Introduction to Quantum Algorithms and Software - Syllabus

A. Course Information

a. Course prefix and number: EE P 539
b. Course title: Introduction to Quantum Algorithms and Software
c. Credits: 4
d. Quarter: Winter 2026
e. Meeting time: Wednesday 6:30 pm - 9:50 pm
f. Meeting location: ECE 003 (Rushmer room)
g. Instructor information
    i. Full name: Mariia Mykhailova
    ii. Email address: mamykhai@uw.edu
    iii. Office hours and location: Monday 6-7 pm, online
h. Teaching assistant information
    i. Full name: Sean Robert Garner
    ii. Email address: seangarn@uw.edu
    iii. Office hours and location: Thursday 4-5 pm, ECE 137 (feel free to email Sean for synchronous Zoom)

B. Course Content

Course description:
Quantum computing harnesses the quantum-mechanical laws of nature to enable new types of algorithms, impossible on traditional computers. Quantum computing nowadays can be compared to classical computing in the first half of the 20th century: the visionaries have created the concept and theories on what kind of tasks the new paradigm can be useful for, and the companies like Microsoft, IBM, and Google started the efforts to bring this vision to life. This means that our understanding of quantum computers, the challenges in their development and the problems they can solve is still in its infancy – but this also means that this new technology can have a huge impact on everybody's lives in the future. It is a perfect time to learn it and be a part of the quantum revolution!

In this course, we will cover the fundamental concepts of quantum computing and learn to implement several of the most famous quantum algorithms, including Grover's search algorithm and Shor's algorithm for integer factorization. We will also review more advanced applications of quantum computing and the challenges of building a full-stack fault-tolerant quantum computer. We will review and compare quantum software development toolkits designed for noisy intermediate-scale quantum device programming and programming for fault-tolerant quantum computers.

Learning objectives: By the end of this course, students should be able to:

1. Describe the necessary components of a full-stack fault-tolerant quantum computer
2. Explain the fundamental concepts of quantum computing
3. Recognize the types of problems that may and may not be a good candidate for quantum computing applications and explain the reasons
4. Summarize several well-known quantum computing algorithms and applications
5. Come up with an algorithm to solve a simple well-defined quantum problem

6. Implement a simple quantum algorithm using Qiskit and Workbench programming toolkits
7. Debug the implementation of a simple algorithm, verify its correctness and evaluate its efficiency using the appropriate tools in Qiskit and Workbench programming toolkits
8. Read and understand resources on quantum computing (papers or books) for further studies

Course materials:
This course assumes no prior experience in quantum computing or quantum physics. The course relies on complex numbers and the basics of linear algebra (vectors and matrices, matrix operations, tensor product of matrices, eigenvectors and eigenvalues). Familiarity with Python and classical programming is required.

Software:
Homework assignments and final projects will require two Python quantum software packages:

- Qiskit, with qiskit-aer (https://github.com/Qiskit/)
- Workbench (access provided via Construct platform, https://www.psiquantum.com/software)

Additional quantum software packages might be demoed during the lectures without corresponding assignments, or used in final projects.

Learning materials:
Lecture recordings will be posted after the lectures, technology permitting.
M. Mykhailova, Quantum Programming in Depth: Solving problems with Q# and Qiskit, Manning, 2025, 978-1633436909 - available via O'Reilly Library with UW account
Additional materials: check out Canvas site

C. Grading

Assignment weight/point distribution:

a. 7 weekly programming assignments, 10 points each
b. Final project, 30 points
c. Extra credit (additional tasks in programming assignments 6 and 7, extending final project), 10 points max

Grading is done based on percentages: 100 points = 100% = 4.0 grade.
Grades are rounded to the nearest decimal:
100+ points → 4.0 grade
99 points = 0.99 * 4.0 = 3.96 → 4.0 grade
98 points = 0.98 * 4.0 = 3.92 → 3.9 grade and so on

67 points = 0.67 * 4.0 = 2.68 → 2.7 grade - the "minimum grade required for the course to apply towards degree requirements" per PMP Grading Resources
17 points = 0.17 * 4.0 = 0.68 → 0.7 grade - the "lowest passing grade" per Standard Grading System

Weekly programming assignments will follow the topics covered in each week's lecture. They will involve solving simple quantum programming problems similar to the ones offered in the course materials, debugging and optimizing quantum programs, and other types of quantum programming tasks. Each assignment will consist of one or several problems of different point values, and each problem will

be graded pass/fail. Programming assignments that use automated grading will include the grading harness you can use to validate your work before submitting it. Some programming assignments will use semi-automated grading, listing limitations on programming constructs your solution can use that will not be validated by the testing harness. Several programming assignments will include extra credit tasks - challenging programming tasks that might require additional experimentation and insight into the topic.

The final project will require choosing a search problem not covered in class and supplemental materials and implementing and evaluating it using Qiskit, Workbench, and/or other quantum software toolkits. The projects will be graded on their technical implementation and class presentation. Extra credit will be given for including additional quantum software development toolkits in the final project.

All work on weekly programming assignments should be done individually. Final projects will be done in small teams.

D. Course Schedule: Topical Outline

Week	Date	Lecture topic	Assignment due
1	Jan 7	Course overview. Single-qubit quantum systems: the qubit, superposition, single-qubit quantum gates, Dirac notation, measurement, random number generation. Qiskit; quantum simulators	Jan 21
2	Jan 14	Multi-qubit quantum systems: entanglement, multi-qubit quantum gates, circuit notation, quantum computing notations comparison, measurement of multi-qubit systems. Qiskit; testing and debugging quantum programs	Jan 28
3	Jan 21	Quantum communication algorithms: no-cloning and no-deletion theorems, quantum key distribution, teleportation, superdense coding. Qiskit	Feb 4
4	Jan 28	Oracular algorithms: phase oracles, Deutsch algorithm, Deutsch-Josza algorithm, Bernstein-Vazirani algorithm. Qiskit	Feb 11
5	Feb 4	Reversible computing: reversible Boolean logic, reversible circuit synthesis, marking oracles, example (implementing quantum oracle for SAT problems). Workbench; quantum memory management, uncomputation	Feb 18
6	Feb 11	Grover's search algorithm. Workbench; resource estimation, circuit optimization	Feb 25
7	Feb 18	Toolbox: Quantum Fourier transform, quantum phase estimation, quantum counting.	Mar 4

		Workbench	
8	Feb 25	Applications: Shor's algorithm for integer factorization, quantum chemistry	N/A
9	Mar 4	Applications: Hybrid quantum algorithms. Variational quantum algorithms. Quantum approximate optimization algorithm (QAOA). Quantum machine learning.	N/A
10	Mar 11	Quantum error correction and fault-tolerant quantum computing.	N/A
11	Mar 18	No lecture. Final project presentations.	N/A

E. Course Policies

Religious Accommodations:

Washington state law requires that UW develop a policy for accommodation of student absences or significant hardship due to reasons of faith or conscience, or for organized religious activities. The UW's policy, including more information about how to request an accommodation, is available at Religious Accommodations Policy (https://registrar.washington.edu/staffandfaculty/religious-accommodations-policy/). Accommodations must be requested within the first two weeks of this course using the Religious Accommodations Request form (https://registrar.washington.edu/students/religious-accommodations-request/).

Statements required for Kuali submission, with language provided by CEP:

Accommodations & Access:

If you have already established accommodations with Disability Resources for Students (DRS), please communicate your approved accommodations to me at your earliest convenience so we can discuss your needs in this course. If you have not yet established services through DRS, but have a temporary health condition or permanent disability that requires accommodations (conditions include but not limited to; mental health, attention-related, learning, vision, hearing, physical or health impacts), you are welcome to contact DRS at 206-543-8924 or uwdrs@uw.edu or disability.uw.edu. DRS offers resources and coordinates reasonable accommodations for students with disabilities and/or temporary health conditions. Reasonable accommodations are established through an interactive process between the student, instructor, and DRS. It is the policy and practice of the University of Washington to create inclusive and accessible learning environments consistent with federal and state law.

Academic Integrity:

Students should not collaborate on any programming assignments or final projects.
Engineering is a profession demanding a high level of personal honesty, integrity and responsibility. Therefore, it is essential that engineering students, in fulfillment of their academic requirements and in

preparation to enter the engineering profession, adhere to the College of Engineering Statement of Principles. Any student in this course suspected of academic misconduct (e.g., cheating, plagiarism, or falsification) will be reported to the College of Engineering Dean's Office and the University's Office of Community Standards and Student Conduct to initiate the student conduct process. For any assignment, quiz, or exam that is suspected of academic misconduct, you will be given an "X" grade until after Prof. Mykhailova has received notification by the Dean's office that the conduct process is complete. If a student is found responsible for academic misconduct, the student will receive a grade of zero on the assignment, quiz, or exam. If a student is found not responsible, the student will receive a grade based on the standard grading criteria for that assignment, quiz, or exam.

Title IX:

The UW, through numerous policies, prohibits sex- and gender-based violence, harassment, and discrimination and expects students, faculty, and staff to act professionally and respectfully in all work, learning, and research environments.

For support, resources, and reporting options related to sex- and gender-based violence, harassment, or discrimination, refer to the UW Title IX's website, specifically the *Know Your Rights & Resources* guide. Should you wish to make the Office of the Office of the Title IX Coordinator aware of a Title IX concern, visit the Make a Title IX Report webpage.

Please know that if you choose to disclose information to me about sex- or gender-based violence, harassment, or discrimination, I will connect you (or the person who experienced the conduct) with resources and individuals who can best provide support and options. You can also access additional resources directly:

- You can request anonymous support, from SafeCampus
- You can request confidential support, from a confidential advocate.
- If you know you want to submit a formal complaint, contact the Civil Rights Investigation Office.

Please note that some senior leaders and other specified employees have been identified as *Officials Required to Report.* If an Official Required to Report learns of possible sex- or gender-based violence, harassment, or discrimination they are required to contact the Office of the Title IX Coordinator and report all the details they have in order to ensure that the person who experienced harm is offered support and reporting options.

Relevant Websites

- Title IX: uw.edu/titleix/
- Survivor resources: uw.edu/titleix/survivor-resources/
- Confidential advocates: uw.edu/sexualassault/support/advocacy/
- SafeCampus: uw.edu/safecampus/
- Officials Required to Report: uw.edu/titleix/employee-reporting-expectations/
- Policies: uw.edu/titleix/policies/

Privacy:

It is possible that some aspects of the course will take place over zoom (e.g. office hours). While students are encouraged to turn on their cameras if they are able, there is no requirement or penalty for keeping

your camera off. For any session that is recorded on Zoom, the recording will capture the presenter's audio, video and computer screen. The recordings will only be accessible to students enrolled in the course to review materials. These recordings will not be shared with or accessible to the public. The University and Zoom have FERPA-compliant agreements in place to protect the security and privacy of UW Zoom accounts. Students who **do not** wish to be recorded should:

- Choose a Zoom username that does not include any personal identifying information like their name or UW Net ID; and
- Not share their computer audio or video during their Zoom sessions.

ADDITIONAL RESOURCES FOR INSTRUCTORS:

Center for Teaching and Learning's syllabus guidance:
https://teaching.washington.edu/topics/preparing-to-teach/designing-your-course-and-syllabus/

Center for Teaching and Learning's Grading Resources:
https://teaching.washington.edu/topics/preparing-to-teach/grading-2/

Resource for articulating learning objectives:
Teaching and Learning STEM: A Practical Guide (Felder & Brent, 2016), Section 2.1

Office of the University Registrar Syllabus Guidelines and Resources, Grading Resources:
https://registrar.washington.edu/staffandfaculty/syllabus-guidelines/
https://registrar.washington.edu/staffandfaculty/grading-resources/

Faculty Council on Academic Standards Syllabus Guidelines:
https://s3-us-west-2.amazonaws.com/uw-s3-cdn/wp-content/uploads/sites/71/2014/05/31162808/FCAS-Syllabus-Guidelines-November-15-final.pdf

Engineering-specific, individual consultation on any teaching/learning matter:
ET&L, Office for the Advancement of Engineering Teaching & Learning

ENGR 101 Syllabus

College of Engineering, Faculty Guidance for Promoting Academic Integrity:
https://www.engr.washington.edu/mycoe/academic/integrity

College of Engineering, Academic integrity and misconduct:
https://www.engr.washington.edu/current/policies/academic-integrity-misconduct

Language updates for DRS accommodation statements:
https://depts.washington.edu/uwdrs/faculty/syllabus-statement/

Title IX policies:
https://www.washington.edu/titleix/policies/