P.H.D

Syllabus: Ph.D. Entrance Exam 2022

PHYSICS

1. **Mathematical Methods of Physics**
   Dimensional analysis; Vector algebra and vector calculus; Linear algebra, matrices Fourier series, Fourier and Laplace transforms; Elementary ideas about tensors
2. **Classical Mechanics**
   Newton's laws; Two-body collisions, scattering in laboratory and centre-of-mass frames; Rigid body dynamics, moment of inertia tensor, non-inertial frames and pseudoforces;, Lagrangian and Hamiltonian formalisms and equations of motion; Theory of relativity
3. **Electromagnetic Theory**
   Electrostatics: Gauss' 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; Scalar and vector potentials; Electromagnetic waves in free space, dielectrics, and conductors; various Optical phenomena; Dynamics of charged particles in static and uniform electromagnetic fields
4. **Quantum Mechanics**
   Wave-particle duality; Schrodinger equations; 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, Time- independent perturbation theory and applications; Time dependent perturbation theory and Fermi's Golden Rule; Selection rules; Semi-classical theory of radiation
5. **Statistical Physics**
   Classical and quantum statistics, ideal Fermi and Bose gases; Principle of detailed balance; Blackbody radiation and Planck's distribution law; Bose-Einstein condensation
6. **Electronics**
   Semiconductor device physics, diodes, junctions, transistors, field effect devices, homo and heterojunction devices, device structure, device characteristics, frequency dependence and applications; Optoelectronic devices, High-frequency devices, Operational amplifiers and their applications; Digital techniques and applications, A/D and D/A converters, optical sensors
7. **Atomic & 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 coupling; Zeeman, Paschen Back & Stark effect; X-ray spectroscopy; Electron spin resonance, Nuclear magnetic resonance; Physics of Lasers, stimulated emission, optical resonator, excimer lasers
8. **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; Relaxation phenomena; Drude model of electrical and thermal conductivity: Fermi's Golden rule, Hall effect and thermoelectric power; Types of magnetism ; Electron motion in a periodic potential, band theory solids; Superconductivity, type – I and type - II superconductors, Josephson junctions, BCS theory, London equations
9. **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; Elementary ideas of alpha, beta and gamma decays and their selection rules; Nuclear reactions, reaction mechanisms, compound nuclei and direct reactions; Elementary particles

10. Physics of Nanomaterials:

Introduction – Nanoscale; Nanomaterials: Methods for synthesis of nanomaterials, Properties of nanomaterials – Electrical, Magnetic, Optical, Mechanical, Characterization techniques – X ray Diffraction (XRD), Electron Microscopies, Nanostructures (0D, 1D, 2D); Carbon nanotubes Characteristics and applications, Nanoelectronics and Nanoelectromechanical systems (NEMS), 2D nanomaterials and nanoparticle characteristics

Sd.
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