

MIT Department of Nuclear Science and Engineering

Doctoral Degree Requirements

Coursework Requirements

Core Modules: 22.11, 22.12, 22.13, 22.14, 22.15, 22.16.

Students may take the coursework, or may register as listener and take only the final exam. Students must complete all core module final exams by the end of the fourth term, and are allowed one re-take. A final exam gpa of 4.5 is needed to clearly pass the written qualifier. A final exam gpa of 4.0-4.5 will require a faculty review prior to the student embarking on doctoral research. Students earning a final exam gpa under 4.0 will not be permitted to progress further in the doctoral program.

Early Module Exams

First-year students are encouraged to petition to take early module exams for any modules in which they have a sufficient amount of prior coursework or research experience with the subject material. Eligibility for the early module exams will be decided by the module instructor, however students may use the syllabus and the self-evaluation material to evaluate whether to petition.

Early Module Exams:

- Are conducted prior to the term in which the module is offered (August for Fall modules; January for Spring modules)
- Results will be communicated prior to Registration Day
- Are only available to students during the first academic year
- Do not count toward the two allowed attempts at the module final exams

Field of Specialization Subjects (36 units)

- Nuclear Reactor Engineering: 22.211, 22.312, and one of (22.39, 22.313, or 22.315)
- Nuclear Reactor Physics: 22.211, 22.312 and one of (22.212, 22.213, or 22.251)
- Nuclear Materials: 22.71, 3.20 (thermodynamics) and one of (22.72, 22.73, 22.74, 22.76 or 3.21 (kinetics))
- Fusion - Plasma Physics: 22.611, 22.62, and one of (22.63, 22.612, 22.615 or 22.67)
- Fusion Engineering: 22.611, 22.62 and one of 22.211 (neutronics), 22.71 or 22.74 (materials) or 22.312 (engineering)
- Quantum Science and Engineering: 22.51, 8.511 and one of (22.52, 8.333, or 8.421)
- Nuclear Security and Policy: 6.3702 (formerly 6.431), 22.90, + one specialist subject by petition

A minimum GPA of 4.0 is required for the Field of Specialization. A FoS GPA of 4.0-4.5 will require review by the faculty prior to embarking on doctoral research; students achieving above 4.5 or higher will automatically fulfill this requirement.

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Fields of specialization not on this list must be approved by the NSE Graduate Committee. Students can begin taking field-of-specialization subjects as early as their first graduate term, and will typically have completed at 1-2 by the end of their first year.

When submitting a petition for a change to the Field of Specialization (FoS), please be sure to include:

- 1) whether you are requesting a substitution of a single course in an existing FoS or proposing a unique FoS. A unique FoS might entail different oral examination questions, while a substitution will not;
- 2) all subjects that will be in your Field of Specialization (number, name) with a brief description of the courses if they are not already included in any existing FoS;
- 3) the justification for the change, including any potential external circumstances that prevent taking a regular FoS and how each proposed subject supports your research area and/or FoS topic; if requesting a unique FoS, define the proposed FoS and the rationale for why a unique FoS is needed (as opposed to a departure from an existing FoS).

Advanced Subjects (24 units)

- Must be an approved program of **two advanced subjects** (24 units) that are closely related to the student's doctoral thesis topic
- Must complete with an average grade of B or better
- None may overlap with Field of Specialization requirement.
- Subjects may be from a different Field of Specialization list (as long as they do not overlap with the student's FoS subjects).
- Must be approved as part of the doctoral thesis prospectus.

Minor Subjects (24 units)

- Must complete at least 24 units of coordinated subjects outside the field of specialization and the area of thesis research
- Must consist of at least two graduate subjects or three undergraduate subjects
- Undergraduate subjects used to fulfill the minor requirement must be taken while registered as a graduate student in the department
- Must be approved as part of the doctoral thesis prospectus.

Research, Thesis and Seminar

- Must register for research, 22.94, each term after joining a project until the term in which the thesis prospectus is submitted, after completing the qualifying process.
- Must register for thesis (22.ThG) and the Graduate Seminar (22.911), each term starting in the Fall of/after the doctoral thesis prospectus is submitted, until the term in which the student intends to defend. During the semester in which a student defends, the student should register for 22.ThG, but not 22.911.
- A student's final semester is determined by the submission of their final thesis document, not the semester in which they defend. Students who miss the thesis submission deadline for the degree list must continue to register for 22.ThG until the thesis is completed.

Non-Coursework Requirements

Oral Examination

- Must be passed by the end of the fourth graduate term, in order to embark on doctoral research.
- The Student Research Component of the Oral Exam will be scheduled by the student, within the time frame defined for the cycle in which they are taking the Oral Exam.
- The Faculty Prepared Component of the Oral Exam will be scheduled by the Qualifying Process Coordinator.
- There will be two exam cycles annually, defined by the Qualifying Process Coordinator with approval from the faculty. Dates will be communicated during the sign-up process, or students may contact the Academic Office.
- Two attempts are permitted.
- To qualify: cumulative gpa of 4.0 or higher.
- Recommended: take all of the core module final exams prior.
- Recommended: pass at least two of the three field of specialization subjects.

The purpose of the oral is to examine:

- the student's ability to think logically, express a point of view, and defend it orally;
- the student's knowledge of a specialized field of research;
- the student's knowledge of the technical foundations of the field of research, including the ability to make connections and integrate across those foundations.

The oral examination consists of two parts, each of which lasts one hour.

Oral Examination

- **Student Research Component:** the student will present a 5-10 page original paper prepared in advance and submit it to the examining committee no less than 10 days prior to the student-scheduled Part I exam. The paper should review a field of research, critique it, and formulate a research plan to approach a specific problem in the chosen field. The examining committee will evaluate the content of the paper, the student's understanding of it, and the quality of the presentation.

This paper will have some similarities to a thesis prospectus, but the problem described will not necessarily turn out to be the student's doctoral thesis problem. If the student has previously carried out a SM thesis, the paper could describe that work. Topics to be explored in the paper and in the examination will include the student's identification of open questions in the research field, the significance of the particular research problem selected by the student, and the proposed approach to the problem, including criteria against which research progress could be judged.

- **Faculty Prepared Component:** the examining committee will ask questions designed to examine the student on her/his broad knowledge within the field of specialization. The committee will have wide discretion in leading the student to explore areas where she/he should have technical background.

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- The oral examination committee will consist of at least four members. At least three members should be NSE faculty members or senior scientists. The chair should be a member of the NSE faculty but may not be the student's research advisor.
- The committee will assign a grade of *pass*, *marginal performance*, or *fail*.
- The chair of the committee will provide feedback to the student shortly after the oral examination. If the student receives a grade of *marginal performance* or *fail*, at least one other member of the committee will also provide feedback.

Petitions

Students wishing to pursue a unique field of specialization, who wish to make changes to their advanced or minor subject plan as submitted in their thesis prospectus, or who require an adjustment to the time limit or gpa requirements because of extenuating circumstances, may submit a petition to the Graduate Chair.

Threshold Requirements for Undertaking Doctoral Research

By the end of the fourth term:

- Passing grade in the oral examination
- Core Module Final Exam GPA of 4.5 or higher.
- Field of Specialization GPA of 4.5 or higher.
- A GPA of 4.0-4.5 in either category will require faculty review; below 4.0 will not be permitted to embark on doctoral research.

The NSE faculty will meet twice a year to review the performance of doctoral students. These meetings will take place shortly after the oral examinations are concluded.

Doctoral students who switch to a master's degree program as their final NSE degree, and fall short of the 48 unit (NSE unit) requirement because they did not take the modules for course credit, but instead passed the early exams or final exam while taking the class as a listener, can submit a petition to the Graduate Committee for adjusted master's degree requirements. If approved, the master's degree will have a reduced NSE unit requirement (36 units instead of 48) if a minimum of 4 module exams have been passed. This does not reduce the total unit requirement of 66 units. Up to two of the NSE module exams the student has passed (as early exams or listener) can also count toward the 2 module requirement for the master's degree. Students will consult with the Graduate Officer by way of submitting a petition, in order to implement these conditional requirement changes, with verification from the Academic Administrator that the student meets the appropriate conditions needed for eligibility.

Students who have passed the qualifying exam may register for thesis in the term in which the exam was given, or the following term. The Thesis Prospectus is due during the first term of thesis registration. Students registered for doctoral thesis must also register for the Doctoral Seminar, 22.911, starting from the Fall term following completion of the qualifying exam.

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Thesis and Doctoral Research

General Institute information relating to theses for advanced degrees is to be found in the ODGE Graduate Policies and Procedures Manual: <http://odge.mit.edu/gpp/degrees/thesis/>.

Students are advised to speak to NSE faculty and/or research scientists engaged in research in areas of interest to them to explore possible thesis topics. A student should select a research advisor and, together, work out a proposed program of thesis research. In some cases, joint thesis advising by more than one faculty member may be appropriate. The program must be approved by the Department before research may be initiated (see **Thesis Prospectus**, below.)

Doctoral research may be undertaken in nuclear science and engineering or in a related field of research, and may be primarily theoretical or experimental, or can combine both approaches. Either the research advisor or the reader must be a faculty member of the Nuclear Science and Engineering Department.

Department Regulations for Research Advising – eligibility for research advising:

- **NSE FACULTY** (NSE faculty; NSE faculty emeritus; NSE professor of practice; faculty having dual and joint appointments with other departments).
- **Non-NSE MIT Faculty and NSE (and affiliated labs — PSFC and MITR) Senior and Principal Research Scientists/Engineers.** This case requires an NSE faculty member as a thesis reader.
- **Visiting Professors, NSE (and affiliated labs — PSFC and MITR) Research Scientists/Engineers, and MIT Senior and Principal Scientists/Engineers (including MIT-Harvard programs).** This case requires approval from the NSE Graduate Committee and requires an NSE faculty member as a thesis reader.

Where there is a single research advisor, there must also be a thesis reader. The reader will be solicited by the doctoral candidate after a thesis topic has been selected. The function of the reader is to read the prospectus and the final thesis report, and to comment on the progress and results of the work. Both the research advisor and the reader will sign acceptance of the final written thesis.

Doctoral Research Committee Regulations

Must be composed of at least 3 members, including

1. Research advisor(s)
2. Reader
3. Additional committee members

A minimum of two (2) members should be MIT affiliates, and other members must be approved by the research advisor.

While the rules for a research committee only require one NSE faculty member, students should be aware that for the thesis defense committee, 3 MIT faculty are required (see Thesis Defense section below).

Research Committee Meetings

The research committee will meet regularly, following these guidelines:

- One primary meeting per year must be a full committee meeting with all members attending in person or online.

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- The student or committee may request that a second meeting take place within 6 months of the primary meeting. This additional meeting can be a series of individual meetings with each member of the committee, or a series of discussions with subsets of the committee members, and should be organized by the student.
- Acknowledgement of the meeting(s) should be submitted to the NSE Academic Office, using the Research Committee Form or an email equivalent.

The meetings with the Research Committee are to be organized by the student. The purpose is to ensure that the research advisor, reader, and student are all in agreement with respect to the scope and quality of the thesis work.

Thesis Prospectus

To facilitate the Department approval of the research subject, each candidate shall submit a brief thesis prospectus. One copy of the approved prospectus must be submitted to the NSE Academic Office.

This prospectus should be around 5 pages long (not including list of courses, title page and references) and should contain:

- a descriptive title of thesis
- the date of general exam
- approvals of research committee members, including research advisor(s) and faculty reader
- general description of the problem; its significance; and background information relating to the problem.
- a list of the subjects to be taken to satisfy the coursework requirements: field of specialization, advances subjects and minor subjects

Doctoral Seminar Requirement

All students registered for doctoral research are required to register for the Seminar in Nuclear Science and Engineering, 22.911, starting the Fall term after passing the qualifying process.

Doctoral Seminar Requirement

- (i) a seminar on their thesis research, and
- (ii) at least one additional technical presentation in oral or poster format each year at an occasion agreed to by the faculty in charge of the seminars in the student's area. See the 22.911 syllabus for more information.

Other requirements for the Seminar in Nuclear Science and Engineering subject can be found in the syllabus.

Students are not required to register for 22.911 during the semester that they defend their thesis.

Research Progress

In addition to the required annual research committee meetings, the NSE Graduate Committee reviews student progress at least annually (but usually twice a year). The purpose is to see that adequate progress is being made toward completion of the research. Unsatisfactory progress may result in a warning or denial of further registration and may have consequences on student funding.

Thesis Defense and Thesis Document Preparation

At least one week prior to the scheduled thesis defense, students must submit electronically to the Academic Office:

- the draft thesis document
- the executive summary document
- draft notice of the thesis defense, including the list the names of the committee members, date, time, and place of the scheduled defense
- approval from the research advisor for both of the above documents

The student may not advertise the thesis defense until informed by the Academic Office that all materials have been received and approved

Thesis Defense

- The candidate will be examined on the content of the thesis and on topics immediately related to it.
- The candidate shall arrange a time for the defense to meet the convenience of the thesis defense examining committee.
- The examining committee shall include at least three members of the MIT faculty (of whom the research advisor(s) and reader may be two).
- The chair of the committee shall be an NSE faculty member who is not a member of the research committee.
- Thesis defense examinations are open to the public.
- A notice of thesis defense should be emailed to all NSE faculty, staff and students at least one week prior to presentation.
- The chair of the thesis defense committee will inform the NSE academic office of the result of the defense. Acceptance will be endorsed by the approvals of the research advisor and reader on the final thesis document.

Final Thesis Document

Prior to submission of the final written thesis, a draft complete in all particulars is required for editorial comment and professional appraisals by the research advisor and reader. In planning a schedule, the student should realize that in excess of one month has customarily been required to complete the editorial comment, professional appraisal, required revisions and review.

Use of Publications in the Thesis Document

Students who wish to incorporate prior publications into their thesis can include publications as appendices in the thesis (with permission from the publisher), and can cite them extensively. However, it is necessary to maintain a consistent voice and single authorship in the PhD thesis. Most papers are multi-authored, including the student's research advisor. It is hard to separate who wrote what. PhD thesis must be single-authored by the student. So, unless the publications are truly single-authored by the student alone, they cannot form the main chapters. It is also necessary for a thesis to have a "grand theme" and a consistent notation. Just putting together papers of disparate topics together without the linkages is not acceptable. It is important to ensure there are enough technical details in the thesis - because of page limitations, most papers are more concise than thesis. NSE expects a thesis that is detailed enough. Students are in no way obligated to include prior publications in the thesis.

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Please review the NSE Graduation Checklist to ensure that you submit all required materials, including your final thesis document and all required forms and surveys. Questions can be directed to the Academic Office.

Copies of the final thesis should also be distributed to your research committee, sponsor and/or fellowship donor, in whatever format they prefer.

Completion

Upon satisfactory completion of this program the student will ordinarily receive the degree of Doctor of Philosophy unless a specific request for the degree of Doctor of Science is made. The requirements for both degrees are the same.

All calculations and records, as well as any equipment or instrumentation developed during the thesis research, are the property of the Institute, at the discretion of the research advisor. Upon completion of the thesis, each student should make arrangements with the research advisor, the Administrative Officer, and the NSE IT Support Specialist, for the transfer of records, code and equipment.

Publication of Materials from MIT Nuclear Science and Engineering Theses

The Department expects that all articles in all publications whose substance is extracted in whole or in part from a thesis in the Department shall be submitted to the MIT research advisor for comments and proofing before they are submitted to the appropriate journal. This step is taken to ensure that all works of the Department which are submitted for publication are of high quality and meet the Department standards.

All articles whose substance is extracted in whole or in part from a thesis should indicate the departments of MIT with which all authors were associated at the time the research was conducted; present affiliations (if other than MIT) should be shown by a footnote to the authors' names.

The student and the research advisor should agree on the basic contents of the articles which are to result from the thesis, methods of publication, appropriate journal, number of authors, and acknowledgements, prior to the student's termination of residence at MIT. In the case of a PhD thesis, this should be done before the final oral examination of the thesis. In the case of an SM thesis, it should be done at the time of submission of the thesis.

It is normal practice for the research advisor to be the coauthor of articles resulting from theses. When authorship of a publication is shared by a member of the staff and a student, and there is no sponsoring project, help in meeting publication costs will be given by the Department.

Doctoral Thesis in Absentia:

MIT requirements and policies can be found here:

<https://oge.mit.edu/gpp/advanced-degrees/thesis/thesis-research-in-absentia/>