BIOMEDICAL ENGINEERING

Department Website: Biomedical Engineering (https://www.gonzaga.edu/school-of-engineering-applied-science/degrees-and-programs/biomedical-engineering/)

Biomedical Engineering is a highly interdisciplinary program at Gonzaga University with the primary goal of improving the quality of life for people everywhere through the advancement of the medical industry. Biomedical engineers use their knowledge in science, engineering, and mathematics to design new solutions and solve problems in the medical field to help fulfill the Gonzaga Mission to be committed "to the dignity of the human person, social justice, diversity, intercultural competence, global engagement, solidarity with the poor and vulnerable, and care for the planet."

The biomedical engineering field is extraordinarily broad, with careers in medical electronics and imaging, medical device design, biochemistry, biology, medicine, manufacturing, business, and human physiology. Students at Gonzaga are prepared for this through a thorough grounding in a variety of mathematical, scientific, and engineering fundamentals while allowing students to specialize later in the curriculum through their choices of technical electives. As one of the most interdisciplinary degrees on campus, students will develop a base in a variety of areas including biology, chemistry, physics, computer science, human anatomy and physiology, all in parallel to their engineering courses. The fundamentals are enhanced with exposure to important engineering tools such as: mathematical techniques; computer programming; computer applications including computer aided design (CAD), electronics, and laboratory equipment. All students engage in design courses beginning in their Freshman year leading to a culminating two-semester capstone design experience in the Senior year. The capstone experience typically entails requiring student design teams, led jointly by faculty and practicing engineers, to solve real industrial design problems. Finally, the degree requirements also include the opportunity for breadth as well as concentration in particular engineering applications through a group of technical electives taken in the senior year (the list of allowed technical electives is given below). Students must take 12 credits of technical electives, 3 credits of which must come from an engineering course. These electives come from a wide range of departments and some include accompanying 1 credit labs. Note that some classes on the technical elective list have additional prerequisites required outside of the standard curriculum or a course on this list may be a prerequisite for another technical elective on the list. Students are encouraged to plan accordingly and discuss their desired area of emphasis and course scheduling with their academic advisor. All semesters in the plan with technical electives have 17 or fewer credits to allow for the additional credit of those courses with an accompanying lab. Information is also available for students planning to enroll in the Gonzaga-in-Florence Engineering Semester program which can be done using the same course schedule as below.

The following curriculum details the course requirements for each semester. In addition to these courses, all students must take the Fundamentals of Engineering Examination prior to graduation (see ENSC 400 Foundations of Engineering Exam course in the Spring semester of the Senior year). Finally, students who follow a curriculum sequence other than that listed below should meet with their Academic Advisors at their first opportunity in order to resolve any scheduling conflicts that may arise due to off-schedule course availability and/or course pre- and co-requisite structure. In all cases, students must comply with the pre- and co-requisite requirements in order to be granted admission into courses.

The Bachelor of Science in Biomedical Engineering degree program is in the process of becoming accredited by the Engineering Accreditation Commission of ABET, www.abet.org (http://www.abet.org/).

Biomedical Engineering (BS) Major Program Requirements

Course	Title	Hours
First Year		
Fall		
CHEM 101	General Chemistry I	3
CHEM 101L	General Chemistry I Lab	1
DEPT 193	FYS:	3
MATH 157	Calculus and Analytic Geometry I	4
COMM 100	Communication and Speech	3
PHIL 101	Reasoning	3
	Hours	**17**
Spring		
ENGL 101	Writing	3
MATH 258	Calculus and Analytic Geometry II	4
BIOL 105	Information Flow in Biological Systems	3
BIOL 105L	Information Flow in Biological Systems Lab	1
MENG 291	Introduction to Mechanical Engineering Design	2
MENG 291L	Introduction to Mechanical Engineering Design Lab	1
PHIL 201	Philosophy of Human Nature	3
	Hours	**17**
Second Year		
Fall		
MATH 259	Calculus and Analytic Geometry III	4
PHYS 121	Physics I	4
PHYS 121L	Physics I Lab	1
ENSC 205	Statics	3
Approved Computing Course		3
CPSC 121	Computer Science I	
CPSC 215	Special Topics	
ENSC 201	Programming for Engineers	
or as approved by Biomedical Engineering Department Chair		
BIOL 106	Energy Flow in Biological Systems	3
	Hours	**18**
Spring		
MATH 260	Ordinary Differential Equation	3
MATH 321	Statistics for Experimentalist	3
ENSC 306	Dynamics	3
ENSC 301	Mechanics of Materials I	3
Ethics Core Elective		3
RELI XXX World or Comparative Religion		3
	Hours	**18**
Third Year		
Fall		
CHEM 230 & 230L	Organic Chemistry I and Organic Chemistry Lab I	4
EENG 201 & 201L	Circuit Analysis I and Circuit Analysis I Lab	4
HPHY 241 & 241L	Human Anatomy and Physiology and Human Anatomy and Physiology Lab	4
1st Core Broadening Requirement: (History, Literature, Social and Behavioral Science)		3
	Hours	**15**

Spring		
PHYS 122 & 122L	Physics II and Physics II Lab	5
Select one of the following:		
BENG 320	Bio Thermo/Fluids	
ENSC 355	Thermal Science	
Technical Elective		3
2nd Core Broadening Requirement: (History, Literature, Social and Behavioral Science)		3
RELI XXX Christianity and Catholic Traditions		3
	Hours	**14**
Fourth Year		
Fall		
BENG 410	Biotransport	3
Select one of the following:		3-4
BENG 301	Biomedical Signals and Systems	
EENG 311	Signals and Systems I	
Select one of the following:		3
EENG 411	Introduction to Control Systems	
MENG 461	System Dynamics and Control	
ENSC 491	Senior Design Project I	2
Technical Elective		3
Technical Elective		3
	Hours	**17-18**
Spring		
ENSC 400	Foundations of Engineering Exam	0
ENSC 492	Senior Design Project II	3
BENG 421 & 421L	Modeling of Biomedical Systems and Modeling of Biomedical Systems Lab	4
BENG 415	FDA Regulations and Ethics	2
Technical Elective		3
BENG 432	CIS: (CIS:)	3
	Hours	**15**
	Total Hours	**131-132**

Technical Electives

The courses used to satisfy the technical elective requirements must normally be selected from the following list. However, students may take other courses for technical elective credits but only with the prior approval of both the student's academic advisor and the Director of the Biomedical Engineering program. The actual technical elective courses offered from the list below varies from year to year and the program may on occasion offer one or more pre-approved technical elective courses that are not listed below. By following the above curriculum, students are not guaranteed to have all the necessary prerequisites for every course on this list. Students wishing to take these courses should plan well in advance in order to comply with all admission requirements prior to enrolling in the course. All students must complete at least 12 credits of technical electives. At least 3 credits must be from engineering courses (i.e. BENG, CPEN, EENG, MENG, or ENSC).

Code	Title	Hours
BIOL 207	Genetics	3
BIOL 207L	Genetics Lab	1
BIOL 351	Advanced Cell Biology	3
BIOL 351L	Advanced Cell Biology Lab	1
BIOL 370	Microbiology	3
BIOL 370L	Microbiology Lab	1
BIOL 456	Molecular Biology	3
BIOL 456L	Molecular Biology Lab	1
CHEM 231	Organic Chemistry II	3
CHEM 231L	Organic Chemistry Lab II	1
CHEM 307	Biochemistry I	3
CHEM 307L	Biochemistry I Lab	1
CHEM 308	Biochemistry II	3
CHEM 405-CHEM 480 Special Topics Electives		3
HPHY 242	Human Anatomy and Physiology II	3
HPHY 242L	Human Anatomy and Physiology Lab II	1
HPHY 274	Musculoskeletal Dynamics and Physiology	3
HPHY 375	Biomechanics	3
HPHY 375L	Biomechanics Lab	1
CPSC 222	Introduction to Data Science	3
CPEN 231	Embedded Computer Systems	3
CPEN 436	Machine Learning in Biomed	3
EENG 322	Signals and Systems II	3
EENG 401	Lower Power Bioelectronics	3
EENG 424	Digital Signal Processing	3
MENG 221	Materials Engineering	3
MENG 330	Machine Design	3
MENG 468	Biomaterials and Biomechanical Engineering	3
MENG 456	Design for Manufacturing	3
MENG 465	Introduction to Finite Element	3
MENG 477	Materials Selection for Design	3
MENG 479	Tribology	3
ENSC 481	Special Topics in Engineering	1-6
PHYS 452	Optics	3
PHYS 456	Biophysical Systems and Modeling	3

[1] Approved courses are: CPSC 121 Computer Science I, ENSC 201 Programming for Engineers, CPSC 215 Special Topics, or as approved by the Biomedical Engineering Program Director

Courses

BENG 301. Biomedical Signals and Systems. (3 Credits)
Study of various signal types, system properties, and analytical tools such as convolution, Fourier series, Fourier and Laplace transforms, and the Sampling Theorem. Emphasizing practical applications in biomedical sciences, students learn to describe and analyze continuous-time and discrete-time signals, apply transforms to understand signal properties, and utilize filters to reduce noise and characterize biological signals.
Prerequisites: Prerequisites exist. Refer to Zagweb.

BENG 320. Bio Thermo/Fluids. (3 Credits)
First and second law of thermodynamics applied to closed and open systems; basics of fluid flow in simple systems; introduction to conduction, convection, and radiation heat transfer. Particular focus on laws of thermodynamics, fluids, and heat transfer in respect to human systems. Spring,
Prerequisites: Prerequisites exist. Refer to Zagweb.

BENG 410. Biotransport. (3 Credits)
Transport phenomena in biological systems and medical devices using quantitative and mathematical approaches. Concepts are applied to quantitative physiology, transport data analysis, and medical devices. Fall.
Prerequisites: Prerequisites exist. Refer to Zagweb.

BENG 415. FDA Regulations and Ethics. (2 Credits)
Introduction into the FDA regulatory requirements for devices and pharmaceuticals. Explores ethical issues in biomedical and medical sciences and engineering practices and includes medical ethics, engineering ethics, the Biomedical Engineering Society (BMES) Code of Ethics, the ethics of human and animal tissue and subjects use, responsible conduct for research, and the impact of biomedical engineering solutions on society and the environment. Spring.

BENG 421. Modeling of Biomedical Systems. (3 Credits)
Apply and solidify signals, systems, and instrumentation principles through examples and electronic device implementation. Instruction will be linked to hands-on lab experiences. Example systems include pulse oximetry, real-time glucose monitoring, ultrasound flow measurements, and fluorescence imaging. The goal is to build prototype devices using modular electronics and develop basic modeling approaches for physiological systems. Spring.
Prerequisites: (BENG 301 with a minimum grade of D or EENG 311 with a minimum grade of D) and EENG 201 with a minimum grade of D
Corequisites: BENG 421L

BENG 421L. Modeling of Biomedical Systems Lab. (1 Credit)
Apply and solidify signals, systems, and instrumentation principles through examples and electronic device implementation. Instruction will be linked to hands-on lab experiences. Example systems include pulse oximetry, real-time glucose monitoring, ultrasound flow measurements, and fluorescence imaging. The goal is to build prototype devices using modular electronics and develop basic modeling approaches for physiological systems. Spring.
Prerequisites: (BENG 301 with a minimum grade of D or EENG 311 with a minimum grade of D) and EENG 201 with a minimum grade of D
Corequisites: BENG 421

BENG 432. CIS:. (3 Credits)