

UCS619: QUANTUM COMPUTING

| L | T | P | Cr |
|---|---|---|----|
| 3 | 0 | 2 | 4 |

Course Objectives: The objective of this course is to provide the students an introduction to quantum computation after covering the concepts of linear algebra, vector space and quantum mechanics.

Mathematics and Quantum Mechanics foundation: Basics of Vector, Inner and outer product, Linear and complex vector space, Hilbert spaces (finite dimensional), Tensor Products, Trace of a matrix, Dirac's notation, Probabilities and measurements, Axioms of quantum probability, Quantum vs Classical probability, Basics of quantum mechanics, Postulates of quantum mechanics, Measurements in bases other than computational basis, Introduction of qubit, Bloch sphere representation of qubit, Quantum Superposition and entanglement, Super-dense coding, Density operators, EPR paradox, Bell's inequality, Euler identity.

Quantum Computing: classical gates, Single qubit gates, multiple qubit gates, quantum gates, universal quantum gates, Quantum circuits, design of quantum circuits.

Quantum Algorithms: Deutsch's algorithm, Grover algorithm, The quantum Fourier transform, Phase estimation, Fourier Sampling, Applications: order-finding and factoring, General applications of the quantum Fourier transform, Period-finding, Shor's factoring algorithm, Discrete logarithms, The hidden subgroup problem.

Quantum Cryptography: Difference between classical and quantum cryptography, Basics of BB84 and E91 protocol.

Quantum Error Correction: Graph states and codes, Quantum error correction, fault-tolerant computation.

Lab: Implementation of Quantum concepts in Qiskit / quantum simulator /MATLAB/ Julia environment.

Course learning outcomes (CLOs):

After the completion of the course, the student will be able to:

- Comprehend the basic concepts of quantum computing.
- Illustrate the concepts of quantum gates and quantum circuits.
- Explore quantum Fourier transformation and quantum error correction mechanism.
- Acquire basic knowledge of quantum protocols.

Text Books:

1. Nielsen M. A., Chuang I. L., *Quantum Computation and Quantum Information*, Cambridge University Press (2010) 10th Anniversary ed.

2. Benenti G, Casati G., Strini G., *Principles of Quantum Computation and Information, Vol. I: Basic Concepts, Vol II: Basic Tools and Special Topics*, World Scientific (2007)

Reference Books:

1. Peres A., *Quantum Theory: Concepts and Method*, Kluwer Academic Publishers (2002) 1st ed..
2. Yanofsky N. S., Mannucci, M. A., *Quantum Computing for Computer Scientists*, Cambridge University Press, 2008.

Evaluation Scheme

MST: 30 marks

EST: 40 marks

Lab Eval1: 11 marks

Lab Eval 2: 19 marks