ANIL NEERUKONDA INSTITUTE OF TECHNOLOGY & SCIENCES
UGC Autonomous
(Affiliated to AU, Approved by AICTE & Accredited by NBA & NAAC with 'A' Grade)
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Department of Physics

Open elective (Common to all Branches) – (R-19)

Fundamentals of Quantum computing

L-T-P-E-O-C
3-1-0-0-0-3
Credits:3

Instruction: 3 Periods&1 Tut/week — Sessional Marks: 40
End Exam : 3 Hours — End Exam Marks: 60

Prerequisites:

Basic knowledge on Modern physics

Course Outcome:

By the end of the course, the student will be able to :	
1	Learn the basics of quantum computing
2	Learn how classical information can be represented and conveyed through quantum mechanical phenomena such as entanglement

SYLLABUS

Unit-I

Introduction: **10 hrs**

Introduction- Young's Double slit Experiment, Quantum superposition, why quantum computing, How is quantum computing different?

The Quantum Mechanics of Photon Polarization - Simple Experiment- Quantum Explanation, Classical bits ,Qubits -Definition of a qubit - a complex vector represents a qubit-state or not , The difference between a bit and a qubit

Mathematical Preliminaries: Bra–ket notation, Perform the inner product operation on $\mathbb{C}^2$, Heisenberg Notation, Linear operators and matrices ,The Pauli matrices, Orthonormal basis , Dirac notation,Adjoints and Hermitian operators, Tensor Product, Superposition of states, Postulates of Quantum mechanics

Unit-II

Single Qubit Quantum Systems: **10 hrs**

Complex Vectors and Qubits - Qubit states in C^2- Basis vectors and State representation,Projections and Photons, Geometrical view of the state space of a single Qubit -The global phase States in Polar Coordinates,Bloch Sphere

Single-Qubit measurement-Given single-qubit state and a measurement basis describe the possible measurement outcomes and compute the probability for each of them. Single-qubit operations - The Pauli Transformations, Unitary transformation and the Hadamard Transformation . Pauli gates, Hadamard gate, Phase shift gate, Quantum gates as rotations in Bloch sphere

Unit-III

Multiple Qubit systems: **10 hrs**

Quantum state transformation- Two-qubit states, representations of two-qubit states, Multi Qubit Transformation - Linear Transformations - Representing "linear" transformations - Phase, Two-Qubitoperations-Tensor Products of vector space, Illustrative Examples

Concept of Entanglement, Entangled Quantum states: Visualizing two-qubit states, Preparing Non-Separable states, The CNOT gate,Generalized controlled gates, Entangled States - A Non-separable basis

Unit- IV

Measurement of Multiple Qubit states: **10 hrs**

Dirac Bra- Ket notation for linear transformation, Projection operator measurements, Hermitian operator formalism for the measurement, EPR Paradox and Bell's Theorem - What Quantum Mechanics Predicts - Special Case of Bell's Theorem: Local Hidden Variable Predictions - Bell's Inequality

Unit -V

Quantum Circuits and applications of Quantum computation **10 hrs**

Introduction to Quantum Circuits - Operations as Circuits - Reading the circuit Classical vs. Quantum computations -Classical Computing- Quantum Computing: limitations, Quantum Computing: practicalities

Applications of Simple Gates-Super-dense Coding, No-cloning theorem, Overview on Quantum Teleportation, Quantum cryptography

TEXT BOOKS:

1. Quantum computation and Quantum information by Michael A. Nielsen & Isaac L. Chuang; 10th Anniversary Edition, Cambridge University
2. Quantum Computing: A Gentle Introduction by Eleanor Rieffel and Wolfgang Polak, The MIT Press Cambridge, Massachusetts London, England

Reference Books

1. Introduction and Quantum Mechanics by Lukac and Perkowski
2. Quantum Computing - Lecture Notes Mark Oskin, Department of Computer Science and Engineering University of Washington
3. Lecture notes by Ronald de Wolf