

Introduction

The first part of the course is an introduction to the basic concepts of quantum mechanics. This includes the wave-particle duality of light and matter, the uncertainty principle, and the Schrödinger equation. We will also discuss the concept of wave functions and how they describe the probability of finding a particle in a certain state.



The second part of the course is a detailed study of the hydrogen atom. We will derive the energy levels and wave functions for the ground state and excited states. We will also discuss the fine structure and hyperfine structure of the hydrogen atom.



The third part of the course is a study of the harmonic oscillator. We will derive the energy levels and wave functions for the ground state and excited states. We will also discuss the concept of zero-point energy and the uncertainty principle for the harmonic oscillator.

The fourth part of the course is a study of the angular momentum. We will derive the commutation relations for the angular momentum operators and the eigenvalues and eigenfunctions of the angular momentum operators. We will also discuss the addition of angular momentum.



The fifth part of the course is a study of the spin of particles. We will derive the Dirac equation and the Dirac spinors. We will also discuss the concept of spin and how it is related to the angular momentum.

The sixth part of the course is a study of the scattering theory. We will derive the Born approximation and the partial wave expansion. We will also discuss the concept of phase shifts and the optical theorem.



The seventh part of the course is a study of the many-body theory. We will derive the Hartree-Fock method and the many-body perturbation theory. We will also discuss the concept of Fermi and Bose statistics and the Pauli exclusion principle.

The eighth part of the course is a study of the quantum field theory. We will derive the Dirac equation and the Klein-Gordon equation. We will also discuss the concept of relativistic quantum mechanics and the Dirac sea.

The ninth part of the course is a study of the quantum electrodynamics. We will derive the Feynman diagrams and the renormalization procedure. We will also discuss the concept of gauge invariance and the photon as a gauge boson.