U.P. EDUCATION SERVICE SELECTION COMMISSION, PRAYAGRAJ

Syllabus

PHYSICS
(Assistant Professor-Higher Education)
(Subject Code-76)

I. Mathematical Physics and Numerical Techniques

Dimensional analysis. Vector algebra and vector calculus. Linear algebra, matrices, Cayley-Hamilton Theorem. eigenvalue problems; Linear differential equations; special functions (Hermite, Bessel, Laguerre and Legendre); Recurrence relations. Fourier series, Fourier and Laplace transforms; Elements of complex analysis: Laurent series-poles, residues and evaluation of integrals; Elementary ideas about tensors; Introductory group theory, SU(2), O(3); Elementary probability theory, random variables, binomial, Poisson and normal distributions. Numerical techniques: roots of functions, interpolation, extrapolation, integration by trapezoid and Simpson's rule, solution of first order differential equations using Runge-Kutta method; Finite difference methods.

II. Classical Mechanics

Newton's laws; Phase space dynamics, stability analysis; Central-force motion; Two-body collisions, scattering in laboratory and center-of-mass frames; Rigid body dynamics, moment of inertia tensor, Non-inertial frames and pseudoforces; Variational principle, Lagrangian and Hamiltonian formalism and equations of motion; Poisson brackets and canonical transformations; Hamilton – Jacobi Theory, Symmetry, invariance and conservation laws, cyclic coordinates; Periodic motion, small oscillations and normal modes; Special theory of relativity, Lorentz transformations, relativistic kinematics and mass–energy equivalence. Twin Paradox.

III. Electromagnetic Theory

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 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; Transmission lines and wave guides; Cavity Resonator, Plasma oscillation, Dispersion relations in plasma; Lorentz invariance of Maxwell's equations;, Dynamics of charged particles in static and uniform electromagnetic fields; Radiation from moving charges, dipoles and retarded potentials.

IV. Thermodynamic and Statistical Physics

Laws of thermodynamics and their consequences; Thermodynamic potentials, Maxwell relations; Chemical potential, phase equilibria; Phase space, macro- and microstates; Microcanonical, canonical and grand-canonical ensembles and partition functions; Free energy and connection with thermodynamic quantities; First- and second-order phase transition; Classical and quantum statistics, Ideal Fermi and Bose gases; Principle of detailed balance; Blackbody radiation and Planck's distribution law; Bose-Einstein condensation; Random walk and Brownian motion; concept of non equilibrium processes; Diffusion equation.

V. Quantum Mechanics

Wave-particle duality; Wave function in coordinate and momentum representations; Commutators and Heisenberg's uncertainty principle; Matrix representation; Dirac's bra and ket notation; Schroedinger equation (time-dependent and time-independent); Eigenvalue problems such as particle-in-a-box, harmonic oscillator ; Tunneling through a barrier; Motion in a central potential; Orbital angular momentum, Angular momentum algebra, spin; Addition of angular momenta; Hydrogen atom, spin-orbit coupling, fine structure; Time-independent and Time dependent perturbation theory, Fermi's Golden Rule; Selection rules; Semi-classical theory of radiation; Elementary theory of scattering, phase shifts, partial waves, Born approximation; Identical particles, Pauli's exclusion principle, spin-statistics connection; Relativistic quantum mechanics: Klein Gordon and Dirac equations.

VI. Electronics

Semiconductor devices : diodes, junction transistors, field effect transistors, homo and heterojunctions; their structure, characteristics, frequency dependence and applications; Optoelectronic devices; solar cells, photodetectors and LEDs; Operational amplifiers and their applications; Digital techniques and applications (registers, counters, comparators and similar circuits); A/D and D/A converters; basics of Microprocessor and microcontroller. Oscillator, Amplifier, Modulation & demodulation, Switching time, High frequency devices including generators and detectors.

VII. Experimental Techniques and data analysis

Data interpretation and analysis; Precision and accuracy, error analysis, propagation of errors, least squares fitting, linear and nonlinear curve fitting, chi-square test; Transducers (temperature, pressure/vacuum, magnetic field, vibration, optical, and particle detectors), measurement and control; Signal conditioning and recovery, impedance matching, amplification (Op-amp based instrumentation and feedback), filtering and noise reduction, shielding and grounding; Fourier transforms; lock-in detector, box-car integrator, modulation techniques.

VIII. Atomic and Molecular Physics

Quantum states of an electron in an atom; Electron spin; Stern-Gerlach experiment; Spectrum of Hydrogen, helium and alkali atoms; Relativistic corrections for energy levels of hydrogen; Hyperfine structure and isotopic shift; width of spectral lines; LS & JJ couplings; Zeeman, Paschen Bach & Stark effect; X-ray spectroscopy; Electron spin resonance, Nuclear magnetic resonance, chemical shift; Rotational, vibrational and electronic spectra of diatomic molecules, Raman spectra of diatomic molecules; Frank -Condon principle and selection rules; Spontaneous and stimulated emission, Einstein A & B coefficients; Lasers, optical pumping, population inversion, rate equations; Modes of resonators and coherence length, U-V and infrared spectrometry.

IX. Condensed Matter Physics

Bravais lattices; Reciprocal lattice, diffraction and the structure factor; Bondings in 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; Quantum Hall effect; Diamagnetism, paramagnetism, and ferromagnetism; Electron motion in a periodic potential, band theory of solids, Defects and dislocations Ordered phases of matter, translational and orientational order, liquid crystals, Conducting polymers; Quasicrystals. Superconductivity: type-I and type-II superconductors. Josephson junctions.

X. Nuclear and Particle Physics

Basic nuclear properties: size, shape and charge distribution, spin and parity; Binding energy, semi-empirical mass formula; Liquid drop model; Fission and fusion; Nature of nuclear forces, form of nucleon-nucleon potential; Charge-independence and charge-symmetry of nuclear forces; Isospin; Deuteron problem; Evidence of shell structure, single-particle shell model, its validity and limitations; Rotational spectra; Elementary ideas of alpha, beta and gamma decays and their selection rules; Nuclear reactions, reaction mechanisms, compound nuclei and direct reactions; Classification of fundamental forces; Elementary particles (quarks, baryons, mesons, leptons); Spin and parity assignments, isospin, strangeness; Gell-Mann- Nishijima formula; C,P, and T invariance and application of symmetry arguments to particle reactions, parity non-conservation in weak interaction; Relativistic kinematics.