Subject Code	Subject Name	Credits
26CS505	QUANTUM COMPUTING	4

Course Objectives

1. To introduce the fundamental mathematical foundations of Quantum Computing, including complex numbers, vector spaces, and Hilbert Space.
2. To understand the representation and manipulation of quantum information using Qubit, quantum gates, and quantum circuits.
3. To study important principles of quantum mechanics used in computing such as Quantum Superposition and Quantum Entanglement.
4. To analyze and implement fundamental quantum algorithms including Deutsch–Jozsa Algorithm, Grover's Algorithm, and Shor's Algorithm.
5. To introduce quantum programming concepts, Quantum Cryptography, and quantum information theory.

Learning Outcomes

After the completion of the course, the graduate will be able to

1. Understand the mathematical foundations of quantum computing such as complex vector spaces, tensor products, and Hilbert Space.
2. Explain the concepts of Qubit, Quantum Superposition, and Quantum Entanglement in quantum information processing.
3. Design and analyze quantum circuits using quantum gates such as Hadamard, CNOT, and phase gates.
4. Evaluate the working of major quantum algorithms including Deutsch–Jozsa Algorithm, Simon's Algorithm, Grover's Algorithm, and Shor's Algorithm.
5. Understand applications of quantum computing such as quantum teleportation, Superdense coding, and Quantum Cryptography.
6. Gain knowledge of quantum programming approaches and the role of quantum computing in future computational technologies..

Unit 1 - Complex numbers (12 Hrs.)

Complex numbers and its geometrical representations, Complex vector spaces, inner products and Hilbert spaces, Hermitian and unitary matrices, Tensor products of vector spaces Deterministic Systems

Unit 2 – Dirac formalism and Quantum circuits (12 Hrs.)

Dirac formalism, superposition of states, entanglement Bits and Qubits. Qubit operations, Hadamard Gate, CNOT Gate, Phase Gate, Z-Y decomposition, Quantum Circuit, Composition, Basic Quantum circuits

Unit 3 - Quantum Algorithm (12 Hrs.)

Quantum Algorithm - I: Quantum parallelism, Quantum Evolution, Deutsch's Algorithm, Deutsch-Jozsa Algorithm, Simon's periodicity algorithm.

Unit 4 - Quantum Algorithm (12 Hrs.)

Quantum Algorithm - II: Grover's search algorithm, Shor's Factoring algorithm. Application of entanglement, teleportation, Superdence coding.

Unit 5 – Quantum programming languages (12 Hrs.)

Quantum programming languages, Probabilistic and Quantum computations, introduction to quantum cryptography and quantum information theory.

References:

1. Quantum computation and quantum information, Michael A. Nielsen and Isaac L. Chuang, Cambridge University Press 2010
2. Introduction to Quantum Mechanics, 2nd Edition, David J. Griffiths, Prentice Hall New Jersey 1995
3. Quantum computing explained, David McMahon, Wiley-interscience, John Wiley & Sons, 2008
4. Quantum computing for computer scientists, Noson S. Yanofsky