Course Change Request

New Course Proposal

Date Submitted: 08/13/25 9:51 pm

Viewing: QSE 501 : Mathematical Foundations of QSE

Last edit: 08/19/25 2:53 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:** 501

Bundled Courses:

Is this course replacing another course? No

Equivalent Courses:

Catalog Title: Mathematical Foundations of QSE

Banner Title: Math Foundations of QSE

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): MATH 203 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 provides mathematical groundwork essential for quantum science and engineering, focusing on linear algebra, asymptotic analysis, abstract algebraic methods, and probability theory as applied in quantum computing contexts.

Justification: What: Creating a new course.

Why: Students in the MS program in Quantum Science and Engineering (QSE) will come from diverse academic and professional backgrounds, often with varying levels of mathematical preparation. This course addresses the mathematical gap by providing the essential mathematical language and tools used throughout QSE, ensuring all students can engage effectively with advanced topics in quantum theory, algorithms, and applications.

The course emphasizes mathematical problem-solving relevant to QSE, using tools from linear algebra, asymptotic analysis, abstract algebra, and probability theory. Students gain fluency in both conventional mathematical notation and bra–ket notation, preparing them to analyze quantum systems and algorithms. Computational assignments using tools like Mathematica and Matlab ensure that students can connect theory with practical modeling and analysis.

By the end of the course, students will have a solid mathematical foundation for advanced study in QSE, reducing the need for remedial instruction and enabling more rapid progress through the program.

The course's focus on QSE-relevant mathematics ensures that, while it does overlap with existing mathematical offerings, there is no single course that would prepare students with equivalent skills. This course also has limited overlap with PHYS 534 (Introduction to Quantum Computation and Quantum Information) and Quantum Algorithms (currently only taught as a special topics course CS 595 / MATH 689). QSE 501 will serve as a foundational course that facilitates de-emphasizing background mathematics in PHYS 534 and all other QSE courses.

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_501_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 Foundational Electives for the new MS program in Quantum Science and Engineering.

Reviewer Comments

Key: 19075

QSE 501: Mathematical Foundations of QSE

Instructor: 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

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 provides mathematical groundwork essential for quantum science and engineering, focusing on linear algebra, asymptotic analysis, abstract algebraic methods, and probability theory as applied in quantum computing contexts.

Recommended Prerequisites

MATH 203 or equivalent

Useful Background

- Basic Linear Algebra
- Familiarity with complex numbers

Textbook

- **Recommended Text:** Wolfgang Scherer, *Mathematics of Quantum Computing: An Introduction* (Springer, 2019)

Course Learning Outcomes

By the end of this course, students will:

- Work in the fundamental language of quantum science and engineering (QSE), including bra-ket and asymptotic notation.

- Perform calculations in areas of linear algebra relevant to QSE, such as eigensystems and unitary matrices.
- Apply the basic mathematical machinery of QSE to foundational quantum problems.
- Use industry-standard software tools such as Mathematica and Matlab to support mathematical analyses relevant to QSE.

Tentative Course Schedule

Week	Topic	Activity
1-3	Linear Algebra Essentials	Eigenvalues, eigenvectors, Gaussian elimination
4-5	Unitary Matrices	Application and eigenstructure analysis
6-7	Asymptotic Notation	Big O, Ω, Θ notation; scaling behaviors
8-9	Bra-ket Notation	Reformulating linear algebra in Dirac notation
10-11	Operators	Eigenstructure, commutativity in abstract algebra
12-13	Probability Theory	Bernoulli trials, expected value, tail bounds
14-15	Applied Quantum Mathematics	Practical quantum mathematics examples

Grade Weights

- **Homework (pen-and-paper, LaTeX submission):** 50%
- **Computational Assignments (Mathematica/Matlab):** 30%
- **Final Exam (Take-home, comprehensive):** 20%

Grading Schema

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

Grading-related Policies

- Assignments must be submitted via Canvas in PDF format created using LaTeX.
- Computational assignments must include scripts or notebooks.
- **Academic Integrity:** Adherence to GMU Academic Standards is mandatory.
- **Attendance:** Recommended for full comprehension of course material.
- **Missed Exams:** TBA
- **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.