Quantum Engineering

Degrees Offered

• Graduate Certificate in Quantum Engineering
• Master of Science (Non-Thesis)
• Master of Science (Thesis)

Program Requirements

Quantum Engineering is an interdisciplinary program that seeks to equip students for careers in emerging technologies based on quantum entanglement. It encompasses a wide range of disciplines that include physics, materials science, computer science, and mathematics, and is necessarily a collaborative effort among many Mines departments. Two Master’s degrees and one Graduate certificate are offered.

For both degrees and the graduate certificate, Quantum Engineering has two "tracks" as summarized below. The Quantum Engineering Hardware (QEH) track will focus on experimental techniques relevant to quantum technology, while the Quantum Engineering Software (QES) track will focus on theory, algorithms and simulation. Students must choose a track to complete the program, but they may take courses from both tracks provided they meet the prerequisite requirements.

MS Degree Curriculum Requirements:

A Master of Science in Quantum Engineering will consist of 30 total credits. Students may choose a thesis or non-thesis option for this degree. For the thesis option, 9 credits out of the 30 are devoted to thesis research leading to an acceptable Master's thesis. Students choosing the non-thesis option will devote all 30 credits to coursework. Regardless of the option chosen, 9 of the coursework credits will be devoted to the required core classes for the chosen track.

Reflecting the interdisciplinary nature of the program, we strongly recommend to our students that at least 9 total credits of the MS degree coursework should come from courses in a department outside of the student's undergraduate major. The required core courses, if outside of the student's major, would count towards this recommendation. Our guiding philosophy is that the problem of building a quantum computer is a complex, interdisciplinary one which requires contributions from a vast array of subfields, and young scientists who appreciate this will likely have a far better perspective on the field than those who do not.

MS Non-Thesis Software Track

PHGN519  FUNDAMENTALS OF QUANTUM INFORMATION 3.0
CSCI581  QUANTUM PROGRAMMING 3.0
PHGN545  QUANTUM MANY-BODY PHYSICS 3.0
Electives  21.0
Total Semester Hrs  30.0

MS Non-Thesis Hardware Track

PHGN519  FUNDAMENTALS OF QUANTUM INFORMATION 3.0
PHGN435/535  INTERDISCIPLINARY MICROELECTRONICS PROCESSING LABORATORY 3.0
EENG/PHGN532  LOW TEMPERATURE MICROWAVE MEASUREMENTS FOR QUANTUM ENGINEERING 3.0
Electives  12.0
PHGN707  GRADUATE THESIS / DISSERTATION RESEARCH CREDIT 9.0
Total Semester Hrs  30.0

MS Thesis Software Track

PHGN519  FUNDAMENTALS OF QUANTUM INFORMATION 3.0
CSCI581  QUANTUM PROGRAMMING 3.0
PHGN545  QUANTUM MANY-BODY PHYSICS 3.0
Electives  12.0
PHGN707  GRADUATE THESIS / DISSERTATION RESEARCH CREDIT 9.0
Total Semester Hrs  30.0

MS Thesis Hardware Track

PHGN519  FUNDAMENTALS OF QUANTUM INFORMATION 3.0
PHGN435/535  INTERDISCIPLINARY MICROELECTRONICS PROCESSING LABORATORY 3.0
EENG/PHGN532  LOW TEMPERATURE MICROWAVE MEASUREMENTS FOR QUANTUM ENGINEERING 3.0
Electives  12.0
PHGN707  GRADUATE THESIS / DISSERTATION RESEARCH CREDIT 9.0
Total Semester Hrs  30.0

Coursework Details:

QES students will be required to take these courses in the following sequence:

In the Fall:

• PHGN519, Fundamentals of Quantum Information

In the Spring:

• CSCI581, Quantum Programming
• PHGN545, Quantum Many-Body Physics

QEH students will be required to take these courses in the following sequence:

In the Fall:

• PHGN519, Fundamentals of Quantum Information

In the Spring:

• PHGN435/PHGN535, Interdisciplinary Silicon Processing Laboratory
• PHGN532, Low Temperature Microwave Measurements for Quantum Applications

Approved Electives:

Physics Electives

PHGN440  SOLID STATE PHYSICS 3.0
PHGN441  SOLID STATE PHYSICS APPLICATIONS AND PHENOMENA 3.0
PHGN466/566  MODERN OPTICAL ENGINEERING 3.0
PHGN480  LASER PHYSICS 3.0
PHGN520  QUANTUM MECHANICS I 3.0
Graduate Certificate Curriculum Requirements:
The certificate option consists of three of the four new courses, plus one additional elective chosen from the above list, for a total of 12 credits.

Graduate Certificate, Software Track
PHGN519  FUNDAMENTALS OF QUANTUM INFORMATION 3.0
CSCI581  QUANTUM PROGRAMMING 3.0
PHGN545  QUANTUM MANY-BODY PHYSICS 3.0
Elective 3.0
Total Semester Hrs 12.0

Graduate Certificate, Hardware Track
PHGN519  FUNDAMENTALS OF QUANTUM INFORMATION 3.0
PHGN435/535  INTERDISCIPLINARY MICROELECTRONICS PROCESSING LABORATORY 3.0
EENG/PHGN532  LOW TEMPERATURE MICROWAVE MEASUREMENTS FOR QUANTUM ENGINEERING 3.0
Elective 3.0
Total Semester Hrs 12.0

Program Director
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**Affiliated Faculty**
Matt Beard, Joint Appointment, NREL and Chemistry
Justin Johnson, Joint Appointment, NREL and Physics
Adele Tamboli, Joint Appointment, NREL and Physics