Robotics

Degrees Offered

- Graduate Certificate in Robotics
- Master of Science in Robotics (Non-Thesis)
- Master of Science in Robotics (Thesis)
- Doctor of Philosophy in Robotics

Program Director

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The Robotics program offers Graduate Certificate, Master of Science and Doctor of Philosophy degrees in Robotics. The Graduate Certificate is intended for working professionals. The Non-Thesis MS is designed to prepare candidates for industry careers in robotics. The Thesis MS and PhD degrees are designed to prepare students for research careers.

Combined Program: The Robotics program also offers combined BS+MS degrees. These degrees offer an expedited graduate school application process and allow students to begin graduate coursework while still finishing their undergraduate degree requirements.

Admissions and Program Policies

Mines' Combined Undergraduate / Graduate Degree Program

Students enrolled in Mines' combined undergraduate/graduate program may double count up to six credits of graduate coursework to fulfill requirements of both their undergraduate and graduate degree programs. These courses must have been passed with "B-" or better, not be substitutes for required coursework, and meet all other University, Department, and Program requirements for graduate credit.

Students are advised to consult with their undergraduate and graduate advisors for appropriate courses to double count upon admission to the combined program.

MS and PhD

The minimum requirements for admission to the MS and PhD degrees in Robotics are:

• Applicants must have a Bachelor's degree, or equivalent, from an accredited institution with a grade-point average of 3.0 or better on a 4.0 scale prior to matriculating into the Robotics degree program.

• Students are expected to have completed the following coursework: (1) two semesters of calculus, (2) differential equations, and (3) data structures. The Robotics graduate admissions committee may require that students who do not meet this expectation demonstrate competency or take remedial coursework. Such coursework may not count toward the graduate degree. The committee will decide whether to recommend regular or provisional admission.

• Graduate Record Examination (Quantitative section) score of 151 or higher (or 650 on the old scale). Applicants who have graduated with a computer science, engineering, or math degree from Mines within the past five years are not required to submit GRE scores.

• Applicants who are not US citizens or permanent residents and whose native language is not English, must prove English proficiency as part of the application process. Refer to the Graduate Admissions website for more details.

• For the PhD program, prior research experience is desired but not required.

Transfer Credit

Graduate level courses taken at other universities for which a grade equivalent to a "B" or better was received will be considered for transfer credit with approval of the Advisor and/or Thesis Committee, and home department head, as appropriate. Transfer credits must not have been used as credit toward a Bachelor degree. For the MS degree, no more than nine credits may transfer. For the PhD degree, up to 24 credits of courses may be transferred. In lieu of transfer credit for individual courses, students who enter the PhD program with a thesis-based master's degree from another institution may transfer up to 36 credits in recognition of the course work and research completed for that degree.

400-level Courses

As stipulated by the Mines Graduate School, students may apply, toward MS and PhD requirements, a maximum of nine (9.0) credits of department approved 400-level course work.

Advisor and Thesis Committees

Students must have an Advisor from the Robotics faculty to direct and monitor their academic plan, research, and independent studies. Advisors must be full-time permanent members of the faculty. In this context, full-time permanent members of the faculty are those that hold the rank of professor, associate professor, assistant professor, research professor, associate research professor or assistant research professor. Upon approval by the Graduate Dean, adjunct faculty, teaching faculty, visiting professors, emeritus professors and off-campus representatives may be designated additional co-advisors. A list of Robotics faculty by rank is available in the faculty tab of the catalog.

The department of the Advisor is the student's home department.

Master of Science (Thesis option) students in Robotics must have at least three members on their Thesis Committee. In addition to the institutional requirements, at least one Committee member who is not the advisor must be Robotics faculty.

Robotics PhD Thesis Committees must have at least four members. In addition to the institutional requirements, at least one Committee member who is not the advisor must be Robotics faculty.

Program Requirements

Graduate Certificate

The Graduate Certificate will require 12 credits of coursework. The table below summarizes the requirements for the Graduate Certificate. Please note: only 3 of the 12 credits can be at the 400-level to achieve the Graduate Certificate.

Robotics Core	Four courses, one from each focus area's core course list	12.0
Total Semester Hrs		**12.0**

MS Degrees

The MS degrees will require 30 credits, with thesis research options substituting for electives.

MS Non-Thesis (MS-NT)

Students must take 30 credits of coursework to complete the degree. The table below summarizes the requirements for the MS-NT degree.

Robotics Core (Breadth)	Four courses, one from each focus area's core course list	12.0
Robotics Electives (Depth)	Two courses from robotics course list	6.0
Technical Electives	Four courses in any participating robotics department (CSCI, EDNS, EENG, MEGN)	12.0
Total Semester Hrs		**30.0**

MS Thesis

Students must take 21 credits of coursework and 9 credits of MS thesis research to complete the degree. The table below summarizes the requirements for the MS Thesis degree.

At the conclusion of the MS Thesis, the student must make a formal presentation and defense of their thesis research. A student must “pass” this defense to earn an MS degree.

Robotics Core (Breadth)	Four courses, one from each focus area's core course list	12.0
Robotics Electives (Depth)	Two courses from robotics course list	6.0
Technical Electives	One course in any participating robotics department (CSCI, EDNS, EENG, MEGN)	3.0
MEGN707	GRADUATE THESIS / DISSERTATION RESEARCH CREDIT	9.0
Total Semester Hrs		**30.0**

PhD Degree

The Robotics PhD requires 36 credits of coursework, plus 36 research credits. The table below summarizes the coursework requirements. PhD students must additionally complete a qualifying examination, a thesis proposal, and a thesis defense.

Robotics Core (Breadth)	Four courses, one from each focus area's core course list	12.0
Robotics Electives (Depth)	Four Courses from robotics course list	12.0
Technical Electives	Four courses in any participating robotics department (CSCI, EDNS, EENG, MEGN)	12.0
MEGN707	GRADUATE THESIS / DISSERTATION RESEARCH CREDIT	36.0
Total Semester Hrs		**72.0**

Robotics PhD Qualifying Examination

The Robotics PhD Qualifying Examination will test a student’s ability to conduct research in their chosen area. The qualifier will have two components: a coursework component and a research component.

Coursework Qualifier: To satisfy the coursework component of the qualifier, the student must complete their four selected Robotics Core courses with a minimum grade of “B” in each class.

Research Qualifier: The research qualifier consists of a research project. Robotics PhD students must take the qualifying examination by the end of their fourth semester (typically by the end of their second year). The examination will be evaluated by a committee consisting of at least the student’s advisor, a Robotics-affiliated faculty member, and one additional faculty member.

For the qualifier, the student will conduct a literature review of 30-40 papers and perform a research project approaching the level necessary for a conference publication. The research project must be approved by the advisor and committee and will likely be some combination of the following:

- Design, analyze and/or simulate a novel robot system;
- Design and evaluate new algorithms or systems for an important research problem;
- Develop a new research software system;
- Solve a set of theoretical problems.

The deliverables will be a literature review (3-4 pages, IEEE style [4]), a research report (4-5 pages, IEEE style), and a research presentation (30 minutes to present, plus questions) delivered to the committee.

At the conclusion of the qualifier presentation, each committee member will vote their evaluation as one of “Strong Support”, “Weak Support”, or “Do not support.” The student must receive at least two “Strong Support” votes to pass. In the case the student does not pass, the committee may decide to offer a “conditional pass” based on extra conditions, such as revisions to the report or additional experiments, the student must perform to pass the qualifier. The committee will set an explicit deadline for student to complete the extra conditions. If the student does not meet the extra conditions as determined by the committee by the deadline, the “conditional pass” becomes a “fail.” If the student does not pass the qualifier on their first attempt (inclusive of a conditional pass), they may make one additional attempt to pass; the same conditional pass procedure may also be applied to the second attempt. A student who fails the qualifier on the second attempt may not continue in the program.

Robotics PhD Proposal and Defense

After passing the qualifying examination, the student must prepare a written thesis proposal and present it formally to the student's Thesis Committee and other interested faculty. Typically, the proposal will take place within 24 months of the student completing the qualifier.

The committee for the thesis proposal and defense will follow institutional requirements. Additionally, at least one committee member who is not the advisor must be robotics-affiliated faculty.

At the conclusion of the student's PhD program, the student must make a formal presentation and defense of their thesis research. A student must "pass" this defense to earn a PhD degree. Typically, the defense will take place within 24 months of the student completing the thesis proposal.

Robotics Course List

The Robotics courses are divided into four focus areas. Each focus area is comprised of core courses and electives, as detailed below. Beyond the courses in these four focus areas, there is also a list of additional Robotics electives.

For the Graduate Certificate only 3 credits may be from a 400 level course. For the MS and PhD degrees, only 9 credits may be from 400 level courses.

Perception

Core Courses

CSCI507	INTRODUCTION TO COMPUTER VISION	3.0
CSCI573	ROBOT PROGRAMMING AND PERCEPTION	3.0
EENG519	ESTIMATION THEORY AND KALMAN FILTERING	3.0

Elective Courses

CSCI508	ADVANCED TOPICS IN PERCEPTION AND COMPUTER VISION	3.0

Cognition

Core Courses

CSCI404	ARTIFICIAL INTELLIGENCE	3.0
CSCI575	ADVANCED MACHINE LEARNING	3.0
CSCI534	ROBOT PLANNING AND MANIPULATION	3.0

Elective Courses - None.

Action

Core Courses

MEGN540	MECHATRONICS	3.0
MEGN544	ROBOT MECHANICS: KINEMATICS, DYNAMICS, AND CONTROL	3.0
MEGN545	ADVANCED ROBOT CONTROL	3.0
EENG517	THEORY AND DESIGN OF ADVANCED CONTROL SYSTEMS	3.0

Elective Courses

EENG417	MODERN CONTROL DESIGN	3.0
EENG515	MATHEMATICAL METHODS FOR SIGNALS AND SYSTEMS	3.0

Interaction & Society

Core Courses

CSCI532	ROBOT ETHICS	3.0
CSCI536	HUMAN-ROBOT INTERACTION	3.0

Elective Courses

CSCI5XX	LINGUISTIC HUMAN-ROBOT INTERACTION	3.0

Additional Robotics Electives

CSCI406	ALGORITHMS	3.0
CSCI561	THEORY OF COMPUTATION	3.0
CSCI562	APPLIED ALGORITHMS AND DATA STRUCTURES	3.0
CSCI565	DISTRIBUTED SYSTEMS	3.0
CSCI572	COMPUTER NETWORKS II	3.0
EENG411	DIGITAL SIGNAL PROCESSING	3.0
EENG511	CONVEX OPTIMIZATION AND ITS ENGINEERING APPLICATIONS	3.0
EENG521	NUMERICAL OPTIMIZATION	3.0
MEGN586	LINEAR OPTIMIZATION	3.0
MEGN587	NONLINEAR OPTIMIZATION	3.0
MEGN588	INTEGER OPTIMIZATION	3.0
MEGN686	ADVANCED LINEAR OPTIMIZATION	3.0
MEGN688	ADVANCED INTEGER OPTIMIZATION	3.0