7. PHYSICS

PAPER– I

Unit-I: Mathematical Physics

1. Complex variable: Cauchy's theorem, Cauchy's integral formula, classification of singularities, branch point and branch cut, Residue theorem, evaluation of integral using residue theorem.

2. Special functions: Basic properties and solutions (series expansion, recurrence and orthogonality relations) of Bessel, Legendre, Laguerre functions, Solution of inhomogeneous partial differential equation by method of Green's function.

3. Tensors: Cartesian tensors, covariant, contravariant and mixed tensor, tensor algebra, properties of symmetric and anti symmetric tensor.

Unit-II: Classical Mechanics

1. Hamilton's principle: Hamilton's principle, Lagrange's equation from Hamilton's principle, Solution of Lagrange equation of motion for Simple harmonic oscillator. Hamilton' equations of motion, canonical equations from variational principle, principle of least action.

2. Canonical transformation: Generating function and Legendre transformation, Integral invariant of Poincare, Lagrange and Poisson's brackets.

3. Rigid body: Independent coordinates orthogonal transformation and rotations (finite and infinitesimal), Euler's angles, Euler's theorem on the motion of rigid body, Inertia Tensor and principal axis transformation, angular momentum and kinetic energy of rotation in terms of Euler's angles. Euler's equation of motion, torque free motion of rigid body, heavy symmetrical top with one point fixed.

Unit-III: Classical Electrodynamics

1. Electrostatics and Magnetostatics: Scalar and vector potential, Gauge transformation, multiple expansion of (i) scalar potential and electrostatic energy due to static charge distribution, (ii) vector potential due to stationary current distribution, Electrostatic and magnetostatic energy, Poynting 's theorem, Maxwell's stress tensor.

2. Relativistic electrodynamics: Equation of motion in an electromagnetic field, electromagnetic field tensor, covariance of Maxwell's equation, Maxwell's equations as equations of motion, Lorentz transformation laws for electromagnetic field, and the fields due to point charge in uniform motion, Field invariants , covariance of Lorentz force equation of motion, and equation of motion of a charged particle in an electromagnetic field.

Energy momentum tensor and conservation laws for electromagnetic field, Relativistic Lagrangian and Hamiltonian of a charged particle in an electromagnetic field.

Unit-IV: Quantum Mechanics-I

1. Wave packet: Gaussian wave packet, spreading of wave packet, coordinate and momentum representation, x and p in these representation, Dirac delta function.

2. Operator method in Quantum Mechanics: Formulation of Quantum Mechanics in vector space language, uncertainty product of two arbitrary operators, one dimensional harmonic oscillator by operator method. Matrix representation of operators, Schrodinger, Heisenberg and interaction pictures. Dirac bracket notation.

3. Symmetry, invariance principle and conservation Laws: Space translational invariance, time translational invariance and rotational invariance and conservation laws.

4. Angular momentum: Angular momentum algebra, addition of two angular momenta $j_1=1/2$, $j_2=1/2$. Clebsch–Gordon Coefficients, examples, matrix representation of $j_1=1/2$ and $j_2=1$. Spin angular momentum, Pauli spin matrices and their properties, eigen value and eigen function,

5. Approximation methods: Time independent perturbation theory, First and second order correction to energy and eigen functions, Degenerate perturbation theory, application to one electron system, relativistic mass correction, Spin-Orbit coupling, Zeeman effect, linear Stark effect. Fine structure of spectral line of H-like atom.

Unit-V: Statistical Mechanics

1. Objectives of Classical Statistical Mechanics: Boltzmann's postulates of entropy, micro canonical ensemble, entropy of ideal gas, Gibb's paradox.

2. Canonical ensemble: Expression for entropy, canonical partition function, Helmholtz free energy, energy fluctuation,

3. Grand canonical ensemble: Grand canonical partition function, chemical potential, density fluctuation, chemical potential of an ideal gas,

4. Quantum Statistical Mechanics: Planck's law of black body radiation, equation of state for ideal Fermi gas at low density-high temperature and at high density-low temperature, theory of white dwarf star, relation between chemical potential and Fermi energy.

PAPER-II

Unit-I: Quantum Mechanics-II

1. WKB Approximation: Connection formulae, Bohr quantization rule, barrier penetration and α-decay,

2. Variational method: He atom as an example, First order perturbation, exchange degeneracy.

3. Time dependant perturbation theory: Interaction picture, Transition probability, constant and harmonic perturbation, Fermi Golden Rule, electric dipole radiation, selection rule, Spontaneous emission, Einstein's A and B coefficients, Principle of Laser

4. Identical Particles: Symmetric and anti-symmetric wave functions, Slater determinant, symmetric and anti-symmetric wave functions of two identical spin ½ particles.

Unit-II: Relativistic Quantum Mechanics and Field theory

1. Dirac Equation: Dirac equation, properties of Dirac γ-matrices,Non-relativistic reduction of Dirac equation,magnetic moment of electron, Spin-Orbit coupling, Covariance of Dirac equation and bilinear covarints.

2. Solution of Dirac Equation: Free particle solution of Dirac equation and its physical interpretation, projection operator for spin and energy.

Unit-III : Electronics

1. Amplifiers: Frequency response of linear amplifier, amplifier pass band, R-C, L-C and transformer coupled amplifier, feed back amplifier, book-strapping the FET, stability, noise.

2. Oscillators: Feedback criteria for oscillation, phase shift, Wien bridge, crystal controlled and Klystron oscillators, multi vibrators- astable, monostale and bistable.

3. Digital Circuits: Logic fundamentals, Boolean theorem, Logic gates-RTL,DTL,TTL, RS flipflop, JK flip-flops.

4.Boolean algebra: De Morgan theorem, AND,NAND,NOT,NOR gates(CMOS,NMOS), MOS circuits.

Unit-IV: Condensed Matter Physics

1. Band Theory of Solid: Bloch equation, empty lattice band, nearly free electron bands, no of states in band, tight binding method, effective mass of electron in the band, concept of holes, classification of metal, semiconductor and insulator, intrinsic and extrinsic semiconductors, intrinsic carrier concentration,

2. Dielectric Properties of solids: Electronic and ionic polarization of molecules, static dielectric constants of gases, Lorentz internal fields, static dielectric constant of solids, classical theory of electronic polarization and optical absorption, Clausius-Mossotti equation, elementary idea of ferroelectricity.

3. Magnetic Properties of Solids: Origin of Magnetism, quantum theory of diamagnetism, paramagnetism, Pauli Paramagnetism, Ferromagnetism, Curie-Weiss law, ferromagnetic domain , ferri and anti ferromagnetism,

4. Superconductivity: Phenomenological description of superconductivity, Meissner effect, Type-I and type-II superconductors, London's equation, outlines of BCS theory.

Unit-V: Nuclear and Particle Physics.

1. Nuclear Properties: Basic nuclear properties: nuclear size, nuclear radius and charge distribution, nuclear form factor, mass and binding energy, Angular momentum, parity and symmetry, Magneticdipole moment and electric quadrupole moment.

2. Two body bound state: Properties of deuteron, Schrodinger equation and its solution for ground state of deuteron, rms radius, spin dependence of nuclear forces, electromagnetic moment and magnetic dipole moment of deuteron and the necessity of tensor forces.

3. β-decay: β- emission and electron capture, Fermi's theory of allowed β-decay, Selection rules for Fermi and Gamow-Teller transitions, Parity non-conservation.

4. Nuclear Reactions and Fission: Different types of reactions, Quantum mechanical theory, Resonance scattering and reactions, Nuclear fission: Experimental features, spontaneous fission, liquid drop model, barrier penetration, statistical model.