(Fourth Semester)

Branch – **COMPUTER SCIENCE**

AI AND QUANTUM COMPUTING

Time: Three Hours | Maximum: 75 Marks

SECTION-A (10 Marks)

Answer **ALL** questions

ALL questions carry **EQUAL** marks (10 × 1 = 10)

Module No.	Question No.	Question	K Level	CO
1	1	The inner product of two vectors gives a ____________ (i) Vector (ii) Scalar (iii) Matrix (iv) Tensor	K1	CO1
	2	The basic unit of quantum information is ____________ (i) Bit (ii) Byte (iii) Qubit (iv) Register	K2	CO1
2	3	The mathematical object used to describe the state of a quantum system is called (i) Operator (ii) Eigenvalue (iii) State vector (iv) Observable	K1	CO2
	4	The notation $\|\psi\rangle$ is associated with (i) Schrödinger formalism (ii) Matrix mechanics (iii) Classical mechanics (iv) Dirac formalism	K2	CO2
3	5	Q# is a quantum programming language developed by (i) IBM (ii) Google (iii) Microsoft (iv) Intel	K1	CO3
	6	Why is Deutsch–Jozsa Algorithm faster than classical algorithms? (i) It checks inputs sequentially (ii) It uses parallel classical processors (iii) It exploits quantum superposition (iv) It avoids function evaluation	K2	CO3
4	7	Quantum cryptography primarily uses _____ principle of quantum mechanics. (i) Relativity (ii) Superposition and no-cloning theorem (iii) Thermodynamics (iv) Classical probability	K1	CO4
	8	The security of the BB84 protocol is based on (i) Mathematical complexity (ii) Heisenberg uncertainty principle (iii) Difficulty of factoring (iv) Large key size	K2	CO4
5	9	Quantum optimization primarily aims to (i) Store data (ii) Solve optimization problems faster (iii) Replace classical computers (iv) Encrypt data	K1	CO5
	10	In Quantum Chess, a piece in superposition means (i) It occupies one definite square (ii) It can exist in multiple possible positions until measured (iii) It moves randomly (iv) It disappears permanently	K2	CO5

SECTION - B (35 Marks)

Answer **ALL** questions

ALL questions carry **EQUAL** Marks (5 × 7 = 35)

Module No.	Question No.	Question	K Level	CO
1	11.a.	What is meant by an Inner Product Space. How does a Hilbert Space differ from a general inner product space? Explain the concept of "completeness" and why it is essential in quantum mechanics.	K2	CO1
		(OR)		
	11.b.	In a quantum computing class, a student says that unlike classical bits, quantum bits can exist in multiple states simultaneously. Explain this principle and describe the mathematical foundation behind it.		
2	12.a.	An electron is accelerated through a potential difference of 150 V. i) Calculate its de Broglie wavelength. ii) Explain how this wavelength justifies electron diffraction experiments. iii) Comment on whether wave behavior would be observable for a cricket ball moving with the same speed.	K3	CO2
		(OR)		
	12.b.	In the Stern–Gerlach experiment, a beam of silver atoms passes through a non-uniform magnetic field. i) Predict the number of beams observed if spin quantum number s = 1/2. ii) What would be observed if s = 1? iii) Explain how the experiment supports quantization of angular momentum.		

Cont...

3	13.a.	i) Examine how the Deutsch–Jozsa algorithm generalizes this for n-bit inputs. ii) Compare their quantum circuit structures and query complexities. iii) Analyze why the quantum version requires fewer function evaluations than classical methods.	K4	CO3
		(OR)		
	13.b.	Compare the time complexity of classical and quantum approaches for • Unstructured search • Period finding • Integer factorization Analyze why exponential speedup is possible in some cases but not all.		
4	14.a.	Evaluate the security foundations of the BB84 protocol. i) Assess how effectively it detects eavesdropping. ii) Critically examine its practical limitations in real-world communication channels. iii) Conclude whether BB84 provides unconditional security in practice.	K5	CO4
		(OR)		
	14.b.	Compare quantum teleportation and superdense coding in terms of resource requirements. i) Evaluate which protocol is more communication-efficient. ii) Assess their practical implementation challenges. iii) Justify which protocol has greater impact on quantum communication networks.		
5	15.a.	Construct a rule-based framework for Quantum Chess where pieces can exist in superposition. i) Propose how quantum moves are represented mathematically. ii) Design a mechanism for measurement during capture. iii) Develop a scoring system accounting for probabilistic outcomes. iv) Justify how your framework differs from classical chess logic.	K6	CO5
		(OR)		
	15.b.	Develop an Industrial Use Case Proposal Select an industry (finance, healthcare, energy, or supply chain). i) Identify a problem suitable for quantum computing. ii) Propose a quantum algorithmic approach. iii) Outline required hardware/software ecosystem. iv) Justify economic and technical feasibility.		

SECTION -C (30 Marks)

Answer **ANY THREE** questions

ALL questions carry **EQUAL** Marks (3 × 10 = 30)

Module No.	Question No.	Question	K Level	CO
1	16	Differentiate between Hermitian and Unitary matrices. Explain their defining properties and discuss their significance in linear algebra.	K2	CO1
2	17	Given the operator: $\hat{A} = \begin{pmatrix} 2 & 0 \\ 0 & -2 \end{pmatrix}$ i) Find its eigenvalues. ii) Determine the corresponding eigenvectors. iii) If the system is in state $\frac{1}{\sqrt{2}}(1,1)$ find the expectation value of A.	K3	CO2
3	18	Analyze the structural differences between Open QASM and Q#. i) Compare their abstraction levels and use cases. ii) Examine advantages and limitations of low-level vs high-level quantum programming. iii) Analyze scenarios where one is preferred over the other.	K4	CO3
4	19	Assess why quantum error correction is more complex than classical error correction. i) Evaluate the impact of decoherence on quantum systems. ii) Critically analyze whether current error correction techniques are sufficient for scalable quantum computing. iii) Justify your conclusion.	K5	CO4
5	20	Design a modified version of Quantum Tic-Tac-Toe that incorporates entanglement between moves. i) Propose new rules incorporating entangled positions. ii) Explain how measurement collapse determines the winner. iii) Justify how your model improves conceptual understanding of quantum mechanics.	K6	CO5

Z-Z-Z END