1-Year

P. G. Department of Physics, University of Kashmir
M.Sc. Physics Entrance Syllabus (16 Units)

Unit–I

Coordinate systems including Cartesian, plane polar, cylindrical and spherical; velocity and acceleration in generalized coordinates; dynamics of particle systems and centre of mass; conservation of momentum and angular momentum; motion in central force fields and Kepler's laws; SHM, energy of oscillations and damping; inertial and non-inertial frames, Coriolis force; Lorentz transformations, time dilation, length contraction and relativistic velocity addition.

Unit–II

Vector calculus—gradient, divergence, curl and integral theorems; electrostatic fields and Gauss's law in integral and differential forms; electric field for symmetric charge distributions; electric potential and relation between field and potential; capacitance of parallel-plate, cylindrical and spherical systems; dielectrics, polarization and Gauss's law in dielectrics; energy density in electrostatic fields.

Unit–III

Biot–Savart law and magnetic fields for wire, loop and solenoid; Ampere's law and magnetic vector potential; magnetic intensity, induction, permeability and susceptibility; Faraday's law and Lenz's law, self and mutual inductance and magnetic energy; displacement current and full Maxwell's equations; electromagnetic wave propagation in vacuum and dielectrics; Poynting vector and polarization of EM waves.

Unit–IV

Simple harmonic motion and its differential equation; superposition of harmonic motions, beats and Lissajous figures; transverse waves on strings and normal modes; dispersion, phase and group velocities; coupled oscillators, normal coordinates and normal modes; damped and forced oscillations, resonance and quality factor; Helmholtz resonator and energy transfer in oscillatory systems.

Unit–V

Fermat's principle and paraxial optical approximations; matrix methods in optical systems and cardinal points; interference in thin films, Newton's rings, Michelson and Fabry–Perot interferometers; Fraunhofer diffraction of single, double and N-slits,

resolving power of grating; Fresnel diffraction, half-period zones and zone plates; polarization—plane, circular, elliptical—and basics of holography.

Unit–VI

Coordinate transformations and Jacobians; double and triple integrals and delta function representations; review of vector spaces and rotations in three dimensions; vector integration and integral theorems; curvilinear coordinates and potential theory; vector spaces, inner products and Gram–Schmidt orthogonalization; linear operators, self-adjoint operators and invariants.

Unit–VII

Eigenvalue equations, Hermitian matrices and degeneracy; diagonalization and spectral decomposition; singular and positive-definite matrices; complex functions, Cauchy–Riemann conditions and analytic continuation; contour integration, residues and Cauchy integral formulas; Fourier series and Fourier transforms with properties; Laplace transforms, PDEs, separation of variables and special functions such as Bessel, Legendre, Hermite and Laguerre.

Unit–VIII

Thermodynamic variables and equations of state; first law and work done in different processes; second law, Carnot cycle and entropy changes; Maxwell relations and thermodynamic potentials; Clausius–Clapeyron equation and phase transitions; kinetic theory, Maxwell velocity distribution and transport phenomena; real gases, van der Waals equation, Joule–Thomson effect and cooling mechanisms.

Unit–IX

Degrees of freedom and equipartition theorem; specific heats of gases and behaviour at low temperatures; molecular collisions, mean free path and Brownian motion; blackbody radiation, Stefan–Boltzmann and Wien laws and Planck spectrum; microstates, macrostates and thermodynamic probability; Maxwell–Boltzmann statistics and limitations; Bose–Einstein and Fermi–Dirac distributions and their applications.

Unit–X

Failure of classical physics and emergence of quantum ideas; blackbody radiation, photoelectric effect, Compton effect and Franck–Hertz experiment; de Broglie waves,

wave packets and uncertainty principle; Schrödinger equation, wave functions, operators and expectation values; particle in a box, potential wells and tunneling; atomic structure, spin–orbit coupling, Zeeman effect; rotational and vibrational spectra and Raman effect (classical view).

Unit–XI

Generalized coordinates and constraints; virtual displacement and d'Alembert's principle; Lagrange's equations and Hamiltonian formalism; variational principle and Euler–Lagrange equations; Hamilton's equations, phase space and Liouville theorem; canonical transformations and Poisson brackets; Hamilton–Jacobi method and separation of variables; central force motion and damped/coupled oscillators with normal-mode solutions.

Unit–XII

Band theory of solids and effective mass; PN-junction physics and drift–diffusion currents; characteristics and biasing of JFET and MOSFET devices; rectifiers, filters, regulated power supplies and Zener diode applications; operational amplifiers in linear circuits; LEDs, solar cells and semiconductor lasers; digital electronics including number systems, binary arithmetic, logic gates and basic logic families.

Unit–XIII

Crystal structures including Bravais lattices and reciprocal lattice; X-ray diffraction and Bragg law; Einstein and Debye models of specific heat; lattice vibrations and phonons in one-dimensional lattices; Drude and free-electron models of metals; electrical and thermal conductivity in metals and their temperature dependence; heat capacity of conduction electrons and density of states in solids.

Unit–XIV

One-dimensional periodic potentials and the Kronig–Penney model; Brillouin zones and origin of energy bands; metals, insulators and semiconductors based on band structure; intrinsic and extrinsic semiconductors and impurity states; temperature dependence of carrier concentration and Hall effect; p–n junction band diagram, rectification equation and device behavior; transistor action, tunnel diode operation and basic liquid crystal phases.

Unit–XV

Poisson and Laplace equations with uniqueness theorem and Green's theorem; method of images for grounded planes and spheres; magnetostatics, vector potential, local-

ized current distributions and magnetic dipole moment; Maxwell equations, displacement current and conservation laws; Poynting theorem and momentum in electromagnetic fields; electromagnetic wave propagation and polarization; scalar and vector potentials, gauge transformations, retarded potentials, Liénard–Wiechert fields and dipole radiation.

Unit–XVI

Fundamental concepts of C programming including data types, operators, expressions, arrays, strings and pointers; program structure, recursion, file handling and user-defined data types; interpolation and finite difference methods; Newton, forward and backward difference formulations with error detection; numerical differentiation and integration using trapezoidal and Simpson rules; numerical solutions of differential equations via Taylor, Euler and Runge–Kutta methods and applications to algebraic and matrix problems in physics.