Brooklyn College
Department of Computer & Information Sciences

CISC 7228 [*728X] Quantum Computing

37½ hours, 3 credits

An introduction to quantum computing. Basic mathematical and physical background for quantum computing. Grover's search algorithm. Shor's factoring algorithm. Quantum cryptography. Quantum complexity. Physical implementations of quantum computers.

Objectives:

At the conclusion of this course, students will be expected to
1. know basics of complex numbers and how to manipulate them;
2. understand some fundamental ideas in vector spaces;
3. know how to manipulate quantum gates;
4. be able to understand and write basic quantum algorithms.
5. They should also have a general outline of the more advanced and speculative parts of the field.

Syllabus:

Week 1: Overview of Quantum Computing
- History (Feynman, Deutch, Grover, Shor)
- Double-slit experiment
- Superposition
- Contemporary experimental results

Week 2 and 3: Basic mathematical preliminaries.

Week 4: Basic quantum theory
- State Spaces,
- Bras and Kets
- Evolution
- Measurements

Week 5: More quantum theory
- Superposition
- Entanglement

Week 6: Gates and Quantum Gates
- Review of Classical Gates

Qubits
Universal quantum gates

Week 7-9: Quantum Algorithms
Deutsch's Algorithm
Deutsch-Jozsa Algorithm
Simon's Periodicity Algorithm
Grover's Search Algorithm

Week 10: Factoring Algorithms
Some mathematical background
Shor's Algorithms
Cutting edge implementations

Week 11: Quantum Complexity Theory
Basic complexity classes
Quantum Turing Machines
BPP, BQP

Week 12: Quantum Cryptography
BB84; B92

Week 13: Implementations and Realizations
Optical photon; Nuclear magnetic resonance; Ion traps

Bibliography:

Course Text:

N.S. Yanofsky, M. Mannucci. Quantum Computing: A First Text for Computer Scientists.

Other Texts:

M.A. Nielsen, I.L. Chuang: *Quantum Computation and Quantum Information*, Cambridge University Press, 2000.

M. Hirvensalo: *Quantum Computing*, Springer-Verlag, 2000.

J. Preskill: Online Lecture Notes on Quantum Computation, available at http://www.theory.caltech.edu/people/preskill/

Supplementary Texts:

D. Deutsch: *Fabric of Reality: The Science of Parallel Universes and Its Implications*, Penguin, 1998.

R.P. Feynman: *Feynman Lectures on Computation*, Addison-Wesley, 1996.

G. Johnson: *A Shortcut Through Time: The Path to the Quantum Computer*, Knopf, 2003.

T. Siegfried: *The Bit and the Pendulum: From Quantum Computing to M Theory The New Physics of Information*, Wiley, John & Sons, Incorporated, 2000.