20-EECE 622: Introduction to Quantum Computing

Required/Elective: Elective for EE and CompE majors

Catalog Data: 20-EECE-622; Credits: 3. This course is aimed at an introduction to the rapidly growing field of quantum computing. The class will be introductory in nature and should benefit beginning graduate students, but also researchers in physics, computer science and engineering, mathematics, and electrical engineering.

Prerequisite: Permission of the instructor(s). The students would benefit from having mastered some fundamentals of discrete mathematics (as taught in 15-MATH-356 at UC) and modern physics (as taught in 15–PHYS-276 at UC) or some equivalent coursework. Students lacking this background are encouraged to complete equivalent coursework in the first quarter of graduate study.

Textbook: Michael A. Nielsen and Isaac L. Chuang
"Quantum Computation and Quantum Information", Cambridge University Press (2000).

References: Feynman lectures (Volume III) + additional classnotes

Goals: The students will be exposed to an introduction to the field of quantum computing, including basic principles of quantum mechanics, the concept of qubit, quantum algorithms, and practical implementations of quantum gates, circuits, and computers.

Topics:

- A brief history of Quantum Computing
  Quantum-Mechanics, Computer Science, Information Theory, Cryptography
- Classical versus Quantum bits - Examples
- Review of Linear Algebra
- Formal Introduction to Quantum Mechanics
- Classical computing: Irreversible versus reversible approaches
- The strange nature of quantum gates
- Quantum Circuits
- Examples of Quantum circuits and algorithms:
  No-cloning Theorem, superdense coding, teleportation, Deutsch-Josha algorithm
- Physical realizations of quantum gates and circuits, quantum computers

Class/Laboratory Schedule: class meets 3 times a week for 50 minutes.

Course Learning Objectives:

- The students will use their knowledge of linear algebra, boolean algebra, and vector space to study basic quantum gates, circuits, and algorithms (a,c,e).
- The students will apply the basic principles of quantum mechanics including projection measurements (a,c,e).
- The students will analyze the Bloch sphere concept and its connection to the field of quantum computing (a,c,e).
- The students will analyze the concept of entanglement and its importance in the development of quantum algorithms (a,c,e).

Outcomes: a,c,e.

Contribution to Professional Component: Engineering Science: 75%, Engineering Design: 25%.

Prepared By: M. Cahay, Ph.D; Date: December 15, 2010.