Introduction to Quantum Computing

Lecturer: Xiaodi Wu

Reading Assignment: Course Website; KLM Chap 1 and 2.

Welcome to CMSC/PHYS 457
Introduction to Quantum Computing

Welcome to CMSC/PHYS 457
Introduction to Quantum Computing

&

Happy New Year!

Teaching Team

Instructor

- Instructor: Prof. Xiaodi Wu
- Contact: xwu@cs.umd.edu
- Research: Quantum Information and Computation
- Joint Center for Quantum Information and Computer Science (QuICS)

Teaching Team

Instructor

- Instructor: Prof. Xiaodi Wu
- Contact: xwu@cs.umd.edu
- Research: Quantum Information and Computation
- Joint Center for Quantum Information and Computer Science (QuICS)

TA

- Jessica Thompson, jktho@cs.umd.edu

Why Quantum Computing? or Why are you here?

- One sentence about who you are (e.g., name, major, graduate/undergraduate).
- One sentence about why you are here. Breakout room.

Why Quantum Computing? or Why are you here?

- One sentence about who you are (e.g., name, major, graduate/undergraduate).
- One sentence about why you are here. Breakout room.
- Please feel free to share your interests or so at piazza.
- Also finish assignment 0 so that we can understand your need better.

Quantum Computing

Tentative topics

- quantum mechanics of qubits; quantum circuits; quantum protocols;

Quantum Computing

Tentative topics

- quantum mechanics of qubits; quantum circuits; quantum protocols;
- quantum algorithms; Shor's algorithm; Grover's algorithm;

Quantum Computing

Tentative topics

- quantum mechanics of qubits; quantum circuits; quantum protocols;
- quantum algorithms; Shor's algorithm; Grover's algorithm;
- quantum error correction;

Quantum Computing

Tentative topics

- quantum mechanics of qubits; quantum circuits; quantum protocols;
- quantum algorithms; Shor's algorithm; Grover's algorithm;
- quantum error correction;
- coding experience of quantum clouds;

Quantum Computing

Tentative topics

- quantum mechanics of qubits; quantum circuits; quantum protocols;
- quantum algorithms; Shor's algorithm; Grover's algorithm;
- quantum error correction;
- coding experience of quantum clouds;
- selective quantum research frontiers: **variational quantum methods; formal verification of quantum programs;**.

CMSC/PHYS 457: Teaching Philosophy

- (1) understand and comprehend the theoretical foundation of quantum information and computation.

CMSC/PHYS 457: Teaching Philosophy

- (1) understand and comprehend the theoretical foundation of quantum information and computation.
- (2) cover a selective collection of fundamental topics in quantum algorithms, quantum complexity, and quantum error correcting codes.

CMSC/PHYS 457: Teaching Philosophy

- (1) understand and comprehend the theoretical foundation of quantum information and computation.
- (2) cover a selective collection of fundamental topics in quantum algorithms, quantum complexity, and quantum error correcting codes.
- (3) learn about the research frontier of one specific topic via the course project.

CMSC/PHYS 457: Teaching Philosophy

- (1) understand and comprehend the theoretical foundation of quantum information and computation.
- (2) cover a selective collection of fundamental topics in quantum algorithms, quantum complexity, and quantum error correcting codes.
- (3) learn about the research frontier of one specific topic via the course project.
- (4) get ready for research in the field of quantum information.

CMSC/PHYS 457: Teaching Philosophy

- (1) understand and comprehend the theoretical foundation of quantum information and computation.
- (2) cover a selective collection of fundamental topics in quantum algorithms, quantum complexity, and quantum error correcting codes.
- (3) learn about the research frontier of one specific topic via the course project.
- (4) get ready for research in the field of quantum information.

CMSC/PHYS 457: Teaching Philosophy

- (1) understand and comprehend the theoretical foundation of quantum information and computation.
- (2) cover a selective collection of fundamental topics in quantum algorithms, quantum complexity, and quantum error correcting codes.
- (3) learn about the research frontier of one specific topic via the course project.
- (4) get ready for research in the field of quantum information.

400-level advanced topic teaching

- Self-motivated.

CMSC/PHYS 457: Teaching Philosophy

- (1) understand and comprehend the theoretical foundation of quantum information and computation.
- (2) cover a selective collection of fundamental topics in quantum algorithms, quantum complexity, and quantum error correcting codes.
- (3) learn about the research frontier of one specific topic via the course project.
- (4) get ready for research in the field of quantum information.

400-level advanced topic teaching

- Self-motivated.
- **Treat Reading Assignment Seriously!** Important to fill in the details of lectures.

CMSC/PHYS 457: Teaching Philosophy

- (1) understand and comprehend the theoretical foundation of quantum information and computation.
- (2) cover a selective collection of fundamental topics in quantum algorithms, quantum complexity, and quantum error correcting codes.
- (3) learn about the research frontier of one specific topic via the course project.
- (4) get ready for research in the field of quantum information.

400-level advanced topic teaching

- Self-motivated.
- **Treat Reading Assignment Seriously!** Important to fill in the details of lectures.
- **A lot of efforts expected!**

CMSC/PHYS 457: Common Questions

There is NO required textbook. We will mainly refer to lecture notes (available online or our own) and the following textbooks.

KLM An Introduction to Quantum Computing, Oxford University Press (2007).

KSV Classical and Quantum Computation (Graduate Studies in Mathematics), AMS, 2002.

Wat The Theory of Quantum Information, Cambridge University Press, 2018.

Aar Introduction to Quantum Information Science (UT Austin 2017).

CMSC/PHYS 457: Common Questions

There is NO required textbook. We will mainly refer to lecture notes (available online or our own) and the following textbooks.

KLM An Introduction to Quantum Computing, Oxford University Press (2007).

KSV Classical and Quantum Computation (Graduate Studies in Mathematics), AMS, 2002.

Wat The Theory of Quantum Information, Cambridge University Press, 2018.

Aar Introduction to Quantum Information Science (UT Austin 2017).

Skills to succeed?

- Math maturity (comfortable with proofs); linear algebra and matrix analysis !!

CMSC/PHYS 457: Common Questions

There is NO required textbook. We will mainly refer to lecture notes (available online or our own) and the following textbooks.

KLM An Introduction to Quantum Computing, Oxford University Press (2007).

KSV Classical and Quantum Computation (Graduate Studies in Mathematics), AMS, 2002.

Wat The Theory of Quantum Information, Cambridge University Press, 2018.

Aar Introduction to Quantum Information Science (UT Austin 2017).

Skills to succeed?

- Math maturity (comfortable with proofs); linear algebra and matrix analysis !!

Interested in working with QuICS?

- Do well! Discuss project topics with QuICS people!

More logistics

Office Hours

- Wu: during the extra time in the lecture or by appointments.
- Thompson: Tu Th 2:00pm - 3:30 pm. Zoom link to be posted at Piazza.

More logistics

Office Hours

- Wu: during the extra time in the lecture or by appointments.
- Thompson: Tu Th 2:00pm - 3:30 pm. Zoom link to be posted at Piazza.

Websites

- **Course website**: syllabus, reading assignments, handouts, and so on. Check **Frequently!!**.

More logistics

Office Hours

- Wu: during the extra time in the lecture or by appointments.
- Thompson: Tu Th 2:00pm - 3:30 pm. Zoom link to be posted at Piazza.

Websites

- **Course website**: syllabus, reading assignments, handouts, and so on. Check **Frequently!!**.
- **Piazza**: announcements, discussion forum, ask for helps.

More logistics

Office Hours

- Wu: during the extra time in the lecture or by appointments.
- Thompson: Tu Th 2:00pm - 3:30 pm. Zoom link to be posted at Piazza.

Websites

- **Course website**: syllabus, reading assignments, handouts, and so on. Check **Frequently!!**.
- **Piazza**: announcements, discussion forum, ask for helps.
- **ELMS**: distribute and submit assignments, grades, solutions.

Important things to check from the course website

- Course Policy.
- Syllabus.
- Projects.

Important things to check from the course website

- Course Policy.
- Syllabus.
- Projects.

Please let us know ASAP if

- you cannot submit assignments electronically.
- time conflicts of exams.
- concerns about the difficulty of the course.
- anything that you wanted to discuss .....

You might be interested in knowing

Some ongoing projects inside QuICS: (incomplete list)

- Circuit Compilation and Optimization.
- Quantum Programming Languages.
- Quantum Algorithms for Optimization.
- Quantum Computing meets Machine Learning.
- Quantum Hamiltonian Simulation.
- Quantum Cryptography.
- ..... (check more at our website) .....

Reading Assignments on Linear Algebra

Linear algebra with Dirac notations

- KLM 2.1-2.6.
- A cheatsheet on our website.