



Tufts
UNIVERSITY

School of
Engineering

Department of Chemical & Biological Engineering

Graduate Programs 2017-2018

Academic Requirements and Guidelines

Updated August 2017

This document describes procedures, rules and regulations relevant to graduate degree programs in the Department of Chemical and Biological Engineering. Another important document is the “Graduate Student Handbook” distributed by the Graduate School of Arts and Sciences, the School of Engineering, and the College for Special Studies, for general guidelines, rules and regulations for all graduate students. The Graduate Student Handbook may be downloaded at <https://asegrad.tufts.edu/academics/graduate-student-handbook>.

ACADEMIC ADVISOR

Each incoming graduate student is assigned an academic advisor who plays an important role in the development and administration of the student’s overall educational program. For the 2017-2018 academic year, Professor Matthew Panzer will serve as the academic advisor to all incoming Ph.D. and Chemical Engineering M.S. students, while Professor Kyongbum Lee will serve as the academic advisor to all incoming Bioengineering M.S. students.

RESEARCH ADVISOR SELECTION

The research advisor is the faculty member with whom the student collaborates closely 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.

All Ph.D. students, as well as M.S. in Chemical Engineering (with thesis track) / M.S. in Bioengineering (with thesis track) students: new students in these programs must discuss potential thesis project topics with their prospective faculty advisors of interest. Incoming students are encouraged to contact potential faculty advisors as early as they wish, after declaring their intent to enroll at Tufts. Approximately three weeks after the start of the Fall semester, all new students will be required to submit to the Department the names of *at least* two (2) different potential faculty advisors with whom they have discussed possible thesis topics, in ranked order of preference. The Department’s Graduate Program Committee will then make research advisor assignments for all new students upon careful examination of student preferences and the availability of research projects; the Department’s best efforts will be made to give students their first choice of advisor, whenever possible. New graduate student-research advisor pairings will be announced by late September/early October.

FINANCIAL SUPPORT

Only full-time Ph.D. candidates are eligible for financial support from the Department, which includes tuition scholarships, teaching assistantships, graduate fellowships, and research assistantships. Please refer to the School-level “Graduate Student Handbook” for a complete description of these different types of financial support.

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, making copies of sample homeworks and exams for ABET course folders, leading recitations and tutorials, planning and supervising laboratory experiments, and proctoring exams. While serving as a TA, students should expect to devote approximately 10 hours per week to TA duties. All full-time Ph.D. students who are financially supported by the Department for their first semester of study at Tufts will serve as a TA for a *minimum* of three (3) courses during their residency in the program. Teaching assistants are allowed two weeks of vacation per calendar year; additional time is permitted only with consent from the Department's Graduate Program Committee.

Teaching assistants should register for ChBE 405 (Grad Teaching Assistant). This zero-credit course is graded Satisfactory/Unsatisfactory by the course instructor; Unsatisfactory performance may constitute insufficient progress toward the degree and result in an academic warning.

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 who are supported with research assistantships may be asked to perform teaching assistant duties at any time during their residency in the program.

Research assistants should register for ChBE 406 (Grad Research Assistant). This zero-credit course is graded Satisfactory/Unsatisfactory by the research advisor; Unsatisfactory performance may constitute insufficient progress toward the degree and result in an academic warning.

DOCTORAL PROGRAMS

The Doctor of Philosophy (Ph.D.) 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 a residence period or the accumulation of credits.

The Department offers a Ph.D. in Chemical Engineering and a Ph.D. in Biotechnology Engineering. Specific core course requirements for each degree program are listed below.

Core course requirements

Ph.D. in Chemical Engineering:

All Ph.D. in Chemical Engineering 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 Advanced Kinetics and Reaction Engineering
- ChBE 203 Advanced Thermodynamics
- ChBE 204 Advanced Transport Phenomena

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 courses by the end of their second academic semester:

- ChBE 160 Biochemical Engineering
- ChBE 161 Protein Purification
- ChBE 166 Principles of Cell & Microbe Cultivation
- One (1) course chosen from the following:
 - ChBE 167 Metabolic & Cellular Engineering
 - ChBE 193 Synthetic Biology

Additional academic requirements and policies common to both programs:

Students who have completed one or more equivalent core 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. Students can request the transfer of credits in SIS. Please note that transfer credits are not approved for courses previously completed as part of a previously awarded degree (*e.g.* a M.S. degree).

While not accepted for transfer credit, students who have completed a core course as part of a previously awarded degree may petition the Department to obtain a waiver from completing the course at Tufts. A grade of A- or higher is required for consideration. A maximum of 2 core course waivers may be allowed. The Graduate Program Committee will inform applicants in writing of all petition decisions. Approval to waive a core course will require the applicant to complete an additional graduate-level elective course.

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 ChBE graduate course offerings. All individual elective courses, as well as the overall course program, must be approved by the student's research advisor. The selection of elective courses affords the student an opportunity to focus one's academic studies in an area consistent with their thesis research.

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

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

All Ph.D. students are also required to complete a total of eight (8) Doctoral Thesis Research credits. Full-time students will typically complete this requirement by registering for 2 credits per semester of ChBE 297 (Fall) and ChBE 298 (Spring) during their third and fourth years.

All full-time graduate students must register for the ChBE Department's seminar series each semester, ChBE 291 (Fall) and ChBE 292 (Spring). Although these are zero-credit courses, a Satisfactory/Unsatisfactory grade will be assigned on the basis of attendance and participation; Unsatisfactory performance may constitute insufficient progress toward the degree and result in an academic warning.

Qualifying procedure

Candidacy for the Ph.D. degree is established by the successful completion of the following three (3) benchmarks:

- [1] Students must satisfactorily complete the **core course sequence**. A minimum average GPA of 3.25 for core courses taken at Tufts must be maintained. Please note that any core course transfer credits will *not* be factored into computing this value for candidacy.
- [2] Students must pass a **preliminary oral examination**. A critical analysis of a technical paper from the literature must be presented by the student to the Department's faculty. The preliminary oral examination will be held in late May/early June. Applicants may seek admission to take the examination only after completing the core course requirements. A collection of approved journal articles will be made available to the student at least two weeks prior to the examination. Students should select one of the articles from this collection to analyze and present to the faculty. Additional, specific guidance regarding faculty expectations for what students should be prepared to demonstrate during the examination will be provided in a memo sent to students via email in early May. The format of the examination will be as follows:

1. Each student will give a presentation to the faculty. Each presentation will be limited to a maximum of 20 minutes, and will be followed by a 25 minute Q&A session.

2. The faculty will meet after all student presentations have been completed to determine an outcome for each student. Students will be given written feedback regarding their examination performance within 48 hours after the faculty discussion.

Students who fail to meet the faculty's level of standard for doctoral candidacy during the preliminary oral examination may, *at the sole discretion of their primary research advisor*, be allowed to move on to the 3rd benchmark of qualification (the submission and oral presentation of a research progress report) in September. These students will be expected to answer additional questions (with additional Q&A time), not necessarily related to their research progress, from the faculty following their research progress report presentation.

- [3] Students must submit and orally present a **research progress report**, which describes and provides context highlighting their individual research contributions/findings to date.

The research progress report should be no longer than five (5) pages, not including a title page or list of references cited. An electronic copy (pdf version) of the research progress report must be submitted via email to the Graduate Program Chair and the student's faculty advisor by September 1, after the student has completed the preliminary oral examination (2nd benchmark). In mid/late-September, each student will also give an oral presentation of their initial research activities and findings to the faculty. Each presentation will be limited to a maximum of 20 minutes, and will be followed by a 25 minute Q&A session. The faculty will meet after all student presentations have been completed to determine an outcome for each student. Students will be given written feedback regarding their research progress report and oral research presentation performance within 48 hours after the faculty discussion.

It is the responsibility of the student to complete all doctoral qualification procedures in a timely manner. Students will be informed of the Department's decision to approve or disapprove qualification for doctoral candidacy within one week after their completion of the 3rd benchmark. The assessment is based on the cumulative analysis of the student's performance over the entire qualifying period. Students who fail to meet the Ph.D. qualification standard may be invited to complete a Master's-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 Research Progress 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 (<http://engineering.tufts.edu/chbe/graduate/forms.htm>), should be given to the Department's Graduate Program Committee.

Thesis proposal

Doctoral candidates are required to prepare and submit a written thesis proposal, typically within one year after completing all portions of the qualifying procedure. The thesis proposal should be submitted to the thesis committee and be defended orally. Failure to complete this oral presentation by the end of the sixth semester after entering the program 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 a signed Thesis Proposal Form (<http://engineering.tufts.edu/chbe/graduate/forms.htm>) to the Graduate Program Committee.

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 one week before its defense.
- 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 their 4th year of study, all Ph.D. candidates will be required to 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. Each student seminar should be limited to 25 minutes, followed by approximately 5 minutes of Q&A.

Thesis defense

The School-level “Graduate Student Handbook” specifies the thesis regulations that 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.

Year 1	Qualifying exam
¹ Year 2	Thesis proposal
² Years 2-n	Annual or biannual thesis progress meetings
Year 4	Departmental seminar
Year n	Final thesis defense

¹The thesis proposal meeting must take place no later than the sixth semester after matriculation.

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

MASTER OF SCIENCE PROGRAMS

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. For a M.S. degree *with thesis*, the 10 credit requirement includes a 3 credit thesis for the Chemical Engineering degree or a 2 credit thesis for the Bioengineering: Cell and Bioprocess Engineering degree. Alternatively, a course-only (*non-thesis*) track is available for each degree. The following courses are required for each program:

M.S. in Chemical Engineering

- ChBE 201 Mathematical Methods in Chemical Engineering
- ChBE 202 Advanced Kinetics and Reaction Engineering

- ChBE 203 Advanced Thermodynamics
- ChBE 204 Advanced Transport Phenomena

Graduate-level elective credits:

- Three (3) elective course credits + 3 Thesis credits (ChBE 295 / 296) for *thesis track*
- Six (6) elective course credits for *non-thesis track*

M.S. in Bioengineering: Cell and Bioprocess Engineering

Track requirements (4 credits):

- At least 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, BME 143 Biological Systems Analysis, or ChBE 170 Design of Experiments¹

Breadth requirement (1 credit)²:

- ONE course from the following:
 - BME 153 Biomaterials and Regenerative Medicine
 - CS 167 Computational Biology
 - CEE 139 Bioremediation: Natural and Enhanced
 - EE 105 Control Systems
 - ME 103 MEMS

Additional policies and requirements. All credits must carry a grade of B- or better. For the Chemical Engineering M.S. degree (either thesis or non-thesis track), a minimum of two (2) of the elective courses must be ChBE graduate course offerings. For students in the Chemical Engineering M.S. non-thesis track, a maximum of 2.0 credits of Engineering Management (EM) courses approved by the Graduate Program Committee may be counted toward the degree. For

¹ Alternative Math selection may be substituted by written petition

² Alternative Breadth selection may be substituted by written petition

the Bioengineering M.S. in Cell and Bioprocess Engineering degree, no additional elective courses are required. The Department follows the standard University policy concerning transfer of credits.

All *full-time* Chemical Engineering M.S. students must register for the Chemical and Biological Engineering Department's seminar series, ChBE 291 (Fall) and ChBE 292 (Spring). Although the credit value for these courses is zero, 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) or two (2) credit thesis research project depending on whether their degree is in Chemical Engineering or Bioengineering. 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.
- 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 statuses a graduate student assumes when he or she has not met the requirements to remain in good standing within the program. For example, failure to submit and present a thesis proposal by the indicated deadline will result in an academic warning. Before being placed on academic warning, a student will be formally notified by their thesis advisor (if the reason for warning is related to research performance) or their academic advisor (if the reason for warning is related to academic performance).

A student on academic 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.