

Course Code	Course Title	L	T	P	C
BCSE431L	Fundamentals of Quantum Computing	3	0	0	3
Pre-requisite	NIL	Syllabus version			
		1.0			
Course Objectives					
<ol style="list-style-type: none"> 1. To provide a mathematical foundation for Quantum Computing and provide the basics of working 2. To interpret the various aspects and applications of quantum computing. 3. To examine the factors that affect Quantum computation. 					
Course Outcomes					
<p>On completion of the course, the student will be able to</p> <ol style="list-style-type: none"> 1. Ability to understand the concept behind quantum physics and the mathematical computations lies in it. 2. Explain the postulates and representation of a Qubit. 3. Explain the different basis in Quantum phenomena and its measurements. 4. Explain the working model of Quantum computing as teleportation and function finding 5. Explain the various factors that affect a qubit and handling methods 					
Module:1	Physical Properties of Quantum Particles and basic Mathematics of Quantum Computing	5 hours			
<p>Physical properties: Double Slit Experiment; Light: Particle Vs Wave; Heisenberg Uncertainty Principle.</p> <p>Linear Algebra: Vector spaces – basis; Inner product; Outer product; Tensor product; Linear operators.</p>					
Module:2	Quantum Mechanics for Quantum Computing	6 hours			
Review of postulates, Bloch sphere, Single qubit states and gates, superposition; Two Qubit States and Gates - Bell States, Entanglement, CNOT gate, Phase oracles, Phase kickback, Entanglement generation					
Module:3	Notation and Basis in QC Quantum gates and circuits	6 hours			
Detailed exposure of one and two qubit gates and states, Examples of Dirac's notation for quantum computing, Computational Basis, Orthonormality, Pauli Gates, Hadamard and Phase Gates- building quantum circuits					
Module:4	Fundamental Algorithms in QC-1	8 hours			
Teleportation Algorithm, Deutsch–Josza Algorithm, Grover search algorithm: Problem definition, Amplitude amplification, Grover oracle, diffuser, multiple solutions in the search space					
Module:5	Fundamental Algorithms in QC-2	8 hours			
Quantum Fourier Transform (QFT), and efficient representation of QFT as a quantum circuit. Application of the QFT to enable Quantum Phase Estimation (QPE). Order-finding problem – eigenvalue estimation approach to order finding – Shor's algorithm for order finding/factoring					
Module:6	Measurements and Errors	6 hours			
Computational complexity – black-box model – lower bounds for searching – general black-box lower bounds – polynomial method – block sensitivity – adversary methods – classical error correction – classical three-bit code – fault tolerance – quantum error correction – three- and nine-qubit quantum codes – fault-tolerant					

quantum computation			
Module:7	Programming a quantum computer		4 hours
The IBMQ, coding a quantum computer using a Simulator to carry out basic quantum measurement and state analysis.			
Module:8	Contemporary Issues		2 hours
Total Lecture hours:			45 hours
Text Book(s)			
1.	Chuck Easttom, "Quantum Computing Fundamentals", 1st edition, Published by Addison-Wesley Professional (June 1st 2021)		
2	Qiskit TextBook - https://qiskit.org/textbook/preface.html (2022)		
Reference Books			
1.	Qiskit basic Quantum Computation course - https://qiskit.org/learn/intro-qc-qh/		
2	Kasirajan, Venkateswaran. <i>Fundamentals of quantum computing</i> . Springer International Publishing, 2021.		
3	Chris Bernhardt, Quantum Computing for Everyone, The MIT Press, Cambridge, 2020		
4	Nielsen, Michael A., and Isaac L. Chuang, "Quantum Computation and Quantum Information" Cambridge University Press (5 April 2013)		
Mode of Evaluation: CAT / written assignment / Quiz / FAT			
Recommended by Board of Studies		24-11-2022	
Approved by Academic Council		No. 68	Date 19-12-2022