Course: Core Paper XI–HPHCR5112T & HPHCR5112P

Semester	V
Paper Number	HPHCR5112T & HPHCR5112P
Paper Title	QUANTUM MECHANICS & APPLICATIONS
No. of Credits	06 (Theory – 4, Lab – 2)
Theory/ Composite	Composite
No. of periods assigned	Th:4 periods/week Pr:3 periods/week
Name of Faculty member(s)	
Course description/ objective	1) This course will expose a student to the formulation of quantum mechanics. 2) The exposure to the formulation of a theory with a completely different philosophy from classical mechanics will enable a student to appreciate of the various diverse ways in which physical reality can be perceived. 3) This course will underline the relevance of learning the language of linear vector space as the mathematical tool to frame the theory of quantum mechanics. 4) This course will expose the students to various applications of quantum mechanics. 5) In this course, first some applications of quantum mechanics for simple systems will be dealt with. This will initiate the idea of how a theoretical framework is applicable to real life problems. 6) At the last section of this course, more advanced applications of quantum mechanics will be discussed which arise in atomic physics, nuclear physics and in other areas of physics.
Syllabus	As enclosed
Texts	As enclosed
Reading/ Reference Lists	As enclosed
Evaluation	Total – 100 (Theory – 60, Practical – 40) Theory – CIA – 10 Semester Examination – 50 Group A (25 marks) — Group B (25 marks) One 10 marks qs out of two qs — One 10 mark qs out of two qs Three 5 mark qs out of five qs — Three 5 mark qs out of five qs

Syllabus:

HPHCR5112T - QUANTUM MECHANICS & APPLICATIONS (Credits: Theory - 04, Practicals- 02)

Module – A [26 Lectures]

Introduction: Postulates of Quantum Mechanics**.** Properties of Wave function. Interpretation of Wave function, Probability and probability current densities in three dimensions; Conditions for Physical Acceptability of Wave Functions. Normalization. Linearity and Superposition Principles. Eigenvalues and Eigenfunctions. Expectation values. **[4** Lectures]

Time dependent Schrodinger equation: Time dependent Schrodinger equation and dynamical evolution of a quantum state. Wave Function of a Free Particle. **[3 Lectures]**

Time independent Schrodinger equation-Hamiltonian, stationary states and energy eigenvalues; expansion of an arbitrary wavefunction as a linear combination of energy eigenfunctions; General solution of the time dependent Schrodinger equation in terms of linear combinations of stationary states; Fourier transforms and momentum space wave function; Position-momentum uncertainty principle. **[7 Lectures]**

General discussion of bound states in an arbitrary potential : continuity of wave function, boundary condition and emergence of discrete energy levels; application to one-dimensional problem-square well potential, rectangular potential barrier; Quantum mechanics of simple harmonic oscillator-energy levels and energy eigenfunctions, ground state, zero point energy & uncertainty principle. **[12 Lectures]**

Module – B [26 Lectures]

Quantum theory of hydrogen-like atoms: Time independent Schrodinger equation in spherical polar coordinates; Separation of variables for second order partial differential equation. Angular momentum operator & quantum numbers; Radial wavefunctions from Frobenius method; shapes of the probability densities for ground & first excited states; Orbital angular momentum quantum numbers l and m; s, p, d,.. shells. **[10 Lectures]**

Atoms in Electric & Magnetic Fields: Electron angular momentum. Space quantization. Electron Spin and Spin Angular Momentum. Larmor's Theorem. Spin Magnetic Moment. Stern-Gerlach Experiment. Zeeman Effect: Electron Magnetic Moment and Magnetic Energy, Gyromagnetic Ratio and Bohr Magneton. **[9 Lectures]**

Many electron atoms: Pauli's Exclusion Principle. Symmetric & anti-symmetric wave functions. Periodic table.Fine structure. Spin orbit coupling. Spectral Notations for Atomic States. Total angular momentum.

Vector Model. Spin-orbit coupling in atoms L-S and J-J couplings. Hund's Rule. **[7 Lectures]**

Reference Books:

1. A Text book of Quantum Mechanics, P.M.Mathews and K.Venkatesan, 2nd Ed.,2010, McGraw Hill
2. Quantum Mechanics, Robert Eisberg and Robert Resnick, 2nd Edn., 2002, Wiley
3. Quantum Mechanics, EugenMerzbacher, 2004, John Wiley and Sons, Inc.
4. Introduction to Quantum Mechanics, D.J. Griffith, 2nd Ed. 2005, Pearson Education
5. Quantum Mechanics by Liboff,
6. Quantum Mechanics by Bransden and Joachain
7. Modern Quantum Mechanics by J. J. Sakurai, Pearson
8. Principles of Quantum Mechanics, R. Shankar, Springer

HPHCR5112P - Quantum Mechanics and Applications Lab (Credits – 2) (39 periods)

Laboratory based experiments:

1. Study of electron spin resonance – determine the magnetic field as a function of the

resonance frequency.

2. To show the tunnelling effect in tunnel diode using I-V characteristics.
3. Quantum efficiency of Photodiode/CCDs
4. Zeeman effect (with external magnetic field; Hyperfine splitting).
5. To determine the wavelength of H-alpha emission line of Hydrogen atom.
6. Frank Hertz Experiment

Paper Structure for laboratory

(a) Marks for experiment : 30 marks

- (i) Class performance on any one expt. – 8
- (ii) Lab. Viva on the same experiment as (i) - 7
- (iii) LNB for each of the three experiments - 5 x 3 = 15

(b) Grand Viva – 8 marks

(c) Attendance – 2 marks

[Students are to complete 3 experiment]