Department of Chemical & Biological Engineering

Graduate Programs 2016-2017

Academic Requirements and Guidelines

Updated August 2016
This document describes procedures, rules and regulations relevant to pursing the graduate degree programs in the Chemical and Biological Engineering Department. Another important booklet is the “Graduate Student Handbook” distributed by the Graduate School of Arts and Sciences (GSAS), for general guidelines, rules and regulations for all graduate students enrolled in the Graduate School of Arts and Sciences. The Graduate Student Handbook may be downloaded at http://ase.tufts.edu/gradStudy in the Student Services sub-section. In addition, please read the Graduate School of Arts and Sciences section from the Tufts Bulletin that includes additional guidelines for graduate students enrolled in GSAS. An online version of the Tufts Bulletin is available at http://ase.tufts.edu/bulletin/Default.htm.

ADVISOR

Each incoming graduate student is assigned an academic program advisor who plays an important role in the development and administration of the student’s overall educational program. Advisors are faculty members of the Department’s Committee for Graduate Education. For the 2016-2017 academic year, Professor Daniel Ryder will serve as the academic program advisor to all incoming graduate students.

SELECTION OF THE RESEARCH ADVISOR

The research advisor is the faculty member with whom the student chooses to collaborate on their research project. Most often, the student selects a project from among several that the professor may suggest as appropriate for the M.S. thesis or the Ph.D. dissertation. The student is expected to contribute to the direction of the work as the research progresses.

At the beginning of the fall semester, faculty in the department of Chemical and Biological Engineering will present topics available for research. All entering graduate students are required to attend. Graduate students may not officially join a research group until after all faculty presentations are completed and students have met with three (3) faculty members to discuss research topics in more detail. New students are strongly encouraged to inform themselves about the research interests of the faculty by reading background material in the library, requesting reprints for in-depth study, and visiting those faculty and their graduate students whose work appears to be of greatest interest.

Three weeks after faculty presentations of available research topics are completed, students are asked to list their top three choices for research advisor. The Department’s Committee for Graduate Studies will then assign a research advisor for each student by careful examination of students’ choices and availability of research projects.

FINANCIAL SUPPORT

Only full time students are eligible for financial support, which includes tuition scholarships, teaching assistantships, graduate fellowships, and research assistantships. Please refer to the “Graduate Student Handbook” distributed by GSAS for a complete description of these different types of financial aid. Priority for financial support is given to students enrolled in the Ph.D. program. For other forms of financial support please contact the financial aid office.
Teaching Assistantship

Teaching assistants (TAs) play an important role in the Department’s educational programs. Teaching assistants are assigned to one or more undergraduate and/or graduate courses. Their duties include: reviewing and grading homework problems, grading reports and exams, leading recitations and tutorials, planning and supervising laboratory experiments, and proctoring exams. A full-time teaching assistant should expect to devote approximately 10-15 hours per week to TA duties. All full-time Ph.D. students will TA a minimum of three (3) courses during their tenure. Teaching assistants in the Chemical and Biological Engineering Department are supported for 12 months. Extension of the support period is contingent on satisfactory performance as TA, progress towards the degree, and availability of funds. Teaching assistants are allowed two weeks of vacation per calendar year; additional time is permitted only with consent from the Department’s Committee for Graduate Studies.

Teaching assistant performance will be assessed based on student course evaluations and written feedback from the course instructor. Copies of the student evaluations and a summary statement of the overall assessment will be provided to the TA at the end of the semester.

Research Assistantship

Research assistants are supported from research contracts or grants, and are supervised by the faculty member associated with the contract or grant. Research assistants are usually supported for periods of up to 12 months. Extension of the support period is contingent on satisfactory progress in their research project and availability of funds. Research assistants are allowed two weeks of vacation per calendar year; additional time is permitted only with consent from the research supervisor. Ph.D. candidates that are supported with research assistantships may be asked to perform teaching assistant duties at any time during their residency at Tufts.

THE DOCTORAL PROGRAM

The Doctor of Philosophy degree is awarded for high achievement in an advanced field of study. It requires competence in independent research and a demonstration of creativity and originality. The Ph.D. degree is not awarded simply for the fulfillment of residence and the accumulation of credits.

The Department offers a Ph.D. in Chemical Engineering and a Ph.D. in Biotechnology Engineering.

Course requirements

Ph.D. in Chemical Engineering:

All Ph.D. candidates are required to successfully complete the following core courses by the end of their second academic semester:

- ChBE 201 Mathematical Methods in Chemical Engineering
- ChBE 202 Chemical and Catalytic Reaction Engineering
• ChBE 203 Adv. Thermodynamics
• ChBE 204 Adv. Transport Phenomena

An overall minimum GPA of 3.25 must be maintained for core courses completed at Tufts in order to qualify to the Ph.D. degree program.

Students who have completed one or more equivalent core graduate courses prior to their matriculation at Tufts and have earned a grade of B or higher may petition to transfer the course credit into the Tufts program. A maximum of 2 course credits can be transferred. Approval of transfer of course credits is subject to Tufts policy as described in the Graduate Student Handbook (http://gradstudy.tufts.edu/documents/graduate_student_handbook.pdf). Please note that transfer credits are not approved for courses previously completed as part of a degree program.

Students who have completed a core course requirement as part of a degree program may petition to obtain a waiver from completing the course at Tufts. A grade of B+ or better is required for consideration. A maximum of 2 core course waivers may be allowed. The Graduate Programs Committee will inform applicants in writing of all petition decisions. Approval to waive a core course will require the applicant to complete a substitute graduate-level elective course. Please note that the minimum core course 3.25 GPA qualifying requirement is based only on courses completed at Tufts.

In addition to the core courses requirement, Ph.D. students must complete an elective course sequence. Students entering with an M.S. engineering degree must successfully complete four (4) elective graduate-level courses, while those with a B.S. engineering degree must successfully complete six (6) graduate-level elective courses. A minimum of two (2) of the elective courses must be from the ChBE graduate course offerings. All individual elective courses, as well as the overall course program, must be approved by the graduate program academic advisor. The selection of elective courses affords the student an opportunity to focus academic studies in an area consistent with thesis research. All full-time graduate students must register for the Chemical and Biological Engineering Department’s seminar series, ChBE 291 (Fall) and ChBE 292 (Spring). Although their credit value is 0.0, a satisfactory/unsatisfactory grade will be assigned on the basis of attendance and participation. Ph.D. candidates are required to present at least one (1) seminar at the Chemical and Biological Engineering Department’s seminar series during their student tenure.

Ph.D. in Biotechnology Engineering:

The core course requirements for the Ph.D. in Biotechnology Engineering program are designed to accommodate the diversified academic program base of our applicants.

Candidates must complete the following core course sequence:

• Two (2) courses from the following list of three:
  o ChBE 160 Biochemical Engineering
  o ChBE 167 Metabolic Engineering
  o ChBE 193 Synthetic Biology
• ChBE 161 Protein Purification
• ChBE 166 Principles of Cell & Microbe Cultivation

An overall minimum GPA of 3.25 must be maintained for core courses completed at Tufts in order to qualify to the Ph.D. degree program. Applicants are encouraged to explore the prerequisite requirements of each of these courses to determine if the initial completion of remedial undergraduate courses is necessary. Please note undergraduate courses do not count towards your GPA.

Students who have completed one or more equivalent core graduate courses prior to their matriculation at Tufts and have earned a grade of B or higher may petition to transfer the course credit into the Tufts program. A maximum of 2 course credits can be transferred. Approval of transfer of course credits is subject to Tufts policy as described in the Graduate Student Handbook (http://gradstudy.tufts.edu/documents/graduate_student_handbook.pdf). Please note that transfer credits are not approved for courses previously completed as part of a degree program.

Students who have completed a core course requirement as part of a degree program may petition to obtain a waiver from completing the course at Tufts. A grade of B+ or better is required for consideration. A maximum of 2 core course waivers may be allowed. The Graduate Programs Committee will inform applicants in writing of all petition decisions. Approval to waive a core course will require the applicant to complete a substitute graduate-level elective course. Please note that the minimum core course 3.25 GPA qualifying requirement is based only on courses completed at Tufts.

In addition to the core courses requirement, Ph.D. students must complete an elective course sequence. Students entering with an M.S. engineering degree must successfully complete four (4) elective graduate-level courses, while those with a B.S. engineering degree must successfully complete six (6) graduate-level elective courses. A minimum of two (2) of the elective courses must be from the ChBE graduate course offerings. All individual elective courses, as well as the overall course program, must be approved by the graduate program academic advisor. The selection of elective courses affords the student an opportunity to focus academic studies in an area consistent with thesis research.

Students entering the program without an academic background in chemical engineering may choose one (1) of the upper-level undergraduate ChBE courses noted below as a graduate elective:

• ChBE 102 Reactor Design
• ChBE 109 Process Dynamics and Control

All full-time graduate students must register for the Chemical and Biological Engineering Department’s seminar series, ChBE 291 (Fall) and ChBE 292 (Spring). Although their credit value is 0.0, a satisfactory/unsatisfactory grade will be assigned on the basis of attendance and participation. Ph.D. candidates are required to present at least one (1) seminar at the Chemical and Biological Engineering Department’s seminar series during their student tenure.
Qualifying procedures

Candidacy for the doctoral degree is established by the successful completion of three (3) benchmarks:

- Students must satisfactorily complete the **core course sequence**. A minimum average GPA of 3.25 for core courses taken at Tufts must be maintained.
- Students must pass a qualifying **oral examination**. A critical review and analysis of a technical paper from the literature will be presented by the student to the Department faculty. A copy of the selected paper will be made available to the student at least two weeks prior to the examination. The format of the examination will be as follows:
  1. Students will make a presentation to two separate faculty sub-groups. Each presentation will be limited to 20 minutes and be followed by a 15 minute Q&A session.
  2. Each student will have a break period of at least one-hour between their first and second presentation. Candidates are free to modify the content of their second presentation in any manner they wish.
  3. As is customary, the faculty will meet as a whole after all student presentations have been completed to determine an outcome for each student applicant. Each applicant will be informed in writing within 48 hours of their exam results.
- Students must submit a satisfactory **Initial Research Report**, which describes their thesis work effort to date by October 1st of their second year. In addition to an electronic copy submitted to the Department Administrator and the thesis advisor, a printed copy of the Initial Research Report should be also submitted to the chair of the Graduate Programs Committee. This report will be reviewed by a sub-group of the Department faculty. Each candidate will receive a written assessment summary of their report within thirty (30) days of their submittal.

The qualifying oral examination will be scheduled each May. Specific exam details will be provided to the applicants during an information session scheduled one month prior to the exam. Applicants may seek admission to the exam only after completing core course requirements. It is the responsibility of applicant to complete all qualification procedures in a timely manner. Students will be informed of the Department decision by the Graduate Programs Committee within one week after their completion of the oral examination. The assessment is based on the cumulative analysis of the student’s performance over the qualifying period.

Students who fail to meet the Ph.D. qualification standard at their first testing may, **at the sole discretion of their research advisor**, be allowed to re-take the exam at the next offering in September. No student will be allowed to take the Ph.D. qualifying exam more than two times. Students who fail to meet the Ph.D. qualification standard may be invited to complete the Master-level degree program.
**Thesis committee**

Within six (6) months after formally qualifying into the Ph.D. program, each candidate, in consultation with his/her research advisor, should select a thesis committee. The thesis committee is composed of at least 4 members, including one member from the Chemical and Biological Engineering department, in addition to his/her thesis advisor(s), one member from another Tufts department, and one member from outside Tufts. The research advisor serves as the chair of the thesis committee. Each member of the thesis committee should be given a copy of the Initial Research Report prepared during the qualification procedure.

The thesis committee is responsible for monitoring the quality and progress of the research. The candidate should meet with his/her thesis committee at least once a year and provide oral and written Progress Reports. A copy of the written Progress Report, along with the PhD Thesis Committee Meeting Record form, should be given to the Department’s Committee for Graduate Studies annually.

**Thesis proposal**

Doctoral candidates are required to prepare and submit a written thesis proposal within one year after passing the qualifying examination. The thesis proposal should be submitted to the thesis committee and be defended orally. Failure to complete this oral presentation within one year after passing the qualifying examination is considered unsatisfactory progress towards the doctoral degree. If the thesis committee does not approve the proposal, a period of up to three months is allowed to submit and defend a new proposal. Completion of the research proposal benchmark requires submission of the Thesis Proposal Form to the Department’s Committee for Graduate Studies.

*Guidelines for preparing the Thesis Proposal*

a. The written portion of the thesis proposal should be in the form of a grant application (such as to NSF or NIH), with an introduction, objectives/specific aims, summary of previous work done on the problem, method of attack, potential problems with suggested solutions, and conclusions. It is not meant to be a document containing a significant volume of already completed research.

b. The proposal should be self contained and include sufficient material to demonstrate the value, originality and creativity in the proposed research.

c. The proposal should be developed independently. Faculty and other students may provide only limited assistance with specific technical problems.

d. A copy of the proposal should be given to each member of the thesis committee at least two weeks before its defense. In addition, one (1) copy of the edited proposal should be given to the Department Graduate Committee.

e. The statement of the problem must be precise and unambiguous. There should be no room for doubts as to what is meant.

f. The literature pertaining to the problem should be documented.

g. The method of attack should be described fully, including the feasibility of each step in the process proposed for solving the problem.
h. The probable results of the proposed research and the conclusions which would follow from each result should be fully described.

i. Assumptions and uncertainties should be stated explicitly.

j. An estimate of the time required to carry out the research should be made on the basis that the student would conduct the work.

Research presentation
During the 4th year of study (i.e., typically 2 years after the research proposal), Ph.D. students will present a research seminar of their work to the Tufts ChBE community. The seminar will be scheduled during the normal ChBE Department Seminar time-block (i.e., Monday 12:00 – 1:00). The ChBE Graduate Programs Committee will contact participating students at the beginning of the Fall and Spring semesters with a list of open dates. Students will reserve their presentation date on a first-come/first-served basis.

Thesis defense
The “Graduate Student Handbook” distributed by the Graduate School of Arts and Sciences specifies the thesis regulations which have been set by the Graduate School. Additional requirements for the thesis are the responsibility of the research advisor. The Chemical and Biological Engineering Department requires, as part of the procedure by which a thesis is approved, a formal oral defense by the candidate before an examination committee. The oral presentation should be open to the public. The examination committee recommends action to the university regarding the thesis. The members of the thesis committee serve as the examination committee. Copies of the thesis must be delivered to the examination committee at least two weeks prior to the defense.

Possible actions of the examination committee
a. Acceptance of dissertation/thesis
b. Acceptance with minor changes. This action requires the candidate to incorporate the minor changes, but allows for the signatures of all committee members at the conclusion of the defense with no further re-examination necessary.
c. Acceptance with major changes. This category requires a re-examination of the corrected thesis by the committee, but no repetition of the oral examination.
d. Rejection. This action requires the student to prepare a new thesis, and generally involves additional research work.

Schedule of committee meetings
Students enrolled in the Ph.D. programs are encouraged to regularly hold thesis committee meetings to seek guidance and to update the members of the committee on the progress of the thesis research. The minimum required number of thesis committee meetings is four (4),
including the thesis proposal and final thesis defense meetings. The following table outlines a recommended schedule of thesis committee meetings and other important milestones.

<table>
<thead>
<tr>
<th>Year</th>
<th>Event</th>
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<tbody>
<tr>
<td>Year 1</td>
<td>Oral qualifying exam</td>
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<tr>
<td>¹Year 2</td>
<td>Thesis proposal</td>
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<tr>
<td>²Years 2-n</td>
<td>Annual or biannual thesis progress meetings</td>
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<tr>
<td>Year 4</td>
<td>Departmental seminar</td>
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<tr>
<td>Year n</td>
<td>Final thesis defense</td>
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¹The thesis proposal meeting must take place no later than one year after the student has passed the oral qualifying exam.

²At least two (2) thesis progress meetings must be held before the final thesis defense.

THE MASTER OF SCIENCE PROGRAM
The Department of Chemical and Biological Engineering offers the M.S. in Chemical Engineering and the M.S in Bioengineering: Cell and Bioprocess Engineering. The degree in Cell and Bioprocess Engineering is one of six (6) tracks in the Bioengineering program of the School of Engineering. Program requirements for Cell and Bioprocess Engineering include Common Core and Breadth courses in addition to departmental track-specific courses. All M.S. programs require the completion of 10 course credits. The 10 credit requirement may include a 3 credit thesis for the Chemical Engineering degree or a 2 credit thesis for the Cell and Bioprocess Engineering degree. Alternatively, a course-only program is available for each degree. The following core courses are required for each degree program:

M.S. in Chemical Engineering
- ChBE 201 Mathematical Methods in Chemical Engineering
- ChBE 202 Advanced Kinetics & Reaction Engineering
- ChBE 203 Advanced Thermodynamics
- ChBE 204 Advanced Transport Phenomena

M.S. in Bioengineering: Cell and Bioprocess Engineering
Track requirements (4 credits):
- Two (2) courses from the following list:
  - ChBE 160 Biochemical Engineering
  - ChBE 167 Metabolic Engineering
  - ChBE 193 Synthetic Biology
- ChBE 161 Protein Purification
- ChBE 166 Principles of Cell & Microbe Cultivation
Common core (3 credits):

- BIOE 291/292 Bioengineering Seminar
- BIO 105 Molecular Biology or BME/ChBE 162 Molecular Biotechnology
- EE 104 Probabilistic Systems Analysis or ChBE 170 Design of Experiments

Breadth requirement (1 credit):

- ONE course from the following:
  - BME 164 Biomaterials and Tissue Engineering
  - CS 167 Computational Biology
  - CEE 139 Bioremediation: Natural and Enhanced
  - EE 105 Control Systems
  - ME 103 MEMS

All credits must carry a grade of B- or better. For the Chemical Engineering degrees, three (3) of the elective courses may be graduate-level courses from outside of the Department. For the M.S. degree in Cell and Bioprocess Engineering degree, no additional elective courses are required. It should be noted that additional courses beyond those required for the M.S. degree are not covered by tuition scholarships. Furthermore, the Department follows the standard University policy concerning transfer of credits.

All full-time Chemical Engineering graduate students must register for the Chemical and Biological Engineering Department’s seminar series, ChBE 291 (Fall) and ChBE 292 (Spring). Although their credit value is 0.0, a satisfactory/unsatisfactory grade will be assigned on the basis of attendance and participation.

M.S. thesis

All students enrolled in the M.S. thesis program must complete a three (3) credit thesis research project. Research for the thesis is supervised by the student’s research advisor. The M.S. thesis should be submitted to the examination committee at least two weeks prior to the defense, which is open to the public. The examination committee is composed of two members from the Chemical and Biological Engineering Department and one member from outside the department or outside the University.

Possible actions of the examination committee

a. Acceptance of thesis

b. Acceptance with minor changes. This action requires the candidate to incorporate the minor changes, but allows for the signatures of all committee members at the conclusion of the defense with no further re-examination necessary.

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1 Alternative Math selection may be substituted by written petition
2 Alternative Breadth selection may be substituted by written petition
c. Acceptance with major changes. This category requires a re-examination of the corrected thesis by the committee, but no repetition of the oral examination.

d. Rejection. This action requires the student to prepare a new thesis, and generally involves additional research work.

ACADEMIC WARNING AND ACADEMIC PROBATION

Academic warning and probation are formal status a graduate student assumes when he or she has not met the requirements to remain in the program. For example, failure to hold a required thesis committee meeting by the indicated deadline will result in an academic warning.

A student on warning has one full semester to rectify the deficiency. If not rectified by the end of the warning semester, the student is placed on academic probation. A student on probation has one full semester to rectify the deficiency. If not rectified by the end of the probationary period, he or she may face dismissal from the graduate program. Students on probation are not eligible to receive financial aid in the form of teaching or research assistantships.