

# QUANTUM SCIENCE AND ENGINEERING (QSE)

## 500 Level Courses

**QSE 500: *Ideas in Quantum Science and Technology*.** 3 credits. This course is designed to equip students with the essential skills necessary for navigating the dynamic landscape of the quantum industry while exposing them to modern quantum technology. By introducing students to the industry's technology and concepts essential for business interactions, they will be equipped to enter an expanding industry. Over the semester, students will develop skills to communicate across diverse disciplines, with a focus on articulating quantum information technical concepts in a clear and concise manner. The practice of communicating these technical concepts will serve as an introduction to quantum information systems and their application. Offered by College of Science (<https://catalog.gmu.edu/colleges-schools/science/>). May not be repeated for credit.

**Registration Restrictions:**

Enrollment limited to students with a class of Advanced to Candidacy, Graduate, Junior Plus, Non-Degree or Senior Plus.

Students in a Non-Degree Undergraduate degree may **not** enroll.

**Schedule Type:** Lecture

**Grading:**

This course is graded on the Graduate Regular scale. (<https://catalog.gmu.edu/policies/academic/grading/>)

**QSE 501: *Mathematical Foundations of QSE*.** 3 credits. 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. Offered by College of Science (<https://catalog.gmu.edu/colleges-schools/science/>). May not be repeated for credit.

**Recommended Prerequisite:** MATH 203 or equivalent

**Registration Restrictions:**

Enrollment limited to students with a class of Advanced to Candidacy, Graduate, Junior Plus, Non-Degree or Senior Plus.

Students in a Non-Degree Undergraduate degree may **not** enroll.

**Schedule Type:** Lecture

**Grading:**

This course is graded on the Graduate Regular scale. (<https://catalog.gmu.edu/policies/academic/grading/>)

**QSE 502: *Programming Foundations of QSE*.** 3 credits. This course introduces fundamental programming concepts, including: variables, lists, classes, and loops, and provides hands-on exercises to practice writing clean code. It also covers the basics of data structures and algorithms, focusing on their design, analysis, and implementation in Python. Offered by College of Science (<https://catalog.gmu.edu/colleges-schools/science/>). May not be repeated for credit.

**Registration Restrictions:**

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**Schedule Type:** Lecture

**Grading:**

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**QSE 505: *Classical and Quantum Information Theory*.** 3 credits. This course introduces students to classical and quantum information theory, which is essential to our understanding of quantum communications and quantum information processing. Students will learn the concepts of Shannon and Von Neumann entropy. Students will also learn to understand the fundamental limits of information transfer, the concept of quantum channels, and how noise impacts communication. Offered by College of Science (<https://catalog.gmu.edu/colleges-schools/science/>). May not be repeated for credit.

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

**Registration Restrictions:**

Enrollment limited to students with a class of Advanced to Candidacy, Graduate, Junior Plus, Non-Degree or Senior Plus.

Students in a Non-Degree Undergraduate degree may **not** enroll.

**Schedule Type:** Lecture

**Grading:**

This course is graded on the Graduate Regular scale. (<https://catalog.gmu.edu/policies/academic/grading/>)

**QSE 511: *Quantum Algorithms*.** 3 credits. 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. Offered by College of Science (<https://catalog.gmu.edu/colleges-schools/science/>). May not be repeated for credit.

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

**Registration Restrictions:**

Enrollment limited to students with a class of Advanced to Candidacy, Graduate, Junior Plus, Non-Degree or Senior Plus.

Students in a Non-Degree Undergraduate degree may **not** enroll.

**Schedule Type:** Lecture

**Grading:**

This course is graded on the Graduate Regular scale. (<https://catalog.gmu.edu/policies/academic/grading/>)

**QSE 520: *Applications of Quantum Technology*.** 3 credits. This course surveys the practical applications of quantum computing and quantum technologies, spanning quantum chemistry, condensed matter physics, combinatorial optimization, machine learning, finance, and cryptanalysis.

Students will understand real-world implications of quantum algorithms, including their capabilities and limitations, through detailed end-to-end complexity analyses. Offered by College of Science (<https://catalog.gmu.edu/colleges-schools/science/>). May not be repeated for credit.

**Recommended Prerequisite:** QSE 500

**Registration Restrictions:**

Enrollment limited to students with a class of Advanced to Candidacy, Graduate, Junior Plus, Non-Degree or Senior Plus.

Students in a Non-Degree Undergraduate degree may **not** enroll.

**Schedule Type:** Lecture

**Grading:**

This course is graded on the Graduate Regular scale. (<https://catalog.gmu.edu/policies/academic/grading/>)

**QSE 570: Quantum Computing System Design.** 3 credits.

Quantum computing is an emerging and promising technology that can be used to solve complex problems that are beyond the capability of classical computing. This course centers on quantum system-level optimization, guiding students through the end-to-end workflow—from designing quantum algorithms for specific applications, to synthesizing them into quantum circuits, and compiling those circuits for execution on quantum devices. The curriculum spans essential mathematical foundations, quantum logic gates, quantum machine learning, circuit optimization, noise modeling, and error mitigation techniques. Emphasizing hands-on programming and system integration, students will develop practical skills through team-based research projects and presentations. By the end of the course, students will gain a deep understanding of both theoretical concepts and practical system-level challenges in quantum computing, preparing them to contribute effectively to this rapidly evolving field. Offered by College of Science (<https://catalog.gmu.edu/colleges-schools/science/>). May not be repeated for credit.

**Recommended Prerequisite:** QSE 500 and (QSE 501 or MATH 203) and (QSE 502 or CS 112), or equivalent

**Registration Restrictions:**

Enrollment limited to students with a class of Advanced to Candidacy, Graduate, Junior Plus, Non-Degree or Senior Plus.

Students in a Non-Degree Undergraduate degree may **not** enroll.

**Schedule Type:** Lecture

**Grading:**

This course is graded on the Graduate Regular scale. (<https://catalog.gmu.edu/policies/academic/grading/>)

## 600 Level Courses

**QSE 611: Advanced Quantum Algorithms.** 3 credits.

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. Offered by College of

Science (<https://catalog.gmu.edu/colleges-schools/science/>). May not be repeated for credit.

**Recommended Prerequisite:** QSE 511

**Registration Restrictions:**

Enrollment limited to students with a class of Advanced to Candidacy, Graduate, Junior Plus, Non-Degree or Senior Plus.

Students in a Non-Degree Undergraduate degree may **not** enroll.

**Schedule Type:** Lecture

**Grading:**

This course is graded on the Graduate Regular scale. (<https://catalog.gmu.edu/policies/academic/grading/>)

**QSE 621: Quantum Error Correction.** 3 credits.

Quantum error correction (QEC) is a rapidly advancing and critical field, underpinning the realization of scalable and fault-tolerant quantum computers. It stands as one of the most important frontiers in quantum science and technology today. This course offers a comprehensive introduction to the theory and practice of QEC, a fundamental discipline for protecting quantum information against quantum noise and errors. The course covers a broad spectrum of topics, beginning with quantum noise models, the 9-qubit code, quantum error correction conditions, stabilizer formalism, and the Clifford group. The course then advances to more complex subjects such as qudit codes, performance bounds, and fault-tolerant strategies—including transversal gates, magic state distillation, and the threshold theorem. The course is delivered through lectures complemented by student-led presentations on advanced QEC topics, fostering deeper understanding, critical thinking, and research skills. Offered by College of Science (<https://catalog.gmu.edu/colleges-schools/science/>). May not be repeated for credit.

**Recommended Prerequisite:** (QSE 501 or MATH 203) and QSE 570, or equivalent

**Registration Restrictions:**

Enrollment limited to students with a class of Advanced to Candidacy, Graduate, Junior Plus, Non-Degree or Senior Plus.

Students in a Non-Degree Undergraduate degree may **not** enroll.

**Schedule Type:** Lecture

**Grading:**

This course is graded on the Graduate Regular scale. (<https://catalog.gmu.edu/policies/academic/grading/>)

## 700 Level Courses

**QSE 798: Master's Research Project.** 1-3 credits.

This course is an experiential learning opportunity designed to provide students with experience in quantum science and engineering research. Directed by QSE faculty, students will engage in research through an academic, industry, or government research opportunity. Note: No more than 3 credits may be counted toward satisfying the master's degree, although students may register for up to 5 credits total until the project is completed. Offered by College of Science (<https://catalog.gmu.edu/colleges-schools/science/>). May be repeated within the degree for a maximum 5 credits.

**Recommended Prerequisite:** At least 15 credits of QSE coursework, excluding foundational courses, QSE 501 and QSE 502

**Registration Restrictions:**

Enrollment limited to students with a class of Advanced to Candidacy, Graduate or Non-Degree.

Students in a Non-Degree Undergraduate degree may **not** enroll.

**Schedule Type:** Thesis

**Grading:**

This course is graded on the Satisfactory/No Credit scale. (<https://catalog.gmu.edu/policies/academic/grading/>)

**QSE 799: Master's Thesis.** 1-3 credits.

This course is an experiential learning course designed to afford students the opportunity to extend the depth of their knowledge of QSE research. The Master's topic will be chosen in collaboration with a committee of GMU faculty. Offered by College of Science (<https://catalog.gmu.edu/colleges-schools/science/>). May be repeated within the degree for a maximum 11 credits.

**Recommended Prerequisite:** 3 credits of QSE 798 with a grade of IP or S

**Registration Restrictions:**

Enrollment limited to students with a class of Advanced to Candidacy, Graduate or Non-Degree.

Students in a Non-Degree Undergraduate degree may **not** enroll.

**Schedule Type:** Thesis

**Grading:**

This course is graded on the Satisfactory/No Credit scale. (<https://catalog.gmu.edu/policies/academic/grading/>)