INSTITUTE OF AERONAUTICAL ENGINEERING
(Autonomous)
Dundigal - 500 043, Hyderabad, Telangana

COURSE CONTENT

QUANTUM COMPUTING								
VI Semester: IT								
Course Code	**Category**	**Hours / Week**			**Credits**	**MaximumMarks**		
		L	**T**	**P**	**C**	**CIA**	**SEE**	**Total**
AITD12	**Elective**	3	0	0	3	40	60	100
Contact Classes: 48	**Tutorial Classes: Nil**	**Practical Classes: Nil**				**Total Classes: 48**		
Prerequisite: Operating Systems								

I. COURSE OVERVIEW:

This course provides a comprehensive introduction to quantum computing, covering fundamental concepts, quantum algorithms, and practical applications. Students will explore quantum mechanics principles, qubits, superposition, entanglement, and quantum gates. The course also introduces quantum programming languages such as Qiskit and Cirq, along with real-world applications in cryptography, optimization, and machine learning.

II. COURSES OBJECTIVES:

The students will try to learn

I. The matrix mathematics, vector spaces, and state-space representation used in quantum computation employing operators such as *Pauli Matrices*.
II. The essential quantum physics concepts including atomic structure, uncertainty, quantum states, and entanglement described by contributions of *Richard Feynman*.
III. The qubit-based architecture, quantum gates, circuit models, and physical realization challenges addressed in systems like *D-Wave Systems*.
IV. The foundational quantum algorithms and secure communication principles enabled through *Quantum Key Distribution*.

III. COURSE OUTCOMES:

At the end of the course students should be able to

CO1 Apply matrix, vector, set theory, and complex number operations to model quantum state amplitudes and transformations.
CO2 Represent and interpret complex numbers graphically and in vector form for quantum state visualization.
CO3 Explain uncertainty, decoherence, and entanglement effects in quantum computational behavior.
CO4 Demonstrate qubit operations by constructing and interpreting quantum gate-level circuits.
CO5 Compare algorithmic logic and applications from major approaches including factoring methods created by Peter Shor and search strategies invented by Lov Grover.
CO6 Summarize the impact of quantum computing on asymmetric cryptography and outline security implications and practical use cases.

IV. COURSE CONTENT:

MODULE I: INTRODUCTION TO ESSENTIAL LINEAR ALGEBRA, COMPLEX NUMBERS (10)

Introduction to Essential Linear Algebra: Some Basic Algebra, Matrix Math, Vectors and Vector Spaces, SetTheory. Complex Numbers: Definition of Complex Numbers, Algebra of Complex Numbers, Complex Numbers Graphically, Vector Representations of Complex Numbers, Pauli Matrice, Transcendental Numbers.

MODULE II: BASIC PHYSICS FOR QUANTUM COMPUTING, BASIC QUANTUM THEORY (09)

Basic Physics for Quantum Computing: The Journey to Quantum, Quantum Physics Essentials, Basic Atomic Structure, Hilbert Spaces, Uncertainty, Quantum States, Entanglement Basic Quantum Theory: Further with Quantum Mechanics, Quantum Decoherence, Quantum Electrodynamics, Quantum Chromodynamics, Feynman Diagram Quantum Entanglement and QKD, Quantum Entanglement, Interpretation, QKE.

MODULE III: QUANTUM ARCHITECTURE, QUANTUM HARDWARE (10)

Quantum Architecture: Further with Qubits, Quantum Gates, More with Gates, Quantum Circuits, The D- Wave Quantum Architecture.

Quantum Hardware: Qubits, How Many Qubits Are Needed? Addressing Decoherence, Topological Quantum Computing, Quantum Essentials.

MODULE IV: REALTIME COMMUNICATION AND FAULT TOLERANCE (09)

Quantum Algorithms: What Is an Algorithm? Deutsch's Algorithm, Deutsch-Jozsa Algorithm, Bernstein- Vazirani Algorithm, Simon's Algorithm, Shor's Algorithm, Grover's Algorithm.

MODULE V: ADVANCED TOPICS AND APPLICATIONS (10)

The Impact of Quantum Computing on Cryptography: Asymmetric Cryptography, Specific Algorithms, Specific Applications.

IV. TEXT BOOKS:

1. Nielsen M. A., Quantum Computation and Quantum Information, Cambridge University Press.
2. Dr. Chuck Easttom, Quantum Computing Fundamentals, Pearson.

VI. REFERENCE BOOKS:

1. Quantum Computing for Computer Scientists by Noson S. Yanofsky and Mirco A. Mannucci.
2. Benenti G., Casati G. and Strini G., Principles of Quantum Computation and Information, Vol.Basic Concepts, Vol.
3. Basic Tools and Special Topics, World Scientific. Pittenger A. O., An Introduction to Quantum Computing Algorithms

VII. ELECTRONICS RESOURCES:

1. https://pages.stat.wisc.edu/~yzwang/paper/QuantumComputation.pdf
2. https://ptgmedia.pearsoncmg.com/images/9780136793816/samplepages/9780136793816_Sample.pdf

VIII. MATERIALS ONLINE

1. Course template
2. Tutorial question bank
3. Tech-talk topics
4. Open-ended experiments
5. Definitions and terminology
6. Assignments
7. Model question paper – I
8. Model question paper – II
9. Lecture notes

10. PowerPoint presentation
11. 11.E-Learning Readiness Videos (ELRV)