

CMSC 395: Special Topics (Quantum Computing)
Fall 2026

<https://marmorstein.org/~robert/Fall2026/cs395.html>

Lecture / Discussion (Stevens 118): 2:00pm – 3:15pm MWF

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Office Hours: 3:15pm – 5:00pm TWR, 2:00pm – 4:00pm F *or by appointment*

To make an appointment, please contact me by Slack or by e-mail with your schedule for the week. Include as much detail as you can about why you need to see me (this saves time). I will reply with some times I am available within the next two days so that we can find a time that works for both of us.

Course Description: Selected topics in computer science. The topics may vary from semester to semester.
3 credits.

Section Description: Classical computing algorithms rely on step-by-step computation in which the expected output of each instruction follows directly from the results calculated in the preceding step. Quantum computing takes a different approach in which data is “entangled”, transformed, and then extracted using a probabilistic process that sometimes returns a correct result and sometimes returns an incorrect one. Through repeated “experiment”, we increase the probability of a correct result until we are satisfied with the answer. This process results in significant performance benefits for certain types of problems. This seminar-style class will introduce students to the potential advantages and limitations of quantum computing. The course will cover the basic theory of entanglement, superposition, and quantum teleportation at a very high-level and will introduce the fundamental “quantum logic gates”. **3 credits.**

Prerequisite: **CMSC 162 AND MATH 175.**

Student Learning Outcomes: By the end of the course, the successful student will be able to:

- describe Quantum Superposition, Quantum Entanglement, and Quantum Teleportation
- explain algorithms for quantum computation
- create simple Quantum Circuits using an appropriate programming library or framework
- discuss the applications and limitations of Quantum Computing

Course Requirements: This is a seminar-style class. The largest part of your grade (50%) will come from successful completion of reading assignments as demonstrated by your answers to reflection questions, your presentation of those answers in class, and your performance on the (unannounced) reading quizzes. The final exam and the midterm exam will each count for 15% of your grade. Laboratory projects will count for an additional 10% of your grade. You will also be expected to prepare a poster about an application of Quantum Computing (5%). The remainder of your grade (5%) will come from participation.

Course Structure and Student Expectations: This course is a seminar class in which I will expect you to come to class each week prepared to discuss a reading assignment. Readings for each week are listed in the tentative schedule of the syllabus. You should take notes on the reading and come to class prepared to discuss what you have read. In addition to the reading assignments, there will four short projects to introduce you to the various languages and software packages experts use to program quantum computers. You should expect to spend roughly six hours a week outside of class reading, preparing for discussion, and completing the projects.

Textbook: The textbook for this course is “Programming Quantum Computers: Essential Algorithms and Code Samples”, by Eric R. Johnston, Nic Harrigan, and Mercedes Gimeno-Segovia, O’Reilly Books, 2019, ISBN: 978-1-492-03968-6.

Intellectual Property, Accessibility, Mental Health Resources, and Reporting of Crimes and Sexual Misconduct

Longwood has posted some helpful resources and policies at <http://www.longwood.edu/academicaffairs/syllabus-statements/>. Please read through these and feel free to reach out if you have questions. In particular, be aware that, as a responsible employee, I am required to report any crimes or sexual misconduct that you share with me.

Students that require accommodations are encouraged to contact the professor and the Accessibility Resources Office to work out a plan. See <http://www.longwood.edu/accessibility/>

Longwood is an Honor Code institution, and students in this course are expected to abide by the tenets of the Honor Code. See <http://www.longwood.edu/studentconduct/honor-code/>

Grading Policy: Your final grade in this course is computed using a weighted average of your scores on each assignment. The weights for each category are given in the course requirements section of this syllabus and can be used by applying the following formula:

$$\text{Final Grade} = 0.10 * (\text{Project Grades}) + 0.55 * (\text{Homework and Quiz Grades}) + 0.05 * (\text{Participation Grade}) + 0.15 * (\text{Midterm Exam Grade}) + 0.15 * (\text{Final Exam Grade})$$

I do not post grades online, but you can compute your score for each of the category grades (such as your projects) by summing the points you’ve earned on each assignment in that category and dividing by the total number of points possible. You’re also welcome to reach out to me by e-mail or Slack for a grade report. Numeric grades are translated to letter grades using the following grading scale:

100 – 91: A
90: A-
89: B+
88 – 81: B
80: B-
79: C+
78 – 71: C
70: C-
69: D+
68 – 64: D
63 or lower: F

There is no grade of D- in this course. Anything below a 64 is failing.

Late Work:

In general, I do not accept late work or grant extensions on assignments unless you have a serious medical or family emergency which prevents you from completing the assignment on time (however, see “Slip days” below). In such cases, you do not need a doctor’s note, but you must notify me of the circumstances within a reasonable amount of time.

Since slip days do not apply to homework or quizzes, I may occasionally be persuaded to grant extensions on these assignments. All requests for extensions **MUST** be submitted by e-mail within a reasonable amount of time (typically twelve hours from the original due date). This e-mail should outline in detail the reason your work is late.

Granting of extensions is entirely at my discretion and may incur additional penalties of up to 25% a day.

Slip Days:

You will be allocated a fixed number of slip days at the start of the semester. You may use your slip days to extend the due date of one or more *programming projects*. You can use all of your slip days on one assignment or you may use them over multiple assignments.

Slip days are calculated from the minute the assignment is due until you turn it in. The number of slip days used is rounded *up* to the nearest integer value. That means that if you turn an assignment in 24 hours and 1 minute after the due date, you will use up *two* slip days. The slip day clock runs over weekends and holidays. If a lab is due on Friday and you turn it in on Monday, you will have used three slip days, not one. Slip days cannot be shared, traded, bought, or sold, but can occasionally be earned by participation in relevant campus activities I select.

Attendance:

I expect you to attend class unless you are sick or engaged in a school-sponsored sport or extracurricular activity. Please **do NOT come to class if you are sick**. Instead, contact me within 12 hours of the absence to check whether you've missed any work and make arrangements to make up any missed quizzes.

When absent, you should make arrangements to get notes from another student in the class. You should also check the course web site for announcements, new assignments, and other important updates.

While I will rely primarily on your honor for enforcement of the attendance policy. I also keep a record of your attendance. In accordance with Longwood policy, missing more than 10% of scheduled class time (5 class sessions) to unexcused absences may, at my discretion, result in loss of one letter grade and missing 25% of class or more (14 sessions), whether excused or not may result in an automatic failing grade.

Cell Phones and Laptops:

Cell phones, music players, and laptops are to be turned off and put away during class, except as needed for the lab sessions. Violations of this policy will be considered an **unexcused** absence.

I will not interrupt class to notify you if you have been counted absent for use of a prohibited device. Feel free to contact me by e-mail at any point in the semester to check on the number of absences you have in my class.

Food and Drink:

You may bring non-alcoholic beverages, including soft drinks, to class. However, please do not eat in class (it distracts me and the other students). Violations of this policy will be considered an **unexcused** absence.

I will not interrupt class to notify you if you have been counted absent for violation of this policy. Feel free to contact me by e-mail at any point in the semester to check on the number of absences you have in my class.

I occasionally grant exceptions to this rule for students who must otherwise forgo lunch or have medical needs that require them to eat in class. If you feel that you need such an exception, you must make arrangements with me in advance (i.e. before bringing food to class).

AI Policy:

The use of Generative AI tools (such as Large Language Models like ChatGPT and Claude) is not permitted in this class. You may not use them in any way on any work that you turn in to me. You may not use them to study for exams or quizzes.

Violations of this policy will result in an automatic failing grade for the course and will be reported as an honor code violation.

Honor Code and Collaboration:

As a strong believer in the Honor Code, I encourage you to actively collaborate with other students and to discuss homework problems and projects.

However, there is a point at which collaboration becomes cheating. To help you understand the line between acceptable discussion of a project and dishonorable behavior, I ask you to observe the following rules:

1. Exams and quizzes are to be completed entirely on your own. You may not discuss them with anyone or use any resources except those specifically outlined on the exam handout.

2. You must give proper attribution.

You do NOT need to cite material you obtain directly from me (in lecture, the assignment handout, or office hours). In general, you also do NOT need to cite material taken from the textbook. However, any other resources you use, including help from other students or other faculty, should be properly cited.

This applies both to homework assignments AND to programming projects. If someone helps you with a homework assignment, you should make a note in the margin of your work indicating which specific problems you collaborated on. If you receive help (or use an online resource) to complete a programming assignment, you should comment your code to give proper credit.

A simple comment like:

```
/* based on http://codewarrior.com */
```

or

```
/* Jessica helped me with the curly braces here */
```

is fine.

Important Note: **These comments should go directly above or on the same line as the code on which you received help**, so that it is clear exactly which parts of your program are original and which are not.

3. The work you submit should, in general, be either your own original work or material which I have provided and you have suitably modified yourself. Do not copy large blocks of code from other students or the Internet.

You MAY assist other students or get assistance with simple problems like syntax errors.

You MAY use references (such as web sites, books, or journal articles) to look up answers to specific questions – as long as you use only short snippets that you find in this way – and you properly cite your source.

You MAY NOT copy large blocks of code, such as entire functions or classes, from each other or external resources. A good guideline of how large is “too large” is that copying more than three complete programming statements is usually too much.

At no point should another student touch your keyboard while helping you with a project.

You MAY print out copies of your code for personal use, such as debugging or to show me during office hours. You MAY NOT share printed code with other students unless working on a group project.

You MAY use web sites, books, and the man pages as reference materials. However, you must cite them appropriately and you MUST re-type any code you find and not just download it or copy/paste it.

4. You are responsible for securing your code.

Helping other students to cheat is also cheating. Furthermore, it is your responsibility to make sure that other students do not use your work to cheat. Be careful with who you let access your account and report any missing files, flash drives, or other devices to me promptly.

Infractions of these policies will be dealt with harshly under the Longwood Honor Code. Any student convicted of an honor offense involving this class will automatically receive a final course grade of **F** in addition to any penalties imposed by the Honor Board. You should consider all work in this class to be pledged work, whether or not the pledge appears on the assignment.

If you have questions about the honor code policy, PLEASE ask me. It is much better to receive a late penalty on a single assignment than to fail the course and face honor board charges. You may find the scenarios at <https://integrity.mit.edu/handbook/writing-code> helpful in understanding this policy. While their honor code policy is not identical to mine it is very, very similar.

5. Do not use ChatGPT or other forms of generative AI

These tools replace practice with the skills I want you to develop, preventing you from adequately retaining course information. Perhaps more importantly, because they do not properly cite their sources (or give misleading citations), they effectively plagiarize everything they produce. Use of these tools on assignments in this course effectively constitutes plagiarism by proxy and will be treated as cheating.

Communications Policy:

The best way to get in touch with me is to use **Slack**. Slack is a chat utility with clients for mobile devices and desktop computers. I recommend you install it on both types of devices. Slack will allow you to easily send me code snippets, ask questions in real time, or set up a Zoom meeting (or Google Hangout) if we need to video chat. You should sign up for a Slack account by visiting <https://longwood-cmsc.slack.com>. Use your @live.longwood.edu email address to register and you will be automatically approved.

Slack is also a good way to communicate with other members of the class. You will be invited to a public **#cmsc-445** channel in which you can discuss the projects and other course topics with other students in the class. Feel free to ask for help on this channel, but please stick to general questions rather than posting code. I will expect you to check the **#cmsc-445** channel every day before class in case I have posted an announcement or asked you to bring something to class.

When you send me a Slack message, I instantly get a notification on my computer, tablet, and phone. Typically, I will reply to Slack messages within 24 hours (often sooner) on weekdays. While I am often available in the evening or on weekends, you may need to be patient if I am busy with other students or family obligations.

You can also reach out to me by e-mail to marmorsteinrm@longwood.edu. However, please do not send me large files by e-mail. They take up space toward my limited quota on the mail server and cause me all sorts of headaches. **E-mail messages containing large files will be deleted unread.**

I am much slower at replying to e-mail (since I do not get a notification and have to log in to check it). Typically, you can expect a reply to an e-mail within 48 hours, but this may be longer on weekends, and I may not receive your message at all or may not be able to respond to it (my inbox is often over the “quota” allowed by campus I. T. and this often prevents me from using the system effectively).

If you are **asking for help with a project or homework problem**, you should attach your work to a direct message in Slack so that I can see where you are at. You should do this by using the “plus” icon to attach the file directly to your message or by copy/pasting the particular snippet of code you are working on to the body of the message.

Please do NOT attach pictures of code taken on your phone. These are blurry and hard to read and do not allow me to run your code to see why it is failing. If you need me to see your screen, you can take screenshots of your Unix system using the “spectacle” program (usually by pressing the Print Screen “PrtSc” key).

One last suggestion: don’t “ask to ask”. Asking, “Can I ask you a question?” wastes my time and yours. The answer is, “Yes.” You are welcome to ask questions at any time and do not need permission first. Interacting with YOU is the best part of my job. I am delighted to answer questions about the projects, lectures, readings, homework assignments, or pretty much anything else related to the class. You should feel free to reach out at any time (yes, even at 3:00 am the night before the project is due – I -might- be online)!

Tentative Course Schedule:

Week 1 (Aug. 25 – 27)

Introduction, What is Quantum Computing?
Application / Motivation: The RSA Public Key Cryptosystem
Quantum Supremacy / Quantum Advantage
(Read Chapter 1)

Week 2 (Sept. 1 – 3)

Logic Gates and Truth Tables
Basic Quantum “Gates”, Superposition, Operations with One Qubit
Dirac Notation, Vector Notation, and Circle Notation
(Read Chapter 2)

Lab 1: Single Qubit Computing

Aug. 31

Last Day to Drop (by 5pm)

Week 3 (Sept. 8 – 10)

Entanglement, Operations with Multiple Qubits
(Read Chapter 3, Pages 37 – 51)

Week 4 (Sept. 15 – 17)

Phase Kickback, Toffoli Gates, and the Swap Test
(Read Chapter 3, Pages 51 – 65)

Lab 2: Multiple Qubit Computing

Week 5 (Sept. 22 – 24)

Quantum Arithmetic and Logic
Addition, Negative Numbers, Subtraction, and Multiplication
Reversability and Uncomputing
Using scratch qubits
(Read Chapter 5)

Week 6 (Sept. 29 – Oct. 1)

Quantum Teleportation, **Midterm Review**
Programming using Qiskit and OpenQASM
(Read Chapter 4)

Week 7 (Oct. 6)

Midterm Exam

Oct. 8 – 9

NO CLASS: Fall Break

Week 8 (Oct. 13 – 15)

Amplitude Amplification
Mirroring and Flipping operations
Applications of Amplitude Amplification
(Read Chapter 6)

Week 9 (Oct. 20 – 22)

Quantum Fourier Transform
DFTs, FFTs, and the QFT
Applications of the QFT
The inverse QFT
(Read Chapter 7)

Week 10 (Oct. 27 – 29)

Catchup and Review
(Poster Draft Due)

Lab 3: Quantum Logic and Amplification

Week 11 (Nov. 3 – 5)

Quantum Phase Estimation, Vectors and Matrices,
Systems of Equations, Eigenvalues, and Eigenvectors
(Read Chapter 8)

Week 12 (Nov. 10 – 12)

Quantum Search / Grover's Algorithm
Phase Logic
Satisfiability Problems: SAT and 3-SAT
(Read Chapter 10)

Week 13 (Nov. 17 – 19)

Factoring, RSA, and Shor's Algorithm
Hidden Subgroup Problems
(Read Chapter 12)

Lab 4: Quantum Search and Factoring

Nov. 18

Research and Creative Inquiry Showcase
(Poster Presentation Due)

Week 14 (Nov. 24)

Applications to Computer Graphics (Read Chapter 11)
Phase Encoded Images, Ray-Tracing and Supersampling
Quantum Supersampling
(Read Chapter 11)

Nov. 25 – 27

Thanksgiving Break: NO CLASS

Week 15 (Dec. 1 – 3)

Final Exam Review

Dec. 9

Final Exam (Wednesday, 3:00pm – 5:30pm)

Major Assignments:

- **Tests:** There will be two exams: a midterm exam on Wednesday, Oct. 6th and a comprehensive final exam on Wednesday, Dec. 9th.
- **Reading and Discussion:** This class will be largely discussion-driven. I expect you to read the textbook and come prepared to discuss it with your peers. I will provide you with reflection questions to guide your reading, which I will collect at the end of class each week. Adequate preparation for discussion includes taking notes on each chapter as you read it and being prepared to share your understanding of the chapter with the rest of the class. Each discussion session will be graded and participation in discussions will count as a homework grade.
- **Poster Presentation:** As a semester project, I expect you to research and present a poster about at least one application of Quantum Computing. You will select your topic from a list of available choices, find sources you can cite that describe the application, and then prepare a poster suitable for presentation at Longwood's Research and Creative Inquiry Showcase.
- **Projects:** While this class is primarily discussion-driven, there will be a few short projects to introduce you to Quantum Programming tools and libraries. While I may give you some time in class to work on these, you should budget a sufficient number of hours outside of class to successfully complete the labs. Please see the tentative schedule for due dates.
- **Quizzes and Homework Problems:** You should expect to be assigned a set of reflection questions due at the beginning of each class (but collected at the end of class) as homework. In addition to homework assignments, I may give unannounced (pop) quizzes over topics from the readings.