system, Base conversion system, Bipolar junction, and Field Effect transistor as switches, Basic digital logic gates (OR, AND and NOT, NOR, NAND, and Exclusive OR), XOR gate, Boolean laws and theorem, Sum of Product (SOP) and Product of Sum (POS) method, Karnaugh map.
IV	Application of Digital Logic Gate: Half adder and Full adder circuit, multiplexers, demultiplexer, Flip- Flop and Registers- RS Flip Flop, D- Flip Flop, T- Flip Flop, JK- Flip Flop, JK Master- Slave Flip Flop. Digital-to-Analog Converters-D/A converter, ladder network, A/D converters
V	Microprocessor-Intel 8085 microprocessor architecture, interfacing devices, BUS timing, instruction set, simple illustrative program.

Text and Reference Books

Electronic Device and Circuit: R. Boylested and L. Nashdsky
Analysis and Design of Digital Integrated Circuit: Hodges, Jackson, and Saleh Digital Principles and Implementation: A.P. Malvino and D.P. Leach
Op-Amp and Linear Integrated Circuit: Ramakant A. Gayakwad

M. Sc. Physics (III Semester): Advanced Quantum Mechanics (MPH-L31)

Unit	Content
I	Approximation methods for stationary systems Time independent perturbation theory. Perturbation of non-degenerate states: first and second-order perturbation. Perturbation of a harmonic oscillator. Perturbation of degenerate states, removal of degeneracy. Zeeman and Stark effects. Variational and WKB methods.
II	Approximation methods for non-stationary systems Schroedinger, Heisenberg and interaction pictures, Equations of Motion. Constant and harmonic perturbation. Discrete and continuous case, transition probability. Fermi golden rule. Adiabatic and sudden approximations.
III	Scattering Theory Scattering of a wave packet. The differential and total Cross section. The Born approximation. Partial waves and phase shifts. The Lippmann Schwinger equation. Definition and properties of S-matrix, T matrix. Optical theorem
IV	Relativistic Quantum Mechanics Klein-Gordon and Dirac equations, properties of Dirac matrices. Lorentz and CPT invariance of Dirac equation. Non-relativistic reduction of the Dirac equation. Central forces and the hydrogen atom.
V	Solution to Dirac Equation Free particle solution, hydrogen atom in Dirac's theory, Dirac electron in a 1constant magnetic field, Foldy-Wouthuysen transformation, Hole theory.

Reference Books:

1. Quantum Mechanics: Franz Schwabl
2. Quantum Mechanics : Eugen Merzbacher
3. Quantum Mechanics: N. Zettili
4. Quantum Mechanics: P. M. Mathews and K. Venkatesan
5. Principles of Quantum Mechanics: P. A. M. Dirac

M. Sc. Physics (III Semester): Atomic & Molecular Physics (MPH-L32)

Unit	Content
I	Basic Concepts Review of Solution of Schrodinger's equation for Coulomb field and Hydrogen atom, dipole approximation, spectroscopic terms, and selection rules, intensities of spectral lines.
II	Interaction with Electromagnetic Field Fine structure of Hydrogen like atoms: spin-orbit interaction, relativistic correction, Lamb shift. Interaction with external fields: Zeeman, Paschen-Back and Stark effects.
III	Atomic Spectra The LS-coupling approximation, J-J coupling, hyperfine structures. The central field approximation, Thomas Fermi-potential, alkali atom spectra, Na doublet.
IV	Molecular Spectra Born-Oppenheimer Approximation, Rotational, Vibrational, Rotational-Vibrational and Electronic spectra of Di-atomic molecules, Selection rules, Frank-Condon principle, Raman spectra, NMR, ESR.

Reference Books:

1. Physics of Atoms and Molecules : B.H. Bransden & C.J. Joachain
2. Elementary Atomic Structure : G.K. Woodgate
3. Introduction to Modem Physics : H.S. Mani & G.K. Mehta
4. Molecular Spectra : G. Herzberg
5. Fundamentals of Molecular Spectroscopy : C.N. Banwell

M. Sc. Physics (III Semester): Nuclear & Particle Physics (MPH-L33)

Unit	Content
I	Basic Nuclear Concepts Angular momentum, Parity and symmetry, Magnetic dipole moment and electric quadrupole moment, Energy levels and mirror nuclei.
II	Nuclear Forces Characteristics of nuclear forces -Range and strength, Simple theory of two nucleon system -deuterons, Spin states of two nucleon system, Effect of Pauli's exclusion principle, Magnetic dipole moment and electric quadrupole moment of deuteron -The tensor forces.
III	Energy deposition and Particle detection Interaction of charged particles with matter. Stopping power and range. Detectors for energetic charged particles; Solid State or Semiconductor detector.
IV	Particle Accelerators Need for accelerator of charged particles, Classification of types of accelerators, Proton Synchrotron, Betatron; Alternating gradient accelerator, Colliding beam accelerator.
V	Elementary particles Classification and properties of elementary particles; Resonances ; Interactions and their mediating quanta, Conservation rules in fundamental interactions; Strangness and associated production, Isospin and its conservation. Parity and charge conjugation, Conservation of parity and its violation Idea of eight fold way and quarks.

Reference Books:

1. Nuclei and Particles : Segre
2. Nuclear Physics : Cohen
3. Nuclear Physics : Enge
4. Physics of Nuclei and Particles : Marmur and Sheldon
5. Introduction to Nuclear and Particle Physics : Das and Ferbel

Skill Enhancement Courses (SEC)
M. Sc. Physics (III Semester): Laser Physics (MPH-L34A)

Unit	Content
I	**Optical Resonators and Gaussian Beam** Brief review of matrix optics, Planar Mirror Resonators, Resonator Modes, Two- and ThreeDimensional Resonators, Spherical-Mirror Resonators, Ray confinement, Gaussian waves and its characteristics: The Gaussian beam, Transmission through optical component, Gaussian Modes, Resonance Frequencies, Hermite-Gaussian Modes, Finite Apertures and Diffraction Loss.
II	**Photons and Atoms** The Photon Optics theory of light in a resonator, Photon Polarization, Transmission and interference of photon, Photon time, Photon streams. Energy levels and Occupation of energy levels in thermal equilibrium, Interaction of single mode light with an atom, Spontaneous Emission, Transition Probabilities, Stimulated Emission and absorption, line shape function, Transition in presence of broadband light, Lineshape broadening: Homogeneous and Inhomogeneous Broadening. Lifetime broadening, Collision Broadening, Doppler Broadening.
III	**LASER Amplifiers** Theory of laser amplifiers, Gain and band width, Phase shift, Rate equations, pumping schemes, Common Laser amplifiers, Doped glass amplifiers, Amplifier Nonlinearity and stability saturation saturated gain in homogeneously and in-homogeneously broadened media. Amplifier noise.
IV	**Lasers** Theory of laser oscillation, Optical amplification and feedback, Condition for laser oscillation, Characteristics of laser output, Mode selection, Common lasers; Selected characterizes of common lasers, Pulsed lasers: Methods of pulsing lasers, Q-switching, Mode locking.

Reference Books:

1. Introduction to Laser Physics : K.Shimoda
2. Principles of Lasers : O. Svelto
3. Lasers- Theory and Applications : Thyagarajan and Ghatak
4. Fundamentals of Photonics: B.E.A. Saleh and M.C. Teich

M. Sc. Physics (III Semester): Experimental Techniques (MPH-L34B)

Unit	Content
I	**Basic Data processing** Recording and analysis of data, data uncertainty, Error: - accuracy and precision, computer-aided data Acquisition.
II	**Introduction to Vacuum** Fundamentals of Vacuum, Gas Flow Mechanism, Concept of Throughput and Pumping Speed, Various types of Pumps - Pressure Measurements gauges, valves, seals - Leak Detection techniques.
III	**Thin Film deposition** Physical vapour deposition, thermal evaporation, e-beam evaporation, sputtering, pulsed laser deposition, molecular beam epitaxy, MOCVD.
IV	**Single Crystal growth** Bridgman-Stockbarger and Czochralski method, flux and hydrothermal method, purification of materials, zone refining.

Reference Books:

1. Vacuum Technology: Alexander Roth
2. The Growth of Single Crystals: R.A. Laudise
3. The Art & Science of Crystal Growth: J.J. Gilman.
4. Material Science and Engineering : V. Raghavan
5. Essentials of Crystallography: M.A. Wahab
6. Crystal growth for beginners : Ivan Markov
7. Physics of Crystal Growth: Alberto Pimpinelli and Jacques Villain

Skill Enhancement Courses (SEC)

M. Sc. Physics (III Semester): Physics of Devices and Instrumentation (MPH-L34C)

Unit	Content
I	MESFET and Related Devices Metal-semiconductor contacts; Basic Characteristics, Schottky Barrier, Ohmic Metal Semiconductor Contact, Current Transport process, Determination of Barrier Height, MESFET; Device Structures, Principles of Operations, Current Voltage Characteristics, High Frequency Performance, MODFET or HEMT; fundamentals, , Current -Voltage Characteristics, Cut off Frequency.
II	MOSFET and Related Devices MOS Diode; SiO2-Si MOS Diode, Charge Coupled Device (CCD), MOSFET Fundamentals; Basic Characteristics, Types of MOSFET, Threshold Voltage Control, MOSFET Scaling; CMOS and BiCMOS; MOS Memory Structures.
III	Quantum Effect and Photonic Devices Quantum-Effect Devices; Resonant Tunneling Diode, Unipolar Resonant Tunnelling Transistor, Semiconductor Laser; Semiconductor Materials, population Inversion at a junction, Emission spectra for p-n junction Lasers, Basic Laser Structure, Photodetector; Photoconductor, Solar Cell; p-n junction Solar cell, conversion Efficiency.
IV	Film Formation and Epitaxial Growth Thermal Oxidation; Dielectric Deposition; Thin Films Deposition Techniques: Thermal evaporation, Sputtering, Chemical Vapour Deposition(CVD), LPCVD, Epitaxial Growth Techniques: Vapour phase Epitaxy, Molecular Beam Epitaxy (Elementary description).
V	Lithography, Etching and Diffusion of impurities Optical Lithography; Exposure Tools, Masks, Photoresist, Electron Beam Lithography (Elementary description), Wet Chemical Etching, Dry Etching, Reactive Plasma Etching techniques and Equipment, Basic Diffusion Process: Diffusion Equations, Doping of Semiconductor.

Reference Books:

1. Semiconductor Devices Physics and Technology: S.M. Sze
2. Introduction to Semiconductor Devices: S.M. Tyagi
3. Physics of Semiconductor Devices: S.M. Sze,
4. Solid State Electronics: Ben G. Streetman
5. Material Science by Engineers: James F. Shackelford
6. The Physics of Semiconductor Devices: D.A. Eraser, Oxford Physics Series (1986)
7. Thin Film Phenomena: K.L. Chopra.
8. Semiconductor Physics and Devices: S.S.Islam

Specialization Elective-1

M. Sc. Physics (IV Semester): Condensed Matter Physics-A (MPH-L41A)

Unit	Content
I	**Bonding in crystals:** Covalent, ionic, metallic, hydrogen bond, van der Waal's bond, and the Madelung constant. Crystalline solids, unit cell, primitive cell, Bravais lattices, Miller indices, closed packed structures. Atomic radius, lattice constant, and density. Connection between orbital symmetry and crystal structure. Scattering from periodic structures, reciprocal lattice, Brillouin Zones.
II	**Phonons - Lattice Dynamics and Thermal Properties:** Lattice dynamics of atoms in crystals, vibrations of monoatomic and diatomic linear chains, acoustic and optical phonon modes, density of states, thermal properties of crystal lattices, thermal energy of the harmonic oscillator, specific heat capacity of the lattice, Debye theory of specific heats.
III	**Free Electron Theory:** Free electrons in solids, density of states, Fermi surface, Fermi gas at T=0 K, Fermi statistics, specific heat capacity of electrons in metals, thermionic emission of electrons from metals.
IV	**Electronic Band Structure:** Electronic band structure in solids, Electrons in periodic potentials, Bloch's Theorem, Kronig-Penney model, Nearly free electron model, Tight-binding model: density of states, examples of band structures. Fermi surfaces of metals and semiconductors.
V	**Transport properties:** Motion of electrons in bands and the effective mass, currents in bands and holes, scattering of electrons in bands, Boltzmann equation and relaxation time, electrical conductivity of metals, thermoelectric effects, the Wiedemann-Franz Law.

Reference Books:

Solid State Physics: Hook and Hall: Hook and Hall
Introduction to Solid State Physics: Kittel
Solid State Physics: Ibach and Luth
Introduction to the Theory of Solids: H. M. Rosenberg
Solid State Physics: Blakemore
Solid State Physics: Ashcroft and Mermin

Specialization Elective-1
M. Sc. Physics (IV Semester): Materials Science & Nanotechnology-A
(MPH-L41C)

Unit	Content
I	Crystal structure, symmetry and electronic energy levels Review of bonding in solids and electronic structure, link between valence electronic states and crystal symmetries, density of states for metals, semiconductors and insulators, dispersion of electron energy levels, van Hove singularities, energy bands, Fermi surfaces, De Haas - van Alphen effect.
II	Experimental determination of electronic structure X-ray and ultraviolet photoelectron spectroscopies and Auger electron spectroscopy. Chemical shift determination. Calculation of electronic energy levels and their dispersion, using angle-resolved photoemission spectra.
III	Density Functional Theory Extension of Central Field Approximation, Hohenberg-Kohn Theorems, statement and proof. Kohn Sham orbitals, pseudo potentials, the self-consistent field method for the calculation of ground state energies in DFT.
IV	Crystal growth and defects Kinetics of Crystal Growth: homogenous and heterogenous nucleation, diffusion and screw dislocation mechanism of crystal growth. Atomic imperfections in crystals- one-, two- and three-dimensional imperfections, Schottky and Frenkel defects, Burger's vector and Burger's circuit, energy of dislocations, grain boundaries and surface reconstructions.

Reference Books:

1. Intro. To Solid State Physics: Chales Kittel
2. Solid State Physics: Ibach & Luth
3. Quantum Theory of Solids: Charles Kittel
4. Solid State Physics: Ashcroft and Mermin
5. Experimental Techniques of Surface Science: Woodruff and Delchar
6. Density Functional Theory: Kieron Burke.
7. Electronic Structure: Richard M. Martin
8. Crystal growth for beginners: Ivan Markov
9. Physics of Crystal Growth: Alberto Pimpinelli and Jacques Villain
10. Material Science and Engineering: V. Raghavan

Specialization Elective-2
M. Sc. Physics (IV Semester): Condensed Matter Physics-B (MPH-L42A)

Unit	Content
I	**Interacting Electrons in Solids** Review of free electron theory, nearly free electron approximation, tight-binding model, LCAO approximation, Wannier functions, Hartree-Fock approximation, Dielectric constant of metals and insulators.
II	**Optical Properties** Electronic, interband and intraband transitions, relation between optical properties and band structure, reflectance, diffraction, dispersion, photoluminescence, electroluminescence, optical constants, Kramers-kronig relations, polarons, excitons, plasmons.
III	**Magnetism** Diamagnetism (including Landau diamagnetism) and Paramagnetism including van Vleck and Langevin paramagnetism), Exchange interaction of free electrons, Band model of Ferromagnetism, superexchange, double exchange, Hubbard model, Antiferromagnetism, Neel temperature, spinwaves, 2D electron gas in a magnetic field :Quantum Hall Effect. Landau levels. Degeneracy. Fractional quantum Hall effect.
IV	**Superconductivity and Superfluidity** Fundamental phenomena of superconductivity, Meissner effect, London equation, Type I and type II superconductors. Ginzburg-Landau Theory, Coopers pairing and BCS theory. BCS wave functions, Josephson Effect, SQUIDS. Weakly interacting Bose gas, Superfluidity.

Reference Books:

1. Introduction to Solid State Theory : O. Madelung
2. Solid State Physics : Ibach and Luth
3. Solid State Physics : Ashcroft and Mermin
4. Introduction to Solid State Physics : C. Kittel
5. Quantum Theory of Solid : C. Kittel
6. Many-Particle Physics (Physics of Solids and Liquids) : G.D. Mahan

Specialization Elective-2
M. Sc. Physics (IV Semester): Materials Science & Nanotechnology-B
(MPH-L42C)

Unit	Content
I	Optical methods of structure determination Optical microscopy, Raman spectroscopy, UV-Vis absorption spectroscopy, FTIR spectroscopy, Photoluminescence
II	Determination of Surface Structure Microscopy techniques: SEM, AFM, TEM, STM. Electron Diffraction techniques : Low Energy Electron Diffraction, Reflection High Energy Electron Diffraction.
III	Surface analytical techniques for electronic structure Auger electron spectroscopy, X-Ray photoelectron spectroscopy, SIMS, Rutherford backscattering
IV	X-Ray Diffraction Studies Diffraction phenomena as applied to Solid State problems, scattering and absorption of X-rays, neutrons and electrons. X-ray method for orienting crystals. Applications of XRD. Diffraction from regular and faulted closed packed structures. Broadening of diffraction spots due to defects. Line prifile analysis, crystal structure analysis, measurement of intensities of X-ray reflection.

Reference Books:

1. Experimental techniques of surface science: Woodruff and Delchar
2. Solid State Physics: Ashcroft and Mermin
3. Amorphous Materials: S.R.Elliot
4. Fundamentals of surfaces and thin film analysis: L.C.Feldman and J.W.Mayer
5. An introduction of X-ray crystallography: M.M.Wofson
6. Use of films in Physical investigations: J. C. Anderson
7. Rutherford backscattering Spectroscopy: W. K. Chu