

Electives for Engineering Curricula

Advisors must approve any course taken for elective credit in the Engineering curricula. Courses excluded for elective credit include PHYS 2000, 2070/2090, 2080/2100.

Registration Requirements

A cumulative grade-point average of 2.0 or higher is required for registration in engineering courses numbered 3000 or higher. Priority for registration in engineering courses is given to those majors for whom the course is a degree requirement. Exceptions to this requirement may be granted by the department offering the course.

Graduation Requirements

In addition to other institutional requirements, candidates for a baccalaureate degree in Engineering are required to have a 2.0 or higher cumulative grade-point average in all engineering courses taken at Clemson. All courses with "Engineering" in the course designator (e.g., ENGR 1300, ME 4530, etc.) are used in this calculation.

The baccalaureate programs in Engineering are designed to be completed in four years (eight regular semesters). Taking a reduced load or participating in cooperative education will extend this time. On average, Clemson engineering students take about four and one-half years to complete the requirements for graduation.

BIOENGINEERING

Bachelor of Science

The undergraduate program in Bioengineering is built upon a rigorous engineering science foundation that is, in turn, based upon a broad curriculum of applied and life sciences, mathematics, electives in humanities, social science, and design. Students select a formal focus that concentrates in a subfield of interest in bioengineering: Bioelectrical Concentration or Biomaterials Concentration.

The curriculum provides undergraduates with a solid background in engineering and life sciences in preparation for advanced studies. Through the Bioengineering program, graduates acquire an understanding of biology, biochemistry, and physiology and the capability to apply advanced mathematics, including differential equations and statistics, science, and engineering, to solve the problems at the interface of engineering and biology. Graduates also have an ability to make measurements on and interpret data from living systems, addressing the problems associated with the interaction between living and nonliving materials and systems.

Combined Bachelor's/Master's Plan

Bioengineering undergraduates may begin a Master of Science degree program while completing the Bachelor of Science degree and use a limited number of courses to satisfy the requirements of both the undergraduate and graduate degrees. Details are available from the Department of Bioengineering.

BIOELECTRICAL CONCENTRATION

Freshman Year

First Semester

- 4 - CH 1010 General Chemistry
- 3 - ENGL 1030 Accelerated Composition
- 1 - ENGR 1050 Engineering Disciplines and Skills I
- 1 - ENGR 1060 Engineering Disciplines and Skills II
- 4 - MATH 1060 Calculus of One Variable I
- 3 - Arts and Humanities Requirement¹ or 3 - Social Science Requirement¹

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Second Semester

- 4 - CH 1020 General Chemistry
- 1 - ENGR 1070 Programming and Problem Solving I
- 1 - ENGR 1080 Programming and Problem Solving II
- 1 - ENGR 1090 Programming and Problem Solving Applications
- 4 - MATH 1080 Calculus of One Variable II
- 3 - PHYS 1220 Physics with Calculus I²
- 3 - Arts and Humanities Requirement¹ or 3 - Social Science Requirement¹
- 1 - Biology Requirement³

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Sophomore Year

First Semester

- 3 - BIOE 2010 Intro. to Biomedical Engineering
- 2 - ECE 2010 Logic and Computing Devices
- 3 - ECE 2020 Electric Circuits I
- 1 - ECE 2090 Logic and Computing Devices Lab.
- 1 - ECE 2110 Electrical Engineering Lab. I
- 4 - MATH 2060 Calculus of Several Variables
- 3 - PHYS 2210 Physics with Calculus II²

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Second Semester

- 3 - CE 2010 Statics
- 1 - ECE 2120 Electrical Engineering Lab. II
- 3 - ECE 2620 Electric Circuits II
- 2 - ENGR 2080 Engineering Graphics and Machine Design
- 4 - MATH 2080 Intro. to Ordinary Diff. Equations
- 3 - MSE 2100 Introduction to Materials Science

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Junior Year

First Semester

- 4 - BIOL 3150 Functional Human Anatomy
- 3 - CH 2010 Survey of Organic Chemistry² and 1 - CH 2020 Survey of Organic Chemistry Lab.²
- 1 - ECE 3110 Electrical Engineering Lab. III
- 3 - ECE 3200 Electronics I
- 3 - ECE 3300 Signals, Systems, and Transforms

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Second Semester

- 3 - BCHM 3050 Essential Elements of Biochem.
- 3 - BIOE 3020 Biomaterials
- 3 - BIOE 3700 Bioinstrumentation and Bioimaging
- 3 - ECE 3800 Electromagnetics
- 3 - BIOE or ECE Technical Requirement³

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Senior Year

First Semester

- 3 - BIOE 3200 Biomechanics
- 3 - BIOE 4010 Bioengineering Design Theory
- 3 - BIOL 4610 Cell Biology
- 3 - Arts and Humanities Requirement¹ or 3 - Social Science Requirement¹
- 3 - BIOE or ECE Technical Requirement³

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Second Semester

- 1 - BIOE 4000 Senior Seminar
- 3 - BIOE 4030 Applied Biomedical Design
- 3 - BIOE 4480 Tissue Engineering
- 3 - Arts and Humanities Requirement¹ or 3 - Social Science Requirement¹
- 6 - BIOE or ECE Technical Requirement³

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128 Total Semester Hours

¹See Policy on Humanities and Social Sciences for Engineering Curricula. Six of these credit hours must also satisfy General Education Cross-Cultural Awareness and Science and Technology in Society Requirements.

²Students planning to enter medical school should take CH 2230/2270 instead of CH 2010/2020 and take CH 2240/2280 as an additional course sequence. Students planning to enter medical school should also take physics laboratories as additional courses ((PHYS 1220 course with PHYS 1240 lab and PHYS 2210 course with PHYS 2230 lab).

³Select from department-approved list.

Notes:

1. To transfer from General Engineering into the Bioengineering degree program, students must have a minimum cumulative grade-point average of 3.0 in courses taken at Clemson and must have earned a C or better in each course in the General Engineering freshman curriculum, including the Arts and Humanities/Social Science Requirements.
2. A student is allowed to enroll in ECE courses (excluding ECE 2070, 2080, 3080) only when all prerequisites have been passed with a grade of C or better.
3. All Bioelectrical Concentration students must have a cumulative engineering grade-point average of 2.0 to enroll in any 3000- or 4000-level ECE courses.
4. No student may exceed a maximum of two attempts, excluding a W, to complete successfully any ECE course.

BIOMATERIALS CONCENTRATION

Freshman Year

First Semester

- 4 - CH 1010 General Chemistry
- 3 - ENGL 1030 Accelerated Composition
- 1 - ENGR 1050 Engineering Disciplines and Skills I
- 1 - ENGR 1060 Engineering Disciplines and Skills II
- 4 - MATH 1060 Calculus of One Variable I
- 3 - Arts and Humanities Requirement¹ or 3 - Social Science Requirement¹

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Second Semester

- 4 - CH 1020 General Chemistry
- 1 - ENGR 1070 Programming and Problem Solving I
- 1 - ENGR 1080 Programming and Problem Solving II
- 1 - ENGR 1090 Programming and Problem Solving Applications
- 4 - MATH 1080 Calculus of One Variable II
- 3 - PHYS 1220 Physics with Calculus I²
- 3 - Arts and Humanities Requirement¹ or 3 - Social Science Requirement¹
- 1 - Biology Requirement³

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Sophomore Year**First Semester**

- 3 - BIOE 2010 Intro. to Biomedical Engineering
- 3 - CH 2010 Survey of Organic Chemistry²
- 1 - CH 2020 Survey of Organic Chemistry Lab.²
- 4 - MATH 2060 Calculus of Several Variables
- 3 - MSE 2100 Introduction to Materials Science
- 3 - PHYS 2210 Physics with Calculus II²

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Second Semester

- 3 - BIOE 3020 Biomaterials
- 3 - CE 2010 Statics
- 2 - ECE 2070 Basic Electrical Engineering
- 1 - ECE 2080 Electrical Engineering Lab. I
- 2 - ENGR 2080 Engineering Graphics and Machine Design
- 4 - MATH 2080 Intro. to Ordinary Diff. Equations

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Junior Year**First Semester**

- 3 - BIOE 3200 Biomechanics
- 4 - BIOL 3150 Functional Human Anatomy
- 3 - MSE 3190 Materials Processing I
- 3 - MSE 3260 Thermodynamics of Materials
- 3 - MSE 3270 Transport Phenomena

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Second Semester

- 3 - BCHM 3050 Essential Elements of Biochem.
- 3 - BIOE 3210 Biofluid Mechanics
- 3 - BIOE 3700 Bioinstrumentation and Bioimaging
- 3 - MATH 3020 Statistics for Science and Engr.
- 3 - BIOE Technical Requirement³

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Senior Year**First Semester**

- 3 - BIOE 4010 Bioengineering Design Theory
- 3 - BIOL 4610 Cell Biology
- 3 - MSE 4150 Intro. to Polymer Science and Engr.
- 3 - Arts and Humanities Requirement¹ or
3 - Social Science Requirement¹
- 3 - BIOE Technical Requirement³

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Second Semester

- 1 - BIOE 4000 Senior Seminar
- 3 - BIOE 4030 Applied Biomedical Design
- 3 - BIOE 4480 Tissue Engineering
- 3 - Arts and Humanities Requirement¹ or
3 - Social Science Requirement¹
- 6 - Bioengineering Technical Requirement³

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128 Total Semester Hours

¹See Policy on Humanities and Social Sciences for Engineering Curricula. Six of these credit hours must also satisfy General Education Cross-Cultural Awareness and Science and Technology in Society Requirements.

²Students planning to enter medical school should take CH 2230/2270 instead of CH 2010/2020 and take CH 2240/2280 as an additional course sequence. Students planning to enter medical school should also take physics laboratories as additional courses (PHYS 1220 course with PHYS 1240 lab and PHYS 2210 course with PHYS 2230 lab).

³Select from department-approved list.

Note: To transfer from General Engineering into the Bioengineering degree program, students must have a minimum cumulative grade-point average of 3.0 in courses taken at Clemson and must have earned a C or better in each course in the General Engineering freshman curriculum including the Arts and Humanities/Social Science Requirements.

BIOSYSTEMS ENGINEERING**Bachelor of Science**

Biosystems engineering is the field of engineering most closely allied with advances in biology. Biosystems engineers apply engineering design and analysis to biological systems and incorporate fundamental biological principles to engineering designs to achieve ecological balance.

The Biosystems engineering program emphasizes two main areas – sustainable bioprocess engineering, with its basis in microbiology, and ecological engineering, with its basis in ecology. Bioprocess engineering focuses on the sustainable production of biorefinery compounds - biofuels, nutraceuticals, bioactive molecules, and biomaterials - using metabolic pathways found in nature and green processing technologies. Ecological engineering focuses on the design of sustainable communities utilizing low-impact development strategies such as bioretention basins, rainwater harvesting, and bioswales for stormwater retention, treatment, and management. Both emphasis areas interface with ecologically-sound food and energy-crop production systems.

Biosystems engineers lead teams to:

- Design bioprocesses and systems for biofuels (biodiesel, hydrogen, ethanol), biopharmaceutical, bioplastics, and food processing industries
- Develop ecological designs (permeable pavement, bioswales, green infrastructure) to integrate water management into the landscape
- Integrate biological sustainability into energy, water and food systems
- Provide engineering expertise for agriculture, food processing, and manufacturing industries.

Biosystems engineering graduates are highly qualified to pursue graduate studies in biosystems engineering, biomedical engineering or ecological engineering fields, or medical or veterinary school.

Students are urged to complete a minor and participate in the Cooperative Education, Biosystems Engineering Intern, and/or Study Abroad Programs. Those interested in medical school can fulfill requirements with the Biosystems Engineering BS degree.

Additional information is available from the departmental offices or at: <http://www.clemson.edu/majors/biosystems-engineering>.

Combined Bachelor's/Master's Program

Under this plan, students may reduce the time necessary to earn both degrees by applying graduate credits to both undergraduate and graduate program requirements.

Undergraduate students in Biosystems Engineering may begin a Master of Science or a Master of Engineering Degree in Environmental Engineering and Science or Master of Science Degree in Bioengineering while completing the BS degree.

Students are encouraged to obtain the specific requirements for the dual degree from the academic departments involved as early as possible in their undergraduate program. See *Academic Regulations* in this catalog for enrollment guidelines and procedures.

Freshman Year**First Semester**

- 4 - CH 1010 General Chemistry
- 3 - ENGL 1030 Accelerated Composition
- 1 - ENGR 1050 Engineering Disciplines and Skills I
- 1 - ENGR 1060 Engineering Disciplines and Skills II
- 4 - MATH 1060 Calculus of One Variable I
- 3 - Arts and Humanities Requirement¹ or
3 - Social Science Requirement¹

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Second Semester

- 4 - CH 1020 General Chemistry
- 1 - ENGR 1070 Programming and Problem Solving I
- 1 - ENGR 1080 Programming and Problem Solving II
- 1 - ENGR 1090 Programming and Problem Solving Applications
- 4 - MATH 1080 Calculus of One Variable II
- 3 - PHYS 1220 Physics with Calculus I
- 3 - Arts and Humanities Requirement¹ or
3 - Social Science Requirement¹

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Sophomore Year**First Semester**

- 2 - BE 2120 Fundamentals of Biosystems Engr.
- 3 - CE 2010 Statics²
- 4 - MATH 2060 Calculus of Several Variables
- 3 - PHYS 2210 Physics with Calculus II
- 4 - Biology Requirement³

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Second Semester

- 2 - BE 2100 Intro. to Biosystems Engineering
- 2 - CE 2080 Dynamics²
- 2 - ENGR 2100 Computer-Aided Design and Engineering Applications
- 4 - MATH 2080 Intro. to Ordinary Diff. Equations
- 3 - ME 3100 Thermodynamics and Heat Transfer
- 4 - MICR 3050 General Microbiology

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Junior Year**First Semester**

- 3 - BE 3200 Principles and Practices of Geomatics
- 3 - BE 4100 Biol. Kinetics and Reactor Modeling
- 3 - CH 2230 Organic Chemistry
- 1 - CH 2270 Organic Chemistry Laboratory
- 2 - ECE 2070 Basic Electrical Engineering
- 1 - ECE 2080 Electrical Engineering Lab. I
- 3 - Mechanics of Materials Requirement⁴

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Second Semester

- 3 - BE 3220 Small Watershed Hydrology and Sedimentology
- 3 - BE 4120 Heat and Mass Transport in BE
- 3 - BE 4380 Bioprocess Engineering Design
- 4 - CE 3410 Introduction to Fluid Mechanics
- 3 - Arts and Humanities Requirement¹ or
3 - Social Science Requirement¹

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¹Students should choose courses to fulfill General Education requirements including Humanities, Social Science, Cross-Cultural Awareness and Science and Technology in society components. See *Undergraduate Announcements* and academic advisor for details.

²ME 2100 may be substituted for CE 2010 and 2080

³BIOL 1030/1050 or 1100

⁴CE 2060 or ME 2040