

GRADUATE STUDY HANDBOOK
for the

**Masters of Science and Engineering (M.S.E.)
Program in Robotics**



GRASP Laboratory
School of Engineering and Applied Science
University of Pennsylvania

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**School of Engineering and Applied Science
University of Pennsylvania**

**Masters of Science and Engineering (M.S.E.)
Program in Robotics**

1. Introduction

The new M.S.E. in Robotics will educate students in the interdisciplinary aspects of the science and technology of robotic and intelligent machines. The program provides state-of-the-art preparation for industrial jobs in the robotics, defense, aerospace, and automotive industries as well as ideal academic foundation for subsequent doctoral studies. Main features of the M.S.E. in Robotics program include:

- * Flexible and balanced curriculum including course from the departments of Computer and Information Science (CIS), Electrical and Systems Engineering (ESE), and Mechanical Engineering and Applied Mechanics (MEAM)
- * Ideal preparation for doctoral studies in robotics and related fields
- * Course advising, teaching, and M.S.E. thesis supervision by world-renowned GRASP faculty
- * Access to state-of-the-art experimental and computational facilities
- * Opportunities for research projects in robotics and related fields in the GRASP Lab
- * Participation in exciting robot competitions such as the Robocup soccer tournament
- * Attendance of weekly GRASP seminars and participation in GRASP social events
- * Professional networking with peers in industry and academia

The M.S.E. in Robotics degree is administered by the General, Robotics, Automation, Sensing and Perception (GRASP) Laboratory of the University of Pennsylvania, one the premier research centers that focuses on fundamental research in robotics, control, vision, and machine learning. GRASP is comprised of faculty members from the Departments of Computer and Information Science (CIS), Electrical and Systems Engineering (ESE), and Mechanical Engineering and Applied Mechanics (MEAM). This unique composition gives students the opportunity to be trained in emerging and interdisciplinary areas that are relevant not only in robotics but also to various related fields of engineering and computer science.

This handbook describes the most important features, rules, and regulations regarding the M.S.E. in Robotics program. More up to date information about the Robotics M.S.E. program, is also available on the program webpage at <http://www.grasp.upenn.edu/education/mse.htm>. Further inquires about the program

may be obtained by directly contacting the GRASP Lab Director, George Pappas (pappasg@seas.upenn.edu), or the Program Coordinator, Janet White (jawhite@seas.upenn.edu).

2. Academic Curriculum

The modern expert in robotics and intelligent systems must be proficient in artificial intelligence, computer vision, control systems, dynamics, machine learning, as well as the design, programming, and prototyping of robotic systems. Such subjects typically reside in different departments, and departmental M.S.E. programs do not offer the flexibility for cross-departmental training. Our M.S.E. program offers a much more balanced and flexible academic curriculum that cuts across multiple departments.

To achieve this, the M.S.E. requirements consist of a total of ten courses, including an optional thesis project. For students that do not wish to do write an M.S.E. thesis, the total of ten course units is decomposed in the following categories

<u>Non-thesis Option</u>	
Foundational Courses	3 course units
Technical Electives	5 course units
Free Electives	2 course units
TOTAL	10 course units

In case students select to write a M.S.E. thesis, then the total of ten course units consists of

<u>Thesis Option</u>	
Foundational Courses	3 course units
Technical Electives	3 course units
Thesis Research Units	2 course units
Free Electives	2 course units
TOTAL	10 course units

To satisfy the above academic requirements, we list courses that can be used in each of the above categories.

Foundational courses (3 course units)

All M.S.E. students are required to choose any three of the following four courses.

MEAM	520	Robotics and Automation
ESE	505	Control Systems Design
CIS	580	Machine Perception
CIS	520	Artificial Intelligence and Machine Learning

Students that may wish to take all four foundational courses, can use three of the above courses to satisfy the Foundational Course requirement, and the remaining course can be used to satisfy either the Technical or Free Elective requirement. Students that have taken equivalent courses at other institutions, can petition replacing the Foundational Course with a Technical Elective course.

Technical Elective Courses (5 course units)

In addition to three foundational courses, all M.S.E. students are free to choose up to five course units as technical elective courses. Technical elective courses are typically courses within the School of Engineering and Applied Science, typically offered by GRASP or related faculty. Technical electives allow the student to strengthen their knowledge in a particular area, expand in related areas, as well as perform an optional M.S.E. thesis with a GRASP faculty member. Technical elective courses include courses such as

MEAM	510	Design of Mechatronic Systems
MEAM	515	Product Design
MEAM	535	Advanced Dynamics
MEAM	620	Motion planning
ESE	500	Linear Systems
ESE	504	Introduction to Optimization
ESE	605	Convex Optimization
ESE	650	Learning in Robotics
ESE	601	Hybrid Systems
ESE	617	Nonlinear Systems
CIS	510	Geometric Methods
CIS	560	Computer Graphics
CIS	561	3D Computer Modeling
CIS	562	Computer Animation
CIS	620	Advanced topics in Artificial intelligence
CIS	680	Vision and Learning
ESE/CIS/ME	899	Independent Study (at most one course unit)
ESE/CIS/ME	999	M.S.E. Thesis Research (2 course units)

More details about the above courses can be found in Appendix A. Depending on the interests and future goals of the student, additional courses may be suggested by the student's academic advisor. At most one course unit may be an 899 Independent Study, and cannot count as a core course. All technical electives must be approved by your academic advisor in the Course Planning Guide which can be found in the Appendix.

Free Elective Courses (2 course units)

Any two graduate-level course units chosen in consultation with your academic advisor.

M.S.E. Thesis (Optional)

All M.S.E. students may choose to perform research and write an M.S.E thesis on a suitable topic under the supervision of a GRASP faculty member (usually but not necessarily their academic advisor). If a student elects M.S.E. thesis option, then the student can register for two course units of thesis research (ESE/CIS/MEAM 999) which count towards the technical electives requirement.

The thesis must be prepared and submitted following the general SEAS and University of Pennsylvania instructions for this purpose. Instructions for preparation of the thesis

can be obtained from the Academic Programs Office, 111 Towne Building. The SEAS and Penn guidelines available at <http://www.upenn.edu/VPGE/masters.html>.

Advising

All M.S.E. students will be assigned an academic advisor from the distinguished members of the GRASP faculty. We encourage you to indicate your choice for potential academic advisor in your application to the program. A program of study will developed with the academic advisor, who is responsible for monitoring the student's academic plan and thesis work. In case the student performs an M.S.E. thesis, the thesis supervisor will be typically the academic advisor. If necessary, the student may request a change of advisor, which will be considered and approved by the GRASP Lab Director as appropriate.

3. Academic Environment

All Robotics M.S.E. students will be part of the intellectually rich GRASP Lab throughout their entire studies. All M.S.E. students will have physical access to the various GRASP laboratories. In addition, they will have computing accounts and access to the state-of-the-art computing facilities that all members of the lab enjoy.

As students become more familiar with the various research projects available in the lab, students interested in the M.S.E. thesis option may coordinate with faculty members supervising the project of interest. Depending on the project and M.S.E. thesis topic, students may be exposed to a variety of state-of-the-art robots and experimental facilities.

GRASP Seminars and Events

As part of their academic training, all M.S.E. students will be invited and be expected to attend the prestigious GRASP Seminar Series that takes place every Friday during the academic year. The GRASP Seminar Series is considered an integral part of your education at the GRASP lab. Every week, faculty, students, and staff are exposed to state-of-the-art techniques and internationally recognized researchers in various areas that are of interest to robotics and intelligent machines. In particular,

- The seminar provides an opportunity to learn about the state-of-the-art in robotics;
- The seminar provides an opportunity for the student to get acquainted with people from other institutions;
- The GRASP Lab seminars are an excellent opportunity to socialize weekly with other lab members. The GRASP Seminar is typically followed by a weekly pizza lunch for all seminar attendees.

The current schedule of speaker and information about their seminars can be found at

<http://www.grasp.upenn.edu/seminar/index.html>

In addition to the GRASP Seminar series which focuses on external speakers and research performed at other institutions, the GRASP Research Seminar takes place

every Wednesday afternoon focuses on internal speakers, typically graduate students and postdocs, and enables all GRASP members to get acquainted with the numerous research activities within the lab.

In addition to the weekly seminar series, there is an array of professional and social events that are hosted or organized the lab. In addition, our very active faculty members organize a variety of professional meetings in various communities of interest.

Job Opportunities

As can be seen from the long list of very successful alumni, GRASP has an excellent tradition of placement in academia, industry, as well as research and government labs. In addition to the career services provided by the University of Pennsylvania, the GRASP lab will assist all M.S.E. students with their career planning and expose them to a variety of academic and industrial opportunities in the broad areas of robotic and intelligent machines.

4. Admissions

Applications to the M.S.E. in Robotics program can be electronically submitted using the online application system Penn ExpressApp at

<https://galaxy.isc-seo.upenn.edu/pls/gaadmin/gapk0101.bf00>

The application deadlines are:

Fall Term 2007 Entry: June 1, 2007
Spring Term 2008 Entry: November 1, 2007

Applicants interested in applying to the program before the above dates above are encouraged to contact the Program Director or Program Coordinator.

Application Requirements:

Every application to the M.S.E program requires the following:

- biographical information;
- personal statement of research and professional interests;
- three (3) official letters of recommendation (one must be from a faculty member who is familiar with the candidate's scholarly abilities);
- one (1) official transcript from each university or college attended, including an academic evaluation that lists candidate's class rank and grade point average;
- non-refundable application fee; and
- official score report for the Graduate Record Exam (GRE)

In addition, applicants whose native language is not English are required to satisfy our English language proficiency requirement by submitting:

- official score report for the Test of English as a Foreign Language (TOEFL) with the score of at least 600 (written test) or 250 (computer-based test);
- this requirement can be waived if the candidate has completed at least three (3) years of academic work on a full-time basis at a university-level institution in the United States or in a country in which English is recognized as the official language.

Admission Decisions:

Admission decisions are made on a rolling basis within the deadlines. When an application is completed within the deadlines, it is evaluated promptly by our faculty. Admittance is based on an estimate of the applicant's ability to successfully complete our graduate program. When an admissions decision is reached, the applicant will be notified by letter from the SEAS Associate Dean for Graduate Education and Research. Applications received after the deadlines may be considered at the discretion of our faculty and the Program Director.

Academic Preparation

Due to the cross-departmental nature of the M.S.E. degree, we expect that successful applicants entering the program will have the right background for performing very well in the Foundational Courses. Therefore, potential applicants are encouraged to look at the prerequisites of the Foundational Courses, and ensure that their undergraduate studies have sufficiently addressed them. In particular, sufficient exposure to courses in Linear Algebra (for CIS 580), Signals and Systems (for ESE 505), and Probability (for CIS 520) will be useful. Applicants that are not exposed to all the above prerequisites, may strengthen their background before taking the corresponding Foundational Course.

Financial Aid

At Penn, M.S.E. students do not receive financial aid. Students are self supported and are encouraged to find their own source of support or financial aid. However, M.S.E. students may be able to find partial financial assistance either as teaching assistants and graders in the Departments of ESE, CIS, and MEAM, or as research staff in a variety of research projects that are under development in the GRASP lab. Such projects can also be used for M.S.E. thesis projects. It should be noted, however, that such forms of partial financial aid is typically possible only after the student has completed one semester of full study at Penn.

5. Rules and Regulations

Grades and Academic Standing

All students in the School of Engineering are expected to maintain a minimum G.P.A. of 3.0 out of 4.0 in their work. A student whose record falls below a B average will be put on academic probation and may be required to withdraw; graduation requires a B average minimum (exclusive of thesis and dissertation grades).

Transfer of Credit Units from Another University

M.S.E. students may obtain credit for up to two courses taken at another institution. These courses are referred to as transfer courses. Transfer courses must be graduate level courses in which at least a grade of B has been earned. Transfer credit will only be considered for courses taken prior to matriculation in the Robotics M.S.E. Program. To obtain credit for courses taken at other institutions, the following procedure must be followed:

- For each transfer course, obtain the course description and the title of the textbook prescribed for the course.
- Identify a professor who teaches a similar course at Penn. If a similar course is not offered at Penn, identify a professor whose areas of expertise are in the general area of the course to be transferred. The professor should certify that the course is of similar level to a graduate course offered at Penn or, if a similar course is not offered at Penn, that the course qualifies for Penn students to take if it were offered here.
- Submit a petition on a standard form (Appendix C) to the GRASP Lab Director. Attach to the petition a copy of the transcript, the professor's certification, and documents and information noted in Appendix C.

In case students have taken some of the core courses at another institution as part of their studies, they can petition to replace a core course with another technical elective course.

Submatriculation

A submatriculant is a University of Pennsylvania undergraduate admitted to a master's program before obtaining the bachelor's degree. The MSE degree is granted after or simultaneously with the bachelor's degree, provided all requirements for both degrees are met. The program is limited to outstanding BSE students with a minimum cumulative grade point average of 3.5 and approval of the Associate Deans for Undergraduate and Graduate Education. Applications to the program must be completed by the end of the junior year. Students may double count credit up to three (3) graduate level courses units (500 or above) taken while a submatriculant for both undergraduate and graduate degrees. The M.S.E. degree may be completed in one to two extra semesters of study. Applications to the program must be completed by the end of the junior year. Submatriculation applications are available in the Office of Graduate Admissions (111 Towne Building).

Full-time Status

All students enrolled in a degree program are required to be continuously registered. To be considered a full-time student, M.S.E. students must be registered for three course units per semester (including thesis research and independent studies). All international students are required to be on full-time status for visa purposes.

Obsolescence:

The maximum time allowed for the completion of all Robotics M.S.E. requirements is

seven years. Course units that are older than seven years may not be counted toward the degree requirements.

Changes in Course Program:

Students may add or drop courses without penalty during a semester if it is done by the deadline listed in the current graduate bulletin. The student's advisor must be informed of the student's decision beforehand and must receive his/her approval.

Doctoral students interested in the M.S.E. Degree

Existing doctoral students in any relevant SEAS department may obtain the M.S.E. degree upon completion of all the degree requirements.

Dual M.S.E. Degree in Two Engineering Disciplines

Students may enroll in a dual degree program and receive an M.S.E. degree in Robotics and any of the other disciplines within SEAS such as Electrical and Systems Engineering, Bioengineering, Mechanical Engineering, Computer Science, Chemical and Biomolecular Engineering, and Materials Science Engineering. The dual degree program requires the completion of at least 17 courses and satisfaction of the M.S.E. requirements of each department in which the student wishes to major. This program typically requires four semesters to complete. To enroll in this program, the student must complete an application form, listing the course plan for both programs and obtain the approval from the Graduate Group Chairman of each department. Applications for this program are available in the Academic Programs Office in 111 Towne Building.

Records

Official graduate student records are kept in 111 Towne Building; transcripts can be viewed on Penn InTouch at <https://sentry.isc.upenn.edu/intouch>. Graduate students are encouraged to periodically check the accuracy of their records and bring any discrepancies to the attention of the GRASP Lab Director.

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