Computational Science and Engineering Doctoral Program Guide
MIT Center for Computational Science and Engineering

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Preface: The following is the initial version of the CSE Doctoral Program Guide. Given there are inevitably errors, poor wordings, oversights, and policies having unintended effects, feedback from CSE PhD candidates, their advisors, CSE faculty, researchers, and students is very welcome. Please send any comments to the CCSE leadership.

1. Center for Computational Science and Engineering (CCSE)

The Center for Computational Science and Engineering (CCSE) is an interdisciplinary academic unit of the MIT Schwarzman College of Computing that offers graduate-level education in computational science and engineering (CSE). The CSE field centers on the development and analysis of state-of-the-art methods for computation, and their innovative application to problems of science and engineering interest. CSE synthesizes intellectual foundations in applied mathematics, statistics, computer science, and the full range of science and engineering disciplines into a discipline of its own—one that links the digital and physical worlds.

Key elements of CSE graduate education include computational mathematics (numerical analysis, optimization, model reduction, high-dimensional approximation), uncertainty quantification, statistical inference, and inverse problems, along with simulation methods ranging from numerical methods for partial differential equations to molecular simulation to Monte Carlo methods. Data-driven methods (e.g., scientific machine learning and computational statistics) are prominent threads within CSE, as are high-performance computing, mathematically-oriented programming languages, and their broader links to algorithms and software.

1.1. CCSE Leadership & Administration

CCSE is led by Co-Directors Nicolas Hadjiconstantinou and Youssef Marzouk. Nicolas Hadjiconstantinou is a professor in MIT's Department of Mechanical Engineering; Youssef Marzouk is a professor in MIT's Department of Aeronautics and Astronautics and is also a core member of MIT's Statistics and Data Science Center. The CSE PhD Graduate Officer (referred to hereafter as the Grad Officer) is David Darmofal, who is also a professor in MIT's Department of Aeronautics and Astronautics. Kate Nelson is CCSE's Assistant Director and Zhao Xian is our Senior Academic Assistant. These individuals are valuable sources of information and support for CCSE's graduate students. If you have any questions or problems we encourage you to reach out to Kate Nelson. CCSE's Co-Directors and Grad Officer are also available for advice and guidance.

Name	CCSE Role	Office Location	Email	Phone Number
Nicolas Hadjiconstantinou	Co-Director	3-364 / 45-421B	ngh@mit.edu	617.452.2280
Youssef Marzouk	Co-Director	32-D714 / 45-421A	ymarz@mit.edu	617.253.1337
David Darmofal	Graduate Officer	37-451	darmofal@mit.edu	617.258.0743
Kate Nelson	Assistant Director	45-421D	kpnelson@mit.edu	617.253.3725
Zhao Xian	Senior Academic Assistant	45-421C	zxian@mit.edu	617.258.6077

1.2. CCSE Suite

CCSE is housed in the Schwarzman College of Computing building, MIT building 45, located at 51 Vassar Street. Limited student desks are available in the CCSE suite, 45-421, with priority given to students enrolled in the standalone CSE PhD program. To be assigned a desk space please contact Zhao Xian. Please note that due to space limitations students are not permitted to have desks assigned in both the CCSE suite and another location on campus (e.g., within the advisor's group area). CCSE community members are welcome to drop into the CCSE suite for coffee, espresso, tea and snacks at any time.

1.2.1. Card Access

CSE PhD students are granted card access to Bldg 45 and the CCSE suite, 45-421. If you experience any issues accessing the building or suite please contact Zhao Xian.

1.2.2. CCSE Printer

There is a color printer available to the CCSE community in 45-421 between offices 45-421C and 45-421D; directions to connect to the printer are posted on the wall adjacent to the printer.

1.2.3. Reserving Rooms in Bldg 45

Building 45 has numerous spaces available for reservation including breakout rooms, huddle rooms, small to medium meeting rooms and conference rooms. Reservation procedures vary by room; please see instructions on the room you need to reserve and contact Zhao Xian with any questions or issues.

1.3. CCSE Communication

CSE PhD students should be checking their MIT email regularly for important updates and information from CCSE leadership and administrators. Students should also receive information via the following elists: cse-phd@mit.edu, cse-grad-students@mit.edu and ccse_announce@mit.edu. If you are not receiving messages from these elists, please notify Zhao so the issue can be remedied.

CCSE administrators routinely receive requests to forward emails covering a wide range of topics from the broader MIT community. In an effort to decrease superfluous email traffic these messages will instead be posted in the "#email-forwards" channel within the MITCCSE Slack workspace (http://mitccse.slack.com/) for students to read at their own convenience. If you are unable to join the CCSE workspace or if you do not have access to the #email-forwards channel please contact Zhao for assistance.

1.4. CCSE Seminar Series

CCSE runs two distinct seminar series. Please see below and https://cse.mit.edu/news/seminars/ for more information.

1.4.1. CSE Community Seminars

This series occurs weekly on Friday from 12–1 PM in 45-432 and focuses mostly on internal speakers (e.g., current graduate students, postdocs, research scientists, and faculty) with occasional informal visits by external CSE-focused researchers (ranging from graduate students to faculty). The objectives of the seminar are to:

- strengthen community among all people at MIT engaged in CSE;
- encourage interdisciplinary dissemination of CSE research across MIT;
- provide an opportunity for early career CSE researchers to present their work, including as practice prior to conferences, job talks, etc.

Individuals interested in presenting during the CSE Community Seminar Series can sign up here.

1.4.2. Distinguished Seminars in Computational Science & Engineering
This Institute-wide seminar series draws a broad audience of CSE-focused researchers from mathematics, science, and engineering, and focuses on innovative methods and applications of computation. The seminar is held monthly during the academic year, and tends to focus on external speakers who are leading research innovation in CSE.

1.5. CCSE Student Group: Association of Computational Science & Engineering Students (ACSES)

The mission of ACSES is to foster social connections among students in CSE and other computation-related programs, provide a platform for discussing ongoing research and popular topics in computational science and engineering, and promote CSE programs to attract more students and scholars interested in this field. The ACSES leadership team can be contacted via acses-board@mit.edu.

2. Admission and Matriculation

2.1. Admission

Prospective students are required to apply for admission via the CSE PhD electronic application in the fall prior to the year of desired enrollment. Incomplete applications will not be considered. The program conducts one admission cycle per year. All admissions decisions are final and not subject to appeal.

2.2. Matriculation

Expected matriculation for the CSE PhD program is in September (beginning of the fall term). Admitted students who wish to enroll 'off-cycle' (spring / summer terms) must contact the assistant director in writing at least one month prior to requested enrollment term. Please note that a request to enroll off-cycle does not guarantee approval; all requests will be considered by the Grad Officer and Co-Directors on a case-by-case basis.

2.3. Deferrals

Requests to defer admission must be submitted in writing to the assistant director as soon as possible. Please note that a deferral request does not guarantee approval; all requests will be considered by the Grad Officer and Co-Directors on a case-by-case basis.

2.4. Required English Language Examinations

2.4.1. Graduate Writing Exam (GWE)
All incoming CSE PhD students, regardless of citizenship or native language, are required to take the MIT Graduate Writing Exam (GWE). The GWE is taken the summer before matriculation and assesses incoming students' competency in technical writing, proper use and citation of sources, and usage of standard written English. Students who do not receive a score of 75 or higher are required to take

21W.794 Graduate Technical Writing Workshop. Students may opt to take the workshop with P/D/F grading (rather than an A-F letter grade), whereby they must receive a P grade.

2.4.2. English Evaluation Test (EET)

In accordance with a requirement approved by the Committee on Graduate Programs (CGP) in Spring 1982, the MIT English Language Studies (ELS) Program provides the English Evaluation Test (EET), a diagnostic test of academic English language skills for incoming graduate students from non-English language academic backgrounds. All entering international graduate students who did not have English as their primary language of instruction in both elementary and secondary school (i.e., from age six through high school) must take the EET as a prerequisite for registration. The EET consists of assessments of listening, speaking, reading, writing, and grammar to identify weaknesses in academic speaking and writing English that may interfere with course work, teaching, and research at MIT.

2.5. CCSE Orientation

CSE PhD students are required to attend CCSE Orientation, which takes place on Registration Day ("Reg Day") in September, the day before classes begin. More information will be communicated via email over the summer.

2.6. Guaranteed Transitional Support

CCSE offers one term of guaranteed financial support to students in good academic standing who need to transition to a different advisor/group due to an unhealthy advising relationship. Students who wish to inquire about this program should get in contact with the assistant director or grad officer as this process will look different for each student.

2.7. "Practical Training" Opportunities for F-1 Students - CPT & OPT

To reiterate, per US federal regulations, international students can not pursue any off-campus employment, paid or unpaid, (e.g., internship, start-ups, or related employment activity) without proper, prior authorization. There are two types of "Practical Training" opportunities available to F-1 students: Curricular Practical Training (CPT) and Optional Practical Training (OPT). F-1 students considering off-campus employment, including internships, must carefully review the information available on the ISO Employment section to ensure they satisfy eligibility criteria as set by the US federal government and follow the process set by MIT ISO.

Internships are not a required component of the CSE PhD curriculum. Therefore, F-1 students interested in CPT must meet criteria 2-5 as outlined on the ISO's CPT page. In particular, there must be coursework left to complete towards the CSE PhD's required 111 graduate credit units in order to meet eligibility requirements for CPT; this is federal policy and is non-negotiable. F-1 students seeking CPT must also have completed one full academic year (fall and spring), be in good academic standing, have advisor approval, register for CSE.999 in the semester they conduct the CPT experience, which includes paying the associated tuition, and the experience must be integrally related to CSE. In order to apply for CPT off-campus work authorization, all F-1 students must first complete the ISO CPT Canvas eCourse and pass the ISO CPT Canvas eCourse Quiz with a grade of 90% or better. Please note that interested students are responsible for arranging the CPT opportunity and must email the CSE assistant director with a letter/memo/email from the sponsoring organization, copying their MIT advisor,

as soon as possible but at least 4 weeks prior to the start date, so CCSE can provide the requisite program support letter in advance of ISO's deadline.

Eligibility requirements for OPT (both pre and post completion) are less stringent; however, the OPT opportunity must be directly related to CSE for F-1 CSE PhD students. Interested students are responsible for making arrangements and should contact the CSE assistant director as soon as possible for the program support letter.

3. Program Requirements

The standalone doctoral program in Computational Science and Engineering (CSE PhD) enables students to specialize at the doctoral level in fundamental, methodological aspects of CSE via focused coursework and a thesis. The emphasis of thesis research activities is the development and analysis of broadly applicable computational approaches that advance the state of the art. Students are awarded the degree of Doctor of Philosophy in Computational Science and Engineering upon successful completion of the program requirements and defense of a thesis describing significant contributions to the CSE field.

Program requirements include a course of study comprising 108 units of graduate subjects and a graduate seminar. The 108-unit subject requirement consists of a core providing graduate level coverage of fundamental areas of CSE, a concentration of two additional subjects in a chosen core area, as well as unrestricted electives. The program requirements—including course-based qualifying evaluation, formation of a thesis committee, written thesis proposal, oral thesis proposal defense, thesis defense and final thesis document—are described in more detail below.

3.1. Program of Study

Students develop their program of study in accordance with the CSE PhD program requirements, listed below, in consultation with their advisor and thesis committee. Once formed, the program of study should receive approval from the grad officer.

Subjects taken as part of an MIT SM program can be counted toward the coursework requirement provided they satisfy core, concentration, or elective requirements as set forth here; consultation and approval by the grad officer, program director(s) and/or assistant director regarding the application of such courses toward program credit is always required.

The CSE PhD program of study comprising 111 graduate credit units, consists of the following:

- Core (60 units)
  - Numerical linear algebra (18.335)
  - 4 subjects, covering 4 of 6 core areas ("ways of thinking" foundational to CSE)
    - Discretization and numerical methods for PDE
    - Optimization methods
    - Inference, statistical computing, and data-driven modeling
    - High performance computing, software engineering, and algorithms
    - Mathematical foundations (e.g., functional analysis, probability)

        - Computational modeling (i.e., a subject that treats the application of computational methods to *modeling* in any science or engineering discipline)
    - Concentration (24 units)
    - Unrestricted electives (24 units)
    - Doctoral seminar in CSE (CSE.900, 3 units)

Core (60 units)
Students are required to take 18.335 and an additional 48 units of graduate-level subjects in four of the CSE core areas chosen from the list of approved CSE PhD subjects (see this Appendix).

Concentration (24 units)
The concentration is designed to provide more depth in one of the four core CSE areas chosen above; each student will complete 24 more units of graduate credit in the selected area. Concentration subjects need to be taken from the list of approved CSE PhD subjects (see Appendix).

Unrestricted Electives (24 units)
Students may choose any 24 units of graduate subjects in any field from the MIT Subject Listing.

CSE.900
This required interdisciplinary seminar explores diverse topics in computational science and engineering (CSE), featuring talks from Institute faculty and external speakers. The seminar surveys current research in CSE methodologies and applications, and discusses important open research areas, as well as the ethical context and implications of research advances in CSE.

3.2. Academic and Research Advising

CSE PhD students' research / thesis advisors also serve as their academic advisors. The CCSE co-directors, grad officer and assistant director are also available to offer academic guidance.

New CSE PhD students are expected to indicate their advisor prior to matriculation via email to the assistant director, with the advisor copied.

Occasionally a research project does not proceed according to the expectations of the student, the research advisor, or both and in some cases the need for a change in research project or research advisor may become apparent. Early recognition of the possibility of switching topics and/or advisors is an important factor in successfully managing this process. Any student contemplating a change in research advisor should contact the grad officer and/or the assistant director for consultation and assistance. If a change in research advisor has been made, the student must notify the assistant director via email, copying the new advisor.

3.3. Thesis Research and CSE.THG

Research is an integral aspect of the CSE PhD program and as such, enrolled students are expected to begin their thesis research upon matriculation into the program.

3.3.1. CSE.THG and Overall Expected Effort

CSE PhD students are required to register for a minimum of one unit of CSE.THG, graduate thesis research, every regular semester. The number of CSE.THG credit units should be representative of the student's effort spent progressing in their thesis research, beyond the time spent conducting research for an RA (if the student's funding includes an RA appointment). A wide range of activities can contribute to a student's thesis research progress beyond directly working on the topic of their thesis. This is in particular true early in a PhD when a thesis topic may not be decided and skills and knowledge of CSE are being strengthened. Some examples of activities that could contribute to thesis research progress include but are not limited to: literature reviews; exploration of topics for consideration of possible thesis topics; building general knowledge and skills that contribute to a student's ability to conduct research in CSE; etc.

The recommended effort for full-time students in the CSE PhD is 56 to 60 hours per week in total between academic and employment efforts. Note that MIT's common accounting is that 1 unit is equivalent to 1 hour/week. Further, a 100% RA or TA appointment is a 20 hour/week obligation. It is the sum of coursework, CSE.THG, and (if applicable) RA/TA employment that is expected to be no more than 60 hours per week. Some example scenarios for students in the CSE PhD program are:

- A first year student funded through a 100% RA:
    - 20 hours RA
    - 27 units of coursework from two 12 unit subjects + 3 units for CSE.900
    - 13 units of CSE.THG
    - Total = 60 units (hours)
- A first year student funded through a fellowship:
    - 27 units of coursework from two 12 unit subjects + 3 units for CSE.900
    - 30 units of CSE.THG
    - Total = 57 units (hours)
- A third year student funded through a 100% RA:
    - 20 hours RA
    - 36 units of CSE.THG
    - Total = 56 units (hours)

The exact breakdown should be agreed upon by the student and advisor prior to registration each semester. Additional information on MIT's account for academic and employment effort can be found on this OGE webpage.

Summer registration is typically optional, but those doing research or thesis work during the summer must register for the summer session in accordance with Graduate Policies & Procedures. Graduate students who are not registered during the summer but who have not graduated or withdrawn from MIT are still considered continuing students.

3.3.2. Thesis Research Progress Evaluation

Before the end of every Fall and Spring term, a formal research progress evaluation is required for all CSE PhD students in conjunction with assigning a grade to CSE.THG. Students should use the CSE PhD Thesis Research Self-Evaluation Form. The student and advisor will then meet to discuss the student's research progress and their self-evaluation. Following this meeting, the advisor will

submit feedback and the CSE.THG grade using the CSE PhD Thesis Research Grade and Advisor Feedback Form.

3.3.3. Expectation of Satisfactory Progress
CSE PhD students are expected to make continued satisfactory thesis research progress, as denoted by the 'J' grade in CSE.THG.

A modifier of minus on a J grade, i.e., a "J-", indicates that a student only partially met expectations of satisfactory academic performance or progress. In this case, the assistant director will compile information provided by the student and advisor in the thesis research self-evaluation and feedback forms, and then confirm that both parties have discussed appropriate next steps for the student to make satisfactory thesis research progress in future terms.

Students who are making unsatisfactory progress, as denoted by the "U" grade in CSE.THG, will receive a formal warning letter from CCSE, and the Graduate Academic Performance Group (GAPG) will be notified. All situations are handled on a case-by-case basis, and additional action(s), ranging from a Vice Chancellor's warning to a denial of further registration, may be taken if necessary.

3.4. Academic Performance and Progress
CSE students are expected to maintain a grade point average (GPA) of at least 4.5 (out of 5) during the course of their studies to be considered in good academic standing. If a student's term GPA is at or below 4.0 for two sequential terms, if a student receives an Unsatisfactory ("U") grade in CSE.THG, or if a grade of C or lower is given in any subject, the student is failing to meet minimum program requirements and a program warning letter will be issued and the MIT Graduate Academic Performance Group (GAPG) may be alerted.

If a student receives a grade of D in any subject, that subject may not be used to satisfy CSE PhD curricular requirements. Additionally, subjects taken with the graduate P/D/F grading option cannot be used to satisfy the CSE PhD Program of Study.

Students who fail to meet the academic performance requirements are expected to make substantial improvement by the end of the following term to return to good academic standing. Failure to meet this expectation may lead to additional actions taken, up to and including a warning from the Vice Chancellor, being allowed to register only for a less advanced degree, and/or denial of further registration.

Students who feel that their performance may not be meeting the CSE PhD academic performance requirements or have extenuating circumstances that need attention should contact the assistant director or grad officer as soon as possible to discuss their individual situation and ways the program and Institute can better support them.

Taking more than 24 units of regular subjects per semester beyond the CSE.900 requirement, if applicable, is strongly discouraged. CSE PhD students who seek to enroll in more than two regular

subjects (24 units) are required to consult with their advisor and the grad officer in advance of registration.

3.5. Qualifying Evaluation

The purpose of the CSE PhD qualifying evaluation is to assess whether students are successfully developing the necessary knowledge and attributes of CSE doctoral candidates at MIT. CSE PhD's qualifying evaluation is course-based. Specifically:

- Students must designate which three of their five core subjects will be used as their qualifying subjects no later than at the start of their third regular semester by submitting the CSE PhD Qualifying Subject Declaration Form for program review and approval.
- A core subject associated with the student's computational concentration must be one of these three qualifying subjects.
- Subjects taken before a student declares and receives program approval for their individual list of qualifying subjects may be used at the discretion of the grad officer.
- Any transfer credit(s) received may not be used towards the qualifying evaluation.
- Students are required to obtain an A grade (with any modifier) in all three qualifying subjects and also have a minimum cumulative GPA of 4.5 out of 5.0 at the time of qualification to be deemed successful.
- If a student receives a grade less than an A- in a designated subject, the student must discuss an alternative with the assistant director and/or grad officer.
- All qualifying subjects must be successfully completed no later than the fourth regular semester.

3.6. Doctoral Thesis Committee

After successful completion of the qualifying evaluation and no later than the end of the fifth regular semester, CSE PhD candidates must form their Doctoral Thesis Committees and hold an initial meeting. The thesis committee consists of a minimum of three members:

- Thesis advisor: must be a MIT faculty member or senior research scientist.
- Committee chair: must be a CCSE faculty member or senior research scientist. Note: if the advisor is CCSE-affiliated, then the advisor may fulfill both the role of the advisor and the chair.
- In addition to the committee chair, one other member must be CCSE-affiliated (in this case, either a CCSE faculty, senior research scientist, or principal research scientist is acceptable).
- Any committee member external to MIT must hold a doctoral degree.

Candidates should form their committees after consultation with their advisors and, if needed, the grad officer by contacting qualified individuals (as described above), discussing research plans and objectives, and verifying their willingness to serve on the committee. Once a candidate has finalized their committee members, this information must be reported to CCSE via the Thesis Committee Membership form.

3.6.1. Role of the Doctoral Thesis Committee Members

The thesis committee is responsible for monitoring and providing advice on the doctoral candidate's academic and research progress. The committee does not assume responsibility for the quality of the research performed; rather, its role is to critically evaluate the progress reported and offer suggestions and advice which may help the candidate in pursuit of their research goals. The quality

of the research is the sole responsibility of the candidate and is the essential measure by which the faculty judge performance in the doctoral program.

3.6.2. Committee Meetings & Frequency

Candidates should be in touch with their committee members regularly and are required to arrange a meeting of the full committee at least once each regular term. Within one week following each committee meeting students are required to submit the Thesis Committee Meeting Report form to document attendees, topics discussed, progress to date and the committee's expectations for future progress.

3.7. Thesis Proposal and Thesis Proposal Defense

After the initial thesis committee meeting, CSE PhD candidates are required to submit a written thesis proposal and participate in an oral thesis proposal defense. The objectives of the thesis proposal and proposal defense are to ensure that the student has:

(a) developed a deep understanding of their research field, including a comprehensive and critical review of the relevant literature,
(b) identified a problem that could produce a doctoral-quality contribution, and
(c) devised a reasonable plan for how to proceed.

The student will prepare a thesis proposal document that is distributed to the student's thesis committee. As well, the thesis proposal will be made available to CCSE faculty and senior research scientists who may provide feedback to the student's thesis committee prior to the thesis proposal defense. The student then defends this proposal to their thesis committee in an oral session. The thesis proposal must be successfully defended by the end of the student's sixth regular semester in the program.

When preparing the written thesis proposal, candidates should think critically about their work in consultation with their advisor, who will help to define the project and identify possible pitfalls and problems. It is important for candidates to remember that this is a proposal, not a summary document of past work nor a binding contract regarding future work. The actual work will be guided and reviewed by the thesis advisor and thesis committee and may evolve in unexpected directions.

Candidates should demonstrate professionalism in presenting their proposal. A typical thesis proposal presentation should be no more than 30 minutes long, with an additional 30 minutes for questions and discussion with the candidate, and an additional 30 minutes for deliberation of the thesis committee. Feedback from the committee should be welcomed and taken constructively. If the candidate's performance is unsatisfactory in the judgment of the committee, the student will be so informed and will be deemed to have failed the thesis proposal defense. Students who fail the oral thesis proposal defense may request to revise and defend the proposal at most a second time, which must be completed by the end of the next regular term. Under no circumstances is a candidate permitted to redo the oral thesis proposal defense more than one additional time.

3.7.1. Formatting requirements

The written thesis proposal should be a maximum of 30 pages, single spaced, inclusive of figures but not including cover page or references, using at least an 11-point font and one inch margins.

Although the format of each written thesis proposal is a matter to be determined between the candidate and their advisor, the outline below may serve as a useful guide:

- Cover Page
    - Includes proposed thesis title, candidate's name, name(s) of research advisor(s) and members of the thesis committee, and date of submission.
    - The mailing addresses, email addresses and telephone numbers of thesis committee members should also be included.
- Abstract
    - Should not exceed one page
- Specific Aims
    - Clearly states the thesis objectives
    - Should not exceed one page
- Background
    - Presents rationale for conducting the proposed research
    - Reviews previous research relevant to the proposed work
- Research Plan
    - Discusses planned research with particular emphasis on expected difficulties and challenges
    - Presents preliminary results
    - Indicates how proposed results will serve to meet the proposed objectives
- Timeline
    - Delineates the expected timeline
- References

3.7.2. Policies

Aligning the schedules of committee members can be quite challenging at certain times during the academic year. It is therefore strongly recommended that candidates not wait to the very end of the allotted time frame to complete the requirement. It is the candidate's responsibility to confirm committee availability, reserve an appropriate room, schedule any audio/video equipment required, and complete the requisite forms.

The written thesis proposal must be emailed to all committee members and the assistant director no less than 2 weeks (10 business days) prior to the oral thesis proposal defense along with a confirmation of when and where the oral thesis proposal defense will take place. After submitting the written thesis proposal to the committee, the candidate should neither solicit nor expect to receive feedback on this document from any committee members, including the advisor, prior to the oral presentation. The advisor and committee members may provide feedback on drafts of the oral presentation; however, it remains solely the student's responsibility to decide how to utilize that feedback.

During and after the oral presentation, the committee members ask questions related to the presentation, written proposal, and general topic of the proposed research. The committee should raise questions about the motivation, novelty, potential impact, and feasibility of the proposed work. The advisor is encouraged to ask questions but may not answer them as this exercise is intended to assess the candidate's understanding of their field and proposed research. At the end of the

question period the candidate is asked to leave the room while the committee evaluates if the candidate has achieved each of the objectives of the proposal and proposal defense (see the objectives listed above in the introduction to 3.7. Thesis Proposal and Thesis Proposal Defense).

Failure to submit the written thesis proposal and/or deliver the oral thesis proposal defense within the aforementioned deadline without prior program approval will constitute unsatisfactory progress toward the doctoral degree and a program warning letter will be issued. The MIT Graduate Academic Performance Group (GAPG) may be alerted and other actions may be taken, up to and including a warning from the Vice Chancellor, being allowed to register only for a less advanced degree, and/or denial of further registration.

3.8. Thesis and Thesis Defense

The doctoral thesis document is a major, original work that makes a significant contribution in its field. It is the principal component of the doctoral program, and the part that serves as the major indicator of the candidate's abilities. Work already completed elsewhere, not under the supervision of a member of the MIT faculty, cannot be accepted in full or partial fulfillment of the thesis requirement.

3.8.1. Thesis Defense Committee

The candidate, in consultation with the advisor and thesis committee, must identify qualified individuals to serve on the thesis defense committee. At least six weeks before the tentative thesis defense date, the candidate must submit their finalized thesis defense committee membership and the tentative defense date to the CCSE assistant director via the Thesis Defense Planning form (link pending).

CSE PhD thesis defense committees must include *all* thesis committee members and consist of no less than five people, all of whom serve as thesis readers and are present at the thesis defense. (Thus a student whose thesis committee comprises three people must identify two additional readers to form the defense committee.) Thesis defense committee membership must include at least three MIT faculty or senior researcher scientists. Any members external to MIT must hold doctoral degrees.

3.8.2. Scheduling

The thesis defense presentation is to be scheduled by the doctoral candidate. The candidate is responsible for coordinating with the thesis defense committee members to identify a mutually agreeable tentative date and time, reserving a room, arranging for any requisite audio/video equipment. Then, at least 4 weeks prior to the tentative defense date, the entire thesis defense committee must agree that the candidate is ready to proceed to the defense. That agreement must be based upon review of preliminary drafts of the thesis content and certifies that the candidate will almost certainly be able to provide a complete draft of the thesis 2 weeks prior to the tentative defense date.

Aligning the schedules of thesis defense committee members can be quite challenging. It is therefore strongly recommended that the candidate begins the identification of a tentative thesis defense date well before the lead time to receive the committee's approval to proceed to the defense. For example, a reasonable timeline could be for the candidate and thesis defense

committee to identify a tentative date that is three months in the future, even though approval to proceed is not required until 4 weeks before the defense. Although the thesis defense committee may agree to a tentative defense date, that agreement does not imply that the candidate will receive the committee's approval to proceed to the defense (e.g. if the preliminary thesis drafts are not acceptable).

The candidate must also complete the MIT Degree Application Form and this will often be submitted before identifying a tentative defense date. Please see the MIT Academic Calendar for specific degree application deadlines, but note that they typically coincide with registration deadlines (i.e., February for May/June graduation, June for September graduation and September for February graduation). Candidates should ensure there is at least one week between the intended thesis defense date and the Institute thesis deadline, as listed in the MIT Academic Calendar.

At least two weeks prior to the defense, the candidate is also responsible for providing an electronic copy (PDF) of a complete final draft of the thesis and a thesis defense announcement (date, time, location, thesis title, thesis committee members and abstract) to CCSE administration and to the thesis committee. Upon receiving it, the CCSE administration will make this final draft and announcement available to all CCSE faculty and senior researchers. No further changes to the thesis will be considered until after the defense.

3.8.3. Thesis Defense Presentation

In the open thesis presentation meeting, the doctoral candidate discusses the motivation, methodology, results, and conclusions of the research in no more than 60 minutes. Immediately following, the candidate is expected to defend the thesis in response to questions by their thesis defense committee and others in attendance. Then, during the closed portion of the meeting, the candidate is also expected to address questions from their thesis defense committee and faculty.

3.8.4. Thesis Defense Outcomes

Immediately following the thesis defense presentation, Q&A period, and closed meeting, the thesis defense committee and any faculty will meet to determine if:

(1) the candidate has successfully defended their thesis, and
(2) the thesis is either accepted, accepted with revisions, or rejected.

The results are recorded on the Thesis Defense Result form [link pending]. If revisions are required, the committee will specify if these modifications are major or minor. Minor revisions may involve the correction of typographical errors, alterations of structure or style of presentation in order to conform to format standards set by the Libraries, changes in content or emphasis which do not substantially alter the candidates analysis, results or conclusions and similar edits. Revisions associated with errors in analysis, misinterpretation of the results, unwarranted conclusions or similar constitute major revisions. In such cases, the committee may require another thesis presentation based on the revised thesis document, to be scheduled at a later date in accordance with the scheduling policies outlined in 3.8.2. Scheduling.

3.8.5. Thesis Submission

After the successful completion of the thesis defense and with the thesis committee determining the thesis (including an necessary revisions) to be final, an electronic document (PDF-A) must be

submitted to CCSE by the Institute thesis deadline, or in cases with prior approval, by no later than the end-of-term CSE PhD doctoral due date [more specific dates to be determined].

Please visit the MIT Libraries Thesis Specifications website for specific information about formatting and preparing the thesis in accordance with MIT standards. Another helpful resource from the MIT Libraries is the Thesis FAQ website, which includes frequently asked student questions.

The Libraries' Thesis Form must be completed by degree candidates no later than the day of graduation. The information provided **must** match the title page and abstract of the thesis.

3.8.6. Early Thesis Completion & Student Appointments
The student's graduate appointment (RA / TA / internal fellowship) will be terminated on the date the thesis is submitted in the case of early thesis completion.. Prorated tuition and fees are available to graduate students who complete their thesis early, please see the following Registrar webpage for specific dates and rates.

3.9. Program Milestone Timetable Overview

Milestone	**Timing**
Indicate faculty member or senior research scientist to serve as research / academic advisor	Prior to matriculation
Begin program of study and thesis research	Upon matriculation
Qualifying evaluation subject declaration	By the start of 3rd regular semester
Qualifying evaluation subject completion	By end of 4th regular semester
Form thesis committee and hold initial meeting	By end of 5th regular semester
Thesis proposal submitted to thesis committee members and assistant director	No less than 2 weeks ahead of the oral thesis defense
Thesis proposal & proposal defense completed	By end of 6th regular semester
Thesis defense committee membership and tentative defense date finalized	No less than 6 weeks prior to the tentative defense date
Approval to proceed to defense	No less than 4 weeks before defense date
Submission of final defensible thesis	No less than 2 weeks before defense date
Thesis defense	At least 1 week in advance of the relevant Institute thesis submission deadline
Thesis submission	As listed in MIT Academic Calendar

Appendix A: CSE PhD Approved Subjects

This appendix describes the approved subjects that can be used for the program's core, the computational concentration, and the qualifying evaluation.

Note: The subjects that can be used for the qualification evaluation are marked with an asterisk (*).

Required of all CSE PhD students (not assigned to a particular core area)
*6.7310/18.335 Introduction to Numerical Methods

Discretization and numerical methods for PDE
2.096/6.7300/16.910 Introduction to Modeling and Simulation
*2.097/6.7330/16.920 Numerical Methods for Partial Differential Equations
2.098 Introduction to Finite Element Methods
*6.7340/18.336 Fast Methods for Partial Differential and Integral Equations
6.8410 Shape Analysis
16.930 Advanced Topics in Numerical Methods for Partial Differential Equations
22.15 Essential Numerical Methods

Optimization methods
1.583/2.083/16.215 Topology Optimization of Structures
*6.C57/15.C57/IDS.C57 (formerly 6.7200/15.093) Optimization Methods
*6.7210/15.081 Introduction to Mathematical Programming
*6.7220/15.084 Nonlinear Optimization
6.7230/18.456 Algebraic Techniques and Semidefinite Optimization
6.7940 Dynamic Programming and Reinforcement Learning
10.557 Mixed-integer and Nonconvex Optimization
15.083 Integer Optimization
16.888/EM.428/IDS.338 Multidisciplinary Design Optimization

Inference, statistical computing, and data-driven modeling
2.156 Artificial Intelligence and Machine Learning for Engineering Design
2.884/10.554 Process Data Analytics
6.3732/IDS.131 Statistics, Computation and Applications
*6.7800 Inference and Information
6.7810 Algorithms for Inference
6.7830 Bayesian Modeling and Inference
*6.7900 Machine Learning
6.7910/9.520 Statistical Learning Theory and Applications
6.C51 Modeling with Machine Learning: from Alg. to App. + one of *.C51 co-reqs
*16.940 Numerical Methods for Stochastic Modeling and Inference

High performance computing, software engineering, and/or algorithms
2.111/6.6410/8.370/18.435 Quantum Computation
*6.5060 Algorithm Engineering

*6.5210/18.415 Advanced Algorithms
6.5220/18.416 Randomized Algorithms
6.5250/18.437 Distributed Algorithms
6.5320 Geometric Computing
*6.7320/18.337 Parallel Computing and Scientific Machine Learning
*Harvard COMPSCI 2050 High Performance Computing for Science and Engineering

Mathematical foundations

Any 12-unit, letter graded (P/D/F grading is not allowed), graduate level Mathematics subject numbered 18.1* or higher that is not listed elsewhere in this approved subject list. Seminar and special topics subjects are in general not allowed. Of these Mathematics subjects, the following subjects have been approved for use in the qualifying evaluation:
*18.1002 Real Analysis
*18.1011 Analysis and Manifolds
*18.1021 Intro to Functional Analysis
*18.1031 Fourier Analysis: Theory and Applications
*18.125 Measure Theory and Analysis
*18.1521 Introduction to Partial Differential Equations
*18.3541 Nonlinear Dynamics: Continuum Systems
*18.4041/6.5400 Theory of Computation
*18.655 Mathematical Statistics
*18.675 Theory of Probability

In addition, credit for the mathematical foundations core can be obtained for the following subject offered outside of the Department of Mathematics:
*6.7700/15.085 Fundamentals of Probability

Computational modeling

*1.545 Atomistic Modeling and Simulation of Materials and Structures
*1.575/4.450 Computational Structural Design and Optimization
*1.723 Computational Methods for Flow in Porous Media
*2.099/16.225 Computational Mechanics of Materials
*2.29 Numerical Fluid Mechanics
*3.320 Atomistic Computer Modeling of Materials
*5.698/10.637 Computational Chemistry
*8.315/18.369 Mathematical Methods in Nanophotonics
*9.660 Computational Cognitive Science
*12.521 Computational Geophysical Modeling
*12.850 Computational Ocean Modeling
*18.417 Introduction to Computational Molecular Biology
*22.315 Applied Computational Fluid Dynamics and Heat Transfer