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| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Course Code** | **Course Title** | | | | | | | | |
| **2USI604** | **Quantum Computing** | | | | | | | | |
|  | **TH** | | | | **P** | | **TUT** | | **Total** |
| **Teaching Scheme(Hrs.)** | **03** | | | | **--** | | **--** | | **03** |
| **Credits Assigned** | **02** | | | | **--** | | **--** | | **02** |
| **Examination Scheme** | **Marks** | | | | | | | | |
| **CA** | | | **ESE** | **TW** | **O** | **P** | **P&O** | **Total** |
| **ISE** | | **IA** |
| **30** | | **20** | **--** | **--** | **--** | **--** | **--** | **50** |

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| **Course prerequisites (if any):**  Data Structure and Algorithm, programming in python  **Course Objectives:**  The objective of this course is to impart necessary knowledge to the learner so that he/she can develop and implement quantum algorithm  **Course Outcomes**  At the end of successful completion of the course the student will be able to  CO1: Explain the working of a Quantum Computing program, its architecture and program model  CO2: Develop quantum logic gate circuits  CO3: Develop quantum algorithm  CO4: Program quantum algorithm on major toolkits |

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| **Module No.** | **Unit No.** | **Details** | **Hrs.** | **CO** |
| **1** | Introduction to Quantum Computing | | **6** | **CO** |
| **1.1** | Motivation for studying Quantum Computing, Origin of Quantum Computing |  |  |
|  | **1.2** | Overview of major concepts in Quantum Computing Qubits and multi-qubits states, Bra-ket notation. Bloch Sphere representation Quantum Superposition Quantum Entanglement |  |  |
|  |  | **#Self Learning –** Major players in the industry (IBM, Microsoft, Rigetti, D-Wave etc.) |  |  |
| **2** | Math Foundation for Quantum Computing | | **9** | **CO** |
|  | **2.1** | Matrix Algebra: basis vectors and orthogonality, inner product and Hilbert spaces, matrices and tensors, unitary operators and projectors, Dirac notation, Eigenvalues and Eigen vectors. |  |  |
| **#Self Learning** |
| **3** | Building Blocks for Quantum Program | | **8** | **CO** |
| **3.1** | Architecture of a Quantum Computing platform, Details of q-bit system of information representation: Block Sphere Multi-qubits States Quantum superposition of qubits (valid and invalid superposition) Quantum Entanglement, Useful states from quantum algorithmic perspective e.g. Bell State Operation on qubits: Measuring and transforming using gates. Quantum Logic gates and Circuit: Pauli, Hadamard, phase shift, controlled gates, Ising, Deutsch, swap etc. |  |  |
| **#Self Learning –** |
| **3.2** | Programming model for a Quantum Computing Program Steps performed on classical computer, Steps performed on Quantum Computer, Moving data between bits and qubits. |
|  |  | **#Self Learning –** |  |  |
| **4** | Quantum Algorithms | | **22** | **CO** |
| **4.1** | Basic techniques exploited by quantum algorithms. Amplitude amplification, Quantum Fourier Transform, Phase Kick-back Quantum Phase estimation Quantum Walks |  |  |
| **#Self learning :** |
| **4.2** | Major Algorithms Shor’s Algorithm Grover’s Algorithm Deutsch’s Algorithm Deutsch -Jozsa Algorithm |
|  |  | **#Self learning - OSS Toolkits for implementing Quantum program IBM quantum experience Microsoft Q Rigetti PyQuil (QPU/QVM)** |  |  |
| **Total** | | | **45** |  |

**# Students should prepare all Self Learning topics on their own. Self-learning topics will enable students to gain extended knowledge of the topic. Assessment of these topics may be included in IA and Laboratory Experiments.**

**Recommended Books:**

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| --- | --- | --- | --- | --- |
| **Sr. No.** | **Name/s of Author/s** | **Title of Book** | **Name of Publisher with country** | **Edition and Year of Publication** |
|  | Michael A. Nielsen, Cambridge | “Quantum Computation and Quantum Information”, | University Press. |  |
|  | David McMahon, , | “Quantum Computing Explained” | Wiley |  |