SN	SPO-441	Course Name: Introduction to Quantum Computing	L	T	P	S	C	CH	Course Type
1		Course Coordinator: Dr. Amit Sharma	3	0	0	0	3	3	Open elective
PRE-REQUISITE		Quantum mechanics-I							
CO-REQUISITE		Nil							
ANTI-REQUISITE		Nil							

A. COURSE DESCRIPTION

This course explores how quantum mechanics unlocks incredible processing power. Students will learn about qubits, superposition, entanglement, and how they revolutionize problem-solving in various field.

B. COURSE OBJECTIVES:

The objective of the course is to develop a basic understanding of the principles of quantum mechanics relevant to quantum computing, difference between classical and quantum computing, quantum gates and quantum algorithms.

C. COURSE OUTCOMES

CO No.	Statement	Performance Indicator	Student Outcome Indicator (ABET)	Level of Learning (Highest BT Level)	Target Attainment
CO1	Develop a solid understanding of the fundamental principles of quantum mechanics, including bra-ket algebra, superposition, entanglement, and quantum states.	PO1.1, 1.4	Nil	BT2	2.1
CO2	Explore the concept of qubits, quantum gates, and quantum circuits, essential building blocks for quantum computation.	P1-1.1, 1.4, P2-2.1	Nil	BT2	2.1
CO3	Describe the key quantum algorithms and understand how they provide exponential speedup over classical counterpart.	P1-1.1,1.4, P2-2.1, P3-3.1, P4-4.1,4.2, P5-5.3	Nil	BT3	2.1
CO4	Apply quantum error correction techniques to identify and mitigate errors in quantum computation.	P6-6.3, P8-8.1, 8.3, P13-13.5	Nil	BT4	2.1
CO5	Evaluate the challenges and solutions in quantum error correction and fault-tolerant quantum computing.	P6-6.1, 6-2, 6.3, P7-7.5	Nil	BT5	2.1
CO6	Discuss the potential applications of quantum computing in various fields, including potential solutions to problems in simulation, optimization, and cryptography.	P7-7.1, 7.2, 7.3, 7.4, 7.7	Nil	BT6	2.1

D. SYLLABUS

Unit-1	**Introduction to Quantum Mechanics**	**Contact Hours:15**
Chapter 1.1	Mathematical foundations of Quantum Mechanics, Linear Algebra, Dirac's bra-ket algebra, Operators: Unitary and Hermitian operators, State of a quantum mechanical system, and its time evolution, Quantum Superposition and Entanglement, Concept of Qubits, Measurement and Probability in Quantum Mechanics	
Unit-2	**Quantum gate and Quantum Algorithms**	**Contact Hours:15**
Chapter 2.1	Quantum Gates and Circuits: Introduction to Quantum Gates, Basic Quantum Circuits, Quantum Gates for Qubit Manipulation, Multi-Qubit Systems and Entanglement Gates, Quantum Circuits and Computational Basis	
Chapter 2.2	Quantum Parallelism and Quantum Speedup, Deutsch's and Simon's Algorithm, Shor's Algorithm for Integer Factorization, Grover's Search Algorithm, Quantum Phase	

	Estimation
Unit-3	**Quantum Error Correction**	**Contact Hours:15**
Chapter 3.1	Quantum Error Correction: Basics of Quantum Error Correction, Shor Code and Steane Code, Fault-Tolerant Quantum Computing, Quantum Error Correction for Qubits and Gates, Topological Quantum Error Correction,

Self-study topics for Advance learners: Universal set of Quantum gates, Super dense coding.

E. PROJECT BASED LEARNING COMPONENTS

1. Simulate a quantum coin flip using single qubits to demonstrate the principle of superposition.
2. Illustrate the concept of entanglement using a simple quantum circuit.
3. Implement a random number generator using quantum bits and observe the quantum nature of randomness.
3. Create a visual representation of entangled qubits and explore their correlated states.
5. Develop a tool for building and visualizing simple quantum circuits using gates.

F. TEXT BOOKS/REFERENCE BOOKS

TEXT BOOKS

1M.A. Nielsen, and I.L. Chuang, Quantum Computing and Quantum Information, Cambridge University press (2000).
2J. Preskill, Quantum Information and Computation, Cambridge University Press (2018).
3 A. Ekert, and R. Jozsa, Qauntum Computation and Information, Oxford University Press (2004).

G. ASSESSMENT PATTERN

The performance of students is evaluated as follows:

	Theory	
Components	**Continuous Internal Assessment (CAE)**	**Semester End Examination (SEE)**
Marks	40	60
Total Marks	100	

Internal Evaluation Component

S. No	**Direct Evaluation Instruments**	**Weightage of actual conduct**	**Frequency of Task**	**Final Weightage in Internal Assessment**	**BT Levels**	**CO Mapping**	**Mapping with SIs (ABET)**	**Mapping with PIs**	**Remarks (Graded/ Non-Graded)**
1	Assignment	10 marks for each assignment	One per unit	10	BT3	CO5			Graded
2	Exam	20 marks for one MST	2 per semester	20	BT3	CO1-4			Graded
3	Quiz/Test	4 marks for each quiz	2 per unit	4	BT1-2	CO1, CO2			Graded
4	Surprise test	12 marks for each test	One per unit	4	BT3-4	CO1-3			Graded
5	Homework	NA	One per lecture topic (of 2 questions)	NA	BT1-4	CO4			Non-Graded
6	Case study	NA	NA	NA					Non-Graded
7	Discussion Forum	NA	One per unit	NA		CO5			Non-Graded
8	Presentation	NA	NA	NA					Non-Graded
9	Attendance	NA	NA	2					Graded

H. CO-PO Mapping

Course Outcome	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PO13	PO14	PO15	PO16	PO17	PSO1	PSO2	PSO3
CO1	3	3	3	2	3	1	1		1	1	1	2	1					1	1	1
CO2	3	3	3	2	3	1	1		1	1	1	2	1					1	1	1
CO3	3	3	3	2	3	1	1		1	1	1	2	1					1	1	1
CO4	3	3	3	2	3	1	1		1	1	1	2	1					1	1	1
CO5	3	3	3	2	3	1	1		1	1	1	2	1					1	1	1
CO6	3	3	3	2	3	1	1		1	1	1	2	1					1	1	1

CO PO correlation matrix of each subject to be mapped with
High correlation (3); Medium correlation (2); Low correlation (1)