Fall 2022 CS 410/510

Intro to Quantum Computing

Instructor:	Fang Song
Course Meeting Schedule:	T/R 10:00 – 11:50 @ EB 92
Email:	fsong@pdx.edu Start email subject line with "f22-4510-qc"
Course webpage:	https://fangsong.info/teaching/f22_4510_qc/
Google Classroom Code:	fxt4khl
Office hours:	TBD

Course Description

The law of quantum physics enables quantum computing, a new paradigm of computation. It enables solving some problems that are intractable on classical computers. In this course, we will study the basic principles and techniques of quantum computing, and discuss some exciting applications. Aside from the technical contents, an important goal of this course is to make you a more critical reader so you will have a better idea when flooded with news articles on quantum computing. For the theory-savvy students, this course would also prepare you for future exploration in this emerging field.

Course Objectives

Upon the successful completion of this class, students will be able to:

1. improve mathematical thinking skill and habits, including thinking precisely about definitions, stating assumptions carefully, critically reading arguments, and being able to write convincingly.
2. understand the basic formalism of quantum information, including qubits, unitary operations, and measurements.
3. describe and analyze key quantum algorithms including phase estimation, the quantum factoring algorithm and Grover's quantum search algorithm.
4. understand the density-matrix formalism of quantum information and the principles of quantum error correction.
5. implement and analyze quantum algorithms and protocols in a quantum programming environment.
6. apply the knowledge to assess and critique misinformation on quantum computing.

Course Prerequisites

Maturity in algorithm analysis and mathematics (especially linear algebra, basic probability theory and group theory). Quantum mechanics is NOT required. This course will be theory-oriented, and it involves reading both technical and non-technical articles, and writing mathematical proofs. Some coding proficiency is required (preferably in Python).

Recommended Readings

- [**IBMQ**] *Learn Quantum Computation using Qiskit*.
- [**W**] John Watrous, *Quantum Computation lecture notes*.
- [**KLM**] Phillip Kaye, Raymond Laflamme, Michele Mosca, *An Introduction to Quantum Computing*, Oxford University Press (2007).

Grading Policy
- Homework: 40%. Biweekly.
- Quizzes: 15%. Biweekly.
- Project: 40%.
- Participation: 5%.

Homework Policy
- You have a quota of 5 days in total for late submissions of homework or quizzes without penalty. You can use them at your will. Once the quota runs out, no late submissions will be accepted.
- Quizzes must be completed on your own. Collaboration on homework problems is highly encouraged, but you must write up solutions entirely on your own and clearly list who you discussed with for each problem. You may NOT use solutions found online.
- All assignments (unless otherwise specified) must be submitted in PDF format. It is recommended to type-set your solutions using LaTeX, and you will get extra credit doing so.
- "I'll take 15%" option on homework problems. Your solutions should be as clear and concise as possible. Partial credit will only be given for answers that make significant progress towards correct solutions. If you realize you cannot solve a problem, you may write "I'll take 15%" instead of your answer, so you get 15% for this problem (or part of the problem). But if you do write an answer, you will get 0 if your solution is completely wrong. "I'll take 15%" option does not apply to problems of bonus credits.
- For each assignment, a random subset of problems will be graded.

Course Topics and Tentative Schedule
Check course webpage for details and updates

Week	Topic	Suggested Reading
1 - 2	Intro, qubit, quantum circuit model.	W 1 - 3
3 – 6	Quantum algorithms: Deutsch-Josza, Simon's algorithm, quantum Fourier transform, phase estimation, factoring, Grover's search algorithm.	W 4 -13
7 – 8	Quantum information theory: entanglement, density matrix formalism.	W 14 - 16
9 - 10	Selected topics and project presentation.	

PSU Policies & Resources

Academic Integrity
Academic integrity is a vital part of the educational experience at PSU. Please see the PSU Student Code of Conduct for the university's policy on academic dishonesty. A confirmed violation of that Code in this course may result in failure of the course.

Student Services

Disability Access Statement

If you have, or think you may have, a disability that may affect your work in this class and feel you need accommodations, contact the Disability Resource Center to schedule an appointment and initiate a conversation about reasonable accommodations. The DRC is located in 116 Smith Memorial Student Union, 503-725-4150, drc@pdx.edu, https://www.pdx.edu/disability-resource-center/

Safe Campus Statement

Portland State University desires to create a safe campus for our students. As part of that mission, PSU requires all students to take the learning module entitled Creating a Safe Campus: Preventing Gender Discrimination, Sexual Harassment, Sexual Misconduct and Sexual Assault. If you or someone you know has been harassed or assaulted, you can find the appropriate resources on PSU's Enrollment Management & Student Affairs: Sexual Prevention & Response website at http://www.pdx.edu/sexual-assault

Title IX Reporting

As an instructor, one of my responsibilities is to help create a safe learning environment for my students and for the campus as a whole. Please be aware that as a faculty member, I have the responsibility to report any instances of sexual harassment, sexual violence and/or other forms of prohibited discrimination. If you would rather share information about sexual harassment, sexual violence or discrimination to a confidential employee who does not have this reporting responsibility, you can find a list of those individuals on PSU's Enrollment Management & Student Affairs: Sexual Prevention & Response website at http://www.pdx.edu/sexual-assault.

Cultural Resource Centers

The Cultural Resource Centers (CRCs) create a student-centered inclusive environment that enriches the university experience. We honor diversity, explore social justice issues, celebrate cultural traditions, and foster student identities, success, and leadership. Our centers include the Multicultural Student Center, La Casa Latina Student Center, Native American Student & Community Center, Pan African Commons, Pacific Islander, Asian, Asian American Student Center and the Middle Eastern, North African, South Asian program. We provide student leadership, employment, and volunteer opportunities; student resources such as computer labs, event, lounge and study spaces; and extensive programming. All are welcome!

Classroom Requirements for All Students and Faculty Due to Covid-19

The University has established rules and policies to make the return to the classroom as safe as possible. It is required for everyone to follow all the Return to Campus rules and policies. To participate in this class, PSU requires students to comply with the following.

Vaccination

- Be vaccinated against COVID-19 and complete the COVID-19 vaccination attestation form. Those students with medical or nonmedical exemptions or who will not be on campus at all must complete the process described on "COVID-19 Vaccine Exemption Request Form" to establish those exemptions.

Health Check, Illness, Exposure or Positive Test for COVID-19

- If you are feeling sick or have been exposed to COVID-19, do not come to campus. Call SHAC to discuss your symptoms and situation (503.725.2800). They will advise you on testing, quarantine, and when you can return to campus.
- If you test positive for COVID-19, report your result to SHAC and do not come to campus. SHAC will advise you on quarantine, notification of close contacts and when you can return to campus.
- Please notify me, (i.e. your instructor), should you need to miss a class period for any of these reasons so that we can discuss strategies to support your learning during this time.
- If I become ill or need to quarantine during the term, either I or the department chair will notify you via PSU email about my absence and how course instruction will continue.

Guidance May Change

Please note that the University rules, policies, and guidance may change at any time at the direction of the CDC, State, or County requirements. Please review the University's main COVID-19 Response webpage and look for emails from the University on these topics.