

CO 481/CS 467/PHYS 467, Winter 2025

Introduction to Quantum Information Processing

Lectures:

(Consult the outline file on LEARN)

Instructor:

Debbie Leung

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Office hours: See course website

Teaching assistants:

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Calvin Yinchen Liu

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IQC support Course Assistant:

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Course websites:

1. <https://learn.uwaterloo.ca/d21/home/1098313>
2. <https://www.math.uwaterloo.ca/~wcleung/intro-qinfo-w25.html>
3. <https://piazza.com/class/m51ycaqod8162>

Textbooks: None required. See website 2 for supplementary textbook suggestions.

Evaluation (no curving or redistribution):

5 assignments (10% each)

1 quiz (18%)

1 final exam (32%)

Assignments will be made available on course website 2, due on Crowdmark by 8:30am on January 27, February 10, March 03, March 17, and March 31. Before 9am, 2% will be deducted per minute late.

Assignments later than 9am will not be graded nor credited. (The due dates have been shifted from Friday 4:30pm to Monday 8:30am as an extension. Start early and turn in what you can complete.)

You are encouraged to discuss homework problems with your peers, with the TAs, and with the course instructor. However, your solutions should be based on your own understanding and written independently in your own words. **Please acknowledge all sources of help on your assignments with precise names – failing to do so constitutes an academic offense.**

The quiz will be held **in-class on February 13**. Quiz score at least 35% is required to pass the course, at least 50% is required to obtain an INC for the final exam.

The final exam will be scheduled by the Registrar's Office.

Overview and objective:

Quantum information processing seeks to exploit quantum mechanical principles to provide a qualitatively different and more powerful way of processing information than is allowed by classical physics. This course provides a basic foundation in the field of quantum information processing. As this is a multidisciplinary subject, the course will cover basic concepts in theoretical computer science, information theory, and quantum mechanics, in addition to introducing core quantum information topics. This introduction will enable students to pursue further study in various aspects of quantum information processing.

Course description:

- Quantum information as pure states, quantum gates, quantum circuits and universality.
- Information theoretic consequences of quantum mechanics: entanglement, nonlocality, superdense coding and teleportation.
- Computational advantages of quantum mechanics: quantum algorithms for factoring and search.
- Quantum noise processes, mixed state quantum information, quantum error correction, fault-tolerance.
- Cryptographic consequences of quantum mechanics: for example, quantum secret sharing, quantum key distribution, quantum authentication, quantum authentication and key recycling.

Prerequisites:

PMATH343 will be useful but not required. Proficiency in linear algebra, proofs, probability, basic understanding of matrix analysis, enumeration and optimization, and **an open mind** are required. We accept students who aspire to learn some of these background during the course.

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. The Office of Academic Integrity at the University of Waterloo maintains a website with a number of items of interest to students. In particular the pages on Academic Integrity for students (<https://uwaterloo.ca/academic-integrity/integrity-students>) provide various examples as well as a tutorial on the subject. For information on categories of offenses and types of penalties, students should refer to Policy #71, Student Discipline (<http://www.adm.uwaterloo.ca/infosec/Policies/policy71.htm>). Students who believe that they have been wrongfully or unjustly penalized have the right to grieve; refer to Policy #70, Student Petitions and Grievances (<http://www.adm.uwaterloo.ca/infosec/Policies/policy70.htm>), as well as Policy #72, Student Appeals (<http://www.secretariat.uwaterloo.ca/Policies/policy72.htm>).

Accommodation of disabilities:

AccessAbility Services, located in 1401 Needles Hall, 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 AccessAbility Services at the beginning of each academic term.