BACHELOR OF SCIENCE IN BIOENGINEERING (BSBE) DEGREE

The program leading to the BSBE degree is accredited by the Engineering Accreditation Commission (EAC) of ABET, https://www.abet.org.

Program Learning Outcomes (Student Outcomes) for the BSBE Degree

Upon completing the BSBE degree, students will be able to demonstrate:

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.

Program Educational Objectives for the BSBE Degree

The overall goal of the Bachelor of Science in Bioengineering (BSBE) degree is to prepare graduates to succeed in professional careers by equipping them with the conceptual and technical expertise sought after by top graduate and medical schools, as well as by companies seeking technical skills in bioengineering. Recognizing that graduates may embark on a number of different educational and career paths, the Program Educational Objectives (PEOs) that graduates are expected to exhibit or achieve with the Bachelor of Science in Bioengineering (BSBE) degree from Rice University are:

1. Graduates demonstrate technical and/or professional skills, which may include engineering problem-solving, scientific inquiry, and/or engineering design, to solve challenging problems in bioengineering and related fields.
2. Graduates are accomplished at communicating and working collaboratively in diverse work environments.
3. Graduates seeking further education at graduate, medical or other professional schools find appropriate levels of success in admission to and progression through these programs. Graduates entering professional careers find appropriate career progression and success.

Requirements for the BSBE Degree

For general university requirements, see Graduation Requirements (ga.rice.edu/undergraduate-students/academic-policies-procedures/graduation-requirements). Students pursuing the BSBE degree must complete:

- A minimum of 37 courses (96 or 98 credit hours, depending on course selection) to satisfy major requirements.
- A minimum of 131 credit hours to satisfy degree requirements.
- A minimum of 20 courses (48 credit hours) taken at the 300-level or above.

The courses listed below satisfy the requirements for this major. In certain instances, courses not on this official list may be substituted upon approval of the major’s academic advisor, or where applicable, the department’s Director of Undergraduate Studies. (Course substitutions must be formally applied and entered into Degree Works by the major’s Official Certifier (https://registrar.rice.edu/facstaff/degeworks/officialcertified/).) Students and their academic advisors should identify and clearly document the courses to be taken.

Summary

<table>
<thead>
<tr>
<th>Code</th>
<th>Title</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Total Credit Hours Required for the Major in Bioengineering</td>
<td>96 or 98</td>
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<tr>
<td></td>
<td>Total Credit Hours Required for the BSBE Degree</td>
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Degree Requirements

<table>
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<tr>
<th>Code</th>
<th>Title</th>
<th>Credit Hours</th>
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<tr>
<td></td>
<td>Core Requirements</td>
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<tr>
<td>BIOC 201</td>
<td>INTRODUCTORY BIOLOGY ²</td>
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<td>BIOC 341</td>
<td>CELL BIOLOGY</td>
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</tr>
<tr>
<td>CHEM 121</td>
<td>GENERAL CHEMISTRY I ¹</td>
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<tr>
<td>or CHEM 111</td>
<td>AP/OTH CREDIT IN GENERAL CHEMISTRY I</td>
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<tr>
<td>CHEM 123</td>
<td>GENERAL CHEMISTRY LABORATORY I ¹</td>
<td>1</td>
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<tr>
<td>or CHEM 113</td>
<td>AP/OTH CREDIT IN GENERAL CHEMISTRY LAB I</td>
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<tr>
<td>CHEM 122</td>
<td>GENERAL CHEMISTRY II ¹</td>
<td>3</td>
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<tr>
<td>or CHEM 112</td>
<td>AP/OTH CREDIT IN GENERAL CHEMISTRY II</td>
<td></td>
</tr>
<tr>
<td>CHEM 124</td>
<td>GENERAL CHEMISTRY LABORATORY II ¹</td>
<td>1</td>
</tr>
<tr>
<td>or CHEM 114</td>
<td>AP/OTH CREDIT IN GENERAL CHEMISTRY LAB II</td>
<td></td>
</tr>
<tr>
<td>CHEM 211 &amp; CHEM 213</td>
<td>ORGANIC CHEMISTRY I and ORGANIC CHEMISTRY DISCUSSION ²</td>
<td>3</td>
</tr>
<tr>
<td>CAAM 210</td>
<td>INTRODUCTION TO ENGINEERING COMPUTATION ¹</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>Computational and Applied Mathematics</td>
<td></td>
</tr>
<tr>
<td>ELEC 243</td>
<td>ELECTRONIC MEASUREMENT SYSTEMS ²</td>
<td>4</td>
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<tr>
<td>Mathematics</td>
<td></td>
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<tr>
<td>MATH 101</td>
<td>SINGLE VARIABLE CALCULUS I ¹</td>
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<td>or MATH 105</td>
<td>AP/OTH CREDIT IN CALCULUS I</td>
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<tr>
<td>MATH 102</td>
<td>SINGLE VARIABLE CALCULUS II ¹</td>
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<td>or MATH 106</td>
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</table>
Bachelor of Science in Bioengineering (BSBE) Degree

MATH 211  ORDINARY DIFFERENTIAL EQUATIONS AND LINEAR ALGEBRA 2  3
MATH 212  MULTIVARIABLE CALCULUS 2  3

Mechanical Engineering
MECH 202  MECHANICS/STATICS  3
or MECH 211 / ENGINEERING MECHANICS
CEVE 211

Physics
Select 1 from the following:  4

<table>
<thead>
<tr>
<th>Course</th>
<th>Description</th>
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<tbody>
<tr>
<td>PHYS 101</td>
<td>MECHANICS (WITH LAB)</td>
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<tr>
<td>PHYS 103</td>
<td>MECHANICS DISCUSSION 1</td>
</tr>
<tr>
<td>PHYS 111</td>
<td>HONORS MECHANICS (WITH LAB) 1</td>
</tr>
<tr>
<td>PHYS 125</td>
<td>GENERAL PHYSICS (WITH LAB) 1</td>
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Select 1 from the following:  4

<table>
<thead>
<tr>
<th>Course</th>
<th>Description</th>
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<tbody>
<tr>
<td>PHYS 102</td>
<td>ELECTRICITY &amp; MAGNETISM (WITH LAB)</td>
</tr>
<tr>
<td>PHYS 104</td>
<td>ELECTRICITY AND MAGNETISM DISCUSSION 1</td>
</tr>
<tr>
<td>PHYS 112</td>
<td>HONORS ELECTRICITY &amp; MAGNETISM (WITH LAB) 1</td>
</tr>
<tr>
<td>PHYS 126</td>
<td>GENERAL PHYSICS II (WITH LAB) 1</td>
</tr>
</tbody>
</table>

Bioengineering Core Courses
BIOE 252  BIOENGINEERING FUNDAMENTALS 2  4
BIOE 320  SYSTEMS PHYSIOLOGY LAB MODULE 2  1
BIOE 322  FUNDAMENTALS OF SYSTEMS PHYSIOLOGY 2  3
BIOE 330  BIOREACTION ENGINEERING 4  3
BIOE 332  BIOENGINEERING THERMODYNAMICS 4  3
BIOE 342 / CHBE 420  LABORATORY IN TISSUE CULTURE 1
BIOE 370  BIOMATERIALS 3
BIOE 372  BIOMECHANICS 3
BIOE 383  BIOMEDICAL ENGINEERING INSTRUMENTATION 3
BIOE 385  BIOMEDICAL INSTRUMENTATION LAB 1
BIOE 391  NUMERICAL METHODS 2  3
BIOE 420 / CHBE 420  TRANSPORT PHENOMENA IN BIOENGINEERING 4  3

Select 1 course from the following:  1 or 3

<table>
<thead>
<tr>
<th>Course</th>
<th>Description</th>
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<tbody>
<tr>
<td>BIOE 439</td>
<td>APPLIED STATISTICS FOR BIOENGINEERING AND BIOTECHNOLOGY</td>
</tr>
<tr>
<td>BIOE 440 / STAT 440</td>
<td>STATISTICS FOR BIOENGINEERING 2</td>
</tr>
</tbody>
</table>
| BIOE 451 | BIOENGINEERING DESIGN I 5  3
| BIOE 452 | BIOENGINEERING DESIGN II 3 |

Bioengineering Laboratory Courses 3

Select 2 courses from the following (different laboratory modules may be offered each year):  2

<table>
<thead>
<tr>
<th>Course</th>
<th>Description</th>
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</thead>
<tbody>
<tr>
<td>BIOE 442</td>
<td>TISSUE ENGINEERING LAB MODULE</td>
</tr>
<tr>
<td>BIOE 443</td>
<td>BIOPROCESSING LAB MODULE</td>
</tr>
<tr>
<td>BIOE 444</td>
<td>MECHANICAL TESTING LAB MODULE</td>
</tr>
<tr>
<td>BIOE 445</td>
<td>ADVANCED INSTRUMENTATION LAB MODULE</td>
</tr>
<tr>
<td>BIOE 446</td>
<td>COMPUTATIONAL MODELING LAB</td>
</tr>
<tr>
<td>BIOE 447</td>
<td>DIGITAL DESIGN &amp; VISUALIZATION 6</td>
</tr>
</tbody>
</table>

BIOE 449 / GLHT 449  CLINICALLY-RELEVANT BIOMEDICAL EQUIPMENT

Technical Electives
Select a minimum of 3 elective courses and 6 Engineering Points from the Technical Elective course offerings (see course list below)  9

Total Credit Hours Required for the Major in Bioengineering 96-98

University Graduation Requirements (ga.rice.edu/undergraduate-students/academic-policies-procedures/graduation-requirements) 34

Total Credit Hours 131

Footnotes and Additional Information
* Includes coursework completed as distribution credit, FWIS, LPAP, upper-level, residency (hours taken at Rice), 60 hours outside of the major (if applicable), and any additional academic program requirements. The “hours outside of the major” requirement may include all of the above university requirements.
1 Students should complete these courses during their freshman year.
2 Students should complete these courses during their sophomore year.
3 BIOE 400 can be counted in place of one of the required senior laboratory courses if taken for at least 3 credit hours at once. If used in this capacity, the student cannot also count that iteration of the course towards an Engineering Point or Technical Elective Requirements.
4 One of BIOE 330, BIOE 332, or BIOE 420 can be replaced with one or more additional Technical Elective courses of equal or greater BIOE Engineering Points value. Engineering points for the courses are: BIOE 330 (2 points), BIOE 332 (3 points), or BIOE 420 (3 points).
5 The Department of Bioengineering anticipates that BIOE 451 will change from 3 credit hours to 4 credit hours in academic year 2020-2021.
6 IF BIOE 447 is taken as a Bioengineering Laboratory course, the student should note that ENGI 355, listed in the Technical Electives section, will not count as a course that satisfies the Technical Electives Requirement.

Course Lists to Satisfy Requirements
Technical Electives
To fulfill the remaining BIOE major requirements, students must complete a minimum of 3 courses (9 credit hours) and 6 Engineering Points from the Technical Elective course offerings. A combination of Technical Electives must be selected that meets this minimum of 3 courses (9 credit hours) and 6 Engineering Points. If a student should choose to replace one of the optional core courses (BIOE 330, BIOE 332, or BIOE 420), then a minimum of 4 Technical Electives will be required as well as adequate Engineering Points for the replaced course’s value (2 to 3 Engineering Points).

Please Note: The following list of courses are those that satisfy the approved Technical Electives requirement. In certain instances, courses not on this official list may be substituted upon approval of the department’s Director of Undergraduate Studies. Students and their academic advisors should identify and clearly document the courses to be taken.
Engineering Points
Courses listed below may count toward the Technical Elective requirement (minimum of 3 courses (9 credit hours) and 6 Engineering Points), and will carry the following Engineering Point values.

**Please Note:** the list of courses and their associated Engineering Point values may change. Students should check with their academic advisor before registering for Technical Elective courses.

<table>
<thead>
<tr>
<th>Code</th>
<th>Title</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>BIOE 401</td>
<td>UNDERGRADUATE RESEARCH</td>
<td>1-4</td>
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**One (1) Engineering Point**

<table>
<thead>
<tr>
<th>Code</th>
<th>Title</th>
<th>Credit Hours</th>
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</thead>
<tbody>
<tr>
<td>BIOE 392 / GLHT 392</td>
<td>NEEDS FINDING AND DEVELOPMENT IN BIOENGINEERING</td>
<td>3</td>
</tr>
<tr>
<td>BIOE 400</td>
<td>ENGINEERING UNDERGRADUATE RESEARCH</td>
<td>1-4</td>
</tr>
<tr>
<td>BIOE 403</td>
<td>ADVANCES IN BIONANOTECHNOLOGY</td>
<td>3</td>
</tr>
<tr>
<td>BIOE 408</td>
<td>SYNTHETIC BIOLOGY</td>
<td>3</td>
</tr>
<tr>
<td>BIOE 422</td>
<td>GENE THERAPY</td>
<td>3</td>
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**Select 1 course from the following:**

<table>
<thead>
<tr>
<th>Code</th>
<th>Title</th>
<th>Credit Hours</th>
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<tbody>
<tr>
<td>BIOE 464 / BIOC 464</td>
<td>EXTRACELLULAR MATRIX</td>
<td>3</td>
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<tr>
<td>BIOE 524 / BIOC 523</td>
<td>EXTRACELLULAR MATRIX</td>
<td>3</td>
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<tr>
<td>BIOE 485 / COMP 485 / ELEC 485</td>
<td>FUNDAMENTALS OF MEDICAL IMAGING I</td>
<td>3</td>
</tr>
<tr>
<td>BIOE 486 / COMP 486 / ELEC 486</td>
<td>FUNDAMENTALS OF MEDICAL IMAGING II</td>
<td>3</td>
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<tr>
<td>BIOE 492</td>
<td>SENSORY NEUROENGINEERING</td>
<td>3</td>
</tr>
<tr>
<td>BIOE 523 / CHBE 523</td>
<td>BIOENGINEERING SYSTEMS AND CONTROL</td>
<td>3</td>
</tr>
<tr>
<td>BIOE 580 / CHBE 580</td>
<td>PROTEIN ENGINEERING</td>
<td>3</td>
</tr>
<tr>
<td>BIOE 587</td>
<td>OPTICAL IMAGING AND NANOBIOPHOTONICS</td>
<td>3</td>
</tr>
<tr>
<td>BIOE 589 / BIOC 589</td>
<td>COMPUTATIONAL MOLECULAR BIOENGINEERING/BIOPHYSICS</td>
<td>3</td>
</tr>
<tr>
<td>BIOE 615</td>
<td>BIOENGINEERING AND CARDIAC SURGERY</td>
<td>3</td>
</tr>
<tr>
<td>BIOE 620 / CHBE 620</td>
<td>TISSUE ENGINEERING</td>
<td>3</td>
</tr>
<tr>
<td>CHBE 310</td>
<td>FUNDAMENTALS OF BIOMOLECULAR ENGINEERING</td>
<td>3</td>
</tr>
<tr>
<td>ENGI 300</td>
<td>ENGINEERING DESIGN WORKSHOP</td>
<td>2-3</td>
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<tr>
<td>ELEC 220</td>
<td>FUNDAMENTALS OF COMPUTER ENGINEERING</td>
<td>4</td>
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<tr>
<td>ELEC 489 / CAAM 416 / NEUR 416</td>
<td>NEURAL COMPUTATION</td>
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<tr>
<td>MECH 311 / CEVE 311</td>
<td>MECHANICS OF SOLIDS AND STRUCTURES</td>
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**Two (2) Engineering Points**

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<tr>
<td>BIOE 321</td>
<td>CELLULAR ENGINEERING</td>
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<table>
<thead>
<tr>
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<tbody>
<tr>
<td>BIOE 348</td>
<td>MOLECULAR TECHNIQUES IN BIOENGINEERING</td>
<td>3</td>
</tr>
<tr>
<td>BIOE 381 / ELEC 381</td>
<td>FUNDAMENTALS OF NERVE AND MUSCLE ELECTROPHYSIOLOGY</td>
<td>3</td>
</tr>
<tr>
<td>BIOE 431</td>
<td>BIOMATERIALS APPLICATIONS</td>
<td>3</td>
</tr>
<tr>
<td>BIOE 481 / ELEC 481 / NEUR 481</td>
<td>COMPUTATIONAL NEUROSCIENCE AND NEURAL ENGINEERING</td>
<td>3</td>
</tr>
<tr>
<td>BIOE 482 / ELEC 482</td>
<td>PHYSIOLOGICAL CONTROL SYSTEMS</td>
<td>3</td>
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<tr>
<td>BIOE 518</td>
<td>INTRODUCTION TO COMPUTATIONAL BIOLOGY</td>
<td>3</td>
</tr>
<tr>
<td>BIOE 643 / BIOC 643 / PHYS 643</td>
<td>CELL MECHANICS, MECHANO TRANSDUCTION AND THE CELL MICROENVIRONMENT</td>
<td>3</td>
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<tr>
<td>CAAM 335</td>
<td>MATRIX ANALYSIS</td>
<td>3</td>
</tr>
<tr>
<td>CHBE 640 / BIOC 540</td>
<td>METABOLIC ENGINEERING</td>
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<tr>
<td>COMP 571 / BIOC 571</td>
<td>BIOINFORMATICS: SEQUENCE ANALYSIS</td>
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<tr>
<td>ELEC 305</td>
<td>INTRODUCTION TO PHYSICAL ELECTRONICS</td>
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<tr>
<td>ELEC 327</td>
<td>IMPLEMENTATION OF DIGITAL SYSTEMS</td>
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<tr>
<td>ELEC 432</td>
<td>MOBILE BIO-BEHAVIORAL SENSING</td>
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**Three (3) Engineering Points**

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<tr>
<td>BIOE 360 / GLHT 360</td>
<td>APPROPRIATE DESIGN FOR GLOBAL HEALTH</td>
<td>3</td>
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<tr>
<td>BIOE 421</td>
<td>MICROCONTROLLER APPLICATIONS</td>
<td>3</td>
</tr>
<tr>
<td>BIOE 454 / MECH 454 / CEVE 454</td>
<td>COMPUTATIONAL FLUID MECHANICS</td>
<td>3</td>
</tr>
<tr>
<td>BIOE 484</td>
<td>BIOPHOTONICS INSTRUMENTATION AND APPLICATIONS</td>
<td>3</td>
</tr>
<tr>
<td>BIOE 490</td>
<td>INTRO COMPUTATIONAL SYSTEMS BIOLOGY: MODELING &amp; DESIGN PRINCIPLES OF BIOCHEM NETWORKS</td>
<td>3</td>
</tr>
<tr>
<td>BIOE 509</td>
<td>POINT-OF-CARE DIAGNOSTICS</td>
<td>3</td>
</tr>
<tr>
<td>BIOE 574</td>
<td>CONTINUUM BIOMECHANICS</td>
<td>3</td>
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<tr>
<td>CHBE 390</td>
<td>CHEMICAL KINETICS AND REACTOR DESIGN</td>
<td>3</td>
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<tr>
<td>COMP 502 / ELEC 502 / STAT 502</td>
<td>NEURAL MACHINE LEARNING I</td>
<td>3</td>
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<tr>
<td>ELEC 301</td>
<td>SIGNALS, SYSTEMS, AND LEARNING</td>
<td>3</td>
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<tr>
<td>ELEC 326 / COMP 326</td>
<td>DIGITAL LOGIC DESIGN</td>
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<td>ELEC 327</td>
<td>IMPLEMENTATION OF DIGITAL SYSTEMS</td>
<td>3</td>
</tr>
<tr>
<td>ELEC 342</td>
<td>ANALOG ELECTRONIC CIRCUITS</td>
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<td>ELEC 422</td>
<td>VLSI SYSTEMS DESIGN</td>
<td>3</td>
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<tr>
<td>ELEC 435 / MECH 435</td>
<td>INTRODUCTION TO ENERGY-EFFICIENT MECHATRONICS</td>
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<td>ENGI 355</td>
<td>DIGITAL DESIGN AND VISUALIZATION</td>
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<tr>
<td>MECH 371</td>
<td>FLUID MECHANICS I</td>
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<tr>
<td>MECH 400 / CEVE 400</td>
<td>ADVANCED MECHANICS OF MATERIALS</td>
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MECH 417 / CEVE 417 | FINITE ELEMENT ANALYSIS | 3
MECH 420 / ELEC 436 | FUNDAMENTALS OF CONTROL SYSTEMS | 3
MECH 488 | DESIGN OF MECHATRONIC SYSTEMS | 3
MSNE 402 | MECH PROPERTIES OF MATERIALS | 3

Four (4) Engineering Points
MECH 343 | MODELING OF DYNAMIC SYSTEMS | 4

Footnotes and Additional Information

1. BIOE 400: Students may earn 1 Engineering Point for every 3 credit hours completed. A maximum of 2 Engineering Points can be applied towards the 6 Engineering Points requirement by completing BIOE 400 courses.

2. ENGI 300: Students may earn 1 Engineering Point for every credit hour completed. A maximum of 4 Engineering Points, and 6 credit hours, may be applied towards the Technical Elective requirement from ENGI 300 or from a combination of independent research and/or design courses (i.e. ENGI 300, BIOE 400, BIOE 401, BIOE 360/GLHT 360, BIOE 392/GLHT 392).

3. BIOE 360 or BIOE 392: These courses are design courses. See ENGI 300 Note. A maximum of 4 Engineering Points, and 6 credit hours, may be applied towards the Technical Elective requirement from independent research and/or design courses.

4. ENGI 355 can be applied toward the Technical Elective requirement only in the event that BIOE 447 is not completed as a Senior Lab requirement. Both MECH 403 and ENGI 355 cannot be counted towards Technical Elective or Engineering Point Requirements.

5. BIOE 400: Students may substitute 3 credit hours (in one semester) of BIOE 400 in place of one credit of the BIOE Laboratory Requirement for BIOE 442, BIOE 443, BIOE 444, BIOE 445, BIOE 446, BIOE 447, or BIOE 449. If this option is chosen, student may not use the same BIOE 400 credit for the Technical Elective or Engineering Point Requirements.

Opportunities for the BSBE Degree

Academic Honors

The university recognizes academic excellence achieved over an undergraduate's academic history at Rice. For information on university honors, please see Latin Honors (ga.rice.edu/undergraduate-students/honors-distinctions/university) (summa cum laude, magna cum laude, and cum laude) and Distinction in Research and Creative Work (ga.rice.edu/undergraduate-students/honors-distinctions/university). Some departments have department-specific Honors awards or designations.

Fifth-Year Master's Degree Option for Rice Undergraduate Students

Rice students have an option to pursue the Master of Bioengineering (MBE) degree by adding an additional fifth year to their four undergraduate years of science and engineering studies.

Advanced Rice undergraduate students in good academic standing may apply to the MBE degree program during their junior or senior year. Upon acceptance, depending on course load, financial aid status, and other variables, they may then start taking some required courses of the master's degree program. A plan of study will need to be approved by the student’s undergraduate advisor and the MBE program director.

As part of this option and opportunity, Rice undergraduate students:

• must complete the requirements for a bachelor's degree and the master's degree independently of each other (i.e. no course may be counted toward the fulfillment of both degrees).
• should be aware there could be financial aid implications if the conversion of undergraduate coursework to that of graduate level reduces their earned undergraduate credit for any semester below that of full-time status (12 credit hours).
• more information on this Undergraduate - Graduate Concurrent Enrollment opportunity, including specific information on the registration process can be found here (ga.rice.edu/undergraduate-students/academic-opportunities/undergraduate-graduate-concurrent-enrollment).

Additional Information

For additional information, please see the Bioengineering website: https://bioengineering.rice.edu/