EE5340: Introduction to Quantum Computing

and Physical Basics of Computing

Fall 2022

1 Course Overview

COORDINATES: M/W 4:00-5:15pm
Keller Hall 3-111
https://canvas.umn.edu/courses/333695

INSTRUCTOR:

Ulya Karpuzcu
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TEACHING ASSISTANT:

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SYNOPSIS: We are going to explore how physical principles/limits have been shaping paradigms of computing, with a primary focus on basic principles of quantum quantum computing. We will cover (i) how information is represented, (ii) processed, (iii) stored, and (iv) communicated.

PREREQUISITES: Basic linear algebra.

REFERENCE MATERIAL: Mainly lecture notes and supplementary reading material posted on course website. *Quantum Computation and Quantum Information, M. Nielsen and E. Chung, Cambridge University Press, January 2011* is recommended. *Feynman Lectures on Computation, R. P. Feynman, Westview, June 2000* represents another interesting read in this context.

GRADING:		
	Machine Problems	50%
	Assignments	50%

ASSIGNMENTS: There will be 4 assignments. Assignments may include thought-provoking open-ended challenge questions, paper summaries/reviews along with basic calculations.

MACHINE PROBLEMS (MPS): There will be 4 MPs. MPs will mostly act as an experimental testbed for what is being covered by assignments. We are going to use an open-source R library called QuantumOps.

MECHANICS:

- Academic integrity and scholastic dishonesty: According to the Office for Student Conduct and Academic Integrity (OSCAI), "Academic integrity is essential to a positive teaching and learning environment. All students enrolled in University courses are expected to complete coursework responsibilities with fairness and honesty. Failure to do so by seeking unfair advantage over others or misrepresenting someone else's work as your own, can result in disciplinary action. The University Student Conduct Code defines scholastic dishonesty as follows: Scholastic Dishonesty: submission of false records of academic achievement; cheating on assignments or examinations; plagiarizing; altering, forging, or misusing a University academic record; taking, acquiring, or using test materials without faculty permission; acting alone or in cooperation with another to falsify records or to obtain dishonestly grades, honors, awards, or professional endorsement." applies. Independent of the scope (be it a homework assignment, exam, ...), any conduct leads to F as the

immediate final grade.

- The students are expected to attend all class meetings. Office hours are not designated to serve as make-up lectures.
- **All assignments are due at the beginning of class, on the designated due date. Late assignments will receive a reduction of 20% for each day they are late, except for documented illnesses and family emergencies.**
- Any question or concern about grading must be communicated to the TA or the instructor within one week after the return of the exam or assignment concerned.
- The student can work in groups to discuss assignments and MPs, as long as the submission reflects each student's own work.
- **To obtain a passing grade, *all* assignments and MPs should be turned in.**
- Any non-submitted or non-graded item will be processed with a grade of 0.
- A healthy learning environment demands diversity in perspectives. Please contact me (anonymously, if preferred) in case you catch escaped manifestations of implicit or explicit biases in any form.

MODALITY: This course is scheduled as an in-person course. I intend to hold all class sessions in-person except if situational factors arise, such as personal illness of the instructor, when the class may be held synchronously via Zoom or recorded for later viewing.

UNITE POLICY: Streaming video archives of class meetings are available to students registered in the on-campus section of this course on a TEN-DAY delay for the length of the semester. UNITE will not make media available to students enrolled in on-campus sections for any reason past the final exam, including when assigned an Incomplete by the instructor. See UNITE's Policy for On-Campus students (link below) for details of access for on-campus students.

This ten-day delay is lifted one week prior to scheduled exams and one week prior to finals as long as students are also enrolled in the course through UNITE Distributed Learning. If there are no UNITE enrollments, the ten-day delay may only be lifted the week prior to finals week.

Access these videos through the UNITE Media Portal with your University of Minnesota Internet I.D. and password (this is what you use to access your University of Minnesota email account).

UNITE partners with the DRC in implementing accommodations approved by University of Minnesota's Disability Resource Center (DRC) consultants. Students working with the DRC may have their DRC consultant contact UNITE directly.

DO NOT ask the instructor or teaching assistants any questions related to the UNITE Media (such as access, technical or troubleshooting assistance). Instead, use the UNITE Troubleshooting FAQ or "Submit a Trouble Report to UNITE" link found on all pages within the UNITE Media Portal or send an email message to UNITE.

- **UNITE's Policy for On-Campus Students:** `https://cse.umn.edu/unite/unite-streaming-video-access-campus-students`
- **Technical FAQ:** `https://cse.umn.edu/unite/troubleshoot-unite-media`
- **UNITE Media Portal:** `https://media.unite.umn.edu/secure/`

COVID-19 POLICY: You should stay at home if you experience any signs of illness or have a positive COVID-19 test (`https://safe-campus.umn.edu/return-campus/mtest`) result. If this occurs, please consult with your healthcare provider about an appropriate course of action. I will follow these same protocols and will let you know if the delivery of this course has to be temporarily changed as the result of my own circumstances. Absences related to illness, including COVID-19 symptoms, for yourself or your dependents, are *legitimate excused absences*: `https://policy.umn.edu/education/makeupwork`.

Vaccines: COVID-19 Vaccinations (or approved exemptions) are required for all students and employees. Learn about vaccine and booster appointments on campus by visiting the FAQ on Get the Vax page: `https://safe-campus.umn.edu/return-campus/get-the-vax`

Face coverings: Up-to-date policy information is available on the Safe Campus page (`https://safe-campus.umn.edu/return-campus/covid-19-prevention-and-wellbeing`). The University expects all community members to respect those who choose to wear a mask, as well as those who choose not to wear one. I do intend to wear a mask in class myself, and I fully support your individual choices around masking.

Indoor masking continues to be an important tool in high risk situations. High-quality masks (N-95 or certified KN-95) will be available t students Fall 2022. Check the Safe Campus website (`https://safe-campus.umn.edu/return-campus/covid-19-prevention-and-wellbeing`) for information on the location(s) for each campus.

Testing: Information on When, Where, and What if for testing is available on MTest webpage : `https://safe-campus.umn.edu/return-campus/mtest`.

The above policies and guidelines are subject to change. The University regularly updates pandemic guidelines (`https://safe-campus.umn.edu/return-campus/covid-19-updates`) in response to guidance from health professionals and in relation to the prevalence of the virus and its variants in our community.

2 (TENTATIVE) SYLLABUS

Week	Mon	Wed
1	*Labor Day*	Introduction
2	Introduction	Quantum Computing Basics
3	Quantum Computing Basics	Universal Quantum Gates
4	Universal Quantum Gates	Universal Quantum Gates
5	Postulates of Quantum Mechanics	Postulates of Quantum Mechanics
6	Postulates of Quantum Mechanics	Postulates of Quantum Mechanics
7	Entanglement	Entanglement
8	Teleportation	Teleportation
9	Quantum Parallelism/Deutsch's Algorithm	Deutsch/Jozsa Algorithm
10	Schor's Algorithm	Grover's Algorithm
11	Quantum Error Correction	Quantum Error Correction
12	Quantum Error Correction	Quantum Error Correction
13	Metrics/Benchmarking	Metrics/Benchmarking
14	Contemporary Examples	Contemporary Examples
15	Contemporary Examples	Contemporary Examples