Guide to

Graduate Study in Mechanical Engineering

at

MIT

2017 – 2018 Edition

Department of Mechanical Engineering

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1 The Graduate Program in Mechanical Engineering

The Mechanical Engineering Graduate Program brings together faculty members and post-baccalaureate students into a community of scholars with a common interest in innovation, creativity and advanced professional study. It seeks to provide, in the atmosphere of a professional school, the widest possible opportunity for advanced study and investigation and for intimate association among workers whose common objective is to extend the boundaries of their profession.

All incoming graduate students are invited to take the seminar subject *2.S981: Get 2 Know MechE* that introduces students to various aspects of graduate student life in the MechE Department, MIT, and the Boston area. It meets for 1 hour each week during the Fall term. Students who do not have a confirmed research advisor by Registration Day, and students whose research advisors are based outside the MIT campus (e.g. a hospital or Draper Labs), are *required* to take this seminar class.

The Mechanical Engineering (MechE) Department offers the following graduate degrees:

1. Master of Science in Mechanical Engineering (SMME)
2. Master of Science in Ocean Engineering (SMOE)
3. Master of Science in Naval Architecture and Marine Engineering (SMNAME)
4. Master of Science in Oceanographic Engineering (SMOGE, joint MIT/WHOI degree)
5. Master of Engineering in Manufacturing (MEng)
6. Mechanical Engineer's degree
7. Naval Engineer's degree
8. Doctor of Philosophy (PhD) or Doctor of Science (ScD), which differ in name only; (this includes the joint MIT/WHOI doctoral degrees)

A Master of Science degree is the first graduate degree offered in MechE. It is awarded for the completion of a program of advanced study, together with a thesis that is considered to be the centerpiece of a student's graduate experience.

The Master of Engineering in Manufacturing is a one-year professional degree program that prepares the student to assume a role of technical leadership in the manufacturing industries.

The Mechanical Engineer's degree offers preparation for a career in advanced engineering practice. It does so through a program of advanced coursework that goes well beyond the Master's level. This degree is not a stepping-stone toward the PhD.

The Doctor of Philosophy (or Science) is the highest academic degree offered. It is awarded for the completion of a program of advanced study and a significant original thesis.

In what follows, we describe how students can gain entry to the MechE graduate programs (sections 2 and 3) and what they must accomplish to obtain the various degrees (sections 4–9). Section 10 describes some of the means available at MIT to provide financial support to graduate students. It also describes the rules for off-campus research.

A list of the key dates on the MIT academic calendar can be found here. It includes add/drop dates, degree application deadlines, and the dates by which theses must be submitted.

2 Entrance Requirements

Applications to the Mechanical Engineering (MechE) Graduate Program are accepted from persons who have completed, or will have completed by the time they arrive, a Bachelor's degree. Most incoming students will have a degree in mechanical engineering or ocean engineering. However, the Department's admission criteria are not specific in this regard, and talented students with backgrounds in other branches of engineering or in science may gain entry.

To qualify for a graduate degree, applicants are expected to have at least an undergraduate-level exposure to most of the core MechE disciplines (solid mechanics, dynamics, fluid mechanics, thermodynamics, heat transfer, materials, control, design and manufacturing), and to be familiar with basic electric circuits and electromagnetic field theory. Those who are deemed deficient may be asked to make up courses in certain areas before they graduate. The make-up courses may be at the undergraduate-level *(*in which case they are relatively elementary and usually *cannot be applied toward graduate credit)*, or at the graduate-level (in which case they carry graduate credit).

3 Admission

The method to apply to the Mechanical Engineering Graduate Program is via our online system. See http://meche.mit.edu/academic/graduate/applying/ for more information.

All *official* transcripts must be submitted directly to the MechE Graduate Office, Room 1-112, Massachusetts Institute of Technology, 77 Massachusetts Avenue, Cambridge, MA 02139 but only *after* the student has been admitted.

The processing of applications for graduate study is done entirely by the Department. The MechE Graduate Admissions Officer, together with a faculty committee, reviews all applications, rank-orders them, and admits the number of applicants that the Department expects it can accommodate.

Foreign nationals applying from abroad may be admitted, but are not permitted to register at MIT unless they have full financial support for at least the first year. This can come in the form of a research or teaching assistantship from an individual MIT professor (Section 10 describes how to seek such support), though for many foreign students this support comes from their family, their government, or an international fellowship.

All applicants are required to submit their scores from the General Exam part of the Graduate Record Examination (GRE). Students from non-English-speaking countries are also required to take the IELTS (preferred) or the TOEFL exam. Students whose citizenship is from India are exempt from taking the IELTS or TOEFL exam. The minimum acceptable score for the IELTS exam is 7.0, and for the TOEFL exam it is 100 (ibt), or 577 (pbt).

Applications are due by December 15 of the previous year and decisions are reported in March.

4 Writing Ability Requirement

All incoming graduate students must demonstrate satisfactory English writing ability, or successfully complete appropriate training in writing. This requirement reflects the faculty's conviction that writing is an essential skill for an engineer with an advanced degree.

The MechE Department requires **all** incoming graduate students, native as well as foreign, to take the Institute's Graduate Writing Examination. This exam is administered in the summer before matriculation (http://cmsw.mit.edu/graduate-writing-exam/). Depending on the results, a student will either (*a*) pass the writing ability requirement, (*b*) be required to take a relatively short, but intensive, seminar-workshop in expository writing (21W.794 Technical Writing Workshop) during the Independent Activities Period in January, or (*c*) be required to take a course in writing. Several courses suitable for engineers and scientists are offered at MIT, and special courses are available for those for whom English is a second language.

In addition, MIT requires that all graduate students for whom English has not been the language of instruction in both elementary and secondary school take an English Evaluation Test. This test is separate from the aforementioned Graduate Writing Examination required by the Department. See https://mitgsl.mit.edu/academics-courses/english-evaluation-test-eet for more details.

5 Master of Science (SM) Degrees

The requirements for the Master of Science degrees offered by the Department pertain to (1) writing ability, (2) credit units, (3) thesis, and (4) a distribution requirement in the case of the three Ocean-related Master's degrees. The SMME degree *does not* have a distribution requirement. The specific requirements are as follows:

5.1 Writing ability

Students must successfully fulfill the writing ability requirement described in Section 4.

5.2 Credit units

- Students must successfully complete at least **72 graduate-level credit units** of coursework, not including credit received for (a) 2.S981 (if taken) and (b) thesis work. Following approval by the Graduate Officer and the Institute, certain advanced undergraduate subjects that go beyond the MIT MechE Department's undergraduate degree requirements may be used to satisfy up to 24 units of graduate credit. Approval should be sought prior to taking such subjects.

- The program is expected **to include at least three graduate-level MechE Department subjects (36 units)**.

- Students must take at least **one graduate-level mathematics subject (12 units)** *offered by MIT's Mathematics Department*. No waivers are allowed.

- A minimum grade point average of 3.5 (A=5, B=4, C=3, D=2, F=0) must be maintained in graduate school.

- Students are allowed to transfer credit toward their Master's degree from *graduate subjects* taken previously at MIT or another accredited institution, and *not used as part of the credits required for an undergraduate or graduate degree*. **The limit is 24 credit units** if the subjects were taken outside MIT. Transferred subjects must have a grade of B or higher. No thesis units may be transferred.

5.3 Thesis

In the MechE Department, *the thesis is considered to be the centerpiece of a student's graduate experience*. The student must complete an acceptable SM thesis under the supervision of an MIT faculty member or a Senior/Principal Research Scientist/Engineer who holds an appointment in the MechE Department. The thesis is an original work of research, design, or development. The supervisor signs and accepts the thesis upon completion.

If the supervisor is *not* a member of the MechE Department, a reader who belongs to the MechE Department faculty must also endorse the thesis.

Entering Master's degree candidates

- must notify the MechE Graduate Office, Room 1-112, of their thesis supervisor within six weeks of registration, and

- must submit a completed thesis by a due date set by MIT, typically no later than one week before the beginning of the examination period. All key dates can be found here.

5.4 Distribution Requirements for Ocean-related master's degrees

- **Master of Science in Ocean Engineering (SMOE). A graduate subject in each of the following areas is required:** (*i*) Marine Hydrodynamics (2.20); (*ii*) a subject that emphasizes professional practice in ocean environment, such as Design Principles for Ocean Vehicles (2.22); and (*iii*) a subject in Acoustics and Sensing (e.g., 2.066), or Structural Mechanics (e.g., 2.080J), or Structural Dynamics (e.g., 2.060J).

- **Master of Science in Naval Architecture and Marine Engineering (SMNAME). A graduate subject in each of the following areas is required:** (*i*)

Marine Hydrodynamics (2.20 or a more advanced subject) and (*ii*) at least 24 units in their area of concentration. (Background requirements in Introduction to Naval Architecture (e.g., 2.701) and Ship Power and Propulsion (e.g., 2.611) can be waived if previously taken as an undergraduate; otherwise, these subjects need to be taken at MIT.)

- **Master of Science in Oceanographic Engineering (SMOGE):** The MIT/WHOI Joint Program Handbook for Oceanographic Engineering lists the requirements for this degree. (Please see http://mit.whoi.edu/handbooks for the current handbook.)

* * *

A typical Master's degree consists of six twelve-unit subjects plus a thesis, and takes a full-time student three regular (fall and spring) terms to complete. Students with a research assistantship will not be able to finish in less than this time because of the limitation on the number of subjects they are allowed to take per term (see Section 10). At the same time, there is no reason, other than the uncertainties of research, why they should take longer. The faculty believes that a typical Master's degree in Mechanical Engineering should not take longer than one and a half years (three full terms plus the intervening summer) and will strive to implement this duration in its graduate program.

The Master's thesis is essentially a research (or development, or design) apprenticeship under a faculty supervisor, and as such is usually the major contributor to the student's professional maturation. Incoming students are urged to find a thesis project and supervisor without undue delay. There are several reasons for avoiding delay. For one thing, the SM thesis is a substantial piece of work and takes time to mature. For another, a student who begins thesis work associates him/herself not only with a faculty member, but usually also with a research group or laboratory where s/he meets other faculty and experienced graduate students from whom to learn and get good advice. It is usually a mistake to think that the degree can be attained more efficiently by taking the coursework first, and putting off the thesis work to the last term.

A student's thesis supervisor usually also serves as the academic advisor. If the thesis supervisor is not a MechE Department faculty member, the student should seek academic advice from an MechE faculty member whose research interests are close to his/her own (such as the departmental thesis reader), or from the Graduate Officer.

5.5 Double SM Degrees

- Students registered in **another engineering department at MIT** who wish to earn a Master of Science in Mechanical Engineering, Ocean Engineering, Naval Architecture and Marine Engineering, or Oceanographic Engineering simultaneously with a Master's degree with specification in their own department may do so by satisfying both departments' requirements, with the credit unit requirements satisfied **separately**, but with a common thesis. Such programs of study **must be approved in advance** by the Graduate Admissions Officers of

both the departments involved. A student who had previously applied for, but was denied, admission to the MIT MechE Department is not eligible to get a dual degree from the MechE Department. The Department's procedural requirements are the following: (*i*) A petition for the dual master's degree in the MechE Department must be filled out, and adhered to. The student must be *admissible* to the MechE Department. (*ii*) The student must select a MechE faculty member as a thesis reader. That faculty member must accept this responsibility **by signing the petition**. (*iii*) Items (*i*) and (*ii*) must be completed well in advance of thesis completion, but no later than June 1 of the year *before* the student expects to graduate.

- The preceding also applies to students registered in **Mechanical Engineering** who wish to earn an SMME degree simultaneously with one of the Ocean-Engineering Master's degrees offered by the Department. In this case item (*ii*) above is modified as follows: the MechE faculty member who serves as the thesis advisor must accept this responsibility **by a letter** to the MechE Graduate Admissions Officer, and ensure that all requirements for the dual degree are met.

6 Master of Engineering (MEng) in Manufacturing

The Master of Engineering in Manufacturing is a one-year professional degree program that is intended to prepare the student to assume a role of technical leadership in the manufacturing industries. The degree is aimed at practitioners who will use this knowledge to become leaders in existing as well as emerging manufacturing companies. The requirements for this degree are (1) writing ability, (2) an integrated set of lecture/laboratory-based subjects for a total of 90 credit units, (3) a professional seminar, and (4) a thesis project for 24 credit units. A minimum grade point average of 3.5 must be maintained in graduate school. The following subjects are required, however, exceptions can be made with approval of the MEng in Manufacturing Coordinator.

6.1 Writing ability

Students must successfully fulfill the writing ability requirement described in Section 4.

6.2 The core subject areas (90 units) are

Manufacturing Physics (24 units): 2.810 Manufacturing Processes and Systems; 2.830 Process Optimization and Control.

Manufacturing Systems (24 units): 2.854 Introduction to Manufacturing Systems; 15.762J (ESD.267J) Supply Chain Planning; 15.763J (ESD.268J) Manufacturing System and Supply Chain Design.

Business Fundamentals (18 units): 2.961 Management in Engineering, 2.S982 New Process Development — "Bench to Money".

Product Design (12 units): 2.739J Product Design and Development or 2.744 Product Design.

Restricted Elective (12 units): 2.120 Introduction to Robotics; 2.171 Analysis and Design of Digital Control Systems; 2.675 Micro/Nano Engineering Laboratory; 2.740 Bio-inspired Robotics; 2.76 Global Engineering; 2.821J Selection and Processing of Structural Materials; 15.871 Introduction to System Dynamics; 15.872 System Dynamics II.

6.3 Professional Seminar in Global Manufacturing Innovation and Entrepreneurship (2.888)

6.4 Thesis Project (24 units)

The thesis project is intended to give each student experience in a manufacturing industry, working on problems with both strategic breadth and technical depth. It is an integrating experience to help pull together the diverse topics treated in class. The projects will explore innovations in technology, systems and business strategy.

7 Mechanical Engineer's Degree

The Mechanical Engineer's degree provides an opportunity for further study beyond the Master's level. This degree emphasizes breadth of knowledge in mechanical engineering and its economic and social implications. The Mechanical Engineer's degree is not a stepping-stone toward the PhD.

The overall course of study and thesis *must comprise a coherent program in Mechanical Engineering*. The candidate is required to prepare a plan of study and to submit it to the MechE Graduate Officer for approval by the Engineer's Degree Coordinator. The student will be considered a Mechanical Engineer's Degree candidate when this plan is approved.

The Engineer's degree has four requirements: (1) writing ability, (2) a program of coursework, (3) a thesis, and (4) an oral presentation. These are described below.

7.1 Writing ability

Students must successfully fulfill the writing ability requirement described in Section 4.

7.2 Program of coursework

The requirements are as follows:

- 162 graduate-level credit units (including credited units taken during the Master's degree program and no more than 12 units of credit received for thesis work done under 2.999 (see below)).

At least one subject from six of the following eleven areas:

- Mechanics of Solids
- Materials
- Fluid Mechanics
- Thermodynamics/Heat Transfer
- System Dynamics & Control
- Dynamics
- Design
- Manufacturing
- Nanotechnology
- Energy
- Bioenegineering

- One subject on management/economics as approved by the Mechanical Engineer's Degree Coordinator.

Students entering MIT's Graduate School with a Master's degree are permitted to transfer **no more than 24 units** of graduate credit from another school to the MIT record. No thesis units may be transferred. Subjects being transferred to MIT records should have a grade of B or higher.

7.3 Thesis

The thesis may be an extension of a SMME/SMOE/SMNAME/SMOGE thesis, or it may be a separate piece of work. An important requirement is that the relevance of the thesis work to the solution of real, practical engineering problems be considered, including both its technical and socio-economic aspects. Students are required to submit a thesis proposal to the Mechanical Engineer's Degree Coordinator shortly after embarking on the program. Students who enter the program with an SM degree from another school must do a separate Engineer's thesis.

The thesis work described in the preceding paragraph can be carried out under the subject 2.999 and/or 2.ThG. A student may receive a maximum of 12 units of credit for thesis work done under 2.999 (the student's thesis advisor determining the actual amount of credit) and these credit units may be counted towards the 162 total credit unit requirement. Thesis work done under 2.ThG cannot be counted towards the 162 credit unit coursework requirement.

7.4 Oral presentation

Candidates must make an oral presentation of their Mechanical Engineer's degree thesis work during their final semester of residence. These presentations are usually scheduled in January and May. The students typically make a ~ twenty-minute presentation on the technical aspects of the thesis work including its usefulness in engineering applications in general. The Mechanical Engineering Degree Coordinator should be contacted in order to schedule this. S/he will invite additional faculty members to attend the presentation. Typically there will be 3 faculty members at the presentation not including the advisor. Completion of the degree requires a satisfactory presentation.

8 Naval Engineer's Degree

Naval Engineering is considered to include all the arts and sciences as applied in the design, construction and operation of surface and sub-surface marine vehicles. The Naval Engineer's degree provides an opportunity for further study beyond the Master's level and is intended for those who wish to enter engineering practice, or who plan a career in the design, acquisition, repair, and modernization of ships and ship systems. This degree emphasizes breadth of knowledge in naval engineering and is quite distinct from the PhD, which emphasizes depth and originality of research.

The overall course of study and thesis must comprise *a coherent program in naval engineering*. The candidate is required to prepare a plan of study and to submit it to the MechE Graduate Officer for approval by the Naval Engineer's degree Subcommittee. The student will be considered a Naval Engineer's degree candidate when this plan is approved.

8.1 Writing ability

Students must successfully fulfill the writing ability requirement described in Section 4.

8.2 Credit units

The credit requirements are as follows:

1. 162 graduate-level credit units (including credited units taken during the Master's Degree program and no more than 12 units of credit received for thesis work done under 2.999 (see below)).

2. At least one subject from eight of the following eleven areas (subjects from various MIT departments are normally taken to satisfy this requirement):

   - Mathematics & Numerical Methods
   - Dynamics
   - Hydrodynamics
   - Materials & Fabrication Technology
   - Power and Propulsion
   - Probability & Statistics
   - Structural Mechanics
   - Acoustics
   - Ship Production
   - Naval Architecture & Systems Engineering
   - Ship Design

3. Ship design is an integral part of the Naval Engineer's Degree curriculum. Candidates are required to complete both a conversion design project (2.704) and a 24-credit new design project (2.705) during their course of study.

8.3 Thesis

Students must complete a thesis that demonstrates the educational maturity and breadth expected of candidates for this degree. An important requirement is that the thesis deal with the solution of real, practical engineering problems, including both their technical and socio-economic aspects. It must be at least equivalent to an advanced master's thesis, and may be an extension of a suitable applications-oriented SMME/SMOE/SMNAME/SMOGE thesis, or it may be a separate piece of work. Students who enter the program with an SM degree from another school must do a separate Naval Engineer's thesis. Students are required to submit a specific thesis proposal to the Naval Engineer's Degree Subcommittee shortly after embarking on the program.

The thesis work described in the preceding paragraph can be carried out under the subject 2.999 and/or 2.ThG. A student may receive a maximum of 12 units of credit for thesis work done under 2.999 (the student's thesis advisor determining the actual amount of credit) and these credit units may be counted towards the 162 total credit unit requirement. Thesis work done under 2.ThG cannot be counted towards the 162 credit unit coursework requirement.

8.4 Qualifying examination

Candidates should take the Naval Engineer's degree qualifying examination during their first year of residence. These exams are given by the Naval Engineer's Degree Subcommittee, usually in January and May. The examination is an oral one in which the students make a twenty-minute presentation of their thesis proposal and work to date, placing approximately equal emphasis on the technical aspects of the work and on its usefulness in engineering applications in general. Questions on the thesis and related areas will be asked, and the Subcommittee will render its judgment based on both the technical content of the work and its utility in engineering practice.

The qualifying examination for the Naval Engineer's degree may be waived for candidates with either 3 years military or 5 years industrial post-Bachelor's Degree experience, and with concurrence from the MechE Graduate Officer.

9 Doctoral Program (PhD/ScD)

The highest academic degree is the Doctor of Science, or Doctor of Philosophy. At MIT, these degrees differ in name only. The doctorate is awarded upon the completion of a program of advanced study, principally at the Institute, and the performance of significant original research, design or development.

9.1 Admission into the doctoral program

1. Students from outside MIT may apply to the doctoral program if they will have completed a master's degree in engineering by the time they enroll for the PhD; see Sections 2 and 3.

2. Students who are in the MechE Department's SM program, and wish to continue for a PhD, will automatically be enrolled in the doctoral program effective the day on which they submit their master's thesis provided they have maintained a cumulative GPA of 4.5 or better in graduate-level subjects at MIT.

All students must take and pass the doctoral qualifying examinations according to the timeline given below. A student is considered to be a (qualified) candidate in the doctoral program upon passing the qualifying examinations.

9.2 Requirements for a doctoral degree

The five basic requirements for the doctoral degree are:

(1) the writing ability requirement, which all graduate students must satisfy;

(2) the doctoral qualifying examination;

(3) a major program of advanced study;

(4) a minor program of study in a field different from that of the major; and

(5) a thesis.

Details of the five basic requirements are given below, followed by the rules (procedure, schedules, etc.) that pertain to the doctoral program.

9.2.1 Writing ability requirement

Students must successfully fulfill the writing ability requirement described in Section 4.

9.2.2 Doctoral qualifying examination

The purpose of the doctoral qualifying examination (QE) is to determine whether the applicant possesses the attributes of a successful doctoral candidate at MIT: mastery of the mechanical/ocean engineering disciplines coupled with ingenuity and skill in identifying and solving unfamiliar problems.

Students who entered the MechE graduate program prior to Fall 2015 must take the QE (for the first time) before the end of three regular semesters (fall and spring) after admission to the PhD program. For students who entered in Fall 2015 (and thereafter): a student whose highest degree (at entry to the graduate program) is a Bachelor's degree, must take the QE (for the first time) no later than the end of 5 regular semesters (fall and spring). A student entering the graduate program with a Master's degree must take the QE no later than the end of 3 regular semesters (fall and spring).

In rare and extraordinary circumstances, a student may be granted one extra semester, but only by prior petition to the Graduate Officer.

The QEs are offered twice yearly (January and May) over a one-week period. In order to be eligible to take the QE the student must have maintained a cumulative GPA of not less than 4.5 in the MIT graduate program. In addition, the candidate must have obtained at least 2 A's and 1 B in graduate-level MechE Department classes at MIT[1].

The QE consists of three components: (A) two subject area examinations exploring the student's breadth of knowledge in selected MechE disciplines, (B1) a third subject area examination exploring the student's depth of knowledge in the student's chosen area of research, and (B2) an examination of the student's research skills. The latter two examinations, B1+B2, are blended into one, and conducted together in the same setting, but are graded separately.

Specifically, the student will take:

(A) Two Oral Qualifying Examinations (OQEs) on Day 1, each consisting of a 30-minute oral examination in two core subject areas selected by the candidate (from an approved list), and

(B) One Research Qualifying Examination (RQE) on Day 2, consisting of one 60-minute oral examination in the student's field of research (see list below) that explores the student's research skills and depth of domain knowledge in the related disciplinary area.

The student must pick 3 *distinct* qualifying examination areas from the approved list of subject areas below, choosing at least 2 from the C (core)-List and not more than 1 from the S (specialized)-List. This choice must be made when the student applies to take the QE. If the student has selected 1 subject area from the S-List, the RQE must be in that field. If all 3 subject areas have been selected from the C-List, the student must indicate the one that the RQE is to be in. New subject areas may be added to these lists with one semester's advanced notice; existing subjects may be removed, but only with a minimum of two year's notice.

During the RQE the student will make a ~ 20-min presentation of his/her original research (such as work for a previously completed SM thesis (at MIT or elsewhere) or initial work at MIT towards a doctoral thesis); respond to questions on that research for ~ 15 minutes; and subsequently answer questions for ~ 20-mins in the broader subject area corresponding to the chosen research field (within the bounds of the content spanned by the corresponding graduate subject(s) noted in the C/S-list below). The student's research skills and depth of knowledge in the research subject area will be graded separately, with one grade for research skills (B2) and another for the depth of knowledge (B1).

At least 2 weeks before the RQE, the student must provide the Graduate Office with a brief one-page (~ 100 words) abstract of the research presentation. This will help the faculty participating in the RQE anticipate and prepare for the specific knowledge domain(s) that will arise during each student's exam.

[1] Exceptions may be granted by the Graduate Officer in the case of an incoming student with an SM degree, who may want to take the QE after one semester at MIT.

The MechE Department faculty as a whole review and discuss each student's performance in the qualifying examinations, together with their GPA and other holistic aspects of their performance in the graduate program at MIT, and make decisions regarding passing, being allowed to repeat the exams, or failing.

A student who passes the research skills part of the RQE, as well as passes any 2 (or more) of the 3 subject area examinations, would pass the doctoral qualifying examination.

A student who does not pass the doctoral qualifying examination may be permitted to retake all or part of the exam. They must do so the next time the exams are offered. **In no case is a candidate allowed to repeat more than once**.

Feedback will be provided to the student after the results of the exam have been decided upon.

Subject specific information on the qualifying examination can be found in the document "Qualifying Exams: Guidelines and Formats" available from the MechE Graduate Office.

Core subject areas: C-List

The subject or subjects most suitable for preparation for these exams are included in parentheses.

Fluids (2.25) *or* Hydrodynamics (2.20), *not both*

Solid Mechanics (2.071) *or* Structures (2.080J), *not both*

Thermodynamics (2.42)

Heat Transfer (2.55 or 2.51+2.52J)

Manufacturing (2.810)

Dynamics (2.032)

Machine Design (2.72 or 2.77) *or* Product Design (2.744 or 2.739J), *not both*

System Dynamics & Controls (2.140 and 2.151)

Stochastic Dynamical Systems (2.122)

Micro and Nano Engineering (OQE: 2.37 RQE: 2.37 or 2.675)

Specialized subjects/fields: S-List

Optics (2.71 or 2.717)

Acoustics (2.066)

Computational Engineering (2.097J or 2.29)

Biomechanical Engineering (2.795J or 2.798J)

9.2.3 Major

The major is a program of advanced study which gives the candidate both depth and breadth in a field of engineering or science approved by the student's thesis committee and the Graduate Officer. *Examples* of the major areas of some current students are: Biomedical Engineering, Computational Engineering, Design of Mechanical Products, Dynamical Systems, Interfacial Engineering, Materials, Nano-engineering, Ocean Acoustics, Renewable Energy & Water, and Robotics. The choice of area should be discussed with Graduate Officer.

The set of major subjects should bring candidates to the state of the art in their chosen field, insofar as that is possible via coursework. Candidates must satisfy their Doctoral Committee and the Graduate Officer that their proposed program meets this intent. The major represents the principal component of the candidate's coursework.

The program of study comprised of the major, minor, and additional supporting subjects will typically consist of **at least 144 graduate-level credit units** (12 subjects). Graduate-level subjects taken toward a Master's degree may be used to satisfy the requirements of the doctorate. Graduate-level subjects taken at another graduate school may also be counted toward the MIT doctorate, if approved by both the Graduate Officer and the candidate's thesis committee. The limit is 72 credit units for subjects taken outside MIT.

9.2.4 Minor

The minor is a program of advanced study that develops competence in an area different from the candidate's principal field of interest. Three subjects (not less than 24 units) must be taken in a coherent field different from the major. These subjects may be taken inside or outside the Department.

If the minor is in an area of mechanical engineering or in mathematics, all three subjects must be at the graduate-level. In other fields, some undergraduate subject content may be acceptable, depending on the remoteness of the field from mechanical engineering and on the prerequisites required for graduate subjects.

Students who have a Bachelor's or Master's degree in a field distinctly different from mechanical engineering may receive complete or partial credit toward the minor. With this exception, all minor subjects must be taken while the student is registered in graduate school.

The minor program must be approved ***in advance*** by the student's thesis committee and by the Graduate Officer, who places on file a record of the anticipated program as soon as it is formulated. Any subsequent modifications must have the Graduate Officer's approval. A minimum grade point average of 3.5 must be attained for the subjects that comprise the minor.

9.2.5 Doctoral Thesis

The thesis is a major, original work that makes a significant contribution in its field. It is the principal component of the doctoral program, and the part that serves as the major indicator of a candidate's abilities.

The thesis is supervised by a faculty advisor and monitored by a doctoral thesis committee, which must include at least three MIT faculty members (including their advisor), and at least two of the three MIT faculty members must be MechE faculty.[2] The doctoral committee is usually chaired by the thesis advisor, unless the advisor is not a member of the MechE faculty, in which case a MechE faculty member must chair the committee. *At least one of the committee members must be from outside the research group with which the candidate is associated*. The candidate may also invite qualified people from outside the MIT faculty to serve as additional members of the committee.

Work already accomplished elsewhere, not under the supervision of a member of the MIT faculty, cannot be accepted in full or partial fulfillment of the thesis requirement.

9.3 Rules and procedures of the doctoral program (post-qualifying examination)

A student is considered to be a (qualified) candidate in the doctoral program upon passing the qualifying examinations. The candidate is responsible for initiating the various parts of the program and for keeping his/her **Online Doctoral Program Record** (informally called the "online History Card") up to date; this may be found on the MechE Department website by navigating to Online Grad Card from the bottom of any page of the MechE website http://meche.mit.edu. The doctoral program should be undertaken as follows:

1. The candidate selects a field of principal interest, finds a faculty member who is willing to act as **thesis advisor**, and defines, at least tentatively, an area of research for the thesis. If the advisor is not in the MechE Department, the student must also find a faculty member from within the Department who will act as **doctoral committee chair**.

2. The candidate must **meet with the Graduate Officer**, in person, within one year of passing the qualifying examination. Topics to be discussed will include the tentative choice of thesis committee members along with the programs of study for the major and minor.

[2] Senior or Principal Research Scientists and Engineers **who hold an appointment in the Mechanical Engineering Department** may supervise PhD students.

3. As soon as possible after that, and under no circumstances later than the end of the first year after passing the qualifying examinations, the student must form the **thesis committee**, having obtained *prior approval* of the membership from the thesis advisor and the Graduate Officer. The names of the committee members should be entered on the online History Card.

The committee is formed according to the Section 9.2.5 Doctoral Thesis (above). In recruiting the most appropriate members for the thesis committee, it is often helpful (but not required) for the candidate to have a written document (a rough "pre-proposal") describing preliminary ideas for the thesis research. The doctoral committee, together with the thesis advisor, will be the student's primary source of advice and guidance. They will monitor and guide the research and act as mentors in the selection of the major, minor, and additional subjects as the student's education evolves.

4. As soon as possible after forming the thesis committee — and under no circumstances later than the end of the first year after passing the qualifying examinations — the student must have a **doctoral thesis proposal** in place.

This is a proposal, not a summary of the doctoral thesis. It represents a plan for work, rather than a binding contract; the actual work will be guided and reviewed by the thesis supervisor and the thesis committee, and may evolve in unexpected directions. The purpose of the proposal is to let the faculty know what the candidate intends to do, and how s/he intends to go about it. It should provide sufficient literature citations to indicate awareness of the broad field and previous work, and enough detail to show how the work is expected to advance the state-of-the-art. The proposal is typically limited to *six pages* of text and figures (not including the cover page).

The one-page cover should (only) include: tentative title of the thesis, student's name, brief abstract, keywords, and a list of the committee members indicating the Chair and/or Advisor, their official titles, departmental affiliations and email addresses.

The candidate must provide the Graduate Office with electronic and hard copies of the complete thesis proposal, *and* a separate electronic copy of the cover page only. Once these have been submitted, it should be so recorded on the online History Card.

The Graduate Office will distribute copies of the cover page with the abstract to all MechE faculty. The full thesis proposal will be made available to any MechE Department faculty member who requests it. Feedback from the faculty should be welcomed and taken constructively.

5. As soon as possible after forming the thesis committee — *and under no circumstances later than the end of the three regular semesters after passing the qualifying examinations* — the student must have in place a proposed program of study for the **major and minor**.

The candidate must get approval of their major and minor list of subjects from the doctoral committee at its first meeting. It must then be submitted for review and approval

to the Graduate Officer. The programs of study for the major and minor should be entered on the online History Card. Subjects may be added to, or taken out of, these programs with the approval of the thesis committee and Graduate Officer.

6. The candidate shall arrange **regular meetings with the doctoral committee** and obtain the committee's comments on his/her work. It is recommended that the thesis committee meet at least once each regular semester (fall and spring); the Department requires that the committee meet at least once each year. The chair of the committee should make a notation of each meeting on the online History Card together with a brief summary of the student's progress. A student whose progress is unsatisfactory may be required by the Department, upon a suitable recommendation (typically a U-grade for thesis research) from the student's Thesis Advisor/Thesis Committee, and/or MechE Graduate Officer, to withdraw from the doctoral program.

7. When the thesis is completed, it shall be presented orally in an **open meeting** of MIT faculty, staff, and students. After the presentation, the thesis is either accepted or rejected **by the thesis committee and any other departmental faculty members present**. The faculty signatures and result should be entered on the online History Card.

The thesis presentation is to be scheduled by the doctoral candidate. The student is responsible for obtaining a time and place for the presentation, and for arranging through the Graduate Office to send an announcement of the presentation to the departmental faculty. ***The thesis defense must be scheduled and announced at least two weeks in advance***. One copy of the thesis must be delivered to the Graduate Office, and one copy should be delivered to each member of the doctoral committee ***at least two weeks prior to the presentation***. The copy in the Graduate Office will be available for the faculty at large.

A student whose thesis defense is scheduled during the summer must provide the Graduate Office with a list of at least 6 MIT faculty members (including Principal/Senior Research Scientists/Engineers) who have expressed the intent of being present at the defense. The 6 faculty members may include the MIT members of the student's thesis committee all of whom are expected to be present.

The thesis must be defended, and the candidate must submit final, archival copies of the thesis to the Graduate Office, by an end-of-term due date established by MIT (see the Graduate Office). If this deadline is not met, the thesis cannot be accepted in the current term.

The key dates and timeline described above are summarized on the next page.

Key dates and timeline

When each of the milestones listed here has been achieved, this information should be recorded in the student's online History Card.

• **During 1st term after qualifying**	➢ Identify thesis advisor (and if needed the Thesis Committee Chair). ➢ Identify general area of thesis research.
• **Within 1 year of qualifying**	➢ Meet with Graduate Officer to discuss tentative plans for membership of the Thesis Committee, major & minor curricula.
• **Within 1 year of qualifying**	➢ Form *Thesis Committee after* getting prior approval of the membership from thesis advisor and the Graduate Officer. ➢ *Write thesis proposal (up-to 6 pages).* After obtaining committee approval, submit the proposal and an abstract to the Graduate Office. The Graduate Office will circulate it to the Department faculty.
• **Within 3 regular semesters of qualifying**	➢ Obtain Thesis Committee's and Graduate Officer's approval *of major & minor curricula.*
• **Once each regular semester (fall & spring)**	➢ Meet with Thesis Committee. ➢ After each meeting Thesis Committee Chair to record progress on online History Card.
• **At least 2 weeks prior to Defense Date**	➢ Student to schedule defense and inform Graduate Office so they can announce it.
• **At least 2 weeks prior to Defense Date**	➢ *Give copy of thesis (draft)* to Thesis Committee and Graduate Office.
• **Immediately after Defense**	➢ Thesis Committee and other department faculty members (present at defense) to sign hardcopy of History Card and record the result.

A list of the key dates on the MIT academic calendar can be found here. It includes degree application deadlines, and the dates by which theses must be submitted.

9.4 Interdisciplinary doctoral programs

Graduate students registered in the Department of Mechanical Engineering may elect to participate in several interdisciplinary doctoral programs of study including those listed below. Students must fulfill all of the MechE Department requirements as described above, and in addition satisfy the specific requirements of the particular interdisciplinary program. The interdisciplinary programs currently available include the following.

9.4.1 Computational Science and Engineering (CSE)

The Computational Science and Engineering doctoral program allows students to specialize in a computation-related field of their choice through focused coursework and a doctoral thesis. The emphasis of the thesis research is on the development of new computational methods and/or the innovative application of computational techniques to important problems in engineering and science. This program is administered jointly by the MechE Department and the Center for Computational Engineering, and students receive a doctoral degree in Mechanical Engineering and Computation. For more information see http://computationalengineering.mit.edu/cse.

9.4.2 Joint Program with the Woods Hole Oceanographic Institution

The Joint Program with the Woods Hole Oceanographic Institution (WHOI) is intended for students whose primary career objective is oceanography or oceanographic engineering. Students divide their academic and research efforts between the campuses of MIT and WHOI and receive a degree in Oceanographic Engineering. The program is described in detail at http://mit.whoi.edu/.

9.4.3 The Program in Polymers and Soft Matter (PPSM)

The Program in Polymers and Soft Matter offers students an interdisciplinary core curriculum in the science and engineering of polymers, gels and other soft matter systems. Fields of research include functional polymers, gels, surfactants and colloids, controlled drug delivery, nanostructured soft materials, polymers at interfaces, biomaterials, molecular modeling, polymer synthesis, biomimetic materials, polymer mechanics and rheology, self-assembly, and processing of complex fluid systems. For more information please see the PPSM website http://polymerscience.mit.edu/.

10 Financial Support and Thesis Supervision

10.1 Types of financial aid available

The Mechanical Engineering Department offers three types of financial assistance to graduate students: fellowships, research assistantships, and teaching assistantships.

A fellowship provides students with a direct grant, and leaves them open to select their own research project and supervisor. A number of students in the Department are

supported by fellowships from outside agencies, and a few are available from MIT. However, the Department itself has relatively few fellowships to offer.

The majority of students in the MechE Department are supported by research assistantships, which are appointments to work on particular research projects with particular faculty members. The faculty members procure research grants for various projects, and hire graduate students to carry out the research. The research is almost invariably structured so that it becomes the student's thesis. A fulltime RA appointment provides a full tuition scholarship (i.e. covers all tuition) plus a salary that is adequate for a single person. In return for a fully funded education, RAs are required to do a certain amount of work for the grant that funds them. In most cases, this work becomes the student's thesis project. Consistent with this requirement, *an RA may register for no more than 24 units of classroom work* (typically two subjects) per regular term, and must do at least the equivalent of 24 units of thesis work (i.e. research on the project) per term. The summer term is usually spent on thesis work.

Teaching assistants are appointed to work on specific subjects of instruction. As the name implies, TAs usually assist a faculty member in teaching, often grading homework problems and tutoring students. In the Mechanical Engineering Department, TAs are seldom used for regular full-time classroom teaching. *TAs are limited to 24 units of credit per regular term, including both classroom subjects and thesis*. A TA appointment usually does not extend through the summer.

Experience has shown that the optimum graduate program consists of about equal measures of coursework and research, consistent with an RA appointment. One advantage of a fellowship is greater freedom in choosing a research project and supervisor. Another is that, unlike an RA, a fellowship student is not limited to two courses per term, and may therefore be able to finish a degree in a somewhat shorter time.

A teaching assistantship gives the student teaching experience and can also be extremely valuable for reviewing basic subject material: for example, in preparation for the doctoral general exams. It does not, however, leave much time for thesis research, and may extend the time that the student will need to complete a degree.

10.2 How to get a research assistantship or teaching assistantship

Once a student is formally admitted to the Department, s/he is eligible for an assistantship. At this point it helps to understand how the funding of graduate research works in MIT's Engineering School. The faculty write proposals for specific research, and when they receive funding, they hire graduate Research Assistants to do the research with/for them. The MechE Graduate Office distributes a list of admitted students to all MechE faculty members, noting each student's interests, previous university affiliation, grade point average, etc. Many faculty select candidates from this list for the positions they have available. (See also the paragraph after next.) They make their final selections after reviewing the students' application files. At that point, they contact a student, with a specific offer for a research assistantship. A particular student may get offers from several professors, in which case he/she has to make a choice about which one to accept.

The graduate research enterprise is thus somewhat like a free enterprise system, with the individual professors looking for the best students for their research projects and the students looking for the most interesting or satisfying research experience.

What can students who have just been accepted do to improve the chances in this process? The first step is to carefully read the research areas as listed on the MechE website http://meche.mit.edu. From these areas students can identify the faculty members they would like to work with, and should not hesitate to write, e-mail, or telephone them; they should not be shy about making the professors aware of any special qualifications that they (the students) might possess (previous research experience, etc.).

Students seeking research assistantships should be aware that many, if not most, commitments are made after April 15. Positions become available through the spring and summer, depending on when the research grants come in, and a significant fraction of new research assistantship offers are made after the beginning of the fall term. Most graduate students end up with funding by the end of their first term.

Teaching Assistantships are relatively few in number, and are usually offered to students who are already at MIT and known to the departmental faculty. A student who has a keen interest in serving as a TA in a particular subject can make it known by contacting the faculty member in charge (listed in the MIT Bulletin under the description of each subject).

10.3 How to find a thesis supervisor if you have independent funding

Students who have fellowships or are privately funded need to associate themselves with a faculty member who will supervise their thesis research. They should choose a supervisor in much the same way as another student would try to secure an RA, identifying prospective faculty members and checking whether there are projects they can work on. Research requires money, and even though these students require no salary from the Department, they are well advised to find a supervisor who has some funding for the intended work. Although their obligations to the research are not the same as those of an RA, in practice they end up working just as hard in order to finish their theses in a reasonable time. It is usually a good idea to associate with a supervisor as soon as possible after arrival at MIT. The student then becomes part of a research group, gets a desk to work at, and is in a position to get advice and learn from his/her supervisor and from the more experienced students in the research group.

10.4 Students with advisors outside the MechE Department

A student whose research advisor is not a member of the Mechanical Engineering Department, must also choose an academic advisor from within the MechE Department. (See also Section 10.5.) This should be arranged in consultation with the research advisor and should be in place before the start of the student's second semester at MIT. The academic advisor could, for example, be the thesis reader for a Masters student and the thesis committee chair for a PhD student. S/he can provide guidance on taking classes, preparing for the doctoral qualifying examination, changes in Department policies, etc.

10.5 Students conducting their research at a site off-campus

If a significant part of the student's research is done off campus (e.g. at a hospital, Draper Lab, Lincoln Labs, etc.,), then both of the following conditions must be fulfilled:

(a) The student must have a MechE faculty co-advisor from day-1 with whom the student meets, at least once a term, to describe to him/her the research progress. A MechE faculty co-advisor is required even when a student (doing off-site research) has a MIT faculty co-advisor who is not a MechE faculty member. This involvement need not lead to the MechE faculty co-advisor being a co-author on any publication.

(b) The off-campus supervisor must submit to the MechE faculty co-advisor and the Graduate Office, a short description of the project and expectations of the student. The MechE faculty co-advisor needs to be comfortable with that plan before the student starts any off-campus research. Each year thereafter, the off-campus supervisor must submit a report to the on-campus advisor describing the progress to-date and the path ahead.

Additional MIT requirements are described at the website of the Office of the Dean for Graduate Education (ODGE): https://odge.mit.edu/gpp/degrees/

10.6 Rules for students who do nonresidential doctoral thesis work off-campus

All such students are required to have a MechE faculty member as either thesis supervisor or co-supervisor, and must have completed all requirements other than the thesis. (This includes having passed the doctoral qualifying examination, having submitted a thesis-committee-approved thesis proposal, and having the student's major and minor programs of study approved by the student's doctoral committee and the Graduate Officer.) Prior to embarking on work away from campus, a student must submit to the Graduate Officer a plan for finishing the degree, including thesis topic, timetable of academic courses at MIT, timetable of planned non-residential periods, and names and coordinates of off-campus supervisors. Both the thesis advisor and the Graduate Officer must approve the plan by signature. Students with off-campus co-supervisors (SM as well as PhD candidates) must arrange joint meetings with both their on- and off-campus supervisors at least once every regular term during this period of non-residency.

Additional MIT requirements are described at the website of the Office for Graduate Education (OGE): https://odge.mit.edu/gpp/degrees/thesis/nonres/