B. Sc. Physical Sciences with Electronics as one of the Core Disciplines

DISCIPLINE SPECIFIC ELECTIVE COURSE – DSE 7 - 3 : QUANTUM MECHANICS

Course Title and Code	Credits	Credit distribution of the course			Pre-requisite of the course
		Lecture	Tutorial	Practical	
Quantum Mechanics DSE 7-3	4	3	1	0	

COURSE OBJECTIVES

The development of quantum mechanics has revolutionized human life. In this course, students will be exposed to the probabilistic concepts of basic non-relativistic quantum mechanics and its applications to understand the subatomic world.

LEARNING OUTCOMES

After completing this course, the students will be able to

- Solve Schrödinger equation for different 1-d potentials, such as finite square potential well, potential steps and barriers and distinguish between scattering and bound states.
- Use the algebraic method to solve the Schrödinger equation for quantum harmonic
- Solve the 3-D Schrodinger equation in spherical coordinates.
- Understand the spectrum and eigenfunctions for hydrogen atom
- Understand the angular momentum operators in position space, their commutators, eigenvalues and eigenfunctions.
- Explain the concept of spin, use Pauli matrices to describe spin-½ systems, and construct the singlet and triplet spin states for two-particle systems.

<u>SYLLABUS OF DSE 7-3</u>
<u>THEORY COMPONENTS</u>
(Hours: 45)

Unit I **(20 Hours)**

Schrödinger Equation for 1- dimensional systems
General solution of 1-D Schrödinger equation for time independent potentials, Solution of Schrödinger equation for a particle in a finite square potential well, reflection and transmission across a step potential and a rectangular potential barrier.
General discussion of bound states in an arbitrary potential: Continuity of wave function, boundary conditions and emergence of discrete energy levels with Application to energy eigenstates for a particle in a finite square potential well.
Momentum space wavefunction, Time evolution of Gaussian Wave packet, Superposition Principle, linearity of Schrodinger Equation, General solution as a linear combination of discrete stationary states, Observables as operators, Commutator of position and momentum operators, Ehrenfest's theorem.
Harmonic oscillator
Energy eigenvalues and eigenstates of a 1-D harmonic oscillator using the algebraic method (ladder operators). Zero-point energy and the uncertainty principle.

Unit II **(12 Hours)**

Schrödinger Equation in three dimensions
Probability and probability densities in 3D. Schrödinger equation in spherical polar coordinates, its solution for the Hydrogen atom solution using separation of angular and radial variables. Solution of angular equation, Spherical harmonics.
Solution of radial equation using Frobenius method, Radial wavefunctions, Probability densities for ground and first excited states, quantum numbers *n*, *l* and *ml*.

Unit III **(7 Hours)**

Angular Momentum: Orbital Angular momentum operators (**Lx**, **Ly** and **Lz**) and ladder operators **L+** and **L-** as differential operators in cartesian coordinates and their commutation relations, Orbital angular momentum operators in spherical polar coordinates, their eigenvalues, eigenfunctions and identification of these with spherical harmonics.

Unit IV **(6 Hours)**

Concept of spin: Spin angular Momentum Operator, Pauli matrices, algebraic theory of spin, General state for spin-1/2 particles, Total spin for a system of two spin-1/2 particles, singlet and triplet states.

REFERENCES

Essential Readings

1. Quantum Mechanics: Theory and Applications, Ajoy Ghatak and S. Lokanathan, Laxmi Publications (2019).
2. Introduction to Quantum Mechanics, D.J. Griffith, Pearson Education (2005).
3. A Textbook of Quantum Mechanics, P.M. Mathews and K. Venkatesan, McGraw-Hill (2010).
4. Quantum Mechanics, B. H. Bransden and C. J. Joachain, Prentice Hall (2000).
5. Quantum Mechanics: Concepts and Applications, Nouredine Zettili, John Wiley and Sons, Ltd. (2009).

Additional Readings

1. Quantum Mechanics for Scientists & Engineers, D.A.B. Miller, Cambridge University Press (2008).
2. Introduction to Quantum Mechanics, R. H. Dicke and J. P. Wittke, Addison-Wesley Publications (1966).
3. Quantum Mechanics, Leonard I. Schiff, Tata McGraw Hill (2010).
4. Quantum Mechanics, Robert Eisberg and Robert Resnick, Wiley (2002).
5. Schaum's Outlines of Quantum Mechanics, Yoav Peleg, Reuven Pnini, Elyahu Zaarur, Eugene Hecht, NcGrawHill (2010).
6. Introductory Quantum Mechanics, R. L. Liboff; 4th Ed., Addison Wesley (2003).