BSBE in Biological Engineering

Degree Program Description

Biological Engineering is a science-based engineering curriculum that integrates engineering and biological sciences in the areas of health, sustainability and environmental stewardship. Students are prepared in three engineering areas: biomedical, bioprocess, and bioenvironmental engineering. In addition to the core program courses, the program includes courses in basic sciences; social, behavioral and engineering sciences; and humanities and fine arts. In a capstone design course, each student completes a design project under the direction of a faculty advisor. Graduates are hired by biotechnology, medical, pharmaceutical, food and agricultural companies and government agencies, or opt to further their education in graduate, medical or veterinary medical school. Graduates are well prepared to take the Fundamentals of Engineering exam during their senior year, which is the first step toward obtaining a Professional Engineer license. The BS in Biological Engineering is accredited by the Engineering Accreditation Commission of ABET.

Major Program Requirements

The curriculum encompasses basic sciences, social and behavioral sciences, humanities and fine arts, engineering sciences and topics, and program core courses. The core courses cover topics of biological engineering principles and design. In a capstone design course, each student completes a design project under the direction of a faculty advisor. Technical electives allow students to place emphasis on biomedical, bioprocess or bioenvironmental engineering.

All requirements listed below are in addition to University graduation requirements (https://catalog.missouri.edu/academicdegreerequirements/universityrequirements/), including University general education (https://catalog.missouri.edu/academicdegreerequirements/generaleducationrequirements/) and College of Engineering requirements. All pre-requisites required for Basic Engineering, Biological Engineering, and Technical Elective courses must be completed with a grade of C- or better.

Major Core Requirements

Mathematics and Statistics		**19**
MATH 1500	Analytic Geometry and Calculus I	5
MATH 1700	Calculus II	5
MATH 2300	Calculus III	3
MATH 4100	Differential Equations	3
STAT 4710	Introduction to Mathematical Statistics	3
or ISE 2110	Probability and Statistics for Engineers	
or BIOL_EN 4270	Design of Experiments and Statistical Quality Control for Process Engineers	
Basic Sciences		**28**
PHYSCS 2750	University Physics I	5
PHYSCS 2760	University Physics II	5
CHEM 1400 & CHEM 1401	College Chemistry I and College Chemistry I Laboratory	4
CHEM 2100	Organic Chemistry I	3
BIO_SC 1500	Introduction to Biological Systems with Laboratory	5
Biological Sciences Electives (from approved list)		6
BIOL_EN 2070	Cell and Molecular Biology for Engineers (suggested)	
BIOL_EN 4050	Zero Hunger Challenge (suggested)	
or BIOL_EN 4050H	Zero Hunger Challenge - Honors	
Basic Engineering		**18**
ENGINR 1000	Introduction to Engineering [a]	1
ENGINR 1050	Foundations of Engineering [a]	2
ENGINR 1100 & ENGINR 1110	Engineering Graphics Fundamentals and Solid Modeling for Engineering Design	3
or MAE 1100	Introduction to Computer Aided Design	
ENGINR 1200	Statics and Elementary Strength of Materials	3
ENGINR 2200	Intermediate Strength of Materials	3
ENGINR 2300	Engineering Thermodynamics	3
or CH_ENG 3261	Chemical Engineering Thermodynamics I	
BIOL_EN 3070	Biological Fluid Mechanics	3
or CV_ENG 3700	Fluid Mechanics	
or MAE 3400	Fluid Mechanics	
Biological Engineering		**17**
BIOL_EN 2000	Professional Development in Engineering	2
BIOL_EN 2080	Introduction to Programming for Engineers	3
BIOL_EN 2180	Engineering Analysis of Bioprocesses	3
BIOL_EN 3180	Heat and Mass Transfer in Biological Systems	3
BIOL_EN 4380	Applied Electronic Instrumentation	4
BIOL_EN 4980W	Bioengineering Design I - Writing Intensive	3
Technical Electives		**21**
Upper-level engineering courses, with 15 credit hours in approved courses, of which 12 credit hours in a track (listed below) are recommended.		21
Additional Requirements		
Economics (from approved list)		3
ECONOM 1014	Principles of Microeconomics (Recommended)	

a The required First-Year Engineering (FYE) courses, ENGINR 1000 and ENGINR 1050, will be waived for a transfer student pursuing Biological Engineering if the student enters MU with 60 or more transfer credits and credit for an acceptable course in Statics or Engineering Analysis of Bioprocesses. The BE Director of Undergraduate Studies may also waive the FYE courses in cases where the transfer student has demonstrated adequate progress in an engineering program.

Biological Engineering Tracks

Bioenvironmental Track		**24**
BIOL_EN 4085	Problems in Biological Engineering	1-5
BIOL_EN 4150	Soil and Water Conservation Engineering	3
BIOL_EN 4250	Irrigation and Drainage Engineering	3
BIOL_EN 4350	Watershed Modeling Using GIS	3
BIOL_EN 4450	Environmental Hydrology	3
BIOL_EN 4560	Observing the Earth from Space	3
BIOL_EN 4940	Engineering Internship	1-3
BIOL_EN 4985	Bioengineering Design II	1-3

BIOL_EN 4990	Undergraduate Research in Biological Engineering	1-5
or BIOL_EN 4995H	Undergraduate Honors Research in Biological Engineering	
CH_ENG 4285	Pollution Prevention	3
CH_ENG 4312	Air Pollution Control	3
CV_ENG 3050	Introduction to Geographic Information Systems GIS	3
CV_ENG 3200	Fundamentals of Environmental Engineering	4
CV_ENG 3400	Fundamentals of Geotechnical Engineering	4
CV_ENG 3702	Fundamentals of Water Resources Engineering	4
CV_ENG 4230	Introduction to Water Quality	3
CV_ENG 4240	Integrated Environmental and Hydrology Laboratory	3
CV_ENG 4250	Environmental Regulatory Compliance	3
GEOG 4940	Advanced Geographic Information Systems (GIS II)	3
ISE 4720	Introduction to Life Cycle Analysis	3
Bioprocessing Track		**24**
BIOL_EN 3075	Introduction to Materials Engineering	3
BIOL_EN 3170	Biomaterials	3
BIOL_EN 3330	Fermentation for Food, Fuel and Beverages	3
BIOL_EN 4085	Problems in Biological Engineering	1-5
BIOL_EN 4160	Food Process Engineering	3
BIOL_EN 4231	Transport Phenomena in Materials Processing	3
BIOL_EN 4310	Feedback Control Systems	3
BIOL_EN 4315	Principles of Biochemical Engineering	3
BIOL_EN 4316	Biomass Refinery Operations	3
BIOL_EN 4360	Biomanufacturing Technologies	3
BIOL_EN 4480	Physics and Chemistry of Materials	3
BIOL_EN 4940	Engineering Internship	1-3
BIOL_EN 4985	Bioengineering Design II	1-3
BIOL_EN 4990	Undergraduate Research in Biological Engineering	1-5
BIOL_EN 4995H	Undergraduate Honors Research in Biological Engineering	1-5
CH_ENG 3235	Separation Processes	3
CH_ENG 3262	Chemical Engineering Thermodynamics II	3
CH_ENG 4315	Principles of Biochemical Engineering	3
CH_ENG 4316	Biomass Refinery Operations	3
CH_ENG 4319	Introduction to Polymers	3
CH_ENG 4363	Chemical Reaction Engineering and Technology	3
ISE 4720	Introduction to Life Cycle Analysis	3
Biomedical Engineering Track		**24**
BIOL_EN 3075	Introduction to Materials Engineering	3
BIOL_EN 3170	Biomaterials	3
BIOL_EN 4070	Bioelectricity	3
BIOL_EN 4075	Brain Signals and Brain Machine Interfaces	3
BIOL_EN 4085	Problems in Biological Engineering	1-5
BIOL_EN 4170	Biomaterials Interfaces of Implantable Devices	3
BIOL_EN 4175	Tissue Engineering	3
BIOL_EN 4231	Transport Phenomena in Materials Processing	3
BIOL_EN 4315	Principles of Biochemical Engineering	3
BIOL_EN 4360	Biomanufacturing Technologies	3
BIOL_EN 4370	Orthopaedic Biomechanics	3
BIOL_EN 4375	Human Movement Biomechanics	3
BIOL_EN 4420	Introduction to Biomedical Imaging	3
BIOL_EN 4470	Biomolecular Engineering and Nanobiotechnology	3
or BME 4470H	Biomolecular Engineering and Nanobiotechnology - Honors	
BIOL_EN 4480	Physics and Chemistry of Materials	3
BIOL_EN 4540	Neural Models and Machine Learning	3
BIOL_EN 4570	Fluorescent Imaging	3
BIOL_EN 4590	Computational Neuroscience	4
BIOL_EN 4770	Biomedical Optics	3
BIOL_EN 4940	Engineering Internship	1-3
BIOL_EN 4970	Nuclear Magnetic Resonance and Magnetic Resonance Imaging	3
BIOL_EN 4972	Engineering in Medical Imaging I: Non-Ionizing Techniques	3
BIOL_EN 4973	Engineering in Medical Imaging II: Ionizing Techniques	3
BIOL_EN 4974	Medical Image Processing	3
BIOL_EN 4985	Bioengineering Design II	1-3
BIOL_EN 4990	Undergraduate Research in Biological Engineering	1-5
BIOL_EN 4995H	Undergraduate Honors Research in Biological Engineering	1-5
BME 4003	Design and Development of Biomedical Innovation	3
CH_ENG 4319	Introduction to Polymers	3
CH_ENG 4363	Chemical Reaction Engineering and Technology	3
ECE 4620	Introduction to BioMEMS	3
ECE 4640	MEMS Laboratory	4

Approved Electives

Biological Science Electives approved list:

AN_SCI 3254	Physiology of Domestic Animals	5
BIOCHM 3630	General Biochemistry	3
BIOCHM 4270	Biochemistry	3
BIOL_EN 2070	Cell and Molecular Biology for Engineers	4
BIOL_EN 4050	Zero Hunger Challenge	3
or BIOL_EN 4050H	Zero Hunger Challenge - Honors	
or F_S 4050	Zero Hunger Challenge	
or F_S 4050H	Zero Hunger Challenge - Honors	
BIO_SC 2200	General Genetics	4
BIO_SC 2300	Introduction to Cell Biology	4
BIO_SC 3700	Human Physiology	5
BIO_SC 4976	Molecular Biology	3
BIO_SC 4990	Vertebrate Histology and Microscopic Anatomy	5

DMU 4200	Principles of Diagnostic Medical Ultrasound	3
F_S 2172	Elements of Food Microbiology	3
F_S 4310	Food Chemistry and Analysis	3
F_S 4370	Food Microbiology	3
MPP 3202	Elements of Physiology	5
MPP 3550	Physiology for Engineers	3
NUCMED 4327	Nuclear Medicine Instrumentation	3
PHYSCS 4110	Light and Modern Optics	4
PLNT_SCI 2110	Who Runs the World? Plants.	3
PLNT_SCI 3213	Genetics of Agricultural Plants and Animals	3
PLNT_SCI 4313	Soil Fertility and Plant Nutrition	3
PLNT_SCI 4314	Soil Fertility and Plant Nutrition Laboratory	2
PLNT_SCI 4315	Crop Physiology	3
PLNT_SCI 4320	Molecular Plant Physiology	3
PTH_AS 2201	Human Anatomy Lecture	3
SOIL 2100	Introduction to Soils	3
SOIL 2106	Soil Science Laboratory	2
SOIL 3290	Soils and the Environment	3
SOIL 3290W	Soils and the Environment - Writing Intensive	3
SOIL 4312	Environmental Soil Microbiology	3
SOIL 4318	Environmental Soil Chemistry	3
Economics approved list:		
ECONOM 1014	Principles of Microeconomics	3
ECONOM 1015	Principles of Macroeconomics	3
ECONOM 1051H	General Economics - Honors	5
ABM 1041	Applied Microeconomics	3
ABM 1042	Applied Macroeconomics	3
ISE 2710	Engineering Economic Decision-Making	3

Accelerated BSBE to MS Option

The accelerated option will allow students to earn a bachelors and masters degree within five years in Biological Engineering. Eligible students who have completed at least 90 credit hours with a cumulative GPA of 3.0 and higher. The academic requirements of the accelerated MS program will require a total of 30 credit hours to graduate. Accepted undergraduate students can take 12 hours of graduate level courses that will count toward both the undergraduate and the graduate degrees. Once the student has completed 126 credit hours, the corresponding bachelor's degree will be conferred and they will become graduate students in our MS programs to complete the remaining 18 hours of graduate credit. A minimum of 15 credit hours must be from courses at the 8000 level or above.

Total credits required for graduation must be at least 140 total credit hours:

- Total undergraduate credit hours: 128
- Total dual enrollment credit hours: 12
- Total graduate credit hours: 30

First Year (as Provisional Graduate Student)	**12**
7000+ level BE tech electives	9
7000+ level statistics course	3
Second Year (as Graduate Student)	**18**
Thesis Option	
BIOL_EN 8402 Research Methods	2
BIOL_EN 8087 Seminar in Biological Engineering	1
BIOL_EN 8180 Numerical Methods in Engineering Research	3
8000+ level BE electives	6
BIOL_EN 8990 Masters Thesis Research in Biological Engineering	6
Non Thesis Option	
7000+ level course	3
BIOL_EN 8180 Numerical Methods in Engineering Research	3
8000+ level BE electives	9
BIOL_EN 8085 Problems in Biological Engineering	3

1. At least 15 hours must be from 8000 level and above. Coursework has to be from at least two different proficiency areas.

Proficiency Areas

A student needs to take at least one course from a minimum of two different areas.

Bioprocess Engineering		
BIOL_EN 7001	Topics in Biological Engineering	1-3
BIOL_EN 7160	Food Process Engineering	3
BIOL_EN 7315	Introduction to Bioprocess Engineering	3
BIOL_EN 7316	Biomass Refinery Operation	3
BIOL_EN 8001	Advanced Topics in Biological Engineering (Topic: Advanced Bioprocessing & Biocatalyst)	1-3
BIOL_EN 8280	Advanced Biological Transport Processes	3
Bioenvironmental Engineering		
BIOL_EN 7150	Soil and Water Conservation Engineering	3
BIOL_EN 7250	Irrigation and Drainage Engineering	3
BIOL_EN 7350	Watershed Modeling Using GIS	3
BIOL_EN 7450	Environmental Hydrology	3
BIOL_EN 7560	Observing the Earth from Space	3
BIOL_EN 8250	Water Management Theory	3
Bioelectronics and Instrumentation		
BIOL_EN 7070	Bioelectricity	3
BIOL_EN 7075	Brain Signals and Brain Machine Interfaces	3
BIOL_EN 7310	Feedback Control Systems	3
BIOL_EN 7380	Applied Electronic Instrumentation	4
BIOL_EN 7540	Neural Models and Machine Learning	3
BIOL_EN 7590	Computational Neuroscience	4
BIOL_EN 8380	Modeling and Identification of Engineering Systems	3
Biomaterials		
BIOL_EN 7170	Biomaterials Interfaces of Implantable Devices	3
BIOL_EN 7370	Orthopaedic Biomechanics	3
BIOL_EN 7480	Physics and Chemistry of Materials	3
BIOL_EN 8001	Advanced Topics in Biological Engineering (Topic: Tissue Engineering)	1-3
BIOL_EN 8370	Materials Characterization Techniques	3

BIOL_EN 8670	Orthopaedic Failure Modes and Effect Analysis	3
BIOL_EN 8870	Molecular and Cell Mechanics	3
Biomedical Innovation		
BIOL_EN 8000	Scientific Discovery Leading to Life Science Innovations	3
BIOL_EN 8004	Regulatory Issues in Clinical Research and Clinical Trials	3
BIOL_EN 8100	Design and Development of Biomedical Innovations	3
BIOL_EN 8200	Commercialization of Life Science Innovations	3
Biophotonics and Bioimaging		
BIOL_EN 7420	Introduction to Biomedical Imaging	3
BIOL_EN 7570	Fluorescent Imaging	3
BIOL_EN 7770	Biomedical Optics	3
BIOL_EN 7970	Nuclear Magnetic Resonance and Magnetic Resonance Imaging	3
BIOL_EN 8270	Principles and Applications of Fluorescence	3
BIOL_EN 8570	Microscopic Imaging	3
BIOL_EN 8970	Nuclear Magnetic Resonance and Magnetic Resonance Imaging	3
Biosensing		
BIOL_EN 7470	Biomolecular Engineering and Nanobiotechnology	3
BIOL_EN 7670	Photonics and Nanotechnologies in Optical Biosensors	3
BIOL_EN 7001	Topics in Biological Engineering (Topic: Wearable Biomedical Devices)	1-3
BIOL_EN 8001	Advanced Topics in Biological Engineering (Topic: Bioelectronics & Biosensors)	1-3
BIOL_EN 8170	Sensors and Biosensors	3
BIOL_EN 8470	Ultrasensitive Biodetection	3

Thesis/Non-Thesis Options

All MS students must complete an independent research project supervised by their faculty advisors. Students can choose a thesis (MST) or non-thesis (MSNT) option to complete the masters degree. Both require a total of 30 graduate credit hours and a research project. MST students can take 6 to 12 credit hours of masters research and are required to complete a masters thesis conforming to the Graduate School thesis specifications. MSNT students must take a minimum of 27 credit hours of graduate courses, excluding research and problems courses, and complete a project report approved by the examination committee. During their last semester in the program, students must defend their thesis or project report in front of an examination committee composed of their graduate advisor and at least two other faculty members.

Semester Plan

Below is a sample plan of study, semester by semester. A student's actual plan may vary based on course choices where options are available.

First Year			
Fall	**CR**	**Spring**	**CR**
MATH 1500	5	MATH 1700	5
CHEM 1400 & CHEM 1401	4	PHYSCS 2750	5
ENGINR 1000	1	ENGINR 1050	2
ENGLSH 1000	3	H/FA Elective	3
BS/SS Economics from approved list	3		
	16		**15**
Second Year			
Fall	**CR**	**Spring**	**CR**
MATH 2300	3	MATH 4100	3
PHYSCS 2760	5	Biological Science from approved list	3
CHEM 2100	3	ENGINR 1200	3
BIO_SC 1500	5	BIOL_EN 2080	3
BIOL_EN 2000	2	BIOL_EN 2180	3
	18		**15**
Third Year			
Fall	**CR**	**Spring**	**CR**
Biological Science from approved list	3	STAT 4710, ISE 2110, or BIOL_EN 4270	3
ENGINR 1100 & ENGINR 1110	3	BIOL_EN 3070, CV_ENG 3700, or MAE 3400	3
ENGINR 2200	3	BIOL_EN 4380	4
ENGINR 2300	3	Technical Elective	3
BIOL_EN 3180	3	BS/SS US Govt or History Elective	3
	15		**16**
Fourth Year			
Fall	**CR**	**Spring**	**CR**
BIOL_EN 4980W	3	Technical Elective	3
Technical Elective	3	Technical Elective	3
Technical Elective	3	Technical Elective	3
Technical Elective	3	H/FA Elective	3
H/FA Elective	3	BS/SS Elective	3
	15		**15**

Total Credits: 125