M1PHY03-CT03: Quantum Mechanics-I

*(**Note**: At the beginning of the semester, students must be provided: Detailed Lecture schedule of topics to be covered in each lecture, tutorial topics, clearly defining chapters/sections of reference books followed, link to web resources etc. Examiners are expected to take into consideration the lecture schedule while setting the question papers to ensure questions are set within scope of the syllabus)*

External: 80 Marks
Internal: 20 marks
Lectures: 40hrs
Tutorials: 10 hrs Additional Contact Hours : 10 (seminars, quiz, assignments, group discussion etc.)

Note: Candidates whose attendance is less than 75% will be awarded zero marks in the Internal

UNIT-I

Introduction, Linear Vector Space, Dual space and representation theory: 5L

Hamilton's principle. Schrödinger equation, Normalisation, probability interpretation of , Admissible wave functions.
Linear Vectors Space: Definition and properties, examples, norm of a vector, orthonormality and linear independence, Basis and dimensions, Completeness (Closure property), Hilbert space, subspace, Inequalities.
Operators: Equality, product, sum, power, function, inverse of operators, eigenvalues and eigenvectors of an operator, Positive definite, continuous and bounded operators, Linear operators, Hermitian operators, Unitary operators, Projection operators.

Dirac Space and Representation Theory: 3L

Completeness of eigenfunctions, Bra and Ket notation for vectors, Dirac-Delta function, Matrix elements of change of basis, Unitary transformation. Representation theory, Coordinate and momentum representations.

UNIT-II

Postulates of Quantum Mechanics & Uncertainty Relations: 3L

Postulates of Quantum mechanics, Uncertainty relations, States with minimum uncertainty product, Commutators, Theorem of simultaneous eigenfunctions,

Quantum Dynamics: 3L

The equations of motion, Schrodinger picture, Heisenberg picture, Linear Harmonic Oscillator: Solutions from Schrodinger and Heisenberg Pictures, the method of second quantization

The Hydrogen Atom: 3L

Two body equation, Separation of variables for spherically symmetric potential, Radial wave equation, Radial wavefunctions and energy states.

UNIT –III

Quantisation of Angular Momentum: 4L

Definition, angular momentum of a system of particles, Matrix representation, Pauli matrices, the spin eigenvectors. Orbital angular momentum: Solutions, Spherical harmonics and properties, addition theorem (no proof).

Addition of angular momenta: 3L

Clebsch-Gordan coefficients, the selection rules, properties of CG coefficients (without proof): symmetry, orthogonality and recursion relations.

UNIT –IV

Perturbation Theory (Non-degenerate case): 5L

Basic formulation of the method and applications: Anharmonic oscillator (x^4), linear harmonic oscillator, infinite square well.

Degenerate case:

Formulation and applications: Stark and Zeeman effects in H, Infinite cube well, Relativistic correction. **3L**

UNIT –V

Path Integrals in Quantum Theory:

Interaction picture, Path Integral-Perspective and the recipe, Approximation to the U(t) for a free particle, Path integral evaluation of the free particle propagator, Equivalence to the Schrodinger equation. Potentials of the form $V=a+bx+cx^2+d(dx/dt)+ex(dx/dt)$. **4L**

Derivation of Path Integrals:

Configuration space path integrals (no application), Phase space path integral (No application), Coherent state path integral (No application), Path integral of the imaginary time propagator. Illustrative example of simple harmonic oscillator. **4L**

Textbooks:

1. Quantum Mechanics, V.K. Thankappan, Wiley Eastern Ltd. (1986).
2. Principles of Quantum Mechanics, R. Shankar, Plenum Press, New York (1994) (for V Unit)

Reference books:

1. Introduction to Quantum Mechanics, D.J. Griffiths, Pearson Education Inc. (2005).
2. Modern Quantum Mechanics, J.J. Sakurai, Addison and Wesley (1994).