Course Outline Form: Fall 2016

General Information

Course Title: MATH4150/NANO4700: Concepts in Quantum Computing

Course Description: This course introduces concepts in quantum computation and quantum information. Following an introduction to the basics of linear algebra, quantum mechanics, and computer science, presented from the viewpoint of quantum information theory, topics covered will include quantum computation, quantum algorithms, quantum error correction, quantum cryptography and quantum communication..

Credit Weight: .5

Academic Department (or campus): Chemistry

Campus: University of Guelph Main Campus

Semester Offering: F16

Class Schedule and Location: M,W,F 10:30-11:20, MCKN 308

Instructor Information

Instructor Name: Jeremy Levick
Instructor Email: jlevick@uoguelph.ca
Office location and office hours: MacN 543, Wed 2:00-3:00, others TBD by student schedule

GTA Information

GTA Name: Comfort Mintah
GTA Email: cmintah@uoguelph.ca
GTA office location and office hours: MacN 535

Course Content

Specific Learning Outcomes:

- Learn the basics of finite dimensional quantum mechanics (observables, measurements, unitary evolution etc.). Students should be able to use the postulates of quantum mechanics and basic liner algebra to compute probabilities of observing outcomes for observables, and should be able to use the basic tools of the spectral theory on normal matrices to do computations

- Learn basic computing (functions on bits, basic complexity classes: P vs. Exp); students should be able to compute truth tables and simple circuits for classical functions, and be able to identify the complexity of a circuit
- Learn the quantum model of computation (Unitary implementation of functions)
- Learn to work with and understand quantum circuits. Students should be able to evaluate quantum circuits, or construct quantum circuits from given data, and should be able to identify the complexity of simple circuits
- Learn important quantum algorithms (Deutsch, Shor, Grover, Simon, Bernstein-Vazirani if time permits); students should understand the basic ideas behind the quantum Fourier transform, and quantum search.
- Learn the basics of quantum error correction (bit-flip errors, phase-flip errors, Shor's code, threshold theorem). Students should be able to show how simple codes correct simple errors, and explain why, even in the presence of certain obstructions, quantum error correction is possible
- Learn basic quantum information protocols (dense-coding, teleportation, etc.). Students should be able to recapitulate the protocols for dense-coding and teleportation, and understand the role of entanglement in these protocols.
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Lecture Content:

- Mathematical background: Hermitian, unitary matrices, spectral decomposition.
- Postulates of quantum mechanics in finite dimensions: measurement, observables, quantum states
- Basics of functions on bits and classical circuits and gates
- The quantum model of computation
- Quantum algorithms:
- Deutsch's algorithm
- Bernstein-Vazirani algorithm (time-permitting)
- Simon's problem (time-permitting)
- Shor's algorithm
- The quantum Fourier transform
- Grover's algorithm
- Classical error correction
- Correcting bit flip errors
- Correcting phase flip errors
- Shor's code
- Seven qubit Code
- Five qubit code
- The threshold theorem
- Quantum cryptography:
- BB84
- Dense coding
- Quantum teleportation
- Gate teleportation

Labs:
N/A

Seminars:
N/A

Course Assignments and Tests:
Five quizzes, one for each major unit. Each quiz is 10% of the total mark, for 50% total
Final examination date and time:
Dec 12, 7:00-9:00pm
Final exam weighting:
50%

Course Resources

Required Texts:

Recommended Texts:
David Mermin, Quantum Computer Science
Lab Manual:

Course Policies

Grading Policies
Quizzes are for full class-time, and are handed in at the end of class directly, and will be returned directly.

Course Policy on Group Work:
All quizzes are entirely individual.

Course Policy regarding use of electronic devices and recording of lectures:
Electronic recording of classes is expressly forbidden without consent of the instructor. When recordings are permitted they are solely for the use of the authorized student and may not be reproduced, or transmitted to others, without the express written consent of the instructor.

University Policies

Academic Consideration

When you find yourself unable to meet an in-course requirement because of illness or compassionate reasons, please advise the course instructor in writing, with your name, id#, and e-mail contact. See the academic calendar for information on regulations and procedures for

Academic Consideration:
http://www.uoguelph.ca/registrar/calendars/undergraduate/current/c08/c08-ac.shtml

Academic Misconduct

The University of Guelph is committed to upholding the highest standards of academic integrity and it is the responsibility of all members of the University community, faculty, staff, and students to be aware of what constitutes academic misconduct and to do as much as possible to prevent academic offences from occurring.

University of Guelph students have the responsibility of abiding by the University's policy on academic misconduct regardless of their location of study; faculty, staff and students have the responsibility of supporting an environment that discourages misconduct. Students need to remain aware that instructors have access to and the right to use electronic and other means of detection. Please note: Whether or not a student intended to commit academic misconduct is not relevant for a finding of guilt. Hurried or careless submission of assignments does not excuse students from responsibility for verifying the academic integrity of their work before submitting it. Students who are in any doubt as to whether an action on their part could be construed as an academic offence should consult with a faculty member or faculty advisor.

The Academic Misconduct Policy is detailed in the Undergraduate Calendar:
http://www.uoguelph.ca/registrar/calendars/undergraduate/current/c08/c08-amisconduct.shtml

Accessibility

The University of Guelph is committed to creating a barrier-free environment. Providing services for students is a shared responsibility among students, faculty and administrators. This relationship is based on respect of individual rights, the dignity of the individual and the University community's shared commitment to an open and supportive learning environment. Students requiring service or accommodation, whether due to an identified, ongoing disability or a short-term disability should contact the Centre for Students with Disabilities as soon as possible.

For more information, contact CSD at 519-824-4120 ext. 56208 or email csd@uoguelph.ca or see the website: http://www.uoguelph.ca/csd/

Drop date

The last date to drop one-semester courses, without academic penalty, is ***Friday*, Nov 4, 2016**. For regulations and procedures for Dropping Courses, see the Academic Calendar:
http://www.uoguelph.ca/registrar/calendars/undergraduate/current/c08/c08-drop.shtml