

## BIOENGINEERING

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**DEGREES OFFERED: BSB, MBE, MS, PHD**

Graduate programs in bioengineering offer concentrations in areas that include cellular and molecular engineering; bioinstrumentation, imaging, and optics; biomaterials and biomechanics; and computational bioengineering. Undergraduate programs in bioengineering offer concentrations in areas that include cellular and molecular engineering; bioinstrumentation, imaging, and optics; and biomaterials and biomechanics. Research areas include biomechanical engineering, biological systems modeling, bioinformatics, biomaterials, biomedical lasers, cellular and molecular engineering, controlled release technologies, metabolic engineering, spectroscopy, statistical mechanics, systems engineering and instrumentation, thrombosis, tissue engineering, and transport processes.

**Undergraduate Program**—The bioengineering undergraduate program will prepare students for careers in rapidly developing areas of biomedical engineer-

ing and bioprocessing. Our unified and comprehensive program leading to the BS degree in bioengineering will:

- Provide students with a fundamental understanding of mathematics and the natural, life, and medical sciences
- Teach students bioengineering principles and their applications in life and medical sciences
- Develop their critical problem-solving skills in bioengineering.
- Develop their ability to communicate effectively and participate in interdisciplinary teams
- Expose students to a broad education that prepares them for diverse careers

Undergraduates in bioengineering will then have the training to pursue further education in graduate school or medical school and will have strong preparation for a career in the biotechnology industry.

The BSB degree is organized around a core of required courses and a selection of elective courses from three areas of specialization. The specialization electives provide a flexibility that can be used to create a focus in cellular and molecular engineering; bioinstrumentation, imaging, and optics; or biomaterials and biomechanics. Because of the number of options, students should consult early with departmental advisors to plan a program that meets their needs.

#### DEGREE REQUIREMENTS FOR BS IN BIOENGINEERING

For general university requirements, see Graduation Requirements (pages 14–15). The curriculum for a BS degree in bioengineering requires 94 credit hours, which count toward the total of 134 hours required to graduate.

**Preparation**—As freshmen, students considering a major in bioengineering should take MATH 101 and 102, CHEM 121 and 122, PHYS 101 or PHYS 125, PHYS 102 or PHYS 126, and CAAM 210. Sophomore students should take MATH 211 and 212, CHEM 211, BIOS 201, ELEC 243 and MECH 211. BIOE 252 should be taken in the first semester of the sophomore year. BIOE 330, BIOE 320, and BIOE 322 should be taken the second semester of the sophomore year.

Students majoring in bioengineering must complete the following courses.

##### **Core Courses**

##### **Bioengineering**

BIOE 252 *Bioengineering Fundamentals*  
 BIOE 320 *Systems Physiology Laboratory Module*  
 BIOE 322 *Systems Physiology*  
 BIOE 330 *Bioreaction Engineering*  
 BIOE 332 *Thermodynamics*  
 BIOE 342 *Tissue Culture Laboratory*  
 BIOE 370 *Biomaterials*  
 BIOE 372 *Biomechanics*  
 BIOE 383 *Biomedical Instrumentation*  
 BIOE 384 *Biomedical Instrumentation Laboratory Module*  
 BIOE 391 *Numerical Methods*

BIOE 420 *Biosystems Transport and Reaction Processes*

BIOE 440 *Statistics for Bioengineers*

BIOE 442\* *Tissue Engineering Laboratory Module*

BIOE 443\* *Bioprocessing Laboratory Module*

BIOE 444\* *Biomechanical Testing Laboratory Module*

BIOE 445\* *Advanced Bioinstrumentation Laboratory Module*

BIOE 451 *Bioengineering Design I*

BIOE 452 *Bioengineering Design II*

##### **Biosciences**

BIOS 201 *Introductory Biology*

BIOS 341 *Cell Biology*

**Computational and Applied Mathematics**

CAAM 210 *Introduction to Engineering Computation*

**Chemistry**

CHEM 121 *General Chemistry*

CHEM 122 *General Chemistry*

CHEM 211 *Organic Chemistry*

**Math**

MATH 101 *Single Variable Calculus I*

MATH 102 *Single Variable Calculus II*

MATH 211 *ODEs and Linear Algebra*

MATH 212 *Multivariable Calculus*

**Electrical Engineering**

ELEC 243 *Introduction to Electronics*

**Mechanical Engineering**

MECH 211 *Engineering Mechanics*

**Physics**

PHYS 101, PHYS 111, or PHYS 125 *Mechanics*

PHYS 102, PHYS 112, or PHYS 126 *Electricity and Magnetism*

\*Students must take the advanced laboratory module in their specialization area: BIOE 442 or BIOE 443 for cellular and molecular engineering, BIOE 442 or 444 for biomaterials and biomechanics, and BIOE 445 for bioinstrumentation, imaging and optics. Students must take one other advanced laboratory module for a total of two of the four listed modules (BIOE 442, 443, 444, and 445).

**SPECIALIZATION AREAS**

Three specialization area elective courses, at least two of which must be at the senior level, will be required in one of the three areas:

- Cellular and molecular engineering
- Bioinstrumentation, imaging, and optics
- Biomaterials and biomechanics

The elective courses in these concentration areas will be announced in future course listings. All three specialization courses must be engineering courses.

**Graduate Program**—The bioengineering graduate program at Rice educates its students so that they can directly interact with physicians and cell and molecular biologists, while still excelling in the quantitative capabilities so important for engineering applications.

**DEGREE REQUIREMENTS FOR MBE AND MS AND PHD IN BIOENGINEERING**

For general university requirements, see Graduate Degrees (pages 57–58).

**MBE Program**—The master of bioengineering degree is intended for those having a BA or BS degree in an engineering or science discipline.

To obtain an MBE from the bioengineering department, you must complete the following course work:

1. Curriculum must be approved by the Academic Affairs Committee of the bioengineering department. (This will be done on a case-by-case basis).
2. Total of 30 credit hours is required (courses must be above and beyond the requirement for the undergraduate degree) as follows:

- At least 15 credit hours of the 30 must be taken as BIOE courses, including Biosystems Transport and Reaction Processes (BIOE 520) and Fundamentals of Systems Physiology (BIOE 572)
- Introduction to Partial Differential Equations (MATH 381) (3 hours)
- One additional engineering course (3 hours)
- Three additional courses approved by the Academic Affairs Committee (9 hours)

In summary, the credit hours required are:

- 15 credit hours of BIOE courses
- 3 credit hours of MATH 381
- 3 credit hours of one additional engineering course
- 9 credit hours of additional courses approved by the Academic Affairs Committee
- 30 Total credit hours

**MS Program**—Candidates for the MS degree must:

- Complete at least 18 semester hours of foundation, supporting, and advanced courses with high standing
- Fulfill a teaching requirement
- Submit an original research thesis
- Defend the thesis in a public oral examination

**PhD Program**—Candidates for the PhD degree must:

- Complete at least 36 approved semester hours of foundation, supporting, and advanced courses, with high standing. With departmental approval, the course requirements may be reduced to not less than 22 hours for students already holding an MS degree.
- Fulfill a teaching requirement. After their first semester in residence, students may be asked to spend the equivalent of 6 to 10 hours per week for a total of three semesters on teaching assignments.
- Submit a thesis proposal. PhD students must submit and successfully defend their thesis proposals by the end of their fourth semester in residence.
- Complete a three- to six-month industrial internship. This requirement may be waived for those with adequate previous industrial experience.
- Submit a thesis that provides evidence of their ability to carry out original research in a specialized area of bioengineering.
- Defend the thesis in a public oral examination.

Graduate students take required courses and electives in the following areas:

- Cellular and molecular engineering
- Bioinstrumentation, imaging, and optics
- Biomaterials and biomechanics
- Computational bioengineering

See **BIOE in the Courses of Instruction section.**