Quantum Science and Engineering (PhD)

Program Educational Goals:

Students who successfully complete the Quantum Science and Engineering Ph.D. degree program will be able to:

1. **Core Concepts:** Demonstrate a mastery of the foundational knowledge and skills of core aspects of research and development for quantum technologies. Utilize foundational knowledge to develop deeper expertise within a specialized area of quantum technologies.
2. **Critical Thinking Skills:** Demonstrate the ability to critically evaluate literature and data, identify key scientific questions, independently develop a scientific research plan to address these questions, and communicate the rationale for the proposed approach through written and oral communication.
3. **Research Skills**: Demonstrate the depth of knowledge and skills required for professional employment in at least one aspect of quantum technology. This includes demonstrating independent scientific thinking, the ability to independently design a scientific research plan, the ability to acquire the technical skills necessary to implement such a research plan, and the ability to develop and employ analytical skills that enable rigorous qualitative and quantitative scientific data evaluation.
4. **Collaboration and Professional Skills**: Act professionally and ethically. Employ a shared vocabulary that enables collaboration between specialists working on different aspects of quantum technologies. Explore the intersection of different aspects of quantum technologies to identify and pursue opportunities that cross the boundaries of traditional disciplines.
5. **Scientific Communication Skills**: Employ methods of effective communication within the discipline. This includes development of the scientific writing skills necessary for publication of independent research and preparation of independent fundable research proposals. This also includes development of the oral presentation skills required to effectively share scientific information and ideas to both specialized and general audiences.

Program Policy Document:

Please see the Program Policy Document for more information.

Requirements for the Degree:

The QSE PhD degree requires a minimum of 41 credit hours. Students must receive a B- or higher in all core courses. Students will follow one of three tracks: Quantum Nanotechnology, Quantum Theory, or Quantum Algorithms and Computation.

Core Courses:

- PHYS 650 - Introduction to Quantum Computation and Quantum Information **Credit(s):** 3
- QSEG 610 - Engineering the Quantum Revolution **Credit(s):** 3
- QSEG 620 - Professional Skills in Quantum Science and Engineering I **Credit(s):** 1

Quantum Nanotechnology Track:

PhD Quantum Nanotechnology track students will take 13 additional credits of core requirements in addition to the 7 credits of core coursework for a total of 20 credits; 6 credits of elective courses, 6 research credits, and 9 dissertation credits.

- ELEG 650 - Semiconductor Device Design and Fabrication **Credit(s):** 3
- MSEG 640 - Applied Quantum Mechanics I **Credit(s):** 3
- QSEG 621 - Professional Skills in Quantum Science and Engineering II **Credit(s):** 1
- QSEG 810 - Introduction to Quantum Hardware **Credit(s):** 3
- QSEG 830 - Experimental Techniques for Quantum Systems **Credit(s):** 3

Elective Requirement:

Two elective courses (3 credits each) from the Electives List below.

Quantum Theory Track:

PhD Quantum Theory track students will take 10 additional credits of core requirements in addition to the 7 credits of core coursework for a total of 17 credits, 9 credits of elective courses, 6 research credits, and 9 dissertation credits.

- MSEG 640 - Applied Quantum Mechanics I **Credit(s):** 3
- QSEG 621 - Professional Skills in Quantum Science and Engineering II **Credit(s):** 1
- QSEG 810 - Introduction to Quantum Hardware **Credit(s):** 3
- QSEG 851 - Advanced Topics in Quantum Information **Credit(s):** 3

Elective Requirements:

Three electives courses (3 credits each) from the Electives List below.

Quantum Algorithms and Computation Track:

PhD Quantum Algorithms and Computation track students will take 10 additional credits of core requirements in addition to the 7 credits of core coursework for a total of 17 credits, 9 credits of elective courses, 6 research credits, and 9 dissertation credits.

- QSEG 621 - Professional Skills in Quantum Science and Engineering II **Credit(s):** 1
- QSEG 820 - Quantum Algorithms **Credit(s):** 3
- QSEG 851 - Advanced Topics in Quantum Information **Credit(s):** 3

One of the following:

- CISC 601 - Elements of the Theory of Computation **Credit(s):** 3
- CISC 621 - Algorithm Design and Analysis **Credit(s):** 3
- CISC 684 - Introduction to Machine Learning **Credit(s):** 3
- CISC 830 - Combinatorial Optimization and Advanced Algorithms **Credit(s):** 3
- MATH 612 - Computational Methods for Equation Solving and Function Min **Credit(s):** 3

Elective Requirement:

Three electives courses (3 credits each) from the Electives List below.

Electives

Please use this list as a starting point for optional electives. Other courses not on this list may be used to satisfy the elective requirement with the advance approval of the Program Committee.

- CISC 601 - Elements of the Theory of Computation **Credit(s):** 3
- CISC 621 - Algorithm Design and Analysis **Credit(s):** 3
- CISC 684 - Introduction to Machine Learning **Credit(s):** 3
- CISC 830 - Combinatorial Optimization and Advanced Algorithms **Credit(s):** 3
- MATH 612 - Computational Methods for Equation Solving and Function Min **Credit(s):** 3
- MATH 630 - Probability Theory and Applications **Credit(s):** 3
- MATH 806 - Functional Analysis **Credit(s):** 3
- MSEG 841 - Solid State Materials I **Credit(s):** 3
- PHYS 624 - Introduction to Condensed Matter Physics **Credit(s):** 3
- PHYS 626 - Introduction to Atomic, Molecular and Optical Physics **Credit(s):** 3
- PHYS 812 - Quantum Mechanics II **Credit(s):** 3
- PHYS 813 - Quantum Statistical Mechanics **Credit(s):** 3
- PHYS 814 - Advanced Quantum Mechanics **Credit(s):** 3

Research and Dissertation:

Students will be required to take 6 hours of approved research credits (QSEG 868) and will be required to take 9 hours of approved dissertation credits (QSEG 969). Students who wish to do a summer internship may opt for internship course credit (QSEG 864) but such credits do not count toward the total number of credits required for the degree.

- QSEG 868 - RESEARCH **Credit(s):** 1-12
- QSEG 969 - DOCTORAL DISSERTATION **Credit(s):** 1-12
- QSEG 864 - INTERNSHIP **Credit(s):** 1-6

Credits to Total a Minimum of 41

Last Revised for 2022-2023 Academic Year