Biological and Agricultural Engineering (BAEG)

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Biological and Agricultural Engineering Website (https://bio-ag-engineering.uark.edu/)

Healthy Planet, Healthy People: this is the aspiration for the Biological Engineering program at the University of Arkansas. We improve people's lives today and help assure a prosperous world for tomorrow by designing sustainable water, food, and energy systems. Where challenges exist, we create solutions by optimizing the living systems of our world (the interactions of human, plant, animal, environment, food, and microbes) using the tools of engineering and biotechnology. Biological engineers contribute significantly to human health and prosperity by ensuring a safe and readily available water supply, a safe and nutritious food supply, and a healthy ecosystem upon which both water and food depend.

The faculty of the Biological Engineering program seeks to provide a challenging technical education in a safe, secure and inclusive learning environment that promotes a desire for service and prepares graduates to:

1. Successfully practice engineering involving the design and management of sustainable water, food, energy and related biological systems,
2. Make ethical, valuable and sustained contributions that benefit employers, communities, Arkansas and the world, and
3. Succeed in graduate education or continuing professional development, as needed for professional growth and licensure.

A Bachelor of Science degree in Biological Engineering is a job-ready degree with opportunities in a variety of industries, government agencies, and consulting firms. It is also excellent preparation for graduate studies (M.S. or Ph.D.) in engineering and related fields, as well as entry into other professional schools (e.g., medical, veterinary, dental, pharmacy, etc.).

The B.S. in Biological Engineering degree can lead immediately to careers in:

- Ecological engineering, such as water quality and watershed management, water resources and irrigation, low impact development in urban watersheds, stream and habitat restoration, and air quality remediation.
- Food and bio-product process engineering, such as food processing, forest products, biotechnology, biofuels, waste treatment and by-product utilization.
- Sustainable resource engineering, such as sustainable agriculture to expand the food supply for a growing population; renewable and bio-energy development; life cycle analysis to assess, design and manage complex biological systems; efficient utilization of organic residues and by-products; conservation of Earth's finite resources.

Completion of degree requirements provides graduates with the following learning outcomes:

- An ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics
- An ability to apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors
- An ability to communicate effectively with a range of audiences
- An ability to recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts
- An ability to function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives
- An ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions
- An ability to acquire and apply new knowledge as needed, using appropriate learning strategies.

Requirements for B.S. in Biological Engineering

The undergraduate program in biological engineering, leading to a Bachelor of Science degree in Biological Engineering, is accredited by the Engineering Accreditation Commission of ABET, www.abet.org (https://www.abet.org/). The B.S. in Biological Engineering degree is conferred by the College of Engineering and is granted after the successful completion of 128 hours of approved course work.

Diverse applications of biological engineering can be pursued through elective coursework. Each student is required to complete 12 semester hours of biological/engineering/technical electives that are relevant to their career goals. At least 3 hours must be selected from a list of acceptable biological electives. At least 3 hours must be engineering courses within BENG or other engineering programs. The remaining hours can be selected from engineering, math, biology, agriculture, sustainability, and other science/technical areas. A list of suggested electives is maintained by the department. Students may petition their adviser to seek approval of other electives that are not on this list. Courses must provide engineering or technical content that is value-added (i.e. not duplicating or remedial) and meets the career goals of the student. Students who choose electives meeting the Environmental Concentration requirements, can earn the concentration, see the 8-Semester Plan for the B.S. in Biological Engineering with an Environmental Concentration.

Students are required to complete 40 hours of upper division courses (3000-4000 level). It is recommended that students consult with their academic adviser when making course selections.

Biological Engineering B.S.B.E. Eight-Semester Degree Program

The Bachelor of Science in Biological Engineering program is eligible for students who want to participate in an Eight Semester Degree Program. See the Eight-Semester Degree Policy (http://catalog.uark.edu/undergraduatecatalog/academicregulations/eightsemesterdegreecompletionpolicy/) for more details. The plan below

lists a semester-by-semester sequence of courses to finish the degree in eight semesters. State minimum core courses for engineering are listed at the bottom of this page. Students may submit a maximum of four (4) hours of “D” in BENG Courses for their degree.

Some courses are not offered every semester, so students who deviate from the suggested sequence must pay careful attention to course scheduling and course pre-requisites.

First Year	Fall	Spring
GNEG 1111 Introduction to Engineering I	1	
ENGL 1013 Composition I (ACTS Equivalency = ENGL 1013) (Satisfies General Education Outcome 1.1)	3	
CHEM 1103 University Chemistry I (ACTS Equivalency = CHEM 1414 Lecture)	3	
MATH 2554 Calculus I (ACTS Equivalency = MATH 2405) (Satisfies General Education Outcome 2.1)	4	
U.S. History or Government Elective - Choose one course from the following (Satisfies General Education Outcomes 3.3 & 4.2):		
HIST 2003 History of the American People to 1877 (ACTS Equivalency = HIST 2113) or HIST 2013 History of the American People, 1877 to Present (ACTS Equivalency = HIST 2123) or PLSC 2003 American National Government (ACTS Equivalency = PLSC 2003)	3	
GNEG 1121 Introduction to Engineering II		1
ENGL 1033 Technical Composition II (ACTS Equivalency = ENGL 1023) (Satisfies General Education Outcome 1.2)		3
Freshman Engineering Science Elective		4
CHEM 1123 University Chemistry II (ACTS Equivalency = CHEM 1424 Lecture) & CHEM 1121L University Chemistry II Laboratory (ACTS Equivalency = CHEM 1424 Lab) or BIOL 1543 and BIOL 1541L		
MATH 2564 Calculus II (ACTS Equivalency = MATH 2505)		4
PHYS 2054 University Physics I (ACTS Equivalency = PHYS 2034)		4
Year Total:	14	16

Second Year	Fall	Spring
BENG 2632 Biological Engineering Design Studio	2	
MATH 2574 Calculus III (ACTS Equivalency = MATH 2603)	4	
Sophomore Science Elective (whichever has not been taken)	4	
CHEM 1123 University Chemistry II (ACTS Equivalency = CHEM 1424 Lecture) & CHEM 1121L University Chemistry II Laboratory (ACTS Equivalency = CHEM 1424 Lab) or BIOL 1543 and BIOL 1541L		
MEEG 2003 Statics	3	
PHYS 2074 University Physics II (ACTS Equivalency = PHYS 2044 Lecture)	4	
BENG 2643 Biological Engineering Methods I		3
MATH 2584 Elementary Differential Equations		4
BIOL 2013 General Microbiology (ACTS Equivalency = BIOL 2004 Lecture) & BIOL 2011L General Microbiology Laboratory (ACTS Equivalency = BIOL 2004 Lab)		4
MEEG 2403 Thermodynamics or CHEG 2313 Thermodynamics of Single-Component Systems		3
Social Science Elective - Choose one course from the list below (Satisfies General Education Outcome 4.1)[1]		3
Year Total:	17	17

Third Year	Fall	Spring
BENG 3653 Global Bio-Energy Engineering	3	
BENG 3733 Transport Phenomena in Biological Systems	3	
BENG 3663 Biological Engineering Methods II	3	
Choose one:	4	
CHEM 3603 Organic Chemistry I & CHEM 3601L Organic Chemistry I Laboratory		
CHEM 2613 Organic Physiological Chemistry (ACTS Equivalency = CHEM 1224 Lecture) & CHEM 2611L Organic Physiological Chemistry Laboratory (ACTS Equivalency = CHEM 1224 Lab)		
CVEG 3213 Hydraulics or MEEG 3503 Mechanics of Fluids or CHEG 2133 Fluid Mechanics	3	
BENG 3723 Unit Operations in Biological Engineering		3
BENG 3113 Measurement and Control for Biological Systems		3
CVEG 3223 Hydrology		3
Biological Elective		3
Technical Elective		3
Year Total:	16	15

Fourth Year	Fall	Spring
BENG 4812 Senior Biological Engineering Design I	2	
BENG 4831 Biological Engineering Professionalism	1	
BENG 4743 Food and Bio-Product Systems Engineering	3	

BENG 4933 Sustainable Watershed Engineering	3	
Humanities Elective - Choose one course from the list below (Satisfies General Education Outcomes 3.2 and 5.1)[2]	3	
Social Science Elective-choose any course listed on the State Minimum Core.	3	
BENG 4823 Senior Biological Engineering Design II (Satisfies General Education Outcome 6.1)		3
BENG 4663 Sustainable Biosystems Designs		3
Technical Elective (Engineering)		3
Fine Arts Elective - Choose one course from the list below (Satisfies General Education Outcome 3.1)[3]		3
Social Science Elective - choose any course listed on the State Minimum Core.		3
Technical Elective		3
Year Total:	15	18
Total Units in Sequence:		**128**

1 This Social Science Elective should be selected from the following courses in order to meet State Minimum Core and the General Education Outcome 4.1: ANTH 1023, COMM 1023, GEOS 2003, GEOS 2003H, HDFS 1403, HDFS 2413, HDFS 2603, HIST 1113, HIST 1113H, HIST 1123, HIST 1123H, HIST 2093, HUMN 1114H, HUMN 2114H, PLSC 2013, or RESM 2853.

2 The Humanities Elective should be selected from the following courses in order to meet State Minimum Core and the General Education Outcomes 3.2 and 5.1: CLST 1003, CLST 1013, PHIL 2003, PHIL 2003H, PHIL 2003C, PHIL 2103, or PHIL 2103C.

3 The Fine Arts Elective should be selected from the following courses in order to meet State Minimum Core and the General Education Outcome 3.1: ARHS 1003, COMM 1003, DANC 1003, MLIT 1003, MLIT 1003H, MLIT 1013, MLIT 1013H, MLIT 1333, THTR 1003, or THTR 1013.

Requirements for B.S. in Biological Engineering with Environmental Concentration

The undergraduate program in biological engineering, leading to a Bachelor of Science degree in Biological Engineering, is accredited by the Engineering Accreditation Commission of ABET, www.abet.org (https://www.abet.org/). The B.S. in Biological Engineering degree is conferred by the College of Engineering and is granted after the successful completion of 128 hours of approved course work.

Diverse applications of biological engineering can be pursued through elective coursework. Each student is required to complete 12 semester hours of biological/engineering/technical electives that are relevant to their career goals. At least 3 hours must be selected from a list of acceptable biological electives. At least 3 hours must be engineering courses within BENG or other engineering programs. The remaining hours can be selected from engineering, math, biology, agriculture, sustainability, and other science/technical areas. A list of suggested electives is maintained by the department. Students may petition their adviser to seek approval of other electives that are not on this list. Courses must provide engineering or technical content that is value-added (i.e. not duplicating or remedial) and meets the career goals of the student. Students who choose electives meeting the Environmental Concentration requirements, can earn the concentration, see the 8-Semester Plan for the B.S. in Biological Engineering with an Environmental Concentration.

Students are required to complete 40 hours of upper division courses (3000-4000 level). It is recommended that students consult with their academic adviser when making course selections.

Requirements for Environmental Concentration

Complete 12 hours from the following courses:

CVEG 3243	Environmental Engineering	3
CVEG 4243	Environmental Engineering Design	3
Biological Electives [1]		3
Technical Electives [1]		3

1 A list of Environmental Concentration electives is maintained by the department.

Biological Engineering B.S. with Environmental Concentration Eight-Semester Degree Program

The Bachelor of Science in Biological Engineering program with Environmental Concentration is eligible for students who want to participate in an Eight Semester Degree Program. See the Eight-Semester Degree Policy for more details. The plan below lists a semester-by-semester sequence of courses to finish the degree in eight semesters. University core courses for engineering are listed at the bottom of this page. Students may submit a maximum of 4 hours of “D” in BENG Courses for their degree.

Some courses are not offered every semester, so students who deviate from the suggested sequence must pay careful attention to course scheduling and course pre-requisites.

First Year	Units	
	Fall	Spring
GNEG 1111 Introduction to Engineering I	1	
ENGL 1013 Composition I (ACTS Equivalency = ENGL 1013)	3	
CHEM 1103 University Chemistry I (ACTS Equivalency = CHEM 1414 Lecture)	3	
MATH 2554 Calculus I (ACTS Equivalency = MATH 2405)	4	
PHYS 2054 University Physics I (ACTS Equivalency = PHYS 2034)	4	
GNEG 1121 Introduction to Engineering II		1
ENGL 1033 Technical Composition II (ACTS Equivalency = ENGL 1023) or ENGL 1023 Composition II (ACTS Equivalency = ENGL 1023)		3
Freshman Engineering Science Elective		4

CHEM 1123 University Chemistry II (ACTS Equivalency = CHEM 1424 Lecture) & CHEM 1121L University Chemistry II Laboratory (ACTS Equivalency = CHEM 1424 Lab) or PHYS 2074 University Physics II (ACTS Equivalency = PHYS 2044 Lecture)		
MATH 2564 Calculus II (ACTS Equivalency = MATH 2505)		4
HIST 2003 History of the American People to 1877 (ACTS Equivalency = HIST 2113) or HIST 2013 History of the American People, 1877 to Present (ACTS Equivalency = HIST 2123) or PLSC 2003 American National Government (ACTS Equivalency = PLSC 2003)		3
Year Total:	15	15

Second Year	Units	
	Fall	Spring
BENG 2632 Biological Engineering Design Studio	2	
MATH 2574 Calculus III (ACTS Equivalency = MATH 2603)	4	
Sophomore Science Elective	4	
CHEM 1123 University Chemistry II (ACTS Equivalency = CHEM 1424 Lecture) & CHEM 1121L University Chemistry II Laboratory (ACTS Equivalency = CHEM 1424 Lab) or PHYS 2074 University Physics II (ACTS Equivalency = PHYS 2044 Lecture)		
BIOL 1543 Principles of Biology (ACTS Equivalency = BIOL 1014 Lecture) & BIOL 1541L Principles of Biology Laboratory (ACTS Equivalency = BIOL 1014 Lab)	4	
MEEG 2003 Statics	3	
BENG 2643 Biological Engineering Methods I		3
MATH 2584 Elementary Differential Equations		4
BIOL 2013 General Microbiology (ACTS Equivalency = BIOL 2004 Lecture) & BIOL 2011L General Microbiology Laboratory (ACTS Equivalency = BIOL 2004 Lab)		4
MEEG 2403 Thermodynamics or CHEG 2313 Thermodynamics of Single-Component Systems		3
Social Science Elective-University Core		3
Year Total:	17	17

Third Year	Units	
	Fall	Spring
BENG 3653 Global Bio-Energy Engineering	3	
BENG 3663 Biological Engineering Methods II	3	
BENG 3733 Transport Phenomena in Biological Systems	3	
Choose one:	4	
CHEM 3603 Organic Chemistry I & CHEM 3601L Organic Chemistry I Laboratory		
CHEM 2613 Organic Physiological Chemistry (ACTS Equivalency = CHEM 1224 Lecture) & CHEM 2611L Organic Physiological Chemistry Laboratory (ACTS Equivalency = CHEM 1224 Lab)		
CVEG 3213 Hydraulics or MEEG 3503 Mechanics of Fluids or CHEG 2133 Fluid Mechanics	3	
BENG 3723 Unit Operations in Biological Engineering		3
BENG 3113 Measurement and Control for Biological Systems		3
CVEG 3223 Hydrology		3
Biological Elective		3
Technical Elective		3
CVEG 3243 Environmental Engineering		
Year Total:	16	15

Fourth Year	Units	
	Fall	Spring
BENG 4743 Food and Bio-Product Systems Engineering	3	
BENG 4812 Senior Biological Engineering Design I	2	
BENG 4831 Biological Engineering Professionalism	1	
BENG 4933 Sustainable Watershed Engineering	3	
Social Science Elective-University Core	3	
Technical Elective	3	
CVEG 4243 Environmental Engineering Design		
BENG 4823 Senior Biological Engineering Design II		3
BENG 4663 Sustainable Biosystems Designs		3
Fine Arts Elective-University Core		3
Humanities Elective-University Core		3
Social Science Elective-University Core		3
Technical Elective (choose a course from the Technical Electives list maintained by the department.)		3
Year Total:	15	18

Total Units in Sequence:	**128**

Costello, Thomas A., Ph.D. (Louisiana State University), M.S.Ag.E., B.S.Ag.E. (University of Missouri-Columbia), Associate Professor, 1986, 1992.

Haggard, Brian Edward, Ph.D. (Oklahoma State University), M.S. (University of Arkansas), B.S. (Missouri University of Science and Technology), Professor, 2006, 2011.

Henry, Christopher Garrett, Ph.D. (University of Nebraska-Lincoln), M.S., B.S. (Kansas State University), Associate Professor, 2011, 2018.

Kim, Jin-Woo, Ph.D. (Texas A&M University), M.S. (University of Wisconsin-La Crosse), B.S. (University of Iowa), Professor, 2001, 2011.

Kwofie, Ebenezer Miezah, Ph.D. (McGill University, Canada), M.Sc. (University of Boras, Sweden), B.Sc. (Kwame Nkrumah University of Science and Technology), Assistant Professor, 2021.

Li, Yanbin, Ph.D. (Pennsylvania State University), M.S. (University of Nebraska-Lincoln), B.S. (Shenyang Agricultural University), Distinguished Professor, Tyson Endowed Chair in Biosensing Engineering, 1989, 2003.
Liang, Yi, Ph.D. (University of Alberta, Canada), M.S., B.S. (China Agricultural University, Beijing, China), Associate Professor, 2007, 2014.
Matlock, Marty D., Ph.D., M.S., B.S. (Oklahoma State University), Professor, 2001, 2009.
Osborn, G. Scott, Ph.D. (North Carolina State University), M.S., Ag.E., B.S. (University of Kentucky), Associate Professor, 2001, 2007.
Runkle, Benjamin R.K., Ph.D., M.S. (University of California–Berkeley), B.S. (Princeton University), Assistant Professor, 2014.
Sadaka, Sammy, Ph.D. (Dalhousie University, Canada, and Alexandria University, Egypt), M.S., B.S. (Alexandria University, Egypt), Associate Professor, 2007, 2017.
VanDevender, Karl, Ph.D. (University of Arkansas), M.S., B.S. (Mississippi State University), Professor, 1995, 2004.
Verma, Lalit R., Ph.D. (University of Nebraska-Lincoln), M.S. (University of Montana), B. Tech. (J.N. Agricultural University, Jabalpub, India), Professor, 2000.
Wang, Dongyi, Ph.D. (University of Maryland), B.S. (Fundan University, Shanghai, China), Assistant Professor, 2021.
Zhu, Jun, Ph.D. (University of Illinois at Urbana-Champaign), M.S., B.S. (Zhejiang University, Hangzhou, China), Professor, 2013.

Courses

BENG 2632. Biological Engineering Design Studio. 2 Hours.
Application of the engineering design process to projects involving living systems. Projects are team-based open-ended design with hands-on construction and testing of design prototypes. Emphasis is placed on understanding, quantifying and controlling complex interacting living systems involving humans, animals, plants and microbes with the goal of creating economically and ecologically sustainable systems. 4 hours of design studio per week. Pre- or Corequisite: PHYS 2054 and BIOL 1543 and BIOL 1541L, and (GNEG 1111 or GNEG 1103). (Typically offered: Fall)

BENG 2643. Biological Engineering Methods I. 3 Hours.
Introduction to software techniques for the graphical and geo-spatial representation of processes, structures, devices, landscapes and watersheds in biological engineering. Process layout and process flow diagrams. Two-dimensional and three-dimensional scale drawings and models. Elements of engineering drawings and plans. Mapping and introduction to geographic information systems. Surface topography, digital elevation modeling, spatial land use, soils and other GIS data sources. Stream networks, watershed delineation, grade planning and introductory runoff modeling. Introductory land surveying. Geo-referencing and integrating designed hydrologic structures with GIS-based site maps. Communicating complex designed systems. Two hours of lecture plus one 3-hour lab per week. Corequisite: Lab component. Prerequisite: PHYS 2054. (Typically offered: Spring)

BENG 3113. Measurement and Control for Biological Systems. 3 Hours.
Principles of sensors, instruments, measurements, controls, and data acquisition systems, with emphasis on applications for biological systems; including basic circuit analysis, sensor calibration and hardware selection. Basic process monitoring and control methods, including hardware and software. Lecture 2 hours, laboratory 3 hours per week. Corequisite: Lab component. Prerequisite: PHYS 2074. (Typically offered: Spring)

BENG 3113H. Honors Measurement and Control for Biological Systems. 3 Hours.
Principles of sensors, instruments, measurements, controls, and data acquisition systems, with emphasis on applications for biological systems; including basic circuit analysis, sensor calibration and hardware selection. Basic process monitoring and control methods, including hardware and software. Lecture 2 hours, laboratory 3 hours per week. Corequisite: Lab component. Prerequisite: PHYS 2074 and honors candidacy. (Typically offered: Spring)
This course is equivalent to BENG 3113.

BENG 3653. Global Bio-Energy Engineering. 3 Hours.
Global energy sources with a focus on renewable energy, solar and biomass derived fuels. Biomass energy production from crops and organic residues or waste products. Conversion of biomass to usable fuels. Utilization of renewable energy in society. Includes detailed systems analyses to examine inputs, efficiencies, usable outputs and by-products. Systems design to select and integrate components which meet client needs while maximizing sustainable global impacts. Three hours of lecture per week. Pre- or Corequisite: MEEG 2403 or CHEG 2313. (Typically offered: Fall)

BENG 3663. Biological Engineering Methods II. 3 Hours.
Modeling biological processes to predict system behavior as part of the design process. Development and use of spreadsheets and script programming code to represent biological phenomena and processes. Introduction to experimental design as applied to biological processes, including data collection and analysis, and elementary statistics. Use of engineering economics to aid comparisons of alternatives. Analysis of engineering designs and management practices to best meet the needs of society and the client in areas of sustainable water, food and energy systems. Lecture 2 hours and lab 3 hours per week. Corequisite: Lab component. Prerequisite: PHYS 2054 and MATH 2564. (Typically offered: Fall)

BENG 3723. Unit Operations in Biological Engineering. 3 Hours.
Design of basic unit operations typical of biological engineering practice; unit operations include pump-pipe, fan-duct, moist air (psychrometric) processes (cool/heater/humidifier/dryer), air mixing, aeration, and refrigeration; unit operations design will account for unique constraints imposed by biological systems. Lecture 2 hours and lab 3 hours per week. Corequisite: Lab component. Prerequisite: (MEEG 2403 or CHEG 2313) and (CVEG 3213 or CHEG 2133 or MEEG 3503). (Typically offered: Spring)

BENG 3733. Transport Phenomena in Biological Systems. 3 Hours.
Basic principles governing transport of energy and mass. Estimating transfer of energy (heat) through solid bodies and liquid/gas boundary layers through conduction, convection, and radiation. Modeling the rates at which biological reactions occur (kinetics). Estimating the transfer of diffusing mass (gas or liquid) through solid bodies and liquid/gas boundary layers, including processes such as drying and oxygen diffusion. Three hours lecture per week. Pre- or Corequisite: (CVEG 3213 or MEEG 3503 or CHEG 2133) and MATH 2584. Prerequisite: (MEEG 2403 or CHEG 2313). (Typically offered: Fall)

BENG 4123. Biosensors & Bioinstrumentation. 3 Hours.
Principles of biologically based sensing elements and interfacing techniques. Design and analysis methods of biosensing and transducing components in bioinstrumentation. Applications of biosensors and bioinstrumentation in bioprocessing, bioenvironmental, biomechanical and biomedical engineering. Lecture 2 hours, laboratory 3 hours per week. Corequisite: Lab component. Prerequisite: BIOL 2013 or BIOL 2533 and BENG 3113. (Typically offered: Spring Odd Years)

BENG 450V. Special Problems. 1-4 Hour.
Selected problems in biological engineering are pursued in detail. Prerequisite: Senior standing. (Typically offered: Fall, Spring and Summer) May be repeated for up to 4 hours of degree credit.

BENG 451VH. Honors Thesis. 1-6 Hour.
Honors thesis. Prerequisite: Honors candidacy. (Typically offered: Fall, Spring and Summer)

BENG 452V. Special Topics in Biological Engineering. 1-6 Hour.
Special topics in biological engineering not covered in other courses. Prerequisite: Engineering student. (Typically offered: Irregular) May be repeated for up to 8 hours of degree credit.

BENG 4663. Sustainable Biosystems Designs. 3 Hours.
Process and methodologies associated with measuring, assessing, and designing sustainable systems in water, energy and food. Quantitatively rigorous methodology for life cycle analysis (LCA) for inventory, assessment and impact analyses. Use of other systems analyses and process control theory to evaluate and design sustainable systems. Application of the methods to a project to gain experience in defining, quantifying and utilizing sustainable metrics. Three hours of lecture per week. Prerequisite: BENG 3653. (Typically offered: Spring)

BENG 4743. Food and Bio-Product Systems Engineering. 3 Hours.
Sustainable bio-product engineering through biosystem design, analysis, modeling, control, and optimization. Life cycle phases for bio-products (food, fiber, feed, and fuel). System analysis of inputs and outputs of energy, water and mass for the purpose of producing and processing biomass for human uses. Advanced bio-process design topics to utilize enzymes, cells, tissues and organisms to create bio-products and methods for deactivating biological agents to preserve the quality and safety of food and other bio-products. Three hours lecture per week. Pre- or corequisite: BENG 3733. Prerequisite: BENG 3723. (Typically offered: Fall)

BENG 4812. Senior Biological Engineering Design I. 2 Hours.
Initiation of comprehensive two-semester team-design projects to design processes, devices and systems to meet needs of clients in sustainable water, food and energy. Practice in following the design process, including the definition of design objectives and constraints, establishing functions and performance criteria, generating alternatives and evaluating alternatives through analysis, modeling and prototype testing; exploring relevant design considerations including performance, efficiency, costs, environmental impacts, sustainability and stewardship, safety and ethics. Developing analytic capability; and practicing design optimization to find best alternative for the client. Lecture 1 hour, laboratory 3 hours per week. Prerequisite: Instructor consent. Corequisite: Lab component. (Typically offered: Fall)

BENG 4823. Senior Biological Engineering Design II. 3 Hours.
Completion of comprehensive two-semester team-design projects to design processes, devices and systems to meet needs of clients in sustainable water, food and energy. Focus on building of prototypes or models, system optimization, evaluation and improvement. Final design details packaged to meet the needs of the client. Interaction with appropriate persons from other disciplines. Written and oral reporting. Communications with peers, supervisor, clients and the public. Lecture 1 hour per week, two 2-hour lab periods per week. Prerequisite: BENG 4812. Corequisite: Lab component. (Typically offered: Spring)

BENG 4831. Biological Engineering Professionalism. 1 Hour.
Preparation to be job-ready, employable and successful in transition to a professional career and further study in Biological Engineering. Introduction to job and graduate study searches. Professional and ethical responsibilities; professional registration. Conflict, change and project management. Effective communications and interactions with supervisors, peers, clients, and stakeholders. Two hour discussion section per week. Prerequisite: Senior standing. (Typically offered: Fall)

BENG 4933. Sustainable Watershed Engineering. 3 Hours.
Provides students with expertise in using advanced tools in watershed monitoring, assessment, and design. Builds on core competencies in hydrology and hydraulics to allow student to evaluate water used by sector in water management regions; evaluate and quantify water demands by sector with emphasis on irrigation; develop risk-based simulations of hydrologic processes, including precipitation, evapo-transportation, infiltration, runoff, and stream flow; quantify and simulate constituent loading to watersheds using GIS-based models, and understand the applications of these methods in water resource management policy. Three hours lecture per week. Prerequisite: CVEG 3223. (Typically offered: Fall)

BENG 4963. Modeling Environmental Biophysics. 3 Hours.
Interactions between the biosphere and the atmosphere. Connecting the physical environment of solar energy, wind, soil, and hydrology to the biosphere through plant ecophysiology. Boundary layer meteorology, photosynthesis and boundary layer modeling strategies, and the soil-plant-atmosphere continuum. Instrumentation, measurement and modeling strategies for understanding leaf-, landscape- and regional behaviors; and, the transfer, kinetics, and balance of momentum, energy, water vapor, CO2, and other atmospheric trace gases between the landscape (vegetation and soil) and the atmosphere. Applications in sustainable agriculture, irrigation, land and water resources, and modeling plant water use and carbon uptake strategies. Three hours of lecture per week. Prerequisite: MATH 2564 and (BENG 4933 or CVEG 3223). (Typically offered: Spring Even Years)

BENG 4973. Practice in Water Quality Monitoring and Analysis. 3 Hours.
Application of water quality principles to a real world problem. Team project experience developing quality assurance project plans, designing monitoring systems, selecting chemical analysis methods, estimating loads, performing trend analysis, basic model calibration and validation, and technical report writing and oral presentations. Working with various clientele to analyze water quality data in the context of evaluating real-world problems and issues. Technical course intended for students in engineering, environmental sciences, agriculture and biology. Three hours of lecture per week. Prerequisite: CVEG 3213 or instructor's consent to allow interdisciplinary student teams. (Typically offered: Spring Odd Years)