

Massachusetts Institute of Technology

The Doctoral Program

In

Aeronautics and Astronautics

Approved Fall 2004
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Summary of modifications:

- More detailed description of Oral General Examination process
- Changes in the timing for scheduling of the thesis defense
- Removal of thesis summary requirement
- Replacing department Doctoral Committee with Graduate Committee (as the separate Doctoral Committee is being eliminated)
- Minor changes in wording for clarification

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THE DOCTORAL PROGRAM IN AERONAUTICS AND ASTRONAUTICS

1. General Description

The Doctoral Program of the Department of Aeronautics and Astronautics offers opportunities for advanced graduate study and research in the disciplines of aeronautics and astronautics. In recognition of creative and independent accomplishment at a high level of excellence, the Department awards either the Doctor of Philosophy (PhD) or the Doctor of Science (ScD) degree. There is no substantive difference between the two degrees, and the choice of degree name is that of the individual recipient.

The two major components of the Doctoral Program are course work and research. Together these are intended to stimulate intellectual growth and develop powers of objective understanding of the physical world. The course work focuses on a program of study in the student's chosen major and minor fields of specialization. Its purpose is to broaden the student's command of basic scientific principles, encourage the imaginative application of science and technology for the productive and economic uses of mankind, and foster the ability to express and communicate ideas in the English language. The research involves an original investigation of an advanced problem, the results of which are summarized in a written thesis and reported in a thesis seminar.

2. Administration of the Doctoral Program

The Doctoral Program is administered by the Department Graduate Committee (GradComm). All questions regarding application of policy and procedures of the Department's Doctoral Program must be resolved and approved by the GradComm. This includes the scheduling of examinations and of thesis presentations, and the certification that requirements have been satisfactorily completed. Students are advised to keep the Chair of the GradComm informed of their plans and progress through the Graduate Program administrator.

3. Doctoral Program Requirements

A checklist of all Doctoral Program requirements is in Appendix A. They are detailed in subsequent sections. Students should also refer to the following documents:

- a. *Thesis Specifications Booklet* - <http://libraries.mit.edu/archives/thesis-specs/>.
- b. *Graduate Student Education Manual* - <http://web.mit.edu/gso/gpp/index.html>.

3.1 English Evaluation Test

All incoming graduate students whose native language is not English are required by Institute rules to take the Department of Humanities English Evaluation Test (EET) offered at the end of January and August. Results of the exam are given directly to the student by the EET staff and a copy forwarded to the Aero/Astro Graduate Administrator. This test is a proficiency examination designed to indicate areas where deficiencies may still exist and recommend specific language subjects available at MIT.

3.2 Diagnostic Test in Technical Writing

The department requires that all entering graduate students demonstrate satisfactory English writing ability by taking the Writing Diagnostic examination offered in early September by the Program in Writing and Humanistic Studies. Students admitted in February must take the examination with those admitted in September. Students admitted into an interdisciplinary program through Aero/Astro will also be required to take the Writing exam. The Writing exam will be waived for students in interdisciplinary programs that require a technical writing class approved by the Aero/Astro GradComm.

Students can only take the exam once and must score 75 or above to fulfill the requirement. Examinees whose score falls between 60 and 75 are required to take a two-unit writing workshop (21W.794) during their first Independent Activities Period (IAP). Students who score below 60 on the Writing exam are required to take a writing subject recommended by the Writing faculty. The remedial work must be done in the Spring term of the student's first academic year in the graduate program.

3.3 Qualifying as a Doctoral Candidate

A student admitted to the Doctoral Program in this department does not become a doctoral candidate until that student passes the following qualifying process:

1. Passing performance on the Qualifying Exam (QE).
2. A faculty review consisting of an examination of the student's achievements including an assessment of the quality of the work done for the SM degree, and an evaluation of the student's academic record in light of the performance on the QE.

The QE format is discussed in more detail in Section 4.

3.4 The Doctoral Stipend Rate

Students who pass the QE become eligible for the doctoral stipend rate after their master's thesis has been accepted by the department. Students who enter the department with the master's degree receive the doctoral stipend rate once they have passed the QE.

3.5 The Thesis Committee

The candidate forms the Thesis Committee by visiting members of the faculty and research staff whose research interests are similar to the candidate's own interests, discussing plans and objectives with them and verifying their willingness to serve. This action should be taken during the term in which the student is selected as a doctoral candidate.

3.5.1 Roles of the Thesis Committee

1. Advising and supervising the candidate's research work
2. Approving a major program of study
3. Sanctioning of the minor program by Thesis Committee Chair
4. Conducting General Exam.
5. Monitoring the quality of the candidate's academic performance in all subjects, and ensuring at all stages of the program that the candidate is making satisfactory progress towards the degree.
6. Participating in the ad hoc Thesis Defense Committee.

The Thesis Committee does not assume responsibility for the quality of the research performed by the candidate--its role in the process is to evaluate critically the progress reported by the candidate, and offer suggestions and advice which might help the candidate in the pursuit of the research goals. The process of conducting research is the sole responsibility of the candidate, and is the essential measure by which the faculty judges performance in the doctoral program.

3.5.2 Membership of the Thesis Committee*

Thesis Committee Chair

The Thesis Committee Chair plays a role as department academic representative on the committee. The role is a management function in addition to an intellectual one. The Thesis Committee Chair *must* be a faculty member¹, emeritus faculty member, Professor of the Practice², or Senior Research Scientist/Engineer/Associate³ in the department. Note: The Thesis Committee Chair will frequently also be the Thesis Advisor. These two roles are not exclusive.

Thesis Advisor

The Thesis Advisor is the main intellectual advisor for the thesis research. Faculty members, emeriti faculty, Professors of the Practice, and Senior Research Scientist/Engineer/Associates are eligible to be Thesis Advisors. Principal Research Scientist/Engineer/Associates are also eligible *providing they have the written permission of the Department Head or Deputy Department Head*⁴.

Current Principal Researchers who are Thesis Advisors of students at the time this policy is put into effect (February 2005) are grandfathered for those specific students only. For any additional doctoral students the written permission must be in place.

Thesis Committee Member

The Thesis Committee must have at least three members. *Two of these must be MIT faculty members, including emeriti faculty, or Professors of the Practice in the major field*, i.e., two faculty who are familiar with the field and are expected to contribute to the research. The other committee members may be MIT faculty, MIT research staff, or individuals who are familiar with the field from industry, government, or another university. The advisor for the minor field (the so-called "minor advisor" as formerly denoted) does not count as one of the two faculty members needed for the committee.

* The policies and procedures governing the make-up of the Thesis Committee are in effect for *all* students who enter the doctoral program in February 2005 or later.

¹ Faculty members, as defined in *Policies and Procedures*, include only Professors, Associate Professors, and Assistant Professors

² *Policies and Procedures* emphasizes the connection of Professors of the Practice with education in the statement that they "demonstrate a deep commitment to teaching and research".

³ Senior S/E/A are academic staff, a different category from other research appointments. Specifically, as stated in *Policies and Procedures*, "Senior Research Scientist, Senior Research Engineer, and Senior Research Associate are the senior positions in the campus research staff structure and for that reason have been designated academic staff positions with special status and prerogatives."

⁴ An Associate or Assistant Head, as has been the case in the past, would also be able to sign off for this.

3.6 Written Record of Thesis Committee Meetings

The formal log of Thesis Committee meetings is the *Doctoral Program Record Form*. The form includes the names of the members of the Thesis Committee, a list of major and minor subjects, which the student must complete, and a record of important dates and milestones in the candidate's progress toward the degree. All important decisions and recommendations of the Thesis Committee, dates of completion of each requirement of the doctoral program and of requirements made by the thesis committee or the department GradComm must be recorded in the *Doctoral Program Record Form* in the Academic Programs Office. It is the responsibility of the candidate to bring the *Doctoral Program Record Form* to each Thesis Committee meeting, to ensure that recommendations for future action are recorded by the Thesis Committee Chair, and to return the form to the Academic Programs Office, Room 33-208.

It is also the responsibility of the candidate to undertake any course of action recommended by the Thesis Committee. Finally, the candidate must keep the Thesis Committee informed of plans and progress by calling a meeting of the Thesis Committee **at least once each term**.

3.7 The Thesis Proposal

After defining a research problem, the candidate must prepare a thesis proposal consisting of:

- A clear, specific statement of the technical problem and the objectives of the proposed research,
- A brief summary of work which may have been previously done on the problem, and
- A plan for the initial approach to the problem, an outline of the major foreseeable steps to a solution of the problem, an estimate of the time that might be required, and a list of the facilities needed.

The purpose of the proposal is two-fold: the work leading to the proposal helps the candidate define the research problem and plan the initial phases of the research, while the proposal itself helps the faculty to determine whether the problem and research path are indeed of doctoral research caliber, and whether the candidate understands both sufficiently to begin exploration.

The proposal should be brief and concise. Formally, it should include:

- The candidate's name, the date, and a list of the members of the candidate's Thesis Committee,
- A separate title page, including a proposed thesis title,
- An abstract contained on a single sheet, and
- The elements of the proposal as enumerated above.

The proposal is submitted to the candidate's Thesis Committee and once approved, one copy is provided to each member of the Committee and one copy to the GradComm Chair through the Graduate Program Administrator. If the direction of research changes so that the Thesis Committee requires a new proposal, the new proposal must be prepared and distributed in the same manner as the first.

3.8 The Major Program of Study

The student should propose to the Thesis Committee for its approval a specific set of subjects that will constitute the major program of study for the degree. At a minimum, this program will

include at least five graduate subjects in the major field. Subjects taken in the SM program can be counted toward this requirement.

Doctoral candidates are normally expected to take their major subjects at the Institute.

3.9 The Minor Program of Study

The Minor Program must consist of a coherent set of related graduate subjects adding up to at least 30 units (typically three courses) in a **technical area** related to Aeronautics and Astronautics, which is not in the candidate's primary field of study. Ultimately, the decision of whether a subject area is acceptable as a minor rests with the Thesis Committee. The aim of the Minor requirement is to broaden the candidate's knowledge and perspective of fields that support the candidate's capabilities as an aerospace engineer.

3.10 The Minor Field Advisor

The Minor Advisor can be any active MIT faculty member. The purpose of the Minor Advisor is to ensure that the Minor courses form a coherent whole. The Minor Advisor will review and formally sign off on the *Minor Proposal Form* the subjects proposed by the student. Only G or H-level courses are acceptable for this requirement and there must be agreement by the Thesis Committee that the minor field is sufficiently different from the major field. The minor advisor will typically not be a member of the Thesis Committee unless he/she can also advise in the major field of study.

3.11 The General Examination (GE)

The purpose of the GE is to ensure that the candidate is sufficiently prepared, through formal classroom instruction and through study of current scientific and technical literature, to interpret and evaluate research results critically, integrate classroom knowledge gained in the major program of study in the solution of complex physical problems, and invent useful and physically meaningful models that may lead to an understanding of unfamiliar phenomena. The GE is discussed further in Section 5.

3.12 Satisfactory Performance in the Minor Field

Satisfactory completion of the Minor program of study is certified by the Minor Advisor. The Minor Advisor has the responsibility of determining what constitutes satisfactory performance in the Minor program.

3.13 The Doctoral Thesis

A major specific objective of the Doctoral Program is the successful completion of a research program and its summary in a doctoral thesis. Ultimately, it is the quality of the research and of the summary in the thesis which reflects the degree of success which a candidate achieves in the Doctoral Program. The Thesis Defense is discussed in Section 6.

3.14 Preparation of the Thesis

An essential requirement in writing a thesis is to ensure that the document conveys information to the technically qualified reader. The style of presentation should be consistent with the style of technical reports found in the professional literature. Structurally, the thesis should begin with a clear introduction to the problem, its history, and importance. It should contain a description of

the technical approach, a summary and discussion of results, the conclusions drawn from the results, and recommendations on research that might be undertaken in the future in the light of the results. If the thesis relies on experimental data found nowhere else, such data must be included in the document.

4. Rules of the Qualifying Examination (QE)

4.1 Admission to the QE

Only graduate students registered in the Department of Aeronautics and Astronautics may take the QE. However, persons not yet registered as regular students may petition to take the QE provided they hold a master's degree and they take the examination within a year of having been offered admission to the Doctoral Program as regular students.

Persons registered in the Department of Aeronautics and Astronautics must receive the written endorsement of one member of the department faculty in order to take the QE. The faculty endorser must also provide the following input:

- 1) length of time and the capacity in which the faculty has known the student, if the faculty member has limited knowledge of the student, an interview should be held; and
- 2) specific strengths and weaknesses of the applicant that may bear on the success of the student as a doctoral candidate.

The faculty member is expected to make a presentation of the candidate's academic achievements at the faculty review following the written and Oral Examinations, as an advocate of the candidate.

In order to be admitted to the QE the student must attain a minimum cumulative grade point average of 4.4 in technical subjects as a graduate student at MIT.

4.2 Scheduling of the QE

The QE is offered once each academic year, usually during the January Independent Activities Period (IAP).

All graduate students who are admitted to this department (with or without a prior SM degree) and who wish to be selected as doctoral candidates must take the QE no later than the IAP which occurs between the third and fourth term following their initial registration as graduate students in the department. (Students who first register in February must take the QE between the second and third term following their registration.)

A candidate for the SM degree who does not take the QE during the time interval specified above must re-apply for graduate admission. A student who decides to take a leave of absence after having passed the QE may defer the start of their doctoral program for up to 2½ years. For example, if a student passes the QE in January 2004, he/she may start the doctoral program any time between then and September 2006. If a student does not return to continue their academic program by the end of the 2½ year period, he/she will also have to reapply to the graduate program and retake the QE. A request to go on leave must be submitted to one of the Graduate Chairs through the Aero/Astro Academic Programs Office.

4.3 The QE Structure and Content

The exam consists of an Oral and a Written part. There is a three tiered structure of material on which the students will be examined: *Basics*, *Professional Area*, and *Research Project*.

4.3.1 The Written Exam

Basics – Mathematics and Physics (see Appendix B)

2 questions

One question from Mathematics:

- 1 - 18.01, 02, 03 (Calculus and basic differential equations), or
- 2 - Discrete Mathematics

One question from Physics:

- 1 – Dynamics, or
- 2 - Fields (Electricity and Magnetism)

Professional Area

3 out of 9 questions from:

- Autonomy
- Communication and Networks
- Control
- Fluid Mechanics
- Human Factors Engineering
- Materials and Structures
- Propulsion and Thermodynamics
- Software Engineering
- Vehicle Design and Performance

This material corresponds to the topics in the syllabi of the department undergraduate Professional Area subjects.

4.3.2 The Oral Exam

The Oral Examination is intended to give the student an opportunity to demonstrate judgment and understanding in a different setting, and to give the faculty a second means of assessing the qualifications of the student to pursue a doctoral program of study successfully. The examination is intended to focus on the student's professional interests, which may ultimately lead to the choice of major and minor fields of study. Accordingly, the candidate will be expected to select in advance two of seven areas (see below) upon which to be examined:

Oral Examinations will be given to all candidates on the same day. The exam consists of two questions in specific areas plus a presentation. The students are given a half-hour to prepare for each question and are then examined for a period of 20 minutes. The presentation is to be prepared before the Oral Exam. The presentation will be 20 minutes followed by 20 minutes of questions.

Professional Area

2 out of 7 questions from:

- Autonomy

Communication and Networks
Control
Fluid Mechanics
Humans Factors Engineering
Materials and Structures
Software Engineering

4.3.3 Research/Design Project Exam

The Oral part of the QE includes a session in which the student discusses a paper which is provided by the department. The department will provide a selection of papers in different disciplines (at least three for each sector) that students can read and prepare a discussion on. The papers will be handed out by end of the Fall semester.

In this phase of the QE, the student will be assessed on their critical thinking skills, their understanding of technical material, and their ability to put it into the context of the field as a whole. Also, the student should aim to identify the strengths and weaknesses of the paper, and, in cases where there are weaknesses to be able to make suggestions as to how the work could have been improved.

A Research Presentation Practicum opportunity will be provided to the students.

The assessors will use the grading scoresheet/rubrics in Appendix C.

4.4 The Faculty Review

After the examination process has been completed, the department faculty is expected to meet and assess each student's performance on the Written and Oral Examinations.

The faculty will review the performance on the 3 parts of the QE, and also the academic achievements of the student. The quality of the work in progress toward the master's degree, and all additional evidence which attests to the student's potential to conduct original research at the doctoral level successfully will also be considered. Following this review, the faculty will vote to decide on one of these three outcomes:

1. **Pass**
2. **No Pass**, but option to--
 - a) retake the entire exam
 - b) retake written and oral only
 - c) retake research presentation only
3. **Fail**, with no option to retake

A student who has failed the exam will be required to withdraw from the Doctoral Program.

4.5 Retake Policies and Procedures

1. Students who have passed the Written and Oral portions of the QE and been given the opportunity to retake the Research Presentation (outcome 2c above), may do so in April/May or the following January. All other students must do the retake the following January, subject to the usual QE entrance rules.
2. For any QE retake, the faculty endorser may submit an amended written assessment of the student.
3. The only possible outcomes for any retake are **Pass** or **Fail**.

5. Rules of the General Examination (GE)

The GE consists of a take home Written examination followed by an Oral Examination. Problems presented at both the Written and Oral Examinations are derived from the candidate's major field of interest.

A candidate whose cumulative grade-point average is below 4.4 will not be permitted to take the GE.

5.1 Scheduling the Written GE

The GE should be scheduled within two years after the candidate has passed the QE. **It is the responsibility of the candidate to bring to the attention of the Thesis Committee, at some stage within this time period, the need to schedule a GE.** Once the Thesis committee has agreed that a GE should be scheduled, it is the responsibility of the candidate to coordinate the exam with the Academic Programs Office staff. Examiners will submit questions to that office by 4 p.m. on the day preceding the exam date. The exam will take 72 hours (3 days).

5.2 Scheduling the Oral GE

In order to schedule the Oral Examination, the student must have permission to do so from the Thesis Committee Chair, indicating adequate performance on the Written part of the GE. Private discussions on the written performance between the student and the examiners may be part of this evaluation. All actions preliminary to the Oral GE should be completed in time to allow the Oral to take place no later than one month after the Written has been completed.

After the candidate has been given permission for an Oral Examination, it is again the student's responsibility to schedule a mutually convenient date with all members of the Thesis Committee. The student will then coordinate final details with the Academic Programs Office staff, who will schedule a department representative and inform the Department faculty and invited guests selected by the Thesis Committee that an Oral Examination is to take place. This announcement must be made at least ten business days prior to the Oral Examination.

5.3 The Structure of the Written GE

The Written examination is compiled by the staff of the Academic Programs Office. It consists of three questions in the candidate's field of interest, contributed as follows:

- One question from the Chair of the candidate's Thesis Committee.
- One question from a second Committee member selected by the student.
- One question from a faculty member outside the Committee, also selected by the student.

The candidate is allowed 72 hours (three days) to complete the written part of the examination. The candidate is encouraged to use any relevant documentary material (books, journals, class notes) in responding to the examination questions, but is expected to deal with the problems alone and without help from any person.

5.4 The Structure of the Oral GE

The Oral GE is intended to further explore the candidate's knowledge in their major field. The Oral is not normally intended to serve as a means of clarifying issues which have not been adequately treated in the candidate's responses to the Written examination. Any doubts the

examiners may have regarding the performance on a specific question in the Written examination should be resolved in conference with the candidate prior to the Oral.

The Oral Examination is administered by the Chair of the Department GradComm (or his/her designated faculty representative), who acts as chair of the examining committee. Accordingly, each examining committee is composed of the following people:

1. the Chair of the GradComm or a designated representative,
2. the candidate's Thesis Committee, and
3. the member of the faculty outside the Thesis Committee who participated in the Written part of the examination.

In addition, any member of the faculty outside the examining committee may attend and participate in the Oral Examination. If after the examination has been scheduled a member of the examining committee cannot attend for any reason, the Chair of the GradComm is empowered to invite any qualified member of the Institute faculty as a replacement.

The typical process for the Oral Examination is:

1. The Oral Examination begins once the candidate and all members of the examining committee are present.
2. A planning discussion is typically held first in which the candidate will be asked to leave the room. The discussion will usually include a brief review of the candidate's performance on each question in the Written Examination and coordination of which examining committee members are planning on asking questions (beyond questions on the optional research presentation) and the order of this subsequent questioning.
3. The student has the option of making a presentation of his/her research. This presentation should not exceed thirty minutes. If the candidate chooses to make a presentation, the committee may follow up with some questions directly related to the presentation. Questioning during the presentation should be only for clarification purposes.
4. After follow-up questions on the optional research presentation, the examining committee may then ask questions of the candidate in his/her major field of study (though not necessarily directly related to the candidate's research topic).
5. Once all questioning is complete, the candidate will leave the room and the examining committee will discuss the candidate's performance. Upon reaching a recommendation, the members of the examining committee will discuss the results with the candidate.

The Oral Examination (if including the optional research presentation) is normally completed in 1.5-2 hours.

5.5 Results of the GE

The candidate's performance in each part of the examination in the major field is reviewed after it is completed. It is assumed that a candidate who has been recommended for an Oral Examination has performed sufficiently well on the Written part so that an overall pass on the GE is possible. After the Oral, the examining committee will reach one of the following conclusions:

1. The candidate has failed the Written and Oral Examinations, and may take the entire GE a second time.
2. The candidate has passed the Written Examination but has failed the Oral and

may take the Oral a second time.

3. The candidate has passed both Written and Oral Examinations.

A passing grade is reported to the Registrar's Office by the Graduate Programs Administrator.

In addition to the above outcomes, the examining committee can make recommendations to the candidate and the candidate's Thesis Committee on how the candidate might improve his/her knowledge of his/her major field.

A candidate who has failed either part of the GE a second time will be required to withdraw from the Doctoral Program.

6. The Thesis Defense

Formally it is the responsibility of the Department faculty as a whole to accept or reject a thesis, and to recommend to the Institute faculty that a candidate be granted a degree. Accordingly, the candidate is required to present and defend the thesis orally, at a thesis seminar, to members of an *ad hoc* Thesis Defense Committee convened for this purpose, as well as other faculty members who wish to attend.

6.1 The MIT Degree Application Form

This form must be completed before the Thesis Defense can take place, and is subject to MIT deadlines.

6.2 The Thesis Defense Committee

It is required that the *ad hoc* Thesis Defense Committee include six members selected as follows: three members of the candidate's Thesis Committee including the Chair; the Chair of the Department GradComm, or a designated representative; and two individuals (generally, but not necessarily, from faculty or senior research staff) whose recognized professional interests and achievements qualify them to judge the quality and merits of the thesis being presented. It is advisable that the candidate seek and recommend to the Thesis Committee and to the Chair of the GradComm the persons who would serve in this capacity.

6.3 The Presentation of the Thesis to the Faculty

The procedure for the presentation, oral defense, and faculty assessment of the doctoral thesis consists of two parts: an appropriately scheduled thesis seminar, and a meeting of the six members of the Thesis Defense Committee and all other faculty present at the seminar to consider accepting or rejecting the thesis, or requiring that it be modified. The thesis seminar is open to all members of the academic community who wish to attend. The faculty meeting convened for the purpose of judging the merit of the thesis is open only to the six members of the *ad hoc* Thesis Defense Committee, who constitute the quorum, and to all other faculty members who were present at the oral defense and wish to participate in the discussion and vote.

6.4 Scheduling the Thesis Defense

For a thesis defense to be scheduled, the candidate must obtain the formal approval of the committee by their signatures on the form titled, "*Authorization to Proceed with Thesis Defense*". Specifically, the following process must be followed leading up to the candidate's thesis defense:

1. The candidate gives to his/her Thesis Defense Committee a draft of the thesis which, in the candidate's opinion, is complete, and upon which the candidate is prepared to have the research work judged by the faculty.
2. The candidate notifies the Academic Programs Office staff that a thesis draft has been given to his/her Thesis Defense Committee with the intent of obtaining approval to proceed with the Thesis Defense. This notification must include telephone and email contact information for all members of his/her Thesis Defense Committee.
3. The Academic Programs Office will contact all members of the candidate's Thesis Defense Committee to confirm (1) that they have received the thesis draft and (2) that, within **ten working days**, they must judge whether it is appropriate to schedule a thesis seminar (see Note below). Furthermore, the earliest date that the candidate's thesis

defense can occur is **thirty working days** after the Academic Programs Office has sent this confirmation.

4. The candidate must submit the (signed) form to the Academic Programs Office staff at least **twenty working days** prior to the defense date.
5. No later than **ten working days** before the thesis defense, the candidate must submit at least seven copies of a proposed final draft of the thesis for distribution, as follows:
 - one copy for each member of the Thesis Committee,
 - one copy for every other faculty member or guest invited to participate in the *ad hoc* Thesis Defense Committee, and
 - one copy to the Department library reserve shelf.

Furthermore, the candidate will send the thesis abstract to the Academic Program Office at least **ten working days** before the defense. This will be sent with the thesis defense announcement made by the Academic Programs Office.

Within the guidelines outlined above, the Chair of the GradComm is empowered to deal with all matters which arise from unforeseen absences at the scheduled time of thesis presentation.

Note: A candidate should not assume that once a thesis committee agrees to schedule a thesis seminar, the Committee considers the research and thesis satisfactory. In some cases, while a great amount of effort may have been expended, and an accomplishment of some form may be identified, the Thesis Committee may question the quality and importance of the results and may agree to schedule a thesis seminar in order to seek the counsel of the faculty-at-large whether the thesis is acceptable as a department document.

6.5 The Thesis Seminar

In the thesis seminar the candidate discusses, in a period of not more than 60 minutes, the motivation, methodology, results, and conclusions of the research. Afterwards the candidate is expected to defend the thesis in response to questions by the faculty and guests. The candidate is also expected to be available to answer questions which may arise at the closed faculty meeting which follows the open presentation.

6.6 Evaluation of the Thesis

At the faculty meeting following the thesis defense, any member of the *ad hoc* Thesis Defense Committee and of the faculty in general may object to accepting the thesis. If the faculty present cannot agree on the merit of the thesis, the matter will be referred to the Department GradComm, who may choose to resolve the issue itself, or may appoint a special review committee which does not include members of the candidate's original Thesis Defense Committee.

There is seldom a question of acceptance when a clearly recognizable advance has been achieved and which has been presented in a definitive, explicitly technical report. In such a case, the professional performance of the competent research worker will be evident to the technically trained colleague, even if the colleague is not a specialist in the field.

It may happen that a significant contribution has been made, but is so poorly presented in the thesis document as to be nearly unintelligible without an inordinate effort on the reader's part. Such a document is not acceptable; it is the candidate's obligation to prepare a written document

and present an oral report that make the achievements clear to a reasonably well qualified, but inhomogeneous audience such as the department faculty. The candidate will not be recommended for the degree and the candidate's name will be withheld from the degree list until a satisfactorily completed document has been presented. The Thesis Committee is responsible for judgment on this point.

6.7 Modification of the Thesis and the Manuscript Prepared for Publication

The faculty will decide, at the meeting following the thesis defense, whether the thesis is acceptable as presented or whether it must be modified. If modifications are required, the faculty will specify whether it considers these modifications to be "major" or "minor."

Minor modifications may involve correction of typing errors, alterations of structure or style of presentation in order to conform to format standards set by the Institute Archives, and changes in content or emphasis which do not substantially alter the candidate's analysis, results, or conclusions.

Revisions associated with errors in analysis, with misinterpretation of the results, or with unwarranted conclusions will require "major" modifications. In such cases, the faculty may require another thesis presentation based on the revised thesis draft, to be scheduled for a later date in accordance with the rules for scheduling a thesis seminar.

6.8 Submitting the Thesis

After a thesis has been accepted by the faculty, all members of the Thesis Committee indicate their endorsement by placing their signatures on the title page of the original copy of the thesis document.

After these signatures have been obtained, the candidate submits the original and one copy of the thesis to the Academic Programs Office. Both loosely bound copies of the thesis document must be on archival bond paper. A member of the staff in the Academic Programs office verifies that these copies satisfy the requirements set by the Institute on style and format. If the document satisfies all requirements, the candidate receives a department receipt for the thesis and a *Special Report Sheet* is sent to the Registrar, stating that the candidate has satisfied the thesis requirements. At this point, a student will not be permitted to make changes to the thesis. The Chair of the Department GradComm signs on behalf of the faculty of the department and both copies of the thesis document are delivered to the Archives Office. The Archives Office keeps one copy and sends the second copy to the Aero/Astro Library.

APPENDIX A**Doctoral Program Checklist**

- ___ English Evaluation Test (for non-native English speakers) (**at entrance**)
- ___ Diagnostic Test in technical writing (**first term**)
- ___ A minimum cumulative grade point average of 4.4
- ___ Faculty endorsement for the Qualifying Exam (QE)
- ___ Qualifying Exam (QE) (**within first three terms**)
- ___ Passing the QE process
- ___ Formation of a Thesis Committee (**within one year of passing QE**)
- ___ *Doctoral Program Record Form*
- ___ Major program selection
- ___ Minor program selection
- ___ *Minor Proposal Form*
- ___ *General Exam Authorization Form*
- ___ General Examination (GE) in the major field (**within two years of passing QE**)
- ___ Satisfactory performance in the minor field
- ___ Institute Residency Requirements
- ___ Thesis Proposal
- ___ A satisfactory thesis
- ___ MIT Degree Application Form
- ___ A defense of the thesis

APPENDIX B

Topical List on the Doctoral Qualifying Examination

Basic Material

Calculus and Differential Equations - 18.01, 18.02, 18.03

18.01 - Differentiation and integration of functions of one variable, with applications.

Concepts of function, limits, and continuity. Differentiation rules, application to graphing, rates, approximations, and extremum problems. Definite and indefinite integration. Fundamental theorem of calculus. Applications of integration to geometry and science. Elementary functions. Techniques of integration.

Approximation of definite integrals, improper integrals, and l'Hopital's rule.

18.02 - Calculus of several variables. Vector algebra in 3-space, determinants, matrices. Vector-valued functions of one variable, space motion. Scalar functions of several variables: partial differentiation, gradient, optimization techniques. Double integrals and line integrals in the plane; exact differentials and conservative fields; Green's theorem and applications, triple integral, line and surface integrals in space, Divergence theorem, Stokes' theorem; applications.

18.03 - Ordinary differential equations. Standard solution methods for one first-order equation, including graphical and numerical methods. Higher-order forced linear equations with constant coefficients. Complex numbers; Laplace transform. Matrix methods for first-order linear systems with constant coefficients. Series solutions to second-order equations. Fourier series solutions. Modeling of physical problems and interpretation of the analytic or graphical solutions.

Discrete Mathematics (Based on excerpts from MIT subjects: 6.042J (discrete math), 6.045J (modeling computation, automata theory), 6.041J (probability and statistics))

Logic (proposition, predicates and quantifiers), sets, functions, sequences and summations, big O, Enumeration: permutations and combinations, discrete probability. Relations. Graphs. Trees. Boolean algebra. Modeling computation: finite-state machines and basic automata

Note that the list does not include *all* the topics covered in the subjects listed. Some other universities do have one-semester classes in Discrete Mathematics that cover the items on the list with the exception of the probability material. The reason for listing the three subjects is the subject organization at MIT.

Dynamics (16.07)

Philosophy of questions: Overall emphasis on modeling - idealization of physical reality to allow for application of mechanics

Coordinate frames, use of vectors for dynamics problems

1-D, 2-D and 3-D Kinematics, including relative motions, frames of reference

Newton's Laws

Forces, moments, free-body-diagrams

General motions

Rotational motions, torques (basically 2-D but option to include some 3-D, including gyroscopic motion)

Dynamics of systems of particles,

Rigid body motions - moments of inertia

Impulse and momentum - conservation of linear and angular momentum

Central force motions including planetary orbits

Work, potential and kinetic energy

Mechanical vibrations, oscillations, systems with one and two degrees of freedom - setting up and solution of governing equations.

Wave equation

Fields - Based roughly on MIT Course 8.02

Electromagnetism and electrostatics: electric charge, Coulomb's law, electric structure of matter; conductors and dielectrics. Concepts of electrostatic field and potential, electrostatic energy. Electric currents, magnetic fields and Ampere's law. Magnetic materials. Time-varying fields and Faraday's law of induction. Basic electric circuits. Electromagnetic waves, Simple Harmonic Oscillations and Maxwell's equations. Vector flow fields, basic vector calculus

Professional Area Subjects

See Aero/Astro Undergraduate Professional Area Subject Syllabi.

APPENDIX C

Qualifying Exam Research Presentation Guidelines for Students and Examiners

Primary purpose:

To contribute to the assessment of the candidate's potential to complete an MIT doctoral thesis

In the research presentation itself, the student is expected to:

- Give motivation for the work, citing previous work as appropriate
- Present the material in a clear and concise manner
- Summarize the main conclusions of the work

In the follow-up Q&A, the student is expected to:

- Show a thorough understanding of the material
- Understand how the material advances or enhances previous work
- Understand any shortcomings of the work
- Suggest any appropriate follow-on work which might be indicated
- Be able to examine the topic from alternative viewpoints

Timing information:

- A research presentation exam session lasts 45 minutes.
- The student is to present for no more than 20 minutes, followed by no more than 20 minutes of Q&A.
- The presentation should not be interrupted by the examiners, except for points of clarification. The time needed to address any such interruptions will not count against the student's allotted time, but will be considered part of the Q&A.