SYLLABUS FOR THE POST OF LECTURER (10+2) PHYSICS

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I. MATHEMATICAL PHYSICS

Fourier Series: Fourier integral and Fourier transform, and Laplace transform with simple applications.

Complex Variables: Algebra of complex numbers, analyticity of complex functions, Cauchy-Riemann equations, complex integration, Cauchy's integral theorem, Cauchy's integral formula, Taylor and Laurent series, residues and the Cauchy residue theorem, contour integration.

Differential Equations: Series solution for the Bessel differential equation, Bessel functions, generating function for Bessel functions, and Laguerre polynomials.

II. CLASSICAL MECHANICS

The Hamiltonian function H, its physical significance, and Hamilton's variational principle; the Hamiltonian formulation for central forces, electromagnetic forces, and coupled oscillators; equations and illustrations of canonical transformations; Poisson Bracket. The problem of the linear harmonic oscillator; the Hamilton-Jacobi equation and its applications, including the one-dimensional harmonic oscillator as an example of the Hamilton-Jacobi method.

III. 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.

IV. QUANTUM MECHANICS

Review of wave mechanics: De Broglie waves, wave-particle duality, Heisenberg's Uncertainty Principle (exact statement and interpretation), wave packets, superposition principle, Schrödinger equation, solution of the Schrödinger equation for the hydrogen atom, wave function and its interpretation, speed of wave packets, Ehrenfest theorem.

Mathematical properties of quantum mechanics: Linear vector spaces, linear operators, adjoint of an operator, Hermitian operators, commuting and non-commuting operators, eigenvalues and eigenvectors, generalized uncertainty principle, change of basis and unitary truth tables.

Transformations, Schrödinger and Heisenberg representations, Heisenberg equation of motion, particle in an electromagnetic field, Lorentz force.

Angular momentum in quantum mechanics: Commutation relations of angular momentum operators, eigenfunctions, ladder operators and their matrix representation, addition of angular momenta.

Time-independent perturbation theory: First- and second-order perturbation theory, application of perturbation theory to the harmonic oscillator, first-order Stark effect, and normal Zeeman effect (without electron spin).

V. SOLID STATE PHYSICS

Crystal systems and Bravais lattices; Miller indices of a crystal face and direction; reciprocal lattice and its applications; reciprocal lattices for BCC and FCC structures.

Generation and absorption of X-rays, scattering of X-rays by atoms, scattering from a crystal, diffraction conditions, Laue equations, Bragg's law, and experimental techniques including Laue method and powder method (significance and diffraction geometry); applications of oscillation methods (elementary ideas). Elements of neutron diffraction, types of crystal bonding, and simple theory of ionic crystals.

Thermal properties of crystals, including specific heat of anisotropic crystals, thermal conductivity, and thermal expansion.

Electron transport in metals, Boltzmann equation, free-electron Fermi gas, electrical conductivity, thermoelectric power, and Hall effect.

The origin of atomic magnetism, contributions from orbital motion, electron spin, and nuclear spin. Diamagnetism (Langevin's theory), paramagnetism (quantum theory, Langevin's theory) and ferromagnetism (Weiss theory, quantum theory).

VI. NUCLEAR PHYSICS

Properties of nuclei, nuclear size and its determination by various methods; spin and moments of nuclei, nuclear mass, Weizsäcker mass formula. Energy loss of a charged particle through matter, Bremsstrahlung, Cherenkov radiation, scintillation counters, bubble chambers, and photographic emulsion techniques.

Nuclear forces: Saturation, exchange forces, charge symmetry, charge independence, and isospin formalism. Theory of the ground state of deuteron, deuteron magnetic dipole and quadrupole moment, n-p scattering, effective range theory, p-p scattering at low energy ($\sim$10 MeV).

Fermi theory of β-decay: Shape of the β spectrum, rate of decay, comparative lifetimes, Fermi-Curie plots, mass of neutrino, parity violation, and Wu's experiment.

Elementary Particles: Classification of particles, concepts of various quantum numbers (isospin, baryon number, lepton number), Gell-Mann–Nishijima scheme, intrinsic parity, parity conservation and violation. Quark model: Classification, basic fermion constituents (quarks and leptons).

VII. ELECTRODYNAMICS

Review of Maxwell's Equations: General boundary conditions, reflection and refraction of electromagnetic waves in dielectric and conducting media, polarization by reflection, total internal reflection, waves in metals, low- and high-frequency approximations, and skin depth.

Dipole Radiation: Radiation from an oscillating dipole, magnetic dipole radiation, and dipole moment. Radiation from a Point Charge: Fields of a point charge in motion, fields of an accelerated moment.

Charge, electric and magnetic fields of a charge moving with constant velocity, and power radiated by a point charge.

VIII. SPECTROSCOPY

Review of atomic spectra, classification of atomic spectra, spectra of two-electron atoms, LS and JJ coupling (central field approximation), energy level diagram for two-electron atoms.

Molecular spectra of diatomic molecules, energy states of diatomic molecules, pure rotational and vibrational spectra, vibration-rotation spectra, and electronic spectra. Stimulated emission, oscillation conditions, population inversion, He-Ne laser, three-level and four-level laser systems, threshold conditions, and requirements of a good laser medium. Electronic spectra of diatomic molecules, vibrational and rotational structures of electronic bands, and intensity distribution in electronic vibrational bands.

IX. STATISTICAL MECHANICS

Concepts of phase space and statistical ensembles; Liouville's theorem; canonical and grand canonical ensembles; derivation of entropy of a perfect gas using the microcanonical ensemble; partition functions and their properties; calculation of thermodynamic quantities in terms of the partition function (ideal monoatomic gas); validity of classical approximation; derivation of Van der Waal's equation from classical statistical mechanics; quantum statistics, quantum ensemble theory, density operator and its physical significance; quantum Liouville's equation; determination of thermodynamic functions; quantum statistics in the classical limit; black-body radiation; Debye model of lattice specific heat.