Department of Bioengineering
Undergraduate Student Handbook
2017-2018 Catalog

http://engineering.missouri.edu/advising/advisers/
http://bioengineering.missouri.edu/undergraduate/
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Welcome Letter

Dear Undergraduate Students:

Welcome to the University of Missouri (MU)! We are delighted to have you join us as a student in the Department of Bioengineering (BE).

As a BE undergraduate, you will be part of a diverse and vibrant department with over one hundred years of excellence in engineering education. We provide a supportive and stimulating environment that combines talented students, a diverse faculty body, and excellent teaching and research facilities. Bioengineering uniquely positions graduates to pursue careers in traditional engineering as well as medicine, veterinary medicine, law, health care, policy, and academics.

We encourage you to explore our student organizations, undergraduate research opportunities, study abroad programs, and more.

Welcome to BE. We strive to make your college experience enjoyable and rewarding. Go Tigers!

Jinglu Tan, Ph.D.
James C. Dowell Professor
Chair, Department of Bioengineering, College of Engineering
Director, Division of Food Systems and Bioengineering, College of Agriculture, Food and Natural Resources
Introduction

This handbook has been prepared to help you plan your program in bioengineering at MU and is intended to guide you through the curriculum, to describe various opportunities and options, and to relay important policies and procedures. You may also find the following links useful:

GENERAL
✓ Academic Departments at MU
   https://missouri.edu/divisions-departments/
✓ College of Engineering
   https://engineering.missouri.edu/
✓ College of Agriculture, Food & Natural Resources
   https://cafnr.missouri.edu/
✓ Department of Bioengineering
   https://bioengineering.missouri.edu/

STUDENT SUPPORT
✓ Student Rights & Responsibilities
   https://osrr.missouri.edu/
✓ Disability Center
   http://disabilitycenter.missouri.edu/
✓ Division of Inclusion, Diversity & Equity
   https://diversity.missouri.edu/
✓ Office for Civil Rights & Title IX
   http://civilrights.missouri.edu/

ACADEMICS
✓ Office of the University Registrar
   http://registrar.missouri.edu/
✓ Academic Policies, Procedures & Forms (academic regulations)
   http://registrar.missouri.edu/policies-procedures/
✓ General Course Catalog (curriculum and course information)
   http://catalog.missouri.edu/courseofferings/
✓ Course Equivalency Guide
   https://admissions.missouri.edu/apply-transfers/credits-transfers/
✓ Schedule of Classes / Course Registration
   https://myzou.missouri.edu/
✓ Academic Calendar
   http://registrar.missouri.edu/academic-calendar/
✓ Academic Information Technologies
   https://doit.missouri.edu/
✓ Pre-Medicine Information
   https://premed.missouri.edu/
✓ Pre-Law Information
   http://law.missouri.edu/prospective/faq/
✓ Financial Aid / Scholarship / Fellowship Information
   http://financialaid.missouri.edu/
   http://engineering.missouri.edu/scholarships/
   http://www.fastweb.com
http://federalstudentaid.ed.gov
http://www.finaid.org
✓ Student Organizations
  https://getinvolved.missouri.edu/find-an-org/
✓ Tuition and Fees
  https://admissions.missouri.edu/costs/
✓ Writing Center
  https://writingcenter.missouri.edu/
Part 1: General Information
1. The Profession of Bioengineering

Bioengineering is an exciting and diverse profession with a tremendous range of occupations and opportunities; our general technical background, combined with deep understanding of chemistry and biology enables our graduates to work effectively in and to adapt quickly to many different fields.

The bioengineer is an expert at combining engineering expertise and knowledge of biochemical systems to address key challenges in health and the environment, sustainability, and processing. Our teaching and research programs reflect these challenges through our five technical expertise areas: biomedical engineering, bioprocess engineering, bioenvironmental engineering, biomaterials engineering, and pre-medicine. The department has a biological engineering B.S. program accredited by the Accreditation Board for Engineering and Technology, and graduate programs offering both M.S. and Ph.D. degrees in biological engineering. Moreover, our department is in the process of having a second degree in biomedical engineering approved by the Board of Curators. While we do not currently offer this degree program, this handbook covers the BSBME potential degree as well. Our department also offers an accelerated, 5-year B.S. / M.S. program (otherwise known as the Integrated Masters Program).

Our biomedical research focuses on disease detection and treatment, and involves research in biosensing, biophotonics and bioimaging, biomechanics, biomaterials, and bioinformatics. Our research in bioprocess engineering emphasizes bioresource use, including biological material-based products, food engineering, and food safety. Lastly, our research in the bioenvironmental area emphasizes water quality issues, including wastewater treatment, bioremediation, precision agriculture, and nonpoint source pollution.

Our bioengineers are employed in a wide variety of industries and companies that span manufacturing, law, management, sales, medicine, regulatory agencies, hospitals, research facilities of companies, governments, and academic / medical institutions, consulting firms, etc. We encourage our students to explore the full range of job opportunities available to them; a degree in biological engineering from the Department of Bioengineering at the University of Missouri is merely the beginning of a lifetime of solving problems that matter (and getting paid to do it).

2. Bioengineering Program History

The Department of Bioengineering (BE) and its biological engineering degree program was developed by building on the strengths and infrastructure of the agricultural engineering (AE) degree program, which was offered at MU for nearly 90 years and was continuously accredited by ABET or its antecedent (ECPD) for most of its history.

The biological engineering degree program was officially approved by the University of Missouri and by the State of Missouri in 1996. From the early 1970s, the AE degree program gradually became more and more biologically-oriented. Over a period, seven faculty members (including one biologist) with substantial biological background joined the department and brought expertise in bioprocess engineering and bioenvironmental engineering. In the early 1990s, the AE faculty began to work towards a biological engineering degree program. After the official approval of the new program in 1996, the first biological engineering degree freshman class entered the program in the Fall of 1997 and the AE program was gradually phased out. The first biological engineering major (a transfer student) completed her degree in December 1997.
In 2016, the department submitted a proposal for the new Bachelor of Science degree in Biomedical Engineering, which we hope to offer to students as soon as approved.

Currently, the undergraduate program leads to a Bachelor of Science degree in Biological Engineering (BSBE). There are no university-approved emphasis areas, however, the broad-based curriculum allows students to pursue technical expertise in:

- Biomedical engineering,
- Bioprocess engineering,
- Bioenvironmental engineering,
- Biomaterials engineering,
- Pre-medicine.

We developed the BSBE program based on the philosophy that there is a common set of bioengineering principles that can be applied across the many different technical expertise areas. The curriculum is thus structured with a set of core required courses plus technical electives in each of the options. The availability of these options and the flexibility to allow changes have been very well-received by students.

BE is a strong research department. The funded research, faculty entrepreneurship, together with support from the College of Engineering (CoE), School of Medicine, and the College of Agriculture, Food and Natural Resources (CAFNR), have provided undergraduate students opportunities for research and creativity. Typically, one third to one half of our students participate in research. These creative activities greatly broaden their educational experiences at MU.

3. Bioengineering Facilities

The Agricultural Engineering Building (AEB) houses classrooms, computer laboratories, research and teaching laboratories, and departmental and staff offices. Due to BE's unique placement within both CAFNR and CoE, BE occupies space within traditionally CAFNR buildings, and close to the School of Medicine and School of Veterinary Medicine.

3.1. Department Administration
The department office and the office of the Department Chair are located in 215 AEB. The department office telephone number is 573.882.2369.

3.2. Bioengineering Student Study Spaces
You have a place to study in the student lounge areas of AEB: outside AEB 105, in the M.M. Jones Lounge, and in the 2nd floor atrium above the lobby, the J.C. Wooley Gallery.

3.3. Computer Labs and Work Spaces
In addition to the computing facilities in Lafferre Hall, BE has its own facilities in 106 AEB; this room is reserved for classes several hours during the week. The available computer laboratories on campus may be found at: https://doit.missouri.edu/services/computer-lab/. Additionally, campus offers software remotely through SoftwareAnywhere: https://doit.missouri.edu/services/software/software-anywhere/. 
4. Release of Student Information

The department routinely receives requests from graduate, medical, and professional schools to provide names of potential candidates to aid them in their recruitment. We will provide such lists using directory information, unless you request that we not include you in such releases. We do not release individual GPA information unless the student has authorized the organization to request it. You may request exclusion by setting your information release preferences in myZou.

5. Advising

http://engineering.missouri.edu/advising/

Academic advising is an intentional, collaborative relationship based on trust and mutual respect. This relationship promotes the student’s development of competence, autonomy, and sound decision-making skills. The goal of academic advising is an individualized, academic experience for each student developed through a mentoring relationship.

The primary point of contact for most advising questions will be your academic adviser. The academic advising staff will help you with the class registration process; Degree Audit corrections; answering questions about MU, the College of Engineering, and departmental policies and procedures; handling class scheduling difficulties, and guiding you to campus resources. See the Academic Calendar for registration advising dates. In addition to our advising team, you should visit with your Director of Undergraduate Studies to discuss academic progress and goals, select electives that support your plan of study, generate career goals, learn more about the profession of bioengineering, gain assistance in applying to graduate school, and for any other issue that requires faculty expertise.

To help the advising team understand your goals at MU, and to ensure that you are fulfilling all graduation requirements, you are expected to complete your Plan of Study (POS) for a more intentional college experience. This should be done prior to meeting with your academic adviser to discuss your upper level elective plans. Degree Audits (DA) show your progress toward completing degree requirements and are available in myZou at any time to you or your academic adviser.

See the Director of Undergraduate Studies for:  
Information about the profession  
Career and profession questions  
Discussing independent study projects  
Obtaining a recommendation letter  
Learning about graduate school

See the advising team for:  
Registering for courses  
Adding or dropping a course  
Information about degree requirements  
Resolving course scheduling problems  
Guidance to campus resources  
Developing an elective package  
Providing copies of forms and publications  
Working on a plan of study  
Registering a co-op or internship

6. Academic Integrity

It is imperative that society be able to rely upon the integrity of the members of our profession. At the university, faculty members expect you to follow high ethical standards in your academic work. Rules and procedures regarding actions that constitute academic dishonesty are clearly stated by the Office of Student Rights & Responsibilities (https://osrr.missouri.edu/academicintegrity/).
These apply to all students. In addition, the bioengineering faculty have adopted the following policy statement, which applies in bioengineering courses.

Faculty members expect that work submitted in your name be entirely your own work. You should not copy assignments, exams, quizzes, computer programs, etc. from others or allow copying of your work, including work from prior classes. It is usually permissible to discuss homework assignments with other students, unless your instructor specifies to the contrary, as long as your collaborators are stated on your homework. For examinations and quizzes, a stricter standard is imposed. For exams and quizzes the presumption, unless otherwise stated, is no discussion, no use of notes, no use of books or journals, and no use of work of others. If in a particular instance the instructor wishes to modify any part of the department policy, you will be so informed in writing.

7. Engineering Code of Ethics

Engineering is an important and learned profession. As members of this profession, engineers are expected to exhibit the highest standards of honesty and integrity. Engineering has a direct and vital impact on the quality of life for all people. Accordingly, the services provided by engineers require honesty, impartiality, fairness, and equity, and must be dedicated to the protection of the public health, safety, and welfare. Engineers must perform under a standard of professional behavior that requires adherence to the highest principles of ethical conduct.

Engineers, in the fulfillment of their professional duties, shall:
- Hold paramount the safety, health, and welfare of the public.
- Perform services only in areas of their competence.
- Issue public statements only in an objective and truthful manner.
- Act for each employer or client as faithful agents or trustees.
- Avoid deceptive acts.
- Conduct themselves honorably, responsibly, ethically, and lawfully so as to enhance the honor, reputation, and usefulness of the profession.

(From the National Society of Professional Engineers)

Please note that bioengineering, as a field, encompasses many professional societies, each of which has its own code of ethics that members must uphold to retain membership.
Part 2: Curriculum and Requirements
1. Objectives and Outcomes of the Program

Our department mission is to educate biological engineers to integrate engineering and biological sciences in the contexts of health, sustainability and environmental stewardship, thus preparing them for productive careers characterized by continual professional growth.

1.1. Program Educational Objectives
The undergraduate program leads to a Bachelor of Science degree in Biological Engineering, producing graduates who will, within 3-5 years:
1) Show proficiency in quantitative analysis, engineering design and development.
2) Interact effectively with life science and other professionals.
3) Leverage principles of biological and engineering sciences for the design and development of innovative systems.
4) Demonstrate leadership and professionalism as they continually add value to their chosen field of endeavor.
5) Succeed in advanced study in engineering, medicine or other fields, if pursued.

1.2. Program Student Outcomes
The bioengineering program should produce graduates that have:
a. an ability to apply knowledge of mathematics, science and engineering;
b. an ability to design and conduct experiments, as well as to analyze and interpret data,
c. an ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability;
d. an ability to function on multi-disciplinary teams;
e. an ability to identify, formulate and solve engineering problems;
f. an understanding of professional and ethical responsibility;
g. an ability to communicate effectively;
h. the broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context;
i. a recognition of the need for, and an ability to engage in, life-long learning;
j. a knowledge of contemporary issues;
k. an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice; and
l. an ability to integrate engineering and biological sciences to develop systems and processes for improved health, bio-resource utilization, and environmental protection.

1.3. Curriculum Alignment with Program Educational Objectives
To show proficiency in engineering analysis, design and development (Objective 1), the curriculum requires 49 credit hours of engineering courses on top of a strong foundation in math, physics, chemistry and biological sciences. The fundamental engineering courses give student skills to analyze a system from a thermodynamic, mechanical, transport, electrical, or biochemical perspective. Lab exercises in science and engineering courses are designed to enhance these skills by connecting the theories with the real world. Major design experiences are provided in both BE 4980 Biological Engineering Design and BE 4380 Applied Electronic Instrumentation, where students carry out design projects under various constraints.
To ensure that graduates can interact effectively with life science and other professionals (Objective 2), 47 credit hours of basic sciences are required. This course work includes physics, general chemistry, organic chemistry, basic biological sciences and a selection of more advanced biological and related sciences. The general education and writing-intensive course requirements are designed to improve graduates’ communication skills and abilities to interact with other professionals.

To leverage principles of biological and engineering sciences for the design and development of innovative systems (Objective 3), the curriculum has the following two important features. First, in addition to a strong physical science background, 11 credit hours (or more) of biological and related sciences are required to give students a strong base in biosciences. Second, most BE courses are designed with integration of biological and engineering sciences as a goal. In particular, this is a major objective for a number of the required BE courses including BE 2180, 3180, 4380, 4980, and quite a number of elective BE courses.

For graduates to demonstrate leadership and professionalism as they continually add value to their chosen field of endeavor (Objective 4), course work and co-curricular activities are designed to help students carry these qualities to their jobs and careers. In BE 2000 Professional Development in Engineering, about one-third of the semester is dedicated to professionalism and ethics to provide a base for other course work and experience. The breadth of our curriculum and the general education requirements give graduates not only a broad education to understand the impact of engineering solutions but also the ability for continual learning. Professionalism and engineering ethics are included in other courses such as BE 3170 Biomaterials. We strongly encourage and help students to become active in the large and growing numbers of student professional organizations. We also provide support for students to interact with professionals from industry and other professions through student-organized activities.

The breadth and depth of the BE curriculum give graduates an edge to succeed in advanced studies in engineering, medicine or other fields (Objective 5). Besides graduate study opportunities in biological and other engineering disciplines, the curriculum is designed with built-in flexibilities in the sciences to satisfy pre-med and pre-vet requirements. We work with the Honors College to advise pre-med students with a pre-med version of the study plan that is available for them. Ample research opportunities allow students to gain an understanding of research and graduate school during their undergraduate years. One-third to one-half of the graduating BE seniors have participated in undergraduate research mentored by bioengineering faculty.
2. Basic Program Requirements

2.1. Admission Requirements
http://engineering.missouri.edu/prospective-students/admission-requirements/

Incoming freshmen must have an ACT MATH score of at least 26, AND an ACT composite score of at least 26 or a class rank in the upper 25 percent. Once admitted to the College of Engineering, students will work to complete a foundational curriculum consisting of math, science, and engineering courses during their first year at MU, known as the Freshman Engineering Program. At least 12 hours of stipulated classes must be completed at MU, and upon completion of requirements, students will be evaluated for admittance into available degree programs. For Bioengineering, this includes the following classes:

- MATH 1500
- MATH 1700
- CHEM 1320
- PHYS 2750
- BIOSCI 1500 (recommended)

High achieving students may receive direct admission (criteria below) into the Engineering Achievement Program (EAP). These students may be eligible for special engineering scholarships and opportunities to interact with college administrators. They will receive invitations to network with faculty who participate in the Undergraduate Research Program, which allows students to work on cutting-edge research projects and offers the potential to fast track an engineering master’s program. Achievement program students also may qualify for acceptance into the MU Honors College, and if all criteria are met upon graduation, they will receive an honors designation and may participate in the honors convocation ceremony. The Honors College option is open to all qualifying freshmen.

Incoming freshmen lacking the qualifying criteria may transfer from the College of Arts and Sciences through the pre-engineering program (http://engineering.missouri.edu/prospective-students/pre-engineering/).

2.2. Graduation Requirements

The current requirements for the Bachelor of Science in Biological Engineering (BSBE) are met when a student completes 126 semester credit hours that (a) meet the University of Missouri's general education requirements (21 credits); (b) exceed the ABET-EAC mathematics and science requirements (48 credits); (c) exceed the ABET-EAC engineering topics requirements (52 credits); and (d) includes Engineering Design Graphics, Professional Development in Engineering, and Programming for Engineers (7 credits).

All students are closely monitored during the course of their study in the BE program. The Undergraduate Director, Academic Adviser, and a BE faculty member assigned to the Academic Appeals work together to review probation notifications, dismissal or suspension notifications, and other academic actions before being filed.

The Academic Adviser and Undergraduate Director review all courses taken to make sure requirements are met and approves the graduation checklist. Upon completion of a student’s final semester, the Academic Adviser and Undergraduate Director reassess the student’s academic...
history. When all requirements of courses and grades have been met, the student is approved for receiving the BSBE degree.

2.3. Core Course Grade Requirement
The College of Engineering requires that each student must have a minimum average GPA of 2.0 in all engineering courses, in addition to a minimum grade of C in a group of core courses designated by the department to meet graduation requirements. The bioengineering faculty have designated the following courses as core courses for this requirement:
BIOL_EN 2000, 2080, 2180, 3180, 4380, 4980

2.4. General Education Requirements (21 credit hours)
https://generaleducation.missouri.edu/requirements/
Both the University of Missouri and industry want our graduates to be well-rounded professionals who can interact with their coworkers, business clients, and society. Behavioral and Social Science (BS/SS) electives, as well as Humanities and / or Fine Arts (H/FA) electives are an important part of your bioengineering degree program. These courses can help you develop or expand skills necessary to achieve success within both industry and society. The MU General Education requirements are met within the BSBE degree program with the following 21 credit hours:
1. ENGLSH 1000 – English Exposition (3)
2. Writing Intensive Courses – (0)
Two courses that meet the campus designation for Writing Intensive requirements (no additional credit required), one with a 3000-level or higher in your major
3. Behavioral Studies and Social Science Courses – (9), including two required courses:
Required: An economics course
<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>ECONOM 1014</td>
<td>Principles of Microeconomics</td>
<td>3</td>
</tr>
<tr>
<td>ECONOM 1015**</td>
<td>Principles of Macroeconomics</td>
<td>3</td>
</tr>
<tr>
<td>ECONOM 1024</td>
<td>Fundamentals of Microeconomics</td>
<td>3</td>
</tr>
<tr>
<td>ECONOM 1051</td>
<td>General Economics</td>
<td>5</td>
</tr>
<tr>
<td>AG_EC 1041</td>
<td>Applied Microeconomics</td>
<td>3</td>
</tr>
<tr>
<td>AG_EC 1042*</td>
<td>Applied Macroeconomics</td>
<td>3</td>
</tr>
<tr>
<td>IMSE 2710***</td>
<td>Engineering Economic Analysis</td>
<td>3</td>
</tr>
</tbody>
</table>

*Note that these courses will not count towards a business minor
**Note that this requires ECONOM 1014 as a pre-requisite
***This course can fulfill either the economics requirement or a technical elective, but not both

Required: American history or American government course
<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>HIST 1100</td>
<td>Survey of American History to 1865</td>
<td>3</td>
</tr>
<tr>
<td>HIST 1200</td>
<td>Survey of American History Since 1865</td>
<td>3</td>
</tr>
<tr>
<td>HIST 1400</td>
<td>American History</td>
<td>3</td>
</tr>
<tr>
<td>HIST 2210</td>
<td>Twentieth Century America</td>
<td>5</td>
</tr>
<tr>
<td>HIST 2440</td>
<td>History of Missouri</td>
<td>3</td>
</tr>
<tr>
<td>HIST 4000</td>
<td>Age of Jefferson</td>
<td>3</td>
</tr>
<tr>
<td>HIST 4220</td>
<td>U.S. Society Between the Wars 1918-1945</td>
<td>3</td>
</tr>
<tr>
<td>HIST 4230</td>
<td>Our Times: United States Since 1945</td>
<td>3</td>
</tr>
<tr>
<td>POL_SC 1100</td>
<td>American Government</td>
<td>3</td>
</tr>
<tr>
<td>POL_SC 2100</td>
<td>State Government</td>
<td>3</td>
</tr>
</tbody>
</table>

4. Humanities and/or Fine Arts – (9)
This must include courses in at least two departments. A foreign language can meet the
requirement if three courses (12 or more credit hours) are taken.
Suggested courses include:

COMMUN 1200  Public Speaking  3
PHIL 1150  Introduction to Bioethics  3
PHIL 2400  Ethics and the Professions  3
PHIL 2440  Medical Ethics  3

5. Note that one of the BS/SS or H/FA courses must be a 2000 level or higher.

2.5. Mathematics & Statistics Requirements (19 credit hours)
1. MATH 1500 – Calculus I (5)
2. MATH 1700 – Calculus II (5)
3. MATH 2300 – Calculus III (3)
4. STATISTICS – from approved list (3):
   - STAT 4710* Introduction to Mathematical Statistics  3
   - IMSE 2110 Probability & Statistics for Engineers  3
   - BIOL_EN 4270 SQC & DOE for Engineers  3
   *Note: If this class is completed, you will only need one additional mathematics class from the approved list to complete a minor in Mathematics

   https://www.math.missouri.edu/undergrad/minor

5. MATH 4100 – Differential Equations (3)

2.6. Basic Science Requirements (28 credit hours)
1. PHYSCS 2750 – University Physics I (5)
2. PHYSCS 2760 – University Physics II (5)
3. CHEM 1320 – General Chemistry I (3)
4. CHEM 2100 – Organic Chemistry I (3)
5. BIO_SC 1500 – Introduction to Biological Systems (5)
6. Biological Science Electives - from approved list (6 – 8):
   - AN_SCI 3254 Physiology of Domestic Animals  5
   - BIO_SC 2200 General Genetics  4
   - BIO_SC 2300 Cell Biology  4
   - BIO_SC 3700 Animal Physiology  5
   - BIO_SC 4976 Molecular Biology  3
   - BIO_SC 4990 Vertebrate Histology and Microscopic Anatomy  5
   - BIOCHM 3630 General Biochemistry  3
   - BIOCHM 4270 Biochemistry  3
   - BIOL_EN 4001 Physiology for Engineers  3
   - DMU 4200 Principles of Diagnostic Medical Ultrasound  3
   - F_S 2172 Elements of Food Microbiology  3
   - F_S 4310 Food Chemistry and Analysis  4
   - F_S 4370 Food Microbiology  3
   - MPP 3202 Elements of Physiology (Human)  5
   - NUCMED 4327 Nuclear Medicine Instrumentation  3
   - PHYSCS 4110 Light and Modern Optics  4
   - PHYSCS 4310 Physics in Cell and Developmental Biology  3
   - PLNT_S 2110 Plant Growth and Culture  3
   - PLNT_S 3213 Genetics of Agricultural Plants and Animals  3
   - PLNT_S 4313 Soil Fertility and Plant Nutrition  3
2.7. Basic Engineering Requirements (14 credit hours)
1. ENGINR 1100 – Engineering Design Graphics (2)
2. ENGINR 1200 – Statics (3)
3. ENGINR 2200 – Strength of Materials (3)
4. Fluid Mechanics – from approved list (3)
   CV_ENG 3700  Fluid Mechanics 5
   MAE 3400  Fluid Mechanics 3
   BIOL_EN 3070  Biological Fluid Mechanics 3
5. Thermodynamics – from approved list (3)
   ENGINR 2300  Engineering Thermodynamics 3
   CH_ENG 3261  Chemical Engineering Thermodynamics I 3

2.8. Bioengineering Core Requirements (18 credit hours)
1. BIOL_EN 2000 – Professional Development in Engineering (2)
2. BIOL_EN 2080 – Introduction to Programming for Engineers (3)
3. BIOL_EN 2180 – Engineering Analysis of Bioprocesses (3)
5. BIOL_EN 4380 – Applied Electronic Instrumentation (4)
6. BIOL_EN 4980 – Biological Engineering Design (3)

2.9. Engineering Technical Elective Courses (24 credit hours)
These courses must include:
• all upper-level engineering courses
• 12 credit hours in a technical emphasis recommended
• 15 credit hours in courses approved by the BE faculty
These courses may include:
• 9 credit hours total can be independent studies: up to 6 credit hours in faculty- mentored undergraduate research, 3 credit hours of problems, and/or 3 credit hours of engineering internship

2.9.1 Bioenvironmental Technical Emphasis Area
1. BIOL_EN 4150 – Soil and Water Conservation Engineering
2. BIOL_EN 4250 – Irrigation and Drainage Engineering
3. BIOL_EN 4350 – Watershed Modeling Using GIS
4. CH_ENG 4285 – Pollution Prevention (online)
5. CH_ENG 4312 – Air Pollution Control
6. CV_ENG 3050 – Introduction to Geographic Information Systems GIS
7. CV_ENG 3200 – Fundamentals of Environmental Engineering (4)
8. CV_ENG 3400 – Fundamentals of Geotechnical Engineering (4)
9. CV_ENG 3702 – Hydrology
10. CV_ENG 4230 – Introduction to Water Quality
11. CV_ENG 4240 – Water Quality Analysis
12. CV_ENG 4250 – Environmental Regulatory Compliance
13. GEOG 4940 – Advanced Geographic Information Systems (GIS2)
14. IMSE 4001 – Life Cycle Analysis

2.9.2. Bioprocessing Technical Emphasis Area
1. BIOL_EN 3075 – Introduction to Materials Engineering (hybrid-in class/online)
2. BIOL_EN 3170 – Biomaterials
3. BIOL_EN 4001 – Biomanufacturing Technologies
4. BIOL_EN 4310 – Feedback Control Systems
5. BIOL_EN 4480 – Physics and Chemistry of Materials
6. BIOL_EN / CH_ENG 4315 – Principles of Biochemical Engineering
7. BIOL_EN / CH_ENG 4316 – Biomass Refinery Operations
8. CH_ENG 3235 – Principles of Chemical Engineering II
9. CH_ENG 4319 – Introduction Polymer Materials
10. CH_ENG 3262 – Chemical Engineering Thermodynamics II
11. CH_ENG 4363 – Chemical Reaction Engineering and Technology
12. IMSE 4001 – Life Cycle Analysis

2.9.3. Biomedical Engineering Technical Emphasis Area
1. BIOL_EN 3075 – Introduction to Materials Engineering (hybrid-in class/online)
2. BIOL_EN 3170 – Biomaterials
3. BIOL_EN 4070 – Bioelectricity
4. BIOL_EN 4001 – Biomanufacturing Technologies
5. BIOL_EN 4001-4 – Brain Signals and Brain Machine Interfaces
6. BIOL_EN 4001-5 – Nuclear Magnetic Resonance and Magnetic Resonance Imaging
7. BIOL_EN 4170 – Biomaterials Interfaces for Implantable Devices
8. BIOL_EN /ChE4315 – Principles of Biochemical Engineering
9. BIOL_EN 4310 – Feedback Control Systems
10. BIOL_EN 4370 – Orthopaedic Biomechanics
11. BIOL_EN 4420 – Introduction to Biomedical Imaging (Summer online)
12. BIOL_EN 4470 – Biomolecular Engineering & Nanobiotechnology
13. BIOL_EN 4480 – Physics and Chemistry of Materials
14. BIOL_EN 4570 – Fluorescent Imaging
15. BIOL_EN 4590 – Computational Neuroscience (4)
16. BIOL_EN 4770 – Biomedical Optics
2.10. Bioengineering Course Offerings

Table 1. Course Offerings within the Department of Bioengineering.

<table>
<thead>
<tr>
<th>Course (Department, Number, Title)</th>
<th>Course Type</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>BIOL_EN 3070 - Biological Fluid Mechanics</td>
<td>SE</td>
<td>3</td>
</tr>
<tr>
<td>BIOL_EN 3075 - Introduction to Materials Engineering</td>
<td>SE</td>
<td>3</td>
</tr>
<tr>
<td>BIOL_EN 3170 – Biomaterials</td>
<td>SE</td>
<td>3</td>
</tr>
<tr>
<td>BIOL_EN 4001 – Physiology for Engineering</td>
<td>SE</td>
<td>3</td>
</tr>
<tr>
<td>BIOL_EN 4070 - Bioelectricity (CL)</td>
<td>SE</td>
<td>3</td>
</tr>
<tr>
<td>BIOL_EN 4085 - Problems in Biological Engineering</td>
<td>SE</td>
<td>1-5</td>
</tr>
<tr>
<td>BIOL_EN 4150 - Soil and Water Conservation Engineering (CL, CLI)</td>
<td>SE</td>
<td>3</td>
</tr>
<tr>
<td>BIOL_EN 4170 - Biomaterials Interfaces of Implantable Devices (CL)</td>
<td>SE</td>
<td>3</td>
</tr>
<tr>
<td>BIOL_EN 4250 - Irrigation and Drainage Engineering (CL)</td>
<td>SE</td>
<td>3</td>
</tr>
<tr>
<td>BIOL_EN 4270 - Design of Experiments and Statistical Quality Control for Process Engineers (CL)</td>
<td>SE</td>
<td>3</td>
</tr>
<tr>
<td>BIOL_EN 4310 - Feedback Control</td>
<td>SE</td>
<td>3</td>
</tr>
<tr>
<td>BIOL_EN 4315 – Principles of Biochemical Engineering (CL, CLI)</td>
<td>SE</td>
<td>3</td>
</tr>
<tr>
<td>BIOL_EN 4316 - Introduction to Biomass Refinery Operation (CL, CLI)</td>
<td>SE</td>
<td>3</td>
</tr>
<tr>
<td>BIOL_EN 4350 - Watershed Modeling Using GIS (CL, CLI)</td>
<td>SE</td>
<td>3</td>
</tr>
<tr>
<td>BIOL_EN 4370 - Orthopaedic Biomechanics (CL)</td>
<td>SE</td>
<td>3</td>
</tr>
<tr>
<td>BIOL_EN 4420 - Introduction to Biomedical Imaging (CLI)</td>
<td>SE</td>
<td>3</td>
</tr>
<tr>
<td>BIOL_EN 4470 - Biomolecular Engineering and Nanobiotechnology (CL)</td>
<td>SE</td>
<td>3</td>
</tr>
<tr>
<td>BIOL_EN 4480 - Physics and Chemistry of Materials (CL, CLI)</td>
<td>SE</td>
<td>3</td>
</tr>
<tr>
<td>BIOL_EN 4570 - Fluorescent Imaging (CL)</td>
<td>SE</td>
<td>3</td>
</tr>
<tr>
<td>BIOL_EN 4590 - Computational Neuroscience (CL)(CLI)</td>
<td>SE</td>
<td>4</td>
</tr>
<tr>
<td>BIOL_EN 4770 - Biomedical Optics (CL)</td>
<td>SE</td>
<td>3</td>
</tr>
<tr>
<td>BIOL_EN 4940 – Engineering Internship</td>
<td>SE</td>
<td>1-3</td>
</tr>
<tr>
<td>BIOL_EN 4990 - Undergraduate Research in Biological Engineering</td>
<td>SE</td>
<td>1-5</td>
</tr>
<tr>
<td>BIOL_EN 4995 - Undergraduate Honors Research in Biological Engineering</td>
<td>SE</td>
<td>2-4</td>
</tr>
</tbody>
</table>

Note that: CL = Cross-Level Course; courses at 4000-7000 levels combined. CLI = Cross-Listed Course; courses listed with one or more other MU departments. Required (R) Elective (E) Selected Elective (SE)

Table 2. Co-requisite and pre-requisite requirements for courses required or recommended for graduation. Bolded courses must be passed with a C grade or higher to fulfill requirements.

<table>
<thead>
<tr>
<th>Course</th>
<th>CO/PRErequisite Course:</th>
</tr>
</thead>
<tbody>
<tr>
<td>BIOL_EN 2000 – Professional Development in Engineering</td>
<td>PRE: Sophomore standing</td>
</tr>
<tr>
<td>BIOL_EN 2080 – Introduction to Programming for Engineers</td>
<td>PRE: MATH 1500</td>
</tr>
<tr>
<td>BIOL_EN 2180 – Engineering Analysis of Bioprocesses</td>
<td>PRE: MATH 1700, CHEM 1320, PHYSCS 2750</td>
</tr>
<tr>
<td>BIOL_EN 3070 – Biological Fluid Mechanics</td>
<td>PRE: MATH 1700, PHYSCS 2750</td>
</tr>
<tr>
<td>Course Number</td>
<td>Course Title</td>
</tr>
<tr>
<td>---------------</td>
<td>--------------</td>
</tr>
<tr>
<td>BIOL_EN 3075</td>
<td>Introduction to Materials Engineering</td>
</tr>
<tr>
<td>BIOL_EN 3170</td>
<td>(WI optional) – Biomaterials</td>
</tr>
<tr>
<td>BIOL_EN 3180</td>
<td>– Heat and Mass Transfer in Biological Systems</td>
</tr>
<tr>
<td>BIOL_EN 4001-2</td>
<td>– Physiology for Engineers</td>
</tr>
<tr>
<td>BIOL_EN 4001-4</td>
<td>– Brain Signals</td>
</tr>
<tr>
<td>BIOL_EN 4001-5</td>
<td>– Nuclear Magnetic Resonance</td>
</tr>
<tr>
<td>BIOL_EN 4001-1</td>
<td>– Environmental Statistics</td>
</tr>
<tr>
<td>BIOL_EN 4070</td>
<td>– Bioelectricity (CL)</td>
</tr>
<tr>
<td>BIOL_EN 4085</td>
<td>– Problems in Biological Engineering</td>
</tr>
<tr>
<td>BIOL_EN 4150</td>
<td>– Soil and Water Conservation Engineering (CL, CLI)</td>
</tr>
<tr>
<td>BIOL_EN 4170</td>
<td>– Biomaterials Interfaces of Implantable Devices (CL)</td>
</tr>
<tr>
<td>BIOL_EN 4231</td>
<td>– Transport Phenomena in Materials Processes (CL, CLI)</td>
</tr>
<tr>
<td>BIOL_EN 4250</td>
<td>– Irrigation and Drainage Engineering (CL)</td>
</tr>
<tr>
<td>BIOL_EN 4270</td>
<td>– SQC and DOE* (CLI)</td>
</tr>
<tr>
<td>BIOL_EN 4310</td>
<td>- Feedback Control Systems</td>
</tr>
<tr>
<td>BIOL_EN 4315</td>
<td>– Principles of Biochemical Engineering (CL, CLI)</td>
</tr>
<tr>
<td>BIOL_EN 4316</td>
<td>– Biomass Refinery Operations (CL, CLI)</td>
</tr>
<tr>
<td>BIOL_EN 4350</td>
<td>– Watershed Modeling Using GIS (CL, CLI)</td>
</tr>
<tr>
<td>BIOL_EN 4370</td>
<td>– Orthopaedic Biomechanics (CL)</td>
</tr>
<tr>
<td>BIOL_EN 4380</td>
<td>– Applied Electronic Instrumentation (CLI)</td>
</tr>
<tr>
<td>BIOL_EN 4420</td>
<td>- Introduction to Biomedical Imaging (CLI)</td>
</tr>
<tr>
<td>BIOL_EN 4470</td>
<td>– Biomolecular Engineering and Nanobiotechnology (CL)</td>
</tr>
<tr>
<td>BIOL_EN 4480</td>
<td>– Physics and Chemistry of Materials (CL, CLI)</td>
</tr>
<tr>
<td>BIOL_EN 4570</td>
<td>– Fluorescent Imaging (CL)</td>
</tr>
<tr>
<td>Course Code</td>
<td>Course Title</td>
</tr>
<tr>
<td>------------</td>
<td>--------------------------------------------------</td>
</tr>
<tr>
<td>BIOL_EN 4575 – Computational Neuroscience (CL, CLI)</td>
<td>PRE: MATH 1500 or equivalent and junior standing</td>
</tr>
<tr>
<td>BIOL EN 4770 – Biomedical Optics (CL)</td>
<td>PRE: PHYSCS 2760 or instructor’s consent</td>
</tr>
<tr>
<td>BIOL_EN 4940: Engineering Internship</td>
<td>PRE: adviser's consent</td>
</tr>
<tr>
<td>BIOL_EN 4980 – Biological Engineering Design [CAPSTONE]</td>
<td>PRE: ENGLSH 1000, senior standing or instructor’s consent</td>
</tr>
<tr>
<td>BIOL_EN 4990 – Undergraduate Research in BE</td>
<td>PRE: instructor’s consent</td>
</tr>
<tr>
<td>BIOL_EN 4995 – Undergraduate Honors Research in BE</td>
<td>PRE: adviser’s consent</td>
</tr>
<tr>
<td>BIO_SC 1500 – Introduction to Biological Systems with Lab</td>
<td>PRE: MATH 1100 and high school chemistry</td>
</tr>
<tr>
<td>BIO_SC 2200 - General Genetics</td>
<td>PRE: BIO_SC 1500, CHEM 1320</td>
</tr>
<tr>
<td>BIO_SC 2300 - Introduction to Cell Biology</td>
<td>PRE: BIO_SC 2200, CHEM 2100</td>
</tr>
<tr>
<td>CHEM 1320 – General Chemistry I with Lab</td>
<td>PRE: AP/grade of C- or better in CHEM 1310, MATH 1100/1120 or equivalent</td>
</tr>
<tr>
<td>CHEM 2100 – Organic Chemistry I</td>
<td>PRE: CHEM 1320</td>
</tr>
<tr>
<td>COMMUN 1200 - Public Speaking</td>
<td></td>
</tr>
<tr>
<td>ECONOM 1014 - Principles of Microeconomics</td>
<td></td>
</tr>
<tr>
<td>ECONOM 1015 - Principles of Macroeconomics</td>
<td>PRE: ECONOM 1014 or ECONOM 1024</td>
</tr>
<tr>
<td>ENGINR 1000 - Introduction to Engineering (for engineering Undeclared Students )</td>
<td></td>
</tr>
<tr>
<td>ENGINR 1100 – Engineering Graphics Fundamentals</td>
<td></td>
</tr>
<tr>
<td>ENGINR 1200 – Statics and Elementary Strength of Materials</td>
<td>PRE: MATH 1500; CO: PHYSCS 2750</td>
</tr>
<tr>
<td>ENGINR 2200 – Intermediate Strength of Materials</td>
<td>PRE: ENGINR 1200</td>
</tr>
<tr>
<td>ENGINR 2300 – Engineering Thermodynamics</td>
<td>PRE: MATH 1700, PHYSCS 2750</td>
</tr>
<tr>
<td>ENGLISH 1000 - Exposition and Argumentation</td>
<td></td>
</tr>
<tr>
<td>HIST 1100 - Survey of American History to 1865</td>
<td></td>
</tr>
<tr>
<td>HIST 1200 - Survey of American History from 1865</td>
<td></td>
</tr>
<tr>
<td>MATH 1500 – Analytic Geometry and Calculus I</td>
<td>PRE: grade of C- or better in MATH 1160 or both 1100 and 1140 or sufficient ALEKS score</td>
</tr>
<tr>
<td>MATH 1700 – Calculus II</td>
<td>PRE: grade of C- or better in MATH 1500</td>
</tr>
<tr>
<td>MATH 2300 – Calculus III</td>
<td>PRE: grade of C- or better in MATH 1700</td>
</tr>
<tr>
<td>MATH 4100 – Differential Equations</td>
<td>PRE: grade of C- or better in MATH 2300</td>
</tr>
<tr>
<td>PHIL 1150 - Introduction to Bioethics</td>
<td></td>
</tr>
<tr>
<td>PHIL 2400 - Ethics and the Professions</td>
<td></td>
</tr>
<tr>
<td>PHIL 2440 - Medical Ethics</td>
<td></td>
</tr>
<tr>
<td>PHYSCS 2750 – University Physics I</td>
<td>PRE: MATH 1500; CO: MATH 1700</td>
</tr>
<tr>
<td>PHYSCS 2760 – University Physics II</td>
<td>PRE: MATH 1700 and a grade of C- or better in PHYSCS 2750; CO: MATH 2300</td>
</tr>
<tr>
<td>POL_SC 1100 - American Government</td>
<td></td>
</tr>
<tr>
<td>POL_SC 2100 - State Government</td>
<td></td>
</tr>
<tr>
<td>STAT 4710 - Introduction to Mathematical Statistics</td>
<td>PRE: grade of C- or better in MATH 2300</td>
</tr>
<tr>
<td>Fluid Mechanics – from approved list of: CV_ENG 3700 - Fluid Mechanics</td>
<td>PRE: PHYSCS 2750</td>
</tr>
<tr>
<td>MAE 3400 - Fluid Mechanics</td>
<td>PRE: PHYSCS 2750 and MAE 2600</td>
</tr>
<tr>
<td>BE 3070 - Biological Fluid Mechanics</td>
<td></td>
</tr>
</tbody>
</table>
Note that courses marked in bold must be completed with a grade of C or better.
2.11. Bioengineering Flowcharts

The general flowchart of the bioengineering curriculum, including the technical expertise areas, are shown in the figures below.

**Figure 1. Sample flowchart for a BSBE degree.** Note that each box designates which terms it is offered (F: fall, S: Spring, SS: Summer, O: online). This is a sample curriculum. Students who enter with AP or transfer credit in Calculus and Physics are encouraged to take the remaining classes in the sequence earlier, rather than later, as this greatly reduces the intensity of the course load during the student’s 3rd and 4th years.
Figure 2. Sample flowchart for a potential BSBME degree (note that the curriculum is not yet set by the faculty; this is subject to change and official approval). Note that each box designates which terms it is offered (F: fall, S: Spring, SS: Summer, O: online). This is a sample curriculum. Students who enter with AP or transfer credit in Calculus and Physics are encouraged to take the remaining classes in the sequence earlier, rather than later, as this greatly reduces the intensity of the course load during the student’s 3rd and 4th years.
Figure 3. Biomaterials Engineering Technical Expertise Area. For students interested in this area, the listed classes are recommended in the order shown.
Figure 4. Bioenvironmental Engineering Technical Expertise Area. For students interested in this area, the listed classes are recommended in the order shown.
Figure 5. Bioprocess Engineering Technical Expertise Area. For students interested in this area, the listed classes are recommended in the order shown.
Figure 6. Biomedical Engineering Technical Expertise Area. For students interested in this area, the listed classes are recommended in the order shown. Note that not all the upper level technical electives must be taken to complete the graduation requirements. However, it is important to ensure that the pre-requisite classes are completed promptly at the time shown, as many of the 4000-level classes are only offered once a year.
Figure 7. Pre-medicine Technical Expertise Area. For students interested in this area, the listed classes are recommended in the order shown. This is intended for students seeking to attend medical school. The MCATS should be taken at the end of the 6th term. We encourage students to take classes during the summer terms, particularly in freshman and sophomore year, to lighten the intensity of the course load.
### Table 3. Sample curriculum for the B.S.B.E. degree program (shown in flowchart format in Figure 1).

<table>
<thead>
<tr>
<th>Fall 1</th>
<th>Spring 1</th>
</tr>
</thead>
<tbody>
<tr>
<td>MATH 1500 Calculus I</td>
<td>5</td>
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<tr>
<td>CHEM 1320 General Chemistry I</td>
<td>4</td>
</tr>
<tr>
<td>ENGINR 1100 Engineering Design Graphics</td>
<td>2</td>
</tr>
<tr>
<td>ENGLISH 1000 Exposition</td>
<td>3</td>
</tr>
<tr>
<td>ENGINR 1000 Engineering Seminar (optional)</td>
<td>1</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Fall 2</th>
<th>Spring 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>BIOL_EN 2080 Programming for Engineers</td>
<td>3</td>
</tr>
<tr>
<td>MATH 2300 Calculus III</td>
<td>3</td>
</tr>
<tr>
<td>PHYSCS 2760 University Physics II</td>
<td>5</td>
</tr>
<tr>
<td>ENGINR 1200 Statics</td>
<td>3</td>
</tr>
<tr>
<td>CHEM 2100 Organic Chemistry I</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>17</td>
<td>17</td>
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<table>
<thead>
<tr>
<th>Fall 3</th>
<th>Spring 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>BIO_SC Elective</td>
<td>3</td>
</tr>
<tr>
<td>ENGINR 2100 Circuit Theory (recommended)</td>
<td>3</td>
</tr>
<tr>
<td>Fluid Mechanics (from approved list)</td>
<td>3</td>
</tr>
<tr>
<td>Statistics (from approved list)</td>
<td>3</td>
</tr>
<tr>
<td>H/FA Elective</td>
<td>3</td>
</tr>
<tr>
<td>15</td>
<td>16</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Fall 4</th>
<th>Spring 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>BIOL_EN 4980 Senior Design</td>
<td>3</td>
</tr>
<tr>
<td>Technical Elective</td>
<td>3</td>
</tr>
<tr>
<td>Technical Elective</td>
<td>3</td>
</tr>
<tr>
<td>H/FA Elective</td>
<td>3</td>
</tr>
<tr>
<td>BS/SS Elective (American Government or History)</td>
<td>3</td>
</tr>
<tr>
<td>15</td>
<td>15</td>
</tr>
</tbody>
</table>
2.12. Completing your Plan of Study (POS)

The purpose of planning your bioengineering degree is to allow you to determine what courses/programs/activities will help you meet your goals in a timely manner.

On the bioengineering flowchart cross off courses that you already have completed and circle the courses in which you are currently enrolled. Complete the Plan of Study (POS) form (two table formats) on the next page by following the steps below:

1. Completely fill out the heading.

2. Identify credits that can be used to meet degree requirements that were earned before entering MU (transfer, AP, test out, etc.). Label this term as “TR” for transfer.

3. List any transfer course that needed to be evaluated in the “Approved Course Substitutions” with the MU course number that it was evaluated as being “equivalent to” or as a “substitute for” under the course title.

4. In the second table, list each term appropriately (e.g., “F17” for Fall 2017; “S18” for Spring 2018; “SS18” for Summer 2018). List all courses taken that term. Do this for each term through the current term.

5. In the second table, list courses that you plan to take for future terms, checking off each course on your flowcharts as you list it on the POS form, and filling in the first table under the requirement that the course will meet with the appropriate course number, name, and term. This will help you to account for each requirement.

6. Keep in mind/make sure:
   A. Courses are available during the term that you have scheduled them (refer to the flowchart for terms offered)
   B. Credit loads for each semester are within acceptable limits (18 credits per semester, or 21 for Honors Program)
   C. All course prerequisites are satisfied
   D. All curriculum requirements for graduation are satisfied.

7. Discuss your POS with your advisor.
2.11.1. B.S. Biological Engineering Plan of Study Tables
As a reminder, here is a summary of graduation requirements:

- 126 credit hours minimum
- 56 - 57 credit hours of engineering courses
- 9 credit hours of Social and Behavioral Science, including economics AND American history or government, plus 9 credit hours of Humanities and/or Fine Arts
- Two Writing Intensive (WI) courses

Table 4. Record of Courses Taken to fulfill graduation requirements.

<table>
<thead>
<tr>
<th>SECTION</th>
<th>COURSE #</th>
<th>COURSE TITLE</th>
<th>CR</th>
<th>TERM</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Mathematics &amp; Statistics (19 cr hr)</strong></td>
<td>MATH 1500</td>
<td>Calculus I</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td></td>
<td>MATH 1700</td>
<td>Calculus II</td>
<td>5</td>
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<tr>
<td></td>
<td>MATH 2300</td>
<td>Calculus III</td>
<td>3</td>
<td></td>
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<td></td>
<td>MATH 4100</td>
<td>Differential Equations</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Statistics from approved list</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Basic Science (28 cr hr)</strong></td>
<td>PHYSCS 2750</td>
<td>University Physics I</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td></td>
<td>PHYSCS 2760</td>
<td>University Physics II</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td></td>
<td>CHEM 1320</td>
<td>General Chemistry I</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td></td>
<td>CHEM 2100</td>
<td>Organic Chemistry</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td></td>
<td>BIO_SC 1500</td>
<td>Introduction to Biological Systems</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>(B-Sc from approved list)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>**Behavioral Studies &amp; Social Sciences (9 cr hr)</td>
<td>ECONOM 1014</td>
<td>Principles of Microeconomics</td>
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</tr>
<tr>
<td></td>
<td>or</td>
<td>Principles of Macroeconomics</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>ECONOM 1015</td>
<td>(BS/SS from approved list)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>(BS/SS from approved list)</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Communications (3 cr hr)</strong></td>
<td>ENGLISH 1000</td>
<td>Exposition</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td><strong>Humanities &amp; Fine Arts (9 cr hr)</strong></td>
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<td>(HFA from approved list)</td>
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<td>(HFA from approved list)</td>
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</tbody>
</table>
One course in this category must be 2000 level or above

<table>
<thead>
<tr>
<th>Basic Engineering Courses (14 cr hr)</th>
<th>ENGINR 1100</th>
<th>Engr. Design Graphics</th>
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<tbody>
<tr>
<td></td>
<td>ENGINR 1200</td>
<td>Statics</td>
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<td></td>
<td>ENGINR 2200</td>
<td>Strength of Materials</td>
<td>3</td>
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<td></td>
<td>(Thermodynamics from approved list)</td>
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<tr>
<td></td>
<td>(Fluid Mechanics from approved list)</td>
<td>3</td>
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</tbody>
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<thead>
<tr>
<th>Biological Engineering Courses (18 cr hr)</th>
<th>BIOL_EN 2000</th>
<th>Professional Development in Engineering (Spring)</th>
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<tbody>
<tr>
<td></td>
<td>BIOL_EN 2080</td>
<td>Introduction to Programming for Engineers</td>
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<tr>
<td></td>
<td>BIOL_EN 2180</td>
<td>Engineering Analysis of Bioprocesses</td>
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<tr>
<td></td>
<td>BIOL_EN 3180</td>
<td>Heat and Mass Transfer in Biological Systems</td>
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<td></td>
<td>BIOL_EN 4380</td>
<td>Applied Electronic Instrumentation</td>
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</tr>
<tr>
<td></td>
<td>BIOL_EN 4980</td>
<td>Biological Engineering Design (WI, Capstone) (Fall)</td>
<td>3</td>
</tr>
</tbody>
</table>

| Engineering Technical Electives (24 cr hr) |  |
| --- |  |
| - Upper-level engineering courses |  |
| - 12 cr in a technical emphasis recommended |  |
| - 15 cr in approved technical electives |  |
| - 9 cr allowed in other upper level engineering |  |

Courses to make 126 cr hr

- ENGINR_1110
- Extra BioSc course
Table 5. Term by term plan of study.

<table>
<thead>
<tr>
<th>Term:</th>
<th>Fall 1</th>
<th>CR</th>
<th>Spring 1</th>
<th>CR</th>
<th>Summer 1</th>
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2.13. Professional Engineer (P.E.) License

Many, but not all, engineering jobs and firms require that their employees be licensed professional engineers (P.E.s). To become licensed, you must first pass the Fundamentals of Engineering (FE) exam, at which point you become an "Engineering Intern" by submitting the Verification of Licensure and Examination form at the NCEES website (https://verify.ncees.org/) to the appropriate state.

BE graduating seniors are strongly encouraged to take this exam during their final term of study, as it assures them that they are eligible for jobs requiring a PE license or a PE in progress. The examination is six hours in length, including a tutorial, breaks, the exam, and a brief survey at the conclusion. The FE examination is a closed-book exam. Supplied reference material will be electronic and available on the NCEES (www.ncees.org) website. Examinees will be allowed to bring and use NCEES approved calculators on the exam.

2.13.1. Fees

To apply for the exam, visit the NCEES website (http://ncees.org/engineering/#missouri). Candidates are required to pay NCEES a $175 fee using a credit card. The cost of the exam will be reimbursed by Bioengineering AFTER YOU TAKE THE EXAM. To obtain a reimbursement, you must provide the Director of Undergraduate Studies with the following forms:

(1) a printed copy of the webpage showing confirmation that you paid the fee to take the exam,
(2) the registration form, and
(3) your credit card statement showing payment.

2.13.2. Schedule of Examination Offerings

There are four testing windows for the examination each year; each window lasts two months, with a month between them. Examination appointments are available: January-February; April-May; July-August; and, October-November (i.e., the exam is not offered March, June, September, or December). There are NO filing deadlines. Study sessions will be provided during a semester by the College of Engineering to help you do your best. Candidates for an exam may take the exam only one time per testing window and no more than three times in a 12-month period.

Computer-based FE examinations are administered only at approved Pearson VUE testing centers. To schedule, visit the Pearson VUE website (https://home.pearsonvue.com/). To find a center: http://cbt.ncees.org/where-will-i-take-my-exam/. Columbia’s location is:
Pearson Professional Centers-Columbia MO
1700 East Pointe Drive
Suite 204
Columbia, Missouri 65201

2.14. Policies

2.14.1. Transfer Credits

1. By departmental policy, only transfer grades of “C” and higher are accepted for curriculum requirements.
2. A maximum of 65 credits from a 2-year school can be applied to degree requirements.
3. The last 32 credits of the degree program must be earned at MU. Exceptions may be granted in special cases. Speak with your adviser for more information.
4. Transfer students with transfer credits in bioengineering core courses must earn at least 15 semester credits in MU courses in this category at the 3000-level or above to qualify for the B.S. degree in biological engineering.

2.14.2. Academic Standing
http://registrar.missouri.edu/policies-procedures/academic-standing.php
http://engineering.missouri.edu/current-students/academic-probation-dismissal/
A student whose term and cumulative MU GPA are 2.0 or higher is in good academic standing. A “term” is defined as a semester or summer session. Academic standing is evaluated each semester (excluding summer) and is based on a student’s GPA in courses that are complete at the end of the term. Incompletes and courses in progress are not considered in evaluating academic standing. A student will be placed on academic probation if while in good academic standing the student has a term GPA less than 2.0 but equal to or greater than 1.0. A student will be dismissed from the College of Engineering if the student receives a term GPA of less than 1.0 or receives a term GPA of less than 2.0 while on probation.

2.14.3. Graduation Requirements
http://commencement.missouri.edu/pre-graduation.php
You are able to obtain a copy of your Degree Audit at any time through the Office of the University Registrar (http://registrar.missouri.edu/degree-audits/). You should check each semester to ensure that each course taken or transferred is properly applied to the correct curricular category. Ask your academic adviser to make any necessary corrections to your Degree Audit to ensure everything is correct by the semester preceding your expected term of graduation.

2.14.4. Satisfactory / Unsatisfactory Grading System
http://registrar.missouri.edu/policies-procedures/grading-options.php
Courses completed with a grade of S may constitute no more than 20 percent of the total credits for the baccalaureate degree. Students cannot elect to enroll in more than one course on an S/U basis in a given semester. This excludes courses taught only with the S/U grading system. Courses completed with a grade of S may be accepted in an area of concentration only with the prior approval of the academic adviser. S/U credits can be applied toward requirements for a B.S. degree in bioengineering only if the course is specified in the curriculum as a behavioral science / social science or humanities / fine arts elective, or is a course not used in the degree program. Satisfactory / Unsatisfactory credits are not acceptable for technical elective courses or bioengineering core courses except for BIOL_EN 4940, engineering internship.

2.15. Student Resources
The University of Missouri and the College of Engineering provide a number of resources to help students succeed academically. These include:
- Engineering Leadership, Engagement and Career Development Academy
  https://engineering.missouri.edu/current-students/engineering-academy/
- The College of Engineering Tutoring Sessions
  https://engineering.missouri.edu/current-students/engineering-academy/engineering-tutoring/
2.16. Graduation Procedures and Forms

https://engineering.missouri.edu/current-students/student-resources/graduation/

Once you have successfully completed your plan of study, you need to do the following things in order to officially graduate:

- Complete the University of Missouri Graduation Survey. This is an online survey, and it will come from wess@webebi.com.
- Complete and submit the Graduation Form online at: https://engineering.missouri.edu/current-students/student-resources/graduation/
- Order regalia for the commencement ceremony at the Mizzou Store https://www.themizzoustore.com/c-716-mizzou-graduation.aspx
- Order your honor cords through the Mizzou Store for Latin or engineering honors.
- Complete and submit the Honors Scholar Completion Form by 4 pm on the third Friday of the term in which you are graduating, if you wish to graduate with the Honors Certificate (and have it show up on your transcript). https://honors.missouri.edu/graduating-with-honors/honors-certificate-application/
Part 3: Opportunities for Undergraduates
1. International Studies in Engineering

http://engineering.missouri.edu/abroad/

There are numerous international programs and experiences available to bioengineering students. Through these programs you have the opportunity to:

- Study for 1-2 semesters at prominent bioengineering departments in Europe, Asia, or South America
- Participate in courses offered during the breaks

MU has several points of contact when it comes to international programs and experiences. Both Engineering Study Abroad (http://engineering.missouri.edu/abroad/) and MU’s International Center (https://international.missouri.edu/study-outside-the-us/) are excellent resources for students who are considering an international experience. Visit with these departments’ websites or go in person to get the most up to date information about programs you are interested in.

2. Honors College

https://honors.missouri.edu/current-students/

Students with high ability and clear educational objectives are encouraged to investigate the opportunities offered by the university Honors College. Founded in 1958, with a current enrollment of over 2550 students, an alumni base of nearly 11,000, almost 200 unique courses offered every year, an active faculty of over 160 of MU’s most accomplished scholars, and over $1.6 million in endowed scholarships, the Honors College at the University of Missouri seeks to serve a diverse group of high-achieving students, with majors in nearly every discipline from Engineering to Art, so that they can excel in all facets of their education. To provide our students with the services and engagement of a small college within the breadth of a large, pluralistic, and distinguished research institution, the Honors College works closely with departments and colleges on campus to provide a range of honors courses, academic programs, and extra-curricular events and activities. We call this exciting and varied set of offerings, the “Honors Experience.”

There are numerous reasons why a student should join the Honors College and why MU’s Honors College is a destination of choice for some of the nation’s most talented students:

- Honors courses and academic programs are designed to create a dynamic, interactive environment that fosters deep intellectual development, enhanced by close interaction with dedicated faculty.
- Co-curricular events and activities are special opportunities designed to enhance the “Honors Experience” through private seminars with distinguished speakers, site tours, study abroad programs, guest visits to graduate seminars, mentoring, partnerships, and hands-on, engaging workshops.
- We also provide a living-learning experience that gives students multiple options to interact with other Honors students, faculty, and professional staff.
- Additional scholarships (above and beyond University-sponsored scholarship and aid programs) and financial support for extended learning activities, are also a hallmark of the College, in support of our students.
- Graduation as a member of the Honors Program is noted on the student’s diploma, permanent record, and in the commencement program.

In order to remain members of the Honors College, students must fulfill both the GPA and Participation Requirements.
2.1. GPA Requirement
For students enrolling at Mizzou for the first time in the fall semester, 2014, or later: To retain membership in the Honors College, students must maintain a cumulative Mizzou GPA of 3.5 or above. Students with a cumulative Mizzou GPA below 3.5 will receive a warning letter the first semester in which this occurs. Students with a cumulative Mizzou GPA below 3.5 for a second consecutive semester will no longer be members of the Honors College. Students with a cumulative Mizzou GPA below 3.0 will be removed immediately. Students wishing to reapply to the Honors College must meet the eligibility requirements for current Mizzou students.
For students enrolling at Mizzou for the first time before the fall semester, 2014: To retain membership in the Honors College, students must maintain a cumulative Mizzou GPA of 3.0 or above. Students with a cumulative Mizzou GPA below 3.0 will receive a warning letter the first semester in which this occurs. Students with a cumulative Mizzou GPA below 3.0 for a second consecutive semester will no longer be members of the Honors College. Students wishing to reapply to the Honors College must meet the eligibility requirements for current Mizzou students.

2.2. Participation Requirement
Students who join the Honors College as first-year students will be required to complete two honors courses per year for their first two years at Mizzou. All honors courses will count toward this requirement, including honors-designated courses, and Honors Learning-by-Contract. Mizzou students who join the Honors College in their sophomore year and transfer students who are admitted with sophomore standing will be required to complete two courses in their first year of Honors College membership. Mizzou students who join the Honors College after their second year and transfer students who are admitted with junior or senior standing will be exempted from the participation requirement.

3. Undergraduate Research, Independent Study, and Departmental Honors
http://engineering.missouri.edu/current-students/undergraduate-research/
http://engineering.missouri.edu/current-students/undergraduate-research/honors/

Students who wish to participate in undergraduate research at the University of Missouri have several options to consider. Research may be done in exchange for:
- Hourly pay
- Technical Elective credits (BIOL_EN 4990 or 4995)
- Departmental honors (enrollment in BIOL_EN 4995, plus completion of requirements)
- A combination of the above

The benefits of becoming involved in undergraduate research include:
- Exposure to research
- Experiential education
- Mentoring by graduate students and faculty
- Graduate students and faculty who could act as references or letter writers for recommendations
- Connections with industry
- Job experience
- Graduate-level credit prior to graduation with a BS degree
These opportunities may be particularly valuable for students planning to obtain an advanced degree or for students desiring work in a specific industry. Note that students may count up to 6 credit hours of 4990, 4995, or a combination of the two, towards their technical elective requirements for graduation. Additionally, enrollment in and successful completion of 4995 will allow students to graduate with departmental honors. Typically, ten hours of research per week are expected for earning 3 credits. Wages for research vary by research group, but are typically $10 / hour).

3.1. Process for Performing Research for Pay
- Find a faculty mentor to mentor your research (same research interest as you).
- Email the faculty member to set up a meeting to discuss the possibility of joining their research group.
- Follow the faculty member's hiring procedure

3.2. Process for Performing Research for Technical Elective Credit
- Find a faculty mentor to mentor your research (same research interest as you).
- Email the faculty member to set up a meeting to discuss the possibility of joining their research group.
- Follow the faculty member's process to select / interview new students
- Before the start of the term you wish to earn technical elective credit, you should:
  - Discuss with your faculty mentor that you wish to earn credit for performing research (typically 3 credits requires 10 h/ week in research performance)
- Write a structured abstract that describes:
  - the project summary
  - the engineering content
    - Engineering sciences have their roots in mathematics and basic sciences but carry knowledge further toward creative application. These studies provide a bridge between mathematics and basic sciences on the one hand and engineering practice on the other.
    - Engineering design is the process of devising a systems, component, or process to meet desired needs. It is a decision-making process (often iterative), in which the basic sciences, mathematics, and the engineering sciences are applied to convert resources optimally to meet these stated needs.
  - Keywords:
    - Design
    - Develop
    - Test
    - Optimize
    - Characterize
  - Key phrases:
    - Develop test methods
    - Analyze data to optimize the system
    - Improve the design
    - Test a new model
    - Develop a prototype
3.3. Process for Earning Departmental Honors (Honors Scholar Designation)

3.3.1. General Requirements for enrollment in BIOL_EN 4995 (Honors)

- Student must have a 3.0 overall GPA for acceptance into the program (transfer students must have an overall 3.0 or higher GPA average for any transfer credit and MU credit).
- Student must maintain and graduate with a 3.0 or higher overall GPA to graduate with Honors and dual-enroll for graduate courses.
- Student must satisfy all departmental, college, and ABET requirements.
- Students are encouraged to take the Fundamentals of Engineering (FE) exam.

3.3.2. Steps

- Find a faculty mentor to mentor your research (same research interest as you).
- Email the faculty member to set up a meeting to discuss the possibility of joining their research group.
- Follow the faculty member’s process to select / interview new students
- Before the start of the term you wish to earn technical elective credit, you should:
- Discuss with your faculty mentor that you wish to earn credit for performing research
- Discuss with your faculty mentor that you wish to enroll in BIOL_EN 4995 and complete the Honors Scholar Requirements
- Inform the Bioengineering Director of Departmental Honors, Dr. Heather K. Hunt (hunthk@missouri.edu) that you wish to be considered for the Honors Scholar designation

- Write a structured abstract that describes:
  - the project summary
  - the engineering content
    - Engineering sciences have their roots in mathematics and basic sciences but carry knowledge further toward creative application. These studies provide a bridge between mathematics and basic sciences on the one hand and engineering practice on the other.
    - Engineering design is the process of devising a systems, component, or process to meet desired needs. It is a decision-making process (often iterative), in which the basic sciences, mathematics, and the engineering sciences are applied to convert resources optimally to meet these stated needs.
    - Keywords:
      - Design
      - Develop
      - Test
- Optimize
- Characterize

### Key phrases:
- Develop test methods
- Analyze data to optimize the system
- Improve the design
- Test a new model
- Develop a prototype

- the number of credit hours to be earned

☐ Ask your faculty mentor to review, revise, and approve the abstract
☐ Submit the abstract to the Director of Undergraduate Studies, who must approve the abstract as well by the **SECOND FRIDAY OF TERM**
☐ Obtain a consent number for enrollment in BIOL_EN 4995 from the administrative assistant for Bioengineering (254 Agricultural Engineering Building)
☐ Enroll in BIOL_EN 4995 Honors Research course for at least three (3) credit hours, with a total maximum of six (6) credit hours, in your faculty mentor’s section
☐ Schedule a poster or oral presentation at either the University of Missouri Undergraduate Research and Creative Achievements Forum (spring or summer terms) OR the Class Research Project Poster Day at the end of fall and spring terms
    [https://undergradresearch.missouri.edu/forums-and-conferences/](https://undergradresearch.missouri.edu/forums-and-conferences/)
☐ Submit a final research report, as an Honors Thesis, to your faculty mentor **SIX WEEKS PRIOR TO GRADUATION**
☐ Make the revisions required by your faculty mentor
☐ Submit your revised thesis to your faculty mentor and a second faculty member by **FOUR WEEKS PRIOR TO GRADUATION**
☐ Obtain approval signatures from both faculty members on your cover page
☐ Submit your approved thesis and a completed Honors Scholar Completion Form to the Bioengineering Director of Departmental Honors, Dr. Heather K. Hunt, and **TWO WEEKS PRIOR TO GRADUATION**

### 4. Process for Earning Dual Credit for Undergraduate Classes
[http://gradschool.missouri.edu/forms-downloads/repository/dual-enrollment.pdf](http://gradschool.missouri.edu/forms-downloads/repository/dual-enrollment.pdf)

To dual enroll for graduate/undergraduate credit, submit Dual Enrollment form to the Graduate School, 210 Jesse Hall. Upon approval, enroll in the graduate course(s) for the corresponding undergraduate course you wish to take (typically listed as 4000/7000 level courses).

### 5. Professional Societies
[http://bioengineering.missouri.edu/undergraduate/organizations.php](http://bioengineering.missouri.edu/undergraduate/organizations.php)

Bioengineering students may enjoy a variety of student organizations and professional societies relevant to their career goals. These include:

#### 4.1. Alpha Epsilon
To promote the high ideals of the engineering profession and encourage and support such improvements in the biological engineering profession that make it an instrument of greater service to mankind.

4.2. Alpha Omega Epsilon Sorority
Alpha Omega Epsilon is a professional and social sorority composed of female engineering and technical science students and alumnae.
National organization website: [www.alphaomegaepsilon.org](http://www.alphaomegaepsilon.org)

4.3. Biomedical Competitive Advancement Team (BioCATs)
Interdisciplinary organization focused on solving potential setbacks and needs in the medical field.

4.4. Biomedical Engineering Society (BMES)
To help students within Biological Engineering understand Biomedical Engineering more fully.
National organization website: [www.bmes.org](http://www.bmes.org)
Mizzou club: Facebook

4.5. Engineering World Health (EWH)
EWH facilitate and encourage the participation of students in activities that inspire and mobilize the biomedical engineering community to improve the quality of health care in vulnerable communities. More specifically, EWH provides its membership with opportunities to travel to developing countries, design medical technologies appropriate for developing countries, build medical devices for use in developing countries, or promote understanding and goodwill between the developed and developing world.

4.6. Graduates’ Club of Biological Engineering (GCBE)
The purpose of the Graduates’ Club of Biological Engineering is to exchange ideas and strengthen the bonds between the graduate students that are working in different areas of biological Engineering, as well between the graduate students and faculty
Mizzou club website: gcbe.students.missouri.edu

4.7. Institute of Biological Engineering (IBE)
A student chapter of IBE, whose goals are to provide the means by which students may interact with fellow biological engineering students, gain knowledge and insight about innovations and opportunities within their area of study by professionals in industry, academia and government, and to allow student leadership opportunities as well as a chance for fun and enjoyment with social activities at the University of Missouri-Columbia.
National organization website: [www.ibe.org](http://www.ibe.org)

4.8. Sigma Alpha Sorority
The objective of Sigma Alpha, the Professional Women in Agriculture Society, shall be to promote its members in all facets of agriculture and to strengthen the bonds of friendship among them.
National organization website: [www.sigmaalpha.org](http://www.sigmaalpha.org)

4.9. Sigma Phi Delta Fraternity
Sigma Phi Delta is an international social and professional fraternity of engineers. The purpose of
the organization is to support its members in their pursuit of academic success and leadership qualities.
Mizzou organization website: https://orgsync.com/86381/chapter

5. Scholarship Opportunities
http://engineering.missouri.edu/scholarships/
Each year, the College of Engineering, through its Scholarships and Awards Committee, offers awards to engineering students. Various companies, trade associations, and individuals donate these awards. These awards are based primarily on academic performance and university involvement. The Office of Student Financial Aid (http://financialaid.missouri.edu/) handles scholarships based on financial need.

6. Co-ops and Internships
http://engineering.missouri.edu/careers/for-students/internships-co-ops/
Co-op and internship experiences provide an opportunity for students enrolled in bioengineering to gain practical experience while working toward their B.S. degrees. Such work arrangements are with companies located throughout the U.S. The College of Engineering hosts a career fair during both the fall and spring semesters so that students can meet with representatives from companies and agencies that offer co-ops and internships. Engineering Career Services maintains an up-to-date listing of co-op, internship, and job opportunities.

Eligible students who accept co-op or internship positions can register these experiences so that they show up on the student’s transcript. You will need to discuss this with your Director of Undergraduate Studies.

Advantages of the program are that students:
- Increase competitive edge for full-time employment
- Enhance career exploration and clarification of professional goals
- Develop greater responsibility and self-confidence
- Improve interpersonal and communication skills
- Create a process of development, assessment, and continuous professional growth
- Maintain full-time student status without tuition and fees (speak to your adviser)
- Reflect work experience on transcript
- Earn money to help cover their college expenses
- Complement classroom learning with practical work experience

Disadvantages include:
- Loss of continuity in some course sequences because of the periodic interruption of work
- Possible limitations in participating in some outside activities
- Lengthening of program

For additional information, speak with your academic adviser (http://engineering.missouri.edu/careers/).

You may also earn credit for engaging in a co-op or internship via BIOL_EN 4940.

6.1. Enrolling
To obtain a permission number and enroll in 1-3 credit hours, you must submit a one-page, written
summary that includes:

☐ An introduction to the company/entity/internship
☐ A summary of the project
☐ A summary of how the project includes engineering content (engineering science, engineering design)
  o NOTE: summaries that do not include this information when first submitted will be rejected, and the student's credit request will be rejected
  o Engineering sciences have their roots in mathematics and basic sciences but carry knowledge further toward creative application. These studies provide a bridge between mathematics and basic sciences on the one hand and engineering practice on the other.
  o Engineering design is the process of devising a systems, component, or process to meet desired needs. It is a decision-making process (often iterative), in which the basic sciences, mathematics, and the engineering sciences are applied to convert resources optimally to meet these stated needs.
  o Keywords:
    ▪ Design
    ▪ Develop
    ▪ Test
    ▪ Optimize
    ▪ Characterize
  o Key phrases:
    ▪ Develop test methods
    ▪ Analyze data to optimize the system
    ▪ Improve the design
    ▪ Test a new model
    ▪ Develop a prototype

☐ Approval from your supervisor (email that includes your name and position)
☐ Approval from the Director of Undergraduate Studies

6.2. Completion requirements

In order to receive the credit for which you applied, you must write a 3000-word minimum formal report of your project and give a 10 – 15 minute presentation on your project. The report should include the following sections:

1. Company/Entity and Job
   a) Organization and Structure of the company
   b) Work duties – daily, regular

2. Project Report/Summary (majority of the report length)
   a) Introduction and Purpose
   b) Summary of activities and data collected
   c) Results, conclusion(s), outcome actions that resulted from your work
   d) Value added to the company
   e) Future project, next steps, recommendations
      NOTE: Proprietary data, analyses, techniques, work product, etc. will remain company property at the conclusion of the reporting and oral presentation.

3. Course work and curriculum
a) Summarize the courses that enhanced your ability to complete the internship.
b) Summarize how the internship enhanced your interest/ability to complete courses.
c) Summarize changes you would make to your plan-of-study, if you were doing the degree again? Any curriculum changes that you would suggest? Why?

The report should be formatted in the following manner:

- Cover Page (see example below)
- Left margin (for binding) = 1.5 in
- Top, bottom, left margins for text = 1 in.
- Page numbering (centered on bottom of page)
- 1.5 to double-spacing
- Double-side printing
- One bound copy for the department

Additionally, you must give a 10 – 15 minute oral presentation at a class or in a meeting at your company. This presentation must include the same information as above. In cases of proprietary information, exclude this from your presentation.
Part 4: Appendices
1. Undergraduate Research Files

1.1. Structured Abstract Template

EXAMPLE Structured Abstract
For
BIOL_EN 4085: Problems in Biological Engineering
OR
BIOL_EN 4990: Undergraduate Research in Biological Engineering
OR
BIOL_EN 4995: Honors Thesis Research in Biological Engineering

Student: Jane Doe
Supervising faculty: Dr. Mark Smith
Title: Flow pattern imaging using shear-sensitive molecular rotors
Semester: Summer 2017 Credit hours: 3

Summary:
The goal of this project is to generate images of flow patterns in various flow channels and flow chambers. Rather than conventional techniques, such as particle tracking, a novel class of fluorescent molecular rotor characterized by an increase of fluorescent intensity in areas of elevated fluid shear stress will be used. The student will design and fabricate flow chambers, setup and use a precise flow apparatus, and acquire images of each chamber at various flow rates. In addition, the student is responsible for image processing, image analysis, and the quantitative analysis of the results (i.e. analysis of computed flow versus intensity).

Engineering content:
The student will design a suitable flow chamber including the estimate or computerized simulation of flow behavior to achieve geometries that can easily be analyzed. The design component (flow chambers, precision flow system, and fluorescent image acquisition system) is an important part of the engineering content.

The study of fluid dynamics (including computed fluid dynamics) is a traditional engineering science. Data will be taken via image techniques and analyzed to determine the validity of the design and suggest improvements to optimize the system.

Approved by: (printed and signature) John Naïsmith
Approved by: (printed and signature) Betty Shay

Version: February 2018
1.2. *Honors Thesis Format*

Please note that first-author papers are acceptable in lieu of an Honors Thesis. However, the cover page must still be included and both turned in to receive credit.

1.2.1. Requirements

1. Cover Page with Abstract
2. Table of Contents
3. Journal Format Body – 12 pages minimum
   a. Introduction
   b. Materials and Methods
   c. Results
   d. Discussion
   e. Conclusions
4. References - use a journal format acceptable to faculty mentor and student.

1.2.2. Format

1. Cover Page (see example on next page)
2. Left margin (for binding) = 1.5 in
3. Top, bottom, right margins for text = 1 in.
4. Page numbering on the right of the bottom margin
5. 1.5 to double-spacing
6. Single-side printing
7. Two bound copies – one for department, one for faculty mentor

1.2.3. Approvals

1. First Reader – Honors Thesis Advisor (Faculty Mentor)
2. Second Reader – Another faculty member chosen by faculty mentor and student.
3. Director of Undergraduate Studies – Dr. Heather K. Hunt ([hunthk@missouri.edu](mailto:hunthk@missouri.edu))
1.3. Honors Thesis Cover Page Template

Title

Student: NAME
Faculty Advisor: NAME
Department of Bioengineering
University of Missouri
DATE

Abstract:
2. Internship / Co-op for Credit Files

2.1. Report Cover Page

BIOL_EN 4940 Engineering Internship
with
XYZ Corp. Inc. – Clinical Engineering
University of Missouri
DATE

Student: NAME Internship
Advisor: NAME, Position

Abstract: 4 line summary

2.2. BIOL_EN 4940 Enrollment Summary Sample

Student: Jane Doe                      Student Number:
Semester: 2017 Spring                  Credit Hours: 3

Title: Pacemaker Manufacturing Intern

Company and Internship Summary
XYZ Corp inc. is a Fortune 500 medical device company that develops technologies to transform
the treatment of epidemic diseases. (http://www.)
This takes the form of treating primarily cardiovascular diseases and chronic pain conditions.

The internship is in the Pacemaker Manufacturing Operation business unit of the Cardiac Rhythm
Management (CRM) division located in Sylmar, California. Pacemakers, Implantable Cardioverter
Defibrillators (ICDs), and the leads that allow monitoring and deliver treatment from these devices
are manufactured at this location.

Project Summary
A consolidation and renovation of the manufacturing clean room is being planned. Combining four
separate product clean rooms into one large clean room could provide efficiency gains,
productivity improvements, and cost savings. My job is to collect data and create a detailed
manufacturing analysis to assist with layout designs for this multiphase renovation.

Engineering Content Summary
The pacemaker manufacturing floor will be analyzed and time studies will be performed. Software
tools will be used to assist in the data collection and analysis. Data will be analyzed to improved
work flow and optimize each assembly area. A new manufacturing system layout will be
developed to optimize the current production lines.

Approved: Intern Supervisor – Name and Position Title
3. Academic Appeals Files

3.1. Outline for your Academic Appeals Letter

If you need to write an academic appeals letter, the department suggests the following format and content.

Format:
- Use Times New Roman size 12 font
- Use single-spaced lines
- The letter greeting should read: Engineering Academic Appeals Committee:
- Two pages maximum
- Check spelling and grammar before submission
- Sign and date the letter
- Convert the letter to a .pdf before submission

Content:
- Be honest and sincere – with yourself and the committee.
- Be respectful.
- Acknowledge your academic problem.
- State and explain what caused the problem. Only give the detail you are comfortable giving, but say something.
- State what you have done (and/or are doing) to address the problem.
- State what you will do to correct the academic situation.