Syllabus for Recruitment of Scientific Officer

SECTION-'C'
Subject- Physics

I. Mathematical Methods of Physics

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

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 pseudo forces; Variational principle- D' Alembert's principle, Hamilton's principle, Lagrangian and Hamiltonian formalisms and equations of motion; Poisson brackets and canonical transformations; 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.

III. Electromagnetic Theory

Electrostatics: Gauss's Law and its applications; Laplace and Poisson equations, boundary value problems; Magneto-statics; Biot-Savart law, Ampere's theorem, electromagnetic induction; Maxwell's equations in free space and linear isotropic media; boundary conditions of field 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; Dispersion relation in plasma; Lorentz invariance of Maxwell's equation; Transmission lines and wave guides; Dynamics of charged particles in static and uniform electromagnetic field, Radiation from moving charges, dipoles and retarded potentials.

IV. Quantum Mechanics

Wave-particle duality; Wave functions in coordinate and momentum representations; Commutators and Heisenberg's uncertainty principle; Matrix representation; Dirac's bra and ket notation; Schrodinger equation (time dependent and time- independent); Eigenvalue problems such as particle-in-box, harmonic oscillator, etc; 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 perturbation theory and applications; Variational method WKB approximation; Time dependent perturbation theory and 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

V. Thermodynamic and Statistical Physics

Laws of thermodynamics and their consequences; Thermodynamics potentials, Maxwell relations; Chemical potential, phase equilibria; Phase space, micro and macro- states; Micro-canonical, canonical and grand canonical, ensembles and partition functions; Free Energy and connection with thermodynamic quantities; First and second-order phase transitions; 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; Introduction to non-equilibrium processes; Diffusion equation.

VI. Electronics

Semiconductor device physics, including diodes, junctions, transistors, field effect devices, homo and heterojunction devices, device structure, device, characteristics, frequency dependence and applications; Optoelectronic-devices, including solar cells, photodetectors and LEDs; High-frequency devices, including generators and detectors; Operational amplifiers and their application; Digital techniques and applications (Logic Gates, Adder/Substractor, multiplexer/Dmultiplexer, Encoder/Decoder, Flip-Flop, registers counters, comparators and similar circuits); A/D and D/Ab converters; Microprocessor and microcontroller basics.

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 amp, feedback), filtering and noise reduction, shielding and grounding; Fourier transforms; lock-in detector, box-car integrator, modulation techniques.

Application of the above experimental and analytical techniques to typical undergraduate and graduate level laboratory experiments.

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 and JJ coupling; Zeeman, Paschen Back and Stark effect; X-ray spectroscopy; Electron spin resonance, Nuclear magnetic resonance, chemical shift; Rotational, vibrational, electronic and 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 equation; Modes of resonators and coherence length.

IX. Condensed Matter Physics

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; Diamagnetism, paramagnetism and ferromagnetism; Electron motion in a periodic potential; band theory of metals, insulators and semiconductors; Superconductivity, type - I and type - II Superconductors, Josephson junctions; Defects and disocations; Ordered phases of matter translational and orientational order, kinds of liquid crystalline order; Conducting polymers; Quasicrystals.

X. Nuclear and Particle Physics

Basic nuclear properties; size shape, charge distribution, spin and parity; Binding energy, semi-empirical mass formula; Liquid drop model; Fission and fusion; Nature of the nuclear force, 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 limitation; 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 applications of symmetry arguments to particle reactions, parity non-conservation in weak interaction; Relativistic kinematics.

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