MP-05
QUANTUM MECHANICS

(Questions will be set from each unit/section with internal choice)

Unit	Topics
I	**Time-Independent Perturbation Theory & Variational Methods** Erhenfest theorem. Expansion of wave function in eigen fuctions, orthogonality, normality and closure property of eigen functions. Dirac Delta function. Time-independent perturbation theory for non-degenerate case upto second order and its application to (i) Ground state of Helium and (ii) Degenerate time-independent perturbation theory and its application to Zeeman effect, with and without electron spin in hydrogen like atom. Variational method and its application to ground state of Helium atom.
II	**Approximation Methods & Time-Dependent Perturbation Theory** Born-Oppenheimer approximation of LCAO, Heitler-London theory of hydrogen molecule. WKB approximation and its application to alpha decay. Time independent perturbation theory. Transition probabilities. Fermi-Golden rule, Emission and Absorption of radiation, Einstein's A and B coefficients. Exchange degeneracy of indistinguishable particles. Wave function for many electron system, Pauli's exclusion principle.
III	**Angular Momentum and Spin** Eigenvalues and eigenvectors of angular momentum, characteristic algebraic relation, spectrum of J2, Jz, eigenvectors of J2 & Jz. Orbital angular momentum and the spherical harmonics. The spectrum of L2 and Lz, definitions and construction of spherical harmonics. Angular momentum and rotation operator, rotational invariance and conservation of angular momentum, rotational degeneracy. **Spin:** electron spin, spin 1/2 and Pauli matrices, observable and wave functions of spin 1 .2 particle, spin of fields, vector fields and particles and spin 1, spin-independent interactions of atoms, Spin-independent nucleon-nucleon interactions. Addition of angular momenta, eigenvectors of total angular momentum Clebsch-Gordon coefficients. Application to two nucleon systems.
IV	**Scattering Theory** Introduction, definition of cross-section, stationary wave of scattering, representation of the scattering phenomenon by a bundle of wave packets, scattering of a wave packet by a potential, calculation of cross-section, laboratory system and centre of mass-system. Scattering by a central potential, partial wave analysis and phase shift method. Impact parameters, relation between phase shift and logarithmic derivatives. Behaviour of phase shifts at low energies scattering by a hard sphere.

Scattering resonances, scattering by a deep square well, study of a scattering resonance, metal stable states. Observation of the lifetime metastable states.

Integral representations of phase-shifts, dependence upon the potential, sign of the phase-shifts, Born approximation, effective range theory, the Bethe formula.

V **Relativistic Quantum Mechanics**

Classical relativistic dynamics and the Lorentz group. The Klein-Gordon equation. Dirac equation, covariant form of Dirac equation. Properties of Dirac matrices. The free electron-plane waves, central potentials, free spherical waves. The hydrogen atoms.

Large and small components, the Pauli theory as the non-relativistic limit of the Dirac theory applications. Hyperfine position theory. Difficulties with the hole theory.

Identical Particles: Similar particles and symmetrical representation, permutation operators. Algebra of permutation operators, identical particles and symmetrization postulate. Bosons and Bose-einstein statistics, Fermions and Fermi Dirac statistics, Exclusion principle.