MIT Department of Nuclear Engineering

77 Massachusetts Avenue, 24-102
Cambridge, MA 02139-4307
617.253.5456
http://web.mit.edu/ned/www/

Graduate Program Description

Revised 17 (February 2002)

The following requirements are applicable to all students entering the Department of Nuclear Engineering after August 1, 1997.

The Department has led the academic world in developing a vision of nuclear engineering as a discipline with a basic core knowledge that supports and fosters many diverse applications.

This core discipline, Applied Nuclear Science, includes low energy nuclear physics, the interaction of ionizing radiation with matter, and plasma science and technology. It provides each graduate student with an education in nuclear engineering broad enough to prepare him or her to choose a focus for research and deeper study.

The curriculum for this core is delivered in four subjects areas taken by all graduate students regardless of their planned thesis research or areas of specialization.

The four subject areas are:

1. Applied nuclear physics
2. Engineering principles in a nuclear environment
3. Microscopic analysis of the interaction of radiation with matter
4. Nuclear engineering laboratory

Applied Nuclear Physics

This subject area covers the fundamentals of nuclear and quantum mechanical processes. The concepts of collisions and cross-sections are discussed in detail. The emission, absorption, stimulation, and relaxation of various types of nuclear particles and radiation are discussed with particular emphasis on the energy ranges of interest to nuclear engineering applications.

Engineering Principles in a Nuclear Environment

The subject of engineering principle in a nuclear environment encompasses the fundamentals of structural mechanics, thermodynamics, heat transfer, and fluid dynamics with a focus on special problems arising in a nuclear environment. The emphasis is on basics rather than applications, although included in the material are applications that cover all areas of interest in the department (e.g., fission heat exchangers, accelerator target design, fusion first wall, and other application areas).

Microscopic Analysis of the Interaction of Radiation with Matter

Microscopic analysis of the interaction of radiation with matter describes a number of microscopic phenomena (e.g., collisions and radiation) and how these phenomena ultimately result in macroscopic behavior (e.g., heat conduction and radiation absorption). Traditionally, most engineering has focused on macroscopic modeling and analysis in order to obtain practical solutions to real world problems. However, by its very nature, microscopic thinking has been integral to nuclear engineering from the outset.

The Nuclear Engineering Laboratory

The nuclear engineering laboratory is a hands-on experience. All students carry out experiments aimed at understanding nuclear measurements, radiation safety and modern data acquisition. In addition the students conduct a set of experiments focused on their research area of interest. Knowing how to collect and interpret data, mostly from particles and radiation that cannot be seen, heard, or felt by the normal human senses, is an important component of a nuclear engineering education. In addition to the technical content, the core curriculum reflects the increasing need for engineering education to emphasize the integrative dimensions of engineering practice. It is built from the recognition that modern engineering professionals need to be concerned with the cultural, political, industrial, social, and work environment in which they practice. As designers and analysts, they will be considering not only the physical attributes of technical artifact the traditional domain of engineering practice but also the design of the organizations that manufacture and use the product, the regulations and public policies governing its use and disposition, the marketing of it, and the relationship with suppliers, distributors, and other participants in the value chain.

Master of Science Degree Requirements

Revised May 2001

The object of the Master's degree program is to give the student as thorough a knowledge of some phase of nuclear engineering as can be obtained in a minimum of one academic year of full-time study. The Master's program may serve either as the first part of a student's work for a more advanced degree or as training for professional employment in nuclear engineering.

General Institute requirements for this degree are listed in the Graduate General Degree Requirements section of the MIT Course Catalogue. The requirements are also listed in the Advanced Degrees section of the Graduate Policies and Procedures. Candidates for the degree of Master of Science in Nuclear Engineering are required to complete an acceptable thesis and at least 66 credit units in subjects more advanced than the required undergraduate preparation for nuclear engineering. Of these units at least 42 must be "H" subjects and at least 34 must be "H" subjects in nuclear engineering. Undergraduate subjects may not be used to satisfy the 66 credit unit requirement, nor may 8.04, or 18.075, nor may graduate subjects taken at other institutions. Remedial courses taken to satisfy the English Requirement may not be used to satisfy the 66 credit unit requirement. Not more than 12 units of graduate "H" special problems (22.901 - 22.904) may be counted toward the degree requirement.

A student must have a cumulative rating of at least 3.5 exclusive of thesis to qualify for the Master's degree, and the average of course work plus thesis must also be at least 3.5.

Recommended Subjects

Students should plan programs of study with their Registration Officers, keeping in mind prior educational background and principal professional interests.

22.101 Applied Nuclear Physics or its equivalent is required for all Master's degree candidates, and 22.211 Nuclear Reactor Physics I is recommended. Other subjects may be selected in accordance with the student's particular field of interest. Most Master's candidates specialize in one of five alternative fields:

1. Fission reactor technology
2. Applied plasma physics
3. Applied radiation physics
4. Nuclear materials engineering
5. Radiation health physics

Fission Reactor Technology

For students specializing in fission reactor technology, additional subjects recommended are:

22.212 Reactor Physics Design Methods
22.312 Engineering of Nuclear Reactors
22.38 Probability and Its Applications to Reliability, Quality Control, and Risk Assessment

Other subjects available to Master's degree candidates specializing in fission reactor technology include:

22.314J Structural Mechanics in Nuclear Power Technology
22.313 Thermal Hydraulics in Nuclear Power Technology
22.812 Nuclear Energy Economics & Policy Analysis

Applied Plasma Physics or Fusion Technology

For students specializing in applied plasma physics or fusion technology, subjects recommended in addition to 22.101 and 22.211 are:

22.62 Fusion Energy
22.611 Introduction to Plasma Physics I
22.612 Introduction to Plasma Physics II
22.63 Engineering Principles for Fusion Reactors
22.104 Nuclear Engineering Laboratory

Applied Radiation Physics

Students specializing in applied radiation physics should select subjects in addition to 22.101 and 22.211 from:

22.54 Neutron Interactions and Applications
22.51 Interactions of Radiation with Matter
22.53 Statistical Processes and Atomistic Simulations
22.104 Nuclear Engineering Laboratory

Nuclear Materials Engineering

Students specializing in nuclear materials engineering should select subjects in addition to 22.101 and 22.211 from those listed immediately above and from:

22.71 Physical Metallurgy
22.72 Corrosion: The Environmental Degradation of Materials

Radiation Health Physics

Students specializing in radiation health physics should select subjects in addition to 22.101 and 22.211 from:

22.55J Principles of Radiation Interactions
22.57J Radiation Biophysics
22.581 Radiation Health Physics
22.104 Nuclear Engineering Laboratory
22.77 Nuclear Waste Management

Students with full undergraduate preparation normally need 12 to 18 months to obtain the Master of Science degree. Under ordinary circumstances students are expected to take a full load of 45 units (including thesis units) per regular term (a regular term is any Fall or Spring term). No regular graduate student is permitted to register in Nuclear Engineering for more than six regular terms without having passed the General Examination.

Master's Thesis Research

General information relating to advanced degrees is to be found in the Graduate Policies and Procedures. Research may be undertaken in nuclear engineering or in a related field under the supervision of a member of the faculty of the Nuclear Engineering Department or another Institute department. Theses can be primarily theoretical or experimental, or can combine both approaches.

A Master's thesis is normally completed within 12 - 18 months. Students should use this as a guide in planning their research schedule. No student will be allowed to register for more than three semesters of Master's thesis work without petitioning for and receiving the express consent of the Departmental Committee on Graduate Students. Once initiated, Master's theses must be completed before a student may start doctoral research.

Careful initial planning is essential for successful completion of a research project. Each thesis student is required, therefore, to turn in three copies of a brief thesis prospectus to the Department Graduate Office by the end of the eighth week of the first term of Master's thesis registration. Thesis registration may be canceled if this requirement is not satisfied.

The prospectus should be a clear and well-organized preliminary report. It should contain (1) an introduction to the subject, giving a brief general statement of the field of interest and a concrete statement of the limited area of work which it is intended to undertake; (2) a review of relevant background information; (3) the proposed method of solution; (4) a tentative time schedule for completion of the work; (5) the name of the faculty member who will act as thesis advisor, and a reader to be selected by the student with the concurrence of the advisor; (6) signature of advisor and reader to indicate approval of the proposed research project. Either the advisor or the reader must be a member of the faculty of the Nuclear Engineering Department.

It is the responsibility of the student to maintain a rate of progress that will insure completion of the thesis within the three semesters allowed. The frequency of conferences with the thesis supervisor should be determined with this goal in mind. The thesis supervisor may require periodic, written reports on the progress of the thesis. Students should be prepared to submit these if requested.

Special regulations and directions on graduate theses are to be found in the Graduate Policies and Procedures; each graduate student preparing a thesis is responsible for compliance with Institute and Department instructions regarding thesis preparation. Three copies of the thesis in final form are to be submitted to the Department Graduate Office: two copies for the MIT Library and one copy for the Department Reading Room. In addition, one copy should be furnished the advisor, the reader if requested, and to satisfy any other obligations incurred (e.g., sometimes copies are required for non-government fellowship sponsors.)

A student admitted for a S.M. degree must petition the Department for admission to the doctoral degree program.

Master of Engineering Degree Requirements

Revised September 2002

The object of the Master of Engineering degree program is to prepare students for productive professional engineering careers by providing additional depth in nuclear-related subjects beyond the bachelor's degree, together with the breadth of perspective necessary for engineering leadership in the field.

The Master of Engineering degree is an intensive fast-paced program that will normally be completed in nine months by students with a strong undergraduate background in engineering. Students without a strong background in engineering may need more time to complete the program. General Institute requirements for this degree are listed in the Graduate General Degree Requirements section of the MIT Course Catalogue. The requirements are also listed in the Advanced Degrees section of the Graduate Policies and Procedures.

The Master of Engineering (M.Eng.) in Nuclear Systems Engineering degree program is more highly structured than the Master of Science (S.M.) degree program. Candidates for the M.Eng. degree must satisfactorily complete an approved graduate program of at least 90 subject units that consists of the following:

1. Two courses in Nuclear Engineering fundamentals
2. Three planned electives
3. One free elective
4. Team-oriented design/practice subjects
5. Practice-oriented thesis

A student must have a cumulative rating of at least 3.5 exclusive of thesis to qualify for the M.Eng. degree, and the average of course work plus thesis must also be at least 3.5. The candidate must be in residence for a minimum of one regular term.

The approved graduate curriculum for the Master of Engineering in Nuclear Engineering degree program is listed on the following page.

1. Two Courses in Nuclear Engineering Fundamentals

Students in both tracks are required to take two courses in nuclear engineering fundamentals from the following:

22.101 Applied Nuclear Physics
22.102 Engineering Principles for Nuclear Technology
22.103 Microscopic Theory of Transport
22.104 Nuclear Engineering Laboratory

2. Three Planned Electives

Students should select one or two courses from the following:

22.211 Nuclear Reactor Physics
22.312 Engineering of Nuclear Reactors
22.313 Thermal Hydraulics in Nuclear Power Technology

They should also select one or two courses from the following:

22.38 Probability and its Applications to Reliability, Quality Control, and Risk Assessment ***or***
22.82 Engineering Risk-Benefit Analysis
22.812 Nuclear Energy Economics and Policy Analysis
22.823 System Dynamics for Engineers
22.843J Technology, Productivity, and Industrial Competition

3. One Free Elective

Students select according to their professional interest or preference.

4. M.Eng. Design/Thesis Project

A key element of the program is the design/thesis project, which will provide a significant practical experience. It is comprised of a *team-oriented design subject* in the Fall semester and a design subject extension during the January Independent Activities Period (IAP), leading to an individual, *practice-oriented thesis* (22.THG) in the Spring semester.

Thesis Preparation

Thesis research will be conducted under the supervision of a member of the faculty of the Nuclear Engineering Department or another Institute department. After discussion with the thesis supervisor, the student must also select a thesis reader. Either the supervisor and/or reader must be a faculty member of the Nuclear Engineering Department.

Special regulations and directions on graduate theses can be found in the Graduate School Manual; each graduate student preparing a thesis is responsible for compliance with Institute and Department instructions regarding thesis preparation. Three copies of the thesis in final form are to be submitted to the Department Graduate Office: two copies for the MIT Library and one copy for the Department Reading Room. In addition, a copy should be given to the advisor, and a copy should be given to the reader, if requested.

Nuclear Engineer's Degree Requirements

Revised May 2001

The object of the Nuclear Engineer's degree program is to provide a broader knowledge of nuclear engineering than required for the Master's degree and to develop competence in engineering application or design but with less emphasis on research than that characterizing a doctoral program. The program includes completion of both an extensive and individually arranged academic course program and a special project of significant engineering value.

General Institute requirements for this degree are listed in the Graduate General Degree Requirements section of the MIT Course Catalogue. The requirements are also listed in the Advanced Degrees section of the Graduate Policies and Procedures. Candidates are required to complete an acceptable thesis and at least 162 credit units in subjects more advanced than the required undergraduate preparation for nuclear engineering. Of the 162 credit units, at least 120 must be "H" subjects. Not more than 24 units of graduate "H" special problem (22.901) may be counted toward the degree requirement. Undergraduate subjects may not be used to satisfy these requirements, nor may 8.04, or 18.075. Remedial courses used to satisfy the English Requirement may not be used to satisfy the 162 credit units. However, a student may petition to have up to 66 equivalent units of graduate credit obtained at other institutions transferred to satisfy partially the 162 credit unit requirement. A student who satisfies the requirement for the Engineer's degree shall be simultaneously approved for the S.M. degree by the Department.

A student with full undergraduate preparation normally needs two years to obtain the Nuclear Engineer's degree. A student registered for an S.M. degree may petition the Department Committee on Graduate Students to change registration to a Nuclear Engineer's degree, provided the requirements of these instructions are satisfied. No regular graduate student is permitted to register in Nuclear Engineering for more than six regular terms without having passed the General Examination. (A regular term is any Fall or Spring term.) A student must have a cumulative rating of at least 3.5 exclusive of any thesis credit to qualify for the Engineer's degree, and the average of course work plus thesis must also be at least 3.5.

Nuclear Engineer's Degree Program

Each Nuclear Engineer's degree program is individually arranged. The principal fields of study are: nuclear reactor physics, applied radiation physics, nuclear reactor engineering, nuclear fuel management, applied plasma physics, nuclear materials engineering, applied fusion technology, and energy technology. Suitable thesis topics may be either analytical or experimental but should be "application oriented" with respect to the particular area in which the research is conducted.

Students should plan a program of study with their Registration Officers. Since a Nuclear Engineer's program is to be more comprehensive than a Master's program, the curriculum recommendations and requirements given in Master of Science Degree Requirements should be consulted.

At the time of registration for the Nuclear Engineer's degree, each student should submit for the Registration Officer's written approval a list of the subjects to be used to satisfy the 162 credit units required for this degree. Also, the general subject by title of the intended thesis or special problem research should be given. Upon registering for thesis credit, a student is required to prepare and submit three copies of an approved thesis prospectus to the Department Graduate Office by the end of the eighth week of the first term of Engineer's thesis registration. The prospectus should be a clear and well-organized preliminary report. It should contain (1) an introduction to the subject, giving a brief general statement of the field of interest and a concrete statement of the limited area of work which it is intended to undertake; (2) a review of relevant background information; (3) the proposed method of solution; (4) a tentative time schedule for completion of the work; (5) the name of the faculty member who will act as thesis advisor, and a reader to be selected by the student with the concurrence of the advisor; (6) the signature of the advisor and reader to indicate approval of the proposed research project. Either the advisor or the reader must be a faculty member of the Nuclear Engineering Department.

Once initiated, an Engineer's thesis-related project must be completed before a student will be allowed to start doctoral research.

Thesis and Special Problem Research

A thesis involving creative work in some applications of engineering must be presented in partial fulfillment of the requirements for the degree of Nuclear Engineer. The thesis required for the Engineer's degree represents a more extensive project than the normal Master's thesis. A substantial Master's thesis may be accepted partly or wholly in place of the Engineer's thesis. If the student's S.M. thesis is judged too limited to satisfy the departmental requirements for the Engineer's degree, the student may extend its scope by registering for a special problem, units of which simultaneously apply to the 162 hour total and thesis credit. The written special problem report in this case would serve as the Engineer's written thesis and therefore should be a comprehensive report of the subject investigation. It should summarize the previous work on the topic presented in the Master's thesis and conform in all editorial and administrative respects to the requirements for the S.M. thesis.

Thesis Examination for the Engineer's Degree

The candidate will be examined on the content of the thesis and on topics immediately related to it. This oral examination may be scheduled at any time after eight days have elapsed following completion of Institute and Department requirements for thesis presentation, but before the date grades are due for that term. Each candidate is expected to arrange a time for the examination to meet the convenience of the supervisor, reader, and at least one other member of the faculty of the Nuclear Engineering Department. Four copies of a notice of the thesis examination time and place should be submitted for posting on Departmental bulletin boards eight days before the examination is to take place. A notice should be sent via e-mail to NED faculty, staff, and students eight days prior to the oral examination. These oral thesis examinations are open to the public.

Exceptions

Any exceptions to these requirements require special permission of the Departmental Committee on Graduate Students. Students should file written petitions with this committee to initiate consideration of any desired exceptions to these requirements.

Doctoral Degree Requirements

Revision 17 (February 2002)

The objective of the program of study leading to the doctoral degree is to give the student comprehensive knowledge of nuclear engineering and to develop competence in original research.

General requirements of the Institute for the doctorate are given in Section 2 of the General Catalogue and in the Graduate School Manual. The specific requirements of the Nuclear Engineering Department are presented here. The three principal parts of the doctoral program are the General Examination, the Core/Major/Minor Requirement, and 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 S.M. or N.E. degree must petition the Department for admission to the doctoral program.

The approved graduate curriculum for the Doctorate Degree in Nuclear Engineering program is listed below.

1. General Examination
2. The Core/Major/Minor Requirement
3. Thesis and Doctoral Research
4. Thesis Presentation
5. Thesis Defense

*Requirements for thesis supervision in RST program:
Radiation Science and Technology (RST) Thesis Supervision Policy

MIT Publication Guidelines:
Publication of Materials from MIT Nuclear Engineering Theses

Appendix:
Approved Courses for Major Requirements

Doctoral Degree: General Examination

Revised February 2002*

The following requirements are applicable to all students entering the Department of Nuclear Engineering after August 1, 1997.

Students wishing to become a candidate for the doctoral degree are required to pass a General Examination whose purpose is to test intellectual potential as well as breadth and depth of knowledge. The structure of the exam is as follows.

The General Examination has two sections, the written component (Part 1) and the oral component (Part 2). Part 1 must be passed before taking Part 2, and both components must be passed in order to register for Doctoral Thesis credits. Part 1 will be offered once per year, early in the fall semester. Part 2 will be offered twice per year. Only registered students are permitted to take either section of the General Examination.

A Ph.D. student in Nuclear Engineering admitted for the fall term is expected to take Part 1 of the exam at the beginning of the next fall term and Part 2 at the beginning of the following spring term. Students admitted for the spring term can either delay or advance the schedule by one term. Students who fail either part of the General Examination will normally be allowed to retake that part of the exam one more time. No regular graduate student is permitted to register in Nuclear Engineering for more than six regular terms without having passed the General Examination. (A regular term is any fall or spring term.)

Students who wish to take either part of the General Examination are expected to have a cumulative Grade Point Average of at least 4.0 (5.0 is an A average for MIT GPA scale). Students with less than a 4.0 GPA may be permitted to sign up for the examination only after completion of a master's thesis of exceptional quality, and then only by special permission granted by the Departmental Committee on Graduate Students acting on a petition submitted by the student.

Part 1 - The Written Exam

Part 1 is a written examination comprised of three 3-hour sections, given over the course of one and a half days. The first two sections, on the first day, cover the basic undergraduate and first year graduate topics considered to provide the foundations of nuclear engineering. The third section, on the morning of the following day, is intended to test knowledge in the student's chosen area of specialization.

First Morning

Questions given on the first morning cover the principles of mathematics, physics, chemistry, and biology. There are four questions, of which three must be answered.

The level of competence expected in this section is equivalent to that attained in the following MIT undergraduate subjects:

1. Mathematics: 18.03; 18.075; 18.076
2. Physics: 8.01; 8.02; 8.03
3. Chemistry: 3.091; 5.11
4. Biology: 7.01(i), where i may be 2, 3, or 4

First Afternoon

There will be two questions on the afternoon of the first day, based on the Engineering and Nuclear Physics core of the department's curriculum.

5. Nuclear Physics: 22.101
6. Engineering Fundamentals: 22.102

Second Morning

Each candidate must answer one 3 hour question, chosen from the department's focus areas. The questions will cover material presented in the indicated subjects.

7. Fission Reactor Technology (22.211, 22.312)
8. Plasmas and Fusion (22.611, 22.62)
9. Principles of Radiation Interactions (22.51, 22.54*)

Part 2 - The Oral Exam

Part 2 is an oral examination, approximately 1.5 hours in length. It must be taken for the first time one semester after passing Part 1, the written portion of the exam. The oral examination will feature two questions, each of approximately 3/4 hour. The first question will be based on the student's area of specialization. The second question will be more narrowly based on the literature in the student's particular research area. The topic of the second question is to be chosen by the student in conjunction with his or her research supervisor, and registered with the Examination Supervisor one week before the examination is scheduled to be taken. If the topic is not so registered, the examination committee will choose the topic without further consultation with the student.

The purpose of the oral exam is to test students' ability to think on their feet and communicate about a technical problem or problem area where the specifics are new to them but where they have the technical background to discuss the problem. The examining committee will conduct the exam to lead a student to such new areas, loosely related to the original question. The committee may exercise a wide range of discretion in the particulars of each individual oral exam, and, consequently, different committees may vary in the details of how the oral exam is conducted.

Oral Exam Options

The above rules describe the recommended sequence and timing of the oral exam. However, there are three additional options that can be exercised by the student in consultation with his or her advisor. These options allow students to take the *oral* in the fall during the first week of classes (before the faculty meeting to discuss the written portion), under the following circumstances:

1. For students who have passed the *written* portion but failed the *oral* in February.

2. For students who failed the *written* exam the first time, we are now providing the option to take both exam portions in September. The faculty *recommends* that a student confer with his or her advisor before taking this option.

3. For students taking the exam for the first time, the option now exists for them to take both the *written* and *oral* portions in September, provided they obtain *written permission from their advisor*, or registration officer if no research advisor exists. This option exists for students who have a high expectation of passing the exam on the first attempt, and is not recommended as a general procedure.

Students should realize that our qualifying exam procedures require that the written portion be passed before the student is permitted to take the oral. Therefore, should a student who exercises option 3 not pass the written portion, the oral exam grade will be discarded, and the student will have to retake the oral exam after passing the written exam.

Doctoral Degree: The Core/Major/Minor Requirement

Candidates for a doctoral degree must also satisfactorily complete with an average grade of B or better an approved program of advanced studies of not less than 96 credit hours of subjects excluding special problems, of which three subjects (36 units) are selected from the following department courses (the Core): 22.101, 22.102, 22.103, 22.104, or 22.105. (*Fission students only* can substitute 22.312 for 22.102.) Three subjects (36 units) comprise a field of specialization (the Major) that will be closely related to the student's doctoral thesis topic. Two subjects (24 units) must consist of coordinated subjects clearly outside the field of specialization (the Minor). None of the 36 units selected by the student in the field of specialization (the Major) may be from the list of subjects specified for the General Examination questions chosen by the student.

The field of specialization should be arranged in consultation with, and have the approval of, the student's Registration Officer. Lists of approved courses for designated fields are included in the attached Appendix. A student may substitute a course within an existing field or may define a new field, subject to the approval of the Registration Officer. Students should also consult with their thesis advisors regarding these fields.

Guidelines for the Minor Requirement

Coordinated subjects from the list of "Approved Courses for Major Requirements" may be used for the minor provided these subjects are neither in the student's area of concentration, nor specified as background for any questions taken by the student on the General Examination.

With the registration officer's concurrence, subjects in fields removed from those covered in the Nuclear Engineering Department may be used to fulfill the minor program. The program must be worth at least 24 credit units, and 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.

With the registration officer's concurrence, graduate courses taken at other institutions may be used to fulfill the minor requirement.

The Major and Minor programs should be arranged in consultation with, and have the approval of, the Registration Officer.

Subjects fulfilling the core, major, and minor requirements may be taken prior to the General Examination.

Doctoral Degree: Thesis and Doctoral Research

General Institute information relating to theses for advanced degrees is to be found in the Graduate Policies and Procedures.

Doctoral research may be undertaken in nuclear engineering or in a related field under the supervision of a member of the faculty of the Nuclear Engineering Department or another Institute department. Theses can be primarily theoretical or experimental, or can combine both approaches.

Before selecting a topic for thesis research, students are advised to read the Nuclear Engineering Department's current list of thesis topics and to speak to faculty members engaged in research in areas of interest to them. A student should then select a supervisor and work out together a proposed program of thesis research. In some cases, joint thesis 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 be a thesis reader for each doctoral candidate. The reader will be solicited by the 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. Either the thesis supervisor or the reader must be a faculty member of the Nuclear Engineering Department. Both the thesis supervisor and the reader will sign acceptance of the final thesis.

The student, thesis supervisor, and reader shall meet formally at several specific stages during the thesis project, and a very brief record of those meetings will be prepared by the thesis supervisor for insertion in the student's file.

These meetings should be held at three specific stages of the thesis project:

1. When plans for the thesis are first formulated
(before the prospectus has been submitted).

2. About six months after the thesis work has begun
(after the prospectus has been submitted and the student has become more familiar with the problem and the detailed steps necessary to attack it).

3. At the early draft stage of the thesis document.

These meetings are to be organized by the student. Their 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 Departmental approval of the research subject that is required before research can be initiated, each candidate shall submit a brief thesis prospectus. This prospectus should be one or two typewritten pages in length and should contain a descriptive title of thesis, names of supervisor or supervisors, 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 that term; failure to comply will result in refusal of thesis registration in further terms until a prospectus is submitted. An approved copy of the form listing the subjects to be taken to satisfy the Core/Major/Minor Requirements (96 units) must be attached to the thesis prospectus for review by the thesis supervisor. Three copies of the approved prospectus must be submitted to the Department Graduate Office.

The prospectus will be reviewed by the supervisor, faculty reader and other interested members of the faculty. Unless informed to the contrary, 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 this 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 Ph.D. thesis research will be reviewed by the Nuclear Engineering Department faculty 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 students registered for doctoral research are required to participate each regular term in the Seminar in Nuclear Engineering, 22.911 and 22.912. Unless otherwise arranged, the subject of each candidate's seminar shall be the thesis research.

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.

Doctoral Degree: Thesis Presentation

Theses in final form are to be submitted to the Department Graduate Office in sufficient number to provide the original and one copy for the MIT Library, one copy for the Departmental Reading Room, and one copy for each sponsor or fellowship donor from whom the candidate received financial support (not required for government or general Institute fellowship awards). The form of submitted theses, their abstract (300 words maximum), and a completed MIT Doctoral Dissertation form, must conform with the Graduate Thesis Specifications as published by the MIT Library (refer to the Graduate Policies and Procedures 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, copies of a thesis summary should be submitted to the Graduate Student Office in sufficient number to provide one to each member of the examining committee, and three for the files or other interested faculty. 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.

As indicated in the Graduate Policies and Procedures, preliminary to the final written thesis, a draft complete in all particulars is required for editorial comment and professional appraisals. 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 before final typing.

Doctoral Degree: 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 at any time after eight days have elapsed following completion of Institute and Department requirements for thesis presentation, but before the date grades are due for that term. Each candidate is expected to arrange a time for the defense to meet the convenience of the supervisor, reader, and at least three members of the faculty of the Nuclear Engineering Department. Notice of the thesis defense time and place should be attached to each of the copies of the thesis summary submitted to the Department Graduate Office. Thesis defense examinations are open to the public; five extra copies of the defense notice should be submitted with the thesis summaries for posting on Departmental bulletin boards. A notice of defense should be e-mailed to all NED faculty and staff at least one week prior to presentation.

Doctoral Degree: Radiation Science and Technology (RST) Thesis Supervision Policy

RST Students Only

Requirements for thesis supervision in RST differ slightly from those in other fields of specialization. In addition to the regular NED Policy, students in the Radiation Science and Technology (RST) group will conduct thesis research under the following guidelines:

1. Thesis Committee
2. Frequency of Committee Meetings
3. Thesis Prospectus
4. Committee Member Responsibility
5. Oral Defense of Prospectus
6. Doctoral Study Plan

1. Thesis Committee

Prior to the end of the term in which the Department examination was passed, the student will identify a Thesis Committee consisting of the principal thesis supervisor and at least two additional members. At least two members (who may or may not include the principal thesis supervisor) must be from the MIT faculty and at least one must be from the Nuclear Engineering Department. A Committee Chairman must be appointed who will be responsible for insuring that the NED and Institute requirements are satisfied by the doctoral candidate. The Committee Chairman must be an MIT faculty member. This is in addition to that individual's role as an active academic Thesis Committee member. A Committee List signed by each Committee member will be submitted to the NED Graduate Office (Clare Egan, Room 24-102) by the end of the first term after passing the exam. Failure to do so may result in a non-retroactive delay in upgrading support from S.M. to Ph.D. funding level.

2. Frequency of Committee Meetings

Beginning in the second term after completing the Department exam, the student is required to meet with the entire Committee at least once every term (Summer and Fall terms will be included together and IAP with Spring term). These meetings may be at the RST seminar given by the student, after which the Committee will meet together with the student. A Thesis Committee meeting form will be signed by all members and turned into the NED Graduate Office after each meeting. Failure to do so may result in a return of RA stipend to S.M. level, and may also result in a grade of F for 22.911.

3. Thesis Prospectus

Within two months after the first meeting with the Thesis Committee, the student will submit a concise thesis prospectus (4 pages maximum) to the Committee for approval. If approved, the prospectus will be signed and forwarded to the NED Graduate Office.

4. Committee Member Responsibility

It is the responsibility of every Thesis Committee member to take an active role in the scientific and educational development of the doctoral candidate and to make the time to meet with him or her and the other Committee members at least once each term. Though often not working directly in the area of the student's research, they are expected to assess the student's progress critically in terms of formulating a solution to an important scientific problem. They agree to accept responsibility for the academic and scientific merit of the thesis work. As much as possible, they will direct the student toward publication of research.

5. Oral Defense of Prospectus

The thesis prospectus must be defended orally to the Thesis Committee prior to approval.

6. Doctoral Study Plan

At the oral defense of the thesis prospectus, the student will present the Committee with a list of advanced graduate courses he or she will take during his or her research period. There are no required courses other than those for Institute and Department credit requirements; however, the courses must represent a study plan that will insure the student will have significant advanced training in his or her research area.

Doctoral Degree: Publication of Materials from MIT Nuclear Engineering Theses

The Nuclear Engineering 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 thesis supervisor at MIT for comments and proofing before they are submitted to the appropriate journal. This step is taken to ensure that all works of the MIT Nuclear Engineering Department which are submitted for publication be of high quality and meet the standards of the Department.

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 Ph.D. thesis, this should be done before the final oral examination of the thesis. In the case of an S.M. 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 Nuclear Engineering Department.

Doctoral Degree: Appendix – Approved Courses for Major Requirements

These courses may be used to fulfill the Major requirement. In some cases, courses listed on the General Examination are incorporated here. These courses may only be used to fulfill this requirement if the student did not answer a question on the exam which listed that specific subject.

(H) after a course name designates an H-Level subject.

Courses by Research Area:

1. Fission
2. Plasma and Controlled Fusion
3. Radiation Science and Technology
4. Energy Economics and Policy

1. Fission

1.1 Reactor Physics and Fuel Management

22.212 Reactor Physics Design Methods (H)
22.77 Nuclear Waste Management (H)
22.33 Nuclear Engineering Design (H)
22.70J Materials for Nuclear Applications (H)
22.351 Current Nuclear Fuel Cycle Issues (H)
22.32 Power Reactor Design and Safety (H)
22.38 Probability and Its Applications to Reliability, Quality Control, and Risk Assessment (H)

1.2 Reactor Engineering

22.212 Reactor Physics Design Methods (H)
22.33 Nuclear Engineering Design (H)
22.38 Probability and its Applications to Reliability, Quality Control, and Risk Assessment (H)
22.70J Materials for Nuclear Applications (H)
22.313 Thermal Hydraulics in Nuclear Power Technology (H)
22.314J Structural Mechanics in Nuclear Power Technology (H)
22.32 Power Reactor Design and Safety (H)
22.72J Corrosion: The Environmental Degradation of Materials (H)

1.3 Reliability and Risk Assessment

22.38 Probability and its Applications to Reliability, Quality Control, and Risk Assessment (H)

22.82 Engineering Risk-Benefit Analysis (H)
15.065 Decision Analysis (H)
15.067 Competitive Decision Making and Negotiation (H)
22.32 Power Reactor Design and Safety (H)
22.812 Nuclear Energy Economics and Policy Analysis (H)

1.4 Nuclear Chemical Engineering and Waste Management

22.76 Nuclear Chemical Engineering (H)
22.77 Nuclear Waste Management (H)
22.72J Corrosion: The Environmental Degradation of Materials (H)
1.381 Rock Mechanics (H)
1.383 Underground Construction (H)
1.72 Groundwater Hydrology (H)
22.351 Current Nuclear Fuel Cycle Issues (H)

1.5 Nuclear Materials Engineering

22.314J Structural Mechanics in Nuclear Power Technology (H)
22.71J Physical Metallurgy (H)
22.72J Corrosion: The Environmental Degradation of Materials (H)
2.093 Computer Methods in Dynamics (H)
2.151 Advanced System Dynamics and Control (H)
3.20 Materials at Equilibrium (H)
3.21 Kinetic Processes in Materials (H)
3.30 Electron Microscopy: Image Interpretation (H)

2. Plasmas and Controlled Fusion

2.1 Applied Plasma Physics Major

22.611J Introduction to Plasma Physics I (H)
22.612J Introduction to Plasma Physics II (H)
22.616 Plasma Transport Theory (H)
22.67 Principles of Plasma Diagnostics (H)
6.633 Electrodynamics of Waves, Media, and Interactions (H)
8.624 Plasma Waves (H)
8.641 Physics of High Energy Plasmas I (H)
8.642 Physics of High Energy Plasmas II (H)

2.2 Fusion Technology Major

22.312 Engineering of Nuclear Reactors (H)
22.211 Nuclear Reactor Physics I (H)
22.313 Thermal Hydraulics in Nuclear Power Technology (H)
22.314J Structural Mechanics in Nuclear Power Technology (H)
22.67 Principles of Plasma Diagnostics (H)

22.70J Materials for Nuclear Applications (H)
22.68J Superconducting Magnets (H)
8.624 Plasma Waves (H)

3. Radiation Science and Technology

Note:
HST = Harvard-MIT Division of Health Sciences and Technology
HSPH = Harvard School of Public Health

3.1 Radiological Sciences

3.30 Electron Microscopy: Image Interpretation (H)
HSPH 109 Radiobiology (H)
HST 011 Human Functional Anatomy (H)
HST 541J Quantitative Physiology: Cells and Tissues
HST 542J Quantitative Physiology: Organ Transport Systems
6.341 Discrete-Time Signal Processing (H)
6.344 Two-dimensional Signal and Image Processing (H)
6.555J Biomedical Signal and Image Processing (H)
22.561J Magnetic Resonance - Analytic, Biochemical, and Imaging Techniques (H)
22.562J Spatial Aspects of Nuclear Magnetic Resonance Spectroscopy (H)

3.2 Applied Radiation Physics and Molecular Simulation

3.2.1 Condensed Matter Spectroscopy and Radiation Physics

8.361 Quantum Theory of Many-Particle Systems (H)
8.511 Theory of Solids I (H)
8.513 Many-Body Techniques in Condensed Matter Physics (H)
8.562 Correlations and Critical Behavior in Condensed Matter (H)

3.2.2 Materials Science and Molecular Simulation

22.70J Materials for Nuclear Applications (H)
22.71J Physical Metallurgy (H)
3.21 Kinetic Processes in Materials (H)
3.22 Mechanical Properties of Materials (H)
3.23 Physics and Chemistry of Materials (H)
3.30 Electron Microscopy: Image Interpretation (H)
3.35 Fracture and Fatigue (H)
8.511 Theory of Solids I (H)
8.562 Correlations and Critical Behavior in Condensed Matter (H)

3.3 Nuclear Materials Science

3.3.1 Materials Science

3.21 Kinetic Processes in Materials (H)
3.30 Electron Microscopy: Image Interpretation (H)
3.22 Mechanical Properties of Materials (H)
3.23 Physics and Chemistry of Materials (H)
3.35 Fracture and Fatigue (H)
8.511 Theory of Solids I (H)
8.562 Correlations and Critical Behavior in Condensed Matter (H)

For students specializing in **phase transformations**, the relevant courses are 3.21, 3.30, 8.562, whereas the courses are 8.511, 8.562 for **theory of solids**, and for **crystalline defects** the courses are 3.21, 8.511.

3.3.2 Materials Engineering

22.314J Structural Mechanics in Nuclear Power Technology (H)
22.72J Corrosion: The Environmental Degradation of Materials (H)
2.093 Computer Methods in Dynamics (H)
2.151 Advanced System Dynamics and Control (H)
3.20 Materials at Equilibrium (H)
3.21 Kinetic Processes in Materials (H)

3.4 Radiation Health Physics

22.57J Radiation Biophysics (H)
22.811J Sustainable Energy (H)
22.312 Engineering of Nuclear Reactors (H)
ESP271b* Occupational and Environmental Radiation Protection
ESP261a,b* Aerosol Technology
6.341 Discrete-Time Signal Processing (H)
22.32 Power Reactor Design and Safety (H)
22.77 Nuclear Waste Management (H)
22.78 Nuclear Techniques in Environmental Analysis (H)
22.38 Probability and its Applications to Reliability, Quality Control, and Risk Assessment (H)
22.56J Principles of Medical Imaging (H)

*Subject offered at HSPH (Harvard School of Public Health)

3.5 Nuclear Waste Technology

22.77 Nuclear Waste Management (H)
22.76 Nuclear Chemical Engineering (H)
22.78 Nuclear Techniques in Environmental Analysis (H)
1.76 Aquatic Chemistry (H)

1.383 Underground Construction (H)
1.72 Groundwater Hydrology (H)
22.72J Corrosion: The Environmental Degradation of Materials (H)
ESD134 Regulation of Chemicals, Radiation, and Biotechnology (H)

4. Energy Economics and Policy

4.1 Electrical Power Systems

22.811J Sustainable Energy (H)
6.334 Power Electronics (H)
6.683J Operation and Planning of Electric Power (H)
14.272 Industrial Organization II (H)

4.2 Energy and the Environment

22.571J General Thermodynamics (H)
22.77 Nuclear Waste Management (H)
1.77 Water Quality Control (H)
22.811J Sustainable Energy (H)

4.3 Energy Economics

22.82 Engineering Risk-Benefit Analysis (H)
15.011 Economic Analysis for Business Decisions
15.412 Financial Management II (H)