BIOLOGICAL SYSTEMS ENGINEERING, BACHELOR OF SCIENCE

College of Engineering

The Biological Systems Engineering Undergraduate Program

Biological Systems Engineering is an engineering major that uses life sciences as its main scientific base. With rapid advances in biology and biotechnology, engineers are needed to work side by side with life scientists to bring laboratory developments into commercial production or field application. Industries in food and fiber production, bioenergy, bioprocessing, biotechnology, food processing, agriculture, forestry, aquaculture, plant and animal production, natural resource management, and waste reduction all need engineers with strong training in biology. In the first two years, the Biological Systems Engineering major requires sequences of courses in mathematics, physics, chemistry, engineering science, and humanities, similar to all accredited engineering programs. In addition to these courses, the major also includes courses in the life sciences and the application to engineering.

Biological Systems Engineering graduates take jobs in biotechnology, energy, food, and medical industries, work for federal, state and local agencies, and pursue graduate work. Students can also use the program as a pathway to professional schools in medicine, veterinary medicine, education, law, or business.

The Biological Systems Engineering (BS) program is accredited by the Engineering Accreditation Commission of ABET (https://www.abet.org/) under the commission's General Criteria and Program Criteria for Biological and Similarly Named Engineering Programs.

Students are encouraged to adhere carefully to all prerequisite requirements. The instructor is authorized to drop students from a course for which stated prerequisites have not been completed.

Lower Division Required Courses

See the Degree Requirements section.

Upper Division Requirements

If your career objective is a professional degree in the health sciences (e.g., medicine, veterinary medicine, nursing, or dentistry), you should consult with advisors from the appropriate school to plan for successful admission and to ensure that you take specific courses that may be required and that you have the necessary experience. Advisors in the Office of Health Professions Advising can also assist students planning to pursue degrees in these areas.

Areas of Specialization

Biological Systems Engineering is a broad major with many possible areas of specialization, with some examples below. Each area of specialization includes recommended electives for planning purposes. Students in the major are NOT required to select or follow an area of specialization. Following the recommended electives for a specialization does not result in specialization or concertation notation on a student's transcript or diploma.

- Biotechnical Engineering.
- Agricultural & Natural Resources Engineering.
- Food Engineering.

The major requirements below are in addition to meeting University Degree Requirements (https://catalog.ucdavis.edu/undergraduate-education/university-degree-requirements/) & College Degree Requirements (https://catalog.ucdavis.edu/undergraduate-education/college-degree-requirements/); unless otherwise noted. The minimum number of units required for the Biological Systems Engineering Bachelor of Science is 159.

Code	Title	Units
Lower Division Required Courses		
Mathematics		
MAT 021A	Calculus	4
MAT 021B	Calculus	4
MAT 021C	Calculus	4
MAT 021D	Vector Analysis	4
MAT 022A	Linear Algebra	3
MAT 022B	Differential Equations	3
Physics		
PHY 009A	Classical Physics	5
PHY 009B	Classical Physics	5
PHY 009C	Classical Physics	5
Chemistry		
CHE 002A	General Chemistry	5
CHE 002B	General Chemistry	5
CHE 008A	Organic Chemistry: Brief Course	2-4
or CHE 118A	Organic Chemistry for Health & Life Sciences	
CHE 008B	Organic Chemistry: Brief Course	4
or CHE 118B	Organic Chemistry for Health & Life Sciences	
Biological Science		
BIS 002A	Introduction to Biology: Essentials of Life on Earth	5
Engineering		
ENG 017	Circuits I	4
or ENG 017V	Circuits I	
ENG 035	Statics	4
ECS 032A	Introduction to Programming	4
or ECS 032AV	Introduction to Programming	
or ENG 006	Engineering Problem Solving	
Biological Systems Engineering		
EBS 001	Foundations of Biological Systems Engineering (Fall only)	4
EBS 075	Properties of Materials in Biological Systems (Winter only)	4
Lower Division Composition/Writing; choose one; a grade of C- or better is required:		*4*
COM 001	Major Works of the Ancient World	
COM 002	Major Works of the Medieval & Early Modern World	
COM 003	Major Works of the Modern World	
COM 004	Major Works of the Contemporary World	
ENL 003	Introduction to Literature	

or ENL 003V	Introduction to Literature	
NAS 005	Introduction to Native American Literature	
UWP 001	Introduction to Academic Literacies (Recommended)	
or UWP 001V	Introduction to Academic Literacies: Online	
or UWP 001Y	Introduction to Academic Literacies	
Choose one:		*4*
ENG 003	Introduction to Engineering Design	
or ENG 003Y	Introduction to Engineering Design	
CMN 001	Introduction to Public Speaking	
or CMN 001V	Introduction to Public Speaking	
Lower Division Required Courses Subtotal		86-88
Upper Division Required Courses		
Engineering		
ENG 100	Electronic Circuits & Systems	3
ENG 102	Dynamics	4
ENG 104	Mechanics of Materials	4
or ENG 104V	Mechanics of Materials	
ENG 105	Thermodynamics	4
ENG 106	Engineering Economics	4
Biological Systems Engineering		
EBS 103/HYD 103N	Fluid Mechanics Fundamentals	4
or ENG 103	Fluid Mechanics	
EBS 125	Heat Transfer in Biological Systems	4
EBS 127	Mass Transfer & Kinetics in Biological Systems	4
EBS 130	Modeling of Dynamic Processes in Biological Systems	4
EBS 165	Bioinstrumentation & Control	4
EBS 170A	Engineering Design & Professional Responsibilities	3
EBS 170B	Engineering Projects: Design	2
EBS 170BL	Engineering Projects: Design Laboratory	1
EBS 170C	Engineering Projects: Design Evaluation	1
EBS 170CL	Engineering Projects: Design Evaluation	2
Statistics		
STA 100	Applied Statistics for Biological Sciences	4
Biological Systems Engineering Electives		
Choose a minimum of 4 units from all upper division Biological Systems Engineering courses not otherwise required, with the exception of:		4
EBS 189 series		
EBS 199	Special Study for Advanced Undergraduates	
Engineering Electives		
Choose a minimum of 8 units; all upper division courses offered by the College of Engineering may be taken as engineering electives with the exception of the following:		8
ECI 123	Urban Systems & Sustainability	
ECS 188	Ethics in an Age of Technology	
ENG 103	Fluid Mechanics	
ENG/PHY 160	Environmental Physics & Society	
All courses 190-197, 199; except ENG 190, may be taken for 2 units of engineering elective credit.		
Biological Science Electives		
All upper division courses in the College of Biological Sciences may be used as biological science electives; with the exception of:		9
EVE 175	Computational Genetics	
EXB 102	Introduction to Motor Learning & the Psychology of Sport & Exercise	
EXB 112	Clinical Exercise Physiology	
EXB 115	Biomechanical Bases of Movement	
EXB 121	Advanced Sport Psychology	
EXB 124	Physiology of Maximal Human Performance	
EXB 125	Neuromuscular & Behavioral Aspects of Motor Control	
EXB 148	Theory & Practice of Exercise Testing	
All 190-199		
May also be taken as biological science electives:		
ABT 161	Water Quality Management for Aquaculture	
ANS 118	Fish Production	
ANS 143	Pig & Poultry Care & Management	
ANS 144	Beef Cattle & Sheep Production	
ANS 146	Dairy Cattle Production	
ATM 133	Biometeorology	
AVS 100	Avian Biology	
BIS 002B	Introduction to Biology: Principles of Ecology & Evolution	
BIS 002C	Introduction to Biology: Biodiversity & the Tree of Life	
CHA 101/EXB 106	Human Gross Anatomy	
CHA 101L/ EXB 106L	Human Gross Anatomy Laboratory	
ENT 100	General Entomology	
ENH 102	(Discontinued)	
ESM 120	Global Environmental Interactions	
ESP 100	General Ecology	
ESP 110	Principles of Environmental Science	
ESP 155	Wetland Ecology	
ETX 101	Principles of Environmental Toxicology	
ETX 131	Environmental Toxicology of Air Pollutants	
FST 102A	Malting & Brewing Science	
FST 104L	Food Microbiology Laboratory	
FST 119	Chemistry & Technology of Milk & Dairy Products	
FST/ETX 128	Food Toxicology	
FST 159	New Food Product Ideas	
IDI 141	Infectious Diseases of Humans	
SSC 100	Principles of Soil Science	
WFC 121	Physiology of Fishes	
Students may choose other upper division courses with substantial biological content offered by the College of Agricultural & Environmental Sciences; consultation with a faculty advisor and approval by petition is required.		
Upper Division Composition Requirement		**0-4**
Choose one; a grade of C- or better is required:		

UWP 101	Advanced Composition
or UWP 101V	Advanced Composition
or UWP 101Y	Advanced Composition
UWP 102B	Writing in the Disciplines: Biology
UWP 102E	Writing in the Disciplines: Engineering
UWP 102F	Writing in the Disciplines: Food Science & Technology
UWP 102G	Writing in the Disciplines: Environmental Writing
UWP 104A	Writing in the Professions: Business Writing
or UWP 104AV	Writing in the Professions: Business Writing
or UWP 104AY	Writing in the Professions: Business Writing
UWP 104E	Writing in the Professions: Science
UWP 104F	Writing in the Professions: Health
or UWP 104FV	Writing in the Professions: Health
or UWP 104FY	Writing in the Professions: Health
UWP 104T	Writing in the Professions: Technical Writing
Passing the Upper Division Composition Exam.	
Upper Division Required Courses Subtotal	73-77
Total Units	**159-165**

Areas of Specialization

Biological Systems Engineering is a broad major with many possible areas of specialization, with some examples below. Each area of specialization includes recommended electives for planning purposes. Students in the major are NOT required to select or follow an area of specialization. Following the recommended electives for a specialization does not result in specialization or concertation notation on a student's transcript or diploma.

Biotechnical Engineering

Biotechnology involves the handling and manipulation of living organisms or their components to produce useful products. Students specializing in biotechnical engineering integrate analysis and design with applied biology to solve problems in renewable energy production, bioprocessing, control of biological systems, and production of biomaterials and bioproducts.

Students may focus on the mechanisms and processes for the sustainable production and use of energy from renewable biological sources. Students may also focus on the challenges in scaling up laboratory developments to industrial production, including production, packaging, and application of biocontrol agents for plant pests and diseases; genetically altered plants; plant materials and food products; and microbial production of biological products, tissue culture, and bioremediation. Students may also focus on the development of biosensors to detect microorganisms and specific substances useful in the development of products based on biological processes and materials.

Biotechnical engineers work in the biotech industries on process design and operation, scale-up, and instrumentation, sensing, automation, and control.

Recommended Biological Science Electives

Code	Title	Units
BIS 101	Genes & Gene Expression	4
or BIS 101V	Genes & Gene Expression	
BIS 102	Structure & Function of Biomolecules	3
BIS 103	Bioenergetics & Metabolism	3
BIT 160	Principles of Plant Biotechnology	3
BIT 161A	Genetics & Biotechnology Laboratory	6
BIT 161B	Plant Genetics & Biotechnology Laboratory	4
MCB 120L	Molecular Biology & Biochemistry Laboratory	3
MCB 121	Advanced Molecular Biology	3
MCB 126	Plant Biochemistry	3
MCB 162	Human Genetics & Genomics	3
MCB 182	Principles of Genomics	3
MIC 102	Introductory Microbiology	3
MIC 103L	Introductory Microbiology Laboratory	2
MMG 115	Recombinant DNA Cloning & Analysis	3
or MIC 115 DISCON		
PLS 152	Plant Genetics	4

Recommended Engineering Electives

Code	Title	Units
BIM 109	Biomaterials	4
BIM 117	Modeling Strategies for Biomedical Engineering	4
BIM 118	Microelectromechanical Systems	4
BIM 140	Protein Engineering	4
BIM 143	Biomolecular Systems Engineering: Synthetic Biology	4
BIM 151	Computational Tools & Applications in Bioengineering & Biomedicine	4
BIM 152	Molecular Control of Biosystems	4
BIM 161A	Biomolecular Engineering	4
BIM 162	Introduction to the Biophysics of Molecules & Cells	4
EBS 135	Bioenvironmental Engineering	4
EBS 161	Kinetics & Bioreactor Design	4
ECH 160	Fundamentals of Biomanufacturing	3
ECI 148A	(Discontinued)	4
ECI 149	(Discontinued)	4
ECI 150	(Discontinued)	4
ECI 153	Deterministic Optimization & Design	4
ENG 180	Engineering Analysis	4

Suggested Advisors

J. de Moura Bell, J. Fan, Y.-L. Hsieh, B. Jenkins, T. Jeoh, J. Mullin, D. Slaughter, G. Sun, R. Zhang

Agricultural & Natural Resources Engineering

With the world population continuing to grow over the next several decades, grand challenges exist in food security and social, economic, and environmental sustainability. Meeting the needs of agriculture and the effective use of natural resources will require continuing innovation. Students specializing in agricultural and natural resources engineering combine analysis and design with applied biology to solve problems in

producing, transporting, and processing biological products to provide food, fiber, energy, pharmaceuticals, and other human needs.

Students may focus on automation and control of field operations and engineered systems, robotics, and the biomechanics of humans and animals. They may also focus on engineering issues related to the sustainable use of natural resources, particularly energy and water, but also land and air.

Agricultural and natural resources engineers are employed as practicing professionals and managers with agricultural producers, equipment manufacturers, irrigation districts, food processors, consulting engineering firms, start-up companies, and government agencies. Graduates with interest in biomechanics work in industry on the design, evaluation, and application of human-centered devices and systems, as well as on improving worker health and safety.

Recommended Biological Science Electives

Code	Title	Units
Animal Emphasis		
AVS 100	Avian Biology	3
ANS 112	Sustainable Animal Agriculture	3
ANS 143	Pig & Poultry Care & Management	4
ANS 144	Beef Cattle & Sheep Production	4
ANS 146	Dairy Cattle Production	5
NPB 101	Systemic Physiology	5
SSC 100	Principles of Soil Science	5
Aquaculture Emphasis		
ANS 118	Fish Production	4
ANS 131	Reproduction & Early Development in Aquatic Animals	4
ABT 163	Aquaculture Systems Engineering	3
WFC 120	Biology & Conservation of Fishes	3
WFC 121	Physiology of Fishes	4
Biomechanics Emphasis		
BIS 102	Structure & Function of Biomolecules	3
NPB 101	Systemic Physiology	5
CHA 101/EXB 106	Human Gross Anatomy	4
Plant Emphasis		
ENT 100	General Entomology	4
ENH 102	(Discontinued)	4
ESP 100	General Ecology	4
ETX 101	Principles of Environmental Toxicology	4
HYD 124	Plant-Water-Soil Relationships	4
MMG 120	Microbial Ecology	3
or MIC 120 DISCONTINUED		
PLB 111	Plant Physiology	3
SSC 100	Principles of Soil Science	5
PLS 101	Agriculture & the Environment	3
PLS 114	Biological Applications in Fruit Production	2

Recommended Engineering Electives

Code	Title	Units
EBS 128	Biomechanics & Ergonomics	4
EBS 145	Irrigation & Drainage Systems	4
BIM 109	Biomaterials	4
BIM 116	Quantitative Physiology	5
BIM 126	Tissue Mechanics	3
ECI 141	Engineering Hydraulics	3
ECI 142	Engineering Hydrology	4
ECI 144	Groundwater Systems Design	4
ECI 145	Hydraulic Structure Design	4
ECI 148A	(Discontinued)	4
ECI 171	Soil Mechanics	4
ENG 111	Electric Machinery Fundamentals	4
ENG 121	Fluid Power Actuators & Systems	4
ENG 180	Engineering Analysis	4

Additional Recommended Electives (Do not count towards major requirements)

Code	Title	Units
ABT 150	Introduction to Geographic Information Systems	4
ABT 161	Water Quality Management for Aquaculture	3
ABT 163	Aquaculture Systems Engineering	3
ABT 165	Irrigation Practices for an Urban Environment	3

Suggested Advisors

A. Daccache, I. Donis-Gonzalez, M. Earles, F. Fathallah, J. Fernandez-Bayo, T-C. Hung, B. Jenkins, F. Khorsandi, I. Kisekka, K. Kornbluth, P. Larbi, A. Pourreza, D. Slaughter, S. Vougioukas

Food Engineering

Producing the food we eat every day constitutes the largest industrial sector of the U.S. economy, and this production involves the work of engineers in a wide variety of food industries, both at home and around the world. Students specializing in food engineering design food processes and operate equipment and facilities for production of high quality, safe, and nutritious food with minimal impact of these operations on the environment.

Students learn to apply engineering principles and concepts to handle, store, process, package, and distribute food and related products. In addition to engineering principles, the food engineering specialization provides an understanding of the chemical, biochemical, microbiological, and physical characteristics of food. Students study concepts of food refrigeration, freezing, thermal processing, drying, and other food operations, food digestion, and health and nutrition in food system design.

Food engineers work as practicing engineers, scientists, and managers in the food industry.

Recommended Biological Science Electives

Code	Title	Units
ANS 112	Sustainable Animal Agriculture	3
BIS 101	Genes & Gene Expression	4
or BIS 101V	Genes & Gene Expression	
BIS 102	Structure & Function of Biomolecules	3
BIS 103	Bioenergetics & Metabolism	3
FST 100A	Food Chemistry	4
FST 100B	Food Properties	4
FST 101A	Food Chemistry Laboratory	3

FST 101B	Food Properties Laboratory	2
FST 102A	Malting & Brewing Science	4
FST 104	Food Microbiology	3
FST 104L	Food Microbiology Laboratory	4
FST 107	Food Sensory Science	4
FST 117	Design & Analysis for Sensory Food Science	4
FST 119	Chemistry & Technology of Milk & Dairy Products	4
FST 123	Introduction to Enzymology	3
FST 123L	Enzymology Laboratory	2
FST/ETX 128	Food Toxicology	3
MIC 102	Introductory Microbiology	3
MIC 103L	Introductory Microbiology Laboratory	2
PLS 172	Biology and Quality of Harvested Crops	4
PLS 174	Microbiology & Safety of Fresh Fruits & Vegetables	3
PLS 196	(Discontinued)	3

Recommended Engineering Electives

Code	Title	Units
EBS 135	Bioenvironmental Engineering	4
EBS 161	Kinetics & Bioreactor Design	4
ECH 160	Fundamentals of Biomanufacturing	3
ENG 180	Engineering Analysis	4

Suggested Advisors

G. Bornhorst, J. de Moura Bell, I. Donis-Gonzalez, T. Jeoh, N. Nitin, Z. Pan, D. Slaughter

Lead Undergraduate Advisor

S. Vougioukas

Students graduating with a B.S. degree in Biological Systems Engineering from UC Davis are prepared to:

- Apply life sciences in engineering at the biochemical, cellular, organism, and macro levels.
- Solve biological systems engineering problems while employed in the private or public sector.
- Consider the environmental, economic, and social consequences of their engineering activities.
- Communicate effectively with professional colleagues and public constituencies.
- Act in an ethical manner.
- Continue their education to adapt and thrive in a changing professional world.