Chemical Engineering Graduate Studies Guide

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The ChE Ph.D. Program

1. Coursework

a. Coursework Consultation

Upon arrival at Caltech, the ChE Ph.D. students will meet with the ChE Option Representative to discuss the program, advisor selection, and expectations for the first and second terms. During these two terms, students are expected to take a normal load of three courses per term plus 9 units of research (ChE 280) to cover the rotation *(see below)*. The courses during the first term include one each in advanced Kinetics (ChE152) and Thermodynamics (ChE165), and a third course in an area of need or an area that lines up with the research interests of the student. The courses during the second term include one each in advanced Transport (ChE151a) and Statistical Thermodynamics (ChE164) and a third course as above. The third course taken during the first and second terms must be at least 9 units and graded. The entire first year of study will also be discussed.

b. Requirements

During the first two terms, Ph.D. students are required to take five core courses: ChE 151ab, ChE 152, ChE 164, ChE 165, plus one additional ChE course from the following list: ChE 112, 115, Ch/ChE 140, 147, 148, 155, ChE/ESE 157, 158, 159, ChE/BE 163, 174. The core courses must be graded and a minimum grade of B- is required in each. There is also a minimum GPA requirement of 2.5 each term of all courses taken. Failure to meet these grade and GPA requirements places the student in a state of deficiency, which may lead to termination of the program if not corrected promptly.

c. Subject Minor or External Course Requirements

Each student is required to complete either a subject minor or a general program of courses outside chemical engineering. The general program of courses consists of at least 54 units. A maximum of 27 units from the following list of doubly-listed courses can be used by graduate students as part of the 54 unit requirement: ESE/ChE 158; Ch/ChE 140, 147, ChE/Ch 148, 155, ESE/Ge/Ch 171. A course in the ACM 100ab sequence will be credited **9** units instead of the nominal 12 units as listed in the catalog. Courses in the Humanities, Arts, and Linguistics are explicitly excluded from the general program.

The general program of courses must be submitted and approved by the Option Representative after the candidacy exam. All courses chosen must be at the graduate level and should constitute an integrated program of study rather than a randomly chosen collection of courses outside chemical engineering. A grade of C or better is required in any of these courses to remain qualified for the Ph.D. program.

The requirements for a subject minor in any option may be found in the current Caltech Catalog. If you choose to pursue a subject minor, complete the minor form at http://www.gradoffice.caltech.edu/documents/176-minor_candidacy_form.pdf. Give the form to the ChE graduate records assistant for approvals.

2. Research Advisor

The choice of a research advisor is perhaps the most important decision a graduate student makes during the first year of graduate study. This decision must be made before the end of the second term of the first year, and so it is reasonable to devote significant thought and effort to this task before then.

In the first two weeks of the Fall quarter, all faculty will present overviews of their research program during informal evening sessions. You are expected to attend all of these sessions because this is perhaps the only time you will be able to obtain a comprehensive idea of the overall breadth of research in Chemical Engineering.

Following these presentations, the students are expected to meet individually with at least two faculty members to discuss proposed research projects and the possibility of doing a rotation during the first or second terms. All students must formally join a group by the end of the second term.

3. Rotations

Rotations serve to acquaint the student with a group's research area and style. Two rotations are required, one each during the first and second terms. During a rotation, the student must participate in research activities in the chosen group for at least nine hours per week under the tutelage of a faculty or senior group member. At the end of a rotation, the student must produce a research report and give a group presentation within two weeks of the term's end. Afterwards, a rotation completion form must be signed by the rotation advisor and returned to the ChE Option Representative. At the same time, the student and the faculty member must determine whether the "match" of research interests and personalities is good. In case of a positive outcome, the student may remain in the same group for a second rotation. Otherwise, the student should proceed to do a second rotation in another group with the same requirements as above. Certain funding agencies (e.g. NIH) require a second rotation in a different group. In that case, the student will be asked to do so, even if she/he desired to remain in a particular group; the student may return to join the first group after completion of the second rotation. All students must find advisors and formally join a group by the end of the second term. Failure to do so terminates the Ph.D. program at Caltech and the student will be asked to leave.

4. Candidacy Exam

All students are required to pass the candidacy examination ideally before the official start of the second year or **at the latest** by the second week of the second academic year (i.e. only in case of faculty schedule conflicts). This oral exam is administered by the candidacy committee and consists of two parts:

a. Presentation by the student based on the contents of a *research progress report*.

b. Background questions *broadly* related to the research problem presented.

The *research progress report* must be submitted to the candidacy committee members and the ChE Option Representative by August 31st of the first year in residence. The report should expound on the research pursued by the student and is expected to exhibit originality and a professional quality of exposition. It should outline the research problem, proposed approach, the expected contributions in the general problem area, and the

progress of the student at the time of writing. It should also provide clear evidence of the student's understanding of the research topic the underlying science and technology related to that research, and the student's mastering of the relevant techniques and methodology necessary to pursue the proposed research.

The candidacy committee should consist of *no fewer than four **voting** members of the Caltech faculty*, with at least three being *Chemical Engineering faculty*. To ensure the impartiality of the committee, the Chair of the committee and at least one more of the committee members must have no direct advisory relationship with the candidate. The choice of the committee will be made by the student and his/her research advisor. A list with the committee member names must be submitted to the ChE Option Representative for approval, indicating the proposed Chair (cannot be the advisor). It is the responsibility of the student to obtain approval from each proposed committee member for the date and time of the oral exam. The list of the recommended committee members must be submitted to the Option Representative at the same time as the research progress report.

There are no explicit guidelines to the oral exam itself. During the research presentation the student should strive to:

a. Convince the committee that she/he has a clear idea of the pursued research
b. Demonstrate good understanding of the literature and the challenges posed
c. Ascertain the novelty and soundness of the proposed approach
d. Substantiate the progress made by her/him along the chosen research path

The second component of the oral exam consists of chemical engineering background questions relating broadly to the student's research topic. The Chair of the committee shall be responsible for ensuring that the questions are at an appropriate level, consistent with that of undergraduates at Caltech. For example, if you are studying heterogeneous catalysis, you must be able to answer questions on basics such as: surface reaction mechanisms, diffusion/reaction in porous media, and multi-component gas-phase transport, etc. Similar considerations apply to Ph.D. projects related to fluid mechanics, thermodynamics, basic biology, physics, chemistry, etc. The advanced courses taken during the first year should help you prepare well for this part of the exam. Serious gaps in the understanding of classical chemical engineering concepts, approaches, and methodologies applicable to your research may lead to failing the exam even if research progress is deemed adequate. Furthermore, for interdisciplinary projects going beyond classical chemical engineering, you will be expected to demonstrate good understanding of the fundamentals in other areas directly relevant to your project. The candidacy exam may have three outcomes: Pass, Conditional Pass, or Fail. Passing the candidacy exam admits you to Candidacy for the Degree of Doctor of Philosophy. Failing the candidacy exam terminates a student's Ph.D. program at Caltech. When course requirements are met, the student may be awarded an M.S. degree at the recommendation of the candidacy committee. Conditional Pass is a special outcome granted only when the student has clearly passed the background questions component, but the committee deems that more is needed on the research front. In this case, the committee chair will put in writing what is required and the time frame to meet those requirements. Under no circumstances is this time to exceed one term. Meeting the stipulated requirements must be reflected in a revised candidacy report, which must be submitted to and approved by the candidacy committee by the set deadline. It is at the discretion of the committee to request a re-examination. In any case, a Pass or Fail decision must be reached at the latest by

December 15th of the second year in residence. This is a hard deadline for both the student and the committee. In case of no communication to the ChE Option Representative by December 15th, a Fail decision will be entered automatically.

5. Thesis Review Committee

After the student passes the candidacy exam, the candidacy committee becomes the "de-facto" Thesis Review Committee, which will be responsible for reviewing the student's progress. The committee must be convened (as a group) during the fourth year of residency and every year thereafter to review progress, suggest improvements in research, or resolve any issues that could potentially delay graduation beyond the fifth year of residency. It is the responsibility of the student to organize the annual meetings of the Thesis Review Committee, which may be convened at any time during the year but at least three months before registration for the next academic year is due. Subsequent registration beyond the fourth year is subject to written approval by the Thesis Review Committee and the ChE Option Representative. In order to expedite the review, the student should submit a two- or three-page *concise outline* of progress and of proposed future research to each member of his/her committee before the annual review meeting.

6. Final Thesis and Oral Defense

As a final step in the Ph.D. program, the student is required to submit a satisfactory thesis, present a ChE seminar (open to the general public), and pass a final oral examination. "Ph.D. Examination Procedures" on page 5 describes the procedures in detail.

7. Graduate Teaching Assignment Duties

All Ph.D. students are required to perform a minimum of **24** term-hours of GTA duties during their studies. The GTA duties will normally be assigned after the first year in residence. Most students find the teaching assistantship a valuable experience for their future careers. TA'ing classes outside ChE does not count toward the 24-hour TA requirements.

Ph.D. Examination Procedures

The final Ph.D. exam will consist of a defense of the candidate's thesis research. Prior to the formal exam, each candidate is required to present a seminar (open to the public) on his/her work; this seminar will be scheduled in the Caltech Calendar as a regular Chemical Engineering Seminar. The exam and seminar must be held at least two weeks before the degree is conferred.

1. Procedures for Seminar, Exam, and Committee Approval

At least *three weeks* prior to the exam date, give the ChE graduate records assistant the title of your seminar, date, time and location. Both the seminar and exam should be scheduled on the same day: the exam (room #113 Spalding Lab) immediately following the seminar (room #106 Spalding Lab). The committee members will be determined by you and your research advisor, and must be approved by the ChE Option Representative and the Dean of Graduate Studies. The examining committee must include at least **four** members, of which at least **three** are voting members of the Caltech faculty and at least **two** are ChE faculty; one member of the committee may be from off-campus with prior approval of the ChE Option Representative.

Check with the members of your committee for agreement on the date and time of the exam and enter the information in REGIS. When the Ph.D. seminar, thesis and exam are satisfactory, the members of the examining committee will indicate their approvals in REGIS. You will be notified later by the Dean of Graduate Studies that you have completed all the requirements for the Degree of Doctor of Philosophy.

2. Procedures for Submitting the Ph.D. Thesis

At least two weeks prior to your exam, supply each member of your committee with a copy of your thesis. Also, submit one copy of your thesis to the Graduate Office for proofreading (you will be notified as soon as the proofreading is complete). If your committee members require corrections or revisions of your thesis, it is your responsibility to:

a. Make the necessary corrections/revisions.

b. Submit the revised thesis to members of your examining committee.

c. Secure committee signatures in Regis after the acceptance of the revised thesis.

After the exam is passed in all respects and the committee members have entered their approvals in REGIS, submit the final and approved thesis to the Grad Office per the Grad Office instructions. Also submit three copies on Perma-Life bond paper, reproduced from the original, to the ChE Graduate records assistant. (These will be bound—one for the ChE department, one for the advisor, and one for the student.) See the ChE graduate records assistant for further instructions.

Ph.D. Residency

The Chemical Engineering faculty believes that, to maintain the vigor and vitality of the Department as well as the quality of the graduate program, the normal period of residence for completion of the Ph.D. degree can be reduced to the minimum level which is consistent, on an individual basis, with the high standards of intellectual accomplishment that we expect of all our students. To facilitate the timely completion of Ph.D. requirements, the faculty has adopted the following policies.

1. The *Thesis Review Committee* monitors the student's progress and serves as a resource in the student's area of research. This committee is selected as described earlier, in section 5 on page 4, and will meet with the student at least once a year beginning in the fourth year, either as a group or individually. It is the responsibility of the student to ensure that arrangements are made for the yearly progress review, and it is obviously important this is not delayed to the last moment. Failure to comply will result in the student not being allowed to register for that or subsequent terms until the requirement is satisfied.

   Each student should submit a two- or three-page, *concise outline* of progress and of research proposed for future work to each member of his/her committee. Beyond this, there are no specific requirements for reports, seminars etc. The *modus operandi* of each committee shall be left to the discretion of its members in consultation with the student. The "ideal" is a continuing communication between the student and committee, leading to "automatic" approval each year, rather than a forced, exam-style meeting.

2. Financial aid for graduate students is awarded on a year-by-year basis in accord with policies of the Institute. The Department will endeavor to provide stipend support for all Ph.D. students through a maximum period of five calendar years in residence, subject in all cases to the approval of the research advisor. In normal circumstances, no support will be awarded **after the fifth year** of residence unless by *petition*.

   To provide support beyond the fifth year in residence ("extended registration"), exceptions may be granted by *petition* from the student to the graduate studies committee. This petition must be submitted before the end of the summer term of the fifth year of residence, and consideration will be based on the following criteria:

   a. Approval of the research advisor and the ChE Option Representative.

   b. A written statement from the student explaining the circumstances that have led to the need for an extended residency—this could include any legitimate reasons such as long-term illness, technical reasons associated with a particular research project, etc.; and a detailed plan of the steps that will be taken to complete the degree requirements.

   c. A written timetable from the student for completion of degree requirements established in consultation mutually agreed upon with his/her advisor.

   d. The petition is then submitted to the Dean of Graduate Studies for approval to register for the sixth year. This form is available online at http://www.gradoffice.caltech.edu/current/petitions.

The ChE M.S. Degree

1. Coursework

Course Requirements

There is no formal M.S. program offered in Chemical Engineering. An M.S. degree is considered when a graduate student is not admitted to Ph.D. candidacy or cannot continue in the program for other reasons. The M.S. program has its own coursework and GPA requirements. The Institute requires completion of at least 135 units, which must include the following courses and research units:

ChE 151ab, ChE 152, ChE 165	42 units
Additional Advanced Courses in Chemical Engineering	18 units
Science or Engineering Electives	27 units
General Electives	18 units
	105
ChE 280 Research	27 units minimum

The 18 units of general electives should pertain to science and engineering, but may with special permission include humanities and social sciences. A student must maintain a GPA of ≥2.0 to qualify for an M.S. degree.

Graduate Studies Advisor, Graduate Option Representative, and ChE Graduate Studies Committee

During graduate studies, students will interact with several members of the Chemical Engineering faculty. The most intensive interaction will be with the research advisor who will advise on all aspects of Ph.D. research, coursework, and will approve various formal requirements. Students will also interact with the members of the Thesis Review Committee, as discussed earlier, and the ChE Option Representative. During the first year, the Option Representative will advise the students about choice of courses. The ChE Option Representative is responsible for GRA or GTA assignments beyond the first year, and for approval of Candidacy and Thesis Review Committees and other formal requirements for the M.S. and Ph.D. degrees. In a case where the relationship between a student and his/her research advisor becomes strained and the student desires advice or help from other faculty, he/she should consult with the Chemical Engineering Grad Studies Committee (GSC) consisting of the ChE Option Representative, the Graduate Studies Advisor and the ChE Option Executive Officer (chair). Students may also contact the Associate Dean of Graduate Studies for a "neutral" consultation.

Policy for Students Joining or Changing a Research Group

When a Caltech faculty member accepts a Chemical Engineering graduate student into his/her group, he/she accepts responsibility for arranging financial support for the student. The student likewise accepts responsibility to honor his/her commitment to the chosen research group.

If an advisor-advisee relationship degrades to the point where termination is necessary, the advisor must notify in writing both the student and the Graduate Studies Committee of the student's planned termination and detail the reasons for this action. The date of this letter is the beginning of a relocation period, not to exceed six weeks, during which the student shall search for a new advisor at Caltech. During the relocation period, the student must continue to be supported in whatever manner had been arranged before termination (e.g., with GRA funds from the previous advisor's grants), and the G.S.C. chairman will accept responsibility for monitoring the student's progress and assigning research grades. During this time, the student may do a rotation in a new group, with the expectation that she/he will join that group at the end of the relocation period.

Switching research groups should not be taken lightly. If there are serious reasons for a student to want such a change, the research advisor and the ChE Option Representative must be informed at once, as research programs and funding may become jeopardized. Failure to notify the advisor promptly may constitute reason for dismissal from the ChE program. If the advisor accepts the reasons and agrees to let a student switch research groups, the advisor is required to provide support only so long as the student continues to carry out research in that advisor's group. If any conflicts arise, the G.S.C. chair must be called upon to mediate.

Chemical Engineering Seminars

Graduate Students are expected to attend *all* regular Chemical Engineering Seminars. The opportunity to learn about the research at other institutions is an important part of a graduate education, even if that research is not in your own specific dissertation area. From time to time, we schedule *Special* Chemical Engineering Seminars, announced on relatively short notice. Although wide attendance at these special seminars is, of course, desired, we recognize that these may be of interest to only a limited number of students and do not necessitate the full attendance that we require at our regular seminars. Notices of seminars are distributed via email, posted on bulletin boards in the Spalding Lab building and announced in the Caltech master calendar.

ChE Grad Student-Faculty Liaison Committee

Please note that there is a ChE Graduate Student-Faculty Liaison Committee, whose members are one graduate student (chosen by their respective group) from each research group, one representative of the first-year students (chosen by the first-year students), and (currently) Professors Brady, Giapis and Seinfeld. This committee serves to foster communication between the graduate students and the faculty. The committee seeks input on all issues affecting you, the department, and Caltech—especially items like the recruitment of new graduate students (what works, what doesn't), graduate courses, advisor selection, seminars, social events, etc. The committee will meet over lunch on Wednesday of the first week of classes in January 2018 to allow time for the first year ChE graduate students to experience the department dynamics. Subsequently, the committee will meet as needed to discuss issues that affect broadly the ChE graduate program or the Department as a whole.

Vacation Policy

Graduate students are entitled vacation on all Institute staff holidays as listed in the Institute Catalog. In addition, the Institute allows two weeks vacation per year. The Chemical Engineering faculty believes that the allowance of two weeks of vacation, in addition to Institute holidays, is adequate. We regard a request for more than two weeks of vacation per year as a special request, which your advisor may grant without compensation or, *at his/her discretion*, with compensation. It is a matter of the personal integrity of all the students and the faculty to ensure that the flexibility in the ChE policy is not abused. In all cases, vacation should be scheduled in consultation with your research advisor.