Course Objectives: This course enables students to work with operator formalism and Schrödinger equation in quantum mechanics. Students will know how to use operators to solve the problems related with barriers and bound states. Also it provides the basic application of quantum mechanics in three dimensions. It also gives concept of spin and angular momentum along with time independent perturbation theory and its application in Zeeman effect in weak magnetic field and spin-orbit interaction as an application to quantum mechanics.

1. **Schrödinger equation, operators and eigenfunctions**: Need of quantum mechanics; de Broglie theory; group and phase velocity; Schrödinger equation and its solution; probability; normalization; momentum operator and eigenfunction; probability current and conservation of probability; Ehrenfest theorem; commutator; equation of motion and application; operators and eigenfunctions: hermitian operator, parity operator and their properties, angular momentum operator and commutation relations; expansion in eigenfunction; uncertainty principle and applications. [12 Hrs.]

2. **Barriers and bound states in one dimension**: Free particle and box normalization; potential step; square potential barrier and tunneling effect; bound states; particle in a box; infinite potential well, finite potential well; $\delta$ function potential well; double well model; periodic potentials: Bloch theorem and Kronig-Penney model. [10 Hrs.]

3. **Harmonic oscillators**: Linear harmonic oscillator: Hermite polynomial wave function, energy and parity states; creation, annihilation operators and their matrix form; harmonic oscillator solution by operator method; coupled harmonic oscillator. [6 Hrs.]

4. **Quantum mechanics in three dimension**: Schrödinger equation for spherically symmetric potentials: angular solutions and spherical harmonics; radial solutions and energy levels of hydrogen atom, energy level degeneracy, Laguerre polynomial solution (wave functions) for hydrogen atom; rigid rotator; angular momentum, total angular momentum and commutation relations. [7 Hrs.]

5. **Spin and addition of angular momenta**: Pauli spin matrices; spinors and expectation values; Pauli operators; magnetic moment of an electron; addition of two spins; addition of two angular momenta: general method, CG coefficients; vector operators: Wigner-Eckart theorem. [7 Hrs.]

6. **Time independent perturbation theory**: Non degenerate perturbation theory and applications; degenerate perturbation theory: two fold degeneracy, higher order degeneracy; fine structure and relativistic correction; spin orbit coupling; Zeeman effect in weak, strong and intermediate fields; Hyperfine splitting. [6 Hrs.]

Text Books


References

2. S. Gasiorowicz. *Quantum Physics*, Wiley India.