CO 481/CS 467/PHYS 467
Introduction to Quantum Information Processing
Tuesdays and Thursdays 10am-11:20am

Instructor: Michele Mosca mmosca@uwaterloo.ca QNC3106 x32673

Objectives
Quantum Information Processing (QIP) seeks to exploit the quantum features of Nature to provide a qualitatively different and more powerful way of processing information than "classical" physics seems to allow. This course aims to give a basic foundation in the field of quantum information processing (often just called "quantum computing"). QIP is a multidisciplinary subject and therefore this course will introduce fundamental concepts in theoretical computer science and physics that will enable students to pursue further study in various aspects of QIP.

Intended Audience
This course is intended for students majoring in CS, C&O or Physics, and is normally completed in a student's third or fourth year. It is intended to be accessible to students with either a CS/Math or Physics background with an interest in the physical and mathematical foundations of computation and/or the role of information in physics.

Related Courses
Prerequisites: A solid background in basic linear algebra (a good performance in MATH 235 or MATH 114 should suffice) is necessary. Students will likely encounter at least one subject with which they have very little familiarity; this is expected. Familiarity with theoretical computer science or quantum mechanics will be an asset, though most students will not be familiar with both.

Textbook: "An Introduction to Quantum Computing", by Kaye et al.
Additional reference: "Quantum Computation and Quantum Information" by Nielsen and Chuang

Outline
General Introduction (3 hrs)
Physics and information. Quantum superposition and interference. Quantum bits, gates and registers.

Introduction to Quantum Mechanics (6 hrs)
Postulates of quantum mechanics. Density matrices. Bloch sphere. Entanglement. Non-locality. Quantum teleportation.

Introduction to Computation and Computational Complexity(6 hrs)
Church-Turing thesis. Quantum circuits. Universality. Basic complexity classes. NP-completeness.

Quantum Algorithms(9 hrs)

Basic algorithms. Quantum Fourier Transform. Phase estimation. Integer factorization. Quantum searching.

Quantum Error Correction(3 hrs)
Quantum error-correcting codes.

Physical Realizations (3 hrs)
Implementations of quantum information processors. Examples of actual or proposed implementations.

Other Topics(6 hrs)
The course will cover additional topics of interest, and include a laboratory tour.

Evaluation
5 assignments (10% each)
1 mid-term exam (15%)
1 project (15%)
1 final exam (20%)

Assignment Policies: Students may assist each other in working through assignment problems, however solutions must be written up independently. Late assignments will not be accepted unless a prior arrangement (with appropriate documentation) is made at least one week in advance of the deadline. Missing assignments will be awarded a grade of 0.
Students may collect their assignments and midterm in class or during the TA office hours.

Teaching Assistants
Laura Mancinska lmancins@uwaterloo.ca
TBD

Office for Persons with Disabilities (OPD)
Note for students with disabilities The Office for Persons with Disabilities (OPD), located in Needles Hall, Room 1132, collaborates with all academic departments to arrange appropriate accommodations for students with disabilities without compromising the academic integrity of the curriculum. If you require academic accommodations to lessen the impact of your disability, please register with the OPD at the beginning of each academic term.

Avoidance of Academic Offences.
Students are expected to know what constitutes academic integrity, to avoid committing academic offenses, and to take responsibility for their actions. Students who are unsure whether an action constitutes an offense, or who need help in learning how to avoid offenses (e.g., plagiarism, cheating) or about "rules" for group work / collaboration should seek guidance from the course professor, TA, academic advisor, or the Undergraduate Associate Dean. For information on categories of offenses and types of penalties, students should refer to Policy #71, Student Academic Discipline, http://www.adm.uwaterloo.ca/infosec/Policies/policy71.html
Students who believe that they have been wrongfully or unjustly penalized have the right to grieve; refer to Policy #70, Student Grievance,
http://www.adm.uwaterloo.ca/infosec/Policies/policy70.html