# Course Change Request

## New Course Proposal

Date Submitted: 08/13/25 10:21 pm

## Viewing: QSE 611 : Advanced Quantum Algorithms

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

Changes proposed by: kgaj

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

**In Workflow**

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

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

No

**Effective Term:** Spring 2026

**Subject Code:** QSE - Quantum Science and Engineering **Course Number:** 611

**Bundled Courses:**

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

**Equivalent Courses:**

**Catalog Title:** Advanced Quantum Algorithms

**Banner Title:** Advanced 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 511

**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 will deepen students' knowledge of quantum algorithms beyond QSE 511. In this course, students will explore modern quantum algorithms that may prove useful with the emergence of quantum technology. Students will learn the concepts of Hamiltonian Simulation, quantum signal processing, quantum walks, quantum complexity, heuristic quantum algorithms, span programs, and other topics of current interest. In particular, students will be introduced to a number of algorithms with exponential speedups.

**Justification:** What: Create a new course.
Why: This course extends the foundations from QSE 511 into advanced topics in quantum algorithm design and analysis, including Hamiltonian simulation, quantum walks, quantum signal processing, span programs, and heuristic methods. Students examine how these algorithms fit into the broader quantum complexity landscape, and learn to interpret their performance in light of both formal theory and practical considerations.

The emphasis is on building the ability to implement and adapt sophisticated algorithms with a full appreciation of their theoretical context and operational constraints. Students learn to abstract away the circuit model and put together algorithms directly while accounting for their subtleties. By the end of the course, graduates can accurately reproduce algorithms from the research literature, recognize the assumptions on which they depend, and avoid common pitfalls that arise when those assumptions are overlooked.

This course does not overlap with any current offering.

**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_611_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 an advanced quantum elective course for the new MS program in Quantum Science and Engineering.

**Reviewer Comments**

Key: 19077

# QSE 611: Advanced 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**


**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 will deepen students' knowledge of quantum algorithms beyond QSE 511. In this course, students will explore modern quantum algorithms that may prove useful with the emergence of quantum technology. Students will learn the concepts of Hamiltonian Simulation, quantum signal processing, quantum walks, quantum complexity, heuristic quantum algorithms, span programs, and other topics of current interest. In particular, students will be introduced to a number of algorithms with exponential speedups.

## Recommended Prerequisites

- QSE 511

## Textbook

- This course will be taught through lecture notes, but students may find https://quantumalgorithmzoo.org/ helpful.

## Course Objectives

By the end of this course, students will be able to:

- Explain various quantum complexity classes and their relationships to classical complexity classes
- Demonstrate how to implement various types of quantum walks, e.g. coin-based, continuous, Szegedy, etc.
- Analyze various Hamiltonian Simulation methods
- Contextualize current heuristic strategies
- Apply advanced algorithms to appropriate problems drawn from CS

## Tentative Course Schedule

| Week | Topic |
|---|---|
| 1-2 | Fundamental Quantum Complexity classes (BQP, QMA, etc.) |
| 3-5 | Hamiltonian Simulation |
| 6-8 | Quantum Walks |
| 9-10 | Heuristic algorithms based on the adiabatic algorithm (Adiabatic, QAOA, Annealing, VQE, etc.) |
| 11-12 | Span programs, st-connectivity, lower bounds |
| 13 | Quantum Signal Processing |
| 14-15 | Current research and student presentations |

## Grade Weights

- **Homework and Assignments:** 40%
- **Midterm Project:** 30%
- **Final Project and Presentation:** 30%

## Grading Schema

| | | | |
|---|---|---|---|
| **A+** | TBA | **B** | TBA |
| **A** | TBA | **B-** | TBA |
| **A-** | TBA | **C** | TBA |
| **B+** | TBA | **F** | TBA |

## Grading-related Policies

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

## 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.