MAHATMA GANDHI INSTITUTE OF TECHNOLOGY (Autonomous)

Kokapet (Village), Gandipet (Mandal), Hyderabad

B.Tech Minor in QUANTUM COMPUTING
Course Structure & Syllabus (MR25 Regulation)
Applicable for the batches from Academic Year 2025-26

S.No	Semester	Course Code	Course Title	L	T	P	Credits
1	IV-Semester	M154AH	Introduction to Quantum Computing	3	0	0	3
2	IV-Semester	M15407	Quantum Programming Lab	0	0	2	1
3	V-Semester	M155AH	Quantum Communication and Cryptography	3	0	0	3
4	VI-Semester	M156AI	Quantum Computing Applications and Project	3	0	0	3
5	VI-Semester	M15608	Quantum Simulation Lab	0	0	2	1
6	VII-Semester	M157AX	Quantum Information and Algorithms	3	0	0	3
7	VII-Semester	M15708	Project/ Experiential Learning	0	0	8	4
			Total	**12**	**0**	**12**	**18**

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L	T	P	C
3	0	0	3

B.Tech Minor in Quantum Computing
IV Semester Syllabus
M154AH: INTRODUCTION TO QUANTUM COMPUTING

Course Outcomes:
At the end of the course, student will be able to:

1. Understand the fundamental principles of quantum mechanics relevant to quantum computing.
2. Explain the concepts of qubits, quantum gates, and quantum circuits.
3. Analyze and implement basic quantum algorithms.
4. Apply quantum computing frameworks such as Qiskit or Cirq for simple quantum programs.
5. 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
- Mathematical foundations: vectors, matrices, complex numbers
- Linear algebra concepts for quantum systems
- 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
- Tensor product and composite 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 Algorithms

- Introduction to quantum algorithms
- Quantum parallelism

- Deutsch and Deutsch–Jozsa algorithms

- Grover's search algorithm
- Quantum Fourier Transform
- Shor's factoring algorithm (overview)
- Quantum Phase Estimation
- Variational Quantum Eigensolver (VQE)
- Quantum Approximate Optimization Algorithm (QAOA)

UNIT-IV: Quantum Programming and Simulation

- Introduction to quantum programming platforms
- Quantum circuit design using Qiskit / Cirq
- Quantum simulators
- Execution on cloud quantum computers
- Implementation of basic quantum algorithms
- Noise in quantum systems
- NISQ (Noisy Intermediate Scale Quantum) devices

UNIT-V: Applications of Quantum Computing

- Quantum cryptography and quantum key distribution
- Quantum communication and teleportation
- Quantum machine learning concepts
- Quantum chemistry simulations
- 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:

1. Phillip Kaye, Raymond Laflamme, and Michele Mosca, An Introduction to Quantum Computing, Oxford University Press.
2. Chris Bernhardt, Quantum Computing for Everyone, MIT Press.
3. Eric R. Johnston, Nic Harrigan, and Mercedes Gimeno-Segovia, Programming Quantum Computers, O'Reilly.
4. Scott Aaronson, Quantum Computing Since Democritus, Cambridge University Press.

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0	0	2	1

B.Tech Minor in Quantum Computing
IV Semester Syllabus
M15407: QUANTUM PROGRAMMING LAB

Course Outcomes:

At the end of the course, student will be able to:

1. Understand the fundamental principles of the course area.
2. Explain theoretical foundations and related models.
3. Analyze and implement algorithms or techniques related to the subject.
4. Use appropriate software tools or frameworks where applicable.
5. Identify practical applications and future research directions.

List of Experiments:

1. Introduction to Qiskit environment
2. Installing and configuring Qiskit
3. Creating simple quantum circuits
4. Quantum assembly language basics using QASM
5. Compose single Quantum Circuits with Q-Gates and measuring output into classical bits.
6. Compose Multi-qubit circuits with Q-Gates and measuring output into classical bits.
7. Implementation of Deutsch algorithm and visualize its results
8. Implementation of Grover search algorithm and visualize its results
9. Implementation of shors algorithm and visualize its results
10. Introduction to IBM Qiskit platform.
11. Running circuits on IBM Quantum hardware and analysis noise
12. Report preparation and experiment documentation

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3	0	0	3

B.Tech Minor in Quantum Computing
V Semester Syllabus
M155AH: QUANTUM COMMUNICATION AND CRYPTOGRAPHY

Course Outcomes:
At the end of the course, student will be able to:

1. Understand the fundamental principles of the course area.
2. Explain theoretical foundations and related models.
3. Analyze and implement algorithms or techniques related to the subject.
4. Use appropriate software tools or frameworks where applicable.
5. Identify practical applications and future research directions.

UNIT-I

- Basics of quantum communication
- Quantum states transmission
- Quantum channels
- Noise in quantum communication

UNIT-II

- Quantum teleportation
- Superdense coding
- Quantum repeaters

UNIT-III

- Quantum key distribution fundamentals
- BB84 protocol
- B92 protocol
- E91 protocol

UNIT-IV

- Eavesdropping strategies
- Security proofs for QKD
- Quantum cryptographic protocols

UNIT-V

- Post-quantum cryptography overview
- Lattice-based cryptography
- Hash-based signatures
- Future quantum communication networks

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L	T	P	C
3	0	0	3

B.Tech Minor in Quantum Computing
VI Semester Syllabus
M156AI: QUANTUM COMPUTING APPLICATIONS AND PROJECT

Course Outcomes:

At the end of the course, student will be able to:

1. Understand the fundamental principles of the course area.
2. Explain theoretical foundations and related models.
3. Analyze and implement algorithms or techniques related to the subject.
4. Use appropriate software tools or frameworks where applicable.
5. Identify practical applications and future research directions.

UNIT-I

- Applications in optimization
- Combinatorial optimization problems
- Quantum annealing overview

UNIT-II

- Quantum chemistry simulations
- Molecular energy calculations
- Variational Quantum Eigensolver applications

UNIT-III

- Quantum machine learning
- Quantum feature spaces
- Variational quantum classifiers

UNIT-IV

- Quantum sensing and metrology
- Quantum imaging
- Precision measurements

UNIT-V

- Mini project work
- Problem formulation
- Quantum algorithm implementation
- Project presentation and evaluation

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0	0	2	1

B.Tech Minor in Quantum Computing
VI Semester Syllabus
M15608: QUANTUM SIMULATION LAB

Course Outcomes:

At the end of the course, student will be able to:

1. Understand the fundamental principles of the course area.
2. Explain theoretical foundations and related models.
3. Analyze and implement algorithms or techniques related to the subject.
4. Use appropriate software tools or frameworks where applicable.
5. Identify practical applications and future research directions.

List of Experiments:

1. Introduction to Qiskit environment
2. Construct 2-Qubit entanglement circuit using Qiskit Terra and Qiskit Aer
3. State vector simulator using Aer.
4. Simulation of quantum circuits with Qiskit using 2-Qubit.
5. Construct circuits with Quantum Gates such as X, H, CNOT, T using 3-Qubit
6. Emulate classical gates (AND, NAND, OR) using quantum gates.
7. Emulate Quantum key distribution for BB8 protocol using 2-Qubit.
8. Simulate Deutsch algorithm and visualize its result using 2 & 3-Qubit
9. Simulate Grover search algorithm and visualize its result using 2 & 3-Qubit
10. Simulate shors algorithm and visualize its result using 2 & 3-Qubit
11. Simulate Simons algorithm and visualize its result using 2 & 3-Qubit
12. Running circuits on IBM Quantum Hardware and analyze noise.

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L	T	P	C
3	0	0	3

B.Tech Minor in Quantum Computing
VII Semester Syllabus
M157AX: QUANTUM INFORMATION AND ALGORITHMS

Course Outcomes:

At the end of the course, student will be able to:

1. Understand the fundamental principles of the course area.
2. Explain theoretical foundations and related models.
3. Analyze and implement algorithms or techniques related to the subject.
4. Use appropriate software tools or frameworks where applicable.
5. Identify practical applications and future research directions.

UNIT-I

- Classical information vs quantum information
- Shannon entropy
- Quantum entropy and von Neumann entropy
- Quantum information measures

UNIT-II

- Quantum circuits
- Reversible computing
- Universal gate sets
- Quantum circuit complexity

UNIT-III

- Deutsch and Deutsch–Jozsa algorithms
- Bernstein–Vazirani algorithm
- Simon's algorithm

UNIT-IV

- Quantum Fourier Transform
- Phase estimation algorithm
- Applications of phase estimation

UNIT-V

- Shor’s factoring algorithm (overview)
- Grover’s search algorithm
- Amplitude amplification
- Complexity advantages of quantum algorithms

SUGGESTED TEXTBOOKS:

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