Carnegie Mellon University

98-106 STUCO: Intuitive Quantum Computing

Meeting Days, Times, Location: Tue 7:00pm-7:50pm POS 145

Semester: Fall**, Year:** 2024

Units: 3**, Section(s):** 1

Instructor Information

Name	Jake Zaia
Contact Info	jzaia@andrew.cmu.edu
Office location	N/A
Office hours	After class or by appointment
Course website	https://intuitiveqcomp.jzaia.net

Course Description

This course will build knowledge and intuition on the emerging field of quantum computation.

Have you ever read a dubious news headline about quantum computers and thought “that can’t possibly be true”? Are you curious what the phrase “quantum teleportation” actually means? Did you know that Shor’s (RSA cracking) algorithm can be explained in plain English using clocks? In this class we’ll explore quantum computing topics by using visuals, analogies, lots of interaction and maybe even a little humor.

The goal is to build an intuitive understanding rather than depending on complex math that is often used for even the most basic quantum concepts. This course is ideal for those with a computer science background who are curious to learn about quantum computing fundamentals.

Familiarity with introductory computer science concepts (binary representation, boolean logic, etc.) is important for this course since it teaches through the lens of computer science. No prior quantum computing experience is expected. A basic familiarity with linear algebra is helpful but not required.

Learning Objectives

After taking this course, students should be able to:

- Comfortably understand and discuss quantum computing topics
- Identify low quality generalizations about quantum computing
- Explain with clarity the fundamentals of quantum computing
- Understand news about advancements in the field of quantum computing

This course should leave a student with a strong conceptual baseline if they choose to take mathematically rigorous quantum courses in the future (which I would wholeheartedly recommend).

Piazza

This term we will be using Piazza for class discussion. The system is highly catered to getting you help fast and efficiently from classmates, the TA, and myself. Rather than emailing questions to the teaching staff, I encourage you to post your questions on Piazza. If you have any problems or feedback for the developers, email team@piazza.com.

Find our class signup link at: https://piazza.com/cmu/fall2024/98106

Grading Policies

Students will be assigned the following final letter grades, based on calculations coming from the course assessment section.

Grade	Percentage Interval
P	60-100%
N	0-59%

Grade Distribution

The final course grade will be calculated using the following categories:

Assessment	Percentage of Final Grade
Attendance	40%
Required Readings	20%
Midterm Project	20%
Final Presentation	20%

Attendance: This course is about discussions, visualizations, and dynamic explanations, so attending lectures is the most important aspect of this class. Attendance will be tracked via a weekly quiz given during class (see the following section for more details). If for some reason this isn't possible (if you are ill, have a family emergency, etc.), please let me know and we will create a situationally-appropriate alternative for receiving attendance points for that class day. However, as per StuCo guidelines, **if you have more than 2 unexcused absences, you will automatically fail this course**. In other words, on your 3rd unexcused absence you will fail the course. This is StuCo policy and **I cannot make exceptions**.

Required Readings: There will be weekly required readings for this class that contain helpful background material relating to each lecture. You are expected to read the required material from the prior week before each class. You will be quizzed each week to assess credit for this aspect of your grade. The quiz is graded on correctness for reading credit and on completion for attendance credit. Each quiz should be short (usually 3-4 questions) and is weighted equally.

Midterm Project: There will be a midterm project worth 20% of your grade. It will involve programming an actual quantum algorithm in Qiskit. The project will be graded on correctness, with partial credit for mostly correct solutions. There is also a small written portion to this project, which is also graded on correctness. More information about this assignment will be given closer to the middle of the semester.

Final Presentation: The final will be a presentation by small groups of students. Each group will give a short presentation of content on any quantum computing topic they desire. It can be a new topic, or one that was already covered in class. If you choose to present an already-covered topic, you must present it in a novel way that adds something new. The presentation may be demonstrated live in front of the class, recorded as a video, or in the form of a short blog post that includes visuals of some form. Students will be graded on accuracy of content as well as delivery of content. Delivery will be graded on simplicity and clarity of explanation.

Late Work / Re-Grades

Late work will be accepted up until the end of the semester with a flat 25% penalty to the received score.

Please contact me if you believe I have made a mistake grading.

Electronics Policy

As lectures and discussions are the most important part of this course, I ask that you avoid using your phone or electronics during class. Staying engaged will help both your own learning, and your ability to help your classmates learn from you during discussion sessions.

I understand that sometimes emergencies arise, or occasionally you have something exceptionally important to do which requires use of a phone or laptop. In these cases please try to sit towards the back of the class to avoid distracting your classmates.

Academic Integrity & Collaboration

Adapted from the Eberly Center Recommended Policy:

Honesty and transparency are important features of good scholarship. On the flip side, plagiarism and cheating are serious academic offenses with serious consequences. If you are discovered engaging in either behavior in this course, you will earn a failing grade on the assignment in question, and further disciplinary action may be taken.

For a clear description of what counts as plagiarism, cheating, and/or the use of unauthorized sources and tools, please see the University's Policy on Academic Integrity (revised in April 2013): https://www.cmu.edu/policies/student-and-student-life/academic-integrity.html

I encourage you to work together on assignments and to make use of resources like Piazza to assist you in your pursuit of academic excellence. Please be cognizant that there is a difference between collaboration, where you work *together* with classmates, and copying. Additionally, please note that in accord with the university's policy you must acknowledge any collaboration or assistance that you receive on work that is to be graded, either from a person, reference, or a tool (including generative AI tools like ChatGPT). So, when you turn in assignments, please include a sentence at the end with acknowledgements if applicable.

Some examples:

- "I used _____ [tool] to complete _____ [specific aspect/section] of this assignment."
- "I worked with _____ [person or people] on this assignment."
- "I received assistance from _____ [person or tool] on this assignment."

If you have questions about my integration of the university's policy into this course, please do not hesitate to ask: my aim is to foster an environment where you can learn and grow, while ensuring that the work we all do is honest and fair. For more information about Carnegie Mellon's standards with respect to academic integrity, you can also check out the following link: http://www.cmu.edu/academic-integrity/

Accommodations for Students with Disabilities

If you have a disability and have an accommodations letter from the Disability Resources office, I encourage you to discuss your accommodations and needs with me as early in the semester as possible. I will work with you to ensure that accommodations are provided as appropriate. If you suspect that you may have a disability and would benefit from accommodations but are not yet registered with the Office of Disability Resources, I encourage you to contact them at access@andrew.cmu.edu.

Statement on Diversity, Equity, and Inclusion

We must treat every individual with respect. We are diverse in many ways, and this diversity is fundamental to building and maintaining an equitable and inclusive campus community. Diversity can refer to multiple ways that we identify ourselves, including but not limited to race, color, national origin, language, sex, disability, age, sexual orientation, gender identity, religion, creed, ancestry, belief, veteran status, or genetic information. Each of these diverse identities, along with many others not mentioned here, shape the perspectives our students, faculty, and staff bring to our campus. We, at CMU, will work to promote diversity, equity and inclusion not only because diversity fuels excellence and innovation, but because we want to pursue justice. We acknowledge our imperfections while we also fully commit to the work, inside and outside of our classrooms, of building and sustaining a campus community that increasingly embraces these core values.

Each of us is responsible for creating a safer, more inclusive environment.

Unfortunately, incidents of bias or discrimination do still occur, whether intentional or unintentional. Students are encouraged to share these experiences using the following resources:

- **Center for Student Diversity and Inclusion:** csdi@andrew.cmu.edu, (412) 268-2150
- **Report-It online anonymous reporting platform:** reportit.net username: tartans password: plaid
- **Ethics Reporting Hotline:** Students, faculty, and staff can anonymously file a report by calling 844-587-0793 or visiting cmu.ethicspoint.com

All reports will be documented and deliberated to determine if there should be any following actions. Regardless of incident type, the university will use all shared experiences to transform our campus climate to be more equitable and just.

Statement on Student Wellness

Take care of yourself. Do your best to maintain a healthy lifestyle this semester by eating well, exercising, avoiding drugs and alcohol, getting enough sleep and taking some time to relax. This will help you achieve your goals and cope with stress.

All of us benefit from support during times of struggle. There are many helpful resources available on campus and an important part of the college experience is learning how to ask for help. Asking for support sooner rather than later is almost always helpful.

If you or anyone you know experiences any academic stress, difficult life events, or feelings like anxiety or depression, we strongly encourage you to seek support. Counseling and Psychological Services (CaPS) is here to help: call 412-268-2922 and visit their website at http://www.cmu.edu/counseling/. Consider reaching out to a friend, faculty or family member you trust for help getting connected to the support that can help.

If you or someone you know is feeling suicidal or in danger of self-harm, call someone immediately, day or night:

CaPS: 412-268-2922
Re:solve Crisis Network: 888-796-8226

If the situation is life threatening, call the police
On campus: CMU Police: 412-268-2323
Off campus: 911

If you have questions about this or your coursework, please let me know. Thank you, and have a great semester.

Course Schedule

The following is a tentative course schedule with expected weekly topics. This schedule is prone to change slightly throughout the semester. The most up-to-date schedule including links to slides (where applicable) and assigned readings can be found at https://intuitiveqcomp.jzaia.net.

#	Class Meets	Theme/Topic
0	Aug 27	Misconceptions About Quantum Computing / History of the Field
1	Sept 3	Bits & Qubits I
2	Sept 10	Bits & Qubits II
3	Sept 17	Quantum Circuits
4	Sept 23	Deep Dive: Superposition, Entanglement, & Interference
5	Oct 1	Quantum Teleportation
6	Oct 8	Quantum Advantage: Deutch-Jozsa & Grover's Algorithm
7	Oct 15	No class
8	Oct 22	Quantum Cryptography I -- BB84
9	Oct 29	Programming Quantum Circuits (Qiskit)
10*	Nov 5	Workshop: BB84
11	Nov 12	Quantum Cryptography II -- Elitzur-Vaidman Bomb, Verifiable Deletion
12	Nov 19	Shor's Algorithm
13*	Nov 26	Special Topics (Undecided)
14	Dec 3	Final Presentations