I	Course Code	**PH 214001**
II	Course Title	Introduction to Quantum Computing
III	Credits	L T P C 3 0 0 3
IV	Prerequisites (if any)	Basic familarility with Linear Algebra, Computer Science and Quantum Mechanics. Aptitude for mathematics is required.
V	Learning Outcome	Quantum computing represents a completely new paradigm in the computing realm, posed to revolutionize entire industries and bring astounding new innovations. This course is aimed to provide the students a broad overview of the area of quantum computation, starting with basic concepts such as superposition and entanglement, to discussing the quantum circuit model of computation and basic quantum algorithms that demonstrate the power of computing with quantum bits. There will also be hands-on sessions for each concept taught using Qiskit (an open source framework for quantum computing that provides tools for creating and manipulating quantum programs and running them on prototype quantum devices on IBM Quantum Experience). Given that an increasing number of companies including well-funded startups and several major players (Intel, Google, IBM, Microsoft) are investing heavily in this space, there are going to be a lot of job/internship opportunities for students interested to explore this area. Thus, after completing the foundation course, students will be able to use the principles of quantum computing, classify the problems that can be expected to be solved well by quantum computers and also discover how they can get involved with this in future.
VI	Course Contents	**Introduction to Quantum Computing:** Motivation for studying quantum computing, origin of quantum computing, overview of main concepts in quantum computing - qubits and multi-qubits states, bra-ket notation, Bloch sphere representation, quantum superposition, quantum entanglement. **Background Mathematics and Physics:** Matrix algebra: basis vectors and orthogonality, inner product and hilbert spaces, matrices and tensors, unitary operators and projectors, Dirac notation, eigenvalues and eigenvectors, basic postulates of quantum mechanics, probabilities and measurements, quantum entanglement, EPR paradox and Bell's inequalities. **Building Blocks for Quantum Program:** Quantum logic gates and circuits: Single qubit gates, multiple qubit gates, controlled gates, universal gates for quantum computation, reversible computation, superdense coding and quantum teleportation. **Quantum Algorithms:** Probabilistic versus quantum algorithm, phase kick back, quantum parallelism and simple quantum algorithms, Deutsch's algorithm, Deutsch's-Jozsa algorithm, quantum fourier transforms and its applications, Shor factorization, Grover search. **Physical Realization of Quantum Computers:** NMR as quantum computers, trapped ions, superconducting qubits, quantum dots. **Practical Content**: Hands-on sessions using QISKIT would be carried out (using IBM quantum experience).

VII	Text books/ References	**Textbooks:** 1. Quantum Computation and Quantum Information, M A Nielsen and I L Chuang. 2. Principles of Quantum Computation and Information, Giuliano Benenti, Giulio Casati and Giuliano Strini. 3. An Introduction to Quantum Computing, Phillip Kaye, Raymond Laflamme and Michele Mosca. 4. Learn Quantum Computation Using Qiskit, A. Asfaw et al, http://community.qiskit.org/textbook **Reference Books:** 1. A short introduction to quantum information and quantum computation, Michel Le Bellac. 2. Feynman lectures on computation, Richard P. Feynman. 3. Quantum Computing Explained, David A. Mcmahon. 4. An Introduction to Quantum Computing Algorithms, Arthur O. Pittenger.