Bioengineering

Great advances have recently been made in the fields of genetics/molecular biology as well as predictive engineering analysis and design, both enabled by rapid progress in computational sophistication. As a consequence, the highly interdisciplinary applied science of bioengineering has emerged as a critical core curriculum.

The bioengineering program at CLU integrates engineering, biology, chemistry, mathematics, computer science, exercise science, and physics with a liberal arts foundation to provide graduates with the knowledge and qualifications needed to enter the fields of health care, medicine, manufacturing, electronics, agriculture and materials, or to continue study toward advanced degrees or professional certification.

The interdisciplinary bioengineering program is centered on a mechanistic understanding of the life sciences and builds upon fundamental molecular, genomic and cellular principles to address challenges and opportunities involving, for example, medical devices, implants and sensors, tissue engineering, bioinformatics and imaging. Specific topics that are addressed include biomaterials and tissue engineering, biosystems analysis and control, biomechanics, bioinformatics, biosensors and imaging, bioinstrumentation, ethics and biochemistry.

Furthermore, the bioengineering program comprises three focus areas as illustrated in the figure above:

- bioinformatics
- bioelectronics/devices
- biomaterials/biomechanics.

Students are able to select a specific area of interest based upon their choice of upper division bioengineering classes.

Bioengineering students at CLU are given multiple opportunities to develop practical, hands-on skills for their careers, emphasizing techniques and practices for acquiring and interpreting data from biological systems. Inquiry-based undergraduate student research is a central component of the bioengineering program, with a focus on the critical analysis of the issues that arise at the interfaces between living and non-living materials. All seniors undertake an independent design project that includes optimized solutions and designs.

The bioengineering program is fully supported by an array of experimental laboratories for classroom and design projects. Coupled with these are sophisticated computer-aided design (CAD) capabilities for predictive modeling of the structure and performance of three-dimensional systems. Together, these capabilities provide the bioengineering students with the powerful ability to develop and refine predictive models to solve complex problems. Finally, bioengineering students are frequently involved in interactive projects requiring integration of these interdisciplinary topics, which prepares them both for personal growth as well as a rewarding career.

Bachelor of Science in Bioengineering

39 credits minimum, 24 credits upper division.

BIEN 210/210L	Introduction to Engineering and Introduction to Engineering Lab	4
BIEN 220	Introduction to Bioengineering/Lab	4
BIEN 450/450	Seminar (2 units of BIEN 450)	2
BIEN 495	Capstone	2
BIOL 121	Intro to Cells and Organisms	3
BIOL 122	Intro. to Genes and Development	3
BIOL 123L	Introduction to Biological Experimentation I	2
or BIOL 124L	Introduction to Biological Experimentation II	
BIOL 461/461L	Vertebrate Physiology and Vertebrate Physiology Lab	4
Select four of the following:		15-16
BIEN 401	Biomaterials/Tissue Engineering/Lab	
BIEN 402	Biosensors and Imaging	
BIEN 403	Biosystems Analysis and Control	
BIOL 482	Selected Topics (Neurobiology)	
BIOL 422	Bioinformatics-Analytical	
CHEM 305/305L	Quantitative Analysis and Quantitative Analysis Lab	
CHEM 306/306L	Chemical Instrumentation and Chemical Instrumentation Lab	
CHEM 425/425L	Biochemistry and Biochemistry Lab	
CSC 412	Bioinformatics-Computational	
EXSC 460	Mechanics of Biosystems - Calculus	
PHIL 345	Bioethics	
PHYS 309/309L	Applied Electronics and Applied Electronics Lab	

PHYS 370	Digital Electronics	
Total Hours		39-40

Required Supporting Courses

CHEM 151	General Chemistry	4
CHEM 151L	General Chemistry Lab	1
CHEM 152	General Chemistry II	4
CHEM 152L	General Chemistry II Lab	1
CHEM 201/201L	Elementary Organic Chemistry and Elementary Organic Chemistry Lab	4
CSC/SCI 205	Programming for Scientists	4
or CSC 210	Introduction to Computer Programming	
MATH 251	Calculus I	4
MATH 252	Calculus II	4
MATH 261	Calculus III	4
MATH 265	Differential Equations	4
MATH 352	Probability and Statistics I	4
PHYS 201/201L	Mechanics and Thermodynamics-Algebra and Mechanics and Thermodynamics-Algebra Lab	4-5
or PHYS 211/211L	Mechanics and Thermodynamics-Calculus	
PHYS 202/202L	Electricity, Magnetism, and Optics - Algebra and Electricity, Magnetism, and Optics - Algebra Lab	4-5
or PHYS 212/212L	Electricity, Magnetism, and Optics - Calculus	
Total Hours		46-48

Recommended Courses

BIOL 341/341L	Comparative Anatomy and Comparative Anatomy Lab	4
BIOL 361/361L	Microbiology and Microbiology Lab	4
MATH 343	Linear Algebra	4
MATH 450	Complex Analysis	4
Total Hours		16

Minor in Bioengineering

20 credits minimum, 11 credits upper division.

BIEN 220	Introduction to Bioengineering/Lab	4
BIOL 122	Intro. to Genes and Development	3
BIOL 124L	Introduction to Biological Experimentation II	2
Select two of the following:		8
BIEN 401	Biomaterials/Tissue Engineering/Lab	
BIEN 402	Biosensors and Imaging	
BIEN 403	Biosystems Analysis and Control	
BIOL 422	Bioinformatics-Analytical	
CSC 412	Bioinformatics-Computational	
Select remaining upper division credits from the following:		3
BIOL 482	Selected Topics (Neurobiology)	
CHEM 305/305L	Quantitative Analysis and Quantitative Analysis Lab	
CHEM 306/306L	Chemical Instrumentation and Chemical Instrumentation Lab	
CHEM 425/425L	Biochemistry and Biochemistry Lab	
EXSC 460	Mechanics of Biosystems - Calculus	
PHIL 345	Bioethics	
PHYS 309/309L	Applied Electronics and Applied Electronics Lab	
PHYS 370	Digital Electronics	
Total Hours		20

Courses

Lower Division

BIEN 210. Introduction to Engineering. (4).
An introduction to the basic concepts of engineering - analysis, design, modeling, systems theory, control. Topics include electronics, mechanics, materials with a brief overview of bioengineering.

BIEN 210L. Introduction to Engineering Lab. (0).

BIEN 220. Introduction to Bioengineering/Lab. (4).
The second semester continuation of BIEN 210, emphasizing the application of engineering analysis and design principles to life sciences. Topics include analytical techniques, characterization and analysis, systems analysis. Biomechanics, biocompatibility, hydrodynamics and bioelectronics are introduced.

BIEN 282. Selected Topics. (1-4).

Upper Division

BIEN 320. Introduction to Robotics. (4).
An introductory study of field of robotics - devices designed and programmed to perform various tasks. Topics include: hardware design (mechanical and electronic); software design; power subsystems; sensors; actuators; effectors; applications; comparison to biological systems; safety; societal impact and ethics. Students will study theory (lecture component) and build/program a robot (laboratory component).

BIEN 401. Biomaterials/Tissue Engineering/Lab. (4).
A study of the fundamental relationships between the physical and biological properties of ceramics, metals, polymers, their composites and their microstructures. Topics include methods of synthesis, 3D scaffolds, crystallography, constitutive relationships and failure criteria, biocompatibility criteria, case studies. Interfaces and their characterization are studied in depth. Prerequisites: BIEN 210, BIEN 220 or consent of instructor.

BIEN 402. Biosensors and Imaging. (4).
An introduction to the central concepts of sensing, feedback and control in biological applications, addressing mechanical, thermal, hydrodynamic, electromagnetic and chemical/biological stimuli and detection. Analog/digital conversion and signal conditioning across multiple length, spectral and temporal domains. Signal processing techniques are treated in depth. Prerequisites: BIEN 210, BIEN 220 or consent of instructor.

BIEN 403. Biosystems Analysis and Control. (4).
The development of biological systems analysis and open/closed loop control with an emphasis on techniques and software for predictive modeling. Optimization of the performance of biosystems comprising multiple, parallel processes will be addressed, with an emphasis on electrical and chemical control systems. Prerequisites: BIEN 210, BIEN 220, PHYS 309 or consent of instructor.

BIEN 450. Seminar. (1).
Key topics of interest aimed at familiarizing first- and second-year bioengineering students with key areas of study at the upper division level. External speakers will be utilized to introduce contemporary bioengineering topics to students in a seminar protocol.

BIEN 482. Selected Topics. (1-4).

BIEN 482L. Selected Topics Lab. (0).

BIEN 490. Independent Study. (1-4).

BIEN 492. Internship. (1-4).

BIEN 495. Capstone. (2).
Investigation, analysis and summary of a basic question or problem statement developed by the student arising from related courses and personal interests. The student is encouraged to explore open-ended questions that involve original thinking and the application of knowledge gained during the undergraduate experience. Prerequisite: senior standing.

BIEN 497. Bioengineering Departmental Honors. (4).