

UPSC Physics Optional Syllabus

Paper 1

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 a 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 tri-atomic 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, viscosity, 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, the 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 optics-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) Polarization and Modern Optics:

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

Kirchhoff's laws and their applications; Biot-Savart law, Ampere's law, Faraday's law, Lenz's law; Self-and mutual-inductances; Mean and r m s values in AC circuits; DC and AC circuits with R, L, and C components; Series and parallel resonances; Quality factor; Principle of transformer.

4. Electromagnetic Waves and Blackbody Radiation:

Displacement current and Maxwell's equations; Wave equations in vacuum, Poincaré 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; Black body 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; Otto and Diesel engines, Gibbs' phase rule and chemical potential; Vander 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 applications; Clausius- Clapeyron equation; Adiabatic demagnetisation, Joule-Kelvin effect and liquefaction of gases.

(b) Statistical Physics:

Macro and micro states, statistical distributions, Maxwell-Boltzmann, Bose-Einstein, and Fermi-Dirac distributions, applications to the specific heat of gases and black body radiation; Concept of negative temperatures.

Paper 2

1. Quantum Mechanics:

Wave-particle duality; Schrodinger equation and expectation values; Uncertainty principle; Solutions of the one-dimensional Schrodinger equation for a 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; Frank 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; Fluorescence and 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 deuteron, magnetic moment and non-central forces; Meson theory of nuclear forces; Salient features of nuclear forces; Shell model of the nucleus - successes 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 electro weak 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 microcopies; Band theory of solids - conductors, insulators and semiconductors; Thermal properties of solids, specific heat, Debye theory; Magnetism: para and ferro magnetism; Elements of superconductivity, Meissner effect, Josephson junctions, and applications; Elementary ideas about high-temperature superconductivity.

Intrinsic and extrinsic semiconductors; pn-p 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; Thermostats, solar cells; Fundamentals of microprocessors and digital computers.