INTRODUCTION TO QUANTUM COMPUTING

Course Learning Outcomes

1. Understand the fundamental principles of quantum mechanics relevant to quantum computing.
2. Explain the concepts of qubits, quantum gates, and quantum circuits.
3. Understand quantum information and basic quantum algorithms.
4. Identify emerging applications of quantum computing in optimization, machine learning, and cryptography.

UNIT – I: Fundamentals of Quantum Mechanics for Computing

Limitations of classical computing
Classical vs quantum computation
Postulates of quantum mechanics
Representation of quantum states
Dirac notation
Measurement postulate
Superposition principle

UNIT – II: Qubits and Quantum Gates

Qubit representation
Bloch sphere representation
Multi-qubit systems
Quantum gates: Pauli gates (X, Y, Z), Hadamard gate, Phase gate, T gate
Multi-qubit gates: Controlled-NOT (CNOT), SWAP gate
Universal quantum gates
Quantum circuit representation

Unit -- III: Quantum Information

Quantum Entanglement
Bell States
No-Cloning Theorem
Quantum Teleportation
Superdense Coding
Quantum Key Distribution

UNIT – IV: Quantum Algorithms

Introduction to quantum algorithms (overview)
Quantum parallelism
Deutsch and Deutsch–Jozsa algorithms
Grover's search algorithm
Quantum Fourier Transform
Shor's factoring algorithm

UNIT – V: Applications of Quantum Computing

Quantum cryptography and quantum key distribution
Quantum communication and teleportation

Optimization problems using quantum computing
Emerging quantum technologies and future directions

Suggested Textbooks

1. Michael A. Nielsen and Isaac L. Chuang, Quantum Computation and Quantum Information, Cambridge University Press.

2. Eleanor Rieffel and Wolfgang Polak, Quantum Computing: A Gentle Introduction, MIT Press.

3. Jack D. Hidary, Quantum Computing: An Applied Approach, Springer.

4. N. David Mermin, Quantum Computer Science: An Introduction, Cambridge University Press.
Reference Books

5. Phillip Kaye, Raymond Laflamme, and Michele Mosca, An Introduction to Quantum Computing, Oxford University Press.

6. Chris Bernhardt, Quantum Computing for Everyone, MIT Press.

7. Eric R. Johnston, Nic Harrigan, and Mercedes Gimeno-Segovia, Programming Quantum Computers, O'Reilly.

8. Scott Aaronson, Quantum Computing Since Democritus, Cambridge University Press.