SEMESTER-VIII

PHYDSC451T

QUANTUM MECHANICS - II

Contact Hours: 60

Full Marks = 100 [ESE (70) CCA(30)]

Course objective: *This course gives emphasis on time dependent perturbation theory, WKB approximation, Variational technique, Scattering Theory, relativistic formulation of Quantum Mechanics and scalar field theories including interpretation of the quantized fields.*

Unit 1: Time dependent perturbation theory

The pictures of quantum mechanics - Schrödinger, Heisenberg and interaction pictures. Time dependent perturbation theory - Fermi Golden rule, Transition probabilities for constant and harmonic perturbation. Adiabatic and sudden approximations. Interaction of atoms with radiation: Absorption and emission of Radiation, Einstein's A, B coefficients, selection rules, transition rates within dipole approximation, Spontaneous Emission. **(12 Lectures)**

Unit 2: WKB approximation and others

WKB approximation, connection with classical limits, connection formula, validity of WKB approximation, Alpha emission (Barrier penetration and tunnelling.). Variational technique – examples of hydrogen atom, helium atom and harmonic oscillator. **(10 Lectures)**

Unit 3: Scattering Theory

Scattering Theory: Amplitude and cross-section, CM and Laboratory frame, Scattering by spherically symmetric potentials, partial waves and phase shifts, Scattering by an attractive square well potential, Breit-Wigner formula. Born approximation and its validity, Coulomb scattering. **(12 Lectures)**

Unit 4: Relativistic Quantum Mechanics

Attempt for relativistic formulation of Quantum Mechanics, Klein-Gordon equation and its significance, Klein Gordon equation in presence of electromagnetic field and its non-relativistic reduction, Dirac equation for a free particle, properties of Dirac. Solution of the free particle, orthogonality and completeness relation for Dirac spinors, fine structure of hydrogen atom, interpretation of negative energy solution. **(14 Lectures)**

Unit 5: Scalar field Theory

Concept of systems with infinite degrees of freedom, Classical fields, Equations of motion, Hamiltonian. Symmetries and invariance principles – Noether's Theorem.

Canonical quantization of scalar field: Creation, annihilation operators, Commutation relations. Interpretation of the quantized field – number operator, connection with harmonic oscillator.

(12 Lectures)

Expected learning outcomes: *At the end of this course the students are expected to learn applications of time-dependent perturbation theory, WKB approximation, Scattering by spherically symmetric potentials, partial waves, Born approximation and its validity, relativistic formulation of Quantum Mechanics, Dirac spinors, fine structure of hydrogen atom, interpretation of negative energy solution, Concept of systems with infinite degrees of freedom, Classical fields and Canonical quantization of scalar field.*

Reference Books:

i. Introduction to Quantum Mechanics, David J. Griffiths, Cambridge India.
ii. R. L. Liboff, Introductory Quantum Mechanics, Pearson Education (2006).
iii. Quantum Mechanics, Vol. 1 and 2: Claude Cohen-Tannoudji, Bernard Diu, Frank Laloe.
iv. L.I. Schiff, Quantum Mechanics, McGraw Hill (1998).
v. A.K. Ghatak and S. Lokanathan: Quantum Mechanics, Macmillan (2000).
vi. J.J. Sakurai, Modern Quantum Mechanics, Addison-Wesley (1990).
vii. E. Merzbacher, Quantum Mechanics, John Wiley & Sons (1999).
viii. Satya Prakash, Advanced Quantum Mechanics, Kedar Nath (1990).
ix. V.K. Thankappan, Quantum Mechanics, New Age Intl. Pub (1996).
x. S. Gasiorowiz, Quantum Mechanics, Wiley (1995).
xi. P M Mathews and S Venkateswan, Quantum Mechanics, Tata McGraw Hill (1976).
xii. N Zettili, Quantum Mechanics, John Wiley (2001).
xiii. John L Powell and B Crasemann, Quantum Mechanics, Narosa (1991).

PHYDSC452T

ELECTROMAGNETIC THEORY

Contact Hours: 60

Full Marks = 100 [ESE (70) CCA(30)]

Course objective: *This course gives emphasis on Electromagnetic field tensor, Motion of a charged particle in electromagnetic field, Saha's equation of ionization, Plasma oscillations, Plasma Parameters, Radiation from an accelerated point charge, Retarded potentials, Dipole radiation, Quadrupole and magnetic dipole radiation and electromagnetic scattering formulations.*

Unit 1: Covariant formalism of electromagnetism

Minkowski space-time, Four vector, Lorentz Transformation matrix, Lorentz transformation of electric and magnetic fields, Lorentz invariant quantities involving $\vec{E}$ and $\vec{B}$ $\left(\text{i.e. } E^2 - B^2 \text{ and } \vec{E}.\vec{B}\right)$, Electromagnetic field tensor, current density 4-vector, 4-vector potential, Maxwell's equations in terms of field tensor. **(12 Lectures)**