PRE- REGISTRATION QUALIFYING
ENTRANCE EXAMINATION FOR Ph.D., PROGRAM
PHYSICS

UNIT- I MATHEMATICAL METHODS OF PHYSICS

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, Special functions (Hermite, Bessel, Laguerre and Legendre functions); Fourier series, Fourier and Laplace transforms; Cauchy – Riemann conditions, Cauchy's integral formula and Calculus of residues and contour integrals; Elementary Ideas about Tensors; Introductory of Group theory, SU(2), O(3); Error analysis, propagation of errors, least square fitting, curve fitting-linear and polynomial regression analysis; Integration by trapezoid and Simpson's rule, solution of first order differential equations using Runge-Kutta method; Finite difference methods; Elementary probability theory, random variables, binomial, Poisson and normal distributions.

UNIT – II CLASSICAL & QUANTUM MECHANICS

Newton's laws; Phase space dynamics, stability analysis; Central-force motion; 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, 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.

Wave particle duality; commutators and Heisenberg uncertainty principle; Schrödinger equation (time dependent and time independent); Potential problems-´ Wells and barriers, Harmonic oscillator, Rigid Rotator and Hydrogen Atom, Different types of operators, Hilbert space, Schrödinger, Heisenberg and Interaction matrix representation, Identical particles, Pauli exclusion principle, Stern-Gerlach experiment, Spin matrices for electron, Angular momentum operator, CG coefficients, Time independent perturbation theory, Non-degenerate and degenerate cases. Time dependent perturbation theory, Harmonic perturbation, Fermi's golden rule, Transition probabilities, Adiabatic and Sudden approximation, Semi classical treatment of radiation; Quantum Theory of Scattering: Collision in 3-D and scattering, Scattering amplitude, Born approximation, Partial Wave Analysis and Phase Shift, Applications of PWA, Relativistic wave equations: Klein-Gordon and Dirac equations.

UNIT – III ATOMIC, MOLECULAR AND NUCLEAR PHYSICS

Quantum states of an electron in an atom; Electron spin; Stern-Gerlach experiment; Spectrum of Hydrogen, helium and alkali atoms; Hyperfine structure and isotopic shift; width of spectral lines; LS & JJ coupling; Zeeman, Paschen Back & 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.

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, form of nucleon-nucleon potential, charge-independence and charge-symmetry of nuclear forces. Deuteron problem. Evidence of shell structure, 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. Application of symmetry arguments to particle reactions. Parity non-conservation in weak interaction. Relativistic kinematics.

UNIT- IV SOLID STATE PHYSICS AND ELECTRONICS

Bravais lattices; Reciprocal lattice, diffraction and the structure factor; Bonding in solids; phonons, lattice specific heat; Free electron theory and electronic specific heat; Drude model of electrical and thermal conductivity; Hall effect and thermoelectric power; Diamagnetism, paramagnetism, and ferromagnetism; Langevin theory, Wiess molecular field theory, ferromagnetic domains, ferrimagnetism and ferrites. Superconductivity: BCS theory, Meissner Effect, London equation, Josephson effect, applications; Defects and dislocations; Ionic conductivity and diffusion. Dielectrics: Polarization and its types, local electric field, Dielectric constant, frequency dependence, piezo and ferro-electricity.

Semiconductor devices (diodes, junctions, transistors, field effect devices, homo- and hetero-junction devices), device characteristics, frequency dependence and applications. Opto-electronic devices (solar cells, photo-detectors, LEDs). Operational amplifiers and their applications. Digital circuits and applications (registers, counters, comparators and similar circuits).A/D and D/A converters. Microprocessor and microcontroller basics (8086, 8051).

UNIT – V ELECTROMAGNETIC THEORY & THERMODYNAMIC AND STATISTICAL PHYSICS

Electrostatics: Gauss' Law and its applications; Laplace and Poisson equations,; 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; Propagation of e.m. waves in free, isotropic, anisotropic, dielectric media and conducting medium, Poynting's theorem; Reflection and refraction, polarization, Fresnel's Law, Normal, anomalous dispersion, dispersion in gases, liquids and solids, Lorentz and clasusius Mossotti relation, scattering and polarization, Microwave generation, wave guides, Plasma existence, charged particle in electric, magnetic fields, plasma waves, magneto hydrodynamics.

Laws of thermodynamics and their consequences; Thermodynamic potentials, Maxwell relations; Chemical potential, phase equilibria; Phase space, micro and macrostates; Microcanonical, 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; Blackbody radiation and Planck's distribution law; Bose-Einstein condensation; Random walk and Brownian motion; Introduction to nonequilibrium processes; Diffusion equation.

BOOKS FOR STUDY:

1. Mathematical Physics – B.D.Gupta – Vikas Publishing House Pvt.Ltd
2. Numerical methods in Science & Engineering - Dr. M.K.Venkitaraman, National Publishing Company.
3. Quantum Mechanics- Dr.S.L.Gupta,Dr.V.Sharma,Dr.H.V.Sharma,Dr.R.C.Sharma – IV Edition, Jai Prasath Nath & Co
4. Molecular Structure and Spectroscopy – G.Aruldhass,2nd Edition PHI Learning
5. Nuclear Physics – D.C.Tayal, Himalaya House, Bombay.
6. Introduction to Solid State Physics – Charles Kittel, 7th Edition, John Wiley & Sons.
7. Millman's Integrated Circuits – Millman Halkias Parikh, McGraw Hill
8. Electromagnetic theory and electrodynamics – Sathya Prakash – Kedar Nath Ramnath, Meerut, Delhi
9. Classical Mechanics – K.Sankara Rao-PHI Private Learning Ltd-Delhi
10. An Introductory course of Statistical Mechanics – Palash B.Pal – Narosha- Delhi