PHYSICS

PAPER-I

1. (a) Mechanics of Particles:

Laws of motion; conservation of energy and momentum, applications to rotating frames, centripetal and Coriolis accelerations.

Motion under a central force; Conservation of angular momentum, Kepler's laws; Fields and potentials.

Gravitational field and potential due to spherical bodies, Gauss and Poisson equations, gravitational self-energy.

Two-body problem; Reduced mass; Rutherford scattering; Centre of mass and laboratory reference frames.

(b) Mechanics of Rigid Bodies:

System of particles; Centre of mass, angular momentum, equations of motion.

Conservation theorems for energy, momentum, and angular momentum.

Elastic and inelastic collisions; Rigid Body; Degrees of freedom, Euler's theorem, angular velocity, angular momentum, moments of inertia, theorems of parallel and perpendicular axes, equation of motion for rotation.

Molecular rotations (as rigid bodies); Di and triatomic molecules; Precessional motion; top, gyroscope.

(c) Mechanics of Continuous Media:

Elasticity, Hooke's law, and elastic constants of isotropic solids and their inter-relation.

Streamline (Laminar) flow, Poiseuille's equation, Bernoulli's equation, Stokes' law and applications.

(d) Special Relativity:

Michelson-Morley experiment and its implications; Lorentz transformations, length contraction, time dilation, addition of relativistic velocities, aberration and Doppler effect, mass-energy relation, simple applications to a decay process.

Four-dimensional momentum vector; Covariance of equations of physics.

2. Waves and Optics:

(a) Waves:

Simple harmonic motion, damped oscillation, forced oscillation and resonance; Beats; Stationary waves in a string; Pulses and wave packets; Phase and group velocities; Reflection and refraction from Huygens' principle.

(b) Geometrical Optics:

Laws of reflection and refraction from Fermat's principle; Matrix method in paraxial optic-thin lens formula, nodal planes, system of two thin lenses, chromatic and spherical aberrations.

(c) Interference:

Interference of light - Young's experiment, Newton's rings, interference by thin films, Michelson interferometer; Multiple beam interference and Fabry Perot interferometer.

(d) Diffraction:

Fraunhofer diffraction - single slit, double slit, diffraction grating, resolving power; Diffraction by a circular aperture and the Airy pattern; Fresnel diffraction: half-period zones and zone plates, circular aperture.

(e) Polarisation and Modern Optics:

Production and detection of linearly and circularly polarized light; Double refraction, quarter wave plate; Optical activity; Principles of fibre optics, attenuation; Pulse dispersion in step index and parabolic index fibers; Material dispersion, single mode fibers.

Lasers—Einstein A and B coefficients.

Ruby and He-Ne lasers.

Characteristics of laser light-spatial and temporal coherence; Focusing of laser beams.

Three-level scheme for laser operation; Holography and simple applications.

3. Electricity and Magnetism:

(a) Electrostatics and Magnetostatics:

Laplace and Poisson equations in electrostatics and their applications; Energy of a system of charges, multipole expansion of scalar potential; Method of images and its applications.

Potential and field due to a dipole, force and torque on a dipole in an external field; Dielectrics, polarization.

Solutions to boundary-value problems—conducting and dielectric spheres in a uniform electric field; Magnetic shell, uniformly magnetized sphere; Ferromagnetic materials, hysteresis, energy loss.

(b) Current Electricity:

Kirchoff's laws and their applications.

Biot-Savart law, Ampere's law, Faraday's law, Lenz' law.

Self and mutual inductances; Mean and rms values in AC circuits; DC and AC circuits with R, L, and C components; Series and parallel resonance; Quality factor; Principle of transformer.

4. Electromagnetic Waves and Blackbody Radiation:

Displacement current and Maxwell's equations; Wave equations in vacuum, Poynting theorem; Vector and scalar potentials; Electromagnetic field tensor, covariance of Maxwell's equations; Wave equations in isotropic dielectrics, reflection and refraction at the boundary of two dielectrics; Fresnel's relations; Total internal reflection; Normal and anomalous dispersion; Rayleigh scattering; Blackbody radiation and Planck's radiation law—Stefan-Boltzmann law, Wien's displacement law, and Rayleigh-Jeans law.

5. Thermal and Statistical Physics:

(a) Thermodynamics:

Laws of thermodynamics, reversible and irreversible processes, entropy; Isothermal, adiabatic, isobaric, isochoric processes, and entropy changes of ideal gases and Diesel engines.

Gibbs' phase rule and chemical potential; Van der Waals equation of state of a real gas, critical constants; Maxwell-Boltzmann distribution of molecular velocities, transport phenomena, equipartition, and virial theorems; Dulong-Petit, Einstein, and Debye's theories of specific heat of solids; Maxwell relations and application; Clausius-Clapeyron equation.

Adiabatic demagnetisation, Joule-Kelvin effect, and liquefaction of gases.

(b) Statistical Physics:

Macro and microstates, statistical distributions, Maxwell-Boltzmann, Bose-Einstein, and Fermi-Dirac Distributions, applications to specific heat of gases and blackbody radiation; Concept of negative temperatures.

PAPER-II

1. Quantum Mechanics:

Wave-particle duality; Schrodinger equation and expectation values; Uncertainty principle; Solutions of the one-dimensional Schrodinger equation for free particle (Gaussian wave-packet), particle in a box, particle in a finite well, linear harmonic oscillator; Reflection and transmission by a step potential and by a rectangular barrier.

Particle in a three-dimensional box, density of states, free electron theory of metals; Angular momentum; Hydrogen atom; Spin half particles, properties of Pauli spin matrices.

2. Atomic and Molecular Physics:

Stern-Gerlach experiment, electron spin, fine structure of hydrogen atom; L-S coupling, J-J coupling; Spectroscopic notation of atomic states; Zeeman effect; Franck-Condon principle and applications; Elementary theory of rotational, vibrational, and electronic spectra of diatomic molecules.

Raman effect and molecular structure; Laser Raman spectroscopy; Importance of neutral hydrogen atom, molecular hydrogen and molecular hydrogen ion in astronomy; Masers and lasers (basic concepts).

Phosphorescence; Elementary theory and applications of NMR and EPR; Elementary ideas about Lamb shift and its significance.

3. Nuclear and Particle Physics:

Basic nuclear properties-size, binding energy, angular momentum, parity, magnetic moment; Semi-empirical mass formula and applications.

Mass parabolas; Ground state of a deuteron, magnetic moment and non-central forces; Meson theory of nuclear forces; Salient features of nuclear forces; Shell model of the nucleus—success and limitations.

Violation of parity in beta decay; Gamma decay and internal conversion; Elementary ideas about Mossbauer spectroscopy; Q-value of nuclear reactions; Nuclear fission and fusion, energy production in stars.

Nuclear reactors.

Classification of elementary particles and their interactions; Conservation laws; Quark structure of hadrons; Field quanta of electroweak and strong interactions; Elementary ideas about unification of forces; Physics of neutrinos.

4. Solid State Physics, Devices, and Electronics:

Crystalline and amorphous structure of matter; Different crystal systems, space groups; Methods of determination of crystal structure; X-ray diffraction, scanning and transmission electron microscopes.

Band theory of solids—conductors, insulators, and semi-conductors; Thermal properties of solids, specific heat, Debye theory; Magnetism: dia, para, and ferromagnetism; Elements of super-conductivity, Meissner effect, Josephson junctions and applications; Elementary ideas about high temperature super-conductivity.

Intrinsic and extrinsic semi-conductors: p-n and n-p-n transistors; Amplifiers and oscillators.

Op-amps; FET, JFET, and MOSFET; Digital electronics—Boolean identities, De Morgan's laws, Logic gates and truth tables.

Simple logic circuits; Thermistors, solar cells; Fundamentals of microprocessors and digital computers.