

QUANTUM SCIENCE AND TECHNOLOGY

Course Code	23EE2702B	Year	IV	Semester	I
Course category	Open Elective IV	Branch		Course type	Theory
Credit	3	L-T-P	3-0-0	Pre-requisite	Basic Physics, Linear Algebra, & Introduction to Modern Physics
Continuous Internal evaluation	30	Semester end Evaluation	70	Total Marks	100

Course Outcomes	
Upon successful completion of the course, the student will be able to	
CO1	Explain the principles of quantum mechanics, quantum information, quantum computing algorithms, quantum communication, and sensing technologies.(L2)
CO2	Apply quantum mechanical operators, Dirac notation, qubit representation, and quantum gates to represent and manipulate quantum state. (L3)
CO3	Analyze quantum states and entangled systems using operators, Bloch sphere representation, and quantum circuit models.(L4)
CO4	Apply quantum algorithms, quantum Fourier transform, and quantum error correction techniques to quantum computing problems.(L3)
CO5	Analyze the performance and limitations of quantum algorithms, quantum communication, and quantum sensing systems.(L4)

Contribution of Course Outcomes towards achievement of Program Outcomes & Strength of correlations (3:High, 2: Medium, 1:Low)													
CO \ PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2
CO1	3	2									2	2	
CO2	3	3			2							3	
CO3	3	3	2		2							3	
CO4	2	2		2	3						2	3	2
CO5	2	3		2	2	2					3	2	3

SYLLABUS		
Unit No.	Contents	Mapped CO
I	Fundamentals of Quantum Mechanics: Historical background: Blackbody radiation, photoelectric effect, and Compton scattering; Dual nature of light and matter; De Broglie hypothesis; Schrödinger equation; Free particle, infinite potential well, step potential; Operators and observables: position, momentum, Hamiltonian; Commutation relations and uncertainty principle; Quantum	CO1 CO2 CO3

	postulates and measurement theory; Eigenvalues, eigenfunctions.	
II	Quantum Information Theory: Classical vs. quantum information; Qubit representation using Bloch sphere; Quantum superposition and quantum entanglement; Dirac notation (bra-ket), tensor products, and composite systems; Bell states and EPR paradox; Quantum gates: Pauli-X, Y, Z; Hadamard; Phase; T; CNOT; Quantum circuit models and notation; Measurement in computational basis; Quantum teleportation and no-cloning theorem; Quantum state tomography (introductory)	C01 C02 C03
III	Quantum Computing: Classical computing review and limitations; Quantum parallelism and interference; Deutsch and Deutsch-Jozsa algorithms; Grover's search algorithm, Oracle and amplitude amplification; Shor's factoring algorithm (overview and significance); Quantum Fourier Transform (QFT); Quantum error correction: Bit-flip, phase flip, and Shor's 9-qubit code; Introduction to quantum programming: Qiskit, Cirq, IBMQuantum Experience (overview	C01 C04 C05
IV	Quantum Communication: Introduction to quantum cryptography; Quantum key distribution (QKD): BB84 protocol; Entanglement-based QKD: Ekert protocol (E91); Eavesdropping and security of QKD; Quantum teleportation (circuit and protocol); Quantum dense coding; Quantum networks and entanglement swapping; Role of quantum repeaters; Single-photon sources and detectors; Implementation challenges (loss, decoherence, noise)	C01 C04 C05
V	Quantum Technologies and Applications: Quantum sensors: magnetometry, gravimetry; Quantum metrology: standard time, atomic clocks; Quantum imaging and lithography; Quantum materials: topological insulators, graphene, quantum dots; NV centers in diamonds for sensing; Hardware platforms: Superconducting qubits, Trapped ions, Photonic quantum processors; Quantum supremacy and NISQ era; Global initiatives: IBM, Google, D Wave, IonQ, India's NQM; Ethical concerns and future prospects	C01 C04 C05

Learning Resources	
Text Books:	
1. "Quantum Computation and Quantum Information" by Michael A. Nielsen and Isaac L. Chuang 2. "Quantum Mechanics: Concepts and Applications" by Nouredine Zettili	
Reference Books:	
1. Quantum computing explained "by David McMahon WILEY-INTERSCIENCE A John Wiley & Sons, Inc., Publication.	
E-Resources:	
1. https://nptel.ac.in/courses/104104082 2. https://nptel.ac.in/courses/115104096 3. https://nptel.ac.in/courses/122106034	