IIT Mandi

Course Name	: **Foundations of Quantum Technologies**
Course Number	: QT 302
Credits	: 3-0-0-3
Prerequisites	: Engineering Mathematics (Linear Algebra, Complex algebra, basics of 2nd of ODEs and initial value problems, 2nd order PDEs and boundary value problems, Probability and Statistics, Random variables). Maxwell's equations and EM theory at the level of the core physics syllabus from AICTE model
Curriculum Intended for	: UG/PG/PhD
Distribution	: Elective PG/Elective UG
Semester	: Odd/Even

Preamble: This course is meant for laying down the central theoretical aspects of quantum mechanics in a rigorous manner where students learn the techniques and develop a good intuition for quantum physics. Students of this course learn (i) The most relevant mathematical techniques (ii) Basic postulates of quantum mechanics and applications, (iii) Basics of Statistical Physics, (iv) Basics of Information Science, (v) Basics of computational complexity

1. Course Content and syllabus:

- Quantum Mechanics (40 - 42 lectures)
  - Brief overview of classical physics (This segment is meant for the student to understand what a Hamiltonian is, which will feature later in quantum mechanics)
    - Hamiltonian function and Hamilton's equations
    - Phase-space description of a system
    - Connection and Equivalence with Newton's laws for simple systems – free particle, particle moving in a conservative potential, examples of Harmonic oscillator, hydrogen atom
  - Historical evolution of quantum mechanics
    - Planck's quantum hypothesis
    - Photo electric effect
    - Atomic spectra
    - Bohr's quantisation principle
    - De Broglie's Wave particle duality
  - Postulates of Quantum Mechanics
    - State vectors and Hilbert Space
    - Dirac Bra-Ket notation
    - Measurables and Hermitian Operators
    - Unitary Transformations
    - Schrodinger Equation and Time evolution of quantum states
    - Measurement Postulate
    - Schrodinger, Heisenberg and Interaction pictures
    - Eigen values, Expectation values and Matrix elements
    - Heisenberg's Uncertainty principle

- Density operator formalism of quantum mechanics – pure and mixed states
- Superposition and Entanglement in quantum mechanics
- No cloning theorem
- Applications of postulates –Particle in a box, Hydrogen atom, Harmonic Oscillator
- Number states, ladder operators and Coherent states of a harmonic oscillator
- Spin and Angular momentum – spin half particles
- Rabi problem of a spin-half particle in a rotating magnetic field
- Bosons and Fermions

Course References:

1. Introduction to Quantum Mechanics, Griffiths D. J., 3rd Edition, Cambridge University Press (2024)
2. Principles of Quantum Mechanics, Shankar, R., 2nd edition, Springer (2014)