

Course Name: Certificate Course in Quantum Computing

Course Objective

This Quantum Computing course aims to equip students with a strong foundational understanding of quantum mechanics and its applications in computing. Through a combination of theoretical lectures, hands-on exercises, and a capstone project, students will learn about key quantum concepts, design and implement quantum algorithms, explore quantum cryptography and error correction, and delve into the emerging field of quantum machine learning.

Course Prerequisite: Any Engineering, Science, Statistics, (10+2+3/ 10+2+4) OR a higher qualification. The course does not require any specific knowledge of Artificial Intelligence, Machine Learning, Programming, and Mathematics.

Course Outcome: Upon successfully completing this Quantum Computing course, students will have a strong understanding of quantum mechanics and its applications. They will be able to design, implement, and analyse quantum circuits, understand key quantum algorithms, and explore concepts like quantum cryptography and error correction. Students will gain practical experience using software tools like Qiskit and be able to apply their knowledge to solve problems in various domains.

Course Duration: 80 Hrs (8 hours/ day for 2 Weeks)

Course Outline:

S. No.	Modules	Hours
1	Introduction to Quantum Computing	4
2	Mathematical Prerequisites	8
3	Quantum Mechanics Fundamentals	8
4	Quantum Gates and Circuits	8
5	Basic Quantum Algorithms	8
6	Advance Quantum Algorithms	12
7	Quantum Cryptography	8
8	Error Correction	3
9	Quantum Hardware and Ecosystem	5
10	Quantum Machine Learning	8
11	Capstone Project	8
	Total	80

Detailed Course Content

1. Introduction to Quantum Computing

- Welcome and Course Overview
- Classical vs. Quantum Computing

2. Mathematical Prerequisites

- a. Linear Algebra
- b. Complex Numbers and Probability
- c. Advanced Linear Algebra for Quantum Computing

3. Quantum Mechanics Basics

- a. Fundamentals of Quantum Mechanics
- b. The Bloch Sphere and Quantum State Visualization

4. Quantum Gates and Circuits

- a. Single Qubit Gates
- b. Multi-Qubit Gates
- c. Designing Quantum Circuits

5. Basic Quantum Algorithms

- a. Introduction to Quantum Algorithms
- b. Deutsch-Josza and Bernstein-Vazirani Algorithms
- c. Grover's Search Algorithm

6. Advanced Quantum Algorithms and Quantum Fourier Transform

- a. Simon's Algorithm
- b. Quantum Fourier Transform (QFT)
- c. Quantum Phase Estimator (QPE)
- d. Shor's Algorithm

7. Quantum Cryptography

- a. Introduction to Cryptography and Quantum Key Distribution
- b. Advanced Quantum Cryptography
- c. Quantum Random Number Generation (QRNG)

8. Error Correction

- a. Quantum Error Correction-Basics

9. Quantum Hardware and Ecosystem)

- a. Overview of Quantum Hardware
- b. Quantum Ecosystem
- c. Hands-on with Real Quantum Hardware

10. Quantum Machine Learning

- a. Basics of Quantum Machine Learning
- b. Variational Quantum Algorithms
- c. Quantum Support Vector Machine (QSVM)
- d. Advance Quantum Machine Learning Algorithms

11. Capstone Project

- a. Participants Design and Implement a Quantum Solution
- b. Examples: Shor's Algorithm, QKD, or QML Applications

