Medi-Caps University

Syllabus for Ph. D. Entrance Exam in Physics

1. Mathematical Physics

Vector algebra and vector calculus. Matrices, 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.

2. Classical Mechanics

Newton's laws of motion and its explanation with problems, various types of forces in nature (explanation), pseudo forces (e.g. Centrifigual force), Coriolis force and its applications, Motion under a central force, Gravitational law and field, Potential due to a spherical body. Gauss and Poission's equation of Gravitational self-energy, System of particles, centre of mass and reduced mass, Conservation of linear and angular momentum, elastic and inelastic collisions and related problem, Lagrangian and Hamiltonian formalism and equations of motion. Special theory of relativity-Lorentz transformations, relativistic kinematics and mass–energy equivalence.

3. 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, Electromagnetic waves in free space. Poynting Vector, Poynting Theorem, Dielectrics and conductors.

4. Quantum Mechanics

Schrödinger wave 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. Motion in a central potential: orbital angular momentum, angular momentum algebra, spin, 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.

5. 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.

6. Electronics

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.

7. Atomic & Molecular Physics

Quantum states of an electron in an atom. Electron spin. Spectrum of helium and alkali atom. Relativistic corrections for energy levels of 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.

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. 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.

9. Laser and Fibre Optics

Principle of Laser, Gain and absorption coefficients, Population inversion, Optical resonator and Condition necessary for active Laser action, line broadening mechanism, Ruby, He-Ne, CO_2 and Nd:YAG Laser, Optical Fibers, Comparision of optical fibre with other interconnectors, Core and cladding, Principle of light guidance in optical fibre, numerical aperture, acceptance angle, Types of optical fibre, Rays and modes, Basic wave guide equation.

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