CSE 598 Quantum Computation

Fall 2024

Class time: Tuesdays and Thursdays 3pm–4:15pm

Classroom: Tempe - WXLR A113

1. **Contact information**

   Instructor: Prof. Zilin Jiang

   Email: zilinj@asu.edu

   Please reserve email only for individual and non-technical matters. Use office hours for technical questions related to lectures and assignments.

2. **Office hours**

   Tuesdays and Thursdays 1:30pm–2:30pm at WXLR A839

3. **Course description**

   An introduction to quantum computation from the perspective of theoretical computer science. Topics include quantum algorithms, quantum error correction, and quantum information. We anticipate the course will be of interest to students working in computer science, mathematics, or physics.

4. **Enrollment requirements**

   Computer Engineering, Computer Science or Industrial Engineering graduate students can enroll by default. Other students need override approval.

   Prerequisites: A strong undergraduate background in linear algebra, discrete probability, and theory of computation. No background in physics is required.

5. **Course objectives**

   - Work with the quantum state of single and multi-qubit systems.
   - Appreciate the novelty of concepts such as reversibility and measurement.
   - Understand the circuit model with single and multi-qubit gates.
   - Analyze a given quantum algorithm and predict its output.
   - Recognize the implication of quantum computing on cryptography.

6. **Expected learning outcomes**

   Upon completion of this course, students will be able to

   - Discern potential performance gains of quantum vs. classical algorithms.
   - Understand the mathematical description of quantum states and basic quantum operations.
   - Design a quantum circuit using single and multi-qubit gates or determine the function of a given circuit.
   - Analyze a given search or phase estimation quantum algorithm.
   - Build a secure channel using quantum cryptography.

7. **Grade policies**

a. A+ ≥ 97%; A ≥ 94%; A- ≥ 90%;
B+ ≥ 87%; B ≥ 84%; B- ≥ 80%;
C+ ≥ 76%; C ≥ 70%; D- ≥ 60%; E otherwise;

b. Homework 60% + Midterms 20% + Final exam 20%

8. Absence policies and the conditions under which assigned work and/or tests can be made up

a. In general, no late submission of assignments will be accepted unless there is a genuine emergency backed up by official documents (such as a physician's note attesting the same).

b. Excused absences for classes will be given without penalty to the grade in the case of (1) a university-sanctioned event ACD 304-02; (2) religious holidays ACD 304-04; a list of religious holidays can be found here https://eoss.asu.edu/cora/holidays; (3) work performed in the line-of-duty according SSM 201-18. Students who request an excused absences must follow the policy/ procedure guidelines. Excused absences do not relieve students of responsibility for any part of the course work required during the period of absence.

9. Faculty recording of class sessions

Class meetings will not be recorded.

10. Textbook, assignments, examinations, special materials and extracurricular activities

a. Primary reference: Mermin, N. David. *Quantum computer science: an introduction.* Cambridge University Press, 2007.

b. Assessment and Assignments:
There will be 6 assignments. Late submission of homework will not be accepted. No grade appeal will be considered after one week of the posting of the grade for any assignment.
Two midterms: September 24, 2024 and October 31, 2024. No make-up test will be given unless a student has notified the instructor before the test is given.
Final exam: December 10, 2024, 2:30-4:20 PM.

c. Course itinerary

Fundamental axioms of quantum mechanics (3 lectures)
Quantum Zeno and anti-Zeno, Elitzur–Vaidman bomb tester, entanglement, teleportation, no-cloning (4 lectures)
Bell's inequality and the CHSH game (1 lecture)
Quantum money, quantum key distribution (2 lectures)
The quantum circuit model of computation (1 lecture)
Quantum algorithms: the Deutsch–Josza algorithm, the Bernstein–Vazirani algorithm, Simon's problem (4 lectures)
Shor's factoring algorithm (1 lecture)
The hidden subgroup problem (1 lecture)
Grover's search algoritihm (1 lecture)
Lower bounds for quantum query algorithms (1 lecture)
Quantum complexity theory (3 lectures)
Quantum probability, mixed states, POVMs, quantum channels (3 lectures)
Quantum tomography: Learning, testing, and discriminating quantum states (1 lecture)
Elements of quantum information theory (2 lectures)
Quantum error correction (1 lecture)

11. Policy regarding expected classroom behavior

Students in this class are expected to acknowledge and embrace the FSE student professionalism expectation located at: https://engineering.asu.edu/professionalism/

12. Generative AI

Generative AI is a technology that can often be useful in helping students learn the theories and concepts in this course. However, unless explicitly allowed by your instructor, the use of generative AI tools to complete any portion of a course assignment or exam will be considered academic dishonesty and a violation of the ASU Academic Integrity Policy. Students confirmed to be engaging in non-allowable use of generative AI will be sanctioned according to the academic integrity policy and FSE sanctioning guidelines.

13. Academic integrity

All engineering students are expected to adhere to the ASU Student Honor Code and the ASU academic integrity policy, which can be found at https://provost.asu.edu/academic-integrity/policy. Students are responsible for reviewing this policy and understanding each of the areas in which academic dishonesty can occur. If you have taken this course before, you may not reuse or submit any part of your previous assignments without the express written permission from the instructor.

All student academic integrity violations are reported to the Fulton Schools of Engineering Academic Integrity Office (AIO). Withdrawing from this course will not absolve you of responsibility for an academic integrity violation and any sanctions that are applied. The AIO maintains a record of all violations and has access to academic integrity violations committed in all other ASU college/schools.

14. Student copyright responsibilities

All course content and materials, including lectures (Zoom recorded lectures included), are copyrighted materials and students may not share outside the class, upload to online websites not approved by the instructor, sell, or distribute course content or notes taken during the conduct of the course (see ACD 304-06, "Commercial Note Taking Services" and ABOR Policy 5-308 F.14 for more information).

You must refrain from uploading to any course shell, discussion board, or website used by the course instructor or other course forum, material that is not the student's original work, unless the students first comply with all applicable copyright laws; faculty members reserve the right to delete materials on the grounds of suspected copyright infringement.

15. Policy against threatening behavior, per the Student Services Manual, SSM 104-02

Students, faculty, staff, and other individuals do not have an unqualified right of access to university grounds, property, or services. Interfering with the peaceful conduct of university-related business or activities or remaining on campus grounds after a request to leave may be considered a crime. All incidents and allegations of violent or threatening conduct by an ASU student (whether on- or off-campus) must be reported to the ASU Police Department (ASU PD) and the Office of the Dean of Students.

16. Disability accommodations

Suitable accommodations are made for students having disabilities. Students needing accommodation must register with the ASU Student Accessibility and Inclusive Learning Services office and provide documentation of that registration to the instructor. Students should communicate the need for an accommodation in enough time for it to be properly arranged. See ACD 304-08 Classroom and Testing Accommodations for Students with Disabilities.

17. Harassment and sexual discrimination

Arizona State University is committed to providing an environment free of discrimination, harassment, or retaliation for the entire university community, including all students, faculty members, staff employees, and guests. ASU expressly prohibits discrimination, harassment, and retaliation by employees, students, contractors, or agents of the university based on any protected status: race, color, religion, sex, national origin, age, disability, veteran status, sexual orientation, gender identity, and genetic information.

Title IX is a federal law that provides that no person be excluded on the basis of sex from participation in, be denied benefits of, or be subjected to discrimination under any education program or activity. Both Title IX and university policy make clear that sexual violence and harassment based on sex is prohibited. An individual who believes they have been subjected to sexual violence or harassed on the basis of sex can seek support, including counseling and academic support, from the university. If you or someone you know has been harassed on the basis of sex or sexually assaulted, you can find information and resources at https://sexualviolenceprevention.asu.edu/faqs.

As a mandated reporter, I am obligated to report any information I become aware of regarding alleged acts of sexual discrimination, including sexual violence and dating violence. ASU Counseling Services, https://eoss.asu.edu/counseling is available if you wish to discuss any concerns confidentially and privately. ASU online students may access 360 Life Services, https://goto.asuonline.asu.edu/success/online-resources.html.

18. Photo requirement

Arizona State University requires each enrolled student and university employee to have on file with ASU a current photo that meets ASU's requirements (your "Photo"). ASU uses your Photo to identify you, as necessary, to provide you educational and related services as an enrolled student at ASU. If you do not have an acceptable Photo on file with ASU, or if you do not consent to the use of your photo, access to ASU resources, including access to course material or grades (online or in person) may be negatively affected, withheld or denied.

19. Syllabus changes

Any information in this syllabus (other than grading and absence policies) may be subject to change with reasonable advance notice.