SC433: Quantum Computation

This course is for 4th year B.Techs. This is a theoretical course discussing the issues of measurement, computation, quantum algorithms and quantum information processing. Computers based on classical gates and binary logic don’t have an efficient algorithm for certain class of problems. Quantum logic has parallel processing inherent in its nature. This promises quantum computers to be much more efficient than classical computers. Quantum cryptography, teleportation and information processing hold the potential to revolutionize the communication technology. Quantum systems by nature being inseparable from the observers in its environment possess challenge to make them error-free. Quantum error correction is an exciting theory that can make quantum computation viable technologically. Not much can be discussed about experimental aspects of quantum computation. This is for students who wish to get introduced to this exciting field which is equally accessible and inaccessible to Physicist, Computer Scientist and Mathematicians. The point of view for this course will be from that of Physics.

Prerequisite: Quantum Mechanics, Linear Algebra.

1. Introduction to Quantum Mechanics
   (i) Blackbody Radiation, Photoelectric Effect, Double slit experiment, Photon polarization, Wave-Particle duality.
   (ii) Postulates of Quantum Mechanics.
   (iii) Measurement in Quantum Mechanics.
   (iv) Density Operator Formalism.
   (v) EPR paradox and Bell Inequality.

2. Introduction to Computer Science.
   (i) Turing Machine.
   (ii) Circuit model of computation.
   (iii) Measures of complexity.
   (iv) Energy for computation.
   (v) Reversible gates.

3. Quantum Circuits.
   (i) Qubits, Quantum Gates.
   (ii) Controlled Operations.
   (iii) Unitarity of gates.
   (iv) Relation to reversibility.

   (i) Quantum Fourier Transforms.
   (ii) Order finding and factoring.
   (iii) Quantum Search Algorithms.
   (iv) Quantum Cryptography.

5. Quantum Noise and Quantum operations.

6. Quantum Error Correction
**Evaluation:** 50% midsem ; 50% endsem.

**Books:**
1) Quantum Computation and Quantum Information  
   Michael A. Nielsen and Isaac L. Chuang  
2) Modern Quantum Mechanics  
   J. J. Sakurai  
3) The Physics of information Technology (Chapter 15)  
   Neil Gershenfeld  
4) An Introduction to Quantum Computing  
   Phillip Kaye, Raymond Laflamme and Michele Mosca

References no. 1) and 2) are sufficient for the course. However for a formal introduction to Quantum Mechanics one need to read other books like L.I Schiff, Eugene Merzbacher, Ghatak and Lokanathan; or Feynmann Lectures in Physics Vol 3.  
Going through Perspectives in Modern Physics by Arthur Beiser may be useful at your first introduction to Quantum Mechanics.