

Branch Name:	Cyber Security
Program Code:	ET207
Course Title:	Introduction to Quantum Computing
Course Code:	2ET2070305T
Pre-requisite Course:	Linear Algebra, Prior knowledge of quantum mechanics

Course Objectives:

A basic introduction to quantum mechanics, linear algebra and familiarity with the Dirac notation is provided first to get one's quantum moorings right . This is then followed byan introductory treatment of quantum computation and quantum information covering aspects of quantum entanglement, quantum algorithms, quantum channels. Rudimentary quantum computing is introduced using the IBM quantum computer and associated simulator

Teaching and Examination Scheme:

Teaching Scheme (Hours per week)					Evaluation Scheme (Marks)								
Credit	L	T	P	Total	Theory (Marks)				Practical (Marks)				Total (Mark)
					SEE		CCA		SEE		CCA		
					Min	Max	Min	Max	Min	Max	Min	Max	
3	3	-	-	3	24	60	16	40	-	-	-	-	100

Subject Contents:

Sr. No	Topic	Total Hours	Weightage (%)
1	Introduction: Elementary quantum mechanics: linear algebra for quantum mechanics, Quantum states in Hilbert space, The Bloch sphere, Density operators, generalized measurements, no-cloning theorem, Linear Combination Of Vectors, Uniqueness of a spanning set, basis & dimensions, inner Products, orthonormality, gram-schmidt ortho gonalization, bra-ket formalism, the Cauchy-schwarz and triangle.	7	20
2	Quantum correlations: Bell inequalities and entanglement, Schmidt decomposition, superdense coding, teleportation	4	10
3	Tensor Products and Density Operator Representing Composite States in Quantum Mechanics, Computing inner products, Tensor products of column vectors, operators and tensor products of Matrices. Density Operator of Pure & Mix state, Key Properties, Characterizing Mixed State, Practical Trace & Reduce Density Operator, Density Operator & Bloch Vector	8	25
4	Quantum Measurement Theory, Noise and error correction Distinguishing Quantum states & Measures, Projective Measurements, Measurement on Composite systems, Generalized Measurements, Positive Operator-Valued Measures, Graph states and codes, Quantum error correction	6	15

5	Quantum Algorithms Classical computation on quantum computers, Relationship between quantum and classical complexity classes. Deutsch's algorithm, Deutsch's-Jozsa algorithm, Shor factorization, Grover search	7	20
6	Programming a quantum Computer: The IBMQ, coding a quantum computer using a simulator to carry out basic quantum measurement and state analysis.	4	10

References books:

- (1) Phillip Kaye, Raymond Laflamme et. al., An introduction to Quantum Computing, Oxford University press, 2007.
- (2) Chris Bernhardt, Quantum Computing for Everyone, The MIT Press, Cambridge, 2020
- (3) David McMahon-Quantum Computing Explained-Wiley-Interscience , IEEE Computer Society (2008)
- (4) Quantum Computation and Quantum Information, M. A. Nielsen & I. Chuang, Cambridge University Press (2013).
- (5) Quantum Computing, A Gentle Introduction, Eleanor G. Rieffel and Wolfgang H. Polak MIT press (2014)
- (6) Quantum Computation and Quantum Information, M A Nielsen and I L Chuang, Cambridge
- (7) University Press.
- (8) Principles of Quantum Computation and Information, Vol. I: Basic Concepts, Vol II: Basic Tools Special Topics, World Scientific.

List of Open Source Software/learning website:

- (1) <https://quantumcomputingreport.com/tools/>
- (2) <https://www.geeksforgeeks.org/introduction-quantum-computing/>
- (3) <https://thequantuminsider.com/introduction-to-quantum-computing/>

Course Learning Outcomes (CLO):

CLO	Description	Bloom's Taxonomy Level
CLO1	Elementary quantum mechanics	1 Remembering, 2 Understanding
CLO2	Deutsch's algorithm, Deutsch's-Jozsa algorithm, Shor factorization, Grover search	3 Applying, 5 Evaluate
CLO3	Understanding the Quantum correlations:	2 Understanding, 3 Applying
CLO4	Tensor Products and Density Operator	2 Understanding, 3 Applying
CLO5	Understanding Quantum Measurement Theory, Noise and error correction	2 Understanding, 3 Applying, 4 Analyze

Mapping of CLOs with POs & PSOs

Course Learning Outcomes	Program Outcomes (POs)												Program Specific Outcomes(PSOs)			
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CLO1	L	L	L	L	M	M						M	L	L		
CLO2	M	M	H	L	M	M						M	M	M		
CLO3	L	L	M	M	M	M						M	L	M		
CLO4	L	L	H	L	M	H						M	M	M	M	
CLO5	H	M	M	M	H	H						M	M	M	M	

H: High, M: Medium, L: Low