BIOENGINEERING

Bioengineering is an emerging branch of engineering that primarily deals with problems of medicine, healthcare, and—in general—quality of human life. It is a multidisciplinary field that combines scientific principles of biology, chemistry, physics, and mathematics with the best engineering techniques developed in traditional areas (for example, mechanical, electrical, chemical, and computer engineering) and new breakthrough methods developed in recent years.

Activities of bioengineers are widely spread. They use their knowledge to design and build medical instruments, artificial organs, prosthetic limbs, therapeutic devices, and medical imaging equipment. They help doctors to design new medical procedures, including new rehabilitation techniques. They also assist pharmaceutical and biotechnology industries in developing new, more efficient bioprocessing technologies. Finally, they find solutions for medical and biology-related problems of consumer technology in the areas of safety, ergonomics, and comfort.

Bioengineering is a rapidly growing profession with expanding career opportunities. By virtue of their vigorous cross-training, bioengineers are well-poised for careers in healthcare, medical device production, pharmaceutical industries, and consulting in health-related fields, as well as other positions in industry, education, and government.

Undergraduate Degree Program

The undergraduate program in bioengineering provides first a strong foundation in all of the basic ingredients of engineering: the natural and physical sciences, mathematics, a comprehensive socio-economic-cultural background, the behavioral sciences, and finally the basic engineering sciences that begin the development of problem-solving skills.

The program integrates natural sciences with engineering analysis and design concepts to advance the fundamental understanding of biological systems and to develop biology-based technologies with applications across a wide spectrum of societal needs. The bioengineering curriculum is designed to cater to students looking to enter the professional world immediately after earning their undergraduate degree, as well as those who are interested in pursuing graduate studies and research. Various fundamental, design, and application oriented courses (e.g. Biomaterials, Biomechanics, Bioinstrumentation, Biotransport, and Bioprocesses) fulfill industrial needs and help students to perform well in biotech, pharmaceutical, and healthcare industries as engineering professionals. At the same time, the exposure to advanced courses and cross-cutting, state-of-the-art research experiences provide a solid foundation to continue graduate studies and emerge as leaders in science and engineering.

Accelerated Master's Options for Bioengineering Students

The accelerated master's (4+1) option allows the most qualified UM-Dearborn undergraduate students to complete both a bachelor and a master's degree in a 5-year accelerated format. This is accomplished by combining portions of undergraduate and graduate coursework. Students enrolled in this option can take eligible 500-level courses during their junior and senior years, with up to 9 credit hours of such coursework being double-counted toward both degrees. Additionally, another 6 credit hours earned but not applied to the bachelor degree can later be counted toward the master's degree. Depending on the number of graduate courses taken while working toward the bachelor program, students will need to complete 15-21 credit hours to finish the master's program after earning their undergraduate degree.

Students enrolled in the BSE in Bioengineering degree program have access to the following 4+1 sequences:

- BSE in Bioengineering combined with MSE in Bioengineering--graduate-level courses may include core, electives, and cognates (limit one course)
- BSE in Bioengineering combined with MSE in Materials Science and Engineering--graduate-level courses may include ME 518, electives, and cognates (limit one course)

Please see the Mechanical Engineering 4+1 Option webpage for more information.

The Bachelor of Science in Engineering in Bioengineering program is accredited by the Engineering Accreditation Commission of ABET (https://www.abet.org/).

Program Educational Objectives

The Program Educational Objectives for the Bachelor of Science in Engineering in Bioengineering are:

- Be successfully employed in their discipline or a closely related field, while contributing to the economy and healthcare
- Continue to enhance their knowledge base and skills, through graduate degrees or other professional developments, to keep abreast of the ongoing changes in technology and health-related disciplines
- Be well rounded and well suited to work with colleagues and professionals with diverse technical backgrounds, cultures and wide range of competencies including those related to healthcare

Student Outcomes

To achieve the educational objectives, the graduates of the program will have:

1. An ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics.
2. An ability to apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors.
3. An ability to communicate effectively with a range of audiences.
4. An ability to recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts.
5. An ability to function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives.
6. An ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions.
7. An ability to acquire and apply new knowledge as needed, using appropriate learning strategies.

Dearborn Discovery Core (General Education)

All students must satisfy the University's Dearborn Discovery Core requirements (http://catalog.umd.umich.edu/undergraduate/gen_ed_ddc/), in addition to the requirements for the major

Major Requirements

A candidate for the degree Bachelor of Science in Engineering (Bioengineering) is required to pursue scholastic quality and to complete satisfactorily the following program of study:

In addition to completion of the Dearborn Discovery Core, the following courses are required to earn a BSE degree in Bioengineering from UM-Dearborn.

Code	Title	Credit Hours
Prerequisite Courses		
COMP 270	Tech Writing for Engineers (Also fulfills 3 credits of DDC Written and Oral Communication)	3
ECON 201	Prin: Macroeconomics (ECON 201 or 202 also fulfill 3 credits of DDC Social and Behavioral Analysis)	3
or ECON 202	Prin: Microeconomics	
MATH 115	Calculus I	4
MATH 116	Calculus II	4
MATH 215	Calculus III	4
MATH 228	Diff Eqns with Linear Algebra	4
CHEM 134	General Chemistry IA	4
CHEM 136	General Chemistry IIA	4
BENG 200	Anatomy and Physiology for Engineers	4
BIOL 140	Intro Molec & Cellular Biology	4
PHYS 150	General Physics I	3
PHYS 150L	General Physics I Lab/Dis	1
PHYS 151	General Physics II	3
PHYS 151L	General Physics II Lab/Dis	1
ENGR 100	Introduction to Engineering and Engineering Design	3
ENGR 126	Engineering Computer Graphics	2
ENGR 216	Computer Meth for Engineers	2
ENGR 250	Principles of Eng Materials	3
ME 230	Thermodynamics	4
ME 265	Applied Mechanics	4
Bioengineering Major Core		**27**
ECE 305	Intro to Electrical Eng	4
BENG 325	Thermofluid for Bioengineering	4
BENG 351	Bio-Sensors & Instrumentation	4
BENG 370	Biomechanics I	4
BENG 364	Prob&Stat in Bioengineering	3
BENG 375	Biomaterial Tissue Engrg	4
BENG 381	Bioprocessing	4
BENG 4671	Senior Design	4
Program Electives		**18**

Select a minimum of 18 credits of upper-level elective courses from the lists below. At least one course must be a design elective (3-4 credits). At least 9 credits (3 courses) must be from BENG courses.		18
Upper-Level Design Electives		
select one course from this area		
BENG 426	Fundamentals of Drug Delivery	
BENG 450	Biophotonics and Optical Metrology	
BENG 451	Microfluidics	
BENG 460	Nanobiosystems Engineering	
BENG 470	Advanced Biomechanics	
BENG 480	Mechanotransduction	
BENG 481	Biomimetics	
BENG 490	Directed Design Project	
ENGR 360	Design Thinking : Process, Method & Practice	
ENGR 493	Exper Hnrs Dir Dsgn	
ME 3601	Design and Analysis of Machine Elements	
ME 445	Sound and Noise Controls	
ME 472	Prin & Appl of Mechatronic Sys	
Upper-Level Technical Electives		
BCHM 370	Principles of Biochemistry	
BENG 410	Bioinformatics	
BENG 425	Transport in Biosystems	
BENG 475	Regenerative Engineering	
BENG 492	Guided Study in Bioengineering	
CHEM 225	Organic Chemistry I	
CHEM 226	Organic Chemistry II	
CHEM 227	Organic Chemistry Laboratory	
CHEM 437	Nano-Biotechnology	
ENGR 345	Effective Use of AI Tools for Scientists and Engineers	
ENGR 350	Nanoscience and Nanotechnology	
ENGR 399	Experiential Honors Prof. Prac	
ENGR 492	Exper Honors Directed Research	
IMSE 381	Industrial Robots	
IMSE 440	Applied stat models in engin	
IMSE 4425	Human Factors and Ergonomics	
IMSE 4675	Six Sigma & Stat Proc Improv	
ME 410	Finite Element Method wth Appl	
ME 442	Control Systems Analysis and Design	
ME 4550	Computational Uncertainty Quantification for Engineering Applications	
ME 491	Directed Research Problems	
ME 4950	Digital Manufacturing and Product Innovation	

Students admitted to the **BSE-BENG to MSE-BENG** 4+1 Option may substitute BENG 526 for BENG 426, BENG 550 for BENG 450, BENG 551 for BENG 451, BENG 560 for BENG 460, BENG 570 for BENG 470, BENG 575 for BENG 475, BENG 580 for BENG 480, ME 510 for ME 410, ME 555 for ME 4550, and BENG 595 for ME 4950.

Students admitted to the **BSE-BENG to MSE-MSCI** 4+1 Option may substitute BENG 575 for BENG 475, ME 555 for ME 4550, and ME 595 for ME 4950.

1. An ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics
2. An ability to apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors.
3. An ability to communicate effectively with a range of audiences
4. An ability to recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts
5. An ability to function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives
6. An ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions
7. An ability to acquire and apply new knowledge as needed, using appropriate learning strategies

BENG 200 Anatomy and Physiology for Engineers 4 Credit Hours
This course introduces undergraduate students in bioengineering to basic concepts in anatomy and physiology. Topics include cell, tissue, nervous, skeletal and muscular, circulatory, respiratory, digestive, endocrine, and urinary systems. Engineering analyses and principles will be used to describe the systems as applicable. Lab sections will be conducted for relevant selected systems. Performance will be assessed based on examinations and laboratory reports. Upon completion of this course, students will have the basic knowledge of anatomy and physiology relevant to bioengineering. (F, W).
Restriction(s):
Can enroll if Level is Undergraduate
Can enroll if College is Engineering and Computer Science

BENG 325 Thermofluid for Bioengineering 4 Credit Hours
This course is an introduction into mass and heat transport phenomena in biomedical systems. Basic mechanisms of fluid flow, heat transfer, and diffusion are presented and applied to biological objects (cells, tissues, organisms) and biomedical devices. Topics include mass, momentum, and energy conservation laws, physical properties of common and biological fluids, elements of fluid statics, control volume analysis, basics of fluid mechanics, conduction and convection heat transfer, diffusion, applications to hyper- and hypothermia, thermal ablation, and cryopreservation, basics of mass and heat transfer in the body. (YR).
Prerequisite(s): ENGR 216 and ME 230 and (ME 265 or ME 345) and MATH 228*
Restriction(s):
Can enroll if College is Engineering and Computer Science

BENG 351 Bio-Sensors & Instrumentation 4 Credit Hours
The course covers measurements in biological materials using a variety of sensor technologies along with electronic instrumentation design and use. Safety and FDA requirements are also presented.
Prerequisite(s): (MATH 216 or MATH 228) and BENG 200 and BIOL 140 and ECE 305 and (ENGR 216 or ECE 270)
Restriction(s):
Can enroll if Class is Junior or Senior
Can enroll if College is Engineering and Computer Science or Arts, Sciences, and Letters

BENG 364 Prob&Stat in Bioengineering 3 Credit Hours
Set theory, combinatorial analysis, probability and axioms, random variables, continuous and discrete distribution functions, expectations, Chebyshev's inequity, weak law of large numbers, central limit theorem, sampling statistics and distributions, point and interval estimation, and linear regression.
Prerequisite(s): MATH 116 or MATH 114
Restriction(s):
Can enroll if Class is Sophomore or Junior or Senior
Can enroll if College is Engineering and Computer Science

BENG 370 Biomechanics I 4 Credit Hours
The course provides a basic understanding of how the human body functions as a mechanical system. Review of mechanics. Musculoskeletal anatomy, statics and kinematics, muscle force redundancy, joint mechanics. Bone and soft tissue mechanics, muscle active force generation. Implant stress shielding and impact safety. Laboratory experiments directed at rehabilitation engineering, biological bone and tissue property measurement, bone and implant structural analysis, and impact safety.
Prerequisite(s): (ME 265 or ME 345) and (MATH 216 or MATH 228)
Restriction(s):
Can enroll if Program is BSE-Bioengineering

BENG 375 Biomaterial Tissue Engrg 4 Credit Hours
The course provides a basic understanding of the structure, properties and therapeutic applications of biomaterials, as well as the opportunities and scientific and technological challenges of tissue engineering. It also provides an integrated and multidisciplinary biological-engineering approach and probes mechanisms and methods of evaluation of tissue/biomaterials and patient/device interactions. Further the course assesses current outcomes, current challenges and cutting edge technological solutions to medical problems, Laboratory topics include key biological concepts, clinical safety, tissue culture, biological cells/bioactive materials interaction, and scaffold testing.
Prerequisite(s): ENGR 250 and BIOL 140
Restriction(s):
Can enroll if College is Engineering and Computer Science

BENG 381 Bioprocessing 4 Credit Hours
This course will introduce the students to the field of bioprocessing where the engineering concepts are applied to convert raw materials to pharmaceuticals, chemicals and food using biological processes. Discussions will include application of bioprocess-engineering knowledge in designing, building, controlling, and operating the biologically driven processes. Typical applications include bioreactor design, material collection and scale-up considerations. The course will also introduce the pharmacokinetics and pharmacodynamics analysis concepts to the students and will serve as an introductory course to teach how to use these concepts to design bioprocess-engineering systems. 4 credit hours (3 credit hours of lecture and 1 credit hour of lab).
Prerequisite(s): (ME 325 or BENG 325) and BIOL 140 and (CHEM 136 or CHEM 146)
Restriction(s):
Can enroll if College is Engineering and Computer Science

BENG 410 Bioinformatics 3 Credit Hours
This course covers fundamental computer skills for using various bioinformatics tools, querying bioinformatics databases, computational approaches and analysis methods for biological problems, and introduction to various programming languages and toolboxes for bioinformatics, data mining, and data visualization.
Restriction(s):
Can enroll if College is Engineering and Computer Science

BENG 425 Transport in Biosystems 3 Credit Hours
The course introduces transport phenomena in biological and medical systems to students already familiar with basic thermal-fluid sciences. Topics include properties of body fluids and cell membranes, blood flow and solute and oxygen transport in biological systems, basic principles of pharmacokinetic analysis, transport phenomena in medical devices and artificial organs.
Prerequisite(s): ME 375 or BENG 325*
Restriction(s):
Can enroll if College is Engineering and Computer Science

BENG 426 Fundamentals of Drug Delivery 3 Credit Hours
This course is designed to provide students with an understanding on the concepts in drug delivery from an engineering perspective. The course will cover drug delivery mechanisms, quantitative understanding of drug transport, nanotechnology, drug delivery devices, toxicity and immune response, FDA regulations, clinical trials and technology transfer. The course will conclude with a design project on nanoparticles development for targeted drug delivery. (F).
Prerequisite(s): (BENG 325 or ME 325*)
Restriction(s):
Can enroll if College is Engineering and Computer Science

BENG 450 Biophotonics and Optical Metrology 3 Credit Hours
The recent explosion of interest in minimally invasive medical diagnostics and contactless metrology has been fueled in part by the development of novel optics and photonics. A large number of optically-based imaging and sensing have moved beyond research laboratories into medical clinics, materials engineering, and industrial applications. Topics include design principles of optical instrumentation, techniques for diagnostics and metrology, and elastic and inelastic light scattering theory. Applications include optical metrology, confocal and multiphoton microscopy, light propagation and tomographic imaging in tissues, and design of minimally invasive spectroscopic systems. Optical systems design is included as a class project. (YR).
Prerequisite(s): PHYS 150 and PHYS 151
Restriction(s):
Can enroll if College is Engineering and Computer Science
Cannot enroll if Major is

BENG 451 Microfluidics 3 Credit Hours
Microscaled systems and devices have enhanced reaction rates, predictable fluid mechanics, reduced reagent volumes, and a cheaper path to rapid prototyping. These advantages benefit many biomedical and processes engineering applications that require sensitive molecular detection and precise flow controls. In this course, a range of microsystem techniques will be discussed, including those based on microfluidics, MEMS, and optofluidics. Lectures will be accompanied by student-driven design projects that will be conducted in 3-hour laboratories.
Prerequisite(s): (BENG 325 or ME 375*)
Restriction(s):
Can enroll if College is Engineering and Computer Science

BENG 460 Nanobiosystems Engineering 3 Credit Hours
Nanobiosystems Engineering is an emerging frontier in nanotechnology. It integrates materials science, bioengineering, physics and life science with the biological and biochemical applications. This fast-developing interdisciplinary field holds the promise to solve many of the medical problems of future. The course will introduce advanced concepts related to nanomaterials and nanofabrication and their application in medicine. The course will also focus on design and development of nano-devices for the applications of pharmaceuticals and healthcare. Typical applications include nano-biosensor, targeted drug delivery, and tissue engineering will also be discussed. Students in Bioengineering will have a chance to present and discuss individual application through team project.
Prerequisite(s): (ME 325 or BENG 325) and (ME 349 or BENG 351) and BENG 375
Restriction(s):
Can enroll if College is Engineering and Computer Science

BENG 4671 Senior Design 4 Credit Hours
A guided design project course where student teams propose design projects, design a device, system or process related to bioengineering and conduct evaluative experiments and/or construct a physical prototype. Engineering ethics and responsibility. At the end of the semester, the students are required to submit written reports and give oral presentations with a demonstration of their projects
Prerequisite(s): BENG 325 and BENG 351 and BENG 370 and (BENG 375 or BENG 381) and BENG 364
Restriction(s):
Can enroll if Class is Junior or Senior
Can enroll if Major is Bioengineering

BENG 470 Advanced Biomechanics 3 Credit Hours
The course covers intermediate level subject matter on structural biomechanics, analysis and design. Topics include: soft tissue biomechanics, human motion analysis including gait, orthopedic implants, fixation and reconstruction, head impact injury, advanced bone models. (YR).
Prerequisite(s): BENG 370
Restriction(s):
Can enroll if College is Engineering and Computer Science

BENG 475 Regenerative Engineering 3 Credit Hours
This course will discuss principles of tissue engineering whereby the properties of stem as well as primary cells, growth factors, and extracellular matrix and their impact in the development of engineered tissue constructs will be explored. In addition, the course will also focus on supporting/enabling technologies typically utilized in engineering these constructs including nano- and micro-fabrication techniques, 3D printing, micro-patterning as well as designing principles of bioreactors, and drug and gene delivery techniques. Additionally, various tissue engineering applications will be discussed including synthetic tissues and organs that are currently under development for regenerative medicine application.
Prerequisite(s): (ME 265 or ME 260) and BENG 375
Restriction(s):
Can enroll if College is Engineering and Computer Science

BENG 480 Mechanotransduction 3 Credit Hours
This course will provide a basic understanding of mechanotransduction and mechanobiology from the perspective of various microenvironments and how the aspects of these microenvironments drive cellular development, homeostasis, health, and disease. Students will learn how to read, interpret, and present information found in research articles as well as design novel bioreactor systems for physiologically relevant microenvironments that recapitulate the major mechanical forces and attributes of particular tissues and diseases. Students will gain group work and presentation experience through the design and presentation of these designs to their classmates. (OC).
Prerequisite(s): (ME 265 or ME 345) and BIOL 140

BENG 481 Biomimetics 3 Credit Hours
The Biomimetic Engineering course will give an overview and in-depth analysis of nature's solutions to specific problems with the aim of determining appropriate engineering analogs. Students will learn mechanical principles in nature and their application to engineering devices. Mechanical behavior of biological materials as governed by underlying microstructure will be discussed. Students will work in teams on projects where they will take examples of designs, concepts and models from biology and determine their potential in specific engineering applications. 3 credit hours
Prerequisite(s): (ME 325 or BENG 325*)
Restriction(s):
Can enroll if College is Engineering and Computer Science

BENG 490 Directed Design Project 1 to 3 Credit Hours
Design project involving not only design but also analysis, fabrication, and/or testing. Topics may be chosen from any of the areas of bioengineering. The student will need to submit a report on their project at the end of the term. Enrollment in this course requires approval from the ME department. Registration for more than 1 credit is only permitted in special cases and will be considered on an individual basis. (F, S, W).
Restriction(s):
Can enroll if College is Engineering and Computer Science
Cannot enroll if Major is

BENG 492 Guided Study in Bioengineering 1 to 3 Credit Hours
Individual study, design, or laboratory research in a field of interest to the student. Topics may be chosen from any areas of bioengineering. The student will need to submit a report on their project at the end of the term. Enrollment in this course requires approval from the ME department. Registration for more than 1 credit is only permitted in special cases and will be considered on an individual basis. (F, S, W).
Restriction(s):
Can enroll if Class is Senior
Can enroll if Level is Undergraduate
Can enroll if College is Engineering and Computer Science
Can enroll if Major is Bioengineering,

*An asterisk denotes that a course may be taken concurrently.

Frequency of Offering

The following abbreviations are used to denote the frequency of offering: (F) fall term; (W) winter term; (S) summer term; (F, W) fall and winter terms; (YR) once a year; (AY) alternating years; (OC) offered occasionally