CSIR-UGC National Eligibility Test (NET) for Junior Research Fellowship and Lecturer-ship

PHYSICAL SCIENCES

SYLLABUS
PART 'A' CORE

I. MATHEMATICAL METHODS OF PHYSICS

Dimensional analysis. Vector algebra and vector calculus. Linear algebra, matrices, Cayley-Hamilton Theorem. Eigenvalues and eigenvectors. Linear ordinary differential equations of first & second order, Special functions (Hermite, Bessel, Laguerre, and Legendre functions). Fourier series, Fourier and Laplace transforms. Elements of complex analysis, analytic functions; Taylor & Laurent series; poles, residues and evaluation of integrals. Elementary probability theory, random variables, binomial, Poisson and normal distributions. Central limit theorem.

II. CLASSICAL MECHANICS

Newton's laws. Dynamical systems, Phase space dynamics, stability analysis. Central force motions. Two body Collisions – scattering in laboratory and Centre of mass frames. 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. Periodic motion: small oscillations, 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. 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.

IV. QUANTUM MECHANICS

Wave-particle duality. Schrödinger equation (time-dependent and time-independent). Eigenvalue 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, the 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.

V. THERMODYNAMIC AND STATISTICAL PHYSICS

Laws of thermodynamics and their consequences. Thermodynamic 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 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.

VI. Electronics and Experimental Methods

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,

PART 'B' ADVANCED

I. MATHEMATICAL METHODS OF PHYSICS

Green's function. Partial differential equations (Laplace, wave, and heat equations in two and three dimensions). Elements of computational techniques: the root of functions, interpolation, extrapolation, integration by trapezoid and Simpson's rule, Solution of the first-order differential equation using Runge-Kutta method. Finite difference methods, Tensors. Introductory group theory: SU(2), O(3).

II. CLASSICAL MECHANICS

Dynamical systems, Phase space dynamics, stability analysis. Poisson brackets and canonical transformations. Symmetry, invariance, and Noether's theorem. Hamilton-Jacobi theory.

III. ELECTROMAGNETIC THEORY

Dispersion relations in plasma. Lorentz invariance of Maxwell's equation. Transmission lines and wave guides. Radiation- from moving charges and dipoles and retarded potentials.

IV. QUANTUM MECHANICS

Spin-orbit coupling, fine structure. WKB approximation. Elementary theory of scattering: phase shifts, partial waves, Born approximation. Relativistic quantum mechanics: Klein-Gordon and Dirac equations. Semi-classical theory of radiation.

V. THERMODYNAMIC AND STATISTICAL PHYSICS

First- and second-order phase transitions. Diamagnetism, paramagnetism, and ferromagnetism. Ising model. Bose-Einstein condensation. Diffusion equation. Random walk and Brownian motion. Introduction to nonequilibrium processes.

VI. ELECTRONICS AND EXPERIMENTAL METHODS

Linear and nonlinear curve fitting, chi-square test. Transducers (temperature, pressure/vacuum, magnetic fields, 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. High-frequency devices (including generators and detectors).

VII. ATOMIC & MOLECULAR PHYSICS

Quantum states of an electron in an atom. Electron spin. The spectrum of helium and alkali atoms. Relativistic corrections for energy levels of the 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.

VIII. 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. Electron motion in a periodic potential, band theory of solids:

metals, insulators and semiconductors. Superconductivity: type-I and type-II superconductors. Josephson junctions. Superfluidity. Defects and dislocations. Ordered phases of matter: translational and orientational order, kinds of liquid crystalline order. Quasi-crystals.

IX. NUCLEAR AND PARTICLE PHYSICS

Basic nuclear properties: size, shape and charge distribution, spin, and parity. Binding energy, semi-empirical mass formula, liquid drop model. Nature of the nuclear force, a 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. Rotational spectra. Elementary ideas of alpha, beta, and gamma decays and their selection rules. Fission and fusion. Nuclear reactions, reaction mechanism, compound nuclei, and direct reactions. 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. Application of symmetry arguments to particle reactions. Parity non-conservation in the weak interaction. Relativistic kinematics.

JOINT CSIR – UGC Test for Junior Research Fellowship and Eligibility for Lectureship in Physical Sciences

The University Grants Commission (**UGC**) conducts **National Eligibility Test (NET)** to determine eligibility for **lectureship** and for the award of **Junior Research Fellowship (JRF)** in order to ensure minimum standards in the teaching profession and research. The **Council of Scientific and Industrial Research (CSIR)** conducts the UGC-CSIR NET for Science subjects.

The tests are conducted **twice a year** generally in the months of **June and December**. UGC has a number of fellowships to the universities for the candidates who qualify for the test. The

Address: Near 124, The Mall Road Near GTB Nagar Metro Gate No. 03, Above Lasona Gym, Delhi, 110009
Phone: 8527271792, 8527271794
Website: www.fiziks,in | Email: institutefiziks@gmail.com

JRFs are awarded to the meritorious candidates from among the candidates qualifying for eligibility for lectureship in the NET.