Department of Physics

School of Material Sciences & Nanotechnology

BABA GHULAM SHAH BADSHAH UNIVERSITY
RAJOURI (J & K) – 185234

Syllabus for Ph.D Entrance Examination (2023-24)
Section-A (Marks weightage 50-70)

Unit I

Dimensional analysis. Vector algebra and vector calculus. Linear algebra, matrices, Cayley-Hamilton Theorem. Eigen values and eigen vectors. Linear ordinary differential equations of first & second order, Partial differential equations (Laplace, wave and heat equations in two and three dimensions).Fourier series, Fourier and Laplace transforms. Elements of complex analysis, analytic functions; Taylor & Laurent series; poles, residues and evaluation of integrals. Binomial, Poisson and normal distributions, Central limit theorem.

Unit II

Newton's laws. Central force motions. Rigid body dynamics- moment of inertia tensor. Non-inertial frames and pseudoforces. Variational principle. Generalized coordinates. Lagrangian and Hamiltonian formalism and equations of motion. Conservation laws and cyclic coordinates. Poisson brackets and canonical transformations. Symmetry, invariance and Noether's theorem. Hamilton-Jacobi theory. Periodic motion: small oscillations, normal modes. Special theory of relativity- Lorentz transformations, relativistic kinematics and mass–energy equivalence.

Unit III

Electrostatics: Gauss's law and its applications, Laplace and Poisson equations, boundary value problems. Magnetostatics: Biot-Savart law, Ampere's theorem. Electromagnetic induction. Maxwell's equations in free space and linear isotropic media; boundary conditions on the fields at interfaces. Scalar and vector potentials, gauge invariance. Electromagnetic waves in free space. Dielectrics and conductors. Reflection and refraction, polarization, Fresnel's law, interference, coherence, and diffraction. Dynamics of charged particles in static and uniform electromagnetic fields. Lorentz invariance of Maxwell's equation. Radiation from moving charges and dipoles and retarded potentials.

Unit IV

Wave-particle duality. Schrödinger equation (time-dependent and time-independent). Eigen value problems(particle in a box, harmonic oscillator, etc.).Tunneling through a barrier. Wave-function in coordinate and momentum representations. Commutators and Heisenberg uncertainty principle. Dirac notation for state vectors. Motion in a central potential: orbital angular momentum, angular momentum algebra, spin, addition of angular momenta; Hydrogen atom. Stern-Gerlach experiment. Time-independent perturbation theory and applications. Variational method. Time dependent perturbation theory and Fermi's golden rule, selection rules. Identical particles, Pauli exclusion principle, spin-statistics connection.

Unit V

Laws of thermodynamics and their consequences. Thermodynamic potentials, Maxwell relations, chemicalpotential,phaseequilibria.Phasespace,micro-andmacro-states.Micro-canonical,canonical and grand-canonical ensembles and partition functions. Free energy and its connection with thermodynamic quantities.Classical and quantum statistics. Ideal Bose and Fermi gases.Principle of detailed balance. Blackbody radiation and Planck's distribution law.

Unit VI

Semiconductor devices (diodes, junctions, transistors, field effect devices, homo- and hetero-junction devices), device structure, device characteristics, frequency dependence and applications. Opto-electronic devices (solar cells, photo-detectors, LEDs).Operational amplifiers and their applications. Digital techniques and applications (registers, counters, comparators and similar circuits).A/D and D/A converters. Microprocessor and microcontroller basics. Data interpretation and analysis. Precision and accuracy. Error analysis, propagation of errors. Least squares fitting.

Unit VII

Quantum states of an electron in an atom. Electron spin. Spectrum of helium and alkali atom. Relativistic corrections for energy levels of hydrogen atom, hyperfine structure and isotopic shift, width of spectrum lines, LS & JJ couplings. Zeeman, Paschen-Bach & Stark effects. Electron spin resonance. Nuclear magnetic resonance, chemical shift. Frank-Condon principle. Born-Oppenheimer approximation. Electronic, rotational, vibrational and Raman spectra of diatomic molecules, selection rules. Lasers: spontaneous and stimulated emission, Einstein A& B coefficients. Optical pumping, population inversion, rate equation.Modes of resonators and coherence length.

Unit VIII

Bravais lattices. Reciprocal lattice, Diffraction and the structure factor, Bonding of solids. Elastic properties, phonons, lattice specific heat. Free electron theory and electronic specific heat. Response and relaxation phenomena. Drude model of electrical and thermal conductivity. Hall effect and thermoelectric power. Electron motion in a periodic potential, band theory of solids: metals, insulators and semiconductors. Superconductivity: type-I and type-II superconductors. Josephson junctions, Defects.

Unit IX

Basic nuclear properties: size, shape and charge distribution, spin and parity. Binding energy, semiempirical mass formula, liquid drop model. Nature of the nuclear force, form of nucleon-nucleon potential, charge-independence and charge-symmetry of nuclear forces. Deuteron problem. Evidence of shell structure, single-particle shell model, its validity and limitations. Elementary ideas of alpha, beta and gamma decays and their selection rules. Fission and fusion. Nuclear reactions, reaction mechanism, compound nuclei and direct reactions.

Unit X

Classification of fundamental forces. Elementary particles and their quantum numbers (charge, spin, parity, isospin, strangeness, etc.). Gellmann-Nishijima formula. Quark model, baryons and mesons. C, P, and T invariance. CP violation. Application of symmetry arguments to particle reactions. Parity non-conservation in weak interaction. Relativistic kinematics.

Section-B (Marks weightage 30-50)

Unit-I

Research Methodology: Meaning of research – Objectives & Motivation of Research – Types of research – Research approaches – Significance of Research – Research Process – Criteria of Good research – Selection of research Problem.

Unit-II

Research Design: Meaning of Research Design – Need for Research Design – Features of Good Design – Concepts – Different Research Design – Basic Principles of Experimental Designs.

Unit-III

Preparation of Technical papers and thesis writing - art of writing of scientific article - writing a thesis - Presentation of data – Symbols - the observations - tables and figures – equations - the style - sentence length - page and chapter format - referencing.