Kadi Sarva Vishwavidyalaya

Faculty of Engineering & Technology

Fourth Year Bachelor of Engineering (Computer/IT)

(To be Proposed For: Academic Year 2020-21)

Subject Code: CT704B-N	**Subject Title:** Quantum Computing
Pre-requisite	Linear Algebra, Prior knowledge of quantum mechanics

Teaching Scheme (Credits and Hours)

Teaching scheme				**Total Credit**	**Evaluation Scheme**					
L	**T**	**P**	**Total**		**Theory**		**Mid Sem Exam**	**CIA**	**Pract.**	**Total**
Hrs	**Hrs**	**Hrs**	**Hrs**		**Hrs**	**Marks**	**Marks**	**Marks**	**Marks**	**Marks**
04	00	02	06	05	03	70	30	20	30	150

Course Objectives:

The objective of this course is to provide the students, an introduction to quantum computation. Much of the background, material related to the algebra of complex vector spaces and quantum mechanics is covered within the course.

Outline of the Course:

Sr. No	**Title of the Unit**	**Minimum Hours**
1	Qubit & Quantum States	14
2	Matrices & Operators	13
3	Tensor Products and Density Operator	13
4	Quantum Measurement Theory, Noise and error correction	12
5	Quantum Algorithms	12

Total hours (Theory): 64
Total hours (Lab): 32
Total hours: 96

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Detailed Syllabus

Sr. No	Topics	Lecture Hours	Weightage (%)
1	**Qubit & Quantum States** Quantum bits, Bloch sphere representation of a qubit, multiple qubits, Vector Spaces. Linear Combination Of Vectors, Uniqueness of a spanning set, basis & dimensions, inner Products, orthonormality, gram-schmidt ortho gonalization, bra-ket formalism, the Cauchy-schwarez and triangle	14	22
2	**Matrices & Operators** Observables, The Pauli Operators, Outer Products, The Closure Relation, Representation of operators using matrices, outer products & matrix representation, matrix representation of operators in two dimensional spaces, Pauli Matrix, Hermitian unitary and normal operator, Eigen values & Eigen Vectors, Spectral Decomposition, Trace of an operator, important properties of Trace, Expectation Value of Operator, Projection Operator, Positive Operators, Commutator Algebra, Heisenberg uncertainty principle, polar decomposition & singular values, Postulates of Quantum Mechanics.	13	20
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	13	20
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	12	19
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	12	19
	Total	**64**	**100**

Instructional Method and Pedagogy:

- At the start of course, the course delivery pattern, prerequisite of the subject will be discussed.
- Lectures will be conducted with the aid of multi-media projector, black board, OHP etc.
- Attendance is compulsory in lecture and laboratory which carries 10 marks in overall evaluation.
- One internal exam will be conducted as a part of internal theory evaluation.
- Assignments based on the course content will be given to the students for each unit and will be evaluated at regular interval evaluation.

- Surprise tests/Quizzes/Seminar/tutorial will be conducted having a share of five marks in the overall internal evaluation.
- The course includes a laboratory, where students have an opportunity to build an appreciation for the concepts being taught in lectures.
- Experiments shall be performed in the laboratory related to course contents.

Learning Outcome:

Students would learn the framework of quantum computation, and how that may be useful for future quantum technologies.

e-Resources or courses:

Courses by: Andrew Childs, Ronald de Wolf, and John Watrous on quantum theory and computing

Reference Books:

- Quantum Computation and Quantum Information, M A Nielsen and I L Chuang, Cambridge University Press.
- Principles of Quantum Computation and Information, Vol. I: Basic Concepts, Vol II: Basic Tools and Special Topics, World Scientific.
- An Introduction to Quantum Computing, Pittenger,
- An Introduction to Quantum Computing, P Kaye, R Laflamme and M Mosca.
- Linear Algebra and its Applications, G. Strang.
- Matrix Analysis, Bhatia.
- Quantum Computing without Magic by Zdzis_law Meglicki
- Quantum Computing Explained By DAVID McMAHON
- Quantum Computer Science By Marco Lanzagorta, Jeffrey Uhlmann

List of experiments

No	Name of Experiment
1	Write a program to implement Deutsch's algorithm
2	Write a program to implement Deutsch's-Jozsa algorithm
3	Write a program to implement Shor factorization technique
4	Write a program to implement Grover search technique
5	Prepare case study for any suitable application on quantum encryption methods for Cyber
6	Prepare case study for any suitable application for Financial Modeling
7	Prepare case study for any suitable application for Traffic Optimization
8	Prepare case study for any suitable application for Weather Forecasting and Climate Change
9	Prepare case study for any suitable application for Artificial Intelligence