# Course Change Request

## New Course Proposal

Date Submitted: 08/13/25 10:16 pm

## Viewing: QSE 511 : Quantum Algorithms

### Last edit: 08/19/25 3:01 pm

Changes proposed by: kgaj

**In Workflow**

1. **SC Curriculum Committee**
2. SC Assistant Dean
3. Assoc Provost-Graduate
4. Registrar-Courses
5. Banner

| | |
|---|---|
| **Programs referencing this course** | : Quantum Science and Engineering, MS |

**Are you completing this form on someone else's behalf?**

No

**Effective Term:** Spring 2026

**Subject Code:** QSE - Quantum Science and Engineering **Course Number:** 511

**Bundled Courses:**

**Is this course replacing another course?** No

**Equivalent Courses:**

**Catalog Title:** Quantum Algorithms

**Banner Title:** Quantum Algorithms

**Will section titles vary by semester?** No

**Credits:** 3

**Schedule Type:** Lecture

**Hours of Lecture or Seminar per week:** 3

**Repeatable:** May only be taken once for credit (NR)

*GRADUATE ONLY*

**Default Grade Mode:** Graduate Regular

**Recommended Prerequisite(s):** QSE 500 and (QSE 501 or equivalent)

**Recommended Corequisite(s):**

**Required Prerequisite(s) / Corequisite(s) (Updates only):**

**Registrar's Office Use Only - Required Prerequisite(s)/Corequisite(s):**

| And/Or | ( | Course/Test Code | Min Grade/Score | Academic Level | ) | Concurrency? |
|---|---|---|---|---|---|---|
| | | | | | | |

**Registration Restrictions (Updates only):**

**Registrar's Office Use Only - Registration Restrictions:**

**Field(s) of Study:**

**Class(es):**

**Level(s):**

**Degree(s):**

**School(s):**

**Catalog Description:** This course offers a rigorous introduction to quantum computation theory, focusing on algorithms. We will explore foundational theorems and develop algorithms that exhibit exponential speedups over classical counterparts. The course prepares students for research or further studies in quantum computing.

**Justification:** What: Create a new course.
Why: This course introduces the structure and analysis of quantum algorithms in the quantum circuit model, covering foundational examples such as Deutsch–Jozsa, Grover's search, Shor's factoring, amplitude amplification, and phase estimation. Students learn to characterize these algorithms through asymptotic methods and resource analysis, developing a clear understanding of how quantum advantage is achieved and expressed relative to classical computation.

Because many of the principles behind quantum speedups arise from the theory's contextual nature — where certain outcomes are defined only relative to the full sequence of operations — the course takes a mathematically oriented approach that develops intuition through formal models and circuit analysis. By reasoning directly about unitaries, transformations, and complexity bounds, students gain a robust framework for understanding quantum algorithms in their idealized form, building the depth of insight needed for advanced study and application.

This course has a limited overlap with PHYS 534 (Introduction to Quantum Computation and Quantum Information). It will merge material covered in 534 with material previously taught only in basic/special topic courses such as CS 595 (Basic Topics in Computer Science) and MATH 689 (Topics in Applied and Computational Mathematics). This will be possible because other additional content currently taught in PHYS 534 will now be covered in QSE 501.

**Does this course cover material which crosses into another department?** No

**Learning Outcomes:**

**Will this course be scheduled as a cross-level cross listed section?** No

**Attach Syllabus** QSE_511_syllabus.pdf

**Additional Attachments**

**Have you reached out to the Libraries to determine whether there are adequate resources to support your course? If not, please email Meg Meiman, Associate University Librarian for Learning, Research, and Engagement at mmeiman2@gmu.edu.**

Yes

**Additional Comments:** This is a core course for the new MS program in Quantum Science and Engineering.

**Reviewer Comments**

Key: 19076

# QSE 511: Quantum Algorithms

**Potential Instructors:**

**Dr. Michael Jarret Baume**
**Department of Mathematical Sciences, College of Science**
**and Department of Computer Science, College of Engineering and Computing**
**Email: mjarretb@gmu.edu**

**Dr. Fei Li**
**Department of Computer Science, College of Engineering and Computing**
**Email: fli4@gmu.edu**

**Dr. Mingzhen Tian**
**Department of Physics & Astronomy, College of Science**
**Email: mtian1@gmu.edu**

**Semester and Year:** TBA

**Class Meeting Day(s) and Time(s):** TBA
**Modality:** Face-to-Face
**Class Location:** TBA

**Office Hours:** TBA
**Office Hours Location:** TBA

## Course Description

This course offers a rigorous introduction to quantum computation theory, focusing on algorithms. We will explore foundational theorems and develop algorithms that exhibit exponential speedups over classical counterparts. The course prepares students for research or further studies in quantum computing.

## Recommended Prerequisites

- QSE 500 and (QSE 501 or equivalent)

## Textbooks

- **Primary Text:**
    - *Quantum Computation and Quantum Information: A Mathematical Perspective* by J. M. Landsberg, American Mathematical Society, 2024.
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- **Supplementary Texts:**
    - *Quantum Algorithms*, by Johannes A. Buchmann, American Mathematical Society, 2024
    - *An Introduction to Quantum Computing*, by Phillip Kaye, Raymond Laflamme, and Michele Mosca, Oxford University Press, 2007
    - *Quantum Computation and Quantum Information*, by Michael A. Nielsen, Isaac L. Chuang, Cambridge University Press, 2011
    - *Quantum Computer Science*, by N. David Mermim, Cambridge University Press, 2007
    - *Classical and Quantum Computation*, by A. Yu. Kitaev, A. H. Shen, M. N. Vyalyi, American Mathematical Society, 2002.

## Course Learning Outcomes

- Asymptotic Analysis of Quantum Algorithms: Acquire the ability to perform asymptotic analysis on quantum algorithms. This involves evaluating the efficiency and scalability of algorithms and understanding their performance in comparison to classical algorithms.

- Familiarity with Basic Quantum Algorithms: Understand the foundational "building block" quantum algorithms that form the basis for more complex quantum computing tasks. This includes learning about algorithms such as the Deutsch-Jozsa algorithm, Grover's algorithm, and others that demonstrate the unique capabilities of quantum computing.

- Understanding of Quantum Circuits: Develop the ability to analyze and interpret quantum circuits. Learn how to use Dirac notation to describe the action of quantum gates and circuits and understand how these circuits implement quantum algorithms.

- Critical Analysis of Quantum Algorithms: Develop the ability to critically analyze and evaluate the strengths and limitations of various quantum algorithms. This includes understanding the conditions under which certain quantum algorithms outperform their classical counterparts.

## Tentative Course Schedule

| Week | Topic |
|---|---|
| 1 | Introduction, Dirac Notation |
| 2 | Qubits and the Framework of Quantum Mechanics |
| 3-4 | Quantum Circuit Model |
| 5 | Superdense Coding and Quantum Teleportation |

| | |
|---|---|
| 6-7 | Introductory Quantum Algorithms |
| 8-10 | Algorithms with Superpolynomial Speed-Up |
| 11-12 | Algorithms Based on Amplitude Amplification |
| 13-14 | Quantum Computational Complexity Theory |
| 15 | Quantum Error Correction |

## Grading Policy, including Grade Weights, Grading Schema, and Grading-related Policies

**Homework Assignments:**

- Each homework assignment corresponds to one of the five units covered in the course.
- Assignments are graded on a Pass/Incomplete (P/I) basis.
- A "Pass" (P) is awarded for scores of 80% or higher.
- An "Incomplete" (I) can be converted to a "Pass" through additional oral assessments or redoing the assignment. The procedure for this will be discussed on the first day of class.

**Term-Long Assignment:**

Proposals for the term-long assignment must be submitted by the end of week 4 of the course. This assignment will be graded based on a rubric that is mutually agreed upon by the student and the instructor.

**Course grade:**

The course grade is determined by the number of units passed and the overall grade on the term-long assignment, as detailed in the table below. The term assignment grade cannot negatively impact the student's course grade.

| Units passed | Term Assignment Grade | Course Grade |
|---|---|---|
| 5 | A+ | A+ |
| 5 | A | A |
| 5 | A- or below | A- |
| 4 | A- or above | B+ |
| 4 | B+ or below | B |
| 3 | B or above | B |
| 3 | B- or below | C |
| 2 or fewer | Any grade | F |

**Impact of Incomplete Project:**

If a graduate student fails to satisfactorily complete the term-long project, as defined by achieving at least the standard of a 'B-' according to the agreed-upon rubric, it will result in a reduction of one 'unit passed' in the final grade calculation. For instance, if a student has successfully passed all 5 units but fails to meet the 'B-' standard in the term-long project, their final grade will be calculated as if they have passed only 4 units.

## Course Policies

- **Assignment Submission:** Upload assignments to Canvas by deadlines.
- **Academic Integrity:** Adherence to GMU Academic Standards is mandatory.
- **Attendance:** Active participation recommended.

## AI (Artificial Intelligence) Tools Policy

The use of AI-based tools is permitted for purposes of learning, exploring ideas, and identifying credible references. Students may use such tools to clarify concepts, brainstorm topics, or locate scholarly sources. However, AI tools must not be used to generate complete solutions to assignments, assessments, or projects, nor may students present AI-generated text, code, or other output as their own original work. Copying, paraphrasing, or otherwise incorporating AI-generated materials without attribution constitutes academic dishonesty and will be treated as plagiarism under the University's Academic Standards. Students are responsible for critically evaluating and verifying any information obtained through AI tools, ensuring that their submissions reflect their own understanding, analysis, and synthesis of course material.

## Common Policies Affecting All Courses at George Mason University

Common policies affecting all courses at George Mason University, including

- Academic Standards
- Accommodations for Students with Disabilities
- FERPA and Use of GMU Email Addresses for Course Communication
- Title IX Resources and Required Reporting,

are available at
https://stearnscenter.gmu.edu/home/gmu-common-course-policies

You are strongly encouraged to get familiar with this additional information.