QUANTUM SCIENCE AND TECHNOLOGY

Course Code	23ME2702F	Year	IV	Semester	I
Course Category	Open Elective – IV	Branch	ME	Course Type	Theory
Credits	3	L-T-P	3-0-0	Prerequisites	Nil
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

	Statement	Skill	Level	UNIT
CO1	Explain core principles of quantum mechanics and their technological implications.	Understand	L2	1
CO2	Illustrate quantum phenomena like superposition and entanglement	Understand	L2	2
CO3	Apply mathematical tools to model and solve quantum systems	Apply	L3	3
CO4	Demonstrate quantum algorithms and quantum circuits	Apply	L3	4
CO5	Illustrate applications and challenges in quantum communication and sensing.	Apply	L3	5

Contribution of Course Outcomes towards achievement of Program Outcomes &Strength of correlations (H: High (3), M: Medium (2), L:Low (1))

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2
CO1	3	2	2	2	2	2					2		
CO2	3	2	2	2	2	2					2		
CO3	3	3	2	2	2	2					2		
CO4	2	2	2	2	3	2					2		
CO5	2	2	2	2	2	2	2				2		

Syllabus

UNIT	Content	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 postulates and measurement theory; Eigenvalues, eigenfunctions..	CO1
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)	CO2

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, IBM Quantum Experience (overview)	**CO3**
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)	**CO4**
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	**CO5**

Learning Recourse(s)
Text Book(s)
1. "Quantum Computation and Quantum Information" by Michael A. Nielsen and Isaac L. Chuang 2. "Quantum Mechanics: Concepts and Applications" by Nouredine Zettili
Online Learning Sources
1. https://nptel.ac.in/courses/104104082 2. https://nptel.ac.in/courses/115104096 https://nptel.ac.in/courses/122106034