CHEMICAL AND BIOMOLECULAR ENGINEERING, MASTER OF SCIENCE IN ENGINEERING

Program Overview

Students have several options in pursuing a Master's degree in Chemical and Biomolecular Engineering:

1. **Coursework-Based MSE**: A coursework-only degree in which students take ten 3-credit graduate-level courses (see "All Students' Course Requirements" below for more details). This option typically takes three semesters to complete. It can be shorter for students who began taking graduate-level courses while an undergraduate at Johns Hopkins (see "Combined BS/MSE Program and Students with BS in ChemBE from Johns Hopkins" below for more details).
2. **Essay/Report-Based MSE:**

- Option 1: *Research-Based MSE*: A research-intensive MSE in which students take six 3-credit graduate-level courses and undertake original research. The end product of the research is in the form of an MSE Essay submitted to the university and a presentation open to the department. (See "Essay-Based Students" below for more details.) This option typically takes four semesters and the intervening summer to complete. It can be shorter for students who began working on their research project while an undergraduate at Hopkins (see "Combined BS/MSE Program and Students with BS in ChemBE from Johns Hopkins" below for more details) or for students who do their research through the INBT Co-op Program (see "INBT Industry Co-Op Program" below for more details).
- Option2: *Design-Based MSE*: Similar to the research-based MSE option, except 3–4 semesters of Product Design are taken in addition to the six other graduate-level courses, and the end product is a written report and a presentation open to the department (see "Chemical Product Design Track (Design-Based MSE)" below for more details).

All MSE Students' Course Requirements

- All students are required to **submit their undergraduate transcript** to the Director of Master's Studies **prior** to the beginning of their first term to discuss their course plan. (An unofficial copy is sufficient.)
- Full-time registration for MSE students is at least 9 credits per semester.
- In the first semester: there is a mandatory Academic Ethics module and quiz which is part of every graduate student's degree requirements and must be completed with a passing grade. Students will see the course EN.500.603 Graduate Academic Ethics added to their SIS enrollments; do not drop this course! Information will be sent closer to the start of the semester. See Graduate Student Orientation (https://engineering.jhu.edu/admissions/graduate-admissions/full-time-programs/newly-admitted-students/graduate-student-orientation/) for more information.
- Students must enroll in at least one semester of Chemical and Biomolecular Engineering Seminar (EN.540.600 Chemical and Biomolecular Engineering Seminar I in Fall or EN.540.601 Chemical and Biomolecular Engineering Seminar II in Spring) throughout their tenure.
- Students must complete Responsible Conduct of Research training (https://engineering.jhu.edu/research/resources-policies-forms/online-training-course-responsible-conduct-of-research/).
- Students must complete a total of
  - 18 credits (for essay-based and design-based students), typically satisfied by six 3-credit courses,
  - 30 credits (for course-based students), typically satisfied by ten 3-credit courses, of graduate-level (i.e. 600-level and above) courses approved by the student's research advisor and the Director of Master's Studies. The student and research advisor will select these courses to design a curriculum appropriate for the student's research interests and educational goals. The courses must be taken for a letter grade (See "COVID-19 P/F Policy" below for more details). These courses cannot include seminars, independent studies, graduate research, or special studies.
- Students may substitute one of their 3-credit courses with a combination of 1–2-credit courses taken for a letter grade (excluding seminars, independent studies, graduate research, or special studies). This typically applies to courses in taken through the Center for Leadership Education (CLE). (See "Technical Writing Requirement" below.)
- Students are allowed to count 400-level courses towards their MSE degree only if (1) the course is not offered at the 600 level, and (2) the department offering the course considers it to be a graduate-level course in their program. (A letter from that department's head, chair, or graduate program director should be included in the submission of graduation materials.) Courses offered at both the 400 and 600 level must be taken at the 600 level to fulfill MSE course requirements. All ChemBE coursework must be taken at the 600 level.
- Minimum ChemBE course requirement:
  - At least 4 of the 6 courses for essay-based and design-based students or 6 of the 10 courses for course-based students must be in the Chemical and Biomolecular Engineering Department (EN.540.6xx or EN.545.6xx). Three of these courses are MSE core courses (see below).
  - Exceptions to this rule are very rare and must be approved by the Director of Master's Studies. A course from a department other than ChemBE may be allowed to count as one of the four courses only if the course has significant ChemBE content, is 3 credits (or if the student intends to use their one allowable substitution on a set of courses that add up to 3 credits), and is consistent with the student's research interests and educational goals as determined by the student's research advisor and the Director of Masters' Studies.
  - Students in the Design-based MSE track must take Product Design, one per semester for 3–4 semesters. These courses do not count towards the 6 courses.

Core Courses

- Students must take three core courses, one from each of the following categories:
  - ***Core 1 – Thermodynamics***
    - EN.540.671 Advanced Thermodynamics in Practice, typically offered in the Spring semester.
    - With approval from the Director of Masters' Studies and the instructor, this course may be substituted for the more

advanced version, EN.540.630 Thermodynamics & Statistical Mechanics, typically offered in the Fall semester.

- ***Core 2 – Transport***
  - EN.540.604 Transport Phenomena in Practice, typically offered in the Fall semester.
  - With approval from the Director of Masters' Studies and the instructor, this course may be substituted for the more advanced version, EN.540.652 Advanced Transport Phenomena, typically offered in the Fall semester.
- ***Core 3 – Kinetics***
  - Any one of the following courses:
    - EN.540.602 Metabolic Systems Biotechnology
    - EN.540.615 Interfacial Science with Applications to Nanoscale Systems
    - EN.540.632 Project in Design: Pharmacokinetics
    - EN.540.633 Pharmacokinetics and Pharmacodynamics
    - EN.540.681 Molecular Kinetics and Catalysis
    - EN.540.638 Advanced Topics in Pharmacokinetics and Pharmacodynamics I

- Substitutions for the core courses are typically granted for students with backgrounds in ChemBE.
  - Between Core 1 and Core 2, only one of these two Cores may be substituted. (Students in the Combined BS/MSE program may substitute for both Core 1 and Core 2.)
  - Students cannot take both versions of the Core 1 courses and have them both count towards their course requirements, and likewise for Core 2. Multiple courses in Core 3 can be taken for course requirements; these excess courses would fall into elective slots.

MSE Program Focus Areas

MSE students in ChemBE may opt to focus their studies within an area of specialization by choosing electives within a focus area.

The program offers three focus areas:

1. Cellular, Molecular, and Biopharmaceutical Engineering
2. Chemical and Sustainability Engineering
3. Molecular Modeling, Data Science, and AI

Students completing the essay-based MSE should consult with their advisor to select two or more courses in the list of options for their focus area; students completing the coursework-based MSE consult with their advisor to select four or more courses in the list of options for their focus area. The list of courses below is subject to change; exceptions by advisor approval only.

Focus Area 1: CELLULAR, MOLECULAR, AND BIOPHARMACEUTICAL ENGINEERING

Course options:

- EN.540.602 Metabolic Systems Bioengineering
- EN.540.640#Micro/Nanotechnology: The Science and Engineering of Small Structures
- EN.540.665 Engineering Principles of Drug Delivery
- AS.030.623 Molecular Synthetic Biology
- EN.540.614 Computational Protein Structure Prediction & Design
- EN.540.618 Cancer Metabolism
- EN.540.626 Fundamentals of Cell Bioengineering
- EN.540.628#Supramolecular Materials and Nanomedicine
- EN.540.637 Application of Molecular Evolution to Biotechnology
- EN.540.667#Targeted Drug Delivery: Mechanistic Concepts
- EN.580.646 Molecular Immunoengineering

Focus Area 2: CHEMICAL AND SUSTAINABILITY ENGINEERING

Course options:

- EN.540.607 Renewable Energy Technologies
- EN.540.673 Advanced Chemical Reaction Engineering in Practice
- EN.540.602 Metabolic Systems Biotechnology
- EN.540.615 Interfacial Science with Applications to Nanoscale Systems
- EN.540.640#Micro/Nanotechnology: The Science and Engineering of Small Structures
- EN.540.681 Molecular Kinetics and Catalysis
- EN.540.658 Modeling and Design of Sustainable Chemical Processes
- EN.510.625 Advanced Materials for Battery
- AS.030.604 Electrochemical Systems for Energy Conversation and Storage
- EN.510.658 Electroanalytical Chemistry and Energy Conversation

Focus Area 3: MOLECULAR MODELING, DATA SCIENCE, AND AI

Course options:

- EN.540.605 Modern Data Analysis & Machine Learning for ChemBEs
- EN.540.614 Computational Protein Structure Prediction & Design
- EN.540.658 Modeling and Design of Sustainable Chemical Processes
- EN.540.635 Software Carpentry

Technical Writing Requirement

- Students must take at least one technical writing elective (at least 1 credit) offered by the CLE at JHU. Often, this is taken in addition to the six or ten graduate-level courses, but students may choose to take 3 credits of writing as one of their any-department electives (one 3-credit course or two 1.5-credit courses, typically). These courses include
  - EN.663.640 Writing Grant and Contract Proposals
  - EN.663.644 Writing for Clarity
  - EN.663.645 Improving Presentation Skills for Graduate Students
  - Students who were JHU undergraduates are exempt from this requirement if they took EN.661.315 Culture of the Engineering Profession. (They must still take the full number of graduate-level credits, 18 or 30.)

Good Academic Standing

- Students must maintain a B average (GPA 3.0) in coursework to complete this degree.
- No D grade in ChemBE courses can be counted toward the requirements.
- In any given semester, an F, D, or two C grades will result in probation (C-, C, and C+ all count as C grades). Once on probation, any additional C+ grade or below will result in termination from the program. A student will remain on academic probation until the courses with the D or F have been retaken for a higher grade or, if no

D or F grades were present, the student attains a B average in their coursework.

Essay-Based Students

Additional Requirements for Research-Based Students

- Students must enroll in EN.500.601 Research Laboratory Safety in their first semester.
  - Students who were Hopkins undergraduates are exempt from this requirement if they took EN.540.490 Introduction to Chemical Process Safety .
- Students must maintain full-time registration for all semesters. In semesters where students are pursuing research, they may need to register for their advisor's research course (e.g. EN.540.801 Graduate Research, Section XX) for a number of credits equal to the difference between 9 and the number of other courses they are taking. (For example, a student taking one 3-credit course would register for 6 credits of research with their advisor to maintain 9 credits for full-time status.)
- Students must remain in good research standing with their research advisor. Failure to do so will result in probation and transfer to the course-based MSE track.
- Research-Based Students must write an essay based on original research and literature review and present their results at an open seminar attended by faculty and students. The essay must be approved by the departmental graduate committee, which consists of at least (1) the graduate research advisor and (2) a faculty member, one of which must be a faculty member from the Department of Chemical and Biomolecular Engineering (primary or secondary appointment). (See "Essay Presentation" below for more details.)

Alternatives to On-Campus Research:

INBT Industry Co-Op Program

To broaden the practical training for Master of Science in Engineering (MSE) students in the Whiting School of Engineering, the Institute for NanoBioTechnology (INBT) collaborates with major industry partners to offer a credited and paid co-op opportunity to MSE students in the Chemical and Biomolecular Engineering, Materials Science and Engineering, and Mechanical Engineering programs.

ChemBE students pursuing the essay-based track have the opportunity to choose the co-op program as an alternative to conducting research in Hopkins laboratories. Students must apply through the INBT office during their first semester. (This application process is separate from and happens after being admitted to the ChemBE MSE program.)

Each student who is accepted to the program will be assigned a research advisor/mentor at the sponsoring company. The company is expected to develop a list of goals and development objectives for the student. Once the project has been determined, a few weeks prior to the start of the co-op or within the first week, students must find a faculty advisor with primary or secondary appointment in ChemBE. During the six-month co-op period, students will meet with the faculty advisor at least every six weeks for progress updates. At the end of the co-op internship, students will complete an essay and present their results at an open seminar attended by faculty and students. The company mentor can serve as the student's second reader as long as they have a PhD or commensurate work experience.

For more information, please visit the INBT page (https://inbt.jhu.edu/masters/).

Additional information can be found in the department MSE Handbook (https://engineering.jhu.edu/chembe/wp-content/uploads/2023/08/2022-23-ChemBE-MSE-Handbook_August2023-1.pdf).