

MASSACHUSETTS INSTITUTE OF TECHNOLOGY

Department of Nuclear Science and Engineering

**REQUIREMENTS FOR THE DOCTORATE IN
NUCLEAR SCIENCE AND ENGINEERING**

Diagnostic Tests in Physics and Math & Engineering Requirement

All incoming students in the graduate programs of NSE (doctoral, masters, engineering, and the five-year) are required to take diagnostic exams in areas of math, physics, and engineering. The latest approach to conducting these exams was reformulated and adopted by the NSE graduate committee as of fall 2010. The new procedure places more emphasis in the diagnostic on areas needed for NSE graduate study, and more of the responsibility to identify the need for remedial actions on the students.

During the summer prior to entrance as a graduate student, final exams (or a compilation of relevant questions) from five MIT UG subjects: 22.02 (mid-term and final); 22.05; 22.06; 22.070; and 22.071 will be sent electronically to each incoming graduate student. The student should then review these exams and determine whether her/his preparation is sufficient to solve the exams from the first two subjects (22.02 and 22.05), and two of the last three subjects (22.06, 22.070, and 22.071).

When the student meets with her/his registration officer on the fall term registration day, she/he should identify any weaknesses to their registration officer, and also any self-study effort undertaken over the summer, to determine the need for remedial subjects. Remedial subjects should be taken during the first year of NSE graduate study.

No specific grade is required for the remedial subjects. However, these grades will become part of your GPA, for which there are already existing guidelines as to what is deemed acceptable for any graduate student (GPA no less than 3.5 (based on 5.0 scale)) and for being allowed into the qualifying exam (GPA no less than 4.0 (based on 5.0 scale)).

NSE DOCTORAL DEGREE REQUIREMENTS

[Approved by the NSE Faculty: May 2013; rev. 30, October 15, 2014]

The following requirements are applicable to all doctoral students entering the Department of Nuclear Science and Engineering after June 1, 2013. Students who began their graduate studies in the department prior to this date should consult the previous guidelines, obtainable from the Graduate Program Administrator.

The objectives of the program of study leading to the doctoral degree are to provide the student with comprehensive knowledge of nuclear science and engineering and to develop the student's competence in conducting original research.

General Institute requirements for the doctoral degree are given in Part 2 of the General Catalog (Bulletin) and in the Graduate Policies and Procedures Manual of the Office of the Dean for Graduate Education (ODGE).

The specific requirements of the Nuclear Science and Engineering Department are presented here. The five principal parts of the doctoral program are: **(1) the Core Requirement; (2) the Field of Specialization Requirement; (3) the Oral Examination; (4) the Advanced Subject and Minor Requirements; and (5) the Doctoral Thesis.** 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.

Students admitted for the SM or NE degrees who subsequently wish to become candidates for a doctoral degree must apply to the Department for admission to the doctoral program.

Core Requirement

Candidates for the doctoral degree must demonstrate competence at the graduate level in the **core areas of nuclear science and engineering**. The NSE core consists of the following six modules: Applied Nuclear Physics; Radiation Interactions, Control, and Measurement; Nuclear Energy Systems; Materials in Nuclear Engineering; Computational Nuclear Science and Engineering; and Nuclear Technology and Society. Each of these modules is offered every year as a 6-unit subject.

Each module has a comprehensive written examination, which is administered at the conclusion of the module.¹ Candidates for a doctoral degree may choose to register for each module for regular MIT subject credit. Alternatively, they may elect to take the

¹ The final examinations in the core modules will have a principal writer and an assisting reader/grader.

final examination in one or more of the modules without registering for credit. In either case, candidates must take the final examination in all six modules.

If a satisfactory final examination grade in one or more of the modules is not achieved the first time, students will be allowed a second attempt (see the section below entitled “Threshold Requirements for Undertaking Doctoral Research” for a description of the grade requirements in the module final examinations). Candidates for a doctoral degree must complete the core requirements by the end of their fourth graduate term.

Field of Specialization Requirement

Candidates for the doctoral degree must choose a field of specialization from the following list.²

- nuclear reactor engineering
- nuclear reactor physics
- nuclear materials
- fusion
- nuclear science and technology
- nuclear security and policy

Students must complete three H-level 12-unit (or greater than 12-unit) subjects within their chosen **field of specialization** with a GPA of 4.0 or higher. The subjects should be selected from the pre-approved lists below.³ All three subjects must be completed by the end of the fourth regular graduate term.⁴ Students must submit a plan to satisfy their field-of-specialization requirement by the beginning of their second graduate term. Where possible the subjects should be selected in consultation with the student’s research advisor, and the plan must be approved by the registration officer.

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, 22.74 or 3.21 (kinetics))

Fusion: 22.611, 22.62, and one of (22.67, 22.615, or 22.616)

Nuclear Science and Technology: 22.51, 8.511 and one of (22.90, 8.333, or 8.421)

Nuclear Security and Policy: 6.431, (22.812 or 22.814), and (22.312 or 22.90)

² Fields of specialization not on this list must be approved by the NSE Graduate Committee.

³ The NSE Graduate Committee must approve individual subjects not on the pre-approved lists.

⁴ Students can begin taking field-of-specialization subjects as early as their first graduate term, and will typically have completed at least one and probably two of these subjects by the end of their first year.

Oral Examination

Candidates for a doctoral degree are required to demonstrate their readiness to undertake doctoral research by passing an oral examination by the end of their fourth graduate term. Oral exams are held twice a year, at the beginning of February and at the end of May. Students will generally take the oral exam for the first time in February of their second year.⁵ They are allowed two attempts at the oral exam. Students with an overall GPA in graduate subjects of less than 4.0 will not be permitted to take the oral.

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 is approximately 2 hours in length and is in two parts.

In the first part, the student will present a 5-10 page paper prepared in advance and submitted no less than 10 days prior to the oral exam date. The paper should review a field of research, critique it, and formulate a research plan to approach a specific problem in the chosen field.⁶ The examining committee will evaluate the content of the paper, the student's understanding of it, and the quality of the presentation.

In the second part, 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.

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*.

⁵ Students admitted into the doctoral program with a master of science or engineers degree will generally take the oral for the first time no later than the end of their first year in the doctoral program.

⁶ 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.

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.

Further information on the oral examination can be found in the companion document entitled “Procedures for the PhD Qualifying Oral Exam”.

Threshold Requirements for Undertaking Doctoral Research

Students will be permitted to embark on doctoral research only if, by the end of their fourth regular graduate term, they have demonstrated satisfactory performance in (1) the core curriculum, (2) the field of specialization, and (3) the oral examination. Specifically,

- Students with a passing grade in the oral examination, a final examination GPA of 4.5 or higher in the 6 core modules, and a GPA of 4.5 or higher in the field of specialization will be permitted to embark on doctoral research.
- Students who by the end of their fourth graduate term have not passed the oral examination, or who have failed to achieve a final examination GPA in the 6 core modules of at least 4.0, or who have failed to achieve a GPA of at least 4.0 in their field of specialization, will not be permitted to embark on doctoral research.
- A student who has a final examination GPA between 4.0 and 4.5 in the 6 core modules, or who has a GPA in the field of specialization between 4.0 and 4.5, or who has a marginal performance grade in the oral examination will be permitted to embark on doctoral research only if approved following a comprehensive review of all aspects of the student’s performance by the NSE faculty.
- 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.
- Students who have not been permitted to embark on doctoral research by the end of their fourth regular graduate term will not be allowed to register in the Department for more than two additional regular terms.

Advanced Subject and Minor Requirements

Candidates for a doctoral degree must satisfactorily complete, with an average grade of B or better, an approved program of **two advanced subjects** (24 units) that are closely related to the student’s doctoral thesis topic. Neither of these subjects may be from the list of three subjects selected by the student to satisfy the field-of-specialization requirement.⁷ The advanced subjects should be arranged in consultation with the

⁷ Students may select, for one or both of their advanced subjects, NSE-H-level subjects taken by other students to satisfy their field-of-specialization requirement.

student's thesis advisor and the student's registration officer, and should have the approval of the registration officer.

Candidates for a doctoral degree must also satisfactorily complete at least 24 units of coordinated subjects outside the field of specialization and the area of thesis research (the **Minor**). The minor 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. The minor program should be arranged in consultation with, and have the approval of, the registration officer.⁸

Subjects fulfilling the Advanced Subject and Minor requirements may be taken prior to the oral examination.

Doctoral Seminar Requirement

Effective Fall 2012, all students registered for doctoral research are required to register for the Seminar in Nuclear Science and Engineering, 22.911 (Fall) and 22.912 (Spring). In 22.911 and 22.912 they will present: (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. Examples of acceptable technical presentations include (but are not limited to) a lecture at the NSE Freshmen Seminars, a lecture in a Course 22 undergraduate class, a talk at the Freshmen Open House, a poster/talk at the Graduate Student Recruitment Weekend, a poster/talk at the NSE Graduate Research Expo, a presentation at a professional conference.

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 available at <http://web.mit.edu/gso/gpp/index.html>.

Doctoral research may be undertaken in nuclear science and engineering or in a related field of research. A thesis can be primarily theoretical or experimental, or can combine both approaches. Either the thesis supervisor or the reader must be a faculty member of the Nuclear Science and Engineering Department. A thesis supervisor may be selected from one of three categories (which can be found at the end of this document).

Before selecting a topic for thesis research, students are advised to speak to NSE faculty and/or research scientists engaged in research in areas of interest to them. A student should then select a supervisor (from one of the approved categories of supervisors) and work out together a proposed program of thesis research. In some cases, joint thesis

⁸ Graduate subjects taken at other institutions may be used to satisfy the Minor requirement if this is endorsed by the registration officer and approved by the NSE Graduate Committee.

supervision by more than one faculty member may be appropriate. The program must be approved by the Department before research may be initiated.

Where there is a single supervisor, 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 thesis supervisor and the reader will sign acceptance of the final written thesis.

Doctoral Supervision Committee

A doctoral supervision committee, composed of at least three members, including the thesis supervisor(s) and reader, will meet with the student each term to review her/his research. The purpose of this review is to see that adequate progress is being made toward completion of the research. This meeting could follow the student's doctoral seminar presentation. At the conclusion of the meeting, a "summary of meeting" form must be signed by the student and committee members and returned to the NSE academic office (24-102). Submittal of this form will determine the student's thesis progress grade for the term. It is the student's responsibility to obtain the signatures and return the form to the NSE academic office.

The meetings with the doctoral supervision committee are to be organized by the student. The purpose is to insure that the supervisor, reader, and student are all in agreement with respect to the scope and quality of the thesis work. All participants will sign the summary report prepared by the thesis supervisor.

To facilitate the Department approval of the research subject, each candidate shall submit a brief **thesis prospectus**. This prospectus should be a few typewritten pages long and should contain a descriptive title of thesis; the date of general exam; signatures of doctoral supervision committee members, including supervisor(s) and faculty reader; general description of the problem; its significance; and background information relating to the problem. Thesis registration is permitted in the term the General Examination is successfully completed, and the prospectus is to be submitted no later than the end of the first term of thesis registration; failure to comply will result in refusal of thesis registration in further terms until an approved prospectus is submitted. An approved copy of the form listing the subjects to be taken to satisfy the advanced subject and minor requirements (48 units) must be attached to the thesis prospectus for review by the thesis supervisor. One copy of the approved prospectus must be submitted to the NSE academic office.

After submittal to the NSE academic office, the prospectus should be sent electronically to NSE faculty members for their review. Unless informed to the contrary within one month after submittal, the candidate may assume the prospectus has been accepted. If the prospectus is considered unacceptable, the candidate will receive, within one month of submittal, a written statement to the effect from the supervisor acting for the department. If this occurs, another prospectus must be submitted for approval.

The progress each student is making with the PhD thesis research will be reviewed by the NSE Graduate Committee at least once each year. The purpose of the review is to see that adequate progress is being made toward completion of the research. If the progress of any student is considered unsatisfactory the student will be warned, and in extreme cases may be denied further registration as a doctoral candidate, and the research topic made available to another student. A thesis in final form must be submitted before the student's name will be recommended for the Institute degree list.

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 supervisor. Upon completion of the thesis, each student should make arrangements with the thesis supervisor for the transfer of records and equipment.

Thesis Presentation

As indicated in the ODGE Graduate Policy and Procedures Manual, prior to submission of the final written thesis, a draft complete in all particulars is required for editorial comment and professional appraisals by the supervisor 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.

Theses are to be submitted to the NSE academic office in sufficient numbers to provide the original and one copy for the MIT library, one copy for each sponsor or fellowship donor from whom the candidate received financial support (not required for government or general Institute fellowship awards), and one electronic copy in PDF format on a CD for the Department. The form of submitted theses, the abstract (300 words maximum), and a completed MIT doctoral dissertation form, must conform to the Graduate Thesis Specifications (<http://libraries.mit.edu/archives/thesis-specs/>) as published by the MIT library (refer to ODGE Graduate Policy and Procedures Manual and other posted information). All candidates must complete and submit the National Research Council form. One copy of the thesis is to be submitted to each supervisor and reader.

At the time the thesis is submitted, one copy of a thesis summary signed by the thesis supervisor must be submitted to the NSE academic office. The candidate will also provide the summary to each member of the thesis defense examining committee. Thesis summaries usually run from five to fifteen pages in length and should be in the form of a professional journal preprint. They should present the important results and conclusions of the research as well as a brief discussion of the significance and possible applications of the work. Inclusion of summary tables and/or important figures is encouraged.

Thesis Defense

The candidate will be examined on the content of the thesis and on topics immediately related to it. The thesis defense may be scheduled to occur at any time after eight days have elapsed following submission of the thesis to the NSE academic office, in conformity with Institute and Department requirements for thesis presentation, but before

the date grades are due for that term. 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 supervisor(s) and reader may be two). The chairman of the committee shall be an NSE faculty member who is not a supervisor or reader. Notice of the thesis defense must be attached to each of the copies of the thesis summary. The notice should list the names of the committee members, date, time, and place of the scheduled defense. Thesis submissions will not be accepted without such a notice, conforming to these regulations. A thesis defense shall not proceed without satisfactory thesis submission being accepted.

Thesis defense examinations are open to the public. A notice of thesis defense must be emailed to all NSE faculty, staff and students at least one week prior to presentation. The chairman of the thesis defense committee will inform the NSE academic office of the result of the defense. Acceptance will be endorsed by the signatures of the supervisor and reader on the thesis title page after the thesis defense.

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 thesis supervisor 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 thesis supervisor 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 staff supervisor 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.

Department Regulations for Thesis Supervision and Research in Absentia

(The following was adopted by the NSE Graduate Committee)

A **thesis supervisor** may be selected from one of the following three categories:

1. **NSE FACULTY** (NSE faculty; NSE faculty emeritus; NSE professor of practice; faculty having dual and joint appointments with other departments).
2. **Non-NSE MIT Faculty and NSE (and affiliated labs – PSFC and MITR) Senior and Principal Research Scientists/Engineers.** A selection from category 2 requires an NSE faculty member as a thesis reader.
3. **Visiting Professors, NSE (and affiliated labs – PSFC and MITR) Research Scientists/Engineers, and MIT Senior and Principal Scientists/Engineers (including MIT-Harvard programs).** A selection from category 3 requires approval from the NSE Graduate Committee and requires an NSE faculty member as a thesis reader.

Doctoral Supervision Committee Regulations:

1. The doctoral supervision committee will be composed of at least three (3) members, including the supervisor(s) and reader(s).
2. A minimum of two (2) members should be MIT affiliates. External committee members require NSE Graduate Committee approval.
3. Supervision committees should meet with students each term.
4. Student should obtain the signatures of committee members (after committee meeting) on the appropriate “meeting sheet” and submit to the NSE academic office (24-102). Required for satisfactory progress grade.
5. Thesis prospectus should be submitted in the first term of registration for doctoral thesis credit with signatures of student and committee members.
6. Approved prospectus should be sent electronically (by the NSE Academic Office) to NSE faculty members.

Doctoral Thesis in Absentia:

Doctoral thesis research is ordinarily done in residence at the Institute. However, on some occasions and in some fields, work such as the gathering of data away from the Institute may be essential or desirable. Approval for thesis research to be done in absentia is given in writing by the departmental graduate officer after establishing that there are compelling educational reasons to approve thesis research in absentia. A copy of that approval must be filed in the Office of the Dean for Graduate Education (ODGE).

The following requirements must also be met:

- The opportunity for the continuing intellectual growth of the student must be clearly evident.
- The thesis must continue to be supervised by an Institute faculty member, or by a senior staff member, approved by the Department.
- The student must be registered as a full-time resident during the final term.

- A doctoral student must normally have completed the General Examination requirement for the degree and devote full-time to thesis research in absentia.
- Major and Minor subjects are to be chosen from MIT subjects and approved by thesis and registration officer. With the concurrence of the registration officer, minor subjects may be satisfied by subjects taken from outside the Institute.

Revision 30 (October 15, 2014)

MASSACHUSETTS INSTITUTE OF TECHNOLOGY

Department of Nuclear Science and Engineering

Procedures for the PhD Qualifying Oral Examination

This document specifies routine procedures for the Ph.D. oral examination in accordance with the NSE Doctoral Degree Requirements approved by the NSE faculty in May 2013 (and described in the companion document “Requirements for the Doctorate in Nuclear Science and Engineering”). It also clarifies interpretations of several matters in the Requirements document, and identifies responsible parties.

Field Exam Coordinator

It is the responsibility of the “Field Exam Coordinator”, a faculty member in the student’s field of specialization who is appointed by the Department Exam Coordinator, to choose or at least approve the proposed examination committee. It is also the responsibility of the Field Exam Coordinator to ensure that the examination committee receives a copy of the 5-10 page Prepared Paper, and to ensure that the question in the student’s field of specialization is prepared.

Prepared Paper

The 5-10 page Prepared Paper is prescribed in detail in the Requirements document. It should follow full professional standards, including citations, and it should not contain passages written by others without proper attribution. The paper should include reference to relevant theory, experiment, past practice, and methodological considerations.

Oral Examination

Part 1 of the examination should occupy one half of the total exam time. It will begin with a limited period of typically one quarter of the total time allocated for this part, during which the student presents the Prepared Paper. During this presentation the student will be interrupted only for brief clarification. Detailed questioning will then occupy the rest of the time. Like the written paper itself, any visual aids used by the student in this part of the oral exam should follow full professional standards.

Part 2 of the oral will consist of a question that is the same for all students in a particular field of specialization during that exam period. The Field Exam Coordinator will arrange for it to be prepared. It must be reviewed and approved by at least two faculty/research staff in the field of specialization.

Immediately following the exam, the student will leave the room and the committee will meet in its assessment session. Members of the oral committee will assign a score out of ten for the two parts of the exam separately, and the average will be used to determine the overall result. A score of 6 will correspond to the middle point of the “Marginal Performance” evaluation. In addition to the overall result, which the Requirements define as *Pass*, *Marginal Performance*, or *Fail*, the oral exam chairman will convey to the Department Exam Coordinator the average and the highest and lowest numerical grade for each part assigned by committee members at the evaluation. Those numerical grades will not be communicated to the student, but they will be available to the faculty in confidence if the student comes up for faculty discussion.

As stated in the Requirements document, the committee chair 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.

Role of the Research Supervisor

The research supervisor cannot reasonably be forbidden from advising a student on the Prepared Paper. Nevertheless, the research supervisor should be able to verify that he or she composed no unattributed passages of the Prepared Paper.

A research supervisor will often be a member of the oral committee. No member of the committee should act as a student’s advocate during the exam. Committee members should not answer questions put to the student and should provide explanations to the committee only during the assessment discussion after the student has left the room.

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