M.Sc. Physics Course Structure

The medium of instruction and examination shall be English only.

First Semester

1. MPHY101 Classical Mechanics
2. MPHY102 Quantum Mechanics
3. MPHY103 Classical Electrodynamics-I
4. MPHY104 Mathematical Methods in Physics
5. MPHY131 Seminar-1
6. MPHY111 Electronics Lab/ General Lab

Second Semester

1. MPHY201 Electronics
2. MPHY202 Atomic and Molecular Physics
3. MPHY203 Classical Electrodynamics-II
4. MPHY204 Numerical Methods
5.MPHY211 Electronics Lab/ General Lab
6 MPHY231 Project work / Summer Training Programme

Third Semester

1. MPHY301 Advance Quantum Mechanics
2. MPHY302 Statistical and Solid State Physics
3. MPHY303 Nuclear Physics -I
4. MPHY304 Core Elective – I (Microwave Electronics – I)
5. MPHY311 Elective/Advance Laboratory Work
6 MPHY331 Seminar -2

Fourth Semester (Alternative)

1. MPHY401 Introduction to Quantum
2. MPHY402 Solid State Physics
3. MPHY403 Nuclear Physics -II
4. MPHY404 Core Elective – II (Microwave Electronics – II)
5. MPHY411 Elective/Advance Laboratory Work
6 MPHY431 Project Work/ Summer Training Programme

Semester - I

PAPER I: MPHY 101: CLASSICAL MECHANICS

Duration : 3 hrs. **Max. Marks : 70**

Note: There will be two parts in end semester theory paper.

Part A of the paper shall contain seven short answer questions of 14 marks. Each question will carry two marks for correct answer.

Part B of the paper will consist four questions one question from each unit with internal choice. Each question will carry 14 marks.

UNIT - I

Holonomic and non-holonomic constraints: D'Alembert's Principle and Lagrange's Equation, velocity dependent potentials, simple applications of Lagrangian formulation. Hamilton Principle, Calculus of Variations, Derivation of Lagrange's equation from Hamilton's principle. Extension of Hamilton's Principle for non-conservative and non-holonomic systems, Method of Lagrange's multipliers, Conservation theorems and Symmetry Properties, Noether's theorem. Conservation of energy, linear momentum and angular momentum as a consequence of homogeneity of time and space and isotropy of space.

UNIT - II

Generalized momentum, Legendre transformation and the Hamilton's Equations of Motion: simple applications of Hamiltonian formulation, cyclic coordinates, Hamiltonian Formulation of Relativistic Mechanics, Derivation of Hamilton's canonical Equation from Hamilton's variational principle.

UNIT - III

Canonical transformation, integral invariant of poincare: Lagrange's and Poisson brackets as canonical invariants, equation of motion in Poisson bracket formulation. Infinitesimal contact transformation and generators of symmetry, Liouvilee's theorem, Hamilton-Jacobi equation and its application.

UNIT - IV

Action angle variable adiabatic invariance of action variable: The Kepler problem in action angle variables, theory of small oscillation in Lagrangian formulation, normal coordinates and its applications. Orthogonal transformation, Euler's theorem, Eigenvalues of the inertia tensor, Euler equations, force free motion of a rigid body.

Reference Books:

(1) Goldstein - Classical Mechanics

(2) Landau and Lifshitz - Classical Mechanics

(3) A. Raychoudhary - Classical Mechanics

Semester - I

PAPER II : MPHY 102: QUANTUM MECHANICS

Duration : 3 hrs. **Max. Marks : 70**

Note: There will be two parts in end semester theory paper.
Part A of the paper shall contain seven short answer questions of 14 marks. Each question will carry two marks for correct answer.
Part B of the paper will consist four questions one question from each unit with internal choice. Each question will carry 14 marks.

UNIT - I

States, Amplitude and Operators: States of a quantum mechanical system, representation of quantum-mechanical states, properties of quantum mechanical amplitude, operators and change of a state, a complete set of basis states, products of linear operators, language of quantum mechanics, postulates, essential definitions and commutation relations.

Observables and Description of Quantum system: Process of measurement , expectation values, time dependence of quantum mechanical amplitude, observable with no classical analogue, spin dependence of quantum mechanical amplitude on position, the wave function, super position of amplitudes, identical particles.

UNIT - II

Hamiltonian matrix and the time evolution of Quantum mechanical States: Permittivity of the Hamiltonian matrix, time independent perturbation of an arbitrary system, simple matrix examples of time independent perturbation, energy given states of a two state system, diagonalizing of energy matrix, time independent perturbation of two state system the perturbative solution: Weak field and Strong field cases, general description of two state system,Pauli matrices, Ammonia molecule as an example of two state system.

UNIT - III

Transition between stationary States: Transitions in a two state system, time dependent perturbations - The Golden Rule, Phase space, emission and absorption of radiation, induced dipole transition and spontaneous emission of radiation energy width of a quasi stationary state.

The co-ordinate Representation: Compatible observables, quantum conditions and uncertainty relation, Coordinate representation of operators, position, momentum and angular momentum, time dependence of expectation values, The Ehernfest Theorem, the time evolution of wave function, the schroodinger equation, energy quantization, periodic potential as an example.

UNIT - IV

Symmetries and Angular Momentum:

1. Compatible observables and constants of motion, symmetry transformation and conservation laws, invariance under spaceand time translations and space rotation and conservation of momentum, energy and angular momentum.
2. Angular momentum operators and their Eigenvalues, matrix representations of the angular momentum operators and their eigenstates, coordinate representations of the orbital angular momentum operators and their eigen state (Spherical Harmonics), composition of angular momenta, Clebsch- Gordon Coefficients tensor operators and Wigner Expart theorem, c commutation relations, of J_x, J_y,J_z with reduced tensor operator, matrix elements of vector operators, time reversal invariance and vanishing of static electric dipole moment of stationary state.

Reference Books:

1. Ashok Das and A.C. Melissions: Quantum Mechanics - A modern approach (Gordon and Breach Science Publishers).
2. P.A.M. Dirac, Quantum Mechanics.
3. E. Merzbecher: Quantum Mechanics, Second Edition (John Wiley and sons)
4. L.P. Landau and E.M. Lifshitz, Quantum Mechanics - Relativistic theory (Pergamon Press)
5. A. Ghatak and S. Lokanathan: Quantum Mechanics - Theory and Applications, Third Edition (Mac. Millan, India Ltd.

Semester - I

PAPER III : MPHY 103: CLASSICAL ELECTRODYNAMICS - I

Duration : 3 hrs. **Max. Marks : 70**

Note: There will be two parts in end semester theory paper.
Part A of the paper shall contain seven short answer questions of 14 marks. Each question will carry two marks for correct answer.
Part B of the paper will consist four questions one question from each unit with internal choice. Each question will carry 14 marks.

UNIT - I

Electrostatics: Electric field, Gauss Law, Differential form of Gaussian law. Another equation of electrostatics and the scalar potential, surface distribution of charges and dipoles and discontinuities in the electric field and potential, Poisson and Laplace equations, Green's Theorem, Uniqueness of the solution with the Dirichlet or Neumann boundary Conditions, Formal Solutions of electrostatic Boundary value problem with Green's function, Electrostatic potential energy and energy density, capacitance.

Boundary Value Problems in Electrostatics: Methods of Images, Point charge in the presence of a grounded conducting sphere, point charge in the presence of a charged insulated conducting sphere, point charge near a conducting sphere at a fixed potential, conducting sphere in a uniform electric field by method of images, Green function for the sphere, General solution for the potential, conducting sphere wit hemispheres at a different potentials, orthogonal functions and expansion.

UNIT - II

Multipoles, electrostatics of Macroscopic Media Dielectric: Multipole expansion, multipole expansion of the energy of a charge distribution in an external field, Elementary treatment of electrostatics with permeable media. Boundary value problems with dielectrics. Molar polarizability and electric susceptibility. Models for molecular polarizability, electrostatic energy in dielectric media.

UNIT - III

Magnetostatics: Introduction and definition, Biot and Savart Law, the differential equations of magnetostatics and Ampere's law, Vector potential and magnetic induction for a current loop, Magnetic fields of a localized current distribution, Magnetic moment, Force and torque on and energy of a localized current distribution in an external induction, Macroscopic equations, Boundary conditions on B and H Methods of solving Boundary value Problems in magnetostatics, Uniformly magnetized sphere, magnetized sphere in an external fields, permanent magnets, magnetic shielding, spherical shell of permeable material in an uniform field.

UNIT - IV

Time varying fields, Maxwell's equations conservation laws: Energy in a magnetic field, vector and scalar potentials, Gauge transformations, Lorentz gauge, coloumb gauge, Green function for the wave equation, Derivation of the equations of Macroscopic Electromagnetism, Poynting's Theorem and conservation of energy and momentum for a system of charged particles and EM fields. Conservation laws for macroscopic media. Electromagnetic field tensor, transformation of four potentials and four currents, tensor dissipation of Maxwell's equations.

Reference Books:

1. J.D. Jackson: Classical Electrodynamics
2. Panofsky & Phillip: Classical electrodynamics and magnetism
3. Griffith: Introduction to Electrodynamics
4. Landau & Lifshitz: Classical Theory of Electrodynamics
5. Landau & Lifshitz: Electrodynamics of continuous media

Semester - I

PAPER IV : MPHY 104: MATHEMATICAL METHOD IN PHYSICS

Duration : 3 hrs. **Max. Marks : 70**

Note: There will be two parts in end semester theory paper.
Part A of the paper shall contain seven short answer questions of 14 marks. Each question will carry two marks for correct answer.
Part B of the paper will consist four questions one question from each unit with internal choice. Each question will carry 14 marks.

UNIT - I

Coordinates Transformation in N - dimensional space: Contravariant and covariant tensor, Jacobian. Relative tensor, pseudo tensors (Example: charge density, angular momentum) Algebra of tensors, Metric tensor, Associated tensors, Riemann space (Example: Euclidean space and 4D Minkowski space), Christoffel symbols, transformation of Christoffel symbols, covariant differentiation, Ricci's theorem, divergence, Curl and Laplacian tensor form, Stress and strain tensors, Hook's law in tensor form. Lorentz covariance of Maxwell equation, Klein Gordon and Dirac Equation, Test of covariance of Schrödinger equation.

UNIT - II

Group of Transformation: (Example: Symmetry transformation of square) Generators of a finite group, Normal subgroup, Direct product of groups, Isomorphism and Homomorphism. Representation theorem of finite groups, Invariants subspace and reducible representations, irreducible representation, crystallographic point groups, Irreducible representation of C_{4V}. Translation group and the reciprocal lattice.

UNIT - III

Fourier Transforms: Development of the Fourier integral from the Fourier Series, Fourier and inverse Fourier transform: Simple Applications: Finite wave train, Wave train with Gaussian amplitude, Fourier transform of derivatives, solution of wave equation as an application. Convolution theorem. Intensity in terms of spectral density for quasi monochromic EM Waves, Momentum representation, Application of Fourier transform to diffraction theory: diffraction pattern of one and two slits.

UNIT - IV

Laplace transforms and their properties: Laplace transform of derivatives and integrals, derivatives and integral of Laplace transform. Convolution theorem. Impulsive function, Application of Laplace transform in solving linear, differential equations with constant coefficient with variable coefficient and linear partial differential equation.

Reference books:

1. Mathematical Methods for Physicists: George Arfken (Academic Press)
2. Applied Mathematics for Engineers and Physicists: L. A. Pipe (McGraw Hill)
3. Mathematical Methods - Potter and Goldberg (Prentice Hall of India)
4. Elements of Group Theory for Physicists: A.W. Joshi (Wiley Eastern Ltd.)
5. Vector Analysis (Schaum Series) (McGraw Hill)

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Semester - I

PAPER – V MPHY 111 /211 Electronics / General Lab

Note: Out of following experiments, 8 experiments must be done by the students.

(3 hrs per day)

Duration : 5 hrs. **Max. Marks : 80**

1. To design a single stage amplifier of a given voltage gain and lower cut of frequencies.
2. To determine Lo. Co. and Rf of a given coil and to study the variations of Rf with frequency.
3. To design a RC coupled two stage amplifier of a given gain and the cutoff frequencies.
4. To study Hartley oscillator.
5. To Study Transistor bias Stability.
6. To design a Multiv~bratorof given frequency and study its wave shape.
7. To study the characteristics ofFET and use it 0 design an relaxation oscillator and measure its frequency.
8. To study the characteristics of an operational amplifier.
9. To study the characteristics of a UJT and use it to design a relaxation oscillator and measure its frequency.
10. To study the addition, integration and differentiation properties of an operational amplifier.
11. Determine Plack constant using solar Cell.
12. To determine Plack constant and work function by a photo-cell.
13. To study regqlated power supply using (A) Zener diode only (b) Zener diode with a series transistor (c) Zener diode with a shunt transistor.
14. To verify Fresnel's formula;
15. To study the percentage regulation and variation of Ripple factor, withload for a full wave rectifier.
16. To study analog to digital and digital to analog conversion.
17. To study a driven mechanical oscillator.
18. To verify Hartmann's formula using constant deviation spectrograph.
19. To find e/m of electron using Zeeman effect.
20. To find Dissociation energy to I.
21. Study of CH Bands.
22. Salt Analysis / Raman effect (Atomic).
23. Design and study of pass filters.
24. Michelson Interferometer.
25. Fabry parot Interferometer.
26. Determination of velocity of Ultrasonic waves.
27. Study of Eliptically polarised light by Babinet Compensator.
28. Veafication of Cauchey's Dispersion relation.
29. Study of DC gatecontrol characteristics and Anode current characteristics of SCR.

Semester - II

PAPER VI : MPHY 201: ELECTRONICS

Duration : 3 hrs. **Max. Marks : 70**

Note: There will be two parts in end semester theory paper.

Part A of the paper shall contain seven short answer questions of 14 marks. Each question will carry two marks for correct answer.

Part B of the paper will consist four questions one question from each unit with internal choice. Each question will carry 14 marks.

UNIT - I

Operational Amplifiers: Differential amplifier - circuit configurations - dual input, balanced output differential amplifier, DC analysis, inverting and non-inverting inputs, CMRR-constant current bias level translator. Block diagram of typical OP-Amp analysis. Open loop configuration, inverting and non-inverting amplifiers, Op-Amp with negative feedback, voltage series feedback, effect of feed back on closed loop gain, input resistance, bandwidth and output offset voltage, voltage follower. Practical Op-Amp, input offset voltage-input bias current-input offset current, total output offset voltage, CMRR frequency response. DC and AC amplifier. integrator and differentiator.

UNIT - II

O**scillators and wave shapping Circuits:** Oscillator Principle, Frequency stability response, the phase shift oscillator, Wein bridge oscillator, LC tunable oscillators, Multivibrators- Monostable, astable and bistable, Comparators, Square wave and triangle wave generation, clamping and clipping circuits.

UNIT - III

Digital Electronics: Combinational logic: Standard representations for logic functions, Karnaugh Map Representation of logical functions, Simplification of logical functions using K-Map, Minimization of Logical functions specified in Minterms / Maxterms or truth table, Don’t care conditions, Adder (half and full), Subtractor (half and full), comparator, Multiplexers and their uses, Demultiplexer / Decoders and their uses. BCD arithmatics, Parity generators / Checkers, Code Converters, Priority Encoders, Decoder / Drivers for display devices, Seven Segment display device. ROM, Programmable Logic Array. Basic concepts about fabrication and characteristics of integrated circuits.

UNIT - IV

Sequential Logic: Flip-Flops: one - bit memory, RS, JK, JK master slave, T and D type flip flops, shift resisters - synchronous and asynchronous counters, cascade counters, Binary counter, Decade counter. A/D and D/A conversion- Basic principles, circuitry and simple applications. Voltage regulators - fixed regulators, adjustable voltage regulators, switching regulators. Basic idea of IC 555 and its applications as multivibrator and sqaure wave generator. Opto-electronic Devices: Photo diode, Phototransistor, Light emitting Diode and their applications

Text and Reference Books:

1. "Electronic Devices and Circuit Theory" by Robert Boylested and Louis Nashdsky, PHI, New Delhi - 110001, 1991.
2. "OP-AMP and Linear Integrated Circuits" by Ramakanth, A. Gayakwad, PHI, Second Edition 1991.
3. "Digital Principle and Applications" by A.P. Malvino and Donald P. Leach, Tata McGraw Hill Company, New Delhi, 1993.

Semester - II

PAPER VII : MPHY 202 : ATOMIC AND MOLECULAR PHYSICS

Duration : 3 hrs. **Max. Marks : 70**

Note: There will be two parts in end semester theory paper.

Part A of the paper shall contain seven short answer questions of 14 marks. Each question will carry two marks for correct answer.

Part B of the paper will consist four questions one question from each unit with internal choice. Each question will carry 14 marks.

UNIT - I

Gross structure of energy spectrum of hydrogen atom. Non degenerate first order perturbation method, relativistic correction to energy levels of an atom, atom in a weak uniform external electric field – first and second order Stark effect, calculation of the polarizability of the ground state of hydrogen atom and of an isotropic harmonic oscillator; degenerate stationary state perturbation theory, linear Stark effect for hydrogen atom levels, inclusion of spin orbit interaction and weak magnetic field, Zeeman effect, effect of strong magnetic field. Magnetic dipole interaction, hyperfine structure and Lamb shift (only qualitative description).

UNIT - II

Indistinguishability and exchange symmetry: many particle wave functions and Pauli's exclusion principle, spectroscopic terms for atoms.The helium atom, Variational method and its use in calculation of ground state energy. Hydrogen molecule, Heitler London method for hydrogen molecule. WKB method for one dimensional problem, application to bound states (Bohr Sommerfeld quantization) and the barrier penetration.

UNIT - III

Spectroscopy (qualitative): General features of the spectra of one and two electronsystem – singlet, doublet and triplet characters of emission spectra, general features of alkali spectra. Rotation and vibration band spectrum of a molecule, P,Q and R branches. Raman spectra for rotational and vibrational transitions, comparison with infrared spectra – application to learning about molecular symmetry. General features of electronic spectra, Frank and Condon's principle.

UNIT - IV

Laser cooling and trapping of atoms: The scattering force, slowing an atomic beam, chirp cooling, optical molasses technique, Doppler cooling limit, magneto optical trap. Introduction to the dipole force, theory of the dipole force, optical lattice. Sisyphus cooling technique – description and its limit. Atomic fountain. Magnetic trap (only qualitative description) for confining low temperature atoms produced by Laser cooling, Bose-Einstein condensation in trapped atomic vapours, the scattering length, Bose-Einstein condensate, coherence of a Bose- Einstein Condensate, The Atom Laser.

Reference Books :

1. G. Banewell – Atomic and Molecular spectroscopy
2. Christopher J. Foot – Atomic Physics, Oxford Master series, 2005
3. G.K. Woodgate, Elementray Atomic Structure, Second Edition Clarendon Press, Oxford.
4. T.A. Littlefield - Atomic and Molecular Physics.
5. Eistaberg and Rasmic- Quantum Physics of Atoms. Molecules Solids and Nuclear Particles.
6. Ashok Das and A.C. Melfessions. Quantum Mechanics ; A Modem Approach (Gordon and Breach Science Publishers).
7. White - Atomic Spectra.
8. Herzberg- Molecular spectra.

Semester - II

PAPER VIII : MPHY 203 CLASSICAL ELECTRODYNAMICS –II

Duration : 3 hrs. **Max. Marks : 70**

Note: There will be two parts in end semester theory paper.

Part A of the paper shall contain seven short answer questions of 14 marks. Each question will carry two marks for correct answer.

Part B of the paper will consist four questions one question from each unit with internal choice. Each question will carry 14 marks.

UNIT - I

Plane Electromagnetic Waves and Wave Equation : Plane wave in a nonconducting medium. Frequency dispersion characteristics of dielectrics, conductors and plasma, waves in a conducting o dissipative medium, superposition of waves in one dimension, group velocity, casualty connection between D and E. Kramers-Kroning relation.

UNIT - II

Magnetohydrodynamics and Plasma Physics : Introduction and definitions, MHD equations, Magnetic diffusion, viscosity and pressure, Pinch effect, instabilities in pinched plasma column, Magnetohydrodynamics waves, Plasma oscillations, short wave length limit of plasma oscillations and Debye shielding distance.

UNIT - III

Covariant Form of Electrodynamic Equations : Mathematical properties of the space- time special relativity, Invariance of electric charge covariance of electrodynamics. Transformation of electromagnetic field.

Radiation by moving charges : Lienard-Wiechert Potential for a point charge, Total power radiated by an accelerated charge : Larmour's formula and its relativistic generalization, Angular distribution of radiation emitted by an accelerated charge, Radiation emitted by a charge in arbitrary extremely relativistic motion. Distribution in frequency and angle of energy radiated by accelerated charges, Thomson scattering and radiation, Scattering by quasifree charges, coherent and incoherent scattering, Cherenkov radiation.

UNIT - IV

Radiation damping, self fields of a particle, scattering and absorption of radiation by a bound system : Introductory considerations, Radiative reaction force from conservation of energy, Abraham Lorentz evaluation of the self force, difficulties with Abraham Lorentz model, Integro-differential equation of motion including radiation damping, Line Breadth and level shift of an oscillator, Scattering and absorption of radiation by an oscillator, Energy transfer to a harmonically bound charge.

Reference Books :

1. Classical Electrodynamics : Jackson
2. Classical Electricity and Magnetism : Panofsky and Philips.
3. Introduction to Electrodynamics : Griffiths.
4. Classical Theory of Field : Landan and Lifshitz.
5. Electrodynamics of Continuous Media : Landau and Lifshitz.

Semester - II

PAPER IX : MPHY 204: NUMERICAL METHODS

Duration : 3 hrs. **Max. Marks : 70**

Note: There will be two parts in end semester theory paper.

Part A of the paper shall contain seven short answer questions of 14 marks. Each question will carry two marks for correct answer.

Part B of the paper will consist four questions one question from each unit with internal choice. Each question will carry 14 marks.

UNIT – I

Errors in Numerical Analysis: Source of Errors, Round off error, Computer Arithmetic, Error Analysis, Condition and stability, Approximation, Functional and Error analysis, the method of Undetermined Coefficients. use of interpolation formula, Iterated interpolation, Inverse interpolation, Hermite interpolation and Spline interpolation, Solution of Linear equations : Direct and Iterative methods, Calculation of eigen values and eigen vectors for symmetric matrices.

UNIT - II

Solution of Nonlinear equation : Bisection method, Newton's method, modified Newton's method, method of Iteration, Newton's method and method of iteration for a system of causation Newtons' method for the case of complex roots. Integration of a function. Trapezoiddal and Simpson's rules. Gaussian quadrature formula, Singular integrals, Double integration.

UNIT - III

Integration of Ordinary differential equation : Predictor-corrector methods, Runga-Kutta method. Simultaneous and Higher order equations. Numerical Integration And Differentiation of Data, Least-Squares Approximations, Fast Fourier Transform.

UNIT - IV

Elementary probability theory, random variables, binomial, Poisson and normal distributions.

Reference :

1. A Ralston and P. Rabinowitz : A First Course in Numerical Analysis, McGraw Hill (1985).
2. S.S. Sastry : Introductory Methods of Numerical Analysis, Prentice-Hall of India (1979).

Semester - II

PAPER – X MPHY 111 /211 Electronics / General Lab

Note: Out of following experiments, 8 experiments must be done by the students.

(3 hrs per day)

Duration : 5 hrs. **Max. Marks : 80**

1. To design a single stage amplifier of a given voltage gain and lower cut of frequencies.
2. To determine Lo. Co. and Rf of a given coil and to study the variations of Rf with frequency.
3. To design a RC coupled two stage amplifier of a given gain and the cutoff frequencies.
4. To study Hartley oscillator.
5. To Study Transistor bias Stability.
6. To design a Multiv~bratorof given frequency and study its wave shape.
7. To study the characteristics ofFET and use it 0 design an relaxation oscillator and measure its frequency.
8. To study the characteristics of an operational amplifier.
9. To study the characteristics of a UJT and use it to design a relaxation oscillator and measure its frequency.
10. To study the addition, integration and differentiation properties of an operational amplifier.
11. Determine Plack constant using solar Cell.
12. To determine Plack constant and work function by a photo-cell.
13. To study regqlated power supply using (A) Zener diode only (b) Zener diode with a series transistor (c) Zener diode with a shunt transistor.
14. To verify Fresnel's formula;
15. To study the percentage regulation and variation of Ripple factor, withload for a full wave rectifier.
16. To study analog to digital and digital to analog conversion.
17. To study a driven mechanical oscillator.
18. To verify Hartmann's formula using constant deviation spectrograph.
19. To find e/m of electron using Zeeman effect.
20. To find Dissociation energy to I.
21. Study of CH Bands.
22. Salt Analysis / Raman effect (Atomic).
23. Design and study of pass filters.
24. Michelson Interferometer.
25. Fabry parot Interferometer.
26. Determination of velocity of Ultrasonic waves.
27. Study of Eliptically polarised light by Babinet Compensator.
28. Veafication of Cauchey's Dispersion relation.
29. Study of DC gatecontrol characteristics and Anode current characteristics of SCR.

Semester - III

PAPER XI : MPHY 301 : ADVANCED QUANTUM MECHANICS

Duration : 3 hrs. **Max. Marks : 70**

Note: There will be two parts in end semester theory paper.

Part A of the paper shall contain seven short answer questions of 14 marks. Each question will carry two marks for correct answer.

Part B of the paper will consist four questions one question from each unit with internal choice. Each question will carry 14 marks.

UNIT – I

Scattering (non-relativistic) : Differential and totall scattering cross section, transformation from CM frame to Lab frame, solution of scattering problem by the method of partial wave analysis, expansion of a plane wave into a spherical wave and scattering amplitude, the optical theorem, Applications-scattering from a delta potential, square well potential and the hard sphere scattering of identical particles, energy dependence an resonance scattering. Breit-Wigner formula, quasi stationary states.

The Lippman-Schwinger equation and the Green's functions approach for scattering problem, Born approximation and its validity for scattering problem, Coulomb scattering problem under first Born approximation in elastic scattering.

UNIT – II

Relativistic Formulation ad Dirac Equation : Attempt for relativistic formulation of quantum theory, The Klein-Gordon equation, Probability density and probability current density, solution free particle K.G. equation in momentum representation, interpretation of negative probability density and negative energy solutions.

Dirac equation for a free particle, properties of Dirac matrices and algebra of gamma matrices, non-relativistic correspondence of the Pauli equation (inclusive of electromagnetic interaction). Solution of the free particle Dirac equation, orthogonality and completeness relations for Dirac spinors, interpretation of negative energy solution and hole theory.

UNIT – III

Symmetries of Dirac Equation : Lorentz covariance of Dirace equation, proof of covariance and derivation of Lorentz boost and rotation matrices for Dirac spinors, Projection operators involving four momentum and spin, Parity (P), charge conjugation (C), time reversal (T) and CPT operators for Dirac spinors, Bilinear covariants, and their transformations, behaviour under Lorentz transformation, P,C,T and CPT, expectation values of coordinate and velocity involving only positive energy solutions and the associated problems, inclusion of negative energy solution, Zitterbewegung, Klein paradox.

UNIT – IV

The Quantum Theory of Radiation : Classical radiation field, transversality condition, Fourier decomposition and radiation oscillators, Quantization of radiation oscillator, creation, annihilation and number operators, photon states, photon as a quantum mechanical excitations of the radiation field, fluctuations and the uncertainty relation, validity of the classical description, matrix element for emission and absorption, spontaneous emission in the dipole approximation, Rayleigh scattering. Thomson scattering and the Raman effect, Radiation damping and Resonance fluorescence.

Reference Books :

1. Ashok Das and A.C. Milissiones : Quantum mechanics - A Modern Approach (Garden and Breach Science Publishers).
2. Eugen Merzbacher : Quantum Mechanics, Second Edition (John Wiley and Sons).
3. Bjorken and Drell : Relativistic Quantum Mechanics (McGraw Hill).
4. J.J. Sakurai : Advanced Quantum Mechanics (John Wiley)

Semester - III

PAPER XII : MPHY 302: STATISTICAL PHYSICS

Duration : 3 hrs. **Max. Marks : 70**

Note: There will be two parts in end semester theory paper.

Part A of the paper shall contain seven short answer questions of 14 marks. Each question will carry two marks for correct answer.

Part B of the paper will consist four questions one question from each unit with internal choice. Each question will carry 14 marks.

UNIT – I

Basic Principles, Canonical and Grand Canonical ensembles :

Concept of statistical distribution, phase space, density of states Liouville's theorem,systems and ensemble, entropy in statistical mechanics Connection between thermodynamic and statistical quantities micro canonical ensemble, equation of state, specific hear and entropy of a perfect gas, using microcanonical ensemble. Canonical ensemble, thermodynamic functions for the canonical ensemble, calculation of means values, energy fluctuation in a gas, grand canonical ensemble, thermodynamic functions for the grand canonical ensemble, density fluctuations.

UNIT – II

Partition functions and Statistics : Partition functions and properties, partition function for an ideal gas and calculation of thermodynamic quantities, Gibbs Paradox, validity of classical approximation, determination of translational, rotational an vibration contributions to the partition function of an ideal diatomic gas. Specific heat of a diatomic gas, ortho and para hydrogen.

Identical particles and symmetry requirement, difficulties with Maxwell-Boltzmann statistics, quantum distribution functions, Bose Einstein and Fermi-Dirac statistics and Planck's formula, Bose Einstein condensation, liquid He4 as a Boson system, quantization of harmonic oscillator and creation and annihilation of phonon operators, quantization of fermion operators.

UNIT – III

Theory of Metals : Fermi-Dirac distribution function, density of states, temperature dependence of Fermi energy, specific heat, use of Fermi-Dirac statistics in the calculation of thermal conductivity and electrical conduction band, Drude theory of light, absorption in metals.

UNIT – IV

Band Theory : Block theorem, Kronig Penny model, effective mass of electrons, Winger-Seqtz approximation, NFE model, tight binding method and calculation of density for a band in simple cubic lattice, pseudo potential method.

Reference Books :

1. Huag : Statistical Mechanics
2. Reif : Fundamentals of Statistical and Thermodynamical Physics.
3. Rice : Statistical mechanics and Thermal Physics.
4. Kittle : Elementray statistical mechanics.
5. Kittle : Introduction to solid state physics.
6. Palteros : Solid State Physics.
7. Levy : Solid State Physics.

Semester - III

PAPER XIII : MPHY 303 : NUCLEAR PHYSICS-I

Duration : 3 hrs. **Max. Marks : 70**

Note: There will be two parts in end semester theory paper.

Part A of the paper shall contain seven short answer questions of 14 marks. Each question will carry two marks for correct answer.

Part B of the paper will consist four questions one question from each unit with internal choice. Each question will carry 14 marks.

UNIT – I

Two Nucleon system and Nuclear forces : General nature of the force between nucleons, saturation of nuclear forces, charge independence and spin dependence, General forms of two nucleon interaction, Central, noncentral and velocity dependent potential, Analysis of the ground state (3S1) of deuteron using a square well potential, range-depth relationship, excited states of deuteron, Discussion of the ground state of deutron under noncentral force, calculation of the electric quadrupole and magnetic dipole moments and the D-state admixture.

UNIT – II

Nucleon-Nucleon Scatterign and Potentials : partial wave analysis of the neutron- proton scattering at low energy assuming central potential with square well shape, concept of the scattering length, coherent scattering of neutrons by protons in (ortho and para), hydrogen molecule; conclusions of these analyses regarding scattering lengths, range and depth of the potential; the effective range theory (in neutron-proton scattering)_ and the shape independence of nuclear potential: the effective range theory (in neutron-proton scattering) and the shape independence of nuclear potential; A qualitative discussion of proton-proton scattering at low energy; General features of two-body scatterign at high energy effect of exchange forces. Phenomemonological Hamada-Johnston ahard core potential ad Reid hard core and soft core potentials; Main features of the One Boson Exchange Potentials (OBEP) no derivation.

UNIT – III

Interaction of radiation and charged particle with matter (Not derivation) : Law of absorption and attenuation coefficient photoelectric effect, Compton, scattering, pair production; Klein-Nishina cross sections for polarized and unpolarized radiation angular distribution of scattered photon and electrons, Energy loss of charged particles due to ionization, Bremstrahlung; energy target and projectile dependence of all three processes, Range-energy curves; Straggling.

UNIT – IV

Experimental Techniques : Gas filled counters; Scintillation counter; Cerenkov counters; Solid state detectors; Surface barrier detectors; Electronic circuits used with typical nuclear detector; Multiwire proportion chambers; Nuclear emulsions, techniques of measurement and analysis of tracks; Proton synchrotron; Linear accelecrators; Acceleration of heavy ions.

Reference Books

1. J.M. Bhatt and V.E. Weisskipf : Theoretical Nuclear Physics.
2. L.R.B. Elton : Introductory Nuclear Theory (ELBS Publicatio, London, 1959).
3. B.K. Agarwal : Nuclear Physics (Lokbharti Publication Allahabad. 1989).
4. R.R. Roy and B.P.Nigam : Nuclear Physics (Willey -Easter, 1979).
5. M.A. Preston & R.K. Bhaduri : Structure of the Nucleus (Addition-Wesley, 1975).
6. R.M. Singru : Introductory Experimental Nuclear Physics.
7. England- Techniques on Nuclear Structure (Vol I).
8. R.D. Evans : The Atomic Nucleus (Mc Graw Hills, 1955)
9. H. Enge. Introduction Nuclear Physics (Additon-Wesley, 1970).
10. W.E. Burcham : Elements of Nuclear Physics (ELBS. Longma. 1988)
11. B.L. Cohen : Concept of Nuclear Phsyics (Tata McGraw Hills, 1988).
12. E. Segre : Nuclei and Particles (Benjamin, 1977).
13. I. Kaplan : Nuclear Physics (Addison Wesley, 1963).
14. D. Halliday : introductory Nuclear Physics (Wiley, 1955).

Semester - III

PAPER – XV MPHY 311/411 : Advance/Elective Physics Laboratory Work

Note: Out of following experiments, 8 experiments must be done by the students.

(3 hrs per day)

Duration : 5 hrs. **Max. Marks : 80**

1. To determine half-life of a radio isotope using GM counter.
2. To study absorption of particles and determine range using at least two sources.
3. To study characteristics of a GM counter adn to study statistical nature of radioactive decay.
4. To study spectrum of b- particles using Gamma ray spectrometer.
5. To calibrate a scintillation spectrometer and determine energy of g-rays from an unknown source.
6. (a) To study variation of energy resolution for a Nai (Tp) detector.
   (b) To determine attenuation coefficient (u) for rays from a given sources.
7. To study Compton scattering of gamma rays and verify the energy shift formula.
8. To study temperature variation of resistivity for a semi-conductor and to obtain band gap using four probe method.
9. To study hall effect and to determine hall coefficient.
10. To study the variation of rigidity of a given specimen as a function of the temperature.
11. To study the dynamics o a lattice using electrical analog.
12. To study ESR and determine g-factor for a given spectrum.
13. To determine ultrasonic velocity and to obtain compressibility for a given liquid.
14. Study the characteristics of a given Klystron and calculate the mode number, E.T.S. and transit time.
15. Study the simulated L.C.R. Transmission line (audio frequency) and to find out the value fora Zo experimentally from the graph.
16. Study the radiation pattern of a given Pyramidal horn by plotting it on a Polar graphy paper. Find the half power beam width and calcualte its gain.
17. Find the dielectric constant of a given solid (Teflon) for three different lengths by using slotted section.
18. Find the dielectric constant of a given liquid (organic) using slotted section of X-band.
19. Verification of Bragg's law using microwaves.

Semester – IV

PAPER XVI : MPHY 401: INTRODUCTORY QUANTUM FIELD THEORY

Duration : 3 hrs. **Max. Marks : 70**

Note: There will be two parts in end semester theory paper.

Part A of the paper shall contain seven short answer questions of 14 marks. Each question will carry two marks for correct answer.

Part B of the paper will consist four questions one question from each unit with internal choice. Each question will carry 14 marks.

UNIT – I

Scalar and Vector fields, Classical Lagrangian field theory, Euler Lagrange's equation, Lagrangian density for electromagnetic field. Occupation number representation for simple harmonic oscillator, linear array of coupled oscillators, second quantization of identical bosons, second quantization of the real Klein-Gordon Field and Complex Klein-Gordon field, the meson propagator.

UNIT – II

The occupation number representation for fermions, second quantization of the Dirac field, the fermion propagator, the em interaction and gauge invariance, covariant quantization of the free electromagnetic field, the photon propagator.

UNIT – III

S-matrix, the S-matrix expansion, Wick's theorem, Diagrammatic representation in configuration space, the momentum representation, Feynman diagrams of basic processes, Feynman rules of QED.

UNIT – IV

Applications of S-matrix formalism : The Coulomb scattering, Bhabha scattering, Moller scattering, and Compton scattering.

Reference Books :

1. Quantum Field Theory by F. Mandal & G. Shaw (Honh-Wiley).
2. Relativistic Quantum Mechanics by J.D. Bjorken & S. Drell (McGraw Hill Book Co.).
3. Advanced Quantum Mechanics by J.J. Sakaurai.
4. Element of Advanced Quantum Theory by J.M. Ziman. (Cambridge University Press).

Semester – IV

PAPER XVII : MPHY 402 : SOLID STATE PHYSICS

Duration : 3 hrs. **Max. Marks : 70**

Note: There will be two parts in end semester theory paper.

Part A of the paper shall contain seven short answer questions of 14 marks. Each question will carry two marks for correct answer.

Part B of the paper will consist four questions one question from each unit with internal choice. Each question will carry 14 marks.

UNIT – I

Lattice Dynamics and Optical Properties of Solids : Interatomic forces and lattice dynamics and simple metals, ionic and covalent crystals. Optical phonons and dielectric constants. Inelastic neutron scattering. Mossbauer effect. Debye-Waller factor. Anharmonicity, thermal expansion and thermal conductivity. Interaction of electrons and phonons with photons. Direct and indirect transitions Absorption in insulators, Polaritions, one-phonon absorption, optical properties of metals, skin effect and anomalous skin effect.

UNIT – II

Semiconductors : Law of mass action, calculation of impurity conductivity, ellipsoidal energy surfaces in Si and Ge, Hall effect, recombination mechanism, optical transitions and Schockely-Read theory, excitions, photoconductivity, photo- luminescence. Points line, planar and bulk defects, colour centres, F-centre and aggregate centres in alkali halides.

UNIT – III

Magnetism : Larmor diamagnetism. Paramagnetism, Curie Langevin and Quantum theories. Susceptibility of rate earth and transition metals. Ferromagnetism : Domian theory, Weiss molecular field and exchange, spin waves: dispersion relation and its experimental determination by inelastic neutrons scattering, heat capacity. Nuclear Magnetic resonance : Conditions of resonance, Bloch equations. NMR-experiment and characteristics of an absorption line.

UNIT – IV

Superconductivity :

(a) Experimental Results : Meissner effect, heat capacity, microwave and infrared properties, isotope effect, flux quantization, ultrasonic attenuation, density of states, nuclear spin relaxation, Giaver and AC and DC Josephson tunnelings.

(b) Cooper pairs and derivation of BCS Hamiltonian, results of BCS Theory (no derviation).

Reference Books :

1. Kittle : Introduction to Solid State Physics, 5th Edition (John Wiley).
2. Levy-Solid State Physics.
3. Patterson - Solid State Physics.
4. Mckelvy - Solid State and Semi-conductor Physics.

Semester – IV

. . PAPER XVIII : PHY 403 : NUCLEAR PHYSICS-II

Duration : 3 hrs. **Max. Marks : 70**

Note: There will be two parts in end semester theory paper.

Part A of the paper shall contain seven short answer questions of 14 marks. Each question will carry two marks for correct answer.

Part B of the paper will consist four questions one question from each unit with internal choice. Each question will carry 14 marks.

UNIT – I

Nuclear Shell Model : Single particle and collective motions in nuclei : Assumptions and justification of the shell model, average shell potential, spin orbit coupling; single particle wave functions and level sequence; magic numbers; shell model predictions for ground state parity; angular momentum, magnetic dipole and electric quadrupole moments; and their comparison with experimental data; configuration mixing; single particle transition probability according to the shell model; selection rules; approximate estimates for the transition probability and Weisskopf units; Nuclear isomerism.

UNIT – II

Collective Nuclear Models : Collective variable to describe the cooperative modes of nuclear motion; Parameterization of nuclear surface; A brief description of the collective model Hamiltonian (in the quadratic approximation); Vibrational modes of a spherical nucleus, Collective modes of a deformed even-even nucleus and moments of inertia; Collective spectra and electromagnetic transition in even nuclei and comparison with experimental data; Nilsson model for the single particle states in deformed nuclei.

UNIT – III

Nuclear Gamma and Beta decay : Electric and magnetic multipole moments and gamma decay probabilities in nuclear system (no derivations) Reduced transition probability, Selection rules; Internal conversion and zero-zero transition.

General characteristics of weak interaction; nuclear beta decay. and lepton caputre; electron energy spectrum and Fermi-Kurie plot; Fermi theory of beta decay (parity conserved selection rules Fermi and Gamow-Teller) for allowed transitions; ft-values; General interaction hamiltonian for beta decay with parity conserving and non conserving terms; Forbidden transitions; Experimental verification of parity violation; The V-A interaction and experimental verification.

UNIT – IV

Nuclear Reactions : Theories of Nuclear Reactions; Partial wave analysis of reaction Cross section; Compound nucleus formatin and breakup; Resonance scattering and reaction-Breit-Wigner dispersion formula for s-waves (1 = 0), continuum cross section; Statistical theory of nuclear reactions, evaporation probability and cross section for specific reactions; The optical model, Stripping and pick-up reactions and their simple theoretical description (Butler theory) using plane wave Born approximation (PWBA) Shortcomings of PWBA Nuclear structure studies with deuteron stripping (d, p) reactions.

Reference Books :

1. M.A. Preston and R.K. Bhaduri : Structure of Nucleus, Addision Wesley, 1975.
2. R.R. Roy and B.P. It Nigam, Nuclear Physics, Wiley-Eastern. 1979.
3. L.R.B. Elton: Introductory Nuclear Theory, ELeBS Pub. London, 1959.
4. B.K. Agrawal : Nuclear Physics. Lokbharati Publt., Allahabad 1989.
5. M.K. Pal-Nuclear Structure, Affiliated East-West Press, 1982.
6. J.B. Blatt and V.F. Weisskopf-Theoretical. Nuclear Physics.
7. H. Enge. : Introduction to Nuclear Physics, Addison - Wesley, 1970.
8. B.L. Cohen-concept of Nuclear Physics, Tata McGraw Hill, 1988.
9. W.E. Burchema - element of Nuclear Physics, ELBS, Longman, 1988.
10. R.D. Evans : The Atomic Nucleus, Mc Graw Hill, 1955.
11. E. Segre Nuclei and Particles, Benjamin, 1977.

Semester - IV

PAPER – XX MPHY 411/311 : Advance /ElectivePhysics Laboratory Work

Note: Out of following experiments, 8 experiments must be done by the students.

(3 hrs per day)

Duration : 5 hrs. **Max. Marks : 80**

1. To determine half-life of a radio isotope using GM counter.
2. To study absorption of particles and determine range using at least two sources.
3. To study characteristics of a GM counter adn to study statistical nature of radioactive decay.
4. To study spectrum of b- particles using Gamma ray spectrometer.
5. To calibrate a scintillation spectrometer and determine energy of g-rays from an unknown source.
6. (a) To study variation of energy resolution for a Nai (Tp) detector.
   (b) To determine attenuation coefficient (u) for rays from a given sources.
7. To study Compton scattering of gamma rays and verify the energy shift formula.
8. To study temperature variation of resistivity for a semi-conductor and to obtain band gap using four probe method.
9. To study hall effect and to determine hall coefficient.
10. To study the variation of rigidity of a given specimen as a function of the temperature.
11. To study the dynamics o a lattice using electrical analog.
12. To study ESR and determine g-factor for a given spectrum.
13. To determine ultrasonic velocity and to obtain compressibility for a given liquid.
14. Study the characteristics of a given Klystron and calculate the mode number, E.T.S. and transit time.
15. Study the simulated L.C.R. Transmission line (audio frequency) and to find out the value for a Zo experimentally from the graph.
16. Study the radiation pattern of a given Pyramidal horn by plotting it on a Polar graphy paper. Find the half power beam width and calcualte its gain.
17. Find the dielectric constant of a given solid (Teflon) for three different lengths by using slotted section.
18. Find the dielectric constant of a given liquid (organic) using slotted section of X-band.
19. Verification of Bragg's law using microwaves.

Semester - III

PAPER- XIV : (A) MICROWAVE ELECTRONICS-I

Duration : 3 hrs. **Max. Marks : 70**

Note: There will be two parts in end semester theory paper.

Part A of the paper shall contain seven short answer questions of 14 marks. Each question will carry two marks for correct answer.

Part B of the paper will consist four questions one question from each unit with internal choice. Each question will carry 14 marks.

UNIT – I

Introduction to microwaves and its frequency spectrum, Application of microwaves. **Wave guides:**

(a) Rectangular wave guides: Wave Equation & its solutions, TE&TM modes. Dominant mode and choice of wave guide Dimensions Methods of excitation of wave guide.

(b) Circular wave guide-wave equation & its solutions, TE, TM & TEM modes.

(c) Attenuation - Cause of attenuation in wave guides, wall current & derivation of attenuation constant, Q of the wave guide.

UNIT - II

Resonators: Resonant Modes of rectangular and cylindrical cavity resonators, Q of the cavity resonators, Excitation techniques, Introduction to Microstrip and Dielectric resonators, Frequency meter.

Ferrites: Microwave propagation in ferrites, Faraday rotation, Devices employing Faraday rotation (isolator, Gyrator, Circulator). Introduction to single crystal ferromagnetic resonators, YIG tuned solid state resonators.

UNIT - III

Microwave Measurement:

(a) Microwave Detectors: Power, Frequency, Attenuation, Impedance Using smith chart, VSWR, Reflectometer, Directivity, coupling using direction coupler.

(b) Complex permittivity of material & its measurement: definition of complex of Solids, liquids and powders using shift of minima method.

UNIT - IV

Microwave tubes: Space charge spreadingof an electronbeam, Beam focussings.

Klystrons: Velocity Modulation, Two Cavity Klystron, Reflex Klystron Efficiency of Klystrons.

Magnetrons: types & description, Theoretical relations between Electric & Magnetic field of oscillations. Modes of oscillation & operating characteristics.

Gyrotrons: Constructions of different ,Gyrotrons, Field. -Particle Interaction in Gyrotron.

Reference Books:

1.Electromagnetic waves & Radiating Systems: Jorden & Balmain.
2. Theory and application of microwaves by A.B. Brownwell & RE. Beam (McGraw Hill) .
3. Introduction to microwave theory by Atwater (McGraw Hill).
4. Principles of microwave circuit by G.C. Montgomery (Mc Graw Hill)
5. Microwave Circuits & Passive Devices by M.L. Sisodia and G.S. Raghuvanshi (New Age International, New Delhi)
6. Foundations of microwave engineering by RE. Collin. (McGraw Hill).
7. Microwave Semiconductor Devices and their Circuit applications by H.A. Watson
8. Microwave by M.L. Sisodia and Vijay Laxmi Gupta. New Age, New Delhi.
9. Antenna Theory, Part-I by RE. Collin & EJ. Zucker (McGraw Hill, New York)
10.Microstrip Antennas by Bahl & Bhartiya (Artech House, Messachausetts)
11. Antenna Theory Analysis by C.A. Balanis Harper & Row. Pub. & Inc. New York.
12. Antenna Theory Analysis by E.A. W01""(J. Willey & Sons)
13. Antenna Theory & Design by RS Elliott (LPHI Ltd. New Delhi)
14. Microwave electronics by RE Soohoo (Addisen Westey pubblic company,).
15.Microwave Active Devices, Vacuoums by M.L. Sisodia new Age International New Delhi.
16. Semiconductors & Electronics device by A. BarIe vs (PHI, India).
17. Solid State physical electronics by A.Vanderziel, (PHI, India).
18. Hand book of microwave measurement Vol-II by M. Sucher & J.Fox (polytechnic Press, New York).
19. Microwave devices & circuits by S.Y.Liao(PHI, India).
20. Microwave Principles by H.J. Reich (CBS).

Semester - IV

PAPER- XIX : (A) MICROWAVE ELECTRONICS-II

Duration : 3 hrs. **Max. Marks : 70**

Note: There will be two parts in end semester theory paper.

Part A of the paper shall contain seven short answer questions of 14 marks. Each question will carry two marks for correct answer.

Part B of the paper will consist four questions one question from each unit with internal choice. Each question will carry 14 marks.

UNIT - I

(a) Avalanche Transit Time Device:Read Diode, Negative resistance of an avalanching p-n Junction diode IMPATT Oscillator.

(b) Transferred Electron Device: Gunn effect, two velley, model, High field Dotrutins, Different Modes for Microwave generation.

(c) Passive Devices: Termination (Short circuit and matched terminations) precision attenuator, precision shifter phase changers, E&H plane Tees, Hybrid Junctions. Directional coupler.

UNIT - II

Parametric Amplifier: Varactor, Equation of Capacitance in Linearly graded & abrupt pn junction, Manely Rowe relations, parametric upconvertor and Negative resistance parametric amplifier,-use of circulator, Noise in parametric amplifiers.

UNIT - III

Microwave Antennas: Introduction to antenna parameters, Magnetic Currents, Electric and magnetic current sheet, Field of Huygen's source, Radiation from a slot antenna, open end of a wave guide and Electromagnetic Horns.

Radiation fields of Microstrip wave guide, Microstrip wave guide, Microstrip antenna calculations, Microstrip design formulas.

UNIT - IV

Microwave Communication:

(a) LOS microwave systems, Derivation of LOS communication range, OTH microwave systems, Derivation of field strength of tropospheric waves, . Transmission interference and signal damping, Ductpropagation.

(b) Satellite Communication: Satellite frequencies allocation, Synchronous satellites,Satellite orbits, Satellite location with respect to earth and look angle, earth coverage and slant range, Eclipse effect, Link calculation, Noise consideration, Factors affecting satellite communication.

Reference Books:

1.Electromagnetic waves & Radiating Systems: Jorden & Balmain.
2. Theory and application of microwaves by A.B. Brownwell & RE. Beam (McGraw Hill) .
3. Introduction to microwave theory by Atwater (McGraw Hill).
4. Principles of microwave circuit by G.C. Montgomery (Mc Graw Hill)
5. Microwave Circuits & Passive Devices by M.L. Sisodia and G.S. Raghuvanshi (New Age International, New Delhi)
6. Foundations of microwave engineering by RE. Collin. (McGraw Hill).
7. Microwave Semiconductor Devices and their Circuit applications by H.A. Watson
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9. Antenna Theory, Part-I by RE. Collin & EJ. Zucker (McGraw Hill, New York)
10.Microstrip Antennas by Bahl & Bhartiya (Artech House, Messachausetts)
11. Antenna Theory Analysis by C.A. Balanis Harper & Row. Pub. & Inc. New York.
12. Antenna Theory Analysis by E.A. W01""(J. Willey & Sons)
13. Antenna Theory & Design by RS Elliott (LPHI Ltd. New Delhi)
14. Microwave electronics by RE Soohoo (Addisen Westey pubblic company,).
15.Microwave Active Devices, Vacuoums by M.L. Sisodia new Age International New Delhi.
16. Semiconductors & Electronics device by A. BarIe vs (PHI, India).
17. Solid State physical electronics by A.Vanderziel, (PHI, India).
18. Hand book of microwave measurement Vol-II by M. Sucher & J.Fox (polytechnic Press, New York).
19. Microwave devices & circuits by S.Y.Liao(PHI, India).
20. Microwave Principles by H.J. Reich (CBS).
21. Simple microwave technique for measuring the dielectric parameters of solids & their powder by J.M. Gandhi, J.S. Yadav, J. of pure & applied physics Vol. 30, pp-427431, 199

Semester - III

PAPER- XIV : (B) Condensed Matter Physics-I

Duration : 3 hrs. **Max. Marks : 70**

Note: There will be two parts in end semester theory paper.

Part A of the paper shall contain seven short answer questions of 14 marks. Each question will carry two marks for correct answer.

Part B of the paper will consist four questions one question from each unit with internal choice. Each question will carry 14 marks.

UNIT - I

Phase transformation and alloys: Equilibrium transformation of first and second order, equilibrium diagrams, phase rule, interpretation of phase diagrams, substitutional solid solutions, Vegard's law, intermediate phases, Hume-Rothery rules, interstitial phases (carbides, nitrides, hydrides, borides). Martensitic transitions.

UNIT - II

High temperature superconductors and GMR/CMR materials: High temperature superconductors, normal state properties (structural phase transition) of cuprates, phase separation and charge distribution into CuO2 planes, striped phase, phase diagram, pseudogap, dependence of T_C on crystal structure, effect of impurities .GMR/CMR materials, Ruddlesden-Popper series of perovskites. Onset of ferromagnetism and metallic conduction. Double exchange.

UNIT - III

Novel organic materials : Special carbon solids, fullerenes and tubules, formation and characterization of fullerenes and tubules. Single wall and multi-wall carbon tubules. Electronic properties of tubules. Carbon nanotubule based electronic devices. Polymers – amorphous polymers, glass transition temperature, effect of molecular architecture on glass transition temperature, free volume theory for glass transition, conducting polymers, optical band gap of polymers, electrical conduction in conducting polymers, mechanical and thermal properties of polymers, polymer blends and composites.

UNIT - IV

Structural characterization and electron structure determination:Basic theory of X-ray diffraction, indexing of Debye-Scherrer patterns from powder samples, examples from some cubic and non-cubic symmetries. Neutron diffraction – basic interactions, cross section, scattering length and structure factor. Basic principles of X-ray absorption spectroscopy, photo emission and positron annihilation techniques. Qualitative discussion of experimental arrangement and of typical results for both simple as well as transition metals.

Books

1. Andrei Mourachkine: Room temperature superconductivity, Cambridge International Science Publishing.
2. C.N.R. Rao: Colossal magnetoresistance, charge ordering and related properties of managanese oxide, Woprld Scientific, 1998
3. Polymer Physics by Ulf W. Gedde, Chapmann & Hall, 2001.
4. Introduction to Polymer Physics by David. I. Bower.
5. Polymer Science by J.R. Fried.

Semester - IV

PAPER- XIX : (B) Condensed Matter Physics-II

Duration : 3 hrs. **Max. Marks : 70**

Note: There will be two parts in end semester theory paper.

Part A of the paper shall contain seven short answer questions of 14 marks. Each question will carry two marks for correct answer.

Part B of the paper will consist four questions one question from each unit with internal choice. Each question will carry 14 marks.

UNIT - I

Disordered systems Substitutional, positional and topographical disorder, short and long range order, glass transition, glass forming ability, nucleation and growth processes. Anderson model for random system and electron localization, mobility and hopping conduction. Metglasses, models for structure of metal glasses. Structure factor for binary metallic glasses and its relationship with radial distribution function. Discussion of electric, magnetic and mechanical properties of glassy systems. Point defects: shallow impurity states in semiconductors. Localized lattice vibrational states in solids. Vacancies,

interstitials and colour centres in ionic crystals.

UNIT - II

Nanomaterials: Free electron theory (qualitative idea), variation of density of states with energy, variation of density of state and band gap with size of crystal. Electron confinement in infinitely deep square well, confinement in two and one dimensional well, idea of quantum well structure , tunneling through potential barrier, quantum dots, quantum wires.Different methods of preparation of nanomaterials. Sol-gel and chemical co-precipitation method, effect of temperature on the size of the particles. Bottom up: cluster beam evaporation, ion beam deposition, top down: ball milling. DC and RF sputtering.

UNIT - III

Films and surfaces Study of surface topography by multiple beam interferometry, conditions for accurate determination of step height and film thicknesses (Fizeau fringes). Electrical conductivity of thin films, difference of behaviour of thin films from bulk material, Boltzman transport equation for a thin film (for diffuse scattering), expression for electrical conductivity for thin film. Enhancement of magnetic anisotropy due to surface pinning.

UNIT - IV

Experimental techniques Basic ideas of the techniques of field emission, scanning tunnelling and atomic force microscopy, scanning electron microscopy, transmission electron microscopy, X-ray diffraction line broadening, small angle X-ray scattering and small angle neutron scattering.

Reference Books:

1. Tolansky: Multiple beam interferometry
2. Heavens: Thin films
3. Chopra: Physics of thin films
4. Quantum dot heterostructures: D. Bimerg, M. Grundmann and N.N. Ledenstov, John Wiley & Sons, 1998
5. Nano particles and nano structured films – preparation, characterization and applications, Ed. J.H. Fendler, John Wiley & Sons, 1998.
6. Physics of low dimensional semiconductors: John H. Davies, Cambridge Univ. Press, 1997
7. Physics of semiconductor nano structures: K.P. Jain, Narosa, 1997
8. Nanostructures and nanomaterials: synthesis properties and applications by Guozhong Cao, P\Impertial College Press, 2004
9. Fundamentals of Nanoelectronics by George W. Hanson, Pearson Education, 2009.
10. Nanotechnology: Principles and practices by Sulabha Kulkarni, Capital Publishing Company, 2009.
11. Handbook of Nanostructured materials and nanotechnology

interstitials and colour centres in ionic crystals.

2. **Nanomaterials:**Free electron theory (qualitative idea), variation of density of states with energy, variation of density of state and band gap with size of crystal. Electron confinement in infinitely deep square well, confinement in two and one dimensional well, idea of quantum well structure , tunneling through potential barrier, quantum dots, quantum wires.Different methods of preparation of nanomaterials. Sol-gel and chemical co-precipitation method, effect of temperature on the size of the particles. Bottom up: cluster beam evaporation, ion beam deposition, top down: ball milling. DC and RF sputtering.
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6. Physics of low dimensional semiconductors: John H. Davies, Cambridge Univ. Press, 1997
7. Physics of semiconductor nano structures: K.P. Jain, Narosa, 1997
8. Nanostructures and nanomaterials: synthesis properties and applications by Guozhong Cao, P\Impertial College Press, 2004
9. Fundamentals of Nanoelectronics by George W. Hanson, Pearson Education, 2009.
10. Nanotechnology: Principles and practices by Sulabha Kulkarni, Capital Publishing Company, 2009.
11. Handbook of Nanostructured materials and nanotechnology

1. Phase transformation and alloys: Equilibrium transformation of first and second order, equilibrium diagrams, phase rule, interpretation of phase diagrams, substitutional solid solutions, Vegard's law, intermediate phases, Hume-Rothery rules, interstitial phases (carbides, nitrides, hydrides, borides). Martensitic transitions.
2. High temperature superconductors and GMR/CMR materials: High temperature superconductors, normal state properties (structural phase transition) of cuprates, phase separation and charge distribution into CuO2 planes, striped phase, phase diagram, pseudogap, dependence of T_c on crystal structure, effect of impurities .GMR/CMR materials, Ruddlesden-Popper series of perovskites. Onset of ferromagnetism and metallic conduction. Double exchange.
3. Novel organic materials : Special carbon solids, fullerenes and tubules, formation and characterization of fullerenes and tubules. Single wall and multi-wall carbon tubules. Electronic properties of tubules. Carbon nanotubule based electronic devices. Polymers – amorphous polymers, glass transition temperature, effect of molecular architecture on glass transition temperature, free volume theory for glass transition, conducting polymers, optical band gap of polymers, electrical conduction in conducting polymers, mechanical and thermal properties of polymers, polymer blends and composites.
4. Structural characterization and electron structure determination:Basic theory of X-ray diffraction, indexing of Debye-Scherrer patterns from powder samples, examples from some cubic and non-cubic symmetries. Neutron diffraction – basic interactions, cross section, scattering length and structure factor. Basic principles of X-ray absorption spectroscopy, photo emission and positron annihilation techniques. Qualitative discussion of experimental arrangement and of typical results for both simple as well as transition metals.

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3. Polymer Physics by Ulf W. Gedde, Chapmann & Hall, 2001.
4. Introduction to Polymer Physics by David. I. Bower.
5. Polymer Science by J.R. Fried.

PHY B02: Condensed Matter Physics-II

1. **Disordered systems** Substitutional, positional and topographical disorder, short and long range order, glass transition, glass forming ability, nucleation and growth processes. Anderson model for random system and electron localization, mobility and hopping conduction. Metglasses, models for structure of metal glasses. Structure factor for binary metallic glasses and its relationship with radial distribution function. Discussion of electric, magnetic and mechanical properties of glassy systems. Point defects: shallow impurity states in semiconductors. Localized lattice vibrational states in solids. Vacancies,

interstitials and colour centres in ionic crystals.

2. **Nanomaterials:**Free electron theory (qualitative idea), variation of density of states with energy, variation of density of state and band gap with size of crystal. Electron confinement in infinitely deep square well, confinement in two and one dimensional well, idea of quantum well structure , tunneling through potential barrier, quantum dots, quantum wires.Different methods of preparation of nanomaterials. Sol-gel and chemical co-precipitation method, effect of temperature on the size of the particles. Bottom up: cluster beam evaporation, ion beam deposition, top down: ball milling. DC and RF sputtering.
3. **Films and surfaces** Study of surface topography by multiple beam interferometry, conditions for accurate determination of step height and film thicknesses (Fizeau fringes). Electrical conductivity of thin films, difference of behaviour of thin films from bulk material, Boltzman transport equation for a thin film (for diffuse scattering), expression for electrical conductivity for thin film. Enhancement of magnetic anisotropy due to surface pinning.
4. **Experimental techniques** Basic ideas of the techniques of field emission, scanning tunnelling and atomic force microscopy, scanning electron microscopy, transmission electron microscopy, X-ray diffraction line broadening, small angle X-ray scattering and small angle neutron scattering.

Books

S. S. Jain Subodh PG (Autonomous) College, Jaipur
Master of Science (M.Sc.) in Physics

1. Tolansky: Multiple beam interferometry
2. Heavens: Thin films
3. Chopra: Physics of thin films
4. Quantum dot heterostructures: D. Bimerg, M. Grundmann and N.N. Ledenstov, John Wiley & Sons, 1998
5. Nano particles and nano structured films – preparation, characterization and applications, Ed. J.H. Fendler, John Wiley & Sons, 1998.
6. Physics of low dimensional semiconductors: John H. Davies, Cambridge Univ. Press, 1997
7. Physics of semiconductor nano structures: K.P. Jain, Narosa, 1997
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