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| **Course Title** | **Course Structure** | **Pre-Requisite** |
| **Fundamentals of Quantum Computation (DCC-12)**  B.Tech. (EP), 5th Sem Lesson Plan | |  |  |  | | --- | --- | --- | | **L** | **T** | **P** | | **3** | **1** | **0** | | Basic quantum mechanics and linear algebra |

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| **Course Objectives:**  To enable students to formulate and explain the research based emerging field of quantum computation with the help of fundamental concepts of quantum mechanics, and describe the propagation of quantum information using logic gates in various fields. |

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| **Course Outcomes (COs)**  Students will be able to   1. Understand the basic quantum mechanics and linear algebra to explain the basic notions of quantum computing including quantum bits and its evolution. 2. Identify the essential difference between the classical paradigm and the quantum paradigm of computation and gain sufficient knowledge of quantum gates and circuits to apply it tackle the real-world problems. 3. Demonstrate an understanding of how information can be represented, stored, and conveyed through quantum mechanical phenomena. 4. Solve some of the basic problems using quantum algorithms and justify the need of quantum computers. 5. Analyse quantum error correction to protect delicate quantum information from noise and errors and weigh the basic requirements for physical implementation of quantum computers |

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| **S. No.** | **Content** | **Contact Hours** |
| Unit 1 | Review of quantum mechanics for quantum computations, Concept of qubit and its Physical implementation. Dynamics of qubit: Bloch Sphere, Pure and mixed states of quantum systems, Density matrix and its properties, Inseparability of quantum systems, The reduced density matrix. | 10 |
| Unit 2 | Classical Complexity vs Quantum Complexity, Quantum Complexity Classes, Classical computations, and Quantum computation, Landauer principle, Quantum gates: Pauli matrices, Single-qubit logic gates. Controlled quantum logic gates, Quantum Circuits | 8 |
| Unit 3 | EPR paradox, Bell states and Bell inequalities, No-cloning theorem; Quantum entanglement: Superdense coding, Quantum teleportation. Quantum Cryptography: Quantum Key Distribution (QKD) and the BB84 Protocol | 8 |
| Unit 4 | Quantum Algorithms: Deutsch algorithm, Deutsch–Jozsa algorithm, Quantum Fourier Transform, Shor’s algorithm for integer factorization, Grover search algorithm | 8 |
| Unit 5 | Quantum error correction: Classical three-bit error correction code, Distinctive features of quantum error correction theory. Quantum three-qubit error correction code: bit-flip and phase-flip code; Shor code. Physical realization of quantum computing | 8 |
|  | Total | **42 hrs** |

**Suggested Books:**

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| **S. No.** | **Name of Books/Authors/Publisher** | **Year of publication/Reprint** |
| 1. | Quantum Computation and Quantum Information by Michael A. Nielsen and Isaac L. Chuang/Cambridge University Press | 2000/ 10th Anniversary Edition 2010 |
| 2. | An Introduction to Quantum Computing by Phillip Kaye, Raymond Laflamme, and Michele Mosca/ Oxford University Press | 2007 |
| 3. | Quantum Computing: From Linear Algebra to Physical Realizations by Mikio Nakahara and Tetsuo Ohmi/ CRC Press | 2008 |
| 4. | Quantum Computing: A Gentle Introduction by Eleanor Rieffel and Wolfgang Polak, The MIT Press | 2011 |