289A. Special Topics in Applied Science: Atomic, Molecular, and Optical Physics (1-5)
Lecture, laboratory, or combination. Prerequisite: graduate standing or permission of instructor. Special topic in Atomic, Molecular, and Optical Physics. May be repeated for credit up to five units per segment when topic differs.—*F, W, S. (F, W, S.)*

289B. Special Topics in Applied Science: Chemical Physics (1-5)
Prerequisite: graduate standing or permission of instructor. Special topic in Chemical Physics. May be repeated for credit up to a total of five units per segment when topic differs.—*F, W, S. (F, W, S.)*

289C. Special Topics in Applied Science Computational Physics (1-5)
Prerequisite: graduate standing or permission of instructor. Special topic in Computational Physics. May be repeated for credit up to a total of five units per segment when topic differs.—*F, W, S. (F, W, S.)*

289D. Special Topics in Applied Science: Biophotonics/Biotechnology (1-5)
Prerequisite: graduate standing or permission of instructor. Special topics in Biophotonics/Biotechnology. May be repeated for credit up to a total of five units per segment when topic differs.—*F, W, S. (F, W, S.)*

289E. Special Topics in Applied Science: Materials Science (1-5)
Prerequisite: graduate standing or permission of instructor. Special topic in Materials Science. May be repeated for credit up to a total of five units per segment when topic differs.—*F, W, S. (F, W, S.)*

289F. Special Topics in Applied Science: Imaging Science and Photonics (1-5)
Prerequisite: graduate standing or permission of instructor. Special topic in Imaging Science and Photonics. May be repeated for credit up to a total of five units per segment when topic differs.—*F, W, S. (F, W, S.)*

289G. Special Topics in Applied Science: Nonlinear Optics (1-5)
Prerequisite: graduate standing or permission of instructor. Special topic in Nonlinear Optics. May be repeated for credit up to a total of five units per segment when topic differs.—*F, W, S. (F, W, S.)*

289H. Special Topics in Applied Science: Plasma/Fusion Energy Physics (1-5)
Prerequisite: graduate standing or permission of instructor. Special topic in Plasma/Fusion Energy Physics. May be repeated for credit up to a total of five units per segment when topic differs.—*F, W, S. (F, W, S.)*

289I. Special Topics in Applied Science: Quantum Electronics (1-5)
Prerequisite: graduate standing or permission of instructor. Special topic in Quantum Electronics. May be repeated for credit up to a total of five units per segment when topic differs.—*F, W, S. (F, W, S.)*

289J. Special Topics in Applied Science: Condensed Matter/Statistical Physics (1-5)
Prerequisite: graduate standing or permission of instructor. Special topic in Condensed Matter/Statistical Physics. May be repeated for credit up to a total of five units per segment when topic differs.—*F, W, S. (F, W, S.)*

289K. Special Topics in Applied Science: Classical Optics (1-5)
Prerequisite: graduate standing or permission of instructor. Special topic in Classical Optics. May be repeated for credit up to a total of five units per segment when topic differs.—*F, W, S. (F, W, S.)*

289L. Special Topics in Applied Science: Microwave and Millimeter-Wave Technology (1-5)
Prerequisite: graduate standing or permission of instructor. Special topic in Microwave and Millimeter-Wave Technology. May be repeated for credit up to a total of five units per segment when topic differs.—*F, W, S. (F, W, S.)*

289M. Special Topics in Applied Science: Synchrotron Radiation Science (1-5)
Prerequisite: graduate standing or permission of instructor. Special topic in Synchrotron Radiation Science. May be repeated for credit up to a total of five units per segment when topic differs.—*F, W, S. (F, W, S.)*

289N. Special Topics in Applied Science: Space Physics (1-5)
Prerequisite: graduate standing or permission of instructor. Special topic in Space Physics. May be repeated for credit up to a total of five units per segment when topic differs.—*F, W, S. (F, W, S.)*

290. Seminar (1-2)
Seminar—1-2 hours. (S/U grading only.)

290C. Graduate Research Group Conference (1)
Discussion—1 hour. Prerequisite: consent of instructor. May be repeated for credit. (S/U grading only.)

298. Group Study (1-5)
(S/U grading only.)

299. Research (1-12)
(S/U grading only.)

Courses in Biophotonics (BPT)

Graduate

290. Biophotonics Seminar (1)
Seminar—1 hour. Prerequisite: graduate standing or consent of instructor. Restricted to graduate standing. Presentation of current research in the area of biophotonics by experts in the field, followed by group discussions. May be repeated up to three times for credit. (S/U grading only.)—*F, W, S. (F, W, S.)* Yeh

Engineering: Biological and Agricultural

(College of Engineering and College of Agricultural and Environmental Sciences)

Bryan M. Jenkins, Ph.D., Chairperson of the Department

Department Office. 2030 Bainer Hall
530-752-0102;
http://bae.engineering.ucdavis.edu

Faculty

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Juliana de Moura Bell, Ph.D., Assistant Professor *(Biological and Agricultural Engineering; Food Science and Technology)*
Irwin Donis-Gonzalez, Ph.D., Assistant Extension Specialist
Zhiliang (Julia) Fan, Ph.D., Associate Professor
Fadi A. Fathallah, Ph.D., Professor
D. Ken Giles, Ph.D., Professor
Mark E. Grismer, Ph.D., Professor
(Land, Air and Water Resources)
Bryan M. Jenkins, Ph.D., Professor
Tina Jeoh, Ph.D., Associate Professor
Michael J. McCarthy, Ph.D., Professor *(Biological and Agricultural Engineering; Food Science and Technology)*
Nitin Nitin, Ph.D., Associate Professor *(Biological and Agricultural Engineering; Food Science and Technology)*
Ning Pan, Ph.D., Professor *(Biological and Agricultural Engineering; Textiles and Clothing)*
David C. Slaughter, Ph.D., Professor
Shrinivasa K. Upadhyaya, Ph.D., Professor
Jean S. VanderGheynst, Ph.D., Professor
Stavros G. Vougioukas, Ph.D., Assistant Professor
Ruihong Zhang, Ph.D., Professor

Emeriti Faculty

William J. Chancellor, Ph.D., Professor Emeritus
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Roger E. Garrett, Ph.D., Professor Emeritus
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Richard E. Plant, Ph.D., Professor Emeritus
James W. Rumsey, M.S., Senior Lecturer Emeritus
Thomas R. Rumsey, Ph.D., Professor Emeritus
Verne H. Scott, Ph.D., Professor Emeritus
R. Paul Singh, Ph.D., Distinguished Professor Emeritus
James F. Thompson, M.S., Extension Specialist Emeritus
Wesley W. Wallender, Ph.D., Professor Emeritus
Wesley E. Yates, M.S., Professor Emeritus

Affiliated Faculty

Tien-Chieh Hung, Ph.D., Assistant Adjunct Professor
Kurt Kornbluth, Ph.D., Assistant Adjunct Professor
Zhongli Pan, Ph.D., Adjunct Professor
Herbert Scher, Ph.D., Professional Researcher
Mir S. Shafii, Ph.D., Lecturer

Mission. The Department of Biological and Agricultural Engineering is dedicated to the advancement of the discipline of biological engineering and to the conduct of research under its many diverse areas of application. Biological engineering or biological systems engineering is the biology-based engineering discipline that integrates life sciences with engineering in the advancement and application of fundamental concepts of biological systems from molecular to ecosystem levels. Within this discipline, our faculty members work in a range of research areas including biotechnology engineering, agricultural and natural resources engineering, and food engineering.

The mission of the Department of Biological and Agricultural Engineering is to discover, develop, apply, and disseminate knowledge for the sustainable production, management, and use of biological materials, and to educate students for this work.

Objectives. We educate students in the fundamentals of mathematics, physical and biological sciences, and engineering, balanced with the application of principles to practical problems. We teach students to develop skills for solving engineering problems in biological systems through use of appropriate analysis, synthesis, and engineering design techniques. We prepare students for entry into engineering practice and graduate education, as well as for engagement in life-long learning. We foster the ability of our students to collaborate and communicate effectively, and provide an awareness of the importance of economics, professional responsibility, and the environment.

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 ecosystem levels,
- Solve biological systems engineering problems while employed in the private or public sector,
- Consider the environmental and social consequences of their engineering activities,
- Communicate effectively with professional colleagues and public constituencies,
- Act in an ethical manner, and
- Continue their education in a changing professional world.

The Biological Systems Engineering Undergraduate Program

Biological Systems Engineering is an engineering major that uses biology 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 bioenergy, bioprocessing, biotechnology, food processing, aquaculture, agriculture, plant production, animal production, and forest production all need engineers with strong training in biology. The heightened concern for environmental resources and their preservation generates many engineering opportunities as society strives to maintain balance within the biosphere.

In the freshman and sophomore 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 course sequences, the Biological Systems Engineering major also requires courses in the biological sciences. Exclusive of General Education units, the Biological Systems Engineering major requires a minimum of 161 units (90 units in the lower division; 71 units in the upper division).

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

The Biological Systems Engineering program is accredited by the Engineering Accreditation Commission of ABET; see *http://www.abet.org*.

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

	UNITS
Mathematics 21A-21B-21C-21D	16
Mathematics 22A-22B	6
Physics 9A-9B-9C	15
Chemistry 2A-2B	10
Chemistry 8A or 118A	2 or 4
Chemistry 8B or 118B	4
Biological Sciences 2A-2B-2C	15
Engineering 6, 35, 17	12
Biological Systems Engineering 1	4
Biological Systems Engineering 75	4
University Writing Program 1, 1Y or 1V (grade of C- or better is required)	4
Communication 1 or 3	4

Upper Division Requirements:

If your career objective is a professional degree in the health sciences (e.g., medicine, veterinary medicine, or dentistry), you should consult with advisers 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. The upper division requirements are listed following the areas of specialization:

- Biotechnology Engineering
- Agricultural and Natural Resources Engineering
- Food Engineering

Areas of Specialization

Biotechnology Engineering. Biotechnology involves the handling and manipulation of living organisms or their components to produce useful products. Students specializing in biotechnology engineering integrate analysis and design with applied biology to solve problems in renewable energy production, large-scale biotechnical production, control of biological systems, and bio-based materials production.

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 and control.

Recommended biological science electives:

Biological Sciences 101, 102, 103
Microbiology 102
Molecular and Cellular Biology 120L
Plant Biology 113

Recommended engineering electives:

Biological Systems Engineering 161
Chemical Engineering 161B, 161C, 161L
Civil and Environmental Engineering 143, 148A, 149, 150, 153
Engineering 180
Mechanical Engineering 161, 162, 163

Suggested advisers. J. Fan, K. Giles, M. Grismer, B. Jenkins, T. Jeoh, N. Nitin, N. Pan, D. Slaughter, J. VanderGheynst, R. Zhang

Agricultural and Natural Resources Engineering. With the world population expected to grow over the next several decades, major concerns lie with meeting the needs of agriculture and with the sustainable use of limited natural resources. 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 leading to food, fiber, energy, pharmaceuticals, and other human needs.

Students may focus on automation and control of field operations and engineered systems, robotics, and on 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 design machinery, processes, and systems for productive plant and animal culture, while improving overall sustainability.

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:

Animal Emphasis

Avian Sciences 100
Animal Science 143, 144, 146
Neurobiology, Physiology, and Behavior 101
Soil Science 100

Aquaculture Emphasis

Animal Science 118, 131, 136A
Applied Biological Systems Technology 163
Wildlife, Fish, and Conservation Biology 120, 121

Biomechanics Emphasis

Biological Sciences 102
Neurobiology, Physiology and Behavior 101
Exercise Biology 103
Cell Biology and Human Anatomy 101

Plant Emphasis

Entomology 100
Environmental Horticulture 102
Environmental Science and Policy 100
Environmental Toxicology 101
Hydrologic Sciences 124
Microbiology 120
Plant Biology 111
Soil Science 100
Plant Sciences 101, 110A, 114, 142

Recommended engineering electives:

Biological Systems Engineering 128, 145
Biomedical Engineering 109, 116, 126
Civil and Environmental Engineering 140, 141, 142, 144, 145, 148A, 171
Engineering 111, 121, 180

Additional recommended electives:

Applied Biological Systems Technology 150, 161, 165

Suggested Advisers. J. Fan, F. Fathallah, K. Giles, M. Grismer, T-C. Hung, B. Jenkins, K. Kornbluth, D. Slaughter, S. Upadhyaya, S. Vougioukas, J. VanderGheynst, R. Zhang

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:

Biological Sciences 101, 102, 103
Environmental Science and Policy 110
Environmental Toxicology 101
Food Science and Technology 104, 104L, 119, 128
Plant Sciences 172

Recommended engineering electives:

Biological Systems Engineering 161
Chemical Engineering 157
Mechanical Engineering 171, 172

Suggested Advisers. G. Bornhorst, J. de Moura Bell, T. Jeoh, M. McCarthy, N. Nitin, Z. Pan, D. Slaughter

Upper Division Required Courses

	UNITS
Engineering 100, 102, 104 105, 106	18
Biological Systems Engineering 103, 125, 127, 130, 165, 170A, 170B, 170BL, 170C, 170CL	29
Biological Systems Engineering electives—Select a minimum of 4 units from all upper division Biological Systems Engineering courses not otherwise required, with the exception of Biological Systems Engineering courses 189-199	4
Statistics 100	4
Engineering electives—Select a minimum of three units. All upper division courses offered by the College of Engineering may be taken as engineering electives with the exception of the following: Civil and Environmental Engineering 123, Computer Science Engineering 188, Engineering 103, 160, all courses numbered 190-197 and 199 (except Engineering 190, which may be taken for 2 units of engineering elective credit)	3
Biological science electives—All upper-division courses in the College of Biological Sciences (with the exception of Biological Sciences 132, Evolution and Ecology 175,	

Exercise Biology 102, 112, 115, 118 through 149L, Microbiology 100 and all courses numbered 190-199) may be used as biological science electives. The following courses may also be taken as biological science electives: Applied Biological Systems Technology 161; Animal Science 118, 143, 144, 146; Agricultural Management and Rangeland Resources 110A; Atmospheric Science 133; Avian Sciences 100; Cell Biology and Human Anatomy 101, 101L; Entomology 100; Environmental Horticulture 102; Environmental Science Policy and Management 120, 182, 185 (offered at UC Berkeley); Environmental Science and Policy 100, 110, 155; Environmental Toxicology 101, 112A, 131; Food Science and Technology 102A, 104L, 119, 120, 121, 128, 159; Infectious Diseases 141; Soil Science 100; Wildlife, Fish, and Conservation Biology 121. Students may choose other upper division courses with substantial biological content offered by the College of Agricultural and Environmental Sciences; consultation with a faculty adviser and approval by petition is required) 3
Upper Division Composition Requirement* one course from the following: University Writing Program 101, 102B, 102E, 102F, 102G, 104A, 104E, 104F, 104T (grade of C- or better is required) 4

** The Upper-Division composition exam administered by the College of Letters and Sciences cannot be used to satisfy the upper-division composition requirement for students in the Biological Systems Engineering program.*

Master Undergraduate Adviser. T. Jeoh

Energy Minor Programs

There is an urgent need to develop and commercialize technologies for the sustainable conversion and use of energy. The goal of these minors is to prepare students for careers that require training in energy science and technology, efficiency, and policy. Clean technologies and green technologies including energy are some of the fastest growing markets for new investments. Well trained individuals in all related fields are needed to provide the level of expertise required to advance technology and policy and to satisfy national and global objectives for greater energy sustainability. The minors are designed to accommodate persons of diverse backgrounds with educational interests in areas that may include engineering, science, policy, economics, planning, and management.

Energy Science and Technology Minor

All courses must be taken for a letter grade. A grade of *C-* or better is required for all courses used to satisfy minor requirements with an overall GPA in the required minor courses of 2.000 or better.

Minor Requirements:

UNITS

Energy Science and Technology............. 20

Engineering 105 or Chemical Engineering 152B 4
Engineering 188 4
Select 12 units from: Biological Systems Engineering 161; Chemical Engineering 146, 158C, 161A, 161B, 161L, 166; Civil and Environmental Engineering 125, 143, 162, 163; Mechanical Engineering 161; Agricultural and Resource Economics 175; Food Science and Technology 123; Applied Biological Systems Technology 182; Atmospheric Science 116; Plant Science 101; Environmental Science and Policy 167 ... 12

Minor Advisers. B. Jenkins *(Department of Biological and Agricultural Engineering)*, K. McDonald *(Department of Chemical Engineering)*, C. van Dam *(Department of Mechanical and Aerospace Engineering)*

Energy Policy Minor

All courses must be taken for a letter grade. A grade of *C-* or better is required for all courses used to satisfy the minor requirements with an overall GPA in the required minor courses of 2.000 or better.

Minor Requirements:

UNITS

Energy Policy.. 18

Engineering 188 and Environmental Science and Policy 167 8
Select 10 units from: Civil Engineering 125; Environmental Science and Policy 171, 163, 168A, 169B; Political Science 105, 109, 122, 164 143, 162, 164..................... 10

Minor Advisers. D. Niemeier *(Department of Civil and Environmental Engineering)*, J. Ogden *(Environmental Science and Policy)*

Energy Efficiency Minor

All courses must be taken for a letter grade. A grade of *C-* or better is required for all courses used to satisfy the minor requirements with overall GPA in the required minor courses of 2.000 or better.

Minor Requirements:

UNITS

Energy Efficiency................................... 20

Engineering 188 and Civil Engineering 125.. 8
Select 12 units from: Civil Engineering 126, 127, 128, 143; Environmental Science and Policy 167; Design 136A, 136B, 137A 12

Minor Advisers. F. Loge *(Civil and Environmental Engineering)*, D. Sperling *(Institute of Transportation Studies)*, M. Modera *(Western Cooling Efficiency Center)*

The Graduate Program in Biological Systems Engineering

Integrated B.S./M.S, M.S., M.Engr., D.Engr., and Ph.D. in Biological Systems Engineering
Designated Ph.D. emphasis available in Biotechnology
http://bae.engineering.ucdavis.edu
530-752-0102

Graduate students in Biological Systems Engineering focus on finding economically and environmentally sustainable solutions to many of the most important global issues of our time-the safety, security and abundance of our food, detection of pathogens, development of bioenergy and other sustainable energy systems, control of insect-borne disease and damage, as well as the preservation of our land, air and water resources.

We enjoy the strategic advantage of being located in California, the national leader in agricultural production and crop diversity, and a major center for biotechnology. With the unique status of belonging to both the College of Engineering and the College of Agricultural and Environmental Sciences, the program benefits from a wide diversity of collaborations across multiple disciplines. We interact with colleagues in both engineering and the life sciences to create multidisciplinary approaches to our teaching and research. Students benefit from this dynamic environment that combines the strengths of nationally ranked engineering, agricultural and environmental programs.

Financial support is available in the form of research assistantships, teaching assistantships, fellowships and financial aid.

Research Highlights:

- Automation and Control
- Bioenvironmental engineering
- Renewable energy
- Industrial biotechnology
- Food safety
- Biosensors
- Bioprocess engineering
- Bioinstrumentation
- Ergonomics, health and safety
- Aquacultural engineering
- Ecological systems engineering
- Food engineering
- Forest and fiber engineering
- Postharvest engineering
- Remote sensing
- Robotics and autonomous systems
- Soil and water engineering
- Machine systems and precision agriculture

Research Facilities and Partnerships:

- Agricultural Ergonomics Research Center
- Fish Conservation and Culture Laboratory
- GIS Visualization Lab
- Energy Institute
- Bodega Marine Lab
- Western Center for Agricultural Equipment

Complete information is available on the departmental website.

Courses in Engineering: Biological Systems (EBS)

Lower Division

1. Foundations of Biological Systems Engineering (4)
Lecture—2 hours; laboratory—3 hours; project—3 hours. Restricted to students in Biological Systems Engineering. Introduction to engineering and the engineering design process with examples drawn from the field of biological systems engineering. Introduction to computer-aided design and mechanical fabrication of designs. Students work on a quarter-long group design project. GE credit: SciEng | OL, QL, SE, SL, VL.—*F. (F.)* Bornhorst, Fathallah, Jenkins

75. Properties of Materials in Biological Systems (4)
Lecture—3 hours; laboratory—3 hours. Prerequisite: Biological Sciences 2A; Physics 9C (may be taken concurrently). Properties of typical biological materials; composition and structure with emphasis on the effects of physical and biochemical properties on design of engineered systems; interactions of biological materials with typical engineering materials. GE credit: SciEng | QL, SE, SL, VL, WE.—*W. (W.)* Slaughter, Zicari

90C. Research Group Conference in Biological Systems Engineering (1)
Discussion—1 hour. Prerequisite: lower division standing in Biological Systems Engineering or Food Engineering; consent of instructor. Research group conference. May be repeated for credit. (P/NP grading only.) GE credit: SE.—*F, W, S. (F, W, S.)*

92. Internship in Biological Systems Engineering (1-5)
Internship. Prerequisite: lower division standing; project approval prior to period of internship. Supervised work experience in biological systems engineering. May be repeated for credit. (P/NP grading only.) GE credit: SE.

98. Directed Group Study (1-5)
Prerequisite: consent of instructor. Group study of selected topics; restricted to lower division students. (P/NP grading only.) GE credit: SE.

99. Special Study for Lower Division Students (1-5)
(P/NP grading only.) GE credit: SE.

Upper Division

103. Fluid Mechanics Fundamentals (4)
Lecture—4 hours. Prerequisite: Physics 9B. Fluid mechanics axioms, fluid statics, kinematics, velocity fields for one-dimensional incompressible flow and boundary layers, turbulent flow time averaging, potential flow, dimensional analysis, and macroscopic balances to solve a range of practical problems. (Same course as Hydrologic Science 103N.) GE credit: SciEng | QL, SE, VL.—*W. (W.)*

114. Principles of Field Machinery Design (3)
Lecture—2 hours; laboratory—3 hours. Prerequisite: Engineering 102, 104. Traction and stability of vehicles with wheels or tracks. Operating principles of field machines and basic mechanisms used in their design. GE credit: SciEng | QL, SE, VL, WE.—*S.*

115. Forest Engineering (3)
Lecture—3 hours. Prerequisite: Engineering 104. Applications of engineering principles to problems in forestry including those in forest regeneration, harvesting, residue utilization, and transportation. GE credit: SciEng | QL, SE, SL, VL.—*S. (S.)* Hartsough

120. Power Systems Design (4)
Lecture—3 hours; laboratory—3 hours. Prerequisite: Engineering 17, 102, 103, 105. Design and performance of power devices and systems including combustion engines, electric generators and motors, fluid power systems, fuels, and emerging technologies. Selection of units for power matching and optimum performance. GE credit: SciEng | QL, SE, SL, VL, WE.—*F. (F.)*

125. Heat Transfer in Biological Systems (4)
Lecture—3 hours; laboratory—3 hours. Prerequisite: course 103; Engineering 105; Biological Sciences 2A, 2B and 2C. Fundamentals of heat transfer with application to biological systems. Steady and transient heat transfer. Analysis and simulation of heat conduction, convection and radiation. Heat transfer operations. GE credit: SciEng | OL, QL, SE, VL, WE.—*S. (S.)* Fan, Nitin

127. Mass Transfer and Kinetics in Biological Systems (4)
Lecture—3 hours; laboratory—3 hours. Prerequisite: course 125. Fundamentals of mass transfer and kinetics in biological systems. Molecular diffusion and convection. Thermodynamics and bioenergetics. Biological and chemical rate equations. Heterogeneous kinetics. Batch and continuous reaction processes. GE credit: SciEng | QL, SE, VL, WE.—*F. (F.)* Jeoh

128. Biomechanics and Ergonomics (4)
Lecture—3 hours; laboratory—3 hours. Prerequisite: Statistics 100, Engineering 102. Limited enrollment. Anatomical, physiological, and biomechanical bases of physical ergonomics. Human motor capabilities, body mechanics, kinematics and anthropometry. Use of bioinstrumentation, industrial surveillance techniques and the NIOSH lifting guide. Cumulative trauma disorders. Static and dynamic biomechanical modeling. Emphasis on low back, shoulder, and hand/wrist biomechanics. GE credit: SciEng | QL, SE, SL, VL, WE.—*S. (S.)* Fathallah

130. Modeling of Dynamic Processes in Biological Systems (4)
Lecture—3 hours; discussion—1 hour. Prerequisite: course 75; Engineering 6 or Computer Science & Engineering 30; grade of C- or better in Mathematics 22B required for enrollment eligibility. Techniques for modeling processes through mass and energy balance, rate equations, and equations of state. Computer problem solution of models. Example models include package design, evaporation, respiration heating, thermal processing of foods, and plant growth. GE credit: SciEng | OL, QL, SE, SL, VL.—*W. (W.)* Fan, Upadhyaya

135. Bioenvironmental Engineering (4)
Lecture—3 hours; laboratory—3 hours. Prerequisite: courses 125, 130. Biological responses to environmental conditions. Principles and engineering design of environmental control systems. Overview of environmental pollution problems and legal restrictions for biological systems, introduction of environmental quality assessment techniques, and environmental pollution control technologies. GE credit: SciEng | QL, SE, SL, VL, WE.—*F. (F.)* Zhang

144. Groundwater Hydrology (4)
Lecture—4 hours. Prerequisite: Mathematics 16B or 21A; Hydrologic Science 103 or Engineering 103 recommended. Fundamentals of groundwater flow and contaminant hydrology. Occurrence, distribution, and movement of groundwater. Well-flow systems. Aquifer tests. Well construction operation and maintenance. Groundwater exploration and quality assessment. Agricultural threats to groundwater quality: fertilizers, pesticides, and salts. Same course as Hydrologic Science 144. GE credit: SciEng | QL, SE, SL, VL.—*F. (F.)* Fogg, Harter

145. Irrigation and Drainage Systems (4)
Lecture—4 hours. Prerequisite: course 103 or Hydrologic Science 103N. Engineering and scientific principles applied to the design of surface, sprinkle and micro irrigation systems and drainage systems within economic, biological, and environmental constraints. Interaction between irrigation and drainage. GE credit: SciEng | QL, SE, SL, VL.—*W. (W.)* Grismer, Wallender

147. Runoff, Erosion and Water Quality Management in the Tahoe Basin (3)
Lecture/laboratory—30 hours; fieldwork—15 hours; discussion—10 hours; term paper. Prerequisite: Physics 7B or 9B, Mathematics 16C or 21C, Civil and Environmental Engineering 142 or Hydrologic Science 141 or Environmental and Resource Sciences 100. Practical hydrology and runoff water quality management from Tahoe Basin slopes. Development of hillslope and riparian restoration concepts, modeling and applications from physical science perspectives including precipitation-runoff relationships, sediment transport, and detention ponds. Five days of instruction in Tahoe City. (Same course as Hydrologic Science 147.) GE credit: SciEng | QL, SE, SL.—Grismer

161. Kinetics and Bioreactor Design (4)
Lecture—3 hours; discussion—1 hour. Prerequisite: course 127. Provide the basic principles of reactor design for bioprocess applications. This course emphasizes the following topics: 1) kinetics and reactor engineering principles; 2) bio-reaction kinetics; and 3) bioreactor design. GE credit: SciEng | QL, SE, VL.—*W. (W.)* Fan, Jeoh

165. Bioinstrumentation and Control (4)
Lecture—3 hours; laboratory—3 hours. Prerequisite: Engineering 100. Instrumentation and control for biological production systems. Measurement system concepts, instrumentation and transducers for sensing physical and biological parameters, data acquisition and control. GE credit: SciEng | QL, SE, SL, VL, WE.—*F. (F.)* Slaughter, Vougioukas

170A. Engineering Design and Professional Responsibilities (3)
Lecture—2 hours; laboratory—3 hours. Prerequisite: course 1, Engineering 102, 104. Engineering design including professional responsibilities. Emphasis on project selection, data sources, specifications, human factors, biological materials, safety systems, and professionalism. Detailed design proposals will be developed for courses 170B and 170BL. GE credit: SciEng | OL, QL, SE, SL, VL, WE.—*F. (F.)* Giles, Zhang

170B. Engineering Projects: Design (2)
Discussion—2 hours. Prerequisite: course 170A; course 170BL required concurrently. Individual or group projects involving the design of devices, structures, or systems to solve specific engineering problems in biological systems. Project for study is jointly selected by student and instructor. GE credit: SciEng | OL, QL, SE, SL, VL, WE.—*W. (W.)* Giles, Zhang

170BL. Engineering Projects: Design Laboratory (1)
Laboratory—3 hours. Prerequisite: course 170B required concurrently. Individual or group projects involving the design of devices, structures, or systems to solve specific engineering problems in biological systems. GE credit: SciEng | OL, QL, SE, SL, VL, WE.—*W. (W.)*

170C. Engineering Projects: Design Evaluation (1)
Discussion—1 hour. Prerequisite: course 170B; required to enroll in course 170CL concurrently. Individual or group projects involving the fabrication, assembly and testing of components, devices, structures, or systems designed to solve specific engineering problems in biological systems. Project for study previously selected by student and instructor in course 170B. GE credit: SciEng | OL, QL, SE, SL, VL, WE.—*S. (S.)* Giles, Zhang

170CL. Engineering Projects: Design Evaluation (2)
Laboratory—6 hours. Prerequisite: required to enroll in course 170C concurrently. Individual or group projects involving the fabrication, assembly and testing of components, devices, structures, or systems designed to solve specific engineering problems in biological systems. GE credit: SciEng | OL, QL, SE, SL, VL, WE.—*S. (S.)*

175. Rheology of Biological Materials (3)
Lecture—3 hours. Prerequisite: course 103 or Engineering 103. Fluid and solid rheology, viscoelastic behavior of foods and other biological materials, and application of rheological properties to food and biological systems (i.e., pipeline design, extrusion, mixing, coating). GE credit: SciEng | QL, SE, VL.—*W. (W.)* K. McCarthy

189A. Special Topics in Biological Systems Engineering: Agricultural Engineering (1-5)
Prerequisite: upper division standing in engineering; consent of instructor. Special topics in Agricultural Engineering. May be repeated for credit when topic differs. GE credit: SciEng | SE.—*F, W, S. (F, W, S.)*

189B. Special Topics in Biological Systems Engineering: Aquacultural Engineering (1-5)
Prerequisite: upper division standing in engineering; consent of instructor. Special topics in Aquacultural Engineering. May be repeated for credit when topic differs. GE credit: SciEng | SE.—*F, W, S. (F, W, S.)*

189C. Special Topics in Biological Systems Engineering: Biomedical Engineering (1-5)
Prerequisite: upper division standing in engineering; consent of instructor. Special topics in Biomedical Engineering. May be repeated for credit when topic differs. GE credit: SciEng | SE.—*F, W, S. (F, W, S.)*

189D. Special Topics in Biological Systems Engineering: Biotechnical Engineering (1-5)
Prerequisite: upper division standing in engineering; consent of instructor. Special topics in Biotechnical Engineering. May be repeated for credit when topic differs. GE credit: SciEng | SE.—*F, W, S. (F, W, S.)*

189E. Special Topics in Biological Systems Engineering: Ecological Systems Engineering (1-5)
Prerequisite: upper division standing in engineering; consent of instructor. Special topics in Ecological Systems Engineering. May be repeated for credit when topic differs. GE credit: SciEng | SE.—*F, W, S. (F, W, S.)*

189F. Special Topics in Biological Systems Engineering: Food Engineering (1-5)
Prerequisite: upper division standing in engineering; consent of instructor. Special topics in Food Engineering. May be repeated for credit when topic differs. GE credit: SciEng | SE.—*F, W, S. (F, W, S.)*

189G. Special Topics in Biological Systems Engineering: Forest Engineering (1-5)
Prerequisite: upper division standing in engineering; consent of instructor. Special topics in Forest Engineering. May be repeated for credit when topic differs. GE credit: SciEng | SE.—*F, W, S. (F, W, S.)*

190C. Research Group Conference in Biological Systems Engineering (1)
Discussion—1 hour. Prerequisite: upper division standing in Biological Systems Engineering or Food Engineering; consent of instructor. Research group conference. May be repeated for credit. (P/NP grading only.) GE credit: SE.—*F, W, S. (F, W, S.)*

192. Internship in Biological Systems Engineering (1-5)
Internship. Prerequisite: upper division standing; approval of project prior to period of internship. Supervised work experience in biological systems engineering. May be repeated for credit. (P/NP grading only.) GE credit: SE.

197T. Tutoring in Biological Systems Engineering (1-5)
Tutorial—3-15 hours. Prerequisite: upper division standing. Tutoring individual students, leading small voluntary discussion groups, or assisting the instructor in laboratories affiliated with one of the department's regular courses. May be repeated for credit if topic differs. (P/NP grading only.) GE credit: SE.

198. Directed Group Study (1-5)
Prerequisite: consent of instructor. (P/NP grading only.) GE credit: SE.

199. Special Study for Advanced Undergraduates (1-5)
(P/NP grading only.) GE credit: SE.

Graduate

200. Research Methods in Biological Systems Engineering (2)
Lecture—2 hours. Prerequisite: graduate standing. Planning, execution and reporting of research projects. Literature review techniques and proposal preparation. Record keeping and patents. Uncertainty analysis in experiments and computations. Graphic analysis. Oral and written presentation of research results, manuscript preparation, submission and review.—*F. (F.)* Zhang, Giles

205. Continuum Mechanics of Natural Systems (4)
Lecture/discussion—4 hours. Prerequisite: Mathematics 21D and 22B, Physics 9B. Continuum mechanics of static and dynamic air, water, earth and biological systems using hydraulic, heat and electrical conductivity; diffusivity; dispersion; strain; stress; deformation gradient; velocity gradient; stretch and spin tensors. (Same course as Hydrologic Science 205.)—*S.*

215. Soil-Machine Relations in Tillage and Traction (3)
Lecture—3 hours. Prerequisite: course 114. Mechanics of interactions between agricultural soils and tillage and traction devices; determination of relevant physical properties of soil; analyses of stress and strains in soil due to machine-applied loads; experimental and analytical methods for synthesizing characteristics of overall systems. Offered in alternate years.—*(W.)* Upadhyaya

216. Energy Systems (4)
Lecture/discussion—4 hours. Prerequisite: course 105. Theory and application of energy systems. System analysis including input-output analysis, energy balances, thermodynamic availability, economics, environmental considerations. Energy conversion systems and devices including cogeneration, heat pump, fuel cell, hydroelectric, wind, photovoltaic, and biomass conversion processes. Offered in alternate years.—*W.* Jenkins

218. Solar Thermal Engineering (4)
Lecture/discussion—4 hours. Prerequisite: course in heat transfer. Analysis and design of solar energy collection systems. Sun-earth geometry and estimation of solar radiation. Steady-state and dynamic models of solar collectors. Modeling of thermal energy storage devices. Computer simulation. Offered in alternate years.—*S.* Jenkins

220. Pilot Plant Operations in Aquacultural Engineering (3)
Lecture—1 hour; laboratory—6 hours. Prerequisite: Civil Engineering 243A-243B or Applied Biological Systems Technology 161, 163. Topics in water treatment as they apply to aquaculture operations. Laboratory study of unit operations in aquaculture. Offered in alternate years.—*(F.)* Hung

228. Occupational Musculoskeletal Disorders (3)
Lecture—2 hours; laboratory—3 hours. Prerequisite: graduate standing and consent of instructor. Epidemiology and etiology of occupational musculoskeletal disorders (MSDs) with focus on low back and upper extremities disorders; anatomical and biomechanical functions of lower back and upper extremities; MSDs risk factors assessment and control; research opportunities related to MSDs.—*S. (S.)* Fathallah

231. Mass Transfer in Food and Biological Systems (3)
Lecture/discussion—3 hours. Prerequisite: graduate standing. Application of mass transfer principles to food and biological systems. Study of mass transfer affecting food quality and shelf life. Analysis of mass transfer in polymer films used for coating and packaging foods and controlling release of biologically active compounds. Offered in alternate years.—*(W.)*

233. Analysis of Processing Operations: Drying and Evaporation (3)
Lecture—3 hours. Prerequisite: course in food or process engineering, familiarity with FORTRAN. Diffusion theory in drying of solids. Analysis of fixed-bed and continuous-flow dryers. Steady-state and dynamic models to predict performance evaporators: multiple effects, mechanical and thermal recompression, control systems. Offered in alternate years.—*(W.)*

235. Advanced Analysis of Unit Operations in Food and Biological Engineering (3)
Lecture—3 hours. Prerequisite: course 132. Analysis and design of food processing operations. Steady state and dynamic heat and mass transfer models for operations involving phase change such as freezing and frying. Separation processes including membrane applications in food and fermentation systems.—*(S.)*

237. Thermal Process Design (3)
Lecture—2 hours; discussion—1 hour. Prerequisite: course in heat transfer. Heat transfer and biological basis for design of heat sterilization of foods and other biological materials in containers or in bulk. Offered in alternate years.—*S.*

239. Magnetic Resonance Imaging in Biological Systems (3)
Lecture—3 hours. Prerequisite: graduate standing. Theory and applications of magnetic resonance imaging to biological systems. Classical Bloch model of magnetic resonance. Applications to be studied are drying of fruits, flow of food suspensions, diffusion of moisture, and structure of foods. Offered in alternate years.—*F.* M. McCarthy

240. Infiltration and Drainage (3)
Lecture—3 hours. Prerequisite: Soil Science 107, Engineering 103. Aspects of multi-phase flow in soils and their application to infiltration and immiscible displacement problems. Gas phase transport and entrapment during infiltration, and oil-water-gas displacement will be considered. Offered in alternate years.—*W.* Grismer

241. Sprinkle and Trickle Irrigation Systems (3)
Lecture—2 hours; laboratory—3 hours. Prerequisite: course 145/Hydrologic Science 115. Computerized design of sprinkle and trickle irrigation systems. Consideration of emitter mechanics, distribution functions and water yield functions. Offered in alternate years.—*S.*

242. Hydraulics of Surface Irrigation (3)
Lecture—3 hours. Prerequisite: course 145, Hydrologic Science 115. Mathematical models of surface-irrigation systems for prediction of the ultimate disposition of water flowing onto a field. Quantity of run-off and distribution of infiltrated water over field length as a function of slope, roughness, infiltration and inflow rates. Offered in alternate years.—*(S.)*

243. Water Resource Planning and Management (3)
Lecture—3 hours. Prerequisite: Hydrologic Science 141 or the equivalent. Applications of deterministic and stochastic mathematical programming techniques to water resource planning, analysis, design, and management. Water allocation, capacity expansion, and reservoir operation. Conjunctive use of surface water and groundwater. Water quality management. Irrigation planning and operation models. (Same course as Hydrologic Science 243.) Offered in alternate years—*(F.)*

245. Waste Management for Biological Production Systems (3)
Lecture—3 hours. Prerequisite: graduate standing or consent of instructor. Characterization of solid and liquid wastes from animal, crop, and food production systems. Study of methods and system design for handling, treatment, and disposal/utilization of these materials.—*W. (W.)* Zhang

260. Analog Instrumentation (4)
Lecture—3 hours; laboratory—3 hours. Prerequisite: Engineering 100. Instrument characteristics: generalized instrument models, calibration, and frequency response. Signal conditioning: operational amplifier circuits, filtering, and noise. Transducers: motion, force, pressure, flow, temperature, and photoelectric. Offered in alternate years.—*W.*

262. Computer Interfacing and Control (4)
Lecture—3 hours; laboratory—3 hours. Prerequisite: Engineering 100, course 165. Procedural and object-oriented programming in C++, analog and digital signal conversion, data acquisition and computer control. Offered in alternate years.—*(S.)* Delwiche

265. Design and Analysis of Engineering Experiments (5)
Lecture—3 hours; lecture/discussion—2 hours. Prerequisite: Statistics 100, Agricultural Systems and Environment 120, or an introductory course in statistics. Simple linear, multiple, and polynomial regression, correlation, residuals, model selection, one-way ANOVA, fixed and random effect models, sample size, multiple comparisons, randomized block, repeated measures, and Latin square designs, factorial experiments, nested design and subsampling, split-plot design, statistical software packages.—*S. (S.)* Slaughter, Upadhyaya

267. Renewable Bioprocessing (3)
Lecture—3 hours. Prerequisite: course 160, Biological Sciences 101 or Microbiology 102. Applications of biotechnology and bioprocess engineering toward the use of agricultural and renewable feedstocks for the production of biochemicals. Design and modeling of microbial- and plant-based production systems including associated fermentation, extraction, and purification processes. Offered in alternate years.—*F.* VanderGheynst

268. Polysaccharides Surface Interactions (3)
Lecture—3 hours. Prerequisite: graduate students in science or engineering. Study of fundamental surface science theories as applied to physical and chemical interactions of carbohydrates and polysaccharides. Offered in alternate years.—*F.* Jeoh

270. Modeling and Analysis of Biological and Physical Systems (3)
Lecture—3 hours. Prerequisite: familiarity with a programming language. Mathematical modeling of biological systems: model development; analytical and numerical solutions. Case studies from various specializations within biological and agricultural engineering. Offered in alternate years.—*S.* Upadhyaya

275. Physical Properties of Biological Materials (3)
Lecture—2 hours; laboratory—3 hours. Prerequisite: consent of instructor. Selected topics on physical properties, such as mechanical, optical, rheological,

and aerodynamic properties, as related to the design of harvesting, handling, sorting, and processing equipment. Techniques for measuring and recording physical properties of biological materials. Offered in alternate years.—*S.* M. McCarthy, Nitin

289A. Selected Topics in Biological Systems Engineering; Animal Systems Engineering (1-5)

Variable—1-5 hours. Prerequisite: consent of instructor. Special topics in Animal Systems Engineering. May be repeated for credit when topic differs.—*F, W, S. (F, W, S.)*

289B. Selected Topics in Biological Systems Engineering; Aquacultural Engineering (1-5)

Variable—1-5 hours. Prerequisite: consent of instructor. Special topics in Aquacultural Engineering. May be repeated for credit when topic differs.—*F, W, S. (F, W, S.)*

289C. Selected Topics in Biological Systems Engineering; Biological Engineering (1-5)

Variable—1-5 hours. Prerequisite: consent of instructor. Special topics in Biological Engineering. May be repeated for credit when topic differs.—*F, W, S. (F, W, S.)*

289D. Selected Topics in Biological Systems Engineering; Energy Systems (1-5)

Variable—1-5 hours. Prerequisite: consent of instructor. Special topics in Energy Systems. May be repeated for credit when topic differs.—*F, W, S. (F, W, S.)*

289E. Selected Topics in Biological Systems Engineering; Environmental Quality (1-5)

Variable—1-5 hours. Prerequisite: consent of instructor. Special topics in Environmental Quality. May be repeated for credit when topic differs.—*F, W, S. (F, W, S.)*

289F. Selected Topics in Biological Systems Engineering; Food Engineering (1-5)

Variable—1-5 hours. Prerequisite: consent of instructor. Special topics in Food Engineering. May be repeated for credit when topic differs.—*F, W, S. (F, W, S.)*

289G. Selected Topics in Biological Systems Engineering; Forest Engineering (1-5)

Variable—1-5 hours. Prerequisite: consent of instructor. Special topics in Forest Engineering. May be repeated for credit when topic differs.—*F, W, S. (F, W, S.)*

289H. Selected Topics in Biological Systems Engineering; Irrigation and Drainage (1-5)

Variable—1-5 hours. Prerequisite: consent of instructor. Special topics in Irrigation and Drainage. May be repeated for credit when topic differs.—*F, W, S. (F, W, S.)*

289I. Selected Topics in Biological Systems Engineering; Plant Production and Harvest (1-5)

Variable—1-5 hours. Prerequisite: consent of instructor. Special topics in Plant Production and Harvest. May be repeated for credit when topic differs.—*F, W, S. (F, W, S.)*

289J. Selected Topics in Biological Systems Engineering; Postharvest Engineering (1-5)

Variable—1-5 hours. Prerequisite: consent of instructor. Special topics in Postharvest Engineering. May be repeated for credit when topic differs.—*F, W, S. (F, W, S.)*

289K. Selected Topics in Biological Systems Engineering; Sensors and Actuators (1-5)

Variable—1-5 hours. Prerequisite: consent of instructor. Special topics in Sensors and Actuators. May be repeated for credit when topic differs.—*F, W, S. (F, W, S.)*

290. Seminar (1)

Seminar—1 hour. Prerequisite: graduate standing. Weekly seminars on recent advances and selected topics in biological systems engineering. Course theme will change from quarter to quarter. May be repeated for credit. (S/U grading only.)

290C. Graduate Research Conference (1)

Discussion—1 hour. Prerequisite: consent of instructor. Research problems, progress and techniques in biological systems engineering. May be repeated for credit. (S/U grading only.)—*F, W, S. (F, W, S.)*

298. Group Study (1-5)

299. Research (1-12)

(S/U grading only.)

Professional

390. Supervised Teaching in Biological and Agricultural Engineering (1-3)

Laboratory—3 hours; tutorial—3-9 hours. Prerequisite: graduate standing; consent of instructor. Tutoring and teaching students in undergraduate courses offered in the Department of Biological and Agricultural Engineering. Weekly conferences with instructor; evaluation of teaching. Preparing for and conducting demonstrations, laboratories and discussions. Preparing and grading exams. May be repeated for a total of 6 units. (S/U grading only.)—*F, W, S. (F, W, S.)*

Engineering: Biomedical

(College of Engineering)

Alyssa Panitch, Chairperson of the Department

Department Office. 2303 Genome and Biomedical Sciences Facility 530-752-1033; *http://www.bme.ucdavis.edu*

Faculty

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Sharon Aviran, Ph.D., Assistant Professor
Ramsey D. Badawi, Ph.D., Associate Professor *(Biomedical Engineering; Medicine: Radiology)*
Craig J. Benham, Ph.D., Professor *(Biomedical Engineering; Mathematics; Genome Center)*
John M. Boone, Ph.D., Professor *(Biomedical Engineering; Medicine: Radiology)*
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Julie L. Sutcliffe, Ph.D., Associate Professor *(Biomedical Engineering; Medicine: Hematology and Oncology)*
Cheemeng Tan, Ph.D., Assistant Professor
Soichiro Yamada, Ph.D., Associate Professor

Emeriti Faculty

Fitz-Roy Curry, Ph.D., Distinguished Professor Emeritus *(Biomedical Engineering; Medicine: Physiology and Membrane Biology)*
Maury Hull, Ph.D., Professor Emeritus *(Biomedical Engineering; Mechanical and Aerospace Engineering)*

The Biomedical Engineering Undergraduate Major

The Biomedical Engineering program is accredited by the Engineering Accreditation Commission of ABET; see *http://www.abet.org*.

Biomedical engineering is an interdisciplinary area of study that integrates knowledge from engineering with the biomedical sciences. It is a very diverse field, with biomedical engineers working in systems ranging from medical imaging to the design of artificial organs. Some major research advances in biomedical engineering include the left ventricular assist device (LVAD), artificial joints, kidney dialysis, bioengineered skin, angioplasty, computed tomography (CT), and flexible endoscopes. Students who choose biomedical engineering are interested in being of service to human health but do not routinely interact directly with patients.

The mission of the BS degree program of the Department of Biomedical Engineering is to combine exceptional teaching with state-of-the-art research for the advancement of technologies and computational techniques that meet medical and societal challenges. As a biomedical engineer, you can choose employment opportunities in industry, hospitals, academic research institutes, teaching, national laboratories, or government regulatory agencies.

The educational objectives of our program are that our graduates develop successful careers related to biomedical engineering or another area of the student's choosing, through employment in industry or government, or through pursuit of graduate or professional degrees; and contribute effectively to society through engineering practice, research and development, education, or in governmental, regulatory or legal aspects.

The biomedical engineering curriculum has been designed to provide a solid foundation in mathematics, life and physical sciences, and engineering, and to provide sufficient flexibility in the upper division requirements to encourage students to explore specializations within the field. Our instructional program is designed to impart knowledge of contemporary issues at the forefront of biomedical engineering research. Exclusive of General Education units, the minimum number of units required for the Biomedical Engineering degree is 157.

For information about graduate degree options, see Biomedical Engineering (A Graduate Group), on page 194.

Lower Division Required Courses

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.

	UNITS
Mathematics 21A or 21AH; 21B or 21BH; 21C or 21CH; 21D	16
Mathematics 22A-22B	6
Physics 9A or 9HA; 9B,9C	15
Chemistry 2A or 2AH; 2B or 2BH, 2C or 2CH	15