Undergraduate Advising Manual

Students Entering the Program Fall 2013 or later

(Version: August 2013)

www.jhu.edu/chembe/

chembe@jhu.edu
I – Introduction
1. What is Chemical and Biomolecular Engineering? .................................................. 3
2. Tracks....................................................................................................................... 4
   Interfaces and Nanotechnology (IN) Track................................................................. 4
   Molecular and Cellular Bioengineering (MCB) Track............................................... 4
3. Graduate or Professional Schools............................................................................ 4
   Graduate School ........................................................................................................ 4
   Pre-Medical Track ....................................................................................................... 4
4. Where are our Chemical and Biomolecular Engineering graduates? ................. 5

II – Program Mission and Objectives ................................................................. 6

III - Departmental Advising Procedures ............................................................. 8
1. Faculty Advisors ........................................................................................................ 8
2. Resources ................................................................................................................... 8
   Manuals and Guides .................................................................................................... 8
   Forms ......................................................................................................................... 8
   Course Guides and Evaluations ................................................................................. 8

III – Example Programs ..................................................................................... 10

IV – Degree Checklists ......................................................................................... 13

V - Degree Requirements .................................................................................... 13
1. Curriculum ................................................................................................................ 13
   Chemical and Biomolecular Engineering Core Courses ........................................ 13
   Other Engineering Courses ..................................................................................... 13
   Physics Courses and Laboratories .......................................................................... 13
   Basic Chemistry Courses and Laboratories ............................................................ 14
   Advanced Chemistry and Biology Courses ............................................................. 14
   Mathematics Requirement ....................................................................................... 14
   Writing Skills ............................................................................................................. 15
   Humanities and Social Sciences Courses ............................................................... 15
   Undesignated Electives ............................................................................................ 16
2. Tracks ....................................................................................................................... 16
   Interfaces and Nanotechnology (IN) Track............................................................... 16
   Molecular and Cellular Bioengineering (MCB) Track ............................................. 16
3. Pre-Professional Preparation Requirements ......................................................... 17
4. Rules and Limitations .............................................................................................. 17
   Grade Requirements and Department Honors ....................................................... 17
   Repetition of Course Content .................................................................................. 18
   Undergraduate Research and/or Independent Study to Fulfill "Other Engineering"
   Requirement ............................................................................................................ 18
   Courses Taken Pass/Fail .......................................................................................... 18
   Exceptions ................................................................................................................ 19
   Course Retakes .......................................................................................................... 19

VI – Options available in Chemical and Biomolecular Engineering ....................... 20
1. Senior Lab at DTU in Copenhagen in the Summer .................................................. 20
2. Undergraduate Research ......................................................................................... 20
3. BS/MSE Program in Chemical and Biomolecular Engineering .......................... 21
   Application Process .................................................................................................. 21
   Double Counting Policy ........................................................................................... 22
4. Graduate School Requirements ............................................................................... 22

Where are our Chemical and Biomolecular Engineering graduates? ................. 5

Introduction
Program Mission and Objectives
Options available in Chemical and Biomolecular Engineering
Degree Checklists
Example Programs
Faculty Advisors
Manuals and Guides
Forms
Course Guides and Evaluations
Chemical and Biomolecular Engineering Core Courses
Other Engineering Courses
Physics Courses and Laboratories
Basic Chemistry Courses and Laboratories
Advanced Chemistry and Biology Courses
Mathematics Requirement
Writing Skills
Humanities and Social Sciences Courses
Undesignated Electives
Interfaces and Nanotechnology (IN) Track
Molecular and Cellular Bioengineering (MCB) Track
Pre-Medical Track
Graduate School
Graduate School Requirements
Chemical and Biomolecular Engineering Core Courses
Interfaces and Nanotechnology (IN) Track
Molecular and Cellular Bioengineering (MCB) Track
Graduate School
Pre-Medical Track

Senior Lab at DTU in Copenhagen in the Summer
Undergraduate Research
BS/MSE Program in Chemical and Biomolecular Engineering
Application Process
Double Counting Policy
Graduate School Requirements
5. Premedical Requirements ................................................................. 23
6. Minors......................................................................................... 24
7. Student Organizations (AIChe/SBE)........................................... 25
8. Cooperative Program ................................................................. 25
9. How to get an internship ............................................................. 25

**VII - Department Contact List**

**VIII - Course Listing**  28
1. Required Courses .................................................................. 28
2. Additional/Alternate Required Courses of the Molecular and Cellular Bioengineering Track ......................................................................................................................... 29
3. Additional Required Courses of the Interfaces and Nanotechnology Track .......... 29
4. Approved Advanced Chemistry and Biology Electives*............................... 29
5. Approved Engineering Electives..................................................... 29
6. Approved Bioengineering Electives.................................................. 30
7. Approved Interfaces and Nanotechnology Electives............................ 31
Welcome to the Department of Chemical and Biomolecular Engineering!

The ChemBE department offers courses and training culminating in a Bachelor of Science degree in Chemical and Biomolecular Engineering. Additionally, students may choose, if they wish, to pursue a Molecular and Cellular Bioengineering (MCB) Track or an Interfaces and Nanotechnology (IN) Track.

1. What is Chemical and Biomolecular Engineering?

Chemical and Biomolecular Engineering (ChemBE) is dedicated to the study and exploitation of chemical, biological, and physical processes and phenomena for chemical and biological applications. As a result of the scope and breadth of this rigorous undergraduate program, our students commonly secure employment in industries such as Chemical and Pharmaceutical Production, Biomedicine, Biotechnology, Material Design, and Green Energy. Graduates may embark on a career to produce

- Novel polymers and materials
- Biopharmaceuticals
- Biofuels
- Drugs and Vaccines
- Gene Therapy Products
- Drug Delivery Devices
- Cells and Tissues
- Semiconductors
- Nanodevices
- Food, Beverage, and Health Care Products

The demands on the modern engineer are high, and graduates must possess a wide range of skills in order to be competitive in a global market. The ChemBE program successfully satisfies these demands. Students take advanced courses in chemistry, physics, mathematics, and biology. Additionally, students are trained in transport, kinetics, and thermodynamics, which are essential to solving real-world engineering problems. Students also hone their professional and communication skills (report writing, oral presentations, and teamwork) in courses involving experimental projects, process design and product design.

Depending on their interests and future career goals, students can choose electives from exciting areas including green engineering, nanotechnology, and bioengineering. These courses, along with undergraduate research opportunities offered by our faculty, are designed to prepare graduates for careers in the chemical industry, biotechnology, pharmaceuticals or microelectronics. The curriculum also offers an outstanding foundation for advanced graduate studies in Chemical and Biomolecular Engineering, Biomedical Engineering, Materials Engineering, or for medical, law, or business school. Graduates receive a Bachelor of Science degree in Chemical and Biomolecular Engineering accredited by the Engineering Accreditation Commission of ABET, http://www.abet.org.
2. Tracks

Students have the opportunity to develop more in-depth specialty in one or two areas within chemical and biomolecular engineering. Our two tracks are Interfaces and Nanotechnology (IN) and Molecular and Cellular Bioengineering (MCB). Students completing a track will have this fact designated on their final checklist audit form.

Interfaces and Nanotechnology (IN) Track

Interesting and new physics exist at nanometer length scales, as the surface area of an object begins to approach and exceed its volume. In this track, students are trained in the fundamental sciences used to solve problems in nanotechnology and interfacial science. Students take a chemistry course in Materials and Surface Characterization, an advanced physical chemistry laboratory course, and two electives such as Colloids and Nanoparticles, Supramolecular Materials and Nanomedicine and Micro/Nanotechnology: the Science and Engineering of Small Structures.

Molecular and Cellular Bioengineering (MCB) Track

Fields in Biotechnology and Biomedicine often involve processes at biological, cellular and molecular levels. Common areas utilizing skills in the MCB track include the genetic manipulation of cells for protein and vaccine production, and the study and treatment of diseases such as arteriosclerosis and cancer. Students in this track must take a laboratory course in Biochemistry, and two electives such as Cellular and Molecular Biotechnology, Bioengineering in Regenerative Medicine, and Computational Protein Structure Prediction. In addition, students will take the Biomolecular Engineering Laboratory to learn the hands-on skills required for future careers in biological systems at the molecular and cellular level.

3. Graduate or Professional Schools

Graduate School

Almost half of our graduates pursue advanced degrees in Chemical Engineering, Environmental Engineering, Biomedical Engineering or Bioengineering. The ChemBE curriculum offers an excellent foundation for MS and PhD programs. Students can elect to take higher level electives in preparation for graduate school during their junior and senior years. The strength of JHU lies in its ability to offer numerous opportunities for undergraduate research throughout the university. Our students usually join research laboratories in the ChemBE department, in other engineering departments or in the medical school. More information on graduate school can be found on pages 21 and 22.

Pre-Medical Track

The Chemical and Biomolecular Engineering degree provides excellent preparation for Medical School. Each medical school has its own admissions standards. These requirements include a few courses not included in the Chemical and Biomolecular Engineering program. As a result, students may want to take additional courses in order
to fulfill requirements of a particular medical school. More information on premedical requirements is included on page 23.

4. Where are our Chemical and Biomolecular Engineering graduates?

The Department of Chemical and Biomolecular Engineering graduates students who are prepared for a variety of professional career paths or for further education. Some of our recent graduates are now part of:

Classes of 2011, 2012 and 2013:

JHU ChemBE BS/MSE Program
Nuclear Propulsion Officer in the Navy
Medical School JHU
Accenture
Medical School University of Maryland
Merck
MedImmune
Dupont
PhD in Bioengineering at MIT
PhD in Chemical Engineering at MIT
Medical School University of Pennsylvania
Biogen
Consolidated Edison
Shell (rotation program)
Masters in Public Health at Bloomberg School
Deloitte
Medical School Stanford
P&G Process Engineering
PhD in Chemical Engineering University of Delaware
PhD in Chemical and Biomolecular Engineering University of Wisconsin
Regeneron
Wild Well Control (petroleum)
PhD in Biological Science New York University
Epic
MIT Sloan Master of Finance
Vanderbilt Medical School
II – Program Mission and Objectives

Our mission is to define and educate a new archetype of innovative and fundamentally-grounded engineer at the undergraduate and graduate levels through the fusion of fundamental chemical engineering principles and emerging disciplines. We will nurture our passion for technological innovation, scientific discovery, and leadership in existing and newly created fields that cut across traditional boundaries. We will be known for developing leaders in our increasingly technological society who are unafraid to explore uncharted engineering, scientific, and medical frontiers that will benefit humanity.

The Department of Chemical and Biomolecular Engineering offers courses and training culminating in the Bachelor of Science degree in Chemical and Biomolecular Engineering. The undergraduate program emphasizes the molecular science aspects of chemical engineering and biology, in concert with engineering concepts essential to developing commercial products and processes. By selecting an appropriate track or by choice of free electives, students can prepare for a professional career path or for further study in chemical, biomolecular, or a related engineering field as well as medical, law, or business school. In the tradition of the Johns Hopkins University, many undergraduates are also involved in research, working closely with faculty and graduate students in research groups.

Program Objectives: Recent graduates of the ChemBE program will:

(1) attain within a few years of graduation positions in which they apply their chemical and biomolecular engineering skills to solve diverse traditional and emerging problems in the workplace
(2) pursue professional careers in industrial, academic, or government organizations related to chemical, physical, and life sciences and engineering, and/or pursue graduate or professional education.

Student outcomes: Our students attain these objectives by following the curriculum presented in this Undergraduate Manual. At the completion of the program, our graduates demonstrate:

i. the ability to apply the fundamentals of chemistry, biology, mathematics and physics to ChemBE practice.
ii. the ability to utilize ChemBE principles to identify, formulate, and solve problems at the interface of engineering, chemistry, and biology.
iii. the ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, ethical, health and safety, manufacturability, and sustainability.
iv. the ability to design, conduct, and evaluate experiments, including the analysis and interpretation of data.
v. the ability to use the techniques, skills, and engineering tools for modern engineering practice.
vi. a recognition of the importance of, and the ability to engage in life-long
learning.
vii. knowledge of emerging applied science within ChemBE, attained through electives and/or research.
viii. the ability to communicate in writing with technical and non-technical audiences.
ix. the ability to give effective oral presentations.
x. the ability to work effectively independently and in multidisciplinary teams.
xi. an awareness of contemporary issues which have an impact on the discipline of ChemBE.
xii. an understanding of the impact of ChemBE solutions in a global, economic, environmental and societal context.
xiii. an appreciation of the professional and ethical responsibilities of chemical and biomolecular engineers.
III - DEPARTMENTAL ADVISING PROCEDURES

1. Faculty Advisors

Each student enrolled in Chemical and Biomolecular Engineering is assigned to a faculty member who will act as his or her advisor until graduation. Students plan their programs with their advisors to reflect individual interests as well as to fulfill program requirements. Students and advisors agree on courses for the semester, and then both sign an updated degree planning checklist. The advisor must lift the hold on registration in order for the student to register on-line or add/drop classes after the semester begins. Lifting the hold will only occur once the student has contacted the advisor and discussed the suggested changes to the course load. See section VII for faculty contact information.

Seniors MUST consult with their advisor before dropping any course at any time during their final year to avoid jeopardizing their chances of graduation. The advisor and the student will make sure that the change will not affect any key requirement in the curriculum nor postpone graduation date in any way.

2. Resources

Manuals and Guides

Students must consult the Johns Hopkins University Undergraduate and Graduate Programs Catalog (ASEN Catalog) for details regarding University requirements, grading options, independent study, etc (http://web.jhu.edu/registrar/catalog). In addition, freshmen should refer to “Engineering 101, Program Planning Guide for First-Year Engineering Students” published by the Whiting School of Engineering (WSE). This guide contains additional information about academic policies, advanced placement credits, resources and opportunities for students, etc.

Forms

Two forms are provided in this manual to aid in your course planning. The example programs (pages 10 to 12) show suggested examples of how the requirements can be fulfilled in four years of study. On this form the suggested elective sequence is arranged so that course loads are reasonably balanced, but note that they can be adjusted when appropriate. The checklist form (see page 13) serves as a checklist to ensure that the degree requirements are fulfilled. This is the most useful form to use to monitor your progress toward your degree. This form is available as an Excel spreadsheet at: http://www.jhu.edu/chembe/undergraduate-programs/index.html. Students of the class of 2017 need to follow the forms labeled “Students who entered after 2013”. Students who transfer in from other programs or who enter with significant advanced credits should find this form especially useful.

Course Guides and Evaluations

The university just introduced a new online guide in which student evaluations including numerical data and written comments are published for courses offered in the Schools of
Engineering and Arts and Science (http://web.jhu.edu/registrar, Office of the Registrar>Students>Teacher Course Evaluations. Prior to selecting a course, be sure to review the past years’ evaluations to see how students have rated the course and the instructor. Keep in mind that the instructor and course content can change from year to year.
**Example Program: Chemical and Biomolecular Engineering Degree**  
Students entering Fall 2013 or later with no advanced placement credits

| Freshman Year/Fall |  
|-------------------|---|
| 030.101 Intro to Chemistry I | 3  
| 030.105 Intro to Chemistry I Lab | 1  
| 110.108 Calculus I | 4  
| 171.101 General Physics I | 4  
| 173.111 General Physics Lab I | 1  
| 540.101 ChemBE Today | 1  
| H/S Elective | 3  
| **Total** | 17 |

| Freshman Year/Spring |  
|---------------------|---|
| 030.102 Intro to Chemistry II | 3  
| 030.106 Intro to Chemistry II Laboratory | 1  
| 110.109 Calculus II | 4  
| 171.102 General Physics II | 4  
| H/S Elective | 3  
| **Total** | 15 |

| Sophomore Year/Fall |  
|---------------------|---|
| 540.202 Intro. Chemical & Biological Process Analysis | 4  
| 540.490 Chemical and Biomolecular Lab Safety and Ethics* | 1  
| 110.202 Calculus III | 4  
| 020.305 Biochemistry | 4  
| 030.205 Organic Chemistry I | 4  
| **Total** | 17 |

| Sophomore Year/Spring |  
|-----------------------|---|
| 540.203 Engineering Thermo | 4  
| 540.303 Transport I | 3  
| 110.302 Differential Equations with Applications | 4  
| 020.306 Cell Biology | 4  
| **Total** | 15 |

| Junior Year/Fall |  
|-----------------|---|
| 540.304 Transport II | 4  
| Ph Chem or Biochem Laboratory ** | 3 or 2  
| 540.305 Modeling and Stat Analysis for ChemBE. | 3  
| Undesignated Elective | 3  
| H/S Elective | 3  
| **Total** | 15-16 |

| Junior Year/Spring |  
|-------------------|---|
| 540.301 Kinetic Processes | 3  
| 540.306 Chemical & Biological Separations | 3  
| 661.315 Culture of the Engineering Profession | 3  
| Advanced Chem/Bio Elective | 2 or 3  
| H/S Elective | 3  
| Undesignated Electives | 3  
| **Total** | 15-18 |

| Senior Year/Fall |  
|-----------------|---|
| 540.311 Chemical Engineering Lab | 6  
| 540.309 Chemical and Biomolecular Process Design Fall | 3  
| H/S Elective | 3  
| Engineering Elective | 3  
| **Total** | 15-18 |

| Senior Year/Spring |  
|-------------------|---|
| 540.310 Chemical and Biomolecular Process Design Spring | 3  
| 540.409 Modeling Dynamics & Control for Chemical and Biological Systems | 4  
| Engineering Elective | 3  
| Undesignated Electives | 5 to 7  
| **Total** | 15-18 |

*This course must be taken no later than the junior year. This course must be passed in order to be allowed to be involved in research in our department.*

**Students with no track have to choose one of the following labs: 030.307 Physical Chemistry Instrumentation Lab III or 020.315 Biochemistry Lab**
## Example Program: Chemical and Biomolecular Engineering Degree
### Molecular and Cellular Bioengineering Track

Students entering Fall 2013 or later with no advanced placement credits

### Freshman Year/Fall
- 030.101 Intro to Chemistry I 3
- 030.105 Intro to Chemistry I Lab 1
- 110.108 Calculus I 4
- 171.101 General Physics I 4
- 173.111 General Physics Lab I 1
- 540.101 ChemBE Today 1
- H/S Elective 3
- **Total** 17

### Freshman Year/Spring
- 030.102 Intro to Chemistry II 3
- 030.106 Intro to Chemistry II Laboratory 1
- 110.109 Calculus II 4
- 171.102 General Physics II 4
- H/S Elective 3
- **Total** 15

### Sophomore Year/Fall
- 540.202 Intro. Chemical & Biological Process Analysis 4
- 540.490 Chemical and Biomolecular Lab Safety and Ethics* 1
- 110.202 Calculus III 4
- 020.305 Biochemistry 4
- 030.205 Organic Chemistry I 4
- **Total** 17

### Sophomore Year/Spring
- 540.203 Engineering Thermo 4
- 540.303 Transport I 3
- 110.302 Differential Equations with Applications 4
- 020.306 Cell Biology 4
- **Total** 15

*This course must be taken no later than the junior year. This course must be passed in order to be allowed to be involved in research in our department.

### Junior Year/Fall
- 540.304 Transport II 4
- 020.315 Biochem Laboratory 2
- 540.305 Modeling and Stat Analysis for ChemBE 3
- Undesignated Elective 3
- H/S Elective 3
- **Total** 15

### Junior Year/Spring
- 540.301 Kinetic Processes 3
- 540.306 Chemical & Biological Separations 3
- 661.315 Culture of the Engineering Profession 3
- Advanced Chem/Bio Elective 2 or 3
- H/S Elective 3
- Undesignated Electives 3
- **Total** 17-18

### Senior Year/Fall
- 540.313 Chemical and Bioengineering Lab 6
- 540.309 Chemical and Biomolecular Process Design Fall 3
- H/S Elective 3
- Bioengineering Elective 3
- **Total** 15

### Senior Year/Spring
- 540.310 Chemical and Biomolecular Process Design Spring 3
- 540.409 Modeling Dynamics & Control for Chemical and Biological Systems 4
- Bioengineering Elective 3
- Undesignated Electives 6 to 7
- **Total** 16-17
**Example Program: Chemical and Biomolecular Engineering Degree**  
**Interfaces and Nanotechnology Track**

Students entering Fall 2013 or later with no advanced placement credits

### Freshman Year/Fall

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>030.101</td>
<td>Intro to Chemistry I</td>
<td>3</td>
</tr>
<tr>
<td>030.105</td>
<td>Intro to Chemistry I Lab</td>
<td>1</td>
</tr>
<tr>
<td>110.108</td>
<td>Calculus I</td>
<td>4</td>
</tr>
<tr>
<td>171.101</td>
<td>General Physics I</td>
<td>4</td>
</tr>
<tr>
<td>173.111</td>
<td>General Physics Lab I</td>
<td>1</td>
</tr>
<tr>
<td>540.101</td>
<td>ChemBE Today</td>
<td>1</td>
</tr>
<tr>
<td>H/S Elective</td>
<td></td>
<td>3</td>
</tr>
</tbody>
</table>

**Total:** 17 credits

### Freshman Year/Spring

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>030.102</td>
<td>Intro to Chemistry II</td>
<td>3</td>
</tr>
<tr>
<td>030.106</td>
<td>Intro to Chemistry II Lab</td>
<td>1</td>
</tr>
<tr>
<td>110.109</td>
<td>Calculus II</td>
<td>4</td>
</tr>
<tr>
<td>171.112</td>
<td>General Physics II</td>
<td>4</td>
</tr>
<tr>
<td>H/S Elective</td>
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<td>3</td>
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</tbody>
</table>

**Total:** 15 credits

### Sophomore Year/Fall

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>540.202</td>
<td>Intro. Chemical &amp; Biological Process Analysis</td>
<td>4</td>
</tr>
<tr>
<td>540.490</td>
<td>Chemical and Biomolecular Lab Safety and Ethics*</td>
<td>1</td>
</tr>
<tr>
<td>110.202</td>
<td>Calculus III</td>
<td>4</td>
</tr>
<tr>
<td>020.305</td>
<td>Biochemistry</td>
<td>4</td>
</tr>
<tr>
<td>030.205</td>
<td>Organic Chemistry I</td>
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**Total:** 17 credits

### Sophomore Year/Spring

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<thead>
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<th>Course Title</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>540.203</td>
<td>Engineering Thermo</td>
<td>4</td>
</tr>
<tr>
<td>540.303</td>
<td>Transport I</td>
<td>3</td>
</tr>
<tr>
<td>110.302</td>
<td>Differential Equations with Applications</td>
<td>4</td>
</tr>
<tr>
<td>020.306</td>
<td>Cell Biology</td>
<td>4</td>
</tr>
</tbody>
</table>

**Total:** 15 credits

### Junior Year/Fall

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credits</th>
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</thead>
<tbody>
<tr>
<td>540.304</td>
<td>Transport II</td>
<td>4</td>
</tr>
<tr>
<td>030.307</td>
<td>Phys Chem Laboratory</td>
<td>3</td>
</tr>
<tr>
<td>540.305</td>
<td>Modeling and Stat Analysis for ChemBE.</td>
<td>3</td>
</tr>
<tr>
<td>H/S Elective</td>
<td></td>
<td>3</td>
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</table>

**Total:** 16 credits

### Junior Year/Spring

<table>
<thead>
<tr>
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<th>Course Title</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>540.301</td>
<td>Kinetic Processes</td>
<td>3</td>
</tr>
<tr>
<td>540.306</td>
<td>Chemical &amp; Biological Separations</td>
<td>3</td>
</tr>
<tr>
<td>661.315</td>
<td>Culture of the Engineering Profession</td>
<td>3</td>
</tr>
<tr>
<td>H/S Elective</td>
<td></td>
<td>3</td>
</tr>
<tr>
<td>H/S Elective</td>
<td></td>
<td>3</td>
</tr>
<tr>
<td>Undesignated Electives</td>
<td></td>
<td>3</td>
</tr>
</tbody>
</table>

**Total:** 18 credits

### Senior Year/Fall

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>540.311</td>
<td>Chemical Engineering Lab</td>
<td>6</td>
</tr>
<tr>
<td>540.309</td>
<td>Chemical and Biomolecular Process Design Fall</td>
<td>3</td>
</tr>
<tr>
<td>030.452</td>
<td>Mat.and Surf. Charact.</td>
<td>3</td>
</tr>
<tr>
<td>I/N Engineering Elective</td>
<td></td>
<td>3</td>
</tr>
</tbody>
</table>

**Total:** 15 credits

### Senior Year/Spring

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>540.310</td>
<td>Chemical and Biomolecular Process Design Spring</td>
<td>3</td>
</tr>
<tr>
<td>540.409</td>
<td>Modeling Dynamics &amp; Control for Chemical and Biological Systems</td>
<td>4</td>
</tr>
<tr>
<td>I/N Engineering Elective</td>
<td></td>
<td>3</td>
</tr>
<tr>
<td>Undesignated Electives</td>
<td></td>
<td>5 to 6</td>
</tr>
</tbody>
</table>

**Total:** 15-16 credits

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*This course must be taken no later than the junior year. This course must be passed in order to be allowed to be involved in research in our department.
IV – Degree Checklists

Degree checklists (as Excel spreadsheets) can be found online at:

JOHNS HOPKINS UNIVERSITY - DEPARTMENT OF CHEMICAL AND BIOMOLECULAR ENGINEERING

V - Degree Requirements

1. Curriculum

Chemical and Biomolecular Engineering Core Courses

The following ChemBE courses are required 540.101, 540.202, 540.203, 540.301, 540.303, 540.304, 540.305, 540.306, 540.309, 540.310, 540.311 (or 540.313), 540.409, and 540.490 (see page 28 for a list of course names and numbers). The total credits of core engineering courses should add up to 42. Students that switch majors into ChemBE too late to take 540.101 in their freshman year may have the requirement for 540.101 waived with permission of the student’s advisor and a waiver form. However, since the total number of engineering credits (“Chemical Engineering Core Courses” plus “Other Engineering Courses”) must be at least 48 credits, the credit requirements for Other Engineering Courses will be raised by one credit.

Other Engineering Courses

A minimum of 48 engineering credits are required for the degree; therefore, students need to take at least 6 engineering elective credits. Students that have had 540.101 waived as a requirement will have one additional “other engineering” credit requirement as discussed above. A list of approved engineering electives is found near the end of this manual. For students who join research groups in the ChemBE department, one course of the category titled “Current Topics” will automatically count as an engineering elective. Most other engineering courses not on the approved list (courses with an E designation) may also be acceptable as engineering elective courses but must be approved by the advisor and the director of undergraduate studies.

Exceptions: courses on Statistics (for example 550.111), Probability and Statistics (for example 550.310) or Linear Algebra (for example 550.291) from the Applied Mathematics and Statistics Departments will not count as engineering electives despite the fact that they carry an E designation.

Physics Courses and Laboratories

The following physics courses are required: 171.101, 171.102 and 173.111.
Basic Chemistry Courses and Laboratories

The following chemistry courses are required: 030.101, 030.102, 030.105, and 030.106. For students with AP credits in chemistry who would like to take a 100-level chemistry course, 030.103 Applied Chemical Equilibrium and Reactivity with Lab (4 credits) can serve as a substitute for one of the required courses.

Advanced Chemistry and Biology Courses

Students are required to take 16 credits of Advanced Chemistry and Biology courses. The following four courses (14 or 15 credits) are required, three lectures 020.305, 030.205, 020.306, and one laboratory course (030.307 or 020.315). The required lab course must be either Physical Chemistry Instrumentation Laboratory III, 030.307 or Biochemistry Laboratory, 020.315. **Students that are concentrating in Molecular and Cellular Bioengineering must take the Biochemistry Lab, 020.315 and those concentrating in Interfaces and Nanotechnology must take Physical Chemistry Instrumentation Laboratory III, 030.307.**

Students need to take at least two additional credits beyond these required courses to meet the 16 credits requirement. Students should meet with their advisor to discuss which courses are most appropriate for their educational objectives. These courses must be chosen from the 030 or 020 codes and should be at the 200 level minimum. Note that Physical Chemistry I (030.301) is not an approved course because most of its content is covered in our required courses (540.202 and 540.203). A list of approved advanced chemistry and biology electives is found on page 29. Other courses not on the approved list may also be acceptable as advanced chemistry and biology elective courses but must be approved by the advisor and the director of undergraduate studies.

The following course is not acceptable as an Advanced Chem/Bio Elective: 030.312 Introduction to the Human Brain

Mathematics Requirement

The following mathematics courses are required: Calculus I, II and III (110.108, 110.109 and 110.202) and Differential Equations with Applications (110.302).

Calculus is so essential to Chemical Engineering that a grade of C- or better in both Calculus I and Calculus II is required. In addition to knowledge of the material covered in Calculus I, II and III, Chemical Engineers need to be able to solve linear differential equations, some simple partial differential equations and systems of differential equations often by numerical methods. Differential Equations with Applications (110.302) provides this additional mathematical background.

Sixteen credits of math are required. Successful completion of the Advance Placement examinations will count toward these credits (see the Undergraduate Academic Manual for scores needed). Students who do not receive advance placement credits but who place out of Calculus I by their score on the math department placement exam are required to take an additional course in mathematics since they do not receive credits for Calculus I
and students must have a total of at least 16 credits in mathematics. For example, a course in Linear Algebra or in Probability and Statistics can be used to satisfy this requirement.

**Writing Skills**

The university requires that two courses designated as a W be taken to graduate and that these two courses be completed with a grade of C or better.

One of the two W courses may be any course with a W designation except for 540.311 and 540.313. The second W course must be The Culture of the Engineering Profession (661.315), a requirement for the laboratory and design courses of senior year.

**Humanities and Social Sciences Courses**

Students need 6 courses coded as humanities (H) or social science (S), at least 3 credits each for a minimum of 18 credits (see ASEN catalog). The goal of this requirement is for students to acquire both *breadth* and *depth* in the humanities and social sciences.

- Therefore, students have to take courses in at least two subject areas in addition to writing.
- At least one of the H/S courses must be an advanced level course at the 300-level or higher.
- No more than 6 credits designated as H or S that are also designated with an N (natural science), an E (engineering) or a Q (quantitative) may count towards fulfilling the 18 credits of H/S electives.

Note that most H or S courses taught during the intersession are less than 3 credits and graded pass/fail, they do not count towards the H/S requirement, they contribute to the undesignated electives.

Acceptable H/S subjects include, but are not limited to: Anthropology, Archaeology, Arts (Visual or Performing), Classics, Communications, Economics, Ethics, Geography, History, Film, Foreign Languages and Cultures, Jurisprudence (Law), Linguistics, Literature, Philosophy, Political Science, Psychology, Religion, and Sociology. Note that many Music courses are not coded as H/S, only Music courses with an H/S designation can contribute to the 6 H/S courses.

Exceptions: the following courses are **NOT** acceptable as H/S electives even though they are or have been designated as an H or an S in the past. They lack significant humanities or social science content.

- 180.334 Econometrics
- 200.314 Advanced Statistical Methods
- 660.203 Financial Accounting
- 660.303 Managerial Accounting
- 660.401 Advanced Corporate Finance

Students are welcome to take these courses but they have to count them as undesignated elective credits.
Foreign language instruction and literature courses are acceptable as Humanities credits. Note that beginning language courses often do not have an H designation because they are not allowed as an H course for Arts & Science majors. However, University rules state that beginning language courses do have an H designation for engineering students. Thus, beginning language courses count towards fulfilling the 18 credits of H/S electives even if they lack an H designator. Be aware that some language departments require that the entire year of an introductory language course be taken in order to receive credits.

Undesignated Electives

A minimum of 128 credits is required for the degree. Therefore, in addition to all the credits taken to fulfill the requirements mentioned in the various sections above (e.g. chemical engineering core courses, engineering electives, advanced chemistry electives, computing requirement, mathematics requirement, and H & S courses) up to 13 additional credits (called undesignated credits) are required. There are no restrictions on the courses that can be used as undesignated electives.

2. Tracks

Students pursuing a degree in Chemical and Biomolecular Engineering have the option of concentrating in two specific fields, Interfaces and Nanotechnology or Molecular and Cellular Bioengineering. Students completing a track will have this fact designated on their final checklist audit form. These tracks have additional and/or alternate requirements, as described below.

Interfaces and Nanotechnology (IN) Track

Students must fulfill the following requirements:

- The Advanced Chemistry and Biology laboratory requirement is fulfilled with 030.307 (Physical Chemistry Lab III).
- Materials and Surface Characterization (030.452) is required and satisfies three credits of the advanced chemistry electives.
- Six credits of interfaces and nanotechnology electives are required. One of these courses can be a “Current Topics” course in the interfacial/nano area. See page 31 for a list of approved electives.

Molecular and Cellular Bioengineering (MCB) Track

Students must fulfill the following requirements:

- The Advanced Chemistry and Biology laboratory requirement is fulfilled with 020.315 (Biochemistry Lab).
- Six credits of bioengineering electives are required. One of these courses can be a “Current Topics” course in the bio area. See page 30 for a list of approved courses.
- Students must take 540.313 Chemical and Biomolecular Engineering Lab instead of 540.311 Chemical Engineering Lab.
3. Pre-Professional Preparation Requirements

Choosing an initial career path and then working toward making it a reality are two very important steps that Chemical & Biomolecular Engineering students will take while at Hopkins. Basic information on preparation for a career and job hunting is available at the Career Center. In addition, the Chemical and Biomolecular Engineering department career network (HCCN) provides regular e-mails on internships and job information. To increase students’ chances of success in the future, key elements on how to prepare for career development have been incorporated into the curriculum. The required tasks become a component of 540.101, 540.303, 540.304 and 540.409.

The steps described below are required for successful completion of the pre-professional preparation.

1. Required for 540.101 Chemical & Biomolecular Engineering Today (Freshmen Year Fall): Attend the workshop ’Resumes and Cover Letters: The Basics’ (presented in class). Write a resume and have it critiqued by the career center.
2. Required for 540.303 Engineering Thermodynamics (Sophomore Year Fall or Spring). Log into your Career Center J-Connect account and complete your profile. Highly recommended to attend one event during the Career Center’s “Internship Extravaganza” and/or the workshop ’Starting Your Internship Search’
3. Required for 540.304 Transport II (Junior Year Fall). Update your resume and have it critiqued by the career center. Attend the workshop ’Interviews: Practical Tips to Market Your Skills’.
   Also this year, consider getting a head-start on senior-year preparation by taking a Mock Interview.
4. Required for 540.409 Modeling, Dynamics and Control for Chemical and Biological Systems (Senior Year Fall). Update your resume and cover letter and have them critiqued by the Career Center. Take a Mock Interview at the Career Center (if not completed during Junior Year).

The faculty strongly recommends that all students also do the following:

- Attend the AIChE/SBE and ChemBE Career Network pre-professional events.
- Take full advantage of the Career Center at Johns Hopkins, including attending the ’Starting Your Job Search’ Workshop
- Read emails sent by the Hopkins ChemBE Career Network (HCCN), and visit the HCCN blog for more internship and job information.

4. Rules and Limitations

Grade Requirements and Department Honors

Students must have a grade point average of at least 2.00 in the Chemical and Biomolecular Engineering Core courses to graduate. These core courses are: 540.202, 540.203, 540.301, 540.303, 540.304, 540.305, 540.306, 540.309, 540.310, 540.311 (or
540.313), 540.409. Students with a ChemBE GPA of 3.6 will automatically receive Department Honors on their Official Transcript at graduation (no application required).

**Repetition of Course Content**

Courses taken to fulfill any requirement, including the requirement of 128 total credits, must not overlap in content to a substantial extent. For example, students cannot count Physical Chemistry I (030.301) because its content is covered in 540.203. At present, the Material Science course, Thermodynamics (510.312) so extensively duplicates our courses that this course also cannot be counted. You should discuss carefully the content of all elective courses with your advisor. His/her approval, and in questionable cases, that of the Director of Undergraduate Studies, is required to avoid problems in fulfilling course requirements.

**Undergraduate Research and/or Independent Study to Fulfill "Other Engineering" Requirement**

No more than four credits earned in Undergraduate Research and/or Independent Study courses can be used to fulfill the engineering electives requirements. Any additional credits in these courses will serve as undesignated credits (i.e. count towards the total 128 credit minimum).

Current Topics courses are included in research credits thus students can automatically count one Current Topics course as an engineering elective. Current Topics Courses from the bio labs count automatically towards the MCB track and those from the I/N labs towards the I/N track. Then only one more credit from Undergraduate Research can count towards the engineering electives. Other research credits or credits from a second Current Topics course will count as undesignated electives.

Students who do not receive any Current Topics credits can use 4 Undergraduate Research credits to fulfill their engineering electives or track elective. To meet this requirement they must complete the Research Credit Elective Request form on the ChemBE undergraduate website and submit it to the Academic Program Coordinator. (http://www.jhu.edu/chembe/undergraduate-programs/docs/Research_Credit_Elective_Request.pdf). Once the request is evaluated, the student and faculty advisor will be notified of the final decision.

For further information about participating in Undergraduate Research, see page 24.

**Courses Taken Pass/Fail**

There is no limit on the number of undesignated credits that may be taken pass/fail. However, all required courses and all courses fulfilling technical electives and H/S requirements cannot be taken pass/fail without special permission. To allow for situations where it may be educationally appropriate for the student to take a course for which he/she has significantly less than the normal preparation, the advisor, with the approval of the director of undergraduate studies, can allow up to four credits of technical electives and up to two courses of H/S courses to be taken pass/fail. The student and his/her
advisor fill out the Waiver and Substitution Form on the ChemBE Undergraduate Website (http://www.jhu.edu/chembe/undergraduate-programs/docs/ReqWaiver.pdf). The form must be delivered to the Academic Program Coordinator for approval.

Exceptions

The procedure for obtaining an exception to any of the above requirements is a recommendation in writing by the advisor, and approval by the Director of Undergraduate Studies. Student and advisor fill out the Waiver and Substitution Form on the ChemBE Undergraduate Website (http://www.jhu.edu/chembe/undergraduate-programs/docs/ReqWaiver.pdf). The form must be delivered to the Academic Program Coordinator for approval. The approved waiver form will be placed in the student’s departmental file, the student will receive an e-mail notice of the approval.

Course Retakes

The university allows students to retake a course to obtain a better grade if the first grade is C+ or lower. The grade from the second attempt is the only grade recorded on the transcript and included in the GPA calculation, even if the second grade is lower than the first. The grade from the first attempt disappears. See ASEN Catalog, under Absolving a grade for details.
VI – Options Available in Chemical and Biomolecular Engineering

1. Senior Lab at DTU in Copenhagen in the Summer

Students have the option to take a Laboratory Course at the Technical University of Denmark (DTU) in Copenhagen during the summer before their senior year. This laboratory course is offered over four weeks in July. See www.kt.dtu.dk for details. The registration fee includes lodging at the university as well as some student activities. The students are responsible for their travel arrangements to Copenhagen. Application forms are available starting in November from the Academic Coordinator and are due in early March. Since this experience is handled as a Study Abroad program, students must go through the Study Abroad office (Levering Hall) as well as the ChemBE department in their planning.

The summer lab work counts as 4 engineering credits. The instructors of the University of Denmark grade the project reports and assign a letter grade sent to the ChemBE department. Students who attend this program need to take 540.312, a follow-up course during the fall of senior year that fulfills writing and bioengineering requirements equivalent to those of 540.311 and 313. The final grade for the whole lab experience combines the grade from DTU and the grade from JHU.

The ChemBE department offers small scholarships to students who complete the DTU lab successfully. These cover travel expenses to Denmark and the University.

2. Undergraduate Research

Many undergraduate students are involved in research. They can find opportunities to work in research laboratories in the ChemBE department or in other programs at Hopkins. Students can start research as early as freshman year.

If you are interested in joining a research group in the engineering school, the first step is to meet with your faculty advisor. He/she will go over your academic record with you to determine if you are prepared for a research project. Next, you should (i) investigate the research interests of the faculty by reading their departmental webpages and publications and (ii) make appointments to talk to faculty members whose research interests you. Contact the faculty member by email in order to learn more about their research and to find out if there is an opening in their lab. Include a resume, a transcript and any useful information in your application. You may also speak to graduate students in the research group for more information.

To register for research credits, the student must fill out the (yellow) Research Form from the registrar’s office. The student and the research professor discuss the expectations for the research project and agree on the nature of the final deliverables (see list on research registration form). They should also clarify how much work (time) is expected per credit of research. At the end of the semester, the research professor will review the accomplishments of the student (experiments, report, presentation, etc.), verify that the
student invested enough time to deserve the number of credits of the course and assign a grade for the research effort.

If students wish to join research laboratories in another school in JHU (for example the Medical School), they must consult with their academic advisor to transfer the final research grade from the other school into the WSE. After receiving approval from their advisor, students use the (yellow) Research Form from the registrar’s office to sign up under the ISIS course number for their ChemBE advisor. They must inform their advisor of the deliverables and expectations discussed with the research professor. At the end of the semester, students must send an e-mail to their advisor explaining the nature of their project and how they met the requirements set by their research professor. It is also the students’ responsibility to remind their research professor to send a final grade and number of credits to the advisor. The advisor will then enter this grade in ISIS.

Students who join a research group must take a course on laboratory safety. Most students meet this requirement since they must take the ChemBE Safety course 540.490, usually in the fall of the sophomore year. Freshmen and students who did not take 540.490 yet and wish to start their research projects, can take an on-line training followed by a list of questions. Contact the administrators in the ChemBE Main Office (MD 221) to receive this training. It does not replace 540.490 but allows students to start research.

Credits received for research from another university can be transferred by following the WSE procedure for any credit transfer. If research takes place outside the United States, the transfer of credits follows the procedures of the Study Abroad office. They will count as undesignated credits. Students may not receive research credits from internships, REUs or any research work for which they receive compensation.

### 3. BS/MSE Program in Chemical and Biomolecular Engineering

The BS/MSE program in Chemical and Biomolecular Engineering allows students to obtain a Masters in Science in Engineering immediately after the Bachelors of Science. The Whiting School of Engineering offers a fifty percent waiver for having received the Bachelor of Science or after the completion of 8 semesters in the undergraduate program.

Admission decisions to the ChemBE BS/MSE program are made on a variety of criteria including undergraduate GPA. Students are expected to have an undergraduate GPA of at least 2.8 (and preferably higher) in order to be admitted to the BS/MSE program.

**Application Process**

Applicants for the BS/MSE program must:
- Consult with their advisor to see if/when they should apply. If applying to the 10-course MSE they should consult their Academic Advisor. If applying to the 6-course program with essay they should consult their Research Professor or proposed MS Research Advisor.
Inform the ChemBE Academic Program Coordinator that they will be applying for the BS/MSE program. The Program Coordinator will then supply them with detailed instructions and waive the application fee.

Apply online through “Apply Yourself” www.grad.jhu.edu, following all instructions from the Program Coordinator. Applications are due at the end of December or beginning of January along with all other graduate student applicants. Check Graduate School website for exact date.

Request only one letter of recommendations for the application file (the department waives the other two). The letter should come from the MS research advisor for the essay/6-course students and from the BS academic advisor for the 10-course students.

There are no GRE requirements.

The TOEFL is waived for international students.

Visit http://www.grad.jhu.edu/bachelors-masters/requirements.php for full information regarding the application process and financial aid/Dean’s Masters Fellowship.

Contact the Academic Program Coordinator for more information:
Caroline Qualls
Academic Program Coordinator
Johns Hopkins University
Department of Chemical and Biomolecular Engineering
Whiting School of Engineering
3400 N. Charles Street
Baltimore, MD 21218
Maryland Hall 223
(410) 516-4166
cqualls1@jhu.edu

Double Counting Policy

Students pursuing both their undergraduate and master’s degrees in ChemBE at JHU should be aware of the department’s rules on double counting courses. Up to two courses can be counted for both degrees. For classes offered at both the 400- and 600-level, students MUST take the course at the 600-level to apply the course to their masters degree. Thus, the ChemBE graduate program’s policy on double-counting courses is stricter than the WSE policy found here: http://eng.jhu.edu/wse/page/graduate-double-counting/

4. Graduate School Requirements

Many graduates from the undergraduate ChemBE program enter graduate schools after receiving their BS. Almost half of every graduating class applies to and succeeds in joining a MS or PhD program right after senior year or a couple years later. Students who plan to get a graduate degree, especially a PhD, should demonstrate dedication to their course of studies and strive to work independently. They should consider the following suggestions:
Join a research laboratory and make a contribution to the projects of the group
Maintain a very high GPA
Take additional courses in math or computer science
Become familiar with technical writing
Sign up for graduate level courses (600 level) during senior year
Prepare for the GRE
Attend AIChE/SBE panels on graduate school and research
Present a poster at a technical meeting
Publish technical papers.

Applications are due in the fall of senior year (due dates vary a lot from university to university but most are in December and January).

5. Premedical Requirements

The Chemical and Biomolecular Engineering degree is an excellent curriculum for preparing students for medical school. Students who intend to apply to medical school must plan their program very carefully. In addition to the courses you must pursue to complete degree and university requirements, you are advised to take the courses necessary in preparation for the MCAT as well as the admission requirements of the majority of medical/dental schools in the U.S. However, realize that it is not possible for you to cover every pre-medical requirement for every medical school in the U.S.

A new MCAT format will be introduced in the spring 2015. Therefore, if you take the MCAT in January 2015 or earlier, you will be taking the current MCAT. Many of you in the Class of 2016, however, will be among the first group of applicants nationally to take the new MCAT. Given this possibility, it is critical that you recognize changes in the new MCAT. These are covered in detail in the Premed Planning Guide One (http://web.jhu.edu/prepro/Forms/Guide.One.pdf).

An important resource for pre-medical students is the Office of Pre-Professional Programs and Advising, 300 Garland Hall (http://web.jhu.edu/prepro). Students should visit this office early, sign up for their listservs and attend their workshops. Even if you are just considering a career in the health professions, be sure to sign up for your listserv and consider making an appointment. These are both accessed on the Office’s webpage noted above.

A strong application to medical school must reflect the personal qualities of the applicants as well as the academic achievements. Applicants must include the courses required by the medical school into their curriculum and maintain a good GPA. But good grades are not sufficient. It is as important to demonstrate interest in service of the community, experience in the health industry, aptitude to leadership and dedication to other projects beneficial to society. Students are encouraged volunteer at school, at home or even abroad, to join a research group, to get some experience in the medical world, etc.
Premed required courses included in the ChemBE curriculum:

- General Chemistry I and II with Lab (8 credits) (030.101/102/105/106)
- Organic Chemistry I (4 credits) (030.205)
- Biochemistry with Lab and Cell Biology (10 credits) (020.305/306/315)
- General Physics I with Lab and General Physics II (9 credits) (171.101/102/111)
- Calculus I and II (8 credits) (110.108/109)
- One course in English, literature or writing (3 credits)
- Two courses in the H/S requirements will have to be an introductory course in Psychology (choose from 200.101/110/132/133/141) and an introductory course in Sociology (choose from 230.101/225/341) (6 credits). Courses such as 050.101/105/203 also meet this requirement.

Additional courses for premed requirements

- Organic Chemistry II and Organic Chemistry Lab (7 credits) (030.206/225)
- Cell Biology Lab (020.316)
- Physics Lab II (171.112)
- A second course in English, literature or writing (3 credits)
- Introductory course in Statistics (3 credits)

Some medical schools might have different specifications on course selection and use of AP credits. Please consult with the Pre-Professional Advising office. The premed course requirements are also covered in detail in the Premed Planning Guide One ([http://web.jhu.edu/prepro/Forms/Guide.One.pdf](http://web.jhu.edu/prepro/Forms/Guide.One.pdf))

### 6. Minors

Minors are available in various departments (Classics, Economics, Music, Russian, Spanish, etc.). Students are responsible for learning the requirements for their minor and receiving clearance from that department for graduation. They must bring this information to their ChemBE advisor in order to design a suitable course plan.

For example, one minor is available in environmental engineering. Detailed information regarding this program can be found at: [http://engineering.jhu.edu/~dogee/undergraduate-programs/](http://engineering.jhu.edu/~dogee/undergraduate-programs/) or by contacting dogeeundergradminor@jhu.edu.

A minor in Entrepreneurship and Management is offered by the Center for Leadership Education. ([The Center for Leadership Education, Johns Hopkins University Whiting School of Engineering](http://engineering.jhu.edu/)). Or contact:

Pam Arrington
105 Whitehead Hall
410-516-6741
Parring2@jhu.edu
7. Student Organizations (AIChE/SBE)

The American Institute of Chemical Engineers (AIChE) student chapter is an organization that eases the transition from the undergraduate learning stage to the actual practice of chemical and biomolecular engineering and promotes the professional development of the students through association with practicing engineers. Social activities include two picnics, one in the fall and one in the spring, and a holiday party. AIChE also organizes tours of local plants and arranges for speakers to discuss topics such as what to expect at graduate school, and the role of the chemical/biomolecular engineer in industry. For more information, please see the AIChE chapter webpage (http://jhuaiche.org/) or email at jhu.aiche.sbe@gmail.com.

8. Cooperative Program

The Department of Chemical and Biomolecular Engineering allows students to join a cooperative program in which students spend up to one year in industry after completing their sophomore or junior year. Students do not pay tuition during the work periods and are paid a salary by their employer. The department helps to identify potential employers with internship opportunities through the Hopkins ChemBE Career Network, however, students are responsible for obtaining an offer from a suitable employer. Students successfully completing a cooperative program receive a notation on their transcript. Interested students should contact their academic advisor and Professor Betenbaugh, Director of the ChemBE Career Network.

9. How to get an internship

The AIChE student group has written the following tips, to assist students in securing an internship:

- Resume – Spend some time working on your resume. Have it critiqued, numerous times. The career center, professors, and parents are good resources. Get lots of opinions and then decide what will work best for you.
- Start Early – Start surfing the net in September/October to figure out what sort of companies and positions are out there and interest you. Don’t limit yourself to any one particular company. Visit their web sites regularly, specifically their career pages, to review and apply to positions. Go to J-connect to find out what is available.
- Practice Interviews – The career center offers these in the fall semester. Take advantage of them. There are real companies that recruit on campus and will give you great feedback on how to improve your interviewing style. Send thank you emails.
- Work your Connections – Talk to professors, deans, parents, relatives, friends, etc. Hopkins has a great alumni network (check out the career center, LinkedIn and the HCCN web pages).
• Go to EVERYTHING – Go to any and every employer showcase, informational session, job fair, alumni panel, etc. that you can. You never know when you might learn something or meet someone.
• Email them, call them, do whatever you have to. Show interest. Follow up. Be annoying in a very nice, polite kind of way.
• Some companies recruit on campus. This is your best bet for an internship because they are seeking Hopkins students specifically. Submit your resume to as many as you can even if you’re not all that interested because the interview practice is always good. Don’t forget to send thank you emails!
• Don’t Forget REU Programs! – Almost every large college/university has some sort of REU – Research Experience for Undergrads – Apply! The deadlines are usually Feb/March/April so start writing essays over Intercession. You do get paid, and usually free housing!
• Don’t panic – Most companies don’t start offering summer positions until mid-March through the end of April and even into May sometimes.
### VII - Department Contact List

**Director of Undergraduate Studies:** Lise Dahuron  
120 Maryland Hall  
(410) 516-6817, dahuron@jhu.edu

**Academic Program Coordinator:** Caroline Qualls  
223 Maryland Hall  
(410) 516-4166, cqualls@jhu.edu

**Engineering Office of Academic Advising:** 103 Shaffer Hall  
(410) 516-7395, wseadvising@jhu.edu

<table>
<thead>
<tr>
<th>Name</th>
<th>Phone</th>
<th>Email</th>
<th>Office</th>
<th>Extension</th>
</tr>
</thead>
<tbody>
<tr>
<td>Michael Betenbaugh</td>
<td>(410) 516-5461</td>
<td><a href="mailto:beten@jhu.edu">beten@jhu.edu</a></td>
<td>Maryland Hall 222</td>
<td></td>
</tr>
<tr>
<td>Mike Bevan</td>
<td>(410)-516-7907</td>
<td><a href="mailto:mbevan@jhu.edu">mbevan@jhu.edu</a></td>
<td>Maryland Hall 123</td>
<td></td>
</tr>
<tr>
<td>Honggang Cui</td>
<td>(410)-516-6878</td>
<td><a href="mailto:Hcui6@jhu.edu">Hcui6@jhu.edu</a></td>
<td>Croft Hall 370</td>
<td></td>
</tr>
<tr>
<td>Marc D. Donohue</td>
<td>(410) 516-7761</td>
<td><a href="mailto:mdd@jhu.edu">mdd@jhu.edu</a></td>
<td>Maryland Hall 117</td>
<td></td>
</tr>
<tr>
<td>Joelle Frechette</td>
<td>(410) 546-0113</td>
<td><a href="mailto:jfrechette@jhu.edu">jfrechette@jhu.edu</a></td>
<td>Maryland Hall 121</td>
<td></td>
</tr>
<tr>
<td>Zachary Gagnon</td>
<td>(410)-516-8489</td>
<td><a href="mailto:zgagnon1@jhmi.edu">zgagnon1@jhmi.edu</a></td>
<td>Maryland Hall 220A</td>
<td></td>
</tr>
<tr>
<td>Sharon Gerecht</td>
<td>(410) 516-2846</td>
<td><a href="mailto:gerecht@jhu.edu">gerecht@jhu.edu</a></td>
<td>Maryland Hall 116</td>
<td></td>
</tr>
<tr>
<td>An Goffin</td>
<td>(410) 516-3484</td>
<td><a href="mailto:agoffin@jhu.edu">agoffin@jhu.edu</a></td>
<td>Maryland Hall 122</td>
<td></td>
</tr>
<tr>
<td>David Gracias</td>
<td>(410) 516-5284</td>
<td><a href="mailto:dgracias@jhu.edu">dgracias@jhu.edu</a></td>
<td>Maryland Hall 125</td>
<td></td>
</tr>
<tr>
<td>Jeffrey Gray</td>
<td>(410) 516-5313</td>
<td><a href="mailto:jgray@jhu.edu">jgray@jhu.edu</a></td>
<td>Maryland Hall 208</td>
<td></td>
</tr>
<tr>
<td>Konstantinos</td>
<td>(410) 516-6290</td>
<td><a href="mailto:kkonsta1@jhu.edu">kkonsta1@jhu.edu</a></td>
<td>Maryland Hall 221</td>
<td>Croft 114</td>
</tr>
<tr>
<td>Marc Ostermeier</td>
<td>(410) 516-7144</td>
<td><a href="mailto:oster@jhu.edu">oster@jhu.edu</a></td>
<td>Maryland Hall 119</td>
<td></td>
</tr>
<tr>
<td>Rebecca Schulman</td>
<td>(410) 516-8457</td>
<td><a href="mailto:rschulm3@jhu.edu">rschulm3@jhu.edu</a></td>
<td>Maryland Hall 220B</td>
<td></td>
</tr>
<tr>
<td>Chao Wang</td>
<td>(410) 516-5843</td>
<td><a href="mailto:Cwang78@jhu.edu">Cwang78@jhu.edu</a></td>
<td>Maryland Hall 218</td>
<td></td>
</tr>
<tr>
<td>Denis Wirtz</td>
<td>(410) 516-7006</td>
<td><a href="mailto:wirtz@jhu.edu">wirtz@jhu.edu</a></td>
<td>Croft Hall 116</td>
<td></td>
</tr>
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</table>
**VIII - Course Listing**

1. **Required Courses**

- 020.305  Biochemistry
- 020.306  Cell Biology
- 020.315  Biochemistry Laboratory*

- 030.101  Intro. Chemistry
- 030.102  Intro. to Chemistry II
- 030.105-106  Intro. Chemistry Lab I and II
- 030.205  Organic Chemistry I
- 030.307  Physical Chemistry Lab III*

- 110.108-109  Calculus I and II
- 110.202  Calculus III
- 110.302  Differential Equations with Applications

- 171.101-102  General Physics I, II,
- 173.111  General Physics Lab I

- 540.101`  Chemical and Biomolecular Engineering Today
- 540.202  Intro to Chemical and Biological Process Analysis
- 540.203  Engineering Thermodynamics
- 540.301  Kinetic Processes
- 540.303  Transport Phenomena I
- 540.304  Transport Phenomena II
- 540.305  Modeling and Statistical Analysis of Data for ChemBE
- 540.306  Chemical and Biological Separations
- 540.311  Chemical Engineering Lab
- 540.409  Modeling Dynamics and Control for Chemical and Biological Systems
- 540.490  Chemical and Biomolecular Lab Safety and Ethics

- 661.315  Culture of the Engineering Profession

(*students must choose one of these two laboratory courses)

The following course is acceptable for students with AP credits in chemistry:

- 030.103  Applied Chemical Equilibrium and Reactivity with Lab
2. Additional/Alternate Required Courses of the Molecular and Cellular Bioengineering Track

020.315 Biochemistry Lab
540.313† Chemical and Biomolecular Engineering Lab

† this course is required in place of 540.311 Chemical Engineering Lab

3. Additional Required Courses of the Interfaces and Nanotechnology Track

030.307 Physical Chemistry Lab III
030.452 Materials and Surface Characterization

4. Approved Advanced Chemistry and Biology Electives*

030.206 Organic Chemistry II
030.225 Intro. Organic Chem Lab
030.228 Intermediate Organic Lab
030.302 Physical Chemistry II
030.356 Advanced Inorganic Lab
030.425 Advanced Mechanistic Organic Chemistry I
030.449 Chemistry of Inorganic Compounds
030.451 Spectroscopy
030.452 Materials and Surface Characterization
020.315 Biochemistry Lab
020.316* Cell Biology Lab
020.330 Genetics
020.332 Photosynthesis by Land and Aquatic Organisms
020.337 Stem Cells and the Biology of Aging and Disease

*Other courses with significant advanced chemistry content may also be acceptable, but must be approved by your advisor and the director of undergraduate studies. Note that courses in which there is significant overlap of content with required courses are not acceptable advanced chemistry or chemistry-related electives.

One course is not acceptable:
020.312 Introduction to the Human Brain

5. Approved Engineering Electives

Approved engineering electives include the courses listed directly below as well as those approved as Bioengineering or Interfaces and Nanotechnology electives that are listed further below.
Other courses with significant engineering content may also be acceptable, but must be approved by your advisor and the director of undergraduate studies. Note that courses in which there is significant overlap of content with required courses are not acceptable engineering electives.

Students should be aware that some elective courses are not offered every year or may not be offered for several years.

510.313 Mechanical Properties of Materials  
510.314 Electronic Properties of Materials  
510.401 Materials in Service  
510.402 Structural Materials Engineering  
510.403 Materials Characterization  
510.405 Materials Physics  
520.142 Digital System Fundamentals  
520.219-220 Fields, Matter, and Waves  
530.352 Materials Selection  
530.405 Mechanics of Solids and Structures  
540.318/319 Project in the Design of a Chemical Car  
540.401 Projects in Design: Alternative Energy  
560.206 Solid Mechanics and Theory of Structures  
570.301 Environmental Engineering I: Fundamentals  
570.302 Water and Wastewater Treatment  
570.304 Environmental Engineering and Science  
570.305 Environmental Engineering Systems Design  
570.443 Aquatic Chemistry  
570.491 Hazardous Waste Management

6. Approved Bioengineering Electives

Students should be aware that some bioengineering elective courses are not offered every year or may not be offered for several years.

Other courses with significant bioengineering content may also be acceptable, but must be approved by your advisor and the director of undergraduate studies. Note that courses in which there is significant overlap of content with required courses are not acceptable as bioengineering electives.

500.410 Surgery for Engineers  
510.316 Biomaterials I  
510.407 Biomaterials II
510.430 Biomaterials Lab
510.431 Biocompatibility of Materials

530.410 Biomechanics of the Cell and Organisms
530.440 Computational Mechanics of Biological Macromolecules
530.445 Introductory Biomechanics
530.446 Experimental Biomechanics

540.400 Projects in Design: Pharmacokinetics
540.402 Metabolic Systems Biotechnology
540.405 The Design of Biomolecular Systems
540.414 Computational Protein Structure
540.421 Projects in Design: Pharmacodynamics
540.426 Biomacromolecules at the Nanoscale
540.428 Supramolecular Materials and Nanomedicine
540.437 Application of Molecular Evolution to Biotechnology
540.449 Logic and Decision-making in Biomolecular Systems
540.459 Bioengineering in Regenerative Medicine

570.411 Environmental Microbiology
570.446 Biological Processes for Water and Wastewater Treatment

580.311/312 Design Team – Junior
580.411/412 Design Team – Senior
580.404 The Bionic Ear
580.425 Ion Channels in Excitable Membranes
580.435 Bioelectromagnetic Phenomena
580.439 Models of Physiological Processes in the Neuron
580.441 Cellular Engineering
580.442 Tissue Engineering
580.448 Biomechanics of Cells and Organisms
580.495 Microfabrication Lab

With instructor’s permission, students with a good academic record also can take the following courses as bioengineering electives:

540.630 Thermodynamics Statistical Mechanics and Kinetics
540.652 Advanced Transport Phenomena

7. Approved Interfaces and Nanotechnology Electives

Students should be aware that some interfaces and nanotechnology elective courses are not offered every year or may not be offered for several years.

Other courses with significant content related to interfaces and nanotechnology may also be acceptable, but must be approved by your advisor and the director of undergraduate
studies. Note that courses in which there is significant overlap of content with required courses are not acceptable as interfaces and nanotechnology electives.

510.311 Structures of Materials
510.421 Nanoparticles
510.422 Micro/nano Structured Materials and Devices

530.495 Microfabrication Laboratory

540.403 Colloids and Nanoparticles
540.415 Interfacial Science with Applications to Nanoscale Systems
540.426 Biomacromolecules at the Nanoscale
540.428 Supramolecular Materials and Nanomedicine
540.438 Interfacial Phenomena in Nanotechnology
540.440 Micro to Nanotechnology