Education and Research in Biosystems or Agricultural and Biological Engineering in Europe; a Thematic Network ERABEE TN

UNIVERSITIES IN USA AND CANADA OFFERING PROGRAMS OF STUDIES IN BIOSYSTEMS ENGINEERING OR RELATED DISCIPLINES

Demetres Briassoulis
Dept. of Natural Resources Management and Agricultural Engineering, AUA, Greece

Athens 2010
### UNIVERSITIES IN USA AND CANADA OFFERING PROGRAMS OF STUDIES IN BIOSYSTEMS ENGINEERING OR RELATED DISCIPLINES

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University of Kentucky: [http://www.bae.uky.edu/about.htm](http://www.bae.uky.edu/about.htm)

University of Maryland: [http://www.bioe.umd.edu/](http://www.bioe.umd.edu/)

University of Maine: [http://www.umche.maine.edu/chb/](http://www.umche.maine.edu/chb/)

University of Missouri: [http://bioengineering.missouri.edu/about/](http://bioengineering.missouri.edu/about/)

University of Montana: [http://bioengineering.missouri.edu/](http://bioengineering.missouri.edu/)

University of Nebraska – Lincoln: [http://bse.unl.edu/](http://bse.unl.edu/)
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Sources:

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A. SCOPE OF PROGRAMS OF STUDIES
A1. Biosystems Engineering (Auburn University)

Biosystems Department

The Department of Biosystems Engineering offers academic programs at the undergraduate and graduate levels. Our programs are offered through the Samuel Ginn College of Engineering with cooperation from the College of Agriculture and the School of Forestry and Wildlife Sciences. Undergraduate Program

This program leads to the Bachelor of Biosystems Engineering degree. Within the Biosystems Engineering degree program, students select from a curriculum in Biosystems Engineering and a curriculum in Forest Engineering.

Graduate Studies

The Department has opportunities for graduate study at both the Doctoral (PhD) and Masters (MS) level. Students may pursue these degrees through cooperative programs with other departments at Auburn University.
A2. **Biosystems Engineering (California State University)**

Applying engineering principles to biological processes and materials to develop alternative energy sources, beneficial products, and to provide alternative strategies for dealing with household, agricultural, industrial, and municipal wastes.

Biological Materials Processing: Biodiesel, Ethanol, Other alternative energy sources
Processing/Bioseparation of Materials to Produce/Purify: Pharmaceuticals, Oils, Other bio-based products

Treatment System Design/Operation: Household wastes, Municipal wastewater, Solid wastes, Agricultural wastes

Alternative Materials Production: i.e. Straw-based fiberboard

**EMPLOYERS**
Food processing companies
Manufacturing firms
Land grant universities
Research and education facilities
Research laboratories
Alternative fuel production companies
Environmental consulting firms
Power/utilities companies
Pharmaceutical companies
Research firms
A3. BioResource and Agricultural Engineering (California Polytechnic State University)

The mission of the BioResource and Agricultural Engineering Department is the study, teaching, and practice of engineering and systems management support for agriculture.

Our students "Learn by Doing" in laboratory-intensive classes. Through practical design and problem solving experiences, our students receive the skills, the tools and the opportunity to build what they design.

Cal Poly San Luis Obispo's BioResource and Agricultural Engineering major (BRAE) offers answers for students who want to be problem solvers. Today's high-tech agricultural industries are looking for graduates who can engineer solutions to the problems of resources and systems as well as for those who can manage advanced technologies.

The BRAE program, accredited by the Engineering Accreditation Commission of ABET, 111 Market Place, Suite 1050, Baltimore, MD 21202-4012 - telephone: (410) 347-7700, offers hands-on experience in a wide range of engineering skills areas. Concentrations include mechanical design, structures, electronic and control systems, irrigation, agricultural safety, renewable energy and waste treatment, and resource information systems.

With the Agricultural Systems Management major, students combine hands-on experience in agricultural technology with practical training in the business and management aspects of agriculture within a curriculum that is recognized by the American Society of Agricultural and Biological Engineering. In addition to the hands-on courses in the department, students may take enough business and management classes to earn a minor in Agribusiness.
A4. Biosystems Engineering (Clemson University)

Biosystems engineering is a science-based engineering discipline that integrates engineering science and design with applied biological, biochemical and environmental sciences. Biosystems engineers use engineering analysis and design to solve problems involving microorganisms, animals, humans and ecosystems. The biosystems engineering degree program is unique among engineering disciplines because it incorporates bioprocess, structural and mechanical design.

Graduate students in Biosystems Engineering find exciting research opportunities in the areas of water quality, bioprocessing, non-pointsource pollution, instrumentation and control, bioseparations, aquaculture, and machine design for biosystems engineering. Please visit the faculty and research pages for more information on the research areas.

The Department of Agricultural and Biological Engineering offers the B.S., M.S. and Ph.D. in biosystems engineering. The programs are nationally accredited by ABET, the Accreditation Board for Engineering and Technology. Students who receive the Bachelor of Science degree are eligible for licensing as professional engineers after gaining acceptable experience and passing the Fundamentals of Engineering and the Principles and Practice of Engineering examinations.

Graduates in biosystems engineering are well equipped to use their expertise in engineering in many areas that affect our quality of life and environment. They have broad training in mathematics, physics, chemistry and biological sciences, as well as a sound background in the engineering sciences. Biosystems engineers are sought by industry and public service organizations primarily for their ability to apply engineering expertise to living systems and to the management of land and water resources.
A5. Chemical and Biological Engineering (Colorado State University)

CBE Opportunities:

The Department of Chemical and Biological Engineering (CBE) at Colorado State has features that set it apart from programs at other universities.

The small class size and high teacher-to-student ratio facilitate personal attention to each student’s education. The small class size also allows for a close-knit student body. The AIChE student lounge is frequented by many of the students as a gathering place to meet, talk, and work on assignments.

The faculty all have active research programs, there are opportunities for undergraduate research experience in CBE. Opportunities for leadership abound within the student chapter of AIChE, active on the Colorado State University campus, and many other campus organizations.

Research Areas and Facilities

Research in the Chemical and Biological Engineering (CBE) department at Colorado State University can be split into 5 main areas:

- Biological Engineering
- Environmental Engineering
- Mathematical Modelling
- Polymer Science
- Transport Phenomena

Opportunities for collaboration with many other departments across the University are abundant, including departments in the Colleges of Engineering, Natural Sciences, and the College of Veterinary Medicine and Biomedical Sciences. CBE houses state-of-the-art research labs, additionally the University's Central Instrument Facility (CIF) provides 24-hour shared user access to several instruments and is maintained by five full time staff scientists. The Macromolecular Resources Center is a campus wide facility that maintains a variety of mass spectrometers. Proteomics and metabolomics services are combined with sample preparation procedures and extensive data interpretation.
A6. Biological and Environmental Engineering (Cornell University)

Department Mission Statement

Educate the next generation of professionals and discover new knowledge in Biological and Environmental Engineering;

Disseminate cutting edge research-based engineering information through the scientific media and outreach programs;

Conduct all programs in the context of a world-class university and deliver the highest value knowledge to our students, citizens and global society.

The Department of Biological and Environmental Engineering (BEE) is diverse with two distinct and highly integrated program areas: Biological Engineering and Environmental Engineering. Although these two program areas share significant commonality in teaching, especially with regard to the core curriculum, there are significant differences in emphasis and course options. These differences result in a flexible program that satisfies the diverse interests of our students. Accordingly, the intellectual breadth of the BEE department is even more strongly reflected by the diversity of the department's research and outreach activities. Biological Engineering integrates engineering practice and quantitative biology, with a focus on food systems, life sciences, human health and the environment. Environmental Engineering is aimed at combining engineering and environmental sciences in a coordinated manner so as to include a balance of basic, developmental and applied investigative efforts. Once concerned primarily with the rural environment, the program now addresses a wide range of environmental issues in both the private and public sectors.

Much of the approximately $6 million annual department expenditures are directed at sponsored research. This research includes the development of nanobiomechanical devices, biosensors, a bio-based industry center, food processing, controlled environmental agriculture, preferential flow, sustainable watersheds as well as many other projects and programs. Most BEE-led research is interdisciplinary and includes links to teaching and outreach.

The approach to extension and outreach used in BEE has changed considerably over the past ten years. A program that was coordinated primarily by full time professional faculty funded almost totally through core college funds is now conducted largely by faculty working with full-time Senior Extension Associates in programs that are largely externally funded. The department has major extension/outreach programs such as local roads, dairy systems, water and watershed management, and controlled environmental agriculture.

BEE is composed of an extraordinarily diverse faculty of twenty. Faculty members have Ph.D.s in agricultural engineering, biological engineering, chemical engineering, civil engineering, environmental engineering, electrical engineering, biotechnology and applied math. While the faculty bring diverse backgrounds and expertise they work in the two interrelated areas of biological and environmental engineering.
BEE has demonstrated the ability and courage to make the changes necessary to effectively address the challenges of the 21st century. We will continue to meet the ever-increasing student demand for technologically advanced and relevant programs. We will improve on our broad-based biological engineering program by placing special emphasis on applications to molecular and cellular biology. Advancements are being made in the biological engineering curriculum, especially in the courses appropriate for biomedical engineering.
A7. The Biological & Agricultural Engineering Program (Kansas State University)

The program is nationally accredited, offering both bachelor of science and graduate degrees.

To prepare for university study in engineering, you are encouraged to take a college preparatory program in high school. Since the ability to communicate effectively is essential to engineers, it is important that you take courses in English and speech. High school courses in physics and chemistry are highly recommended. Mathematics entrance requirements for the college include two units of algebra, one unit of geometry, one-half unit of trigonometry, and calculus if it is available.

Once at K-State, all engineering students prepare themselves for their engineering coursework with chemistry, physics, biology, mathematics, communications, engineering science, and other basic courses throughout the freshman and sophomore years. You'll gain an understanding of basic engineering principals, a knowledge of biological sciences, and the ability to develop new concepts and methods.

Due to the diversity of biological and agricultural engineering, four curriculum options are available: a general option with a chosen area of specialization, a machinery engineering option, an environmental engineering option, and a processing engineering option.

Classroom instruction for all the options is enhanced by practical hands-on experience and the application of computers to class problems and exercises. The curriculum is supported by faculty members with strong academic qualifications, as well as research, extension, industry, and foreign and domestic consulting experiences. This provides a firm basis for a comprehensive education in biological and agricultural engineering.
A8. Biological and Agricultural Engineering (LSU)

The Bachelor of Science in Biological Engineering (BE) from LSU provides an opportunity to apply the principles of analysis, synthesis, and design to physical problems and processing systems associated with plants, animals, humans, and their respective environments. Biological Engineering integrates applied biology into the fundamental principles of engineering for the purpose of designing processes and systems that influence, control, or utilize biological materials and organisms to benefit humanity. An undergraduate education in BE is excellent preparation for professional studies in various fields of engineering (including biomedical engineering), human or veterinary medicine, and dentistry. The curriculum is designed to teach students the practical skills needed for professional engineering and the understanding to adapt to new and dynamic situations.

"The Biological Engineering program is accredited by the Engineering Accreditation Commission of ABET, 111 Market Place, Suite 1050, Baltimore, MD 21202-4012 - telephone: (410) 347-7700," [www.abet.org](http://www.abet.org). Graduates are well prepared to take the Fundamentals of Engineering (FE) Examination during their senior year, which is the first step toward obtaining a license to practice engineering professionally.

The BE curriculum includes the study of basic sciences (mathematics, physics, chemistry, and biology), humanities (arts, economics, and social sciences), applied biology (organic chemistry, microbiology, and physiology), engineering sciences (statics, dynamics, strength of materials, fluid mechanics, electrical principles, and thermodynamics), and engineering design. Students can select technical and engineering electives that enable them to pursue specific career objectives. Elective courses can be used to complete the requirements for minor programs in environmental engineering, mechanical engineering, surveying, or technical sales.

**Departmental Facilities:**

As a student in Biological Engineering, one can use a state-of-the-art computer lab that has 50 engineering workstations. (See Figure 2.) This lab is also used for instruction in the areas of Computer Aided Design (CAD/CAM), Computer Modeling and Artificial Intelligence Expert Systems (AI/ES).

The department's student-teacher ratio is about 16:1, and this results in a close, personal instructional atmosphere in Biological Engineering classes. This personal instruction is enhanced by providing access to modern equipment for use and study in laboratory classes. Students also complete a senior design project that requires one-on-one direction from a faculty member. Numerous social activities with faculty, staff, and graduate students foster camaraderie that extends beyond the classroom. (See Figure 3.) Students may gain professional insight and potential employment contacts through participation in national engineering and technical organizations. The department also sponsors a student club and encourages students to become involved in professional activities.

Opportunity to gain valuable experience is provided by working in internships with faculty members. Some internships are paid. Several scholarships are available to upperclass students who are seeking the Biological Engineering degree. A graduate program leading to the M.S. degree is available in the department. A Ph.D. in Engineering Science through the College of Engineering, administered by the BE department, may also be pursued.
Career Opportunities:

The demand for Biological Engineers continues to exceed the supply, due to the need for increased food and fiber production and the increasing sophistication of biological systems and processing practices. Environmental quality; health, medical care, and safety concerns; increased use of biotechnology; constraints on energy availability, and the demand for a better life by an increasing portion of the world's population will further strengthen the future demand for biological engineers.

Career opportunities in Biological Engineering include design, development, and implementation of technologies: to recycle municipal wastes and agricultural byproducts, to clean contaminated water and soil, to develop equipment and procedures that prevent repetitive motion injuries, processing operations to ensure high quality foods, and to develop machinery or sensors applied to human, animal, plant, and ecological systems. Graduates of the BE program have the opportunity for local, national, or international work. Recent graduates are employed in engineering and consulting companies and state or federal governmental agencies. Many are pursuing graduate degrees.

An education from LSU in Biological Engineering provides students with the skills needed to solve today's problems and the knowledge required to master the rapid changes in technology and address the problems of tomorrow.
A9. Biological and Agricultural Systems Engineering (FAMU)

Biological and Agricultural Systems Engineering (BASE) is an emerging branch of engineering that integrates the agricultural, biological, chemical, and environmental engineering sciences.

It focuses on solving problems related to natural resources management and conservation as well as biological and agricultural production and processes. BASE provides students an opportunity to choose from two major areas of emphasis: Natural Resources Conservation Engineering or Bioprocess and Food Engineering. Students in BASE receive a broad engineering background, with courses such as mechanics, materials, thermodynamics, electronics and circuits, transport processes, instrumentation, and design. These engineers study life sciences and the ways biological systems interact with the environment. This diverse background makes them capable of understanding the engineering aspects of many different facets of a project and enables them to function exceptionally well on multidisciplinary teams. BASE is accredited by the Engineering Accreditation Commission of ABET.

Program of Studies

ABE Program Educational Objectives:
The Biological and Agricultural Systems Engineering Program will produce graduates who:

- Are successful in graduate or professional study in Science, Technology, Engineering, and Mathematics (STEM) and related fields;
- Are successful practitioners in the engineering profession at all levels (e.g. engineering design, management, consulting, engineering education etc);
- Are capable of operating in the global arena to meet societal needs for agricultural, biological, and natural resource systems; and
- Have a sense of professional and societal responsibility.

ABE Teaching Program Outcomes: The following expected outcomes of ABE engineering teaching program have been established by ABET to demonstrate that graduates attain the following outcomes:

(a) an ability to apply knowledge of mathematics, science, and engineering
(b) an ability to design and conduct experiments, as well as to analyze and interpret data
(c) an ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability
(d) an ability to function on multidisciplinary teams
(e) an ability to identify, formulate, and solve engineering problems
(f) an understanding of professional and ethical responsibility
(g) an ability to communicate effectively
(h) the broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context

(i) a recognition of the need for, and an ability to engage in life-long learning

(j) a knowledge of contemporary issues

(k) an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.
A10. Biosystems and Agricultural Engineering (Iowa University)

We are dedicated to the study and engineering of a wide array of biological systems and processing technologies. Our research spans from biomass pretreatment to sensor development, from life-cycle analysis to novel processing techniques, from food-safety to fermentation modeling, and from grain quality to bio-nanotechnology. In addition, much of our current work addresses critical needs within the developing bioeconomy. We are also tightly connected to ABE degree options in Biological Systems Engineering, Agricultural Engineering, and Agricultural Systems Management, and Industrial Technology.
A11. Bioproducts and Biosystems Engineering (Minnesota University)

We produce well-educated citizens who are leaders in their chosen field and offer excellent educational programs that achieve global prominence. BBE attracts a diverse population of students through an array of opportunities that offer many bioproducts and biosystems-related career options. We offer both undergraduate and graduate programs related to bioproducts and biosystems engineering, bio-based products marketing and management and residential building science and technology. Our undergraduate bioproducts and Biosystems engineering major is offered through the Institute of Technology (IT), the University of Minnesota's college of engineering, physical sciences, and mathematics, in affiliation with the College of Food, Agricultural and Natural Resource Sciences (CFANS).
A bio-based revolution is underway in the United States that will fundamentally change the way we produce and consume food, feed, fiber, materials, chemicals, fuel and energy. BBE serves as a prominent leader in developing sustainable biomass conversion solutions to meet the world’s growing materials and energy demand. “Green” materials, chemicals, and energy are made from renewable bio-resources like wood, agricultural residues, fiber crops, and other biomass. Current bioproducts and renewable energy topics of research in BBE include biofuels and renewable energy, cellulosic ethanol, biocomposites, conversion of algae to biodiesel, biodegradable plastics, building and structural materials, natural fibers, pulp and paper, environmentally benign adhesives, and a wide array of chemicals, and industrial feed stocks.
The Department of Biological Engineering at Mississippi State University provides students with opportunities to pursue careers in the fields of biomedical engineering, medicine, environmental engineering, and agriculture and natural resources. Biological engineering is characterized by the application of engineering principles to problems in biological systems. These systems can consist of cells in tissue culture responding to corrosion byproducts, the human body as it reacts to medical implants, animals generating solid wastes at animal production facilities, or production and processing of plants in agricultural systems. These problems are multi-disciplinary in nature and present challenges for which biological engineers are uniquely qualified.

In addition to taking a solid core of traditional engineering courses, students in biological engineering take

**Bagley College of Engineering Certificate Programs:**
- Materials
- Entrepreneurship
- Software Engineering
- Six Sigma
- Shackouls Honors College
- Coop Programs
- Summer Internship and Research Opportunities

Courses in chemistry, biological sciences, biochemistry, and microbiology. The bachelor of science program was the first biological engineering curriculum in the country and has been continuously accredited since 1972. The department offers programs that lead to bachelor of science, master of science, and doctor of philosophy degrees. A large number of biological engineering undergraduates go on to graduate and professional school.

Undergraduate students may choose from the following emphasis areas: biomedical engineering, environmental engineering, precision agriculture/agricultural systems, or premedical studies.

The base curriculum flowchart for undergraduates is available here.

In addition, undergraduate students may also choose to minor in leadership or other areas, and several certificate programs in the Bagley College of Engineering are also available for interested students

- BE Undergraduate Advising Guide (pdf, currently under revision)
- Fine Art, Humanities, and Social/Behavioral Science Electives: (See MSU Bulletin pages 1-3)
- Course Substitution Form
- Computer Ownership Requirements

The biological engineering program continues to grow and improve in both academics and research. The department now requires all freshmen students to have personal computers and has aggressively integrated computers into the curriculum.

The Agricultural Engineering Technology and Business (AETB) program provides and educational opportunity for students interested in applying technical, business and management skills to problems in agricultural production, commodity-related and natural resource management. A Bachelor of Science degree is offered by the Agricultural and Biological Engineering Department through the College of Agricultural and Life Sciences.
Employment for AETB graduates include: Food/Fiber Production (Farming), Agrochemical Industries, Agricultural Lending, Aquaculture, Banking, Cotton Ginning, Seed and Grain Processing, Crop Consulting, Agricultural Equipment Manufactures and Sales, Farm Management, Engineering, Land Surveying, and Food Processing.

Students may choose from five emphasis areas: Aquacultural Systems, Enterprise Management, Gin Management and Technology, Natural Resources and Environmental Management, and Precision Agriculture; or the Land Surveying Concentration. These options provide an academic pathway for students to pursue specific career goals.
A14. Agricultural Engineering (North Carolina Agricultural and Technical State University)

North Carolina Agricultural and Technical State University is a public, high research activity, 1890 land-grant university committed to exemplary teaching and learning, scholarly and creative research, and effective engagement and public service. The University offers degrees at the baccalaureate, master’s and doctoral levels and has a commitment to excellence in a comprehensive range of academic disciplines. Our unique legacy and educational philosophy provide students with a broad range of experiences that foster transformation and leadership for a dynamic and global society.
A15. Biosystems and Agricultural Engineering (North Dakota State University)

College of Engineering and Architecture

The agricultural and biosystems engineering (ABEN) program prepares men and women for careers requiring application of physical, biological and engineering sciences to problems that involve living systems. Agricultural and biosystems engineers provide engineering for the necessities of life.

The Program

Agricultural and biosystems engineers are uniquely qualified to use their knowledge of mathematics, biological and physical sciences, and engineering principles to solve problems relating to the production, handling, and processing of biological materials for food, feed, fiber, and fuel, the preservation of natural resources and environment quality, and the design and production of machine systems. A major in agricultural and biosystems engineering can serve a broad range of career interests and can provide excellent career opportunities for men and women from diverse backgrounds.

The program is accredited by the Accreditation Board for Engineering and Technology (ABET). Agricultural and biosystems engineering students are well qualified for and encouraged to take the national Fundamentals of Engineering examination. This is the first step in the process of registration as a professional engineer.

Agricultural and biosystems engineering integrates engineering topics, engineering design, and biological sciences in a single program with two concentrations; agricultural engineering and biosystems engineering.

Although not required by the curriculum, students are very much encouraged to take advantage of co-operative education experiences (paid internships). These experiences allow students to spend a summer, or more typically, a summer and a semester doing engineering work for an employer of program graduates. Students gain hands-on experience in engineering for the first time. This experience allows students to make an informed decision on their major, to make better selections of elective courses, and to open doors for employment at graduation.

Position titles of graduates for both concentrations may include: design engineer, test engineer, project engineer, plant engineer, quality control engineer, process engineer, energy adviser, consulting engineer and environmental engineer. Starting salaries are among the highest paid to college graduates and are comparable to those in other fields of engineering. Recent starting salaries range from $42,000 to $62,000 per year. Placement of graduates has been at or near 100% for many years.

Biosystems Engineering Concentration

Graduates in biosystems engineering integrate engineering, biology and chemistry in a variety of applications. Graduates may work in careers with the following goals: develop innovative green products and industries; convert bio-based resources to food, fuel and other renewable products; design new generations of devices or systems for biological systems; and control biological systems for natural resource protection,
waste remediation and ecosystem restoration. Graduates may work with industries to create new and improved processes through the innovative use of microorganisms, plant and animal cells and enzymes or they may develop sensors, control systems and computer models to monitor and control biological processes occurring in industry or the environment. Graduates with a biosystems engineering concentration may also pursue a professional or graduate degree in engineering, medicine, veterinary medicine, management or law.

**Agricultural Engineering Concentration**

Career opportunities for graduates in agricultural engineering are many and diverse. Graduates may work for companies and agencies that: design, develop, test and manufacture agricultural power and machine systems; handle, store, process and enhance or protect the quality of agricultural commodities and processed products; design environment control and housing systems for plant and animal production; design equipment and systems for processing, manufacturing, distribution and quality protection of food products; manage air, land and water resources; design and manage crop irrigation systems; and develop electrical and electronic applications for agricultural problems. Graduates with an agricultural engineering concentration may also pursue graduate degrees in engineering, business or law.
A16. Biosystems and Agricultural Engineering (Oklahoma State University)

Biosystems Engineers are professionals who use engineering tools to utilize, protect and manage natural resources. They engineer systems for the production of biological products and design methods to preserve and protect our environment. Graduates of our program can be found working in state and Federal government, private consulting and industry. Our broad-based program that stresses engineering fundamentals provides graduates the confidence and ability to succeed in a rapidly changing world.

We are jointly administered by the College of Engineering, Architecture and Technology, and the Division of Agricultural Sciences and Natural Resources. Offering BS, MS, and Ph.D. Degrees in Biosystems Engineering, Departmental faculty also advise students in Environmental Science. In addition to teaching, we have major missions in research and extension. Read our Mission Statement for more details.

Oklahoma State University, in compliance with Title VI and VII of the Civil Rights Act of 1964, Executive Order 11246 as amended, Title IX of the Education Amendments of 1972, Americans with Disabilities Act of 1990, and other federal laws and regulations, does not discriminate on the basis of race, color, national origin, sex, age, religion, disability, or status as a veteran in any of its policies, practices or procedures. This includes but is not limited to admissions, employment, financial aid, and educational services.

What Do Biosystems Engineers Do?

Biosystems engineers design efficient solutions to technical problems involving living things and the natural environment. Students receive a broad engineering background, with courses such as mechanics, materials, thermodynamics, electronics and circuits, transport processes, unit operations, instrumentation, and design. They study life sciences and the ways biological systems interact with the environment. This diverse background makes them capable of understanding the engineering aspects of many different facets of a project and enables them to function exceptionally well on multidisciplinary teams.

Environmental Permitting and Remediation

Most mining, heavy construction and environmental cleanups require a permit and remediation plan before work begins. These site investigations and engineering designs require knowledge of soils, hydrology, ground water, water quality and reclamation; all specialties of the Biosystems Engineer. By combining expertise in the environmental sciences and engineering design, Biosystems Engineers understand both how natural systems are impacted and how to eliminate unwanted consequences.

Food and Process Engineering
How do you monitor the inside of a commercial oven? A specialized data logger (the silver box) is used to record temperatures in cooking and cooling as these steaks move through a continuous oven. The data will maximize product quality and process efficiency. Biosystems engineers work in all sectors of the food industry, from harvest to table, as well as in pharmaceuticals and waste treatment.

**Biological Engineering**

Want a material tough enough for an athletic wheelchair? Biosystems engineers are not limited to the usual alloys and composites. They know about the astounding diversity of materials that the living world offers, and can integrate this knowledge with engineering principles. Experts in biological engineering develop uses for fibers and other biological materials, design biomedical equipment, and work with complex biological systems.

**Biofuels**

The release of CO2 from fossil fuels has caused great concern with global warming. Thus, there is increasing interest in renewal fuels that recycle carbon from the atmosphere. Technology being developed by Biosystems Engineers converts abundant biomass such as grass, wood chips, and municipal solid wastes, to liquid fuels. Fermentation of grain to alcohol is ancient; however, those methods cannot be used on materials such as grass without very expensive preprocessing. Biosystems Engineers are now developing a combination of gasification and fermentation so that one day your car may run on your lawn clippings and garbage.

**Forest Engineering**

Biosystems Engineers specializing in forest engineering do more than develop systems and equipment for growing and harvesting trees. They balance harvest and replanting with wildlife and recreational uses of forests. They plan access roads and design equipment that reduces the environmental impact of logging. These engineers also find innovative uses for forest products.

**Information and Electrical Technologies**

Biosystems Engineers develop sensor systems that detect nutrients in crops, test food for unwanted bacteria, or find contaminants in milk. Such systems typically integrate sensors with embedded computer controls. Biosystems combine capabilities in electrical engineering and physics, with a sound understanding of biology, to produce instruments that cross between mechanical and living systems.

**Power and Machinery**

With every wave, kelp is deposited on San Diego beaches. Every day, city workers scoop it up and haul it away. Their job is easier now, thanks to this machine designed to pick up kelp efficiently while leaving the sand on the beach. For innovative, mechanically sound, biologically sensitive machines, Biosystems Engineers have the expertise.
Natural Resources and Environmental Engineering

Protection of environmental quality under constant threat from urban and rural productive land use is becoming a major concern. Biosystems engineers use knowledge of hydrology, chemistry, and biology in watershed planning, design of non-point source pollution control systems, and management of organic wastes and crop residuals. Biosystems engineers use computers and computer models to manage flows of our major rivers and to design and evaluate best management practices of agriculture, forestry, and the construction, transportation, and mining industries.

Irrigation and Drainage

Where does water go after it falls on soil? Biosystems engineers with expertise in soil and water use their knowledge to make decisions about irrigation and drainage. This expertise is used to help crops grow more efficiently while reducing erosion and protecting water quality.

Structures and Environment

This Biosystems Engineer develops systems to regenerate air and water for growing food in space. Other Biosystems engineers with expertise in structures and environment work with greenhouses, animal housing, storage structures, waste handling facilities, and food processing plants. Some develop uses for biological products as construction materials.

Aquaculture

Efficient, non-polluting production and use of seafood, and other aquatic products is the goal of engineers specializing in aquaculture. In one system designed by an Biosystems engineer, algae grown with shrimp feed on the shrimp waste. The algae are then fed to oysters. Other kinds of algae are grown for dyes and pharmaceuticals.

Standards and Safety Engineering

Biosystems engineers develop standards that are used in the design and testing of machines and systems. These far ranging standards may specify communications protocol for on-board computers or methods for preventing electrical shocks from equipment. Standards document the common understanding needed to allow engineers to design and test safer and more effective systems.
A17. Biological & Ecological Engineering (Oregon State University)

Dr. Louis A. Licht, President of Ecolotree, Inc. says:

“Oregon State's Biological & Ecological Engineering program is an innovative program nested in a state where nature and human activities are both so diverse. To understand ecology with the depth of OSU sciences and engineering problem solving skills is unique. I hope to soon hire a BEE graduate to help design and build plant systems that clean urban storm water and recharge aquifers while diversifying habitat to include endangered species. Where else could that set of skills be learned as an undergrad? And all new students will help the program evolve - these are exciting times.”

From current BEE Senior Undergraduate Student, Benjamin Morelli:

"Ecological Engineering embodies a more holistic/systems approach to traditional engineering problems. Because of this it is less closely tied to specific disciplines and more about the way that you understand and shape the world in which you live. It is exciting that we have such opportunity to define the depth and breadth of our field."

"Ecological Engineering and Systems Thinking which will come to penetrate a broader segment of society and have a role to play in the repair of damaged ecological and social systems. As a student in this major we have the opportunity to positively affect the world in which we live.”
A18. Agricultural Engineering (Purdue University)

Agricultural Engineering prepares engineers for careers in industries whose products are based upon biological materials or on applications for production agriculture. Agricultural and natural resource engineers apply their knowledge of natural resource systems and engineering to equipment design and assure environmental compatibility of practices used by production agriculture. The ANRE curriculum offers great breadth, with specialization choices in machine systems engineering and environmental and natural resources engineering. The emphasis is on fundamental engineering sciences and design that may involve biological materials or the environment. Subject areas include computer-aided engineering, fluid power, finite element analysis, natural resource conservation, and engineering properties of biological materials. National and international careers include: product engineering, design and test engineers for equipment manufacturers, engineers with consulting firms and government agencies responsible for environmental quality, facilities design, safety engineering, forest engineering, and engineering management.

The Agricultural Engineering program leads to a B.S. degree from the College of Engineering and is ABET accredited. Its unique strengths include: 1) career diversity, because your education includes the vital fundamentals that prepare engineers for a dynamic world; 2) the challenge of working with complex biological-based systems and on important problems; and 3) excellent salaries and work environments.

The curriculum’s foundation is the Mathematical and Physical Sciences together with the Engineering science courses common to all Engineering curricula. Agricultural Engineers then specialize by adding Biological Science courses and departmental courses including: engineering design, mobile hydraulics, soil and water conservation, finite element analysis, off-highway vehicle design, and sensors and controls. Students may choose a specific area of specialization. Hands-on laboratories and personal access to the most advanced engineering workstation computer network in the country bring the student’s knowledge of advanced engineering tools to a practical level of utility.

In addition to an excellent technical education, agricultural engineers also learn communications, economics and professional ethics. The department’s relatively small size provides a level of personal attention not usually available at a major university.

Also available is the 5 year dual BS/MS degree.

Areas of emphasis/specialization:

Machine Systems Engineering (MSE)

Environmental and Natural Resources Engineering (ENRE)
A19. **Biosystems Engineering (South Dakota State University)**

**Mission and goals**

The mission of the Agricultural and Biosystems Engineering Department is to provide professional education at the undergraduate and graduate levels for engineers and technologists who will serve agricultural, biological, and environmental industries and to conduct research and provide technological leadership in engineering design and management for the agricultural community and its affiliated industries.

The program educational objectives for the Agricultural and Biosystems Engineering program are fulfilled as graduates develop successful careers in which they continue to grow in their professional skills; assume increasing professional responsibility; and show leadership in their careers, professional organizations, and communities. Specifically, graduates of the Agricultural and Biosystems Engineering program at SDSU will:

1. Advance within the agricultural and biosystems engineering profession as practicing engineers and consultants to positions of management, supervision, or leadership in a diversity of organizations or companies within the areas of agricultural and off-road machines; processing of food, fiber, and energy products; management of natural resources; structural systems; information and control systems; or other related areas.

2. Obtain graduate degrees at recognized research universities in agricultural and biosystems engineering or related fields.

3. Obtain professional registration or other professional certification where appropriate.

Our graduates can

a) apply knowledge of mathematics, science, and engineering.

b) design and conduct experiments and analyze and interpret data.

c) design a system, component, or process to meet desired needs.

d) function on multi-disciplinary teams.

e) identify, formulate, and solve engineering problems.

f) conduct themselves in a professional and ethical manner.

g) communicate effectively.

h) understand the impact of engineering solutions in a global and societal context.

i) recognize the need for life-long learning and then follow through.

j) understand contemporary issues.

k) use the techniques, skills, and modern engineering tools necessary for engineering practice.

l) possess competence in relevant fields such as biological materials, computer and automatic control systems, information systems, machine systems, modified environmental design, natural resource systems, processing systems, and structural design.

The SDSU Ag and Biosystems Engineering Department has three components:
Teaching. We are excited about our two majors, Ag & Biosystems Engineering (ABE), dealing with the development and design of major systems and equipment that impact our world's food sources, and Ag Systems Technology (AST) dealing with practical applications in the agricultural market.

Research. Our research is cutting edge, spanning everything from biofilters and manure odor reduction to food safety, distillers grain, biodiesel fuel, center pivot irrigation, and ground water runoff research.

Extension. Accurate, up-to-date, information from our Extension area provides assistance to South Dakotans in irrigation and water, farm safety, outdoor air quality, farm machinery, ag structures, and environmental, and rural handicap-accessible issues.

The Agricultural and Biosystems Engineering Department offers the opportunity for students to improve and impact the food chain and natural resources of America.
A20. **Biosystems Engineering & Soil Science (Tennessee University)**

Welcome to the department of Biosystems Engineering & Soil Science at the University of Tennessee! Whether you are a potential student, research collaborator, alumnus, or just browsing for information, our people, programs, and projects have something to offer you.

Our people are a unique mix - a faculty of biosystems engineers, soil scientists, and a bioclimatologist, together with a gifted technical support staff. The department has many graduate students who contribute immensely to the breadth of its overall program. With an exceptional commitment to working together, this allows us to target a broad spectrum of agricultural, biological, and environmental systems, with emphases on engineering, soil science, and environmental science.

Our programs encompass the full range of the Land Grant University mission - teaching, research, outreach, and service - and are administered by the College of Agricultural Sciences and Natural Resources, the Tennessee Agricultural Experiment Station, and University of Tennessee Extension. The department works closely with the College of Engineering in its engineering-related teaching pursuits.

Our projects? They touch on sensors and soil testing, spray technology and water quality, precision agriculture and environmental modeling, soil physics and vegetable production systems, agricultural safety and chemical transport, food quality and machinery systems, waste treatment and environmental rehabilitation, electrical systems and subsurface hydrology. Please explore the site to learn more.

Whoever you are, we want to hear from you! Contact us at bess@utk.edu or call 865-974-7266 with your questions, thoughts, and input. If you are in the area, we invite you to arrange a tour of our facilities and meet some of our faculty and/or students.
A21. Bioenvironmental Engineering (Texas A&M University)

The Texas A&M University Department of Biological & Agricultural Engineering, one of the largest in North America, ranks among the best in the nation as evidenced by the accomplishments of the students, graduates, former students and faculty. The department is jointly administered by the Dwight Look College of Engineering and the College of Agriculture and Life Sciences. Students in the Texas A&M University Department of Biological & Agricultural Engineering enjoy small class size and frequent one-to-one contact with professors, even though our department is among the largest of its kind. What's more, our faculty will be actively involved in helping develop your career, from advising you on the selection of your courses to helping you make contact with our many industrial partners, many of whom are among our more than 2,000 Former Students.

The Department of Biological & Agricultural Engineering offers undergraduate curricula in Biological and Agricultural Engineering and Agricultural Systems Management.
A22. Biological Engineering (The Ohio University)

WHAT CAN YOU TELL ME ABOUT BIOLOGICAL ENGINEERING?

Biological engineering involves the engineering of living systems and the application of engineering principles to problems that also require a strong knowledge of biology and ecology. Starting salaries generally range from $35,000 to $45,000.

BIO ENVIRONMENTAL:

Bio-environmental engineering includes the design, development, and management of biological systems to improve the quality of the environment. Students learn to address water quality, air pollution, and environmental contamination issues for farmers, municipalities, and industries using a biological systems approach. Bio-environmental engineers work to remediate past environmental problems and prevent future pollution. Industries involved in waste management or remediation, government agencies, and environmental consulting firms provide job opportunities for graduates who choose this option.

BIO-SYSTEMS:

Bio-systems engineers have the opportunity to work with plants, animals, humans, cells in tissue culture, and microorganisms. Graduates who have chosen this specialty pursue careers in biotechnology, biomedical engineering, biochemical processing, and bio-instrumentation.

COURSES INCLUDE:

- Math and physical sciences (chemistry, organic chemistry, physics)
- Biological sciences (biology, biochemistry, ecology, microbiology)
- Engineering design and mathematical modeling of biological systems.
A23. Agricultural and Biological Engineering (The Pennsylvania State University)

Graduate programs and accredited undergraduate programs in Biological Engineering and Agricultural Systems Management provide highly qualified engineers, systems managers, researchers, outreach educators and university teaching faculty for Pennsylvania, the nation, and the world. The educational programs offered are the B.S., M.S., and Ph.D. in Biological Engineering and the B.S. degree in Agricultural Systems Management.

Agricultural Engineering

Agricultural Engineering is the application of engineering design and analysis to:

Protection of natural resources

Conservation of our water and soil resources and protection of the environment from non-point source pollution, including soil loss, nutrient and chemical runoff from crop and forest lands and construction sites.

Power systems

Power transmission and motion control, power generation and fluid power circuits for off-road equipment, food and feed manufacturing.

Structural analysis and environmental control

Structural design using engineered wood products, and environmental control systems for buildings housing plants, animals, microorganisms, and food production operations.

Natural Resource Engineering

Natural Resource Engineering is the application of engineering design and analysis to:

Protection of air and water resources from the effects of human activities, and includes stormwater management, erosion control, waste handling and storage facility design, systems to protect the environment from nutrient and chemical run-off from crop land and development.

Food and Biological Process Engineering

Food and Biological Process Engineering is the application of engineering design and analysis to:

Microbiological production and processing: bioreactors, fermenters, and other systems for the production of pharmaceuticals, vitamins, preservatives, and food supplements. This also includes the use of biological organisms to produce energy, including fermentation to produce ethanol and anaerobic digestion for methane generation.
A24. Bioenvironmental Engineering (The State University of New Jersey)

Undergraduate Program of Bioenvironmental Engineering

What Is Bioenvironmental Engineering?
Bioenvironmental Engineers utilize engineering principles and the physical, chemical and biological sciences to prevent and solve environmental problems related to human activities.

Program Mission for Bioenvironmental Engineering
The mission of the Bioenvironmental Engineering Program is to provide students with a broad and thorough education in bioenvironmental engineering fundamentals, applications, and design so as to prepare graduates for the practice of bioenvironmental engineering at the professional level with confidence and skills necessary to meet the technical and social challenges of the future and for continuing their studies at the graduate level.

In pursuit of this mission, the educational objectives of the Bioresource-Bioenvironmental Engineering Program are as follows:

- Our graduates will apply their creativity in solving complex environmental engineering design problems, to approach unstructured and interdisciplinary problems, to synthesize and design potential solutions and to evaluate the impact of their solutions within the broader context of society.

- Our graduates will have the following technical skills:
  - The collection, analysis and interpretation of data relevant to problems arising in the bioresource and environmental engineering sectors (Encourage students to take the FE/PE tests).
  - The methodological and computational skills with which to operate effectively within the bioresource and environmental engineering sectors
  - Skills in current technologies and fundamentals to enable students to adapt to the changing field

- Our graduates will have the following leadership skills:
  - To facilitate, lead, coordinate and participate in interdisciplinary teams as well as understand organizational processes and behavior.
  - To effectively communicate their solutions in the context of written, oral, and electronic media
  - To participate in professional associations and activities in the field

- Our graduates will be positioned for life-long learning

- Our graduates will understand and be sensitive to the importance of professional ethics and will uphold these ethics in their professional practice.

Course Requirements
Bioenvironmental Engineering students take basic engineering courses and physical, chemical and biological science classes in their freshman and sophomore years. In the junior and senior years these fundamentals are applied for multidisciplinary problem solving in various environmental fields.
What Do Bioenvironmental Engineers Do?
Bioenvironmental Engineers are employed in the following areas:
- Engineering consulting firms
- Drinking water, wastewater, solid waste and air pollution treatment facilities
- Manufacturing industries
- Environmental regulatory and planning agencies
- Research laboratories
- International development agencies
- Public-interest groups

Bioenvironmental Engineering Is An Accredited Engineering Program resulting in preparation for the Fundamentals of Engineering Exam and licensure as a Professional Engineer
A25. Agricultural & Biosystems Engineering (University of Arizona)

The Department of Agricultural and Biosystems Engineering (ABE), affiliated with both the College of Agriculture and Life Sciences and the College of Engineering, offers programs leading to the Bachelor of Science, Master of Science and Doctor of Philosophy degrees.

Major areas of emphasis, which merge the physical with the biological sciences, include Water Resource Engineering and Biosystems/Biological Engineering.
Biological Engineers improve people’s lives today and help assure a sustainable quality of life for tomorrow. They create solutions to problems by coupling living systems (human, plant, animal, environmental, food, and microbial) with the tools of engineering and biotechnology. Biological engineers improve human health through biomedical engineering; ensure a safe, nutritious food supply and create critical, new medicines through food and bioprocess engineering; secure a healthy and safe environment through ecological engineering; and create tools to manage agriculture, the environment, and the products of biotechnology through bioresource engineering. Biological Engineering is an ABET accredited program leading to the B.S. degree. M.S. and Ph.D. degrees are also offered. The curriculum is under the joint supervision of the dean of the College of Engineering and the dean of the Dale Bumpers College of Agricultural, Food and Life Sciences. The Bachelor of Science 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.

The educational objectives of the Biological Engineering program are to produce graduates who:

1) Effectively apply engineering to biological systems and phenomena (plants, animals, humans, microbes, and the environment) with demonstrated proficiency in basic engineering skills, technical knowledge, and professional and personal skills.

2) Are well prepared for diverse careers in biological engineering, life-long learning, and professional and ethical contributions to society through sustained accomplishments in biomedical engineering, ecological engineering and biotechnology.
A27. Biological & Agricultural Engineering (University of California)

Mission

Our Department of Biological and Agricultural Engineering is recognized as the leading one of its kind in the western United States and is consistently viewed as one of the top biological/agricultural engineering departments in the world. As you browse the descriptions of our various academic programs, you will notice a common theme in all our missions-integration of engineering principles with biological systems. Our department enjoys the unique status of belonging to both the College of Engineering and the College of Agricultural and Environmental Sciences. In this environment, where collaboration is the rule, we interact with colleagues in both engineering and biological sciences to create multidisciplinary approaches to our teaching and research.

Our ABET-accredited undergraduate major in Biological Systems Engineering brings together courses in biology and engineering for the analysis and design of biological systems. Engineers who understand living systems are in increasing demand to create equipment, processes, and systems to produce and use biological materials. Our graduate program offers four degrees. The Master of Science (M.S.) and Doctor of Philosophy (Ph.D.) degrees prepare students for basic scientific research in engineering. Programs for the Master of Engineering (M.E.) and Doctor of Engineering (D.E.) emphasize design, analysis, economics, and management for the professional engineer. In the College of Agricultural and Environmental Sciences, our department provides two undergraduate minors - Geographic Information Systems, and Precision Agriculture.

In research, we enjoy the strategic advantage of being located in California, which leads the nation in agricultural production and in the diversity of its crops, and is a center of biotechnology. Since the department's beginnings in 1915, the following research programs have evolved: Agricultural Engineering, Aquacultural Engineering, Bioenvironmental Engineering, Bioinstrumentation Engineering, Biomedical Engineering, Biotechnical Engineering, Energy Systems Engineering, Food Engineering, Forest and Fiber Engineering, and Postharvest Engineering. These areas are described in the research section of this web site.

If you desire additional information or answers to questions, our faculty and staff will be pleased to respond.
A28. Bioresources Engineering (University of Delaware)

The College has established program-to-program articulation agreements that connect Delaware Tech associate degree programs with baccalaureate programs to create smooth transfer opportunities. The Connected Degree programs offer clear and economical pathways to high quality educational attainment. The articulation agreements enable a graduate to transfer to the senior institution as a junior, provided the required courses have been completed and the appropriate CUM GPA has been achieved as required by the receiving institution. The student must apply to the senior institution and complete all required admission processes. Click on the Connected Degrees listed below for information about the courses required at Delaware Tech and the senior institution for associate-bachelor’s completion and for contact information to learn more about these opportunities. Students need to see their Delaware Tech academic advisor for detailed information about the articulation agreements.

The College also participates in a Transfer of Credit Matrix agreement that delineates how individual courses transfer between the three Delaware public higher education institutions. (Delaware State University, Delaware Technical & Community College, and the University of Delaware) Transfer credit depends on the decision of the receiving institution. Click here of the Transfer for Credit Matrix.

Credits from another institution may be accepted at Delaware Tech as they apply to the established curricula of the College.

Bioresources Engineering
Engineering Technology is about giving life to ideas and turning visions into realities. With a blend of technical skills and scientific and engineering knowledge, the major teaches students to creatively handle challenges associated with manufacturing processes, construction design, project management, machinery systems, and environmental issues.

In the College of Agriculture and Natural Resources, business, education, science and technology are used to solve problems related to environmental protection; food and fiber production; and animal and plant health. Comprising nearly 25% of the nation's workforce, agriculture and natural resources provide career opportunities in research, industry, education and government.

The curricula provide a flexible program of study designed to educate students on the rapid changes and improvements in agriculture and natural resources. Frequent consultation with faculty advisors helps students progress toward achieving their educational goals. College faculty encourage and support students to pursue Degrees with Distinction, to take courses in the University Honors Program, and to participate in the Science and Engineering Scholars summer research program.

Undergraduate majors are offered in agriculture and natural resources, agricultural education, animal and food sciences, engineering technology, entomology, environmental soil science, food and agribusiness marketing and management, food science, landscape horticulture and design, natural resource management, plant protection, plant science, preveterinary medicine and animal biosciences, resource economics, statistics, and wildlife conservation.
A29. Agricultural & Biological Engineering (University of Florida)

Graduates of the Department of Agricultural & Biological Engineering help preserve our world's resources by designing environmentally sound solutions to complex problems.

Through a degree in Agricultural & Biological Engineering you can address issues related to the basic necessities of life…plentiful food, clean water, and a safe environment.

Agricultural Operations Management prepares graduates to apply technology and management skills to energy, environmental and agricultural construction systems, agricultural production, and technical sales.

Packaging Science graduates develop products to contain, preserve, protect, or enhance the value of goods thru innovative packaging solutions.

Graduate students may pursue advanced degrees in all areas. Highly qualified students should consider our combined Bachelor's/Master's degree program.

What is ABE? Agricultural and Biological Engineers help ensure that we have the basic necessities of life…safe and plentiful food supplies, pure water to drink and a safe, healthy environment. As the world population continues to increase, food production and protection of our natural resources become increasingly important. ABE applies engineering principles to biological sciences to produce food, feed, fiber and other agricultural products from renewable bio-resources. It also aims to protect the environment and conserve and replenish our natural resources.

Food and agribusiness is the largest single industry in the United States and Florida. It is the most highly sophisticated and technologically advanced industry in the world. Its status is due in part to the successes of agricultural and biological engineers.

Coursework The curriculum in ABE provides a foundation to address with the engineering problems of agricultural and related biological systems. These problems will be of even greater concern in the future. Courses in ABE unify learned concepts into a practical ability to solve a broad range of engineering problems encountered in agriculture, biotechnology and food processing. Students must meet the requirements in the College of Engineering. The Agricultural and Biological Engineering program is accredited by ABET. The ABE Academic Learning Compact identifies the skills students should acquire if they follow the course of study (see examples). Three specializations are available:

* **AGRISYSTEMS ENGINEERING** - is concerned primarily with the design and implementation of agricultural power and machinery, structures and their environments, greenhouses and instrumentation, robotics for agriculture and computer modeling and control.

* **BIOLOGICAL ENGINEERING** - provides a framework for integrating fundamental engineering sciences and practice with biological sciences. The curriculum prepares students for advanced studies in biomedical engineering, bioprocess engineering and agricultural engineering and fulfills the requirements for admission to pre-professional programs at the University of Florida. Click here for a list of the approved electives for this program.
* **LAND AND WATER RESOURCES ENGINEERING** - is concerned with all aspects of water and rural environmental management, including irrigation, water conservation, drainage, water control and structures, soil erosion, waste and wastewater recycling, water quality, ecosystems preservation and environmental quality. Click here for a list of the approved electives for this program.

Careers Agricultural and Biological Engineers work with farmers, agri-businesses, and conservation organizations to develop solutions to problems relating to the use and conservation of soil, water and forest resources. They also work to develop technologies to improve crop and livestock production, improve food-processing techniques, and extend the storage-life of perishable products like produce or flowers. They work to preserve and protect wetlands, improve the quality of our water supply and find new uses for biological resources. Starting salaries average over $45,000/year.

ABE graduates have a wide variety of career options, depending on their area of specialization. Employers include water management districts, government agencies, civil engineering firms, food companies such as Kraft, Tyson and Nestle, NASA, Walt Disney World, Abbot Laboratories, pharmaceutical companies, machinery companies, and many others.

The work environment for Agricultural and Biological Engineers varies from laboratories to offices to field types of environments. Most of our students are offered positions prior to or immediately upon graduation.
A30. Biological and Agricultural Engineering (University of Georgia)

Agricultural and environmental sciences are only as important as the food you eat, the clothes you wear, the water and air around you. To improve the quality and guard the safety of life's necessities, the University of Georgia College of Agricultural and Environmental Sciences has gathered world-renowned scientists and exceptional students.

The CAES is one of the oldest and among the best U.S. colleges of agriculture. In its classrooms, its Agricultural Experiment Stations and its statewide network of Cooperative Extension offices, the faculty and staff of the CAES are dedicated to discovering, teaching and delivering the science required for healthy living to flourish in Georgia.

The University of Georgia began offering engineering degrees over 130 years ago. As the first public institution in the state to educate Georgians in the engineering sciences, UGA continues to offer engineering degree programs that focus on the comprehensive education needed in today's technological world. The BAE Department benefits from being a part of a major land-grant and sea-grant institution and a strong liberal arts university. The BAE Department was the only academic engineering unit at UGA from 1932 until the establishment of the Faculty of Engineering in 2001. Hence, the academic offerings of the BAE Department are more diverse than similarly-named departments elsewhere, including fundamental courses in all areas of engineering as well as the agricultural and biological specializations. The diverse interests of students, other UGA academic programs, and external clientele during this period caused the BAE Department to broaden its instruction, research and public service programs in ways that have proven to be unique and enduring. Indeed, the BAE Department incorporates a diversity of offerings equivalent to that found in many comprehensive schools of engineering.

From the 1930s until the late 1980s, the Department's name was Agricultural Engineering and only two engineering degrees were offered: (1) a BS in Agricultural Engineering, and (2) an MS in Agricultural Engineering. In 1989, the Department faculty launched a "biological" engineering initiative which resulted in significant changes and expansion in engineering programs at UGA. In 1990, the Department was renamed Biological and Agricultural Engineering. Three new engineering degree programs were initiated in the 1990s: (1) a PhD in Biological and Agricultural Engineering in 1991, (2) a BS in Biological Engineering in 1994, and (3) an MS in Biological Engineering in 1996.

In 2000, under the leadership of BAE Department faculty, UGA identified the establishment of comprehensive engineering as a strategic university initiative for the first decade of the 21st century. This resulted in the establishment of the Faculty of Engineering in 2001 with the leadership of BAE Department faculty. The Faculty of Engineering now offers several engineering degree programs and, with the strong support and heavy engagement of the faculty of the BAE Department, the Faculty of Engineering will likely evolve into a school of engineering in the near future. When that occurs, the BAE Department will remain a separate engineering unit home-based in the College of Agricultural and Environmental Sciences as is typical of similarly-named units at other land-grant universities in the U.S. However, the BAE Department will have a strong partnership with the future school of engineering with
complementary programs that are synergistically integrated to assure a comprehensive engineering program at UGA.

**The objectives of the B.S.A.E. program are to provide graduates with:**

- Educational experiences using mathematics, natural sciences, engineering sciences and engineering design which motivate and qualify graduates to recognize and solve complex engineering problems.
- Superb technical skills in the areas of computers, information transfer, and communication; innovative and imaginative attitudes; and an appreciation for the management function.
- Learning experiences necessary for the synthesis of knowledge across disciplines in the social sciences, humanities, and natural sciences in order to understand the ethical, environmental, and social impacts of decisions.
- An appreciation for continued professional development through life-long learning.

The basic engineering curriculum concludes with a major senior project that integrates the breadth of the curriculum and requires the student to design a useful product under the constraints typical of private practice.

The fundamental philosophy of Engineering at UGA is to expose students to topics from several engineering disciplines before they select their upper division course work. This design gives the students an appreciation of the many career paths taken by professional engineers and produces graduates who are qualified to take advantage of employment opportunities related to civil, mechanical, electrical, biomedical, environmental, biochemical, agricultural and process engineering. By focusing on the fundamentals of engineering as well as the natural sciences and humanities, the UGA graduate is well prepared for the engineering profession, a global job market and a wide range of careers.

This approach to an engineering education is enhanced by the nature of the department responsible for UGA's engineering instruction program. This department is comprised of a faculty with expertise in over 12 engineering disciplines including aeronautical engineering, biomedical engineering, chemical engineering, computer systems engineering, civil engineering, electrical engineering, environmental engineering and mechanical engineering. Engineering students also have opportunities to participate in innovative interdisciplinary research programs through the University's Institute of the Faculty of Engineering.

The overall goals of the Bachelor of Science in Agricultural Engineering program are to provide a fundamental understanding of the natural, mathematical and engineering sciences and then to apply this understanding to design devices and processes in any general area. Graduates from this program are qualified to take advantage of employment opportunities related to civil, mechanical, electrical, agricultural and process engineering. Students enrolled in this program may choose from five engineering areas of emphasis: mechanical systems, electrical/electronic systems, structural systems, natural resource management and process operations.

**The objectives of the B.S.B.E. program are to provide graduates with:**
Education experiences using mathematics, natural sciences, engineering sciences and engineering design which motivate and qualify graduates to recognize and solve complex engineering problems.

Superb technical skills in the areas of computers, information transfer, and communication; innovative and imaginative attitudes; and an appreciation for the management function.

Learning experiences necessary for the synthesis of knowledge across disciplines in the social sciences, humanities, and natural sciences in order to understand the ethical, environmental, and social impacts of decisions.

An appreciation for continued professional development through lifetime learning.

The basic engineering curriculum is comprised of:

- A general education component that provides an understanding and appreciation of the basic sciences, social sciences, humanities and the arts;
- A mathematics component that provides quantitative skills needed to measure, estimate, model and simulate;
- An engineering science component that provides skills needed to integrate scientific knowledge with engineering applications; and
- An engineering design component that provides knowledge of the systematic process for creating new devices, systems, and structures for human use.

The basic engineering curriculum concludes with a major senior project that integrates the breadth of the curriculum and requires the student to design a useful product under the constraints typical of private practice.

The fundamental philosophy of Engineering at UGA is to expose students to topics from several engineering disciplines before they select their upper division coursework. This design gives the students an appreciation of the many career paths taken by professional engineers and produces graduates who are qualified to take advantage of employment opportunities related to civil, mechanical, electrical, biomedical, environmental, biochemical, agricultural and process engineering. By focusing on the fundamentals of engineering as well as the natural sciences and humanities, the UGA graduate is well prepared for the engineering profession, a global job market and a wide range of careers.

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The goals of one of the Bachelor of Science in Biological Engineering are to provide a fundamental understanding of biology, chemistry, physics, mathematics and engineering and to apply this understanding to design devices and processes related to biosystems. Graduates have an excellent understanding of the complementary aspects
of biology and engineering and work as professionals capable of implementing new ideas and technologies in complex biologically based industries. This degree program allows students to choose from three engineering areas of emphasis: biomedical, biochemical and environmental.

A31. Biological Engineering (University of Hawaii)

The Department of Molecular Biosciences and Bioengineering is part of the College of Tropical Agriculture & Human Resources at the University of Hawaii. The majority of the faculty and research programs are housed on the Manoa campus in St. John Laboratory, Gilmore Hall and the Agricultural Science Building. Members of the Department conduct research on molecular biology, biochemistry, bioengineering, functional genomics, bioinformatics and biotechnology related to living organisms and, the environment. The goal of these research programs is to gain new knowledge and develop new technologies relevant to modern agriculture, bioremediation, bioprocessing, and biotechnology industries. The technologies developed within the Department help improve bioproduction systems for food, fiber, and therapeutic applications, as well as reduce and remediate the impact of human activities on the environment. The Department also offers educational opportunities in the various disciplines cited above under the following degree programs:

• MS and PhD in Molecular Biosciences & Bioengineering
• BS in Plant & Environmental Biotechnology
• BS in Biological Engineering
• MS in Biological Engineering

Mission
The mission of the Department of Molecular Biosciences & Bioengineering is to develop and apply state-of-the-art techniques of molecular and cellular biology and biotechnology to problems of tropical agriculture and to facilitate the transfer of this technology to others in the College, University, State and Pacific Region. This role of leadership in agricultural biotechnology is accomplished through development of research programs utilizing the latest methods in molecular and cellular biology and biotechnology; through formal and informal collaborative research with other faculty in the College and University, and other researchers in the State and throughout the world; and through instruction and development of a graduate program based in tropical agricultural biotechnology and bioengineering.

AREAS OF RESEARCH

* Aquaculture
* Biotechnology
* Bioinformatics
* Biological (renewable) energy
* Biological production systems
* Bioremediation
* Environmental Biochemistry
* Functional Genomics
* Gene Regulation
* Genetics
* Mineral Nutrition
* Metabolomics
* Photosynthesis
* Plant-Microbe Interactions
* Plant Molecular Biology
* Proteomics
* Signal Transduction
* Stress Physiology
* Value added/ material processing
A32. Biological and Agricultural Engineering (University of Idaho)

Departmental Mission Statement

The Department of Biological and Agricultural Engineering's mission is teaching, research, and extension for solving engineering and technological management problems in agriculture, environment, biotechnology, and natural resources through an understanding of the biological, chemical and physical sciences.

Departmental Vision Statement

We will be an excellent source of engineering and technology education, knowledge and application in the fields of agriculture and biological sciences, and be widely recognized as such by the public and our peers due to the success of our graduates and extension clientele, and the significance and usefulness of our research.

Departmental Core Values

The members of the Department of Biological and Agricultural Engineering hold these values that govern our decisions and actions:

- Professional Competence
- Cooperation
- Professional Ethics
- Open Communication
- Personal Integrity
- Innovation

Engineering Student Learning Goals and Objectives

BAE graduates can apply their technical expertise in solving engineering problems and apply their skills in designing components, systems, and processes. Graduates can communicate and work effectively in teams. Graduates will have adequate knowledge of appropriate biological, chemical, natural resources, and agricultural science topics. They are able to apply their educational skills in a broad context related to an ever-changing world. The engineering program is ABET accredited.

Agricultural Systems Management Student Learning Goals and Objectives

ASM graduates will have knowledge in business and in the physical and biological sciences applicable to system and technology development to creatively solve agricultural problems. They will have mechanical skills needed to develop, construct, alter and repair agricultural equipment systems. They will be able to communicate with clientele and the public about solutions to agricultural technology and management problems. They will have computer skills that can be used in the analysis and development of agricultural systems and mathematical skills to quantify physical and biological processes in agriculture, and will have a social science and humanities background to provide sensitivity for the concerns of society and appreciate different points of view. ASM programs are ASABE recognized.
A33. Agricultural and Biological Engineering (University of Illiniois)

Program Objectives

The educational objectives for the Agricultural and Biological Engineering program reflect the mission of the Department of Agricultural and Biological Engineering and the importance placed on successful professional practice, the ability to pursue advanced degrees, the assumption of professional and societal leadership roles, and a commitment to life-long learning. University of Illinois Agricultural and Biological Engineering graduates will…

Objective 1: Successfully enter the agricultural and biological engineering profession as practicing engineers and consultants with prominent companies and organizations in diverse areas that include agricultural and off-road equipment manufacturing and automation, food and fiber production, renewable energy production, environmental conservation and water quality engineering, indoor environmental control, systems informatics and analysis, or other related fields.

Objective 2: Pursue graduate education and research at major research universities in agricultural and biological engineering, and related fields.

Objective 3: Advance in their chosen fields to supervisory and management positions.

Objective 4: Engage in continued learning through professional development.

Objective 5: Participate in and contribute to professional societies and community services.

Educational Outcomes

Engineering design, teamwork, and communication are integrated throughout the curriculum, culminating in a capstone design experience. By choice of electives, students not only meet all the outcomes listed below and those listed as college-wide outcomes in the introduction to the Programs of Study in the CoE, but are also provided with the opportunity to specialize in bioenvironmental engineering, food and bioprocess engineering, off-road equipment engineering, or soil and water resource engineering. The curriculum requires 128 hours for graduation, except for the concentration in food and bioprocess engineering, which requires 132 hours for graduation.

The Agricultural and Biological Engineering degree program includes coursework to provide exposure, practice and evaluation to demonstrate that our students attain:

(a) an ability to apply knowledge of mathematics, science, and engineering;

(b) an ability to design and conduct experiments, as well as to analyze and interpret data;

(c) an ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability;

(d) an ability to function on multi-disciplinary teams;

(e) an ability to identify, formulate, and solve engineering problems;

(f) an understanding of professional and ethical responsibility;

(g) an ability to communicate effectively;
(h) the broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context;

(i) a recognition of the need for, and an ability to engage in life-long learning;

(j) a knowledge of contemporary issues;

(k) an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.
A34. Biosystems and Agricultural Engineering (The University of Kentucky)

The mission of the Department of Biosystems and Agricultural Engineering is to serve and benefit the people of Kentucky and beyond through learning, discovery, and engagement in engineering for food, agricultural and biological systems.

Vision Statement:

The Department of Biosystems and Agricultural Engineering (BAE) strives to be:

- **Recognized and valued as a critical information source because its members:**
  - Provide timely BAE information to address vital contemporary problems.
  - Are responsive to all clientele groups.
  - Contribute solutions to critical issues confronting society.
  - Are catalysts for positive, innovative technological change.
  - Contribute to the enhancement of the quality of life.
  - Are the primary source of BAE discovery and expertise.

- **A leader:**
  - In the development and dissemination of knowledge in BAE program areas.
  - In multidisciplinary/multi-institutional team approaches to problem-solving.
  - In the design and implementation of undergraduate and graduate instruction.

- **A role model for all BAE departments in the nation because:**
  - It has achieved excellence and balance in its instructional, research, and extension programs.
  - It has achieved excellence in its BAE programs.
  - It has great faculty, staff, and students who cooperatively work together to achieve excellence.

Educational Objectives:

Faculty members in the department meet on a regular and recurring basis to review and revise the missions and goals of the program. In view of the strategic plans for the university, colleges, department, ABET criteria, and criteria set forth by the American Society of Agricultural and Biological Engineers (ASABE), the educational objectives for the BAE Program are:

1. Educate engineers to design components and/or processes for advancement of agricultural, biological, or environmental systems.

Prepare engineers for successful careers in industry, government, consulting firms, or academia. Successful careers begin with employment in a chosen field or admission
to graduate and professional programs, continue with steady advancement, and include professional development.
A35. Bioengineering (University of Maryland)

The Fischell Department of Bioengineering is an engineering and scientific academic organization dedicated to utilizing engineering and scientific knowledge and methods to assist the citizens of Maryland and the nation in developing biologically based knowledge and products to promote human and animal health, and improve the quality of life while maintaining a healthy environment.

The Undergraduate Program in Bioengineering at the University of Maryland

The undergraduate program in the Fischell Department of Bioengineering at the University of Maryland, College Park is founded in biology, driven by human health issues, and emphasizes innovation. Our objective is to merge the principles and applications embedded in engineering with the sciences of biology, medicine, and health.

Program Objectives

Maryland bioengineers gain a broad-based education in which engineering approaches are used to understand and improve living systems and their environments. We educate students to excel in the field of bioengineering and carry out research, development, and commercialization of bioscience systems and tools that will improve the lives of people throughout the world.

Program Learning Outcomes

- Knowledge of fundamental principles in mathematics, physics, design, engineering science and biology
- Knowledge of fundamental tools of engineering and bioscience including computer software and laboratory tools and techniques
- Experience with a disciplined work environment involving deadlines and deliverables
- Experience with a multicultural teamwork environment
- Experience working in an interdisciplinary environment

Educational Objectives

The undergraduate program in the Fischell Department of Bioengineering provides students with a broad and fundamental education relating engineering with the biological sciences. The program has focuses in biomedical devices, human health, biotechnology, and ecosystems. These focuses all contain a components of fundamental sciences, design, and communications skills. The students' educational achievements all contribute to enabling a wide range of career paths after graduation.

Owing to the breadth of our program, Maryland graduates are presented with a full range of career opportunities, including from those in medicine, human health, government, dentistry, law, pharmaceuticals, biotechnology, ecology, biomedical devices, bioprocessing, and teaching. Courses offered by this department may be found under the following acronym: BIOE

Educational objectives have been formulated to satisfy:

- Faculty insights and visions for Bioengineering
- Student interests
Employer needs

**Detailed Educational Objectives**

The goal of the undergraduate Bioengineering program is to produce engineers that possess many specific abilities:

- The ability to design products and processes related to living systems at all levels
- The ability to communicate well, especially with engineers and non-engineering biological specialists
- The ability to work successfully in teams
- The ability to conceptually categorize information, especially biological information, in order to deal effectively with technical advances coming at a rapid pace

Our graduates are grounded in fundamentals that will serve them throughout their professional careers. They will have an understanding of human behavior, societal needs and forces, and the dynamics of human efforts and their effects on human health and that of our environment. With these underpinnings and abilities our **specific educational objectives** are to graduate engineers that will:

- Gain employment in bioengineering or related professions.
- Participate in life-long learning activities that will further their careers and their impact on society

Serve their profession and community.
A36. Biological Engineering (University of Maine)

The mission of the Biological Engineering program reflects the mission of Maine’s Land Grant University, specifically to provide teaching, research and public service in the discipline of biological engineering. The goal of the Bachelor of Science program is to provide high quality undergraduate engineering instruction related to biological systems. The program educational objectives are to:

- provide students with a solid foundation in biological engineering through the understanding and application of mathematics, science, and engineering principles.
- prepare students for a broad range of career opportunities through the use of problem solving and critical thinking methods.
- help students develop the ability to function effectively in the workplace through teamwork and effective communication of technical/professional information.
- help students become aware of their moral, ethical, legal, and professional obligations to hold paramount the safety, health, and welfare of the public.
- help students develop an appreciation for the necessity for lifelong learning.

Biological engineers primarily design processing systems that render biological raw materials into value-added products. Many biological engineers work on problems of scale-up related to biological processing and therefore need to be conscious of system costs, efficiencies, and environmental impacts. This curriculum provides a unique background so that students may solve engineering problems and produce engineering designs in fields associated with biomedical, bioprocessing, biotechnology as well as other biologically related fields.

Employment Opportunities

Employment opportunities for biological engineers are as diverse as the biologically-based industries themselves. Graduates in Biological Engineering find employment as design or sales engineers in industries such as biomedical, bioprocessing, food, or pharmaceutical; in federal government entities such as EPA, NIH, USDA, or similar state agencies; in biological waste utilization industries; in government, industry, or state experimental facilities as research engineers; or in colleges and universities as teachers or instructors. Expanding engineering opportunities are available in the evolving fields of biomedical and biotechnology and the engineering of their related systems.
A37. Biological Engineering (University of Missouri)

Recognizing the immense promise of bioengineering and the unique position of Mizzou for a strong bioengineering program, the College of Agriculture, Food and Natural Resources (CAFNR) and the College of Engineering (CoE) joined forces to form the department of Biological Engineering (BE).

BE unites existing faculty and infrastructure from both colleges. CoE contributes biomedical engineering capabilities while CAFNR brings strengths in bioprocess and bioenvironmental engineering.

About Biological Engineering

What is Biological Engineering? Biological Engineering is a science-based engineering discipline that integrates engineering and biological sciences in one curriculum. Biological engineers develop products and design systems or processes for improved human health, use of bio-resources, and protection of the environment.

The three career emphasis areas include:

* Biomedical Engineering provides health care advances through:
  o Medical processes.
  o Disease diagnosis and treatment.
  o Patient rehabilitation.

* Bioprocess Engineering facilitates value-added products and food safety through:
  o Innovative technological use of renewable biological materials.
  o Enhanced packaging, quality and distribution of bioproducts.

* Bioenvironmental Engineering provides advances in environmental protection through:
  o Water and air quality systems.
  o Advanced conservation techniques.

Teaching and research programs have three emphasis areas: biomedical engineering, bioprocess engineering and bioenvironmental engineering.

BE has a B.S. program accredited by the Accreditation Board for Engineering and Technology and graduate programs offering M.S. and Ph.D. degrees in biological engineering. The undergraduate program is administered by CoE.

Since the establishment of the BE major, undergraduate student enrollment has seen significant increases every year. We boast an outstanding undergraduate student body. The average ACT score leads Mizzou by a significant margin.

In biomedical research, the focus is on bioengineering techniques for disease detection and treatment. This involves research in biosensing, biophotonics and bioimaging, biomechanics and bioinformatics.

Research in bioprocess engineering emphasizes bioresource use. Areas of research include biological material-based products, food engineering and food safety.
In the bioenvironmental area, the emphasis is on water quality issues, including wastewater treatment, bioremediation, precision agriculture and nonpoint source pollution.
A38. Chemical and Biological Engineering (Montana State University)

Welcome to Chemical and Biological Engineering!

Our goal is to prepare students to use their knowledge and skills to contribute to society and their profession. We offer undergraduate degrees in both chemical engineering and bioengineering.

The basis of both chemical and biological engineering is the useful transformation of matter from one form to another. That transformation can be brought about by direct chemical reactions, or chemical reactions mediated by living organisms.

Right now, chemical and biological engineers can work in many of the same areas. That may change as bioengineering develops as a profession, but bioengineers are likely to work closely with chemical engineers for the foreseeable future.

Both chemical and biological engineers are working with:

- Novel materials
- Energy sources
- Food products
- Pharmaceuticals
- Food products
- Pharmaceuticals
- Energy sources
- Novel materials
- Food products
- Pharmaceuticals

The list is expanding all the time - tomorrow's graduates may find careers in fields that do not even exist today as chemical and biological engineering research continually expands the opportunities.

If you haven’t decided whether you want a career in chemical or biological engineering, take heart - the curricula for chemical engineering and bioengineering are identical for the first three semesters.

In the first three semesters the focus is on basic math and science courses, and both bioengineers and chemical engineers need chemistry, calculus, and physics. The curricula start diverging in the junior year when bioengineering majors take more bio-based science courses while chemical engineering majors take more engineering courses.
A39. **Agricultural and Biological Engineering (University of Nebraska)**

**Agricultural Engineering**

From field to home, and everything in between, Agricultural Engineering is alive and well in Nebraska. Do you like to tinker with machinery, or try to invent new or better ways to do things? Are you interested in designing and testing machinery, reclaiming a stream bank, or working with flow devices? Do you enjoy challenges and solving problems in math and science? This is the education for you if you like working to save the environment, or working with the design and testing of powerful equipment. Nebraska is the home of the Tractor Testing Laboratory and center pivot irrigation, two major accomplishments in the world of Agricultural Engineering. Wouldn't you rather study something you already like?

Students have three emphasis areas to select from in the Agricultural Engineering program.

**Machine Design Engineering | Soil and Water Resources Engineering | Sensors and Controls Engineering**

**Machine Design Engineering**

Look at all the ways machines have been designed to help us realize achievements unheard of 60 years ago. Become a part of the next wave in the industrial revolution by devising ways to increase machine power while making efficient use of the power systems you create. Use your engineering education to invent, design, or improve the machines used by agriculture, heavy construction, industry, and households. You can learn to test equipment in the Nebraska Tractor Test Laboratory, or participate in building the Quarter-scale Tractor. Develop equipment and processes to transport, handle and process farm products (such as grains, vegetables, fruits and animals) into food products for human and animal consumption. Put some power into your education with a focus on machine design.

**Relevant issues**: precision agriculture, sensors, control systems, farm equipment design, power and energy, tractor performance

**Courses**: Unit Operations of Agricultural Machines, Power Systems Design, Machine Design, Instrumentation and Controls, Kinematics & Dynamics of Machinery, Materials Science, Failure Analysis

**Soil and Water Resources Engineering**

Soil is the thin skin covering the land; water is becoming more precious every day. Find out how engineering helps conserve these two valuable resources as you study the interactions between soils, plants, and water that influence the way these resources are used in planning irrigation systems, conservation buffers, and animal production facilities. Apply engineering and design skills to improve water quality and minimize pollution from nonpoint sources.

Develop irrigation systems, drainage systems, methods to reduce and control erosion, methods to reduce and control pollution of streams, rivers and lakes, and developing biological systems as cleaning systems, such as biofilters to clean air or constructed wetlands to clean water. There are many applications for this career field, and if you want to play a role in improving and protecting the environment, and don't want to sit behind a computer all the time, this is the field of study for you.

**Relevant issues**: irrigation system design, irrigation water management, soil erosion, drainage systems, water supplies, water quality and quantity, geographic information systems, nonpoint source pollution control

Resources Development, Nonpoint Source Pollution Control, Groundwater Engineering

**Sensors and Controls Engineering**

Sensors are being used more frequently and in more ways as new technological applications are designed. From machine vision to monitoring equipment, the engineer who knows sensors and controls will be designing solutions for greenhouses, animal environments, more effective and safer guidance systems, or controlling equipment on the farm or in industry.

Develop building systems to provide safe and healthy environments for animals or plants including hearing and cooling, clean air, lighting, clean water, food, and remove and process wastes. Develop new instrumentation systems and procedures (especially rapid, non-destructive methods) to measure things like nitrogen (fertilizer) in soil, phosphorous in soil, soil moisture, crop yield while combining, crop moisture content, estrous in animals, density of crop pests (insects diseases, weeds), and development of control systems to increase production rates, decrease waste, and increase safety. Whether creating systems for manufacturing or agricultural uses, the intricate world of sensors and controls will be a rewarding career path for the right engineering student.

**Relevant issues:** animal facilities, precision agriculture, processing, greenhouse environment, farm equipment control, geographic information systems, global positioning, waste management

**Courses:** Instrumentation and Controls, Design of Light-Frame Structures, Unit Operations of Agricultural Machines, Power Systems Design, Animal Waste Management, Digital Control, Control Systems Design, Site Specific Crop Management

Agricultural Engineering (AGEN) is an accredited engineering program by ABET. All ABET-accredited programs must publish their Program Objectives for access by employers, parents, students and others interested in what graduates of the program are expected to be capable of doing once they enter the workforce. The following are the Program Objectives for Agricultural Engineering at the University of Nebraska.

Upon entering the workforce, AGEN graduates (whether they are involved in machine design, sensors and controls, soil and water resources, or other professional endeavors such as business or law) will be:

1. applying their unique educational backgrounds in agricultural engineering by providing appropriate solutions to problems and adding value to the research, development, and design processes encountered in a variety of work environments;
2. considering systems as a whole when solving problems, looking beyond components and subsystems individually;
3. confidently using the necessary elements of mathematics, statistics, physical science, engineering, computer based measurement and analysis tools and current literature in solving problems and providing design solutions;
4. successfully integrating their technical knowledge with skills in communication and persuasion, leading and working effectively in teams, and understanding cultural diversity and social and political forces that impact engineering decisions, as well as having the capability of competing in an international atmosphere;
5. responsibly addressing issues of health and safety, ethics, and environmental impacts of engineering decisions.
6. continuing their personal growth, education and professional development through various opportunities provided by institutions, professional societies and other venues; and
7. valuing their educational experience by remaining involved in the department as alumni and continually promoting the agricultural engineering program and profession.

**Biological Engineering**

Would you like to use your math and science skills to help people or the environment? How about designing a medical instrument that makes surgery easier or designing a way to prevent soil erosion? How about inventing the latest and greatest food snack? Or discovering a fuel for cars made from agricultural residue?

Biological Systems Engineering brings engineering to life—working with living systems and the environment, by using biology, mathematics, and engineering to improve peoples' lives and our world.

This major leads to rewarding careers in Biomedical Engineering, Food & Bioproducts Engineering, and Environmental and Water Resources Engineering. We provide students with a broad, flexible engineering background with a biological emphasis. A high percentage of graduates go to work immediately in well-paid positions.

Many of our students go on to professional careers in engineering, law, medicine, food research, and academia. One thing is for certain—you'll never be bored in this field of study.

Biological Systems Engineering (BSEN) is an engineering program accredited by ABET. ABET-accredited programs publish their Program Objectives for access by employers, parents, students, and others interested in what graduates of the program are "expected to be capable of doing once they enter the workforce." The following Program Objectives are for Biological Systems Engineering at the University of Nebraska-Lincoln.

After graduation, BSEN alumni will share the attribute of improving the organization for which they work, and the community and country in which they live. They will do this whether they are involved in biomedical engineering, environmental and water resources engineering, food or bioproducts engineering, or other professional endeavors such as business, law, or medicine. In doing so, they will:

1. provide innovative and effective solutions to problems in a variety of work environments through the use of their unique background in biological systems engineering and the biological sciences;
2. look beyond components in isolation thereby providing holistic solutions to complex issues involving, for example, interactions at the ecosystem, organism, organ, cellular or subcellular level;
3. think logically using appropriate elements of mathematics, science and engineering to develop, manage and interpret data, to correctly interpret new research findings and, to design new systems for the benefit of society;
4. successfully integrate technical knowledge with communication and interpersonal skills to lead and work effectively in teams, and to articulate the role of engineering decisions in the workplace, community and world;
5. responsibly address issues such as health and safety, personal and professional ethics, cultural diversity, as well as the social, environmental and global impacts of their work;
6. continue their personal growth, education, and professional development through various opportunities provided by institutions, professional societies and other venues; and
7. remain involved in the department as active alumni who promote the biological systems engineering program and discipline, and mentor future generations of engineers.
A40. Agricultural and Biosystems Engineering (University of Puerto Rico)

The program of Mechanical Technology in Agriculture, administered by the Agricultural and Biosystems Engineering Department for students of agriculture emphasizes the practical application of engineering principles to the problems encountered in modern farming. In pursuing this objective, all of the major divisions of the agricultural engineering field are considered: farm power and machinery, soils and water management, farm structures and environmental control, rural electrification, and agricultural products processing.

The first year of the Mechanical Technology in Agriculture Curriculum is the same as that prescribed in most of the other undergraduate curriculums in the College of Agricultural Sciences; specialization gradually begins during the second year. The student, in consultation with his advisor, selects 12 credits of professional electives during the last two years of his program. The professional electives are chosen from the course offerings of the Agricultural and Biosystems Engineering Department and related areas. The student also selects 12 credits of free electives to refine curricular balance in accordance with his particular interests. During the summer between the third and fourth year, the student participates in a summer field practice which is administered in cooperation with the various government agencies and private industries.

Most of the agricultural activities in Puerto Rico need to be effectively mechanized in order to be economically viable and profitable. As a result of a continuing process of agricultural mechanization, there has been an increasing demand for graduates of the Mechanical Technology in Agriculture program.
A41. Bioenvironmental Engineering (University of Wisconsin)

The College of Agriculture, Food and Environmental Sciences has earned an outstanding reputation for excellence in education and service to the region, nation and the world since 1912.

The on-going challenges and opportunities related to food, soil and crop sciences, production agriculture, agricultural education, geo-sciences, natural resources and environmental sciences on regional, national and global scales create a broad range of exciting career opportunities.

Additional special areas of emphasis include dairy science, horse science, meat animal science, agricultural business, horticulture, crop and soil science, agricultural engineering technology, environmental sciences, land use planning, conservation and geology.

Our graduates are employed in government, industry, private enterprise, education, food and agricultural sciences, biotechnology, agricultural business, resource management and state extension.

Many CAFES graduates have elected to pursue careers in research and university teaching after earning advanced degrees.
A42. Biological Systems Engineering (Virginia State University)

The Department of Biological Systems Engineering develops and disseminates engineering knowledge and practices that protect natural resources and improve sustainable production, processing, and utilization of biological materials. BSE is part of the College of Agriculture and Life Sciences and the College of Engineering. Biological Systems Engineering is the field of engineering that combines biology, chemistry and engineering to solve problems associated with the production, processing and distribution of food, fiber and other biological materials; environmental protection; and conservation of natural resources. The curriculum and areas of specialization offered by the Department differ from other engineering programs in that they focus on biological materials. The curriculum includes a minimum of twenty hours of biology and chemistry, and emphasizes environmentally sound production and utilization of renewable resources. A broad-based engineering education is provided. Alumni consistently report that this diversity is one of the greatest strengths of the program.

The Bachelor of Science degree in Biological Systems Engineering is offered through the College of Engineering and is accredited by the Accreditation Board of Engineering and Technology (ABET). Two areas of limited specialization are emphasized.

- Land and Water Resources Engineering
- Bioprocess Engineering

Land and Water Resources Engineering is designed for students with an interest in environmental and natural resources management and protection. Biological, chemical, ecological and engineering principles are applied to the wise use, conservation, and protection of natural resources and the environment, particularly water, land and air. Traditionally, land and water resources engineers have been heavily involved in environmental protection of rural areas and management of food production systems and natural resources to insure that food and fiber production is accomplished in an environmentally acceptable manner. Today, land and water resources engineers are concerned with environmental protection in both rural and urban areas.

Bioprocess Engineering involves the design and development of equipment and procedures for the environmentally responsible manufacture of food and industrial products from biological materials. Students in this limited specialization combine knowledge of biological, chemical, and engineering principles to produce food, fuels, pharmaceuticals, plastics, construction materials and other products from biological materials. Bioprocess engineering plays a crucial role in the development of a sustainable and environmentally responsible food and biological engineering industry. In addition to the above areas of specialization, students can develop limited specialization in additional areas, such as aquacultural engineering, forest engineering, structural engineering with wood products, pre-vet and pre-med, through careful selection of electives. Graduates of the Biological Systems Engineering Department are typically employed by engineering, management, and manufacturing firms, as well as government agencies.

The Biological Systems Engineering program is relatively small, therefore, class sizes are generally less than twenty-five. There is greater faculty-student contact and more personal advising. Many Biological Systems Engineering courses include a laboratory component to provide "hands-on" experience.
The department participates in the five-year Cooperative Education Program through which qualifying students not only obtain valuable industrial experience while working toward their engineering degrees but also help finance their engineering education. The department has more than a dozen scholarships for students majoring specifically in Biological Systems Engineering.

In addition to the undergraduate program, programs of graduate study are available leading to the M.Eng., M.S., and Ph.D. degrees in Biological Systems Engineering. A combined B.S./M.S. program is also available that allows honors students to obtain both their B.S. and M.S. degrees in five years.
A43. Biological System Engineering (Virginia Tech)

Welcome to the Department of Biological Systems Engineering (BSE) at Virginia Tech! BSE "brings engineering to life" by combining biological sciences and engineering. The BSE program focuses on the two areas of Bioprocess Engineering and Land and Water Resources Engineering.

**Bioprocess Engineering** focuses on the design and development of processes for environmentally responsible manufacturing of food and industrial products from biological materials. Areas of interest include bioenergy, renewable materials, protein recovery, byproduct utilization, bioresidue management and utilization, systems biology, food safety, food engineering, biopharmaceuticals, and enzymes.

**Land and Water Resources Engineering** focuses on environmental protection and natural resources management. Areas of interest include nonpoint source pollution (water pollution caused by rainfall and runoff from land surfaces such as parking lots, golf courses, urban areas, agricultural fields, and construction sites), stream & wetland restoration, low impact development, and watershed management.
A44. Bioenvironmental Engineering (Washington State University)

We are a growing dynamic engineering department with exciting educational research opportunities for graduate students, post-doctoral research associates, and visiting scholars.

Our department has fourteen full-time faculty members that are nationally and internationally recognized for their scholarship and commitment to excellence. Supporting these highly qualified professionals are five support staff, six technical staff, thirteen post-doctoral researchers, and over fifty graduate students. This is a great team effort dedicated to offering you the best possible graduate educational research experience in:

- Bioprocessing & Bioproducts Engineering
- Food Engineering
- Land, Air, Water & Environmental Engineering.

And our newest emerging area:

- Automation and Mechanization

Overview

Bioengineers devise innovative solutions to today's most pressing health-care challenges. Through an understanding of the intersection of biology and engineering, our students are uniquely prepared to meet these challenges. Bioengineering applies engineering methods and concepts to living systems and utilizes biological methods and concepts to improve engineering practice. It is among the fastest growing disciplines in the nation, with many exciting and diverse career options.

Strengths of the program

- Graduates from the program have many options for professional practice and advanced study.
- Learn to work as a team to create new products and technologies.
- Pursue opportunities to participate in faculty research projects.
- Gain an edge from caring, knowledgeable faculty who are geared toward student success and are available to advise students.
- WSU’s program benefits from strong ties to veterinary medicine on the Pullman campus and human medicine in Spokane.
- You can join a math, science, and engineering community residence hall at WSU Pullman—share classes with your neighbors, study together, get free tutoring, and use the hall’s computer lab.

Courses are selected from subjects in several engineering and science fields, offering a strong integration in both areas.
A45. Canadian Biosystems Engineering and Technology University Programs

Biosystems Engineering and Technology undergraduate, graduate and post-graduate certificates and degrees available in Canada organized by province and university. Universities in Canada offering bachelor's, master's or a doctorate (PHD) programs in Biosystems Engineering and Technology.

Provinces and Universities in Canada offering Biosystems Engineering and Technology Programs

- Alberta
- British Columbia
- Manitoba
- Newfoundland
- Nova Scotia
- Ontario
- Quebec
- Saskatchewan
A46. Biological Engineering (Dalhousie University)

Biological Engineering covers a wide range of topics:

* Biotechnology
* Food Engineering
* Biomedical Engineering
* Waste Management
* Design of Biomachines
* Robotics

Biological engineers pursue careers in both the public and private sector. In the public sector, Bio-engineers are employed in the federal and provincial departments of agriculture and food, fisheries, and environment. In the private sector, Bio-engineers are to be found in consulting, machinery manufacturing, and food processing industries.
A47. Biosystems Engineering (University of Manitoba)

The Department of Biosystems Engineering at University of Manitoba provides students with educational opportunities to pursue careers in the fields of environmental engineering, bioprocess engineering, biomedical engineering, and agriculture and natural resources. The Department offers an accredited undergraduate program that integrates biological sciences into engineering, and graduate programs leading to MSc, MEng, and PhD.

The research efforts in the Department of Biosystems Engineering include stored grain ecosystems, biological treatment of wastes, phytoremediation of polluted soils, management of environmental odours, bio-processing, hyperspectral imaging techniques, animal and plant production environment, and alternative building systems.
Bioresource Engineering at McGill University is an accredited program recognized by the Canadian Engineering Accreditation Board and is accepted in every province of Canada, as well as by professional engineering societies in the United States of America and most other countries around the world.

The Bioresource Engineering interdisciplinary program integrates engineering science and design with biological sciences. Bioresource Engineering includes the design, construction, operation, maintenance, remediation and upgrading of systems that contain biological components.
B. UNDERGRADUATE CURRICULA
B1. Undergraduate Biosystems Engineering (Auburn University)

Undergraduate Program

The Biosystems Engineering Department offers the only accredited degree in Biosystems Engineering in Alabama. It is committed to preparing students for productive professional careers in the biosystems industries and related natural resource and environmental systems sectors. Specific educational objectives of the Biosystems Engineering Degree program are to produce graduates with:

1. The skills necessary to solve engineering problems associated with the environment and natural resources, and the production, processing, storage, manufacture, utilization, and recycling of biological products;
2. A fundamental understanding of engineering and biological sciences and the ability to combine knowledge from both domains to develop solutions to problems;
3. The ability to analyze critically and conduct scientific experimentation and engineering analysis that leads to development of environmentally and economically feasible design solutions that can be practically implemented; and
4. The ability to understand and expand the role of engineering in society; communicate, work, and provide leadership in multidisciplinary environments; and continue developing professionally and ethically throughout their career.

The Biosystems Engineering program is coordinated by the Samuel Ginn College of Engineering, the College of Agriculture, and the School of Forestry and Wildlife Sciences. Students should apply for admission to the Samuel Ginn College of Engineering and complete the Pre-Biosystems Engineering program.
### Biosystems Engineering Curriculum

#### Freshman Year

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<th>Course Code</th>
<th>Course Title</th>
<th>Credits</th>
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<td>Great Books I</td>
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Total Hours to Graduate = 130
BSEN Courses

**ENGR 1110-016 Introduction to Biosystems Engineering** Dr. Tim McDonald

ENGR 1110-016. Introduction to Biosystems Engineering. (2) Lec. 1 h/wk, Lab. 3 hrs/wk. Students work in teams to accomplish specified designs. Design work includes elements of team organization, graphical design representation, design analysis, and design presentation in written and oral form. (Fall and Spring). **Course Objectives:** Students will acquire sufficient skill and familiarity with the following subjects to allow them to use basic skills in these subjects to enhance their academic and professional performance; and acquire more advanced skills in each subject through individual study and practice:

**BSEN 3210 Mechanical Power for Biosystems** Dr. Tim McDonald

BSEN 3210. Mechanical Power for Biosystems (3). Lec. 2, Lab 3. Prerequisites: ENGR 2010, MECH 2110. Corequisite: MATH 2650. Basic engineering analysis, synthesis, and design concepts applied to power sources, mobile equipment and machinery applications for agricultural, forestry and natural resource systems. Fall. **Course Objectives:** Gain an understanding of the fundamentals of off-road machinery performance and function. Review the fundamentals of engine thermodynamics, ideal engine cycles, and factors that influence deviation from ideal performance. Use theoretical analysis and engine simulation to understand how selection of engine components changes performance characteristics, and how performance relates to overall success of a machine design. Present fundamentals of traction and machine stability. Review performance measurement techniques used in evaluating machines and engines.

**BSEN 3230 Natural Resources Conservation Engineering** Dr. Kyung Yoo

BSEN 3230. Natural Resource Conservation Engineering (3). Lec 2/wk, Lab 3/wk, Prerequisite. CIVL 3110. Design principles and practices in rainfall-runoff relationships, soil erosion and its prediction and control, hydraulic structures, and open channel hydraulics. Spring. **Course Objectives:** Provide students with a basic understanding of hydrology and applied hydraulics, prediction of soil erosion and non-point source pollution using computer simulation models, and design of hydraulic structures to control flow.

**BSEN 3240 Thermal Process Operations in Biosystems** Dr. Oladiran Fasina

BSEN 3240. Thermal Process Operations in Biosystems. (3) Lec. 2 hrs/wk, Lab. 3 hrs/wk. Prerequisites: ENGR 2010. Psychrometrics; Heat Transfer Fundamentals; Ventilation of Animal Housing and Greenhouse; Evaporation; Refrigeration and Freezing; Drying; Biological Product Preservation. Spring. **Course Objectives:** Acquaint students with the theory and application of thermal process operations to biological systems. The course is also designed to train students to identify, formulate and solve thermal process operation problems in biosystems engineering.

**BSEN 3260 Engineering for Precision Agriculture and Forestry** Dr. John Fulton

BSEN 3260. Engineering For Precision Agriculture and Forestry. (3) Lec. 2, Lab 3. Prerequisites: ELEC 3810, MATH 2650, or departmental approval. Engineering aspects of spatial technologies applied to agricultural and forest production. Data collection in the field using GPS and use of field data in site-specific applications. Fall. **Course Objectives:** Introduce concepts important in modern farming and forestry, including the ideas of location-specific treatment, mapping of field or stand...
performance and characteristics, equipment and technology for spatial assessments, autonomous operation of mechanized farm and forestry equipment, and variable rate technology for custom application of inputs. Investigate issues related to accuracy and granularity of measurements for particular applications. Also cover instrumentation fundamentals related to measuring important management variables in a spatial context. Topics will include general performance of instruments, reading and recording location information from GPS equipment, and creating instrument packages to record data in the field.

BSEN 3500 Natural Resource Systems Conservation

BSEN 3510 Agricultural Power and Machinery Fundamentals

BSEN 3530 Agricultural Production and Processing Facility Technology

BSEN 3560 Turf Systems Irrigation Design

**BSEN 4210 Irrigation System Design for Biosystems** Dr. Mark Dougherty
**BSEN 4210. Irrigation System Design For Biosystems** (3) Lec. 2 hrs/wk, Lab. 3 hrs/wk. Theory and design of irrigation systems for the application of water and wastewater including surveying techniques and soil-plant-atmospheric relationships for system design. Systems include solid-set, traveler, center-pivot and trickle. **Course Objectives:** determine the appropriate information required to design a complete and efficient irrigation system; determine where to acquire the data for an irrigation design; apply the collected data to design an irrigation system; analyze alternative methods of irrigation design and utilization; and incorporate irrigation design methodologies to wastewater applications.

**BSEN 4230 Waste Management and Utilization Engineering for Biosystems** Dr. David Hill
**BSEN 4230. Waste Management and Utilization Engineering for BioSystems.** (3) LEC. 2 hrs/wk, LAB. 3 hrs/wk. Prerequisites: CHEM 1040, BSEN 3230, BIOL 3200. Theory and design of physical and biological treatment processing systems for biological waste management and utilization. The technologies of lagoons, land. **Course Objectives:** To learn the important aspects of confined animal production with respect to environmental waste problems and current pollution abatement practices. To gain competence in analysis of waste problems and design of systems to control pollution and provide effective utilization of the waste on-site. To introduce the student to waste transport systems, biological treatment systems and utilization techniques involving land application; use as a feed stuff; and methane production through anaerobic digestion.

**BSEN 4240 Mechanical and Electrical Process Operations in Biosystems** Dr. Oladiran Fasina
**BSEN 4240. Mechanical and Electrical Process Operations in Biosystems.** (3) Lec. 3 hrs/wk, Lab. Prerequisites: ENGR 2070, CIVL 3110, ELEC 3810. Introduction to Renewable Energy, Biomass Processing, Biomass Handling, Storage and Transportation, Biomass Conversion, Wind Power Systems, Solar Resource, Electrical Energy Generation, Wiring Methods and Electrical Distribution, Electric Motors and Controls, Lighting Fall. **Course Objectives:** To acquire the techniques,
skills and engineering tools needed to design and analyze renewable energy systems; identify, formulate and solve problems related to the handling, transportation, storage and conversion of biomass materials; and to develop the skills needed to solve problems associated with the generation and application of electricity in biological systems.

**BSEN 4250 Hydraulic Control Systems Design** Dr. Tim McDonald

**BSEN 4250. Hydraulic Control Systems Design** (3) Lecture 2, Lab 3. Prerequisites CIVL 3010 or MECH 3030. Principles of energy transfer by means of fluid power. Design of hydraulic control systems using prime movers, valves, actuators, and accessories. Spring. **Course Objectives:** Provide students an understanding of the design, use, and analysis of hydraulic circuits. Specific goals are: Analyze the construction, function, and operation of hydraulic components used in stationary and mobile power systems, including pumps, valves, actuators, and other hydraulic accessories; assemble and test hydraulic circuits that employ both hydraulic and electrical controls; design hydraulic circuits to meet specified needs, including sizing and selection of components to achieve design criteria.

**BSEN 4310 Engineering Design for Biosystems** Dr. John Fulton

**BSEN 4310. Engineering Design for Biosystems.** (4) Lec. 2 hrs/wk, Lab 6 hrs/wk. Prerequisites: BSEN 4240 or FOEN 6710. Capstone design course in Biosystems Engineering emphasizing teamwork, communication, safety engineering, and economic analysis to complete and engineering design project. Spring. **Course Objectives:** 1) To develop a working knowledge of the engineering design process - professionalism, engineering graphics, advanced engineering mechanics, safety, product liability, manufacturability, incorporating engineering standards, and intellectual property; 2) To learn the importance of individual and team time management and scheduling, teamwork, conception of a design problem, communication, motivation, project supervision, ethical conduct, and salesmanship in the engineering design process; and 3) To learn the engineering design process through the application of engineering principles - develop a solution for a specified design project.

**BSEN 4900 Special Problems in Biosystems Engineering**

**BSEN 4967 Honors Reading**

**BSEN 4970 Special Topic-Bioprocessing Unit Operations** Dr. Oladiran Fasina

**BSEN 4970. Special Topics. (Bioprocessing Unit Operations taught Spring 2004).** (3) Lec. 2 hrs/wk, Lab. 3 hrs/wk. Prerequisites: ENGR 2010, BSEN 3240. Rheology and Texture, Thermal Processing, Mechanical Separation, Membrane Separation, Mixing, Extrusion, Packaging, Novel Bioprocessing Methods. Spring. **Course Objectives:** Acquaint students with unit process operations used in processing biological materials. The course is also designed to train students to identify, formulate and solve bioprocess operation problems.

**BSEN 4997 Honors Thesis**

**BSEN 5220 Introduction to Spatial Technologies for Biosystems** Dr. Puneet Srivastava
BSEN 5220. Introduction to Spatial Technologies for Biosystems Engineering. (3) Lec. 2hrs/wk, Lab. 3 hrs/wk. Introduction to geospatial technologies including global positioning system (GPS), geographical information system (GIS), and remote sensing systems as applied to Biosystems. Methodologies to collect, manage, and analyze spatial data for biosystems. (Spring). Course Objectives: Provide students with a basic understanding of how to collect and analyze geospatial data utilizing GPS and GIS. The course also introduces students to the integration of Biosystems models with GIS to perform spatial analysis.

BSEN 5250 Deterministic Modeling for Biosystems

BSEN 5550 Principles of Food Engineering Technology

BSEN 6220 Introduction to Spatial Technologies for Biosystems

BSEN 6250 Deterministic Modeling for Biosystems

BSEN 6550 Principles Of Food Engineering Technology Dr. Oladiran Fasina

BSEN 6550. Principles Of Food Engineering Technology. (4) LEC. 3, LAB. 3, Pr., MATH 1130, PHYS 1000. Engineering Concepts and unit operations used in processing food products. Fall. Course Objectives: The student will be provided with an understanding of engineering concepts and principles, and unit operations used in the processing, storage and handling of food and biological materials.

BSEN 7050 Soil Dynamics of Tillage and Traction

BSEN 7120 Stochastic Modeling for Biosystems

BSEN 7900 Special Problems in Biosystems Engineering

BSEN 7950 Seminar

BSEN 7970 Special Topics in Biosystems Engineering

BSEN 7990 Research and Thesis
B2. Undergraduate Biosystems Engineering (California State University)

BIOPROCESS ENGINEERING AREAS
Applying engineering principles to biological processes and materials to develop alternative energy sources, beneficial products, and to provide alternative strategies for dealing with household, agricultural, industrial, and municipal wastes.
Biological Materials Processing: Biodiesel, Ethanol, Other alternative energy sources
Processing/Bioseparation of Materials to Produce/Purify: Pharmaceuticals, Oils, Other bio-based products
Treatment System Design/Operation: Household wastes, Municipal wastewater, Solid wastes, Agricultural wastes
Alternative Materials Production: i.e. Straw-based fiberboard

EMPLOYERS
Food processing companies
Manufacturing firms
Land grant universities
Research and education facilities
Research laboratories
Alternative fuel production companies
Environmental consulting firms
Power/utilities companies
Pharmaceutical companies
Research firms

STRATEGIES
Seek related production and processing experience through co-ops, internships, or part-time jobs. Maintain knowledge of current alternative energy and product industry trends and regulations. Develop strong verbal and written communication skills. Seek extensive laboratory and research experience to obtain research positions. Learn team and individual design skills. Obtain Ph.D. for optimal teaching and research careers. Become familiar with the federal job application and employment procedures. Participate in related clubs and organizations like the student chapter of The American Society of Agricultural and Biological Engineers to build contacts and cultivate related interests.

SOIL AND WATER CONSERVATION ENGINEERING AREAS
Applying engineering principles to the complex environmental problems facing development and conservation of soil and water resources including soil erosion, water pollution by sediment and other contaminants from various land uses, stormwater runoff that causes flooding and damages the environment, and the impact of various land uses on aquatic ecosystems.
Erosion and Sediment Control: Construction sites, Reclaimed mines, Disturbed forests and pasture, Agricultural lands
Stormwater Management for Urban Settings to Reduce: Downstream flooding, Negative ecological impacts
Measuring and Monitoring Hydrologic Phenomena: Hydrologic elements, Water
quality concerns
Protecting Water Resources from Waste-Management Operations: Municipal wastewater and solid waste, Household wastewater, Agricultural animal and solid wastes, Pesticide-contaminated rinsewater
Automated Characterization of Aquatic Habitat: Underwater video mapping
Development of Instrumentation and Control Systems: Hydrologic and water quality phenomena

EMPLOYERS
Land grant universities
Research and education facilities
Research laboratories
State Environmental and Conservation Agencies
State Departments of Transportation
Environmental design and consulting firms
Architectural and building firms
Forest product and mining companies

STRATEGIES
Maintain knowledge of current environmental issues including policy, conservation, and industry trends. Seek related experience through co-ops, internships, or part-time jobs in specialized area of interest. Develop strong verbal and written communication skills. Seek extensive laboratory and research experience to obtain research positions. Learn team and individual design skills. Obtain Ph.D. for teaching and research careers. Participate in related clubs and organizations like the student chapter of The American Society of Agricultural and Biological Engineers and/or The Plant, Soil and Environmental Sciences Club to build contacts and cultivate academic interests.

MACHINERY SYSTEMS AND CONTROLS AREAS
Improving equipment efficiency in terms of energy, labor, and economics, while minimizing negative environmental impacts.
Site-Specific Control of Machinery (to reduce inputs/encourage optimal plant growth): Agricultural tillage, Seeding, Irrigation, Chemical application equipment
Determining/Predicting the Impact of Military Vehicles: Environmental quality of training areas
Control of Spraying Systems to Target Pest/Nutrient Needs
Development of Sensors/Control of Equipment Using Sensors: Crop and process yield monitors, Crop health monitors, Spray applicators
Collection/Use of Spatial Information: Global Positioning System (GPS), Geographic Information System (GIS)

EMPLOYERS
Agricultural and construction equipment manufacturers
Electronic instrumentation and control companies
Manufacturing firms
Biological production, management, and design companies including: Agricultural, Forest products, Nursery, Turf, Greenhouse, Mining
Agricultural and environmental design and consulting firms
Bulk product handling, processing, and transport manufacturers

STRATEGIES
Develop strong knowledge of engineering principles with practical application to design and integrate equipment, sensors, and facilities that handle, process, and control biological materials. Seek related experience through co-ops, internships, and part-time jobs. Develop strong verbal and written communication skills. Learn team and individual design skills. Obtain Ph.D. for optimal teaching and research careers. Participate in related clubs and organizations like the student branch of The American Society of Agricultural and Biological Engineers to build contacts and cultivate academic interests.

GENERAL INFORMATION
The Bachelor's degree provides a wide range of engineering career opportunities in industry, business, and government. The B.S. also provides a strong foundation for pursuing technical graduate degrees, as well as professional degrees in Business Administration, Medicine, or Law. Graduate degrees offer more opportunities for career advancement. Related work experience obtained through co-op, internships, part-time, or summer jobs is extremely beneficial. Plan informational interviews or job shadowing opportunities to make contacts in government and industry and to learn more about specific fields. Engineers need to think in design, scientific and mathematical terms, and must have the ability to study data, sort out important facts, solve problems, and think analytically. Engineers should be able to see how entire systems are affected and influenced by the various parts of the system. Creativity is useful. Other helpful traits include curiosity, technical aptitude, perseverance, a commitment to teamwork, and a basic understanding of the economic and environmental context in which engineering is practiced. Develop excellent verbal and written communications skills including presentation and technical report writing. Develop computer skills to assist in determining solutions to problems, collecting and analyzing data, and to control various processes. Join related professional organizations. Rapid changes occur in engineering fields, so continuing education and knowledge of new developments are very important. All states and the District of Columbia require registration of engineers whose work may affect the life, health, or safety of the public. Learn about state requirements for licensure as a Professional Engineer including the Fundamentals of Engineering (FE) and the Principles of Practice of Engineering (PE) exams.
B3. Undergraduate BioResource & Agricultural Engineering (California Polytechnic State University)

The Cal Poly BioResource and Agricultural Engineering department provides the following programs:

Bachelors of Science

- Agricultural Systems Management (ASM)
- BioResource and Agricultural Engineering (BRAE)
  Minors
  - Geographic Information Systems (GIS) for Agriculture
  - Water Science.

The bioresource/agriculture engineer represents the most general type of engineer, adept at utilizing electrical and mechanical energy sources, water resources, and designing structural units. The curriculum features a unique combination of engineering and applied science coursework, with a focus on preparing graduates for practice in professional engineering.

The mission of the BioResource and Agricultural Engineering program is to provide a "Learn by Doing" undergraduate educational experience that will prepare students for engineering practice in support of agriculture and related industries throughout the West.

The objectives of the BioResource and Agricultural Engineering program are to produce graduates who, in 3-5 years after graduation, are successful as one of the following:

- Engineers in positions of professional responsibility and leadership in a modern multi-disciplinary, system-oriented environment that emphasizes problem solving
- Actively pursuing or have achieved a degree in an advanced degree program
- Applying unique engineering problem-solving skills and principles within a career outside traditional engineering environments, such as management, teaching, research, or other professional fields

For advisor information and other forms, please click here.

(2009-11 Catalog)

- 60 units upper division
  - GWR
  - 2.0 GPA
  - USCP
* = Satisfies General Education requirement

Note: No major or support courses may be taken as credit/no credit

**Major Courses**

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<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credits</th>
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<tbody>
<tr>
<td>BRAE 128</td>
<td>Careers in Bioresource &amp; Ag Engr.</td>
<td>2</td>
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<tr>
<td>BRAE 129</td>
<td>Laboratory Skills and Safety</td>
<td>1</td>
</tr>
<tr>
<td>BRAE 133</td>
<td>Engineering Design Graphics</td>
<td>2</td>
</tr>
<tr>
<td>BRAE 151</td>
<td>CAD for Agricultural Engineering</td>
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<tr>
<td>BRAE 216</td>
<td>Fundamentals of Electricity</td>
<td>4</td>
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<tr>
<td>BRAE 232</td>
<td>Agricultural Structures Planning</td>
<td>4</td>
</tr>
<tr>
<td>BRAE 234</td>
<td>Intro Mechanical Systems-Agric</td>
<td>4</td>
</tr>
<tr>
<td>BRAE 236</td>
<td>Principles of Irrigation</td>
<td>4</td>
</tr>
<tr>
<td>BRAE 239</td>
<td>Engineering Surveying</td>
<td>4</td>
</tr>
<tr>
<td>BRAE 312</td>
<td>Hydraulics</td>
<td>4</td>
</tr>
<tr>
<td>BRAE 320</td>
<td>Principles of Bioresource Engineering</td>
<td>4</td>
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<tr>
<td>BRAE 328</td>
<td>Measurements/Computer Interfacing</td>
<td>4</td>
</tr>
<tr>
<td>BRAE 331</td>
<td>Irrigation Theory</td>
<td>3</td>
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<tr>
<td>BRAE 403</td>
<td>Agricultural Systems Engineering</td>
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<tr>
<td>BRAE 414</td>
<td>Irrigation Engineering</td>
<td>4</td>
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<tr>
<td>BRAE 421, 422</td>
<td>Equipment Engineering</td>
<td>3,4</td>
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<tr>
<td>BRAE 433</td>
<td>Agricultural Structures Design</td>
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<tr>
<td>BRAE 460</td>
<td>Senior Project Organization</td>
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<tr>
<td>BRAE 461, 462</td>
<td>Senior Project I, II</td>
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Adviser approved electives (click for approved list) 10

**Subtotal** 75

**Support Courses**

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<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
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<tbody>
<tr>
<td>BIO 213</td>
<td>and ENGR/BRAE 213 or</td>
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<tr>
<td>ENGR 213</td>
<td>Microbiology (*B2)</td>
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<tr>
<td>CE 201</td>
<td>Mechanics of Materials (6) or</td>
<td>6</td>
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<tr>
<td>CE 204, CE 207</td>
<td>Mechanics of Materials I, II (3)(3)</td>
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<tr>
<td>CHEM 124</td>
<td>General Chemistry for the Engineering Disciplines (*B3/B4)</td>
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<tr>
<td>CHEM 125</td>
<td>General Chemistry for the Engineering Disciplines (*Add'l Area B)</td>
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<tr>
<td>CSC 231, CSC 232, CSC 234</td>
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<td>2/3</td>
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<tr>
<td>ECON 201</td>
<td>Survey of Economics (*D2)</td>
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<tr>
<td>EE 321</td>
<td>Electronics and EE 361 Electronics Lab or</td>
<td>3,1</td>
</tr>
<tr>
<td>PHYS 206</td>
<td>Instr/Exp Physics and PHYS 256 Elect Measurements Lab</td>
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</tr>
<tr>
<td>ENGL 149</td>
<td>Technical Writing for Engineers (*A3)</td>
<td>4</td>
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<tr>
<td>MATH 141, 142</td>
<td>Calculus I, II (*B1)</td>
<td>4,4</td>
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<tr>
<td>MATH 143</td>
<td>Calculus III (*Add'l Area B)</td>
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<tr>
<td>MATH 241</td>
<td>Calculus IV</td>
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<tr>
<td>MATH 244</td>
<td>Linear Analysis I</td>
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ME 211 Engineering Statics 3
ME 212 Engineering Dynamics 3
ME 302 Thermodynamics 3
PHYS 141 General Physics 1A 4
PHYS 132, 133 General Physics 4,4
SS 121 Introductory Soil Science 4
STAT 312 Statistical Methods-Engr. (*B6) 4

Subtotal 81-82

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<tr>
<th>General Education (GE)</th>
<th>Units</th>
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<tbody>
<tr>
<td>72 units required; 36 units are in Support.</td>
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<tr>
<td>Minimum of 8 units required at the 300-400 level.</td>
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<tr>
<td>Area A Communication</td>
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<tr>
<td>A1 Expository Writing</td>
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<tr>
<td>A2 Oral Communication</td>
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<tr>
<td>A3 Reasoning, Argumentation, and Writing * 4 units in Support</td>
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<tr>
<td>Area B Science and Mathematics (no additional units are required)</td>
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<tr>
<td>B1 Mathematics/Statistics * 8 units in Support</td>
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<tr>
<td>B2 Life Science * 4 units in Support</td>
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<tr>
<td>B3 Physical Science * 4 units in Support</td>
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<tr>
<td>B4 One lab taken with either a B2 or B3 course</td>
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<tr>
<td>B5 (requirement for Liberal Arts students only)</td>
<td>0</td>
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<tr>
<td>B6 Upper-division Area B *4 units in Support</td>
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<tr>
<td>Additional Area B units *8 units in Support</td>
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<tr>
<td>Area C Arts and Humanities</td>
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<tr>
<td>C1 Literature</td>
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<tr>
<td>C2 Philosophy</td>
<td>4</td>
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<tr>
<td>C3 Fine/Performing Arts</td>
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<tr>
<td>C4 Upper-division elective</td>
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<tr>
<td>Area D/E Society and the Individual</td>
<td>(12)</td>
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<tr>
<td>D1 The American Experience (40404)</td>
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<tr>
<td>D2 Political Economy *4 units in Support</td>
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<tr>
<td>D3 Comparative Social Institutions</td>
<td>4</td>
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<tr>
<td>D4 Self Development (CSU Area E)</td>
<td>4</td>
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</table>

Subtotal 36
Total 192
Undergraduate Biosystems Engineering (Clemson University)

The Agricultural and Biological Department at Clemson University offers the Bachelor of Science degree in biosystems engineering with a focus in one of two concentration areas -- biotechnology or natural resources and environment.

APPLIED BIOTECHNOLOGY CONCENTRATION

The applied biotechnology concentration focuses on bioprocessing, the microbial conversion of compounds for production of high-value compounds and biological treatment of wastes. This area includes design of:

- biorefineries to produce nutraceuticals, pharmaceuticals, biomaterials and biofuels;
- advanced extraction and separation technologies for bioproducts;
- bioreactor systems design for bioprocessing and waste treatment;
- heat and mass transfer systems; and
- instrumentation and process control systems.

Download the Applied Biotechology concentration list. (PDF, 10 KB)

THE NATURAL RESOURCES AND ENVIRONMENT CONCENTRATION

Students who like engineering and who have an interest in the natural beauty of our planet and its resources will enjoy working in this focus area of biosystems engineering. This concentration allows students to apply engineering and biological principles to the wise use, conservation and enhancement of our natural resources and environment — water, land and air.

The program emphasizes water, its sources and controls as it moves from the air across the landscape and into impoundments such as ponds and wetlands. Clemson’s undergraduate program in natural resources and environment prepares students for entry-level engineering jobs and for graduate studies in biosystems engineering or other programs such as environmental engineering. There is an increasing demand for graduates in this area.

Download the Natural Resources and Environment concentration list. (PDF, 10 KB)

Biosystems Engineering Core Curriculum:

Undergraduate students take courses in four broad areas:
- basic sciences - mathematics, physics, and chemistry
- engineering sciences of statics, dynamics, fluid mechanics, thermodynamics, and electrical circuitry;
- biosystems engineering analysis and design courses, including a team-structured senior engineering design course.
- applied sciences, selected based on the student's concentration.
### BIOSYSTEMS ENGINEERING (BE) CURRICULUM

#### Applied Biotechnology (AB) Concentration

**Effective Fall 2006**

**Revised: Sept 2007**

<table>
<thead>
<tr>
<th>FRESHMAN YEAR (Gen. Engr.)</th>
<th>Credits</th>
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<tbody>
<tr>
<td>CH 102 Introduction to Engineering (Portfolio)</td>
<td>2(1,3)</td>
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<tr>
<td>CH 101 General Chemistry</td>
<td>4(3,3)</td>
</tr>
<tr>
<td>ENGR 153 Composition I or AP Test</td>
<td>3(3,0)</td>
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<tr>
<td>MTHSC 106 Calculus of One Variable</td>
<td>4(4,0)</td>
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<tr>
<td>Humanities/Social Science Requirement</td>
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<table>
<thead>
<tr>
<th>SOPHOMORE YEAR</th>
<th>Credits</th>
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</thead>
<tbody>
<tr>
<td>BE 210 Introduction to Biosystems Engnr.</td>
<td>2(1,3)</td>
</tr>
<tr>
<td>MTHSC 206 Calculus of Several Variables</td>
<td>4(4,0)</td>
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<tr>
<td>PHYS 221 Physics w/Calculus II</td>
<td>3(3,0)</td>
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<tr>
<td>Biology Requirement</td>
<td>4(3,3)</td>
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<tr>
<td>Statics Requirement</td>
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<tr>
<td>MTHSC 208 Intro. Ord. Diff. Equations</td>
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<table>
<thead>
<tr>
<th>JUNIOR YEAR</th>
<th>Credits</th>
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<tbody>
<tr>
<td>BE 312 Bio. Kinetics/Reactor Modeling</td>
<td>3(3,3)</td>
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<tr>
<td>CE 341 Introduction to Fluid Mechanics or CHE 230 Fluids/Heat Transfer</td>
<td>4(3,2)</td>
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<tr>
<td>EE&amp;CE 307 Basic Electrical Engineering</td>
<td>2(2,0)</td>
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<tr>
<td>Mechanics of Materials Requirement</td>
<td>3(3,0)</td>
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<td>Organic Chemistry Requirement</td>
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<table>
<thead>
<tr>
<th>SENIOR YEAR</th>
<th>Credits</th>
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<tbody>
<tr>
<td>BE 414 BE Unit Operations</td>
<td>3(3,3)</td>
</tr>
<tr>
<td>BE 438 Bioprocess Engineering Design</td>
<td>3(2,2)</td>
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<tr>
<td>BE 474 BE Capstone Design/Project Mgmt</td>
<td>2(1,3)</td>
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<tr>
<td>Humanities/Social Science Requirement</td>
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<tr>
<td>Life Science Requirement</td>
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<tr>
<td>Technical Elective</td>
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</table>

**128 Total Semester Hours**

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1. To avoid additional hours, students should choose courses to fulfill General Education requirements including Humanities, Social Science, Cross-Cultural Awareness and Science and Technology in Society components. See Undergraduate Announcement and academic advisor for details.

2. BIOL 103 or BIOL 110

3. Statics: EM 201; Dynamics: EM 202 or CE 206; alternatively ME 201 for both

4. CH 229 and 227 (preferred) or CH 201

5. ME 302 or EM 206 (prerequisite for CE 321)

6. Choose BIOSCI 306/506 or BIOSCI 301/500

7. MICRO 415 or approved BIOSCI, GEN, MICRO, BIOSCI, 300/400 level courses (minimum 600 level for BS/MS program)

8. Choose engineering course from BE 408, 417, 522, 584, EEBS 401, 402, 430, 480, 484, 485, 489, BIO E 302, 325, 401 or other approved engineering course (Minimum 600 level for BS/MS program)

9. Choose for minor, BS/MS (600 level), or other technical (200, 300, 400 level) course

**Notes:**

- Biosystems Engnr. students must maintain a minimum cumulative engineering GPA of 2.0 to enroll in 300/400 level BE courses.
- Biosystems Engineering students are encouraged to complete a Minor and/or a Coop program and/or an Internship (BE 307) and/or a Study Abroad Program.
- Probable minors include Bioengineering, Life Science cluster, Envir. Engr. (see Minor Recomm. Sheet for Applied Biotech).  
- Departmental Honors Thesis (BE H500H/H300H) is available for qualifying Junior/Senior students.
- Biosystems Engineering majors are encouraged to consider possibilities of graduate study early in the undergraduate program and plan accordingly, including the possibility of participating in Clemson's BS/MS program wherein six credits may count in both the BS and a MS degree.  Probable graduate programs include Biosystems Engineering, Environmental Engineering, Bioengineering, and other engineering and non-engineering programs.  BS/MS agreements exist for BE.
- Students must update Portfolio’s per individual course completion.
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BIOSYSTEMS ENGINEERING (BE) CURRICULUM

Natural Resources and Environment (NRE) Concentration

Effective Fall 2006
(revised: Sept 2007)

FRESHMAN YEAR (Gen. Engr.)

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credits</th>
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<tbody>
<tr>
<td>CES 102</td>
<td>Intro. to Engineering (Portfolio)</td>
<td>2(1.3)</td>
</tr>
<tr>
<td>CH 101</td>
<td>General Chemistry</td>
<td>4(3.3)</td>
</tr>
<tr>
<td>ENGL 103</td>
<td>Composition I or AP Test</td>
<td>3(3.0)</td>
</tr>
<tr>
<td>MTHSC 106</td>
<td>Calculus of One Variable</td>
<td>4(4.0)</td>
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Humanities/Social Science Requirement† | 3 |

SOPHOMORE YEAR

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
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<tbody>
<tr>
<td>BE 210</td>
<td>Introduction to Biosystems Engr.</td>
<td>2(1.3)</td>
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<tr>
<td>BE 223</td>
<td>Geomaterials</td>
<td>2(1.3)</td>
</tr>
<tr>
<td>MTHSC 206</td>
<td>Calculus of Several Variables</td>
<td>4(4.0)</td>
</tr>
<tr>
<td>PHYS 221</td>
<td>Physics w/Calculus II</td>
<td>3(3.0)</td>
</tr>
<tr>
<td>Biology Requirement†</td>
<td>4(3.0)</td>
<td></td>
</tr>
<tr>
<td>Statics Requirement†</td>
<td>3(3.0)</td>
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JUNIOR YEAR

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<tr>
<th>Course Code</th>
<th>Course Title</th>
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<tbody>
<tr>
<td>BE 312</td>
<td>Biol. Kinetics/Reactor Modeling</td>
<td>3(2.3)</td>
</tr>
<tr>
<td>CSE 321 or GSENV 322†</td>
<td>3(2.0)</td>
<td></td>
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<tr>
<td>GE 341</td>
<td>Introduction to Fluid Mechanics</td>
<td>4(3.2)</td>
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<tr>
<td>ECE 371</td>
<td>Basic Electrical Engineering</td>
<td>2(2.0)</td>
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<tr>
<td>MME 362</td>
<td>Mechanics of Materials Requirement†</td>
<td>3(3.0)</td>
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</table>

BE 415 Instrumentation/Control EE | 4(3.3) |

Structural Design Requirement† | 3 |

SENIOR YEAR

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<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credits</th>
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</thead>
<tbody>
<tr>
<td>BE 414</td>
<td>BE Unit Operations</td>
<td>3(2.3)</td>
</tr>
<tr>
<td>BE 445</td>
<td>Non-Point Source Mgmt/Engr. Ecosys.</td>
<td>3(2.3)</td>
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<tr>
<td>BE 475</td>
<td>BE Capstone Design</td>
<td>2(0.5)</td>
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<tr>
<td>Humanities/Social Science Requirement†</td>
<td>3</td>
<td></td>
</tr>
</tbody>
</table>

Engineering Requirement† | 6 |

Technical Elective† | 3 |

Total Semester Hours | 128 [To avoid additional hours, students should choose courses to fulfill General Education requirements including Humanities, Social Science, Cross-Cultural Awareness and Science and Technology in Society components. See Undergraduate Announcement and academic advisor for details.]

† To avoid additional hours, students should choose courses to fulfill General Education requirements including Humanities, Social Science, Cross-Cultural Awareness and Science and Technology in Society components. See Undergraduate Announcement and academic advisor for details.

‡ BIOL 103 or BIOL 110

§ ECE 331 or ECE 336; alternatively ME 301 for both

¶ ME 302 or ME 206 (prerequisite for CE 321)

* CE 321 for structural design (engineering) interest; CSENV 202 for non-point source (environmental science) interest.

+ Choose AE 301 or AE 301

Choose engineering course from BE 405, 417, 422, 454; EES 401, 402, 410, 430, 480, 484, 485, 486; CE 402, 406, 422; ECE 428, 421; or other approved engineering course (Minimum 300 level for BS/MS program)

Choose for minor, BS/MS (300 level), or other technical (200, 300, 400 level) course

Notes:

1. Biologics Engineering students must maintain a minimum cumulative Engr. CPR of 2.0 to enroll in 300-400 level BE courses.

2. Biologics Engineering students are encouraged to complete a Minor or/and Coop in Program and/or an Internship (BE 370) and/or a Study Abroad Program.

3. Students must be enrolled in Environmental Engineering, Environmental Science and Policy (see Minor Recomm. sheet for NRE).

4. Departmental Honors Thesis (BE 470/380/480) is available for qualifying junior/senior students.

5. Biologics Engineering majors are encouraged to consider possibilities of graduate study early in the undergraduate program and/plan accordingly, including the possibility of participating in Clarkson’s BS/MS program wherein six credits may count in both the BS and a MS degree. Probable graduate programs include Biologics Engineering, Environmental Engineering, and other engineering and non-engineering programs. BS/MS agreements exist for BE.

6. Students must update Portfolio’s per individual course completion.
B5. Undergraduate Chemical and Biological Engineering (Colorado State University)

B.S. Degree in Chemical and Biological Engineering

Program Objectives

Chemical and Biological Engineering B.S. graduates from Colorado State University should be able to achieve the following within the first five years after graduation:

1. Successfully identify, formulate, and solve engineering problems associated with their professional position, both independently and as a team member;
2. Using a broad, systems perspective, manage multi-faceted and multi-disciplinary projects with significant legal, ethical, regulatory, social, and economic considerations;
3. Communicate effectively with co-workers, professional clients, and the public;
4. Demonstrate commitment and progress in lifelong learning, professional development, and leadership.

Program Outcomes

When they graduate, Colorado State University Chemical and Biological Engineering B.S. graduates will be able to:

1. apply knowledge of mathematics, science, and engineering [Criterion (a)];
2. design and conduct experiments, and analyze and interpret data [Criterion (b)];
3. design a system, component, or process to meet desired needs within realistic economic, regulatory, ethical, social or other constraints [Criterion (c)];
4. function on teams, including those with members from different disciplines [Criterion (d)];
5. identify, formulate, and solve chemical and biological engineering problems [Criterion (e)];
6. communicate effectively [Criterion (g)];
7. understand the impact of chemical and biological engineering solutions in a global, economic, environmental, and societal context [Criterion (h)]; and
8. use the techniques, skills, and modern engineering tools necessary for chemical and biological engineering practice [Criterion (k)].

In addition, these graduates will

- possess an understanding of professional and ethical responsibility [Criterion (f)];
- possess knowledge of contemporary issues [Criterion (j)]; and
- recognize the need for, and possess an ability to engage in life-long learning [Criterion I].

Course Requirements for students entering the program Fall 2007 or later
Academic Subjects
The course requirements for the chemical and biological engineering degree can be grouped as (a) foundation courses, (b) chemical and biological engineering topics, (c) electives, and (d) communication, humanities, and social sciences.

Foundation Courses:

- Calculus and Differential Equations (4 semesters)
- Introductory Chemistry (2 semesters, with labs)
- Organic Chemistry (2 semesters, with lab)
- Physics (2 semesters, with labs)
- Computer Programming
- Chemical and Biological Engineering I & II (CBE 101 & 102)

Chemical and Biological Engineering Courses:

- Material and Energy Balances (CBE 201)
- Chemical Engineering Thermodynamics (CBE 210)
- Molecular Concepts and Applications (CBE 310)
- Chemical Reactor Design (CBE 320)
- Heat Transfer and Thermal Separations (CBE 332)
- Momentum Transfer and Mechanical Separation (CBE 331)
- Process Simulation (CBE 330)
- Momentum and Heat Transfer Laboratory (CBE 333)
- Equilibrium-Staged Separations (CBE 341)
- Process Control and Instrumentation (CBE 430)
- Rate-Controlled Separations (CBE 442)
- Mass Transfer and Separation Laboratory (CBE 443)
- Chemical and Biological Engineering Design I and II (CBE 451 & 452)
- Professional Development Seminar (CBE 493)

Electives:
Students choose a bioscience science elective course (such as microbiology or materials science) as well as 7 credits of technical elective course, and 3 additional credits of engineering classes.

- Bioscience Electives (pdf)
- Technical Electives (pdf)
- Engineering Electives (pdf)

Communication, Humanities, and Social Sciences:
Students choose communication, humanities, and social science courses in accordance with the University's Core Curriculum (pdf) requirements.

Minors and Specializations:
Students majoring in chemical engineering also have the opportunity to pursue a minor or interdisciplinary studies program. Popular options include minors in chemistry and environmental engineering, and interdisciplinary studies programs in biotechnology and biomedical engineering. Other students may elect to take additional courses to prepare for medical, veterinary, or law school.

- Minors and Specializations (pdf)
B6.  Undergraduate Biological Engineering (Cornell University)

Biological Engineering Program

The Program Educational Objectives of Biological Engineering are to:

- Produce graduates who pursue careers related to Biological Engineering based on a solid educational background in appropriate mathematics, physical and life sciences, liberal studies and engineering.

- Produce graduates who pursue advanced degrees in engineering and related professional fields.

Biological 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. It incorporates the tremendous developments in quantitative, mechanistic and molecular level understanding and manipulation capabilities of biological systems. Biological Engineering impacts the well-being of humans, plants, and animals through:

- new or improved medical devices and diagnostics
- more effective and safer pharmaceuticals
- new or improved bio-based industrial products
- new and safer foods
- preservation and enhancement of natural resources and the environment.

Biological engineers study characterization, measurement and representation of systemic processes within an organism; interactions between organisms and their environment; and engineering design to develop processes and systems that monitor, simulate, replace, modify, control, or utilize the mechanisms of living organisms and their products.

The Department of Biological and Environmental Engineering offers a bachelor degree program in Biological Engineering. It is a joint program between the College of Engineering and the College of Agriculture and Life Sciences at Cornell. Strong emphasis is placed on mathematics, the physical and biological sciences, and engineering analysis and design. The Biological Engineering program in BEE meets the academic requirements of both colleges. The program is accredited by the Engineering Accreditation Commission of the Accreditation Board for Engineering and Technology, and students may seek engineering professional licensing after graduation.

Core topics in Biological Engineering program include molecular and cellular principles, chemical and enzyme kinetics, thermodynamics, transport of water and energy, and biomaterials. The science core of the program includes mathematics, physics, chemistry, biochemistry, and introductory and advanced biology. Beyond these there are electives to be chosen from several areas including biomedical engineering, bioprocess engineering, Bioenvironmental engineering and computational biological engineering. Throughout the curriculum, emphasis is placed on communication and teamwork skills. All students participate in a major design experience near the end of the curriculum.

Opportunities outside the classroom abound. Many students participate in:
industry internships and cooperative education
research assistantships on campus
community service projects
design competitions
off-campus study, including study abroad

Environmental Engineering Program

The Program Educational Objectives (PEOs) of the Environmental Engineering Major are to:

- Produce graduates who pursue careers in Environmental Engineering based on a background in mathematics, physical and life sciences, liberal studies and engineering.
- Produce graduates who pursue advanced degrees in engineering and related professional fields.
- Produce graduates who assume leadership positions and contribute to solutions of societal problems involving environmental systems.

We live at a time when no part of the natural environment is untouched by human activities. Although we have made great strides in addressing many of the natural resources and environmental problems caused by societal activities, growth in the world population and rising standards of living continue to stress the natural environment and generate a spectrum of environmental problems that need to be solved. Environmental engineers are called upon to understand, arrange, and manipulate the biological, chemical, ecological, economic, hydrological, physical, and social processes that take place in our environment in an effort to balance our material needs with the desire for sustainable environmental quality.

At Cornell University, research and teaching activities related to environmental engineering are found in many of the traditional engineering fields. For example undergraduate majors in Biological Engineering and in Civil Engineering are offered by the Department of Biological and Environmental Engineering (BEE) and by the School of Civil and Environmental Engineering (CEE), respectively. Both of these majors include concentrations related to environmental engineering. BEE and CEE also jointly offer a major leading to a B.S. degree in Environmental Engineering. The Environmental Engineering major is structured to provide students with appropriate background in the physical, chemical and biological sciences together with the mathematical, planning, analysis and design tools necessary to address complex environmental engineering problems. The graduate and research programs in BEE and CEE focus on water and wastewater treatment processes, fate and transport of contaminants in natural aquatic systems, design and management of environmental and water resource systems, environmental fluid mechanics, and hydraulics and hydrology.

The collaborative undergraduate program in Environmental Engineering is supported by excellent teaching and research facilities including: laboratories for the analysis of water chemistry, physical/chemical/biological processes, biochemistry and microbiology. Cornell University is also the home of Cornell’s Super Computer Technology Center for Advanced Computing, the New York State Center for
Advanced Technology in Biotechnology Institute for Biotechnology and Life Science Technologies, and the Center for a Sustainable Future which oversees and supports many interdisciplinary environmental research programs. The wide variety of teaching and research activities, the world-class research facilities and the interdisciplinary centers at Cornell University provide students with excellent opportunities for study and research in Environmental Engineering.

WHAT DO OUR GRADUATES DO?

Many graduates from the Environmental Engineering Program continue their education at the finest graduate schools around the world. They pursue Master of Engineering (M. Eng.), Master of Science (M.S.), or Doctoral (Ph.D.) programs in various related engineering disciplines, or they sometimes complement their engineering degrees with a Master of Business Administration (MBA) or Doctor of Law (LLD) degree. Because of the requirements for coursework in biology and chemistry, the undergraduate major in Environmental Engineering is also an excellent choice for students interested in medical school.

Career opportunities for Environmental Engineering graduates cover the spectrum of private industry, public agencies, educational institutions, and graduate and professional programs in engineering, science, medicine, and law. In recent years graduates have pursued careers in consulting, management and business, and international development.

Courses of Study 2009-2010

Biological and Environmental Engineering

BEE 1200 The BEE Experience
BEE 1510 Introduction to Computer Programming
BEE 2220 Bioengineering Thermodynamics and Kinetics
BEE 2510 Engineering for a Sustainable Society (also ENGRD 2510)
BEE 2600 Principles of Biological Engineering (also ENGRD 2600)
BEE 3050 Principles of Navigation (also NAVS 3050)
BEE 3299 Sustainable Development: A Web-Based Course
BEE 3310 Bio-Fluid Mechanics
BEE 3500 Biological and Environmental Transport Processes
BEE 3600 Molecular and Cellular Bioengineering (also BME 3600)
BEE 3650 Properties of Biological Materials
BEE 3680 Biotechnology Applications: Animal Bioreactors
BEE 3710 Physical Hydrology for Ecosystems -- Not Offered This Year
BEE 4010 Renewable Energy Systems
BEE 4270 Water Measurement and Analysis Methods
BEE 4350 Principles of Aquaculture
BEE 4500 Bioinstrumentation
BEE 4530 Computer-Aided Engineering: Applications to Biomedical Processes (also MAE 4530)
BEE 4540 Physiological Engineering -- Not Offered This Year
BEE 4590 Biosensors and Bioanalytical Techniques
BEE 4600 Deterministic and Stochastic Modeling in Biological Engineering
BEE 4640 Bioseparation Processes
BEE 4710 Introduction to Groundwater (also EAS 4710) -- Not Offered This Year
BEE 4730 Watershed Engineering
BEE 4740 Water and Landscape Engineering Applications
BEE 4750 Environmental Systems Analysis
BEE 4760 Solid Waste Engineering
BEE 4800 Our Changing Atmosphere: Global Change and Atmospheric Chemistry (also EAS 4800)
BEE 4810 LRFD–Based Engineering of Wood Structures (also CEE 4810)
BEE 4840 Metabolic Engineering
BEE 4860 Industrial Ecology of Agriculturally Based Bioindustries
BEE 4870 Sustainable Energy Systems
BEE 4890 Entrepreneurial Management for Engineers
BEE 4900 Biofuels: The Economic and Environmental Interactions (also AEM 6900)
BEE 4930 Technical Writing for Engineers
BEE 4940 Special Topics in Biological and Environmental Engineering
BEE 4960 Capstone Design in Biological and Environmental Engineering
BEE 4970 Individual Study in Biological and Environmental Engineering
BEE 4980 Undergraduate Teaching
BEE 4990 Undergraduate Research
BEE 4991–4992 BEE Honors Research
BEE 5010 Bioengineering Seminar (also BME 5010)
BEE 5330 Engineering Professionalism
BEE 5901–5902 M.P.S. Project
BEE 5951–5952 Master of Engineering Design Project
BEE 6430 Veterinary Perspectives on Pathogen Control in Animal Manure (also VTMED/BIOMI 6430)
BEE 6470 Water Transport in Plants (also BIOPL 6510)
BEE 6490 Solute Transport in Plants (also BIOPL 6490) -- Not Offered This Year
BEE 6510 Bioremediation: Engineering Organisms to Clean Up the Environment -- Not Offered This Year
BEE 6550 Thermodynamics and Its Applications
BEE 6590 Biosensors and Bioanalytical Techniques
BEE 6710 Analysis of the Flow of Water and Chemicals in Soils -- Not Offered This Year
BEE 6720 Drainage
BEE 6740 Ecohydrology
BEE 6870 The Science and Engineering Challenges to the Development of Sustainable Bio-Based Industries
BEE 6940 Graduate Special Topics in Biological and Environmental Engineering
BEE 6970 Graduate Individual Study in Biological and Environmental Engineering
BEE 7000 Orientation to Graduate Study

BEE 7010 BEE Seminar Series

BEE 7540 The Right to Water

BEE 7600 Nucleic Acid Engineering (also BME 7600)

BEE 7710 Soil and Water Engineering Seminar

BEE 8900 Master’s-Level Thesis Research

BEE 9900 Doctoral-Level Thesis Research
B7. Undergraduate Biological Systems Engineering (Kansas State University)

**Bachelor degree requirements**

*Environmental Option*

**Freshman year**

Fall semester (15 credit hours)
- BAE 020 - Engineering Assembly Credits: (0)
- BAE 101 - Introduction to Biological and Agricultural Engineering and Technology Credits: (1)
- BAE 131 - Introductory Design for Biological and Agricultural Engineers Credits: (1)
- CHM 210 - Chemistry I Credits: (4)
- COMM 105 - Public Speaking I Credits: (2)
- ECON 110 - Principles of Macroeconomics Credits: (3)
- MATH 220 - Analytic Geometry and Calculus I Credits: (4)

Spring semester (16 credit hours)
- BAE 020 - Engineering Assembly Credits: (0)
- BAE 231 - Biological Systems Engineering Project I Credits: (1)
- BIOL 198 - Principles of Biology Credits: (4)
- CHM 230 - Chemistry II Credits: (4)
- ENGL 100 - Expository Writing I Credits: (3)
- MATH 221 - Analytic Geometry and Calculus II Credits: (4)

**Sophomore year**

Fall semester (17 credit hours)
- *Humanities or Social Science Elective Credits: (3)
- BAE 020 - Engineering Assembly Credits: (0)
- BAE 331 - Biological Systems Engineering Project II Credits: (1)
- CHM 350 - General Organic Chemistry Credits: (3)
- MATH 222 - Analytic Geometry and Calculus III Credits: (4)
- PHYS 213 - Engineering Physics I Credits: (5)
- STAT 490 - Statistics for Engineers Credits: (1)

Spring semester (16 credit hours)
- BAE 020 - Engineering Assembly Credits: (0)
- BAE 345 - Properties of Biological Materials Credits: (2)
- CE 530 - Statics and Dynamics Credits: (3)
- IMSE 530 - Engineering Economic Analysis Credits: (2)
- MATH 240 - Elementary Differential Equations Credits: (4)
- PHYS 214 - Engineering Physics II Credits: (5)

**Junior year**

Fall semester (16 credit hours)
- AGRON 305 - Soils Credits: (4)
- BAE 020 - Engineering Assembly Credits: (0)
- BAE 545 - Biological Process Engineering Credits: (3)
- GEOG 508 - Geographic Information Systems I Credits: (3)
- ME 513 - Thermodynamics I Credits: (3)
- ME 571 - Fluid Mechanics Credits: (3)

Spring semester (16 credit hours)
- **Biology Elective Credits: (3)**
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- BAE 020 - Engineering Assembly  Credits: (0)
- BAE 560 - Natural Resource Engineering I Credits: (3)
- BAE 651 - Air Pollution Engineering Credits: (3)
- ECE 519 - Electric Circuits and Control Credits: (4)
- *** ENGL 415 - Written Communication for Engineers Credits: (3)

### Senior year

#### Fall semester (16 credit hours)

- **Ecoengineering Elective Credits: (3)
- **Environmental Technical Elective Credits: (1)
- *Humanities or Social Science Elective Credits: (3)
- BAE 020 - Engineering Assembly Credits: (0)
- BAE 535 - Structures and Environment Engineering Credits: (3)
- BAE 536 - Biological Systems Engineering Senior Design Credits: (3)
- BAE 660 - Natural Resource Engineering II Credits: (3)

#### Spring semester (15 credit hours)

- **Environmental Technical Elective Credits: (3)
- **Environmental Technical Elective Credits: (3)
- *Humanities or Social Science Elective Credits: (3)
- **Science Elective Credits: (3)
- BAE 020 - Engineering Assembly Credits: (0)
- BAE 640 - Instrumentation and Control for Biological Systems Credits: (3)

### Notes

*Humanities and Social Science electives are to be selected from the approved list and need not be taken in order listed in the curriculum (2 courses must be 300 level or above).

**Environmental Technical, Ecoengineering, Science and Biology electives are to be chosen from an approved departmental list of courses with the advice and approval of the faculty advisor and department head.

***Prerequisites for Written Communication for Engineers (ENGL 415) must be met from Expository Writing I or II. If both ENGL 100 and ENGL 200 must be taken, the additional 3 credit hours do not count towards the 128 credit hours required for graduation.

**Biological Option**

#### Freshman year

#### Fall semester (15 credit hours)

- BAE 020 - Engineering Assembly Credits: (0)
- BAE 101 - Introduction to Biological and Agricultural Engineering and Technology Credits: (1)
- BAE 131 - Introductory Design for Biological and Agricultural Engineers Credits: (1)
- CHM 210 - Chemistry I Credits: (4)
- COMM 105 - Public Speaking IA Credits: (2)
- ECON 110 - Principles of Macroeconomics Credits: (3)
- MATH 220 - Analytic Geometry and Calculus I Credits: (4)

#### Spring semester (16 credit hours)

- BAE 020 - Engineering Assembly Credits: (0)
- BAE 231 - Biological Systems Engineering Project I Credits: (1)
- **BIOL 198 - Principles of Biology** Credits: (4)
- **CHM 230 - Chemistry II** Credits: (4)
- **** **ENGL 100 - Expository Writing I** Credits: (3)
- **MATH 221 - Analytic Geometry and Calculus II** Credits: (4)

### Sophomore year

#### Fall semester (16 credit hours)
- *Humanities or Social Science Elective** Credits: (3)
- **BAE 020 - Engineering Assembly** Credits: (0)
- **BAE 331 - Biological Systems Engineering Project II** Credits: (1)
- **CHM 350 - General Organic Chemistry** Credits: (3)
- **MATH 222 - Analytic Geometry and Calculus III** Credits: (4)
- **PHYS 213 - Engineering Physics I** Credits: (5)

#### Spring semester (16 credit hours)
- **BAE 020 - Engineering Assembly** Credits: (0)
- **BAE 345 - Properties of Biological Materials** Credits: (2)
- **CE 530 - Statics and Dynamics** Credits: (3)
- **CHM 351 - General Organic Chemistry Laboratory** Credits: (2)
- **MATH 240 - Elementary Differential Equations** Credits: (4)
- **PHYS 214 - Engineering Physics II** Credits: (5)

### Junior year

#### Fall semester (16 credit hours)
- **Biology/Biochemistry/Chemistry Elective** Credits: (3)
- **BAE 020 - Engineering Assembly** Credits: (0)
- **BAE 545 - Biological Process Engineering** Credits: (3)
- **ECE 519 - Electric Circuits and Control** Credits: (4)
- **ME 513 - Thermodynamics I** Credits: (3)
- **ME 571 - Fluid Mechanics** Credits: (3)

#### Spring semester (16 credit hours)
- **BAE Elective** Credits: (3)
- **College of Engineering Elective** Credits: (3)
- *Humanities or Social Science Electives** Credits: (3)
- **BAE 020 - Engineering Assembly** Credits: (0)
- **BIOL 455 - General Microbiology** Credits: (4)
- **STAT 510 - Introductory Probability and Statistics I** Credits: (3)

### Senior year

#### Fall semester (17 credit hours)
- **BAE Elective** Credits: (3)
- **College of Engineering Elective** Credits: (3)
- **Biology/Biochemistry/Chemistry elective** Credits: (3)
- **BAE 020 - Engineering Assembly** Credits: (0)
- **BAE 536 - Biological Systems Engineering Senior Design** Credits: (3)
- **** **ENGL 415 - Written Communication for Engineers** Credits: (3)
- **IMSE 530 - Engineering Economic Analysis** Credits: (2)

#### Spring semester (15 credit hours)
- **College of Engineering Elective** Credits: (3)
- **College of Engineering Elective** Credits: (3)
- **Biology/Biochemistry/Chemistry Elective** Credits: (3)
- *Humanities or Social Science Elective** Credits: (3)
- **BAE 020 - Engineering Assembly** Credits: (0)
- **BAE 640 - Instrumentation and Control for Biological Systems** Credits: (3)
Notes
*Humanities and Social Science electives are to be selected from the approved list and need not be taken in order listed in the curriculum (2 courses must be 300 level or above).
**Biology, Biochemistry, and Chemistry electives are to be chosen from an approved departmental list of courses with the advice and approval of the faculty advisor and department head. Six of the 9 credit hours must be 400 level or higher.
***College of Engineering and BAE electives are to be chosen from an approved departmental list of courses with the advice and approval of the faculty advisor and department head.
****Prerequisites for Written Communication for Engineers (ENGL 415) must be met from Expository Writing I or II. If both ENGL 100 and ENGL 200 must be taken, the additional 3 credit hours do not count towards the 128 credit hours required for graduation.

Machine Systems Option

Freshman year
Fall semester (15 credit hours)
- BAE 020 - Engineering Assembly Credits: (0)
- BAE 101 - Introduction to Biological and Agricultural Engineering and Technology Credits: (1)
- BAE 131 - Introductory Design for Biological and Agricultural Engineers Credits: (1)
- CHM 210 - Chemistry I Credits: (4)
- COMM 105 - Public Speaking IA Credits: (2)
- ECON 110 - Principles of Macroeconomics Credits: (3)
- MATH 220 - Analytic Geometry and Calculus I Credits: (4)

Spring semester (16 credit hours)
- BAE 020 - Engineering Assembly Credits: (0)
- BAE 231 - Biological Systems Engineering Project I Credits: (1)
- BIOL 198 - Principles of Biology Credits: (4)
- CHM 230 - Chemistry II Credits: (4)
- *** ENGL 100 - Expository Writing I Credits: (3)
- MATH 221 - Analytic Geometry and Calculus II Credits: (4)

Sophomore year
Fall semester (16 credit hours)
- *Humanities or Social Science Electives Credits: (3)
- BAE 020 - Engineering Assembly Credits: (0)
- BAE 331 - Biological Systems Engineering Project II Credits: (1)
- BAE 350 - Agricultural Machinery Systems Credits: (2)
- BAE 351 - Agricultural Machinery Systems Lab Credits: (1)
- MATH 222 - Analytic Geometry and Calculus III Credits: (4)
- PHYS 213 - Engineering Physics I Credits: (5)

Spring semester (16 credit hours)
- BAE 020 - Engineering Assembly Credits: (0)
- BAE 345 - Properties of Biological Materials Credits: (2)
- CE 333 - Statics Credits: (3)
- MATH 240 - Elementary Differential Equations Credits: (4)
- ME 212 - Engineering Graphics Credits: (2)
- PHYS 214 - Engineering Physics II Credits: (5)

Junior year

Fall semester (16 credit hours)
- BAE 020 - Engineering Assembly Credits: (0)
- BAE 535 - Structures and Environment Engineering Credits: (3)
- CE 533 - Mechanics of Materials Credits: (3)
- CHM 350 - General Organic Chemistry Credits: (3)
- ME 512 - Dynamics Credits: (3)
- ME 513 - Thermodynamics I Credits: (3)
- STAT 490 - Statistics for Engineers Credits: (1)

Spring semester (15 credit hours)
- BAE 020 - Engineering Assembly Credits: (0)
- BAE 560 - Natural Resource Engineering I Credits: (3)
- CE 522 - Soil Mechanics I Credits: (3)
- IMSE 530 - Engineering Economic Analysis Credits: (2)
- ME 533 - Machine Design I Credits: (3)
- ME 571 - Fluid Mechanics Credits: (3)

Senior year

Fall semester (19 credit hours)
- *Humanities or Social Science Elective Credits: (3)
- **Machine Systems Technical Elective Credits: (3)
- BAE 020 - Engineering Assembly Credits: (0)
- BAE 536 - Biological Systems Engineering Senior Design Credits: (3)
- BAE 545 - Biological Process Engineering Credits: (3)
- **ENGL 415 - Written Communication for Engineers Credits: (3)
- ECE 519 - Electric Circuits and Control Credits: (4)

Spring semester (15 credit hours)
- *Humanities or Social Science Elective Credits: (3)
- **Machine Systems Technical Elective Credits: (6)
- BAE 020 - Engineering Assembly Credits: (0)
- BAE 640 - Instrumentation and Control for Biological Systems Credits: (3)
- BAE 650 - Energy and Biofuel Engineering Credits: (3)

Notes
*Humanities and Social Science electives are to be selected from the approved list and need not be taken in order listed in the curriculum (2 courses must be 300 level or above).
**Students may take either CE 522 Credits: (3) or AGRON 305 Credits: (4).
***Prerequisites for Written Communication for Engineers (ENGL 415) must be met from Expository Writing I or II. If both ENGL 100 and ENGL 200 must be taken, the additional 3 credit hours do not count towards the 128 credit hours required for graduation.
****Machine Systems Technical Electives are to be chosen from an approved departmental list of courses with the advice and approval of the faculty advisor and department head.

Total hours required for graduation (127)
### B8. Undergraduate Biological and Agricultural Engineering (Louisiana State University)

#### 2008 - 2009

**1st Semester Freshman Year Semester Hours**

<table>
<thead>
<tr>
<th>Course Num.</th>
<th>Course Description</th>
<th>Hours</th>
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<tbody>
<tr>
<td>BE 1250</td>
<td>Introduction to Engineering Methods</td>
<td>2</td>
</tr>
<tr>
<td>BIOL 1201</td>
<td>Biology for Science Majors I</td>
<td>3</td>
</tr>
<tr>
<td>BIOL 1208</td>
<td>Biology Lab for Science Majors I</td>
<td>1</td>
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<tr>
<td>CHEM 1201</td>
<td>General Chemistry</td>
<td>3</td>
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<tr>
<td>ENGL 1001</td>
<td>English Composition</td>
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<tr>
<td>MATH 1550</td>
<td>Analytical Geometry and Calculus-I</td>
<td>5</td>
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<td><strong>Total</strong></td>
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**2nd Semester Freshman Year Semester Hours**

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<tr>
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<tbody>
<tr>
<td>BE 1252</td>
<td>Biology in Engineering</td>
<td>2</td>
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<tr>
<td>BIOL 1202</td>
<td>Biology for Science Majors II</td>
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<tr>
<td>BIOL 1209</td>
<td>Biology Lab for Science Majors II</td>
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<td>CHEM 1202</td>
<td>General Chemistry</td>
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<td>MATH 1552</td>
<td>Analytical Geometry and Calculus- II</td>
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<tr>
<td>PHYS 2101</td>
<td>General Physics for Tech Students</td>
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**1st Semester Sophomore Year Semester Hours**

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<thead>
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<th>Course Description</th>
<th>Hours</th>
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<tbody>
<tr>
<td>BE 2352</td>
<td>Quantitative Biology in Engineering</td>
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</tr>
<tr>
<td>BIOL 2051</td>
<td>General Microbiology</td>
<td>4</td>
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<tr>
<td>CE 2450</td>
<td>Statics</td>
<td>3</td>
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<tr>
<td>CHEM 1212</td>
<td>General Chemistry Laboratory</td>
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<tr>
<td>MATH 2065</td>
<td>Elementary Differential Equations</td>
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<td>PHYS 2102</td>
<td>General Physics for Tech Students</td>
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**2nd Semester Sophomore Year Semester Hours**

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<tr>
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<tbody>
<tr>
<td>BE 2350</td>
<td>Experimental Methods for Engineers</td>
<td>3</td>
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<tr>
<td>CE 3400</td>
<td>Mechanics of Materials</td>
<td>3</td>
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</tbody>
</table>
CHEM 2261  Organic Chemistry  3
ENGL 2000  English Composition  3
EE 2950  Comprehensive Electrical Engineering  3

1st Semester Junior Year Semester Hours

<table>
<thead>
<tr>
<th>Course Num.</th>
<th>Course Description</th>
<th>Hours</th>
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<tbody>
<tr>
<td>BE 4303</td>
<td>Engr Properties of Biol Materials</td>
<td>3</td>
</tr>
<tr>
<td>BIOL 2083</td>
<td>The Elements of Biochemistry</td>
<td>3</td>
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<tr>
<td>CE 2200</td>
<td>Fluid Mechanics</td>
<td>3</td>
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<td>ME 3333</td>
<td>Therodynamics</td>
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<tr>
<td></td>
<td>Engineering Design Elective</td>
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2nd Semester Junior Year Semester Hours

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<td>BE 3340</td>
<td>Process Design for Biological Engr.</td>
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<tr>
<td>BE 4352</td>
<td>Transport Phenomena in Biological Engr.</td>
<td>3</td>
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<tr>
<td>CE 2460 or ME 3133</td>
<td>Dynamics</td>
<td>3</td>
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<tr>
<td>AGEC 2003 or ECON 2030</td>
<td>Introduction to Agr Econ or Economic Principles</td>
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<tr>
<td>BE 3290</td>
<td>Professionalism for Biological Engr.</td>
<td>2</td>
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<tr>
<td></td>
<td>Elective or ROTC</td>
<td>3</td>
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1st Semester Senior Year Semester Hours

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<th>Course Description</th>
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<tbody>
<tr>
<td>BE 3320</td>
<td>Mechanical Design for Biological Engr.</td>
<td>3</td>
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<tr>
<td>BE 4290</td>
<td>Senior Engr Design and Professionalism</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>Engineering Design Elective</td>
<td>6</td>
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<tr>
<td></td>
<td>General Ed., Humanity Electives</td>
<td>3</td>
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<tr>
<td></td>
<td>General Ed., Social Science Elective</td>
<td>3</td>
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<tr>
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2nd Semester Senior Year Semester Hours

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<tr>
<th>Course Num.</th>
<th>Course Description</th>
<th>Hours</th>
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</thead>
<tbody>
<tr>
<td>BE 4292</td>
<td>Senior Engineering Design Laboratory</td>
<td>2</td>
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</tbody>
</table>
Engineering Design Elective 3
Technical Elective or ROTC 3
General Ed., Arts Elective 3
General Ed., Humanity Elective 3
General Ed., Social Science Elective 3

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Click [here](#) for a flowchart diagram of this recommended curriculum

**Engineering Design Electives**

BE 3381  Nonpoint Source Pollution Engineering
BE 4323  Biomechanics for Engineers
BE 4332  Molecular Methods in Biological Engineering
BE 4340  Food and Bioprocess Engineering
BE 4341  Biological Reactor System Design
BE 4342  Sugar Process Engineering
BE 4347  Sugar Factory Design
BE 4360  Mobile Fluid Power Control
BE 4380  Aquacultural Engineering
BE 4383  Natural Resource Engineering
CHE 4420  Genetic Engineering
EVEG 3110  Water and Wastewater Treatment
FDSC 4005  Food Engineering Systems
IE 4461  Human Factors Engineering
IE 4462  Safety Engineering
ME 4133  Machine Design I

Students planning to enter Medical, Dental, or Veterinary School must complete the additional requirements of: CHEM 2262 Organic Chemistry, CHEM 2364 Organic Chemistry Laboratory, PHYS 2108 Introductory Physics Laboratory, and PHYS 2109 Laboratory Work in Technical Physics beyond this curriculum.

Students planning to receive a Minor in Environmental Engineering must take BE 3381 Nonpoint Source Engineering, BE 4341 Biological Reactor Systems Design, BE 4383 Natural Resource Engineering, EVEG 3100 Water Distribution and Wastewater Collection, EVEG 3110 Water and Wastewater Treatment, EVEG 4153 Hazardous Waste Management, and EVEG 4105 Quantitative Water Management or CHE 4253 Introduction to Industrial Pollution Control.
B9. Undergraduate Biological and Agricultural Systems Engineering
(Florida Agricultural and Mechanical University)

ABE 1010 Introduction to Biological and Agricultural Systems Engineering (BASE). 1 credit. An introduction of mathematical and engineering concepts utilized in food and agricultural systems design.

ABE 4661 Biochemical Engineering. 3 credits. Use of microorganisms and enzymes for the production of chemical feedstocks, single cell protein, antibiotics and other fermentation productions. Topics include kinetics and energetics of microbial metabolism, design and analysis of reactors for microbial growth and enzyme catalyzed reactions, and consideration of scale-up, mass transfer, and sterilization during reactor design.

ABE 4XXX Biomass Conversion Processes for Energy and Chemicals. 3 credits. There are a variety of physical and biological processes available for converting plants and other biomass resources into energy, industrial chemicals, and foods. The design is accomplished through fusing concepts from biochemistry, microbiology, and plant biology with the concepts and methods of engineering. There are four components of this course: plants as biochemical resources, heat and mass transfer, enzyme catalysis, and fermentation kinetics. Each component concludes with a case study that demonstrates how the scientific concepts and methods are used to design a biomass conversion process.

ABE 4812 Food and Bioprocess Engineering. 3 credits. An analysis of the most common unit operations utilized in the processing of food products. The principles of heat and mass transfer and reaction kinetics associated with processing operations will be used in defining process systems for drying, evaporation, refrigeration, freezing, fermentation, etc.

ABE 3012 Introduction to Design and Analysis. (3) Pre-req: MAC 3312, ABE 2001L or permission. Introduction to the scientific method through the flow process from hypothesis to experimental design, collection of data, analyzing, interpreting, and reporting results.

ABE 3650 Engineering Properties of Biological Materials. 3 credits. Physical properties important to the design of harvesting, storage, and processing systems for agricultural crops; principles and techniques for measurement of properties including frictional effects, particle size, strength, moisture content, specific heat, and thermal conductivity.

ABE 4030 Instrumentation for Agricultural and Biological Systems. 3 credits. Overview of modern instrumentation techniques in agricultural and biological engineering systems. Emphasis is on laboratory use of the equipment. Topics include performance characteristics of instruments, analog signal conditioning, transducer theory and applications, and digital systems for data acquisition control.

ABE 4611 Environmental Modifications and Controls. 3 credits. Fundamentals of heat and mass transfer, psychometrics, solar radiation, and illumination, including their measurements and their interactions with plant and animals in controlled
environments. Applications of fundamental principles to the design of animal and plant production structures and other intensively managed biological systems.

ABE 3212C Natural Resources Conservation Engineering. 4 credits. Introduction to hydrologic cycle, precipitation, infiltration, evapo-transpiration, soil erosion, erosion best management practices, nutrient movement, flood routing, GIS (geographic information systems), channel flow, pipe flow, drainage and irrigation.

ABE 4232 Water Management System Design. 3 credits. To acquaint the student with the science and design of drainage, irrigation, rural water supply and rural sanitation systems. There will be an integration of economic, environmental, and social considerations into the various design projects.

ABE 4224 Non-Point Source Pollution. 3 credits. Covers the chemical and physical processes involved in the transport of nutrients, pesticides, and other potential pollutants in runoff and percolation. Emphasis is placed on algorithms and computer models that predict water and chemical movement into surface waters and ground water.

ABE 2001L Introduction to Computer Applications. 1 credit. Hands-on-experience with computer application packages such as word processing, spreadsheets, database management, and presentation graphics. Also provides exposure to GIS and programming using Pascal plus, C , or FORTRAN at a very basic level.

ABE 4042 Senior Design Project I (2) Pre-req:Senior Standing. Capstone design experience. The first of two senior design courses. Preliminary investigation of an assigned multi-faceted team project incorporating computer aided design, evaluation and synthesis. A written and orally presented project progress report is required.

ABE 4043 Senior Design Project II Pre-req: Senior Standing. Second semester continuation and competition of the team project assigned in ABE 4042. A written and orally presented final report is required. Second semester continuation of above described Senior design course.
B10. Undergraduate Biological Systems Engineering Profession (Iowa University)

Biological systems engineering involves the sustainable production, storage, and conversion of biobased materials into useful products. Examples range from breakfast cereals to biologically derived fuels like today’s ethanol and biodiesel. What will the second- and third-generation biofuels look like? How can we convert low-cost biomass into a liquid fuel? How do we make biomass production systems more sustainable? What are the best opportunities for improving them? Biological systems engineers at Iowa State learn to innovate, to communicate, and to work as team members to address these sorts of critical questions.

Biological systems engineers have high-impact careers. Maintaining air quality, a secure food supply, and clean water is important to everyone. In today’s global marketplace, grains, produce, and livestock are transported from country to country, and food security is increasingly of concern. Biological systems engineers help safeguard our air, water, and food supply by developing sensors to detect problem compounds and by developing management plans to track materials and to minimize the chances of contamination.

Biological Systems Engineering Courses and Degree Planning
Courses in Biological Systems Engineering (coming in March)
Curricula (required coursework) and four-year plans (BS degree)
List of approved Social Science courses 07-09
List of approved Humanities courses 07-09
Approved List of International Perspectives Courses 07-09

Undergraduate Study

For the undergraduate curriculum in agricultural engineering leading to the degree bachelor of science, see College of Engineering, Curricula. This curriculum is accredited by the Engineering Accreditation Commission of the Accreditation Board for Engineering and Technology. Agricultural Engineering Curriculum Educational Goal, Objectives, and Learning Outcomes: The goal of the curriculum in agricultural engineering is to train men and women to integrate basic physical and biological sciences through application of engineering fundamentals and design of systems for the production, processing, storage, handling, distribution, and use of food, feed, fiber and other biomaterials, and the management of related natural resources worldwide.

The agricultural engineering degree program has the following educational objectives for its graduates. Two to five years after undergraduate graduation, through the professional practice of engineering, graduates should have:

1. Demonstrated competence in methods of analysis involving use of mathematics, fundamental physical and biological sciences, engineering sciences, and computation needed for the practice of biological systems engineering in food, fiber, energy and environmental companies and agencies.

2. Developed skills necessary to the design process; including the abilities to think creatively, to formulate problem statements, to communicate effectively, to synthesize information, and to evaluate and implement problem solutions.
3. Be capable of addressing issues of ethics, safety, professionalism, cultural diversity, globalization, environmental impact, and social and economic impact in engineering practice.

4. Demonstrated continuous professional and technical growth, with practical experience, so as to be licensed as a professional engineer or achieve that level of expertise.

5. Demonstrated the ability to:

a. be a successful leader of multi-disciplinary teams,

b. efficiently manage multiple simultaneous projects, c. work collaboratively,

d. implement multi-disciplinary systems-based solutions,

e. apply innovative solutions to problems through the use of new methods or technologies,

f. contribute to the business success of their employer, and

g. build community. The agricultural engineering degree program outcomes are statements that describe what our students are expected to know and be able to do by the time of graduation. To meet the established agricultural engineering program educational objectives, the expected outcomes of the BS Agricultural Engineering graduates are:

a) an ability to apply knowledge of mathematics, science, and engineering

b) an ability to design and conduct experiments, as well as to analyze and interpret data

c) an ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability

d) an ability to function on multi-disciplinary teams

e) an ability to identify, formulate, and solve engineering problems

f) an understanding of professional and ethical responsibility

g) an ability to communicate effectively

h) achievement of the broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context

i) a recognition of the need for, and an ability to engage in life-long learning

j) a knowledge of contemporary issues
k) an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice

l) proficiency in mathematics through differential equations

m) proficiency in biological and engineering sciences

n) competence in the application of engineering to agriculture, aquaculture, food, forestry, human, natural resource, or other biological systems. Graduates find employment in diverse ag- and bio-related industries and government agencies related to agricultural equipment, building animal and environmental control, grain processing and handling, soil and water resources, food, and biotechnology. They work in areas that include engineering design, development, testing, research, manufacturing, consulting, sales, and service. The department has cooperative programs established for interested and qualified students. The four-year curriculum is extended over a five-year period and interspersed with work periods at cooperating organizations. This plan offers valuable practical experience and financial assistance during the years in college.

The department also offers an undergraduate curriculum and courses in agricultural systems technology, see College of Agriculture, Curricula. Well-qualified juniors and seniors in agricultural engineering who are interested in graduate study may apply for concurrent enrollment in the Graduate College to simultaneously pursue both B.S. and M.S. degrees. Refer to Graduate Study for more information.

Courses primarily for undergraduate students

A E 110. Experiencing Agricultural and Biosystems Engineering. (0-2) Cr. 1. S. Laboratory-based, team-oriented experiences in a spectrum of topics common to the practice of agricultural and biosystems engineering. Report writing, co-ops, internships, careers, registration planning.

A E 201. Entrepreneurship and Internship Seminar. (Cross-listed with TSM). (1-0) Cr. 1. S. Prereq: Sophomore classification in AE, AST, or I Tec. Exposure to the importance of entrepreneurship through seminar presentations by entrepreneurs, development of a business plan, case studies on economic impacts of entrepreneurship, and strategic strengths of Iowa. Preparation for internship experience. Relationship of workplace competencies to entrepreneurship and internships; portfolios.


A E 216. Fundamentals of Agricultural and Biosystems Engineering. (2-2) Cr. 3. F. Prereq: 110, Engr 160, credit or enrollment in Math 166. Application of mathematics and engineering sciences to energy and mass balances in agricultural and biological systems. Emphasis is on solving engineering problems in the areas of air and water vapor systems; electrical systems, grain systems; food systems, hydrologic systems, and bioprocessing.
A E 271. Engineering Applications of Parametric Solid Modeling. (1-2) Cr. 1. F.S.  
Prereq: Engr 170 or TSM 116 or equivalent. Creating, editing, and documenting part and assembly models using Solidworks.

A E 272. Parametric Solid Models, Drawings, and Assemblies Using Pro/ENGINEER. (1-2) Cr. 1. F.S. Prereq: Engr 170 or TSM 116 or equivalent. Applications of Pro/ENGINEER software. Create solid models of parts and assemblies. Utilize the solid models to create design documentation: standard drawing views, dimensions, and notes.

A E 298. Cooperative Education. Cr. R. F.S.SS. Prereq: Permission of department and Engineering Career Services. First professional work period in the cooperative education program. Students must register for this course before commencing work.

A E 301. Leadership and Ethics Seminar. (Cross-listed with TSM). (1-0) Cr. 1. S. Prereq: 201. Leadership and ethics experiences through case studies and seminar presentations by practitioners. Relationship of workplace competencies to leadership and ethics; portfolios.


A E 388. Sustainable Engineering and International Development. (Cross-listed with C E, E E). (2-2) Cr. 3. F. Prereq: Junior classification in engineering. Multidisciplinary approach to sustainable engineering and international development, sustainable development, appropriate design and engineering, feasibility analysis, international aid, business development, philosophy and politics of technology, and ethics in engineering. Engineering-based projects from problem formulation through implementation. Interactions with partner community organizations or international partners such as nongovernment organizations (NGOs). Course readings, final project/design report.


A E 404. Instrumentation for Agricultural and Biosystems Engineering. (Dual-listed with 504). (2-2) Cr. 3. S. Prereq: 363 or Cpr E 210. Interfacing techniques for computer-based data acquisition and control systems. Basic interfacing components including A/D and D/A conversion, signal filtering, multiplexing, and process control. Sensors and theory of operation applied to practical monitoring and control problems.

A E 406. Applied Computational Intelligence for Agricultural and Biological Systems. (Dual-listed with 506). (2-2) Cr. 3. Alt. F., offered 2008. Prereq: Math 166, Stat 305, AE 203, or equivalent. Applications of biologically inspired computational intelligence tools to solve problems in agricultural and biological systems. Introduction to Artificial Neural Networks, Support Vector Machines, Fuzzy Logic, Genetic Algorithms, Bayesian and Decision Tree Learning. Fundamental machine vision techniques will be introduced in the first part of course and integrated into the lab exercises for learning different computational intelligence techniques. MATLAB will be used throughout the course for algorithm implementation. Nonmajor graduate credit.

A E 408. GIS and Natural Resources Management. (Dual-listed with 508). (Cross-listed with EnSci). (2-2) Cr. 3. F. Prereq: Working knowledge of computers and Windows environment. Introduction to fundamental concepts and applications of GIS in natural resources management with specific focus on watersheds. Topics include: basic GIS technology, data structures, database management, spatial analysis, and modeling; visualization and display of natural resource data. Case studies in watershed and natural resource management using ArcView GIS.

A E 413. Fluid Power Engineering. (Cross-listed with M E). (2-2) Cr. 3. F. Prereq: Credit or enrollment in EM 378 or ME 335, AE 216 or ME 270. Properties of


A E 416. Agricultural Engineering Design II. (1-2) Cr. 2. F.S. Prereq: 415. Selection of promising solutions to design problems identified in 415 for development by design teams. Presentation of designs through oral and written reports and prototypes. Nonmajor graduate credit.


A E 469. Grain Processing and Handling. (Dual-listed with 569). (2-3) Cr. 3. S. Prereq: 216. Cereal grain and oilseed properties, quality measurement, processing,
and end-use value. Design of drying systems using computer simulation. Corn wet and dry milling. Soybean oil extraction. Grain handling systems.

A E 472. Design of Environmental Modification Systems for Animal Housing. (Dual-listed with 572). (3-0) Cr. 3. S. Prereq: 216, M E 330. Principles and design of animal environmental control systems. Insulation, heat and mass transfer, fans, ventilation, air distribution, heating and cooling equipment, duct design, controls.


A E 480. Engineering Analysis of Biological Systems. (Dual-listed with 580). (2-2) Cr. 3. F. Prereq: 216; Math 266; Biol 211 or 212; M E 330. Systems-level engineering analysis of biological systems. Economic and life-cycle analysis of bioresource production and conversion systems. Global energy and resource issues and the role of biologically derived materials in addressing these issues.


BIOLOGICAL SYSTEMS ENGINEERING CURRICULUM
PRE-FRORPEssIONAL AND PRE-GRADUATE OPTION
A total of 127.5 credits required for graduation
(2009-2011 Catalog)

I. Communications (9.5 credits)
3 cr. Engr 150 (FSSS) Critical Thinking and Communication
3 cr. Engr 250 (FSSS) Written, Oral, Visual, and Electronic Composition
3 cr. Engr 369 (FS) Report and Proposal Writing
or 3 cr. Engr 214 (FS) Technical Communication
or 3 cr. CE 201 (FS) Economic Analysis and Technical Communication
or 3 cr. SP CN 211 (FSSS) Fundamentals of Public Speaking
or 3 cr. AG ED 311 (FS) Presentation and Sales Strategies for Ag Audiences
0.5 cr. Lib 160 (FSSS) Library Instruction

II. Mathematical Sciences (15 credits)
4 cr. Math 165 (FSSS) Calculus I
4 cr. Math 166 (FSSS) Calculus II
4 cr. Math 267 (FSSS) Elementary Differential Equations and Laplace Transforms
3 cr. Stat 305 (FSSS) Engineering Statistics

III. Biological and Physical Science Common Core (22 credits)
4 cr. Chem 167 (FS) General Chemistry for Engineering Students
1 cr. Chem 167L (F) Laboratory in General Chemistry for Engineers
5 cr. Phys 221 (FSSS) Introduction to Classical Physics I
5 cr. Phys 222 (FSSS) Introduction to Classical Physics II
3 cr. Biol 212 (FS) Principles of Biology II
3 cr. Micro 102 (FS) Biology of Microorganisms
1 cr. Micro 102L (F) Microbiology lab

V. Social Sciences and Humanities (12 credits)
3 cr. U. S. Diversity Course
3 cr. International Perspective Course
6 cr. Social Science and Humanities Electives (Select from departmental-approved list).

VI. Engineering Core (23 credits)
1 cr. ENGR 101 (FS) Engineering Orientation
1 cr. ESE 110 (S) Experiencing Biological Systems Engineering
3 cr. ENGR 160 (FS) Engineering Problems with Computer Applications Laboratory
3 cr. ENGR 170 (FS) Engineering Graphics and Introductory Design
3 cr. EM 274 (FSSS) Statics of Engineering
3 cr. EM 330 (FSSS) Mechanics of Materials
1 cr. EM 327 (FSSS) Mechanics of Materials Laboratory
3 cr. M E 330 (FS) Thermodynamics
3 cr. CH E 358 (FS) Transport Phenomena I
3 cr. CH E 357 (FS) Transport Phenomena II
D. Briassoulis  UNIVERSITIES IN USA AND CANADA OFFERING PROGRAMS OF STUDIES IN BIOSYSTEMS ENGINEERING OR RELATED DISCIPLINES

Ag & Biosystems Engineering Dept.  Iowa State University

Revised 11/13/2009

<table>
<thead>
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<th>VII. Biological Systems Engineering Core (25 credits)</th>
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<tr>
<td>1 cr. BSE 201 (FS)  Entrepreneurship Seminar</td>
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<tr>
<td>3 cr. BSE 216 (S)  Fundamentals of Agricultural and Biological Engineering</td>
</tr>
<tr>
<td>1 cr. BSE 330 (FS)  Leadership and Ethics Seminar</td>
</tr>
<tr>
<td>3 cr. BSE 316 (F)  Computer Applications and Systems Modeling</td>
</tr>
<tr>
<td>4 cr. AE 363 (F)  Agric-Industrial Applications of Electric Power and Electronics</td>
</tr>
<tr>
<td>3 cr. BSE 380 (S)  Principles of Biological Systems Engineering</td>
</tr>
<tr>
<td>1 cr. BSE 401 (FS)  Professionalism Seminar</td>
</tr>
<tr>
<td>3 cr. AE 404 (F)  Instrumentation for Agricultural and Biological Engineering</td>
</tr>
<tr>
<td>2 cr. BSE 415 (FS)  Biological Systems Engineering Design I</td>
</tr>
<tr>
<td>2 cr. BSE 416 (FS)  Biological Systems Engineering Design II</td>
</tr>
<tr>
<td>3 cr. BSE 480 (F)  Engineering Analysis of Biological Systems</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>VIII. Pre-Professional and Pre-Graduate Option (15-20 credits)</th>
</tr>
</thead>
<tbody>
<tr>
<td>3 cr. Chem 331 (FS)  Organic Chemistry</td>
</tr>
<tr>
<td>1 cr. Chem 331L (FS)  Laboratory in Organic Chemistry</td>
</tr>
<tr>
<td>3 cr. Chem 332 (FS)  Organic Chemistry</td>
</tr>
<tr>
<td>1 cr. Chem 332L (FS)  Laboratory in Organic Chemistry</td>
</tr>
</tbody>
</table>

Select 3 credits from:

| 3 cr. BSE 463 (Alt.)  Process Modeling and control for Biosystems Engineering |
| 3 cr. AE 466 (F)  Applied Computational Intelligence for Agricultural and Biological Systems |

Select 3-9 credits of 200 level or above in a two to three course sequence:

| 8 cr. Biol 255, 256 + Lab Human Physiology Sequence |
| 8 cr. BBMB 404, 405, & 451 Biochemistry Sequence |
| 9 cr. Corn S 201, BCBio 401, & 402 Bioinformatics Sequence |
| 9 cr. Mgmt 110, 313, 414 or 415 Management Sequence |
| 9 cr. JLiMC 201, 202 & 347 Science Writing Sequence |
| 9 cr. Pol S 215, 319, & 120 Political Science Sequence |
| 9 cr. AE 348, Agron 342, M E 484 Globalization Sequence |
D. Briassoulis  UNIVERSITIES IN USA AND CANADA OFFERING PROGRAMS OF STUDIES IN BIOSYSTEMS ENGINEERING OR RELATED DISCIPLINES

Ag & BioSystems Engineering Dept  Iowa State University

Revised 11/13/2009

BIOLOGICAL SYSTEMS ENGINEERING CURRICULUM
BIORENEWABLE RESOURCES ENGINEERING OPTION
A total of 127.5 credits required for graduation
(2009-2011 Catalog)

I. Communications (9.5 credits)
3 cr. Engl 150 (FSSS) Critical Thinking and Communication
3 cr. Engl 250 (FSSS) Written, Oral, Visual, and Electronic Composition
3 cr. Engl 399 (FS) Report and Proposal Writing
or 3 cr. Engl 314 (FS) Technical Communication
or 3 cr. CE 201 (FS) Economic Analysis and Technical Communication
or 3 cr. Sp Chn 211 (FSSS) Fundamentals of Public Speaking
or 3 cr. Ag Ed 311 (FS) Presentation and Sales Strategies for Ag Audiences
0.5 cr. Lib 160 (FSSS) Library Instruction

II. Mathematical Sciences (15 credits)
4 cr. Math 165 (FSSS) Calculus I
4 cr. Math 166 (FSSS) Calculus II
4 cr. Math 267 (FSSS) Elementary Differential Equations and Laplace Transforms
3 cr. Stat 306 (FSSS) Engineering Statistics

III. Biological and Physical Science Core (22 credits)
4 cr. Chem 167 (FS) General Chemistry for Engineering Students
1 cr. Chem 167L (FS) Laboratory in General Chemistry for Engineers
5 cr. Phys 211 (FSSS) Introduction to Classical Physics I
5 cr. Phys 222 (FSSS) Introduction to Classical Physics II
3 cr. Biol 212 (FS) Principles of Biology II
3 cr. Micro 301 (FS) Biology of Microorganisms
1 cr. Micro 302L (FS) Microbiology lab

V. Social Sciences and Humanities (12 credits)
3 cr. U. S. Diversity Course
3 cr. International Perspective Course
0 cr. Social Science and Humanities Electives (Select from departmental-approved list).

VI. Engineering Core (23 credits)
E cr. Engr 101 (FS) Engineering Orientation
1 cr. BM E 110 (FS) Experiencing Biological Systems Engineering
1 cr. Engr 100 (FS) Engineering Problems with Computer Applications Laboratory
3 cr. Engr 170 (FS) Engineering Graphics and Introductory Design
3 cr. E M 274 (FSSS) Statics of Engineering
3 cr. E M 324 (FSSS) Mechanics of Materials
1 cr. E M 327 (FSSS) Mechanics of Materials Laboratory
3 cr. E M 330 (FS) Thermodynamics
3 cr. CE E 359 (FS) Transport Phenomena I
3 cr. CE E 357 (FS) Transport Phenomena II

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D.Briassoulis  UNIVERSITIES IN USA AND CANADA OFFERING PROGRAMS OF STUDIES IN BIOSYSTEMS ENGINEERING OR RELATED DISCIPLINES

VII. Biological Systems Engineering Core (25 credits)

1 cr. BSE 301 (FS) Entrepreneurship Seminar
3 cr. BSE 316 (S) Fundamentals of Agricultural and Biological Engineering
1 cr. BSE 301 (FS) Leadership and Ethics Seminar
3 cr. BSE 316 (F) Computer Applications and Systems Modeling
4 cr. A E 363 (F) Agri-Industrial Applications of Electric Power and Electronics
3 cr. BSE 380 (S) Principles of Biological Systems Engineering
1 cr. BSE 401 (FS) Professionalism Seminar
3 cr. A E 404 (F) Instrumentation for Agricultural and Biological Engineering
2 cr. BSE 415 (FS) Biological Systems Engineering Design I
2 cr. BSE 416 (FS) Biological Systems Engineering Design II
3 cr. BSE 480 (F) Engineering Analysis of Biological Systems

VIII. Biorenewable Resources Engineering Option (20 credits)

3 cr. Chem 331 (FS) Organic Chemistry
1 cr. Chem 331L (FS) Laboratory in Organic Chemistry (lab-based focus)
3 cr. Chem 332 (FS) Organic Chemistry
3 cr. A E 380 (F) Sustainable Engineering and International Development
3 cr. BSE 403 (Alt. S) Process Modeling and Control for Biosystems Engineering

Select 7 additional credits from the following:

3 cr. Biol 312 (FS) Ecology
3 cr. Biol 313 (FS) Principles of Genetics
3 cr. TSM 310 (S) Total Quality Improvement
2 cr. TSM 317 (F) Introduction to Occupational Safety
2 cr. TSM 372 (F) Legal Aspects of Occupational Safety and Health
3 cr. Econ 307 (S) Applied Economic Optimization
3 cr. BSE 325 (F) Biorenewable Systems
4 cr. BSE 490 (S) Grain Processing and Handling
3 cr. FS EN 471 (F) Food Processing
3 cr. BRT 501(S) Fundamentals of Biorenewable Resources
3 cr. BRT 544 (S) Bioprocesses
3 cr. A E 406 (Alt. F) Applied Computational Intelligence for Agricultural & Biological Systems
3 cr. Mgmt 370 (FS) Management of Organizations
BIOLOGICAL SYSTEMS ENGINEERING CURRICULUM

FOOD ENGINEERING OPTION

A total of 127.5 credits required for graduation
(2006-2011 Catalog)

I. Communications (6.5 credits)
3 cr. Engl 150 (FSSS) Critical Thinking and Communication
3 cr. Engl 250 (FSSS) Written, Oral, Visual, and Electronic Communication
3 cr. Engl 300 (FS) Report and Proposal Writing
or 3 cr. Engl 314 (FS) Technical Communication
or 3 cr. CE 205 (FS) Economic Analysis and Technical Communication
or 3 cr. Sp Cm 213 (FSSS) Fundamentals of Public Speaking
or 3 cr. Ag Ed 311 (FS) Presentation and Sales Strategies for Ag Audiences
0.5 cr. Lib 160 (FSSS) Library Instruction

II. Mathematical Sciences (15 credits)
4 cr. Math 165 (FSSS) Calculus I
4 cr. Math 166 (FSSS) Calculus II
4 cr. Math 267 (FSSS) Elementary Differential Equations and Laplace Transforms
3 cr. Stat 305 (FSSS) Engineering Statistics

III. Biological and Physical Science Common Core (22 credits)
4 cr. Chem 167 (FS) General Chemistry for Engineering Students
1 cr. Chem 107 L (FS) Laboratory in General Chemistry for Engineers
5 cr. Phys 261 (FSSS) Introduction to Classical Physics I
5 cr. Phys 262 (FSSS) Introduction to Classical Physics II
3 cr. Biol 212 (FS) Principles of Biology II
3 cr. Micro 301 (FS) Biology of Microorganisms
1 cr. Micro 302L (FS) Microbiology lab

V. Social Sciences and Humanities (12 credits)
3 cr. U.S. Diversity Course
3 cr. International Perspective Course
6 cr. Social Science and Humanities Electives (Select from departmental-approved list).

VI. Engineering Core (23 credits)
5 cr. Engr 101 (FS) Engineering Orientation
1 cr. BSE 110 (S) Introduction to Biological Systems Engineering
1 cr. Engr 160 (FS) Engineering Problems with Computer Applications Laboratory
3 cr. Engr 170 (FS) Engineering Graphics and Introduction Design
3 cr. Engr 274 (FSSS) Statics of Engineering
3 cr. Engr 324 (FSSS) Mechanics of Materials
1 cr. Engr 327 (FSSS) Mechanics of Materials Laboratory
3 cr. ME 330 (FS) Thermodynamics
3 cr. Ch E 358 (FS) Transport Phenomena I
3 cr. Ch E 359 (FS) Transport Phenomena II

VII. Biological System Engineering Core (25 credits)
1 cr. BSE 201 (FS) Entrepreneurship Seminar
3 cr. BSE 216 (S) Fundamentals of Agricultural and Biological Engineering
1 cr. BSE 301 (FS) Leadership and Ethics Seminar
3 cr. BSE 316 (P) Computer Applications and Systems Modeling
4 cr. AE 363 (P) Agri-Industrial Applications of Electric Power and Electronics
3 cr. BSE 380 (S) Principles of Biological Systems Engineering
1 cr. BSE 401 (P) Design Seminar
3 cr. AE 404 (P) Instrumentation for Agricultural and Biological Engineering
2 cr. BSE 415 (FS) Biological Systems Engineering Design I
2 cr. BSE 416 (P) Biological Systems Engineering Design II
3 cr. BSE 480 (P) Engineering Analysis of Biological Systems

VIII. Food Engineering Option (20 credits)
3 cr. Chem 231 (FSSS) Elementary Organic Chemistry
1 cr. Chem 313L (FSSS) Elementary Organic Chemistry Laboratory
4 cr. FSHN 311 (P) Food Chemistry
2 cr. AE 451 (S) Food Engineering
3 cr. BSE 460 (S) Grain Processing and Handling
2 cr. FSHN 420 (P) Food Microbiology
3 cr. FSHN 471 (P) Food Processing
BIOSYSTEMS ENGINEERING CURRICULUM
BIOENVIRONMENTAL ENGINEERING OPTION
A total of 127.5 credits required for graduation
(2009-2011 Catalog)

I. Communication (9.5 credits)
   3 cr. Engl 150 (FSSS) Critical Thinking and Communication
   3 cr. Engl 250 (FSSS) Written, Oral, Visual, and Electronic Composition
   3 cr. Engl 350 (FS) Report and Proposal Writing
   3 cr. Engl 354 (FS) Technical Communication
   3 cr. CE 305 (FS) Economic Analysis and Technical Communication
   3 cr. Sp Cn 312 (FSSS) Fundamentals of Public Speaking
   3 cr. Ag Ed 311 (FS) Presentation and Sales Strategies for Ag Audiences
   0.5 cr. Lib 160 (FSSS) Library Instruction

II. Mathematical Sciences (15 credits)
   4 cr. Math 165 (FSSS) Calculus I
   4 cr. Math 166 (FSSS) Calculus II
   4 cr. Math 267 (FSSS) Elementary Differential Equations and Laplace Transforms
   3 cr. Stat 303 (FSSS) Engineering Statistics

III. Biological and Physical Science Common Core (21 credits)
   4 cr. Chem 167 (FS) General Chemistry for Engineering Students
   1 cr. Chem 167L (FS) Laboratory in General Chemistry for Engineers
   5 cr. Phys 221 (FSSS) Introduction to Classical Physics I
   5 cr. Phys 222 (FSSS) Introduction to Classical Physics II
   3 cr. Biol 212 (FS) Principles of Biology II
   3 cr. Micro 302 (FS) Biology of Microorganisms
   1 cr. Micro 302L (FS) Microbiology lab

V. Social Sciences and Humanities (12 credits)
   3 cr. U. S. Diversity Course
   3 cr. International Perspective Course
   6 cr. Social Science and Humanities Electives (Select from departmental-approved list)

VI. Engineering Core (23 credits)
   4 cr. Engr 101 (FS) Engineering Orientation
   1 cr. BSE 110 (S) Experiencing Biological Systems Engineering
   3 cr. Engr 160 (FS) Engineering Problems with Computer Applications Laboratory
   3 cr. Engr 170 (FS) Engineering Graphics and Introductory Design
   3 cr. E M 274 (FSSS) Statics of Engineering
   3 cr. E M 324 (FSSS) Mechanics of Materials
   1 cr. E M 327 (FSSS) Mechanics of Materials Laboratory
   3 cr. ME 330 (FS) Thermodynamics
   3 cr. Ch E 356 (FS) Transport Phenomena I
   3 cr. Ch E 357 (FS) Transport Phenomena II
### VII. Biological Systems Engineering Core (25 credits)

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>BSE 216</td>
<td>Fundamentals of Agricultural and Biological Engineering</td>
</tr>
<tr>
<td>BSE 301</td>
<td>Entrepreneurship Seminar</td>
</tr>
<tr>
<td>BSE 316</td>
<td>Leadership and Ethics Seminar</td>
</tr>
<tr>
<td>BSE 318</td>
<td>Computer Applications and Systems Modeling</td>
</tr>
<tr>
<td>A E 363</td>
<td>Agri-Industrial Applications of Electric Power and Electronics</td>
</tr>
<tr>
<td>BSE 368</td>
<td>Principles of Biological Systems Engineering</td>
</tr>
<tr>
<td>BSE 401</td>
<td>Professionalism Seminar</td>
</tr>
<tr>
<td>A E 404</td>
<td>Instrumentation for Agricultural and Biological Engineering</td>
</tr>
<tr>
<td>BSE 415</td>
<td>Biological Systems Engineering Design I</td>
</tr>
<tr>
<td>BSE 416</td>
<td>Biological Systems Engineering Design II</td>
</tr>
<tr>
<td>BSE 480</td>
<td>Engineering Analysis of Biological Systems</td>
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### VIII. Bioenvironmental Engineering Option (20 credits)

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chem 231</td>
<td>Elementary Organic Chemistry</td>
</tr>
<tr>
<td>Chem 231L</td>
<td>Laboratory in Elementary Organic Chemistry</td>
</tr>
<tr>
<td>Chem 231I</td>
<td>Quantitative and Environmental Analysis</td>
</tr>
<tr>
<td>Chem 231L I</td>
<td>Quantitative and Environmental Analysis Laboratory</td>
</tr>
<tr>
<td>CE 326</td>
<td>Principles of Environmental Engineering</td>
</tr>
<tr>
<td>A E 341</td>
<td>Design and Evaluation of Soil and Water Conservation Systems</td>
</tr>
</tbody>
</table>

**Select 3 credits from the following:**

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>A E 406</td>
<td>Design and Evaluation of Soil and Water Monitoring Systems</td>
</tr>
<tr>
<td>CE 411</td>
<td>Environmental Biotechnology</td>
</tr>
<tr>
<td>CE 428</td>
<td>Water and Wastewater Treatment Plant Design</td>
</tr>
<tr>
<td>En Sci 311</td>
<td>Environmental Systems</td>
</tr>
</tbody>
</table>

**Select 3 credits from the following:**

<table>
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<tbody>
<tr>
<td>Biol 312</td>
<td>Ecology</td>
</tr>
<tr>
<td>TSM 310</td>
<td>Total Quality Improvement</td>
</tr>
<tr>
<td>A E 318</td>
<td>Sustainable Engineering and International Development</td>
</tr>
<tr>
<td>A E 406</td>
<td>Applied Computational Intelligence for Agricultural &amp; Biological Systems</td>
</tr>
<tr>
<td>Environ 251</td>
<td>Environmental Biodynamics</td>
</tr>
<tr>
<td>Agron 405</td>
<td>Environmental Biophysics (Biometeorology)</td>
</tr>
</tbody>
</table>
B11. Undergraduate Bioproducts and Biosystems Engineering (Minnesota University)

BBE Courses

We offer a number of exciting courses at the undergraduate and graduate level. The courses cover a variety of topics related to sustainable use of renewable resources and enhancement of the environment including:

- Renewable energy and the environment
- Renewable energy technologies
- Biomaterials chemistry
- Biomass conversion
- Bioproducts engineering
- Food engineering
- Bioproducts marketing and management
- New products development and management
- Bioprocess engineering
- Environmental and ecological engineering
- Water quality
- Hydrologic modeling

Please visit the links below for range of course offerings in BBE, ESPM, Chem, and Mgmt.

- BBE Bioproducts and Biosystems Engineering and related courses
- ESPM Environmental Science, Policy and Management courses
- CHEM Chemistry
- MGMT Management
- IE Industrial Engineering
BIOPRODUCTS AND BIOSYSTEMS ENGINEERING (BBE)
College of Food, Agricultural and Natural Resource Sciences; Institute of Technology
Bioproducts and Biosystems Engineering

BBE 1001 - Bioproducts and Biosystems Engineering Orientation
(1.0 cr; S-N or Aud, fall, every year)
Academic programs/careers related to bioproducts and biosystems engineering. Required field trip.

BBE 1002 - Wood and Fiber Science
(3.0 cr; =BBE 5202; A-F or Aud, spring, every year)
Wood as a bio-material. Wood's anatomical/cellular structure compared with other plant-derived materials. Wood's physical properties/characteristics in various applications. Non-wood fiber, bio-product characteristics.

BBE 1005 - Introduction to Pulp and Paper Technology
(3.0 cr; spring, every year)
Technology of pulp/paper manufacturing. Terminology, key parameters. Stepwise description of processes, from harvesting of trees through fiber production and papermaking. Vista based online course.

BBE 1011 - Biosystems and Agricultural Engineering Orientation
(1.0 cr; S-N or Aud, fall, spring, every year)
Introduction to biosystems and agricultural engineering profession through readings and discussions by faculty, practicing engineers, and students; curriculum and intern, undergraduate research, and honors opportunities. Ethics, safety, environmental issues.

BBE 1302 - Wood as a Raw Material
(3.0 cr; Prereq-#; spring, every year)
Physical/chemical nature of wood and wood fiber. Raw material requirements, manufacturing processes, product characteristics for principal forest products. World wood supply, consumption trends.

BBE 1901 - Freshman Seminar
(3.0 cr [max 6.0 cr]; Prereq-freshman; fall, spring, every year)
Issues/topics related to natural resources and the environment. Topics vary each semester.

BBE 1906W - Freshman Seminar (ENV, WI)
(3.0 cr; Prereq-Fr; fall, spring, every year)
Issues/topics related to natural resources and the environment. Topics vary each semester.

BBE 2113 - Introduction to Design
(3.0 cr; Prereq-Math 1271; A-F or Aud, fall, every year)
BBE 2201 - Renewable Energy and the Environment (TS)
(3.0 cr; fall, every year)
Renewable energy technologies. Environmental, technical, social, and economic challenges/opportunities for each technology.

BBE 3001 - Mechanics and Structural Design
(4.0 cr; Prereq-[MATH 1272 or MATH 1372], [PHYS 1101 or PHYS 1301]; A-F or Aud, fall, every year)
Fundamental treatment of statics, dynamics, and principles of structural design. Techniques for individual components, including trusses, beams, and columns. Using conventional lumber products, engineered wood products, and steel. Lab.

BBE 3002 - Introduction to Engineering Design
(3.0 cr; Prereq-[MATH 1271 or MATH 1371, CHEM 1021, BBE lower div (soph) or upper div (jr), freshman writing req] or #; A-F only, fall, every year)
Identify, formulate, develop-complete open-ended designs in bioproducts & biosystems engineering at the conceptual level; engineering economics principles, safety/health considerations, and ethics for design project. Written, graphical, and oral presentations.

BBE 3013 - Engineering Principles of Molecular and Cellular Processes
(3.0 cr; =[01737]; Prereq-Biol 1009, [Chem 1022 or &Chem 1022], Math 1272; A-F or Aud, fall, every year)
Applied engineering principles in biological processes, classification of microbes of industrial importance, parameters for cellular control, modeling of cell growth/metabolism, enzymatic catalysis, bioreactor design, product recovery operations design, case studies.

BBE 3023 - Ecological Engineering Principles
(3.0 cr; Prereq-BIOL 1009, [CE 3502 or &CE 3502] or #; fall, every year)

BBE 3033 - Material and Energy Balances in Biological Systems
(3.0 cr; Prereq-CHEM 1022, [MATH 1272 or MATH 1372], PHYS 1302; A-F or Aud, spring, every year)
Basic principles of materials and energy balances, their applications in biological systems.

BBE 3043 - Biological and Environmental Thermodynamics
(3.0 cr; Prereq-BIOL 1009, CHEM 1021, [MATH 1272], PHYS 1302; A-F or Aud, spring, every year)

BBE 3093 - Directed Studies
(1.0 - 5.0 cr [max 5.0 cr]; Prereq-#; fall, spring, every year)
Independent study of topic(s) involving physical principles as applied to agricultural production and land resources.

**BBE 3101 - Introductory Statics and Structures for Construction Management**
(3.0 cr; Prereq-Working knowledge of [trigonometry, geometry, algebra]; A-F or Aud, fall, spring, every year)
Statics, engineering wood design principles, mechanical properties of wood. Design techniques for individual components. Trusses, beams, columns. Using conventional lumber products, engineered wood products, and steel. Simple structures explored through examples, assignments.

**BBE 3102 - Residential Indoor Air Quality**
(3.0 cr; = [BBE 5102]; Prereq-[Jr, one yr of college-level [physics or chemistry or biology]] or #; A-F or Aud, fall, every year)
Indoor air pollution issues found in residential structures, especially in north central region of the United States. Pollutant descriptions, including measurement techniques and typical ranges of concentrations. Health effects 3) Pathways and transport mechanisms. Control strategies, including mitigation and prevention.

**BBE 3393 - Directed Study**
(1.0 - 3.0 cr [max 12.0 cr]; Prereq-#; fall, spring, every year)
Opportunity to pursue projects not available through independent study or extra credit. In consultation with an adviser, students develop a prospectus and complete progress reports and a final report on the project.

**BBE 3396 - Industrial Internship (Industrial Assignment)**
(1.0 cr; Prereq-BBE cooperative ed student; A-F or Aud, fall, spring, every year)
Industrial work assignment in forest products cooperative education program. Evaluation based on formal report.

**BBE 3411 - Introduction to Residential Construction**
(2.0 cr; fall, every year)
Housing/construction terminology, building materials/components. Design, construction, and sales process: basic building science concepts, blueprint reading, computer-aided design, construction site logistics.

**BBE 3412 - Introduction to Residential Building Materials Estimating**
(1.0 cr; A-F or Aud, fall, every year)

**BBE 3480 - Special Topics**
(3.0 - 4.0 cr [max 12.0 cr]; = [BBE 5480]; fall, spring, every year)
Topics specified in Class Schedule.

**BBE 3503 - Marketing of Bio-based Products**
(4.0 cr; = [BBE 5503]; A-F or Aud, fall, every year)
Intro to marketing function as it relates to current/emerging bio-based products industries (building materials, paper, fuels, etc.). Product positioning, pricing,
promotion, and channel management within strategic planning and environmental marketing management.

**BBE 4001 - Chemistry of Plant Materials**
(4.0 cr; = [BBE 5001]; Prereq-CHEM 2301, [jr or sr or #]; A-F or Aud, fall, every year)
Chemical principles underlying structure, properties, processing, and performance of plant materials.

**BBE 4013 - Transport in Biological Systems**
(3.0 cr; Prereq-[3013 or &3013 or ChEn 3701], CE 3502, [ME 3331 or ChEn 4101], upper div IT; A-F or Aud, spring, every year)
Application of thermodynamics, fluid flow, heat/mass transfer to design problems involving biological processes and materials at cell, organism, and system level. Agricultural, environmental, food, and bioprocess applications. Solution of equations involving computer programming assignments. Hands-on instruction in Visual Basic.

**BBE 4023W - Process Control and Instrumentation (WI)**
(3.0 cr; = [BBE 5023]; Prereq-Upper div IT or grad student; A-F or Aud, fall, every year)
Measurement of motion, force, pressure, flow, temperature, size, shape, color, texture, rheology, moisture, water mobility, fat, and pH. Linking physical and biological control systems.

**BBE 4114W - Capstone Design Project (WI)**
(4.0 cr; Prereq-2113, [upper div IT or sr] or #; A-F or Aud, fall, offered periodically)
Design concepts, design process. Case studies involving engineering design. Health, safety, and ethical issues facing engineers. Proposal for capstone design team project, including oral presentation of written proposal. Comprehensive design project, including written report, poster, and oral presentation of final design.

**BBE 4200H - Honors Seminar**
(1.0 cr; Prereq-BP upper div honors, #; A-F or Aud, fall, spring, every year)
Current topics presented by faculty/students. Lecture/discussion.

**BBE 4301 - Surface and Colloid Science in Bio-based Products Manufacturing**
(3.0 cr; = [BBE 5301]; Prereq-Chem 3501, [jr or sr or #]; fall, every year)
Principles of surface/colloid science, their application to understanding manufacturing/performance of bio-based products.

**BBE 4302 - Organisms Impacting Bio-based Products**
(3.0 cr; = [BBE 5302]; Prereq-1002 or WPS 1301 or #; spring, every year)
Organisms of importance to bio-based products. Deterioration, control, bioprocesses for benefit.

**BBE 4303 - Introduction to Bio-based Materials Science**
(3.0 cr; = [BBE 5303]; Prereq-3001; A-F or Aud, spring, every year)
Principles of materials science, their application to bio-based materials.

**BBE 4305 - Pulp and Paper Technology**
D.Briassoulis  UNIVERSITIES IN USA AND CANADA OFFERING PROGRAMS OF STUDIES IN BIOSYSTEMS ENGINEERING OR RELATED DISCIPLINES

(3.0 cr; Prereq-Jr or #; fall, every year)

BBE 4312 - Pulp and Paper Unit Operations
(4.0 cr; Prereq-4305 or #; fall, every year)
Application of principles of momentum, heat, and mass transfer to unit operations in pulp/paper industry. Fluid transport, filtration, sheet formation, sedimentation, drainage, pressing, heat exchange, evaporation, washing, bleaching, humidification/drying, chemical/energy recovery. Computer simulation of multiple-stage systems. Online course.

BBE 4313 - Design of Machine Systems
(3.0 cr; Prereq-AEM 2021, AEM 3031, [CE 3502 or &CE 3502], upper div IT; A-F or Aud, spring, odd years)

BBE 4314 - Papermaking Processes and Process Engineering Laboratory
(3.0 cr; Prereq-#; spring, every year)

(3.0 cr; Prereq-Math 1272 or #; spring, every year)
Presented through the Internet. Basic concepts and most frequently used methods in statistical process control, analysis of variances, experiment design, and regression analysis. Online course.

BBE 4323 - Machinery Elements
(3.0 cr; Prereq-AEM 2021, AEM 3031, [CE 3502 or &CE 3502], upper div IT; spring, even years)

BBE 4333 - Off-road Vehicle Design
(4.0 cr; =[BBE 5333]; Prereq-[[3001, 4303] or [AEM 2021, AEM 3031], [CE 3502 or &CE 3502], upper div IT] or #; A-F or Aud, spring, every year)
BBE 4355 - Design of Wood Structures  
(3.0 cr; Prereq-3001 or WPS 4301 or CE student or #; spring, every year)  
Design of wood structures using Allowable Stress Design. Wood properties/characteristics important to structural design. Heavy/light frame wood construction.

BBE 4362 - Pulping and Bleaching  
(4.0 cr; =[00819]; Prereq-BP 4305 or WPS 4305; spring, every year)  
Chemistry/technologies in producing paper-making raw material. Focuses on wood pulping/bleaching, including non-wood fibers and recycled fiber materials. Online course.

BBE 4401 - Bioproducts Engineering  
(3.0 cr; =[01308]; Prereq-[3033, CE 3502, UD] or #; A-F or Aud, fall, every year)  
Unit operations of bioproducts engineering/manufacture.

BBE 4402 - Bio-based Products Engineering Lab I  
(1.0 cr; =[BBE 5402]; Prereq-CHEM 2301, [jr or sr or #]; A-F or Aud, spring, every year)  
Lab exercises in bio-based products engineering.

BBE 4403 - Bio-based Products Engineering Lab II  
(1.0 cr; =[BBE 5403]; Prereq-CHEM 2301, [jr or sr or #]; A-F or Aud, fall, every year)  
Lab exercises in bio-based products engineering.

BBE 4404 - Bio-based Composites Engineering  
(3.0 cr; =[BBE 5404]; Prereq-3001, Chem 3501, [jr or sr or #]; A-F or Aud, spring, every year)  
Properties of bio-based composites.

BBE 4406 - Understanding Wood  
(2.0 cr; Prereq-UC only; fall, every year)  
For woodworking professionals and serious craftspersons. Cellular structure of wood, identification of hardwoods and softwoods, interaction of water and wood. No prior technical training in wood properties is needed, although general experience with woodworking is helpful.

BBE 4407 - Bio-based Products Manufacturing and Applications I  
(3.0 cr; =[BBE 5407]; Prereq-1002 or #; fall, every year)  

BBE 4411 - Application and Performance of Wood-based Composites in Services  
(2.0 cr; Prereq-[1002 or WPS 1301 or 4406 or WPS 4406 or #], [UC or CEE]; A-F or Aud, spring, every year)  
Physical/mechanical properties of composites. Composite applications/installations.

BBE 4412W - Bio-based Products Manufacturing and Applications II (WI)  
(3.0 cr; =[BBE 5412]; Prereq-1002, upper div BP; spring, every year)
Manufacturing processes, end-use applications of bio-based products.

**BBE 4413 - Systems Approach to Residential Construction**  
(4.0 cr; = [BBE 5413, HSG 4413]; Prereq-Upper div or #; spring, every year)  
Dynamic/interrelated issues of energy, moisture control, indoor air quality in residential bldgs. Design, construction, and operational aspects for energy efficient, durable structure/healthy living environment. Interaction between moisture and wood products within building system.

**BBE 4414 - Advanced Residential Building Science (WI)**  
(3.0 cr; = [BBE 5414]; Prereq-3001 or WPS 4301; fall, every year)  
Theory, advanced applications for residential buildings. Focuses on heat/mass transfer.

**BBE 4415 - Advanced Residential Building Science Lab**  
(1.0 cr; = [BBE 5415]; Prereq-[[3001, 4302, 4413W] or #] or [[WPS 4301, 4303, 4333] or #]; [4414 or WPS 4334]; A-F or Aud, fall, every year)  
Exercises on advanced applications of heat/mass transfer to predict performance of residential buildings.

**BBE 4416 - Building Testing and Diagnostics**  
(2.0 cr; = [BBE 5416]; Prereq-4413; spring, every year)  
Theoretical basis for performance testing. Diagnostics applications for residential structures. Existing structures, retrofit/remedial applications. Digital differential pressure gauges, blower doors, airflow hoods/grids, duct pressure testing, infrared thermography. Hands-on equipment use, problem solving.

**BBE 4491 - Senior Topics: Independent Study**  
(1.0 - 4.0 cr [max 4.0 cr]; Prereq-sr, #; fall, spring, every year)  
Independent study in student's area of interest.

**BBE 4501 - Process and Product Design I**  
(2.0 cr; Prereq-[4001, 4301, 4303, [4401 or &4401], [4403 or &4403], fr writing req, [jr or sr]] or #; fall, every year)  
Students develop, formulate, and complete an open-ended, engineering process-design project at conceptual level.

**BBE 4502W - BBE Capstone Design (WI)**  
(4.0 cr; Prereq-[2113 or 4501], sr; A-F or Aud, spring, every year)  
Students develop, select, formulate, and complete an open-ended, comprehensive engineering process/product design project.

**BBE 4504W - Bio-based Products Development and Management (WI)**  
(3.0 cr; = [00832]; Prereq-Jr or sr or #; A-F or Aud, spring, every year)  
Concepts of new-product development and product management, their application to bio-based products.

**BBE 4523 - Ecological Engineering Design**  
(3.0 cr; = [BBE 5523]; Prereq-[CHEM 1022, [BIOL 3407 or BIOL 3807 or EEB 4068 or LA 3204], CE 3502, upper div IT] or #; A-F or Aud, spring, every year)  
Application ecological engineering to design of remediation systems. Artificial
ecosystems, ecosystem/wetland restoration, constructed wetlands, biological engineering for slope stability, waste treatment using biological systems. Restoring ecological service of watersheds.

**BBE 4533 - Agricultural Waste Management Engineering**  
(3.0 cr; Prereq-3023, upper div IT; A-F or Aud, spring, even years)  
Sources and characteristics of agricultural wastes, including livestock, food processing, and domestic wastes. Physical, biological, chemical, rheological, and microbiological properties. Effects on environment. Collection, storage, treatment (aerobic and anaerobic), and use/disposal. Land application.

**BBE 4535 - Assessment and Diagnosis of Impaired Waters**  
(3.0 cr; =[BBE 5535]; Prereq-Upper division IT or CFANS or CBS student or #; A-F only, fall, every year)  
Assessing impaired waters and developing TMDL for conventional pollutants. Preparing/communicating legal, social, and policy aspects. TMDL analysis of real-world impaired waters problem. Field trip to impaired waters site.

**BBE 4713 - Biological Process Engineering**  
(3.0 cr; =[BBE 5713]; Prereq-[3033, [4013 or &4013], upper div IT] or #; A-F or Aud, spring, every year)  

**BBE 4723 - Food Process Engineering**  
(3.0 cr; =[BBE 5723]; Prereq-[[4013 or &4013] upper div IT] or #; A-F or Aud, spring, every year)  
Material/energy balance, fluid dynamics, heat/mass transfer in refrigeration, freezing, psychometrics, dehydration, evaporation, non-thermal processing, and separation. Development control for production of food products.

**BBE 4733 - Renewable Energy Technologies**  
(3.0 cr; =[BBE 5733]; Prereq-Upper div IT or grad student or #; A-F or Aud, spring, every year)  

**BBE 4744 - Engineering Principles for Biological Scientists**  
(4.0 cr; =[FSCN 4331]; Prereq-[Math 1142 or Math 1271], Phys 1101; intended for non engineering students; A-F or Aud, fall, every year)  
Material/energy balances applied to processing systems. Principles of fluid flow, thermodynamics, heat, mass transfer applied to food and bioprocess unit operations such as pumping, heat exchange, refrigeration/freezing, drying, evaporation, and separation.

**BBE 4801H - Honors Research**  
(2.0 cr; Prereq-BP upper div honors; A-F or Aud, fall, spring, every year)
First semester of independent research project supervised by faculty member.

**BBE 4802H - Honors Research**  
(2.0 cr; Prereq-BP upper div honors, #; A-F or Aud, fall, spring, every year)  

**BBE 4900 - Intern Reports**  
(2.0 cr [max 4.0 cr]; Prereq-IT or COAFES student in BAE, #; S-N or Aud, fall, spring, summer, every year)  
Reports on intern work assignments reviewed by faculty and industry advisers.

**BBE 5001 - Chemistry of Plant Materials**  
(4.0 cr; = [BBE 4001]; Prereq-Grad student or #; A-F or Aud, fall, every year)  
Chemical principles underlying structure, properties, processing, and performance of plant materials.

**BBE 5023 - Process Control and Instrumentation**  
(3.0 cr; = [BBE 4023W]; Prereq-Grad student or #; fall, every year)  
Fundamental principles in system dynamics/control. Emphasizes process systems and problems faced by process engineers.

**BBE 5095 - Special Problems**  
(1.0 - 5.0 cr [max 5.0 cr]; Prereq-#; fall, spring, summer, every year)  
Advanced individual-study project. Application of engineering principles to specific problem.

**BBE 5102 - Residential Indoor Air Quality**  
(3.0 cr; = [BBE 3102]; Prereq-Grad student or #; A-F or Aud, fall, every year)  
Indoor air pollution issues found in residential structures, especially in the north central region of the United States. Pollutant descriptions, including measurement techniques and typical ranges of concentrations. Health effects. Pathways, transport mechanisms. Control strategies including mitigation and prevention.

**BBE 5202 - Wood and Fiber Science**  
(3.0 cr; = [BBE 1002]; A-F or Aud, spring, every year)  
Wood as a bio-material. Wood's anatomical/cellular structure compared with other plant-derived materials. Wood's physical properties/characteristics in various applications. Non-wood fiber, bio-product characteristics.

**BBE 5203 - Environmental Impacts of Food Production**  
(3.0 cr; Prereq-intended for non-engineering students; Credit will not be granted if credit has been received for AGET 5203; A-F or Aud, fall, spring, every year)  
Crop production intensity, animal raising options, food processing waste alternatives, pest control.

**BBE 5212 - Safety and Environmental Health Issues in Plant and Animal Production and Processing**  
(3.0 cr; Prereq-grad student or sr or #; Credit will not be granted if credit has been received for AGET 5212.; A-F or Aud, fall, spring, summer, every year)  
Safety/health issues in food production, processing and horticultural work
environments using public health, injury control, and health promotion frameworks: regulation, engineering, education. Traumatic injury, occupational illness, ergonomics, pesticide health effects, biotechnology, air contaminants.

BBE 5301 - Surface and Colloid Science in Bio-based Products Manufacturing
(3.0 cr; =BBE 4301; Prereq-Grad student or #; spring, every year)
Principles of surface and colloid science, their application to manufacturing/performance of bio-based products.

BBE 5302 - Organisms Impacting Bio-based Products
(3.0 cr; =BBE 4302; Prereq-Grad student or #; spring, every year)
Organisms and their importance to bio-based products: deterioration, control, bioprocesses for benefit.

BBE 5303 - Introduction to Bio-based Materials Science
(3.0 cr; =BBE 4303; Prereq-Grad student or #; spring, every year)
Principles of materials science, their application to bio-based materials. Project required.

BBE 5305 - Pulp and Paper Technology
(3.0 cr; Prereq-Grad student or #; fall, every year)

BBE 5314 - Papermaking Processes and Process Engineering Laboratory
(3.0 cr; Prereq-Grad student or #; spring, every year)

(3.0 cr; Prereq-Grad student or #; spring, every year)
Presented through the Internet. Basic concepts and most frequently used methods in statistical process control, analysis of variances, experiment design, and regression analysis. Online course.

BBE 5333 - Off-road Vehicle Design
(4.0 cr; =BBE 4333; Prereq-[3001, 4303] or [AEM 2021, AEM 3031], [CE 3502 or
BBE 5362 - Pulping and Bleaching (WI)
(4.0 cr; Prereq-Grad student or #; spring, every year)
Chemistry/technologies in producing paper-making raw material. Focuses on wood pulping/bleaching, including non-wood fibers and recycled fiber materials. Online course.

BBE 5401 - Bioproducts Engineering
(3.0 cr; =[01294]; Prereq-Grad student or #; A-F or Aud, fall, every year)
Unit operations of bioproducts engineering/manufacture. Project required.

BBE 5402 - Bio-based Products Engineering Lab I
(1.0 cr; =[BBE 4402]; Prereq-Grad student or #; A-F or Aud, spring, every year)
Laboratory exercises in bio-based products engineering.

BBE 5403 - Bio-based Products Engineering Lab II
(1.0 cr; =[BBE 4403]; Prereq-Grad student or #; A-F or Aud, fall, every year)
Laboratory exercises in bio-based products engineering.

BBE 5404 - Bio-based Composites Engineering
(3.0 cr; =[BBE 4404]; Prereq-Grad student or #; A-F or Aud, spring, every year)
Properties of bio-based composites.

BBE 5407 - Bio-based Products Manufacturing and Applications I
(3.0 cr; =[BBE 4407]; Prereq-Grad student or #; fall, every year)

BBE 5412 - Manufacturing and Applications of Bio-based Products
(4.0 cr; =[BBE 4412W]; Prereq-Grad student or #; spring, every year)
Manufacturing processes, end-use applications of bio-based products.

BBE 5413 - A Systems Approach to Residential Construction
(4.0 cr; =[HSG 4413, BBE 4413]; Prereq-Grad student or #; spring, every year)
Dynamic/interrelated issues of energy, moisture control, indoor air quality in residential bldgs. Emphasizes design, construction, and operational aspects to provide an energy efficient, durable structure, and healthy living environment. Interaction between moisture and wood products within building system.

BBE 5414 - Advanced Residential Building Science
(3.0 cr; =[BBE 4414]; Prereq-Grad student or #; fall, every year)
Building science theory, advanced applications for residential buildings. Focuses on heat/mass transfer.
BBE 5415 - Advanced Residential Building Science Lab  
(1.0 cr; = [BBE 4415]; Prereq-Grad student or #; A-F or Aud, fall, every year)  
Concurrent with 4334. Exercises on advanced applications of heat/mass transfer to predict performance of residential buildings.

BBE 5416 - Building Testing & Diagnostics  
(2.0 cr; = [BBE 4416]; Prereq-Grad student or #; spring, every year)  
Theoretical basis for performance testing. Diagnostics applications for residential structures. Focuses on existing structures and retrofit/remedial applications. Digital differential pressure gauges, blower doors, airflow hoods/grids, duct pressure testing, infrared thermography. Hands-on sessions for equipment use, problem solving.

BBE 5480 - Special Topics  
(3.0 - 4.0 cr [max 12.0 cr]; = [BBE 3480]; Prereq-Sr or grad student; fall, spring, every year)  
Topics specified in Class Schedule.

BBE 5503 - Marketing of Bio-based Products  
(4.0 cr; = [BBE 3503]; Prereq-Grad student or #; A-F or Aud, fall, every year)  
Introduction to marketing function as it relates to current/emerging bio-based products industries (building materials, paper, fuels, etc.). Product positioning, pricing, promotion, and channel management within strategic planning and environmental marketing management.

BBE 5504 - Bio-based Products Development and Management  
(3.0 cr; Prereq-Grad student or #; A-F or Aud, spring, every year)  
Concepts of new product development and product management and their application to bio-based products.

BBE 5513 - Watershed Engineering  
(3.0 cr; Prereq-3023, upper div IT; A-F or Aud, fall, every year)  
Application of engineering principles to managing surface runoff from agricultural, range, and urban watersheds. Design of facilities and selection of land use practices for controlling surface runoff to mitigate problems of flooding and degradation of surface-water quality.

BBE 5523 - Ecological Engineering Design  
(3.0 cr; = [BBE 4523]; Prereq-CHEM 1022, [BIOL 3407 or BIOL 3807 or EEB 4068 or LA 3204], CE 3502, upper div IT; A-F only, spring, every year)  

BBE 5535 - Assessment and Diagnosis of Impaired Waters  
(3.0 cr; = [BBE 4535]; Prereq-Grad student or #; A-F only, fall, every year)  
Assessing impaired waters and developing TMDL for conventional pollutants. Preparing/communicating legal, social and policy aspects. TMDL analysis of real-world impaired waters problem. Field trip to impaired waters site.
BBE 5713 - Biological Process Engineering
(3.0 cr; = [BBE 4713]; Prereq-[3033, [4013 or &4013], [upper div IT or grad student]] or #; A-F only, spring, every year)

BBE 5723 - Food Process Engineering
(3.0 cr; = [BBE 4723]; Prereq-[4013 or &4013], [upper div IT or grad student]] or #; A-F only, spring, every year)
Food processing engineering. Applications of material balance, energy balance, fluid dynamics, and heat/mass transfer to refrigeration, freezing, psychometrics, dehydration, evaporation, non-thermal processing, and separation. Development/control for food products.

BBE 5733 - Renewable Energy Technologies
(3.0 cr; = [BBE 4733]; Prereq-Upper div IT or grad student or #; A-F only, fall, every year)
Solar thermal energy, solar photovoltaics, biomass energy, wind energy, hydroelectricity, tidal power, and geothermal energy. Sustainable development: energy security, environmental, economic, and societal considerations.
B12. Undergraduate Bioproducts & Biosystems engineering (Michigan State University)

1. University Requirements (24)
   - Writing, Theoric and American Cultures (WTA) 4
   - Integrative Studies in Humanities (IASH) 8
   - Integrative Studies in Social Sciences (ISSS) 6
   - Bioscience Bio 110 Organisms and Populations 8

2. College Requirements (56)
   - CEM 141 General Chemistry 4
   - EGR 103 Introduction to Engineering Design 2
   - EGR 102 Introduction to Engineering Modeling 2
   - MTH 132 Calculus I 3
   - MTH 132 Calculus II 3
   - MTH 234 Multivariable Calculus 4
   - MTH 238 Differential Equations 3
   - PHY 183 Physics for Scientists & Engineers I 4
   - PHY 184 Physics for Scientists & Engineers II 4

3. Major Requirements: (51)
   a. Complete all of the following courses:
      - BE 121 Introduction to Biosystems Engineering 1
      - BE 200 Engineering Analysis of Biological Systems 3
      - BE 252 Engineering Properties of Biological Materials 3
      - BE 333 Biosystems Engineering Laboratory 1
      - BE 350 Heat and Mass Transfer in Biosystems 3
      - BE 351 Thermodynamics for Biological Engineering 3
      - BE 350 Microbial Systems Engineering 3
      - BE 382 Enzyme & Biocatalysis 3
      - BE 389 Bio Design & Optimization in Biological Sys 3
      - BE 456 Biosystems Design Tactiques 3
      - BI 487 Biosystems Design Project (W) 3
      - BS 211 Cells and Molecules 3
      - CE 211 Global 3
      - CE 221 Fluids 3
      - CEM 141 Survey of Organic Chemistry 4
      - CHE 345 Electronic Instrumentation and Systems 3
      - STT 351 Probability and Statistics for Engineering 3
   b. Select one of the following courses: (3-4)
      - MNO 201 Introductory Microbiology 3
      - P/B 301 Introductory Plant Physiology 3
      - PSL 290 Introductory Physiology 4
   c. Select one of the following courses: (3)
      - CGD 449 Cell Biochemistry 3
      - PFR 451 Food and Agricultural Physiology 3
      - FSC 445 Food Microbiology 3
      - MNO 425 Microbial Ecology 3
      - MNO 445 Microbial Biotechnology 3
      - PSL 421 Physiological Biochemistry 3

4. General Education Core (31)
   - EC 445 Biotechnology 4
   - BE 454 Biostatistics and Data Analysis 3
   - CHE 322 Advanced Biochemistry 3
   - CHE 333 Analytical Methods 3
   - CHE 335 Biochemical Engineering 3
   - CHE 389 Biocatalysis 3
   - CHE 422 Bioreactor Technology 3
   - CHE 427 Environmental Chemistry 3
   - CHE 449 Environmental Toxicology 3

5. General Education Electives (3-4)
   - CHE 322 Advanced Biochemistry 3
   - CHE 333 Analytical Methods 3
   - CHE 335 Biochemical Engineering 3
   - CHE 389 Biocatalysis 3
   - CHE 422 Bioreactor Technology 3
   - CHE 427 Environmental Chemistry 3
   - CHE 449 Environmental Toxicology 3

6. Technical Electives (3)
   - Complete at least 6 credits selected from a list of approved engineering, technical, or science electives available from the academic advisor. Approved courses include, but are not limited to, those listed in the various concentrations/specializations listed below and additional courses from items above.

Optional Concentrations

The department offers several concentrations for students and when to focus on a specific application area in the discipline. The concentrations are available to, but not required of, any student enrolled in the Bachelor of Science program in Biosystems Engineering. Courses complete to satisfy requirements 1, above may also be used to satisfy the requirements of a concentration. Upon completion of the required courses for a given concentration, certification will appear on the student's official transcript.

Bioenergy Engineering Concentration (15-16)

To earn a Bachelor of Science degree in Biosystems Engineering with a bioenergy engineering concentration, students must complete requirements 1, 2, 3, and above, and the following:

   - CHE 322 Advanced Biochemistry 3
   - CHE 333 Analytical Methods 3
   - CHE 389 Biocatalysis 3
   - CHE 422 Bioreactor Technology 3
   - CHE 449 Environmental Toxicology 3
   - MNO 445 Microbial Biotechnology 3

One of the following courses: (3-4)

- CHE 451 Bioreactor Engineering 3
- CHE 452 Biochemical Engineering 3
- CHE 453 Multiscale Engineering Laboratory 3
- CHE 454 Bioreactor Technology 3
- CHE 455 Biochemical Engineering 3
- CHE 456 Bioreactor Technology 3
- CHE 457 Biochemical Engineering 3
- CHE 458 Bioreactor Technology 3
- CHE 459 Biochemical Engineering 3

**Note:** The above information is a representation of the contents of the document and may not be entirely accurate due to the limitations of the text extraction process.
**Biomedical Engineering Concentration (14-16)**

To earn a Bachelor of Science degree in Biomedical Engineering with a biomedical engineering concentration, students must complete requirements 1, 2, and 3: above and the following:

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>BE 446</td>
<td>Biocomputers for Medical Diagnostics</td>
<td>3</td>
</tr>
<tr>
<td>ME 454</td>
<td>Biomechanics and Heat Transfer</td>
<td>3</td>
</tr>
<tr>
<td>PSL 425</td>
<td>Physiological Biophysics</td>
<td>3</td>
</tr>
</tbody>
</table>

Two courses from the following (3-6):

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>BLD 204</td>
<td>Biomechanics of Disease</td>
<td>3</td>
</tr>
<tr>
<td>BLD 230</td>
<td>Molecular Laboratory Diagnostics</td>
<td>3</td>
</tr>
<tr>
<td>BLD 434</td>
<td>Clinical Immunology</td>
<td>3</td>
</tr>
<tr>
<td>BLD 450</td>
<td>Eukaryotic Pathogens</td>
<td>3</td>
</tr>
<tr>
<td>MGE 425</td>
<td>Biostatistics and Bioinformatics</td>
<td>3</td>
</tr>
<tr>
<td>PUB 400</td>
<td>Introduction to Bioinformation</td>
<td>3</td>
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</tbody>
</table>

**Food Engineering Concentration (15-16)**

To earn a Bachelor of Science degree in Biomedical Engineering with a food engineering concentration, students must complete requirements 1, 2, and 3: above and the following:

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>BE 477</td>
<td>Food Engineering Fluids</td>
<td>3</td>
</tr>
<tr>
<td>RF 478</td>
<td>Food Engineering Foods</td>
<td>3</td>
</tr>
<tr>
<td>FSC 440</td>
<td>Food Microbiology</td>
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</table>

Two courses from the following (6-7):

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<th>Credits</th>
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</thead>
<tbody>
<tr>
<td>BLD 500</td>
<td>Introduction to Biochemistry</td>
<td>3</td>
</tr>
<tr>
<td>FSC 211</td>
<td>Principles of Food Science</td>
<td>3</td>
</tr>
<tr>
<td>FSC 401</td>
<td>Food Chemistry</td>
<td>3</td>
</tr>
<tr>
<td>FSC 420</td>
<td>Food Processing: Fruits &amp; Vegetables</td>
<td>3</td>
</tr>
<tr>
<td>FSC 421</td>
<td>Food Processing: Cereals</td>
<td>3</td>
</tr>
<tr>
<td>FSC 432</td>
<td>Food Processing: Dairy Foods</td>
<td>3</td>
</tr>
<tr>
<td>FSC 453</td>
<td>Food Processing: Muscle Foods</td>
<td>3</td>
</tr>
</tbody>
</table>

**Ecosystems Engineering Concentration (15)**

To earn a Bachelor of Science degree in Ecosystems Engineering with an ecosystem engineering concentration, students must complete requirements 1, 2, and 3: above and the following:

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
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<tbody>
<tr>
<td>BE 181</td>
<td>Land and Water Conservation Engr</td>
<td>3</td>
</tr>
<tr>
<td>BE 182</td>
<td>Non-point Source Pollution Control</td>
<td>3</td>
</tr>
<tr>
<td>MGE 425</td>
<td>Microbial Ecology</td>
<td>3</td>
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Two courses from the following (6):

<table>
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<tr>
<td>CE 280</td>
<td>Principles of Env. Engineering and Sci</td>
<td>3</td>
</tr>
<tr>
<td>CE 322</td>
<td>Applied Hydraulics</td>
<td>3</td>
</tr>
<tr>
<td>CE 657</td>
<td>Hydrology for Env. Sci. and Engineering</td>
<td>3</td>
</tr>
<tr>
<td>COS 210</td>
<td>Fundamentals of Soil Science</td>
<td>3</td>
</tr>
<tr>
<td>CSS 445</td>
<td>Soils Biophysics</td>
<td>3</td>
</tr>
<tr>
<td>CSS 455</td>
<td>Pollutants in the Soil Environment</td>
<td>3</td>
</tr>
<tr>
<td>FW 443</td>
<td>Restoration Ecology</td>
<td>3</td>
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</table>

Other electives (variables) 12

Total Credits Required for Degree 120

These requirements are effective for students admitted to the Biomedical Engineering major beginning Fall 2005. The Department of Biosystems and Agricultural Engineering (BSE) reserves the right to make changes as necessary. Consequently, each student is encouraged to consult with her/his advisor to obtain assistance in planning an appropriate schedule of courses. Students who have questions about Biomedical Engineering should contact the Biomedical Engineering Advising Office, 1140 Engineering Building, phone (617) 353-5516. Extension 1.

Last revised May 2008
Biosystems Engineering

Sample Program

<table>
<thead>
<tr>
<th>Freshman Year</th>
<th>Credits</th>
<th>Fall</th>
<th>Spring</th>
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<tbody>
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<td>BS 101</td>
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<td>BS 111</td>
<td>3</td>
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<tr>
<td>CRB 141</td>
<td>4</td>
<td>ENGR 103</td>
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<tr>
<td>CEM 161</td>
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<td>IDES 233</td>
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<tr>
<td>EGR 100</td>
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<td>MTH 133</td>
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<td>PHY 102</td>
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<td>WRA 700</td>
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<td><strong>Total</strong></td>
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<td><strong>Fall</strong></td>
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<th>Sophomore Year</th>
<th>Credits</th>
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PROGRAM EDUCATIONAL OBJECTIVES

The overall purpose of the MSU biosystems engineering undergraduate program is to prepare graduates who will integrate and apply principles of engineering and biology to a wide variety of socially important problems. To achieve that purpose, the primary objectives of the biosystems engineering program are to prepare graduates to:

- Identify and solve problems at the interface of biology and engineering, using modern engineering techniques and the systems approach, and
- Analyze, design, and control components, systems, and processes that involve biological components.

Additionally, the biosystems engineering program is designed to help graduates succeed in diverse careers by developing a professional foundation that includes vision, adaptability, a practical mindset, effective communication skills, the ability to work in multidisciplinary teams, an appreciation for global, economic, and societal issues, and a commitment to continuing professional growth and ethical conduct.

(Approved by the Biosystems Engineering faculty, student group, and Industry Advisory Board, April 2004)
B13. Undergraduate Biological and Agricultural Engineering (Mississippi State University)
D. Briassoulis  UNIVERSITIES IN USA AND CANADA OFFERING PROGRAMS OF STUDIES IN BIOSYSTEMS ENGINEERING OR RELATED DISCIPLINES

**Biological Science Electives:**

- BIO 2103 – Cell Biology
- BIO 3103 – Genetics (with Lab)
- BIO 3204 – Comparative Anatomy (with Lab)
- BIO 4114 – Cellular Physiology (with Lab)
- BIO 4413 – Immunology
- BIO 4023 – Vertebrate Histology (with Lab)
- BIO 4504 – Comp Vertebrate Embryology (with Lab)
- BIO 3114 – Animal Physiology (with Lab)
- BIO 3104 – Ecology (with Lab)
- BIO 4204 – Path Anatomy (with Lab)
- BIO 4123 – Path Biology (with Lab)
- BIO 4124 – Cell Microbiology (with Lab)
- BIO 4044 – Environmental Microbiology (with Lab)
- BIO 4022 – Toxicology
- WF 3133 – Applied Aquatic Ecology (with Lab)
- WF 3772 – Water Quality Management
- ADS 3511 – Performance Analysis of Animal (with Lab)
- ADS 4211 – Livestock Nutritional Analysis
- PGS 4101 – Forage and Pasture Crops (with Lab)
- FO 4462 – Remote S Dent Applications (with Lab) + FO 4461

**Engineering Electives:**

- ABE 4123 – Rehabilitation Engineering
- ABE 3173 – Land Surveying (with Lab)
- ABE 3013 – OP/R/O for Water & Air (with Lab)
- CE 3803 – Environmental Resources Engineering I (with Lab CE 3801)
- CE 3813 – Environmental Resources Engineering II (with Lab CE 3811)
- CE 4803 – Advanced Hydraulic Analysis
- CE 4503 – Hazardous Waste Management
- CHE 4613 – Air Pollution Control Design
- CHE 4623 – Hazardous Waste Management
- CHE 4903 – Pollution Abatement and Control
- ECE 3714 – Digital Devices and Logic Design (with Lab)
- ESG 1143 – Graphic Communication
- EME 4123 – An Intro to Finite Element Method
- EME 4203 – Mechanics of Composite Materials
- EME 3213 – Advanced Mechanics of Materials
- EME 3103 – Engineering Economy
- EME 4173 – Occupational Safety Engineering
- MA 3113 – Intro to Linear Algebra
- MA 3373 – Intro to Partial Differential Equations
- MA 4543 – Intro to Mathematical Statistics I
- ME 4033 – Machine Design
- ME 4833 – Intermediate Fluid Mechanics
- ME 4433 – Computer Aided Design
- ME 4633 – Fluid Power Control
B14. Undergraduate Agricultural Engineering (North Carolina A&T State University)

**BIOE 114 - Home and Farm Maintenance**

This course provides instruction in the selection, sharpening, care, and correct use of shop tools and equipment, woodworking and simple carpentry, simple electrical repairs, sheet metal work, electric arc and oxyacetylene welding, pipe fitting, and simple plumbing repairs. (F;S;SS)

0.000 OR 3.000 Credit hours
3.000 Lecture hours
0.000 Lab hours

**Levels:** Undergraduate  
**Schedule Types:** Laboratory, Lecture

Civl, Arch & Agri Engineering Department

**BIOE 216 - Geographic Information Systems**

This course introduces Geographic Information System (GIS) concepts and applications. GIS theory is presented, and hands-on exercises are used to demonstrate the application and use of GIS in agriculture, arts and sciences, health, political sciences, engineering, technology, and other disciplines. (F,S)

0.000 OR 3.000 Credit hours
3.000 Lecture hours
0.000 Lab hours

**Levels:** Undergraduate  
**Schedule Types:** Laboratory, Lecture

Civl, Arch & Agri Engineering Department

**BIOE 330 - Engineering Systems Analysis and Design**

This course introduces the analysis and the design of engineering systems. Concepts, methods, and procedures associated with the engineering design process are studied. Specific topics include project management; customer need identification; team behavior; concept generation and evaluation; embodiment design; modeling and simulation; finite element analysis software; material selection; engineering statistics; and legal and ethical issues in design. Prerequisites: CAAE 332 or MEEN 336 or equivalent. (F;S)

0.000 OR 4.000 Credit hours
4.000 Lecture hours
0.000 Lab hours
Levels: Undergraduate  
Schedule Types: Laboratory, Lecture  

Civl, Arch & Agri Engineering Department  

**BIOE 360 - General Hydrology**  
This course is an introduction to the study of surface and subsurface hydrology. Topics include hydrologic cycle, rainfall-runoff relationships, precipitation measurements and hydrographs, unit hydrograph analysis, flood routing, planning and design of runoff/detention systems, and computer applications in hydrology. Prerequisites: CAAE 362 or MEEN 416. (F;S;SS)  
0.000 OR 3.000 Credit hours  
3.000 Lecture hours  

Levels: Undergraduate  
Schedule Types: Lecture  

Civl, Arch & Agri Engineering Department  

**BIOE 400 - Soil and Water Engineering I**  
This course studies the sustainable soil and water use by evaluating and applying present conservation practices and models. Water conveying and retaining structures, and soil conservation, drainage and irrigation systems are discussed and designed. The course emphasizes sound environmental design practices. Prerequisites: CAAE 364. (F;S;SS)  
0.000 OR 3.000 Credit hours  
3.000 Lecture hours  
0.000 Lab hours  

Levels: Undergraduate  
Schedule Types: Laboratory, Lecture  
All Sections for this Course  

Civl, Arch & Agri Engineering Department  

**BIOE 403 - Power and Machinery**  
This course covers the design principles of field machinery, evaluation of functional performance, and the efficiency of these machines. Also considered is the thermal analysis of internal combustion engines. Measurement and calculation of tractive and engine powers are included. Prerequisites: CAAE 332 or MEEN 336 or equivalent. (F;S)  
0.000 OR 3.000 Credit hours  
3.000 Lecture hours
0.000 Lab hours

**Levels:** Undergraduate  
**Schedule Types:** Laboratory, Lecture

Civl, Arch & Agri Engineering Department

### BIOE 404 - Structures and the Environment

This course covers the fundamentals of timber-framed building design and construction. Topics include selection of materials, design of foundations, beams and columns, reinforced concrete, and environmental considerations, such as temperature, humidity, condensation, and ventilation. Prerequisites: CAAE 332 or MEEN 336 or equivalent. (F;S)

0.000 OR 3.000 Credit hours
3.000 Lecture hours
0.000 Lab hours

**Levels:** Undergraduate  
**Schedule Types:** Laboratory, Lecture

### BIOE 422 - Introduction to Bioprocess Eng

This course covers the engineering concepts for biological conversion of raw materials to food, pharmaceuticals, fuels, and chemicals. Emphasis is placed on energy balance, material balance, fluid flow and mixing, heat and mass transfer, bioreaction kinetics, design, analysis, instrumentation, and control of bioreactors. Prerequisites: BIOE 330. (F;S;SS)

0.000 OR 3.000 Credit hours
3.000 Lecture hours
0.000 Lab hours

**Levels:** Undergraduate  
**Schedule Types:** Laboratory, Lecture

### BIOE 423 - Fund of Renewable Energy Sys

This course discusses the production, utilization and system design for energy in food and agricultural productions. Specific topics include: biogas, biomass, solar energy, energy analysis, conservation and management, and electric power supply and motor control. Energy production through photosynthesis and energy flow in biological systems will also be studied. Prerequisites: MEEN 441 or CHEN 310 and BIOL 221 or equivalents. (F;S;SS)
BIOE 424 - Water Resources Engineering

This course emphasized the analysis and design of water resources systems. Topics include water resources planning and development, hydraulic structures, introduction to aquifer analysis and contamination, well development, pump evaluation and selection, water quality, best management practices, total maximum daily load, water laws, detention and retention pond, wastewater management, and remediation. Prerequisites: CAAE 364. (F;S;SS)

0.000 OR 3.000 Credit hours
3.000 Lecture hours
0.000 Lab hours

Levels: Undergraduate
Schedule Types: Laboratory, Lecture

Civil, Arch & Agri Engineering Department

BIOE 440 - Engineering Properties of Biological Materials

This course covers engineering properties of plant and animal materials. Specific topics include structure and composition of plant and animal materials, elastic and viscoelastic properties, food rheology and thermal properties, aerodynamic and hydrodynamic properties, and electromagnetic properties. Prerequisites: BIOL 101 or equivalent; CAAE 332 or MEEN 336 or equivalent. (F)

0.000 OR 3.000 Credit hours
3.000 Lecture hours
0.000 Lab hours

Levels: Undergraduate
Schedule Types: Laboratory, Lecture

Civil, Arch & Agri Engineering Department

BIOE 442 - Phys Prop Soil Engin Design

This course is a study of fundamental principles or laws which govern the
movement or behavior of water and air in soil. The impact of soil physical properties, structure and texture on drainage and irrigation design is discussed. Some computational methods in soil water flow are presented. Prerequisite: CAAE 364 or equivalent. (F;S;S)

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<thead>
<tr>
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<tbody>
<tr>
<td>3.000 Lecture hours</td>
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<td>0.000 Lab hours</td>
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</table>

**Levels:** Undergraduate  
**Schedule Types:** Laboratory, Lecture

Civl, Arch & Agri Engineering Department

**BIOE 501 - Engineering Design I**

In this course, each student identifies a design project, defines the problem, collects all required resources and databases, and outlines the work plan. This project integrates design concepts from previous courses. Prerequisites: BIOE 330. (F;S)

<table>
<thead>
<tr>
<th>1.000 Credit hours</th>
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<tbody>
<tr>
<td>1.000 Lecture hours</td>
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**Levels:** Undergraduate  
**Schedule Types:** Lecture

Civl, Arch & Agri Engineering Department

**BIOE 502 - Engineering Design II**

In this course students complete the work plan established in BIOE 501. Prerequisites: BIOE 501. (F;S)

<table>
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<tr>
<td>2.000 Lecture hours</td>
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</table>

**Levels:** Undergraduate  
**Schedule Types:** Lecture

Civl, Arch & Agri Engineering Department

**BIOE 522 - Food Engineering**

The general engineering principles of solids, fluids, and process equipment are discussed. Topics include energy, heat, enthalpy, psychometrics, heat and mass transfer, drying and refrigeration of food products. Prerequisites: CHEM 107. (F;S)

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<thead>
<tr>
<th>0.000 OR 3.000 Credit hours</th>
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<tbody>
<tr>
<td>3.000 Lecture hours</td>
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</table>
D.Briassoulis  UNIVERSITIES IN USA AND CANADA OFFERING PROGRAMS OF STUDIES IN BIOSYSTEMS ENGINEERING OR RELATED DISCIPLINES

0.000 Lab hours

**Levels:** Undergraduate  
**Schedule Types:** Laboratory, Lecture

Civl, Arch & Agri Engineering Department

**BIOE 619 - Instrumentation & Measurement**

This course emphasizes quantitative evaluation of well established parameters such as temperature, humidity, fluid flow, pressure, displacement, velocity, acceleration, force, stress, and strain.  
Prerequisites: CAAE 332 or MEEN 336 or equivalent. (F;S)

0.000 OR 3.000 Credit hours  
3.000 Lecture hours  
0.000 Lab hours

**Levels:** Graduate, Undergraduate  
**Schedule Types:** Laboratory, Lecture

Civl, Arch & Agri Engineering Department
The Agricultural and Biosystems Engineering (ABEN) program prepares men and women for careers requiring application of physical, biological, and engineering sciences to solve problems that involve living systems. Agricultural and biosystems engineers provide engineering for the necessities of life.

Agricultural and biosystems engineering integrates engineering topics, engineering design, and biological sciences in a single program with two concentrations; agricultural engineering (AGEN) and biosystems engineering (BSEN).

Courses in the first two years are similar to those required in mechanical, civil, electrical, and industrial engineering. Agricultural and biosystems engineering courses are emphasized in the last two years of the program. Successful completion of 133 semester credits is required for graduation. While there is considerable overlap between the AGEN and the BSEN concentrations, requirements for the BSEN concentration include a heavier concentration on fundamental biological and chemical sciences. The AGEN concentration includes a heavier concentration in the engineering sciences.

Although not required for graduation, a co-operative education internship with industry is highly encouraged. Internships usually include one semester and a summer work experience, but length and timing vary by company. An internship gives you the opportunity to experience engineering prior to graduation. Many companies now look for co-operative work experience when hiring new graduates.

The curriculum is accredited by the Engineering Accreditation Commission of ABET, 111 Market Place, Suite 1050, Baltimore, MD 21202-4012 - telephone: 410-347-7700. ABEN students are well qualified and encouraged to take the national Fundamentals of Engineering (FE) examination during their last semester of college. This is the first step in the process of becoming a registered professional engineer.

Sample Curriculum

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<td>ABEn. 189 - Skills for Academic Success</td>
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<td>Communication</td>
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<td>Comm. 110 - Fund of Public Speaking</td>
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<td>Engl. 110, 120 - College Composition I, II</td>
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<td>English Upper Level Writing Course</td>
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<td>Math. 165 - Calculus I</td>
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<td>Chem. 121, 122 - General Chemistry I, II</td>
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<td>University Physics II, Lab</td>
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**Major Requirements (Both Concentrations)**

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<td>ABEn. 110</td>
<td>Intro to Ag &amp; Biosystems Engineering</td>
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<td>ABEn. 255</td>
<td>Comp Aided Analysis &amp; Design</td>
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<td>ABEn. 263</td>
<td>Biomaterials Processing</td>
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<td>ABEn. 482</td>
<td>Instrument and Measurements</td>
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<td>ABEn. 486, 487</td>
<td>Design Project I, II</td>
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<td>ABEn. 491</td>
<td>Seminar</td>
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<td>ABEn. 496</td>
<td>Ag Technology Expo</td>
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<td>CE 309</td>
<td>Fluid Mechanics</td>
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<td>Engr. 402</td>
<td>Engineering Ethics/Social Responsibility</td>
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<td>IME 440</td>
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<td>Eval of Engineering Data or Stat. 330 - Introductory Statistics</td>
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**Agricultural Engineering Requirements**

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<td>ECE 301</td>
<td>Electrical Engineering I</td>
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<td>ME 212</td>
<td>Fundamental of Visual Communications</td>
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<td>ME 223</td>
<td>Mechanics of Materials</td>
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Biosystems Engineering Requirements

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<td>ABEn. 444 - Transport Processes</td>
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<td>Biol. 150 - General Biology I.</td>
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<td>Chem. 121L, 122L - General Chemistry Lab I or II</td>
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<td>Chem. 240 - Survey of Organic Chemistry</td>
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<td>Computer Electives</td>
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</table>

*May double count with other select general education courses.

This sample curriculum is not intended to serve as a curriculum guide for current students, but rather an example of course offerings for prospective students. For the curriculum requirements in effect at the time of entrance into a program, consult with an academic adviser or with the Office of Registration and Records.
Course Index - ABEN

ABEN 110 - Introduction to Agricultural and Biosystems Engineering - 2 Cr.
Introduction to the agricultural and biosystems engineering profession with emphasis on engineering problem solving.
2 lectures

ABEN 189 - Skills for Academic Success - 1 Cr.

ABEN 255 - Computer-Aided Analysis and Design - 3 Cr.
Application and use of software in engineering analysis and design.
3 lectures

ABEN 263 - Biological Materials Processing - 3 Cr.
Processing equipment design and physical properties of biological materials that influence their harvesting, handling, processing, storage, marketing, and quality evaluation.
2 lectures, 1 three-hour laboratory. Prereq: ABEN 255 or equivalent.

ABEN 358 - Electric Energy Application in Agriculture - 3 Cr.
Electrical distribution/services. Electrical control units, solid state and digital electronics, electromagnetic sensors, and sensing techniques with applications to food, agricultural, and biological systems.
2 lectures, 1 three-hour laboratory. Prereq: PHYS 252.

ABEN 377 - Numerical Modeling in Agriculture and Biosystems Engineering - 3 Cr.
Numerical modeling using finite element and other techniques. Engineering applications include modeling of stress/strain, heat, and mass transfer in physical, natural resource, and biological systems such as grain and food products.
3 lectures. Prereq: MATH 266, ME 223.

ABEN 383 - Structural Design for Biosystems - 3 Cr.
Study of framing systems, building materials, and load requirements. Analysis of structures for biosystems.
3 lectures. Prereq: ME 223.

ABEN 444/644 - Transport Processes - 3 Cr.
Energy and mass transport principles applied to biological and environmental systems. Prereq: MATH 266 and CE 309 or ME 352.

ABEN 452/652 - Bioenvironmental Systems Design - 3 Cr.
Study of Psychrometrics, heat and mass transfer, and physiological requirements for livestock and bioproducts. Design of environmental modification and control systems.
3 lectures. Prereq: CE 309, ME 350.

ABEN 458/658 - Food Process Engineering - 3 Cr.
Analysis and design of food processing equipment and plants. Emphasis is on application of fluid flow, thermodynamics, and heat and mass transfer principles.
3 lectures. Prereq: Junior standing.

ABEN 464/664 - Resource Conservation and Irrigation Engineering - 4 Cr.
Resource principles and design of systems for soil and water resource management and environmental protection.

3 lectures, 1 three-hour laboratory. Prereq: CE 309.

ABEN 473/673 - Agricultural Power - 3 Cr.

Theory, analysis, and testing of internal combustion engines, traction, power trains, hydraulic systems, vehicle dynamics, stability, and ergonomics in tractor design. Electrical power units including motors. Alternative energy systems.

2 lectures, 1 three-hour laboratory. Prereq: ME 350.

ABEN 482/682 - Instrumentation and Measurements - 3 Cr.

Application of instrumentation and sensor concepts to measurement and control of environmental, biological, and mechanical parameters. Includes sensor principles, signal conditioning, data collection, and data analysis methods.

2 lectures, 1 three-hour laboratory. Prereq: ME 223, PHYS 252.

ABEN 486 - Design Project I - 1 Cr.

Capstone learning experience involving principles of design, project management, and evaluation. Student teams define a capstone project in their area of interest.

1 lecture/laboratory. Prereq: Senior standing.

ABEN 487 - Design Project II - 2 Cr.

Continuation and completion of capstone learning experience begun in ABEN 486. Communication in oral, written, and graphic forms is emphasized.

2 lectures/laboratory. Prereq: ABEN 486

ABEN 758 - Electrical and Electronic Applications - 3 Cr.

Sensors and non-destructive principles (e.g., computer vision, spectroscopy, imaging, fiber optic sensing) for bioproduction and processing applications. Data/signal acquisition, signal conditioning/analysis, signal interpretation, and pattern recognition using statistical, neural networks, and fuzzy logic techniques.

3 lectures. Prereq: Graduate standing.

ABEN 763 - Theory of Drying Biological Products - 3 Cr.

Theory used to describe the drying processes of biological products.

3 lectures. Prereq: Graduate standing.

ABEN 765 - Small Watershed Hydrology and Modeling - 3 Cr.

Study and representation of hydrologic processes on small watersheds. Application of hydrologic models for surface flow, subsurface flow, nutrient and sediment transport, and water quality.

Prereq: ABEN 464/664.

ABEN 783 - Advanced Structures and Environmental Systems - 3 Cr.

Detailed analysis of building components and advanced design problems relating to agricultural and environmental systems.

3 lectures, Prereq: ABEN 383.
B16. Undergraduate Biosystems and Agricultural Engineering
(Oklahoma State University)

Biomechanical Option
The Biomechanical option integrates biology into the design of machines and mechanisms that directly interact with biological materials, including soil, plants, and animals. Off-road equipment design, sensor and control systems development, intelligent machine design, precision agriculture, and systems engineering are a few areas that utilize biomechanical engineers.

Learn More About the Biomechanical Option
See the Academic Flowchart for the Biomechanical option

Bioprocessing & Biotechnology Option
The Bioprocessing and Biotechnology option emphasizes the engineering aspects of biochemical processes. Students learn how to utilize ideas from both the life and physical science disciplines and may choose a career path bringing laboratory-scale research involving plant systems, mammalian systems, bioenvironmental systems, or industrial biological processes into commercial production.

Learn More About the Bioprocessing & Biotechnology Option
See the Academic Flowchart for the Bioprocessing & Biotechnology option

Environmental & Natural Resources Option
The Environment and Natural Resources option unites concepts from engineering and biology in the design and analysis of systems that protect and sustain the quantity and quality of water, soil, and other natural resources. Hydrology, storm water management, environmental protection, environmental remediation, water quality, erosion control, water treatment systems, irrigation, and water resources production and development are examples of career pursuits.

Learn More About the Environment & Natural Resources Option
See the Academic Flowchart for the Environment & Natural Resources option

Food Processing Option
The Food Processing option involves the design of processes, products, and equipment used in the production of food, feed, fiber, pharmaceuticals, and other biomaterials. Practical applications can involve all aspects of processing, including packaging, storage, preservation, energy utilization, and environmental protection.

Learn More About the Food Processing Option
See the Academic Flowchart for the Food Processing option
D. Briassoulis  UNIVERSITIES IN USA AND CANADA OFFERING PROGRAMS OF STUDIES IN BIOSYSTEMS ENGINEERING OR RELATED DISCIPLINES

BIOSYSTEMS ENGINEERING
Name:  
Advisor:  

PROFESSIONAL SCHOOL OF BIOSYSTEMS ENGINEERING
(BIOPROCESSING & BIOTECHNOLOGY OPTION)

Oklahoma State University
College of Engineering, Architecture & Technology

PREREQUISITES

MASTERS PROGRAMS

Criteria for admission to the Graduate College to pursue the Master of Science include:

1. receive a B.S. degree from an accredited institution
2. academic performance in undergraduate work at a level that indicates a high probability of success in a graduate program requiring a 3.0/4.0 minimum grade point average.
3. recommended for admission to the Graduate College by a Professional School in the College of Engineering.

For further information, contact the School or the Office of the Dean of Engineering.

A flexible study plan is designed to meet each student’s individual goals.

* A “C” or better is required in each course that is a prerequisite for a major course.
A flowchart showing the curriculum for the Pre-Engineering Food Processing Option at Oklahoma State University, College of Engineering, Architecture & Technology. The chart outlines the required courses and prerequisites for the first and second years of study, with shaded areas indicating common engineering curriculum requirements. The chart also includes notes on admission requirements for the Biosystems Engineering Professional School, such as completion of specific courses and minimum GPA requirements.
BIOSYSTEMS ENGINEERING

PROFESSIONAL SCHOOL OF BIOSYSTEMS ENGINEERING
(Food Processing Option)

Year 3

ENGC 2313

ENG 2252

RAE 2122

BASF 2011

ENGC 2230

MATH 2232

RAE 2021

MATH 2223

CHEM 1455

Biol 1324

ENGC 2143

ENG 2230

RAE 2123

BASF 2413

RAS 5110

MATH 2223

STAT 5915

ENG 2063

CHEM 2465

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Grade Semi

Grade Semi

Grade Semi

Grade Semi

Grade Semi

Grade Semi

Grade Semi

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Grade Semi

Grade Semi

GRADE PROGRAMS

Criteria for admission to the Graduate College to pursue the Master of Science include:

1. receive a B.S. degree from an accredited institution.

2. academic performance in undergraduate work at a level that indicates a high probability of success in a graduate program requiring a 3.0/4.0 minimum grade point average.

3. recommended for admission to the Graduate College by a Professional School in the College of Engineering.

For further information, contact the School or the Office of the Dean of Engineering.

A flexible study plan is designed to meet each student's individual goals.

* A "C" or better is required in each course that is a prerequisite for a major course.

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BIOSYSTEMS ENGINEERING

Preparatory Courses

Year 1
- MATH 115
- PHYS 2014
- ESE 1012
- ENOL 1114
- ENOL 1115
- ENGR 1352

Year 2
- MATH 2144
- PHYS 2114
- ESE 1012
- ENOL 1215
- ENGR 1412
- ENGR 2133

Admission Requirements for the Biocomputing Professional School
- Completion of at least 60 college level semester credit hours (OCH).
- Completion of at least 11 semester hours from OSU.
- Completion of MATH 2144, 2153, and 2160, PHYS 2014 and 2114, CHEM 1414, ENOL 1114, ENGR 2133 plus two additional ENGR courses, ENOL 1113, BAE 2132 and 2133.
- An overall GPA of 2.3 or better at OSU.
- A GPA of 2.5 or better in all above courses plus any additional math or engineering courses taken at OSU (excluding STAT, MATH, PHYS, CHEM, ENOL, ENGR, BAE).

A final grade of "C" or better in each of the above-mentioned courses.

NOTE: This flow chart is for planning purposes only. Students majoring in 2006 must meet the degree requirements as stated in the official degree requirement sheet dated "Academic Year 2005-2007."
D. Briassoulis  UNIVERSITIES IN USA AND CANADA OFFERING PROGRAMS OF STUDIES IN BIOSYSTEMS ENGINEERING OR RELATED DISCIPLINES

BIOSYSTEMS ENGINEERING

Preparatory Courses

MATH 1103
Cell Algebra
Grade: Sem

MATH 1113
Calculus I
Grade: Sem

MATH 2103
Calculus II
Grade: Sem

BACE 1022
Biology II
Grade: Sem

BACE 1022
Biology III
Grade: Sem

MATH 1101
Linear Algebra
Grade: Sem

MATH 2101
Linear Algebra
Grade: Sem

BACE 1012
Biology I
Grade: Sem

BACE 1022
Biology II
Grade: Sem

MATH 1101
Linear Algebra
Grade: Sem

MATH 2101
Linear Algebra
Grade: Sem

Admission Requirements for the Biosystem Engineering Professional School

To be admitted into the Professional School, the student must have met the Professional School requirement. They are:

- Completion of at least 90 college level credit hours (CCH).
- Completion of at least 12 CCH from OSU.
- Completion of at least 12 CCH from OSU.
- Completion of MATH 1104, 2113, and 2133, PHYS 2114 and 2115, CHEM 1411, ENVE 2103, ENVE 3103, plus two additional ENVE courses, ENGL 1113, BAE 2101, BAE 2102.
- An overall GPA of 2.5 or better at OSU.
- A GPA of 2.5 or better in all sophomore courses plus any additional math or engineering courses taken at OSU (excluding STAT, MATH, PHYS, CHEM, ENVE, BAE).
- A final grade of "C" or better in each of the above-mentioned courses.

NOTE: This flow chart is for planning purposes only. Students matriculating in 2000 must meet the degree requirements as stated on the OLA/ENGINEERING DEPARTMENT degree requirement sheet dated "Academic Year 2000-2007."
List of undergraduate and graduate courses

1012 Data Analysis in Biosystems Engineering : Lab 02. Prerequisite: Engineering major. Introduction to application of computer based tools in biosystems engineering. Introduction to the conduct, analysis, and reporting of laboratory experiments. Offered every FALL.

1022 Experimental Methods in Biosystems Engineering : Lab 02. Prerequisite: BAE 1012 or consent of instructor. Introduction to the basics of instrumentation, measurement techniques, and data analysis, with an emphasis on written communication skills. These objectives are achieved through the use of lecture and laboratory exercises, which address measurement principles including accuracy, precision, and error analysis. Offered every SPRING.

2012 Introduction to Engineering in Biological Systems : Lab 0. Prerequisite: BIOL 1114, MATH 2144. Introduction to the engineering aspects of various biological systems. Focus on case studies that emphasize the interface between engineering and biology in plant systems, mammalian systems, bioenvironmental systems, and industrial biological processes. Offered every FALL.

2023 Physical Properties of Biological Materials : Lab 02. Prerequisite: BAE 1022, BIOL 1114, PHYS 2014. Basic engineering fundamentals applied to characterization and determination of physical properties of biological materials including water relations, rheological, thermal, and electromagnetic properties, materials drying concepts, fans, psychometrics, and refrigeration. Offered every SPRING.

3013 Heat and Mass Transfer in Biological Systems : Lab 0. Prerequisite: ENSC 3233. Mechanisms of heat and mass transfer, with specific applications in transport processes of biological systems. Introduction to steady state and transient heat conduction and convection, radiation, diffusion, simultaneous heat and mass transfer, and generation and depletion of heat and mass in biological systems. Offered every FALL.

3023 Instruments and Controls : Lab 02. Prerequisite: MATH 2233, ENSC 2613. Design of control and instrumentation systems including sensor and actuator principles, interface electronics, system identification, modeling, and performance specification. Applications in biological and agricultural systems. Design project is required. Offered every SPRING.

3113 Microbial Technologies in Biosystems Engineering : Lab 0. Prerequisite: BAE 2012, ENSC 2213, 3233; MATH 2233. Introduction to engineering applications of industrial microbiology. Technologies covered include fermentation systems, enzyme kinetics, wastewater treatment, and bioremediation. Offered every SPRING.

3213 Energy and Power in Biosystems Engineering : Lab 02. Prerequisite: BAE 1022, ENSC 2123, 2143, 2213, 2613. Analysis and design of energy generation, transmission, and utilization in the production and processing of biological materials. Offered every SPRING.

3313 Natural Resources Engineering : Lab 03. Prerequisite: BAE 2023, ENSC 3233. Principles and practices of engineering analysis and design applied to hydrology, water quality, erosion and sedimentation, air quality, irrigation, and animal waste management. Offered every FALL.
4001 Professional Practice in Biosystems Engineering  Lab 0. Prerequisite: Concurrent enrollment in BAE 4012. Preparation for professional practice through case studies about ethics, legal liability, safety, and societal issues. Practical professional communications experience. Offered every FALL.

4012 Senior Engineering Design Project (I) : Lab 02. Prerequisite: Completion or concurrent enrollment in BAE 3013,3023, 3113,3213,3313,4001 and ENSC 2143; admission to professional school Team work on professional level design projects, using design procedures to develop specifications, propose alternative solutions, consider external constraints, develop drawings or plans, construct, test, and evaluate designs. Offered every FALL.

4023 Senior Engineering Design Project (II) : Lab 04. Prerequisite: BAE 4012. Second of two-semester sequence of senior design courses. Offered every SPRING.

4224 Machinery for Production and Processing : Lab 0. Prerequisite: BAE 3213. Analysis and design of machines and machine systems for production and processing of biological materials. Soil dynamics with emphasis on traction and soil compaction. Interactions of machines with biological systems. Offered every FALL.

4283 Bioprocess Engineering: Lab 0. Prerequisite: ENSC 3233, BAE 3113, or consent of instructor. Application of fundamental engineering principles to biochemical and biological processes. Introduction to cellular processes, fermentation technology, biological mass transfer and kinetics, bioreactor design and scale-up, and downstream processing. Offered every SPRING.

4313 Hydrology : Lab 0. Prerequisite: BAE 3313, ENSC 3233. Basic principles of surface groundwater hydrology and their application in engineering problems. The hydrologic cycle, weather and hydrology, precipitation, evaporation, transpiration, subsurface waters, stream flow hydrographs, hydrologic and hydraulic stream routing, probability of hydrologic events, application of hydrologic models. Offered every FALL.

4400 Special Problems. 1-4 CREDITS, MAXIMUM 8. Lab 0. Prerequisite: null Investigations in specialized areas of biosystems engineering. Offered every FALL, SPRING and SUMMER.

4413 Food Engineering : Lab 0. Prerequisite: BAE 3013,3413; ENSC 3233,2213. Analysis and design of various unit operations in food processing including thermal processing, drying, evaporation, freezing, processing non-Newtonian fluids, and quality changes during processing. Offered every SPRING.

5000 Thesis and Research.1-6 credits, maximum 6. Lab 0. Prerequisite: null Prerequisite, consent of major professor. Offered every FALL, SPRING and SUMMER.

5030 Engineering Practice: 1-12 credits, maximum 12. Lab 0. Prerequisite: B.S. degree in Biosystems & Agricultural Engineering. The identification, analysis, and synthesis of an authentic problem in agricultural and biosystems engineering. Solution of the problem will involve making engineering decisions tempered by real-time restraints, economic realities, and limited data with due consideration for environmental and social implications. Offered every FALL, SPRING and SUMMER.
5213 Renewable Energy Engineering: Lab 0. Prerequisite: ENSC 2213, ENSC 3233 or consent of instructor. Renewable technologies such as solar, wind, geothermal, hydroelectric, and biomass to generate energy for electricity, heating, transportation, and other uses. Offered every _____

5283 Advanced Bioprocess Engineering: Lab 0. Prerequisite: Consent of Instructor Application of fundamental engineering principles to biochemical and biological processes. Introduction to cellular processes, fermentation technology, biological mass transfer and kinetics, bioreactor design and scale-up, and downstream processing. Same course as CHE 5283. Offered every SPRING

5313 Watershed Modeling and Water Quality: Lab 06. Prerequisite: BAE 4313, or equivalent. A computer modeling course with an emphasis on chemical and physical processes governing nonpoint source pollution (nitrogen, phosphorus, sediment) at the basin scale. The laboratory component utilizes state-of-the-art models applied to a variety of agricultural systems. Students will have the opportunity for "hands on" use of comprehensive hydrologic/water quality models that utilize spatial data in a geographic information system. Specific topics include model/ Offered every _____

5333 Applied Water Resources Statistics: Lab 03. Prerequisite: STAT 5013 or equivalent. Applied statistical methods for hydrologists, engineers, and environmental scientists for analysis of environmental data. Parametric and nonparametric methods and exploratory data analysis applied to observed environmental data sets. Laboratory exercises emphasize hands-on application of statistical problems to reinforce concepts. Offered every _____

5343 Environmental Contaminant Transport: Lab 0. Prerequisite: BAE 4313 Conceptual and mathematical models for the transport of contaminants in natural systems with an emphasis on agricultural pollutants. Basic transport processes relevant to the three environmental media - air, water, and soil. Common features underlying pollutant transport. Offered every _____

5413 Instrumentation in Biological Process Control Systems: Lab 0. Prerequisite: 3023 or equivalent. Analysis of transducers for on-line measurement and control of biological processes. Emphasis on selection of measurement techniques and transducers to sense physical properties of biological materials. Application to agricultural and food processing industries. Offered every SPRING.

5433 Biosensors: Lab 0. Prerequisite: PHYS 2114, CHEM 3053 (or equivalent). Principles and applications of biosensors in food analysis, disease diagnostics, and environmental monitoring. Emphasis on conceptual design and characterization of biosensors. Introduction to recent advances in biodetection using nanotechnology. Offered every _____

5501 Seminar: Lab 0. Prerequisite: null Discussion of current literature with special emphasis on research and experimental techniques. Offered every SPRING and FALL.

6000 Research and Thesis: 1-10 credits, maximum 30. Lab 0. Prerequisite: Approval by student's advisory committee. Independent research and doctoral thesis preparation under the cognizance of a graduate faculty member in the student's field of specialization. Offered every FALL, SPRING and SUMMER.

6100 Teaching Practicum in Biosystems Engineering: 1-3 credits, maximum 3. Lab 02-06. Prerequisite: One semester of doctoral study in Biosystems Engineering, or consent of instructor. Philosophies and techniques of resident and non-resident teaching including experiences in
preparation, presentation, and evaluation of lectures, laboratories, extension or continuing education programs.

Offered every _____

6313 Stochastic Methods in Hydrology: Lab 0. Prerequisite: CIVE 5843, STAT 4053 or equivalent. Stochastic and statistical hydrologic analysis of surface water and ground water systems. Analysis of urban and rural drainage and detention systems. Same as CIVEN 6843. Offered every SPRING.

6333 Fluvial Hydraulics: Lab 0. Prerequisite: BAE 3013 or equivalent. Principles of sediment detachment and transport in fluvial systems. Design of stable channels and flow resistance relationships for sediment-laden flows.

Offered every _____

6343 Groundwater Contaminant Transport: Lab 0. Prerequisite: SOIL 5583 or CIVE 5913 or GEOL 5453. Principles of solute and multiphase transport in soil and ground water. Effects of advection, diffusion, dispersion, degradation, volatilization and adsorption. Relationships between laboratory and field scale transport. Contamination by nonaqueous phase liquids.

Offered every FALL.

6520 Problems in Soil and Water Engineering: 2-6 credits, maximum 6. Lab 0. Prerequisite: Consent of instructor. Problems associated with erosion control, drainage, flood protection, and irrigation.

Offered every FALL, SPRING and SUMMER.

6540 Problems in Power and Machinery: 2-6 credits, maximum 6. Lab 0. Prerequisite: Consent of instructor. Literature review and analytical studies of selected farm power and machinery problems. Written report required.

Offered every FALL, SPRING and SUMMER.

6580 Problems in Transport Processes: 2-6 credits, maximum 6. Lab 0. Prerequisite: Consent of instructor. Literature review and analysis of heat and mass transport and interval diffusion in biological materials. Transport phenomena at interfaces, thermal and cryogenic processing, drying, packed and fluidized bed systems. Thermal and moisture control processing affecting quality of food products. Written report required.

Offered every FALL, SPRING and SUMMER.

6610 Advanced Research and Study: 1-10 credits, maximum 20. Lab 0. Prerequisite: Approval by student's advisory committee. Research and study at the doctoral level on the topic related to the student's doctoral program and field of interest.

Offered every FALL, SPRING and SUMMER.
## B17. Undergraduate Biological & Ecological Engineering (Oregon State University)

### Courses

#### Schedule

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<td>Chaplen – Introduction to Process Engr Design</td>
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<td></td>
<td>BEE 433/533</td>
<td>Cuenca – Irrigation System Design</td>
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<td>Chaplen – Metabolic Engr</td>
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<td>BEE 101</td>
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<td>Bolte – Biosystems Analysis and Modeling</td>
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For Course Descriptions, [click here](#)
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B18. Undergraduate Agricultural Engineering (Purdue University)

Plan of Study
(Students entering Fall 2009 and after)
(Credit Hours Required for Graduation: 131

Freshman Year
First Semester Second Semester
(0.5) AGR 11100 Introduction to Agricultural and Biological Engineering (recommended) 3/4
Science Selective (CHM 11600 (4) for ENRE option; CHM 11600 (4) or CS
15900 (3) for MSE option
4 CHM 11500 General Chemistry 3 COM 11400 Fundamentals of Speech Communications
4 ENGL 10600 English Composition I 2 ENGR 19500 Transforming Ideas to Innovation II
2 ENGR 19500 Transforming Ideas to Innovation I 4 MA 16600 Plane Analytic Geometry and
Calculus II
4 MA 16500 Plane Analytic Geometry and Calculus I 4 PHYS 17200 Modern Mechanics
3 Humanities Elective
17 16/17

Sophomore Year
Third Semester Fourth Semester
3 ABE 20500 Engineering Computations for Biological Systems 3 ABE 21000 Biological
Applications of Material and Energy Balances
1 ABE 29000 Sophomore Seminar 3 NUCL 27300 Mechanics of Materials
4 MA 26100 Multivariate Calculus 4 MA 26200 Linear Algebra and Differential Equations
4 Biological Sciences Elective 3 ME 27400 Basic Mechanics II
3 AGRY 25500 Soil Science 3 ECE 20100 Linear Circuit Analysis I
4 CE 34000 Hydraulics (3cr) AND CE 34300 Elementary Hydraulics Lab (1cr) 3 Economics
Elective**
OR ME 30900 Fluid Mechanics (4 cr) 3 Free Elective
3 Free Elective
18 16

Junior Year
Fifth Semester Sixth Semester
3 ABE 30500 Physical Properties of Biological Materials 3 ABE 33000 Design of Machine
Components
4 ABE 32500 Soil and Water Resource Engineering 4 Biological Sciences Elective
3 AGRY 25500 Soil Science 3 ECE 20100 Linear Circuit Analysis I
4 CE 34000 Hydraulics (3cr) AND CE 34300 Elementary Hydraulics Lab (1cr) 3 Economics
Elective**
OR ME 30900 Fluid Mechanics (4 cr) 3 Free Elective
3 Free Elective
17 16

Senior Year
Seventh Semester Eighth Semester
3 ABE 43500 Hydraulic Control Systems for Mobile Equipment 4 ABE 48500 Agricultural
Engineering Design
3 ABE 45000 Finite Element Method in Design and Optimization 3 Engineering Technical Elective
1 ABE 49000 Professional Practice in Agricultural & Biological Engineering 3 Social Sciences Elective**
3 Engineering Technical Elective 3 Humanities Elective**
3 Agricultural Elective 1/2 Free Elective (2 hours for those taking CS 15900)
3 Written and Oral Communication Elective**
16 14/15

*Eighteen credit hours of general education electives must be chosen in accordance with the general education document (available in the Student Academic Center, ABE 201). Of the 18 credit hours, 3 must be Economics (ECON 25100 or 25200), and 3 must be an additional Communication elective. Six credits within the plan of study must meet College of Agriculture International Understanding requirements.
### AST Undergraduate Courses

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<tr>
<td>AST 202</td>
<td>Construction Technology and Materials</td>
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<td>AST 213</td>
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<td>AST 262</td>
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<td>AST 273</td>
<td>Microcomputer Applications in Agriculture</td>
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<td>AST 298</td>
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<td>AST 303</td>
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<td>Soil and Water Mechanics (CI)</td>
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<td>AST 342</td>
<td>Applied Electricity (CI)</td>
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<td>AST 423</td>
<td>Rural Structures (CI)</td>
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<td>AST 462</td>
<td>Advanced Topics in Natural Resources Technology</td>
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<td>AST 463</td>
<td>Agricultural Waste Management (CI)</td>
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<td>AST 491</td>
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<td>AST 494</td>
<td>Internship</td>
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<td>AST 496</td>
<td>Field Experience</td>
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### DUAL LISTED COURSES

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<td>Hydraulic and Pneumatic Systems and Controls</td>
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<td>AST 422-522</td>
<td>Environmental Control in Structures</td>
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<td>AST 482-582</td>
<td>Advanced Farm Engines</td>
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### Business

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<tr>
<td>AGEC 354</td>
<td>Ag Marketing and Prices</td>
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<td>STAT 281</td>
<td>Introduction to Statistics or equivalent</td>
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<td>ECON 330</td>
<td>Money and Banking</td>
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<tr>
<td>ECON 201</td>
<td>Principles of Microeconomics</td>
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<tr>
<td>BADM 380</td>
<td>Personal Finance</td>
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<tr>
<td>AGEC 271-271L</td>
<td>Farm and Ranch Management and Lab</td>
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<td>BADM 474</td>
<td>Principles of Selling</td>
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<td>BADM 360</td>
<td>Organization and Management</td>
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<td>BADM 334</td>
<td>Small Business Management</td>
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<td>AST 303</td>
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<td>AGEC 470</td>
<td>Ag Policy</td>
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### Environmental

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<td>AST 460</td>
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<td>BIOL 311</td>
<td>Principles of Ecology</td>
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<td>CHEM 380</td>
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<td>PS 243-244</td>
<td>Geology and Lab</td>
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<td>PS 475</td>
<td>Water Quality in Agriculture</td>
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<td>WL 110</td>
<td>Environmental Conservation</td>
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<td>NFSH 341-341L</td>
<td>Food Science and Lab</td>
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<td>AS 241</td>
<td>Meat: Production to Consumption</td>
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<td>AS 341</td>
<td>Fresh Meat Operations</td>
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<td>DS 321-321L</td>
<td>Dairy Product Processing I and Lab</td>
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<td>Dairy Plant Management</td>
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<td>MICR 311-311L</td>
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<td>PS 312</td>
<td>Grain and Seed Production &amp; Processing</td>
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<td>MICR 231-231L</td>
<td>General Microbiology and Lab</td>
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Production
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<tr>
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<td>Ag Production Electives</td>
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<td>Animal Science Electives</td>
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<td>Horticulture Electives</td>
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<tr>
<td></td>
<td>Plant Science Electives</td>
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B20. Undergraduate Bioenvironmental Engineering (Texas A&M University)

B.S. in Biological and Agricultural Engineering

Biological and Agricultural Engineers apply their knowledge of physical and biological sciences, mathematics, engineering principles and engineering design to the production and processing of food and fiber, to the preservation of environmental quality, to biological systems and processes, and to machine systems that interface with all of these. Because of their broad general engineering background, biological and agricultural engineering graduates are sought by a wide variety of employers. Recent employers include environmental consulting firms, equipment manufacturers, crop storage and handling industries, the cotton and forest products industries, food and feed processing industries, concentrated animal production industries, biotechnology companies, electric utility companies, chemical companies, and governmental agencies. Biological and agricultural engineers are making significant contributions to meeting many basic needs of society such as maintaining food quality, quantity and safety; improving environmental quality; and enhancing the quantity and quality of our water resources.

The Biological and Agricultural Engineering Department provides quality education, research and outreach in engineering and technology for the world's agricultural, biological, environmental and food systems. Our undergraduate programs provide a high quality education for engineering and systems management students to fulfill the needs of industries we serve and advance our reputation as a world leader in engineering and systems management education.

The biological and agricultural engineering program develops graduates who can pursue engineering careers in industry, academia, consulting or government. The curriculum is designed:

- to produce graduates to serve the engineering needs of clientele in environmental and natural resources, machine systems, food processing, bioprocessing, and agricultural production and processing;
- to produce graduates who are successfully employed in engineering jobs in industry, government or academia;
- to maintain our national and international reputation for program excellence; and
- to produce graduates who continue to be engaged in professional development.

Students learn to apply fundamental knowledge of biological and physical sciences, mathematics, and engineering principles to formulate and solve engineering problems. Engineering design is integrated throughout the curriculum, along with opportunities to develop communication, learning, and teamwork skills, culminating in a capstone design experience. Electives in the curriculum allow the student to specialize in:

- **Environmental and Natural Resources Engineering:** design and management of systems affecting soil, water, and air resources.

- **Food and Bioprocess Engineering:** design and development of systems for processing and handling of food and agricultural products and processes involving cells, enzymes, or other biological components.

- **Machine Systems Engineering:** design and development of machines and machine systems for food, feed and fiber production and processing.

Students select courses with the assistance of faculty advisors in an individualized advising system. Faculty members also assist with professional development and job...
placement for students.

The biological and agricultural engineering program is jointly administered by the College of Agriculture and Life Sciences and the Dwight Look College of Engineering, and the curriculum is fully accredited by the Engineering Accreditation Commission of the Accreditation Board for Engineering and Technology. The department is one of the largest in North America and is consistently ranked as one of the top two in the nation.

Course Descriptions

Biological and Agricultural Engineering (BAEN)

150. Introduction to Biological and Agricultural Engineering Design. (0-2). Credit 1. I

Introduction to the engineering design process using design problems presented by biological and agricultural engineers from industry; problem definition, information search, idea generation and development of design concepts. Prerequisite: Engineering major or approval of department head.
265. Investigative Techniques for Biological and Agricultural Engineers. (1-6). Credit 3. II
Use of field and laboratory techniques to reinforce fundamental engineering concepts; applications of techniques for data collection and analysis to problems in biological and agricultural engineering; design of experiments and communication of experimental results. Prerequisite: MEEN 221 or registration therein.

Familiarization with engineering design process used in professional environments where BAEN and AGSM graduates are employed; discussion of professional development topics; improvement of technical communication skills. May be taken 4 times for credit.

Selected problems in any phase of agricultural engineering; credit and specific content dependent upon background, interest, ability and needs of student enrolled; individual consultations and reports required. Prerequisites: Freshman or sophomore classification; approval of department head.

289. Special Topics in… Credit 1 to 4.
Selected topics in an identified area of agricultural engineering. May be repeated for credit. Prerequisite: Approval of instructor.

291. Research. Credit 1 to 3.
Research conducted under the direction of faculty member in biological and agricultural engineering. Prerequisites: Freshman or sophomore classification and approval of instructor.

First and second laws of thermodynamics; properties of pure substances; analysis of closed and open systems; applications to steady-flow and non-flow processes; power and refrigeration cycles; psychrometrics. Prerequisites: MEEN 221, MATH 251 or registration therein; junior or senior classification.

Fundamentals of fluid properties; basic conservation principles of momentum, energy and continuity; flow through closed conduits; open channel flow; principles of turbomachines and compressible flow. Prerequisites: MEEN 221; BAEN 320; junior classification.

Relationships between composition, structure and properties of biological materials; definition and measurement of mechanical, physical, thermal and other material properties; variability of properties; application of properties to engineering analysis and design of biological and agricultural processes and systems. Prerequisite: MEEN 222.

365. Unit Operations for Biological and Agricultural Engineering. (2-3). Credit 3. II
Theoretical and practical understanding of basic unit operations required to design processes and equipment in the agricultural, biological, environmental, and food industries, with unique constraints presented by biological and agricultural systems
considered in design of all units. Prerequisites: BAEN 340; CVEN 305 or registration therein; junior or senior classification.

366. Transport Processes in Biological Systems. (3-0). Credit 3. II
Basic principles governing transport of energy and mass; application of these principles to analysis and design of processes involving biological, environmental and agricultural systems. Prerequisites: BAEN 340; BAEN 354; BAEN 365 or registration therein; MATH 308; junior or senior classification.

370. Measurement and Control of Biological Systems and Agricultural Processes. (2-2). Credit 3. II
Theory and application of sensors and techniques in the design of systems for automatic control in biological systems and agricultural production and processing; sensor operation; signal processing; control techniques; automation and robotics. Prerequisite: ECEN 215.

375. Design Fundamentals for Agricultural Machines and Structures. (3-0). Credit 3. I
Applications of stress/strain relationships and failure theory to the design of agricultural machines and structures; structural properties of engineering materials; finite element analysis and computer aided engineering design. Prerequisite: CVEN 305.

Hydraulic power systems; energy and power relationships; hydraulic fluid properties; frictional loses in pipelines; hydraulic pumps, cylinders, valves and motors; servo and proportional valves; circuit design and analysis; conductors, fittings and ancillary devices; maintenance of hydraulic systems; pneumatic components and circuits; electrical controls and fluid logic; electro-hydraulic systems. Prerequisites: BAEN 340 and 375.

Introduction to properties and engineering aspects of materials for use as components of a package and/or packaging system; principles of design and development of packages; evaluation of product-package-environment interaction mechanisms; testing methods; environmental concerns; regulations. Prerequisite: Senior classification or approval of instructor.

458. Environmental Control for Biological Systems. (3-0). Credit 3.
Analysis of physical and biological factors affecting living organisms in controlled environment systems; air quality, gas exchange, water use, radiant energy, energetics of living systems; design of environmental control systems for greenhouses, livestock housing and closed environment life support systems. Prerequisites: BAEN 365; BAEN 366.

460. Principles of Environmental Hydrology. (3-0). Credit 3. I
Hydrologic cycle; precipitation, evaporation, evapotranspiration, infiltration, percolation, runoff, streamflow; groundwater and surface water flow; transport of contaminants in surface water; measurement and analysis of hydrologic data for engineering design. Prerequisites: BAEN 340; senior classification.

464. Irrigation and Drainage Engineering. (2-2). Credit 3. I
Engineering principles and design of both surface and pressurized irrigation systems; introduction to the design of surface and subsurface drainage systems including crop water requirements, soil moisture, irrigation scheduling, surface irrigation, sprinkler irrigation, trickle irrigation, pumps, pipelines, irrigation canals, irrigation wells, and surface and subsurface drainage. Prerequisite: BAEN 340.


Management and treatment of high organic content wastes, with emphasis on agricultural and food processing wastes; engineering design of biological waste treatment processes; regulatory aspects affecting management of agricultural wastes. Prerequisites: BAEN 365; junior or senior classification.

468. Soil and Water Conservation Engineering. (2-2). Credit 3. II

Engineering principles of soil and water conservation; open channel flow principles, hydraulic grade stabilization, erosion control, storm water management, design of structures for floodwater routing, culvert design, design of waterways and agricultural reservoirs, stream bank protection, water quality assessment, groundwater flow, surface water modeling. Prerequisites: BAEN 340; CVEN 305.

469. Water Quality Engineering. (3-0). Credit 3. II

Nonpoint source pollution processes including transport mechanisms and contaminant fate; design of best management practices for abating nonpoint source pollution. Prerequisites: BAEN 340 or equivalent; CVEN 305.

471. Introduction to Biochemical Engineering. (3-0). Credit 3. I, II

Fundamentals of microbial and enzyme processes; application of biochemical reaction kinetics, transport phenomena and chemical reactor design principles to design and analysis of enzyme reactors and fermentation systems. Prerequisite: Senior classification in engineering or approval of instructor. Cross-listed with CHEN 471.

474. Unit Operations in Food Processing. (2-2). Credit 3. I

Design of food process engineering systems; basic concepts of rheology and physical properties of foods; fundamentals of heat and mass transfer and process control. Prerequisites: CHEN 205 and 304, or CVEN 305. Cross-listed with CHEN 474.

477. Air Pollution Engineering. (3-0). Credit 3. I

Design of air pollution abatement equipment and systems to include cyclones, bag filters and scrubbers; air pollution regulations; permitting; dispersion modeling; National Ambient Air Quality Standards. Prerequisite: CVEN 305 or equivalent. Cross-listed with MEEN 477 and SENG 477.

479. Biological and Agricultural Engineering Design I. (1-2). Credit 2. I

Capstone design project selection from problems posed by biological and agricultural engineers in industrial practice; project to be completed in BAEN 480; completion of project feasibility study and outline; design philosophy, teamwork and communication; economics; product liability and reliability; use of standards and codes; goal setting and time management. Prerequisites: BAEN 365 ; BAEN 370 and 375; senior classification.

480. Biological and Agricultural Engineering Design II. (0-6). Credit 3. II
Continuation of engineering design experience through team solution of design problem developed in BAEN 479; preparation of design solution under supervision of biological and agricultural engineering staff and clients; critical evaluation of results by students; staff and industrial consultants. Prerequisites: BAEN 479; senior classification.

481. Seminar. (1-0). Credit 1. II

Review of current literature dealing with agricultural engineering problems presented by staff members and students. Prerequisite: Senior classification.

485. Directed Studies. Credit 1 to 4 each semester. I, II, S

Selected problems in any phase of agricultural engineering. Credit and specific content dependent upon background, interest, ability and needs of student enrolled. Individual consultations and reports required. Prerequisites: Junior or senior classification and approval of department head.

489. Special Topics in… Credit 1 to 4. I, II, S

Special topics in an identified area of agricultural engineering. May be repeated for credit. Prerequisite: Approval of department head.

491. Research. Credit 1 to 3.

Research conducted under the direction of faculty member in biological and agricultural engineering. May be repeated 2 times for credit. Registration in multiple sections of this course are possible within a given semester provided that the per semester credit hour limit is not exceeded. Prerequisites: Junior or senior classification and approval of instructor.
B21. Undergraduate Bio Engineering (Ohio University)

Option: Ecological, Bio-Environmental, Bio-Systems 2009-2010

<table>
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<td>Chem 125 (Chem for Eng) 4</td>
<td>Biology 113 (Energy Trans &amp; Dev) 5</td>
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<td>EnGraph 187 (Proc &amp; Str Eng) 3</td>
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<td>Math 152.OX (Calc &amp; Analytic Geo) 5</td>
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<td>Physics 131 (Particles &amp; Motion) 5</td>
<td>Math 153.OX (Calc &amp; Analytic Geo) 5</td>
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<td>Biology 114 (Form, Fact, Dovt Ecol) 5</td>
<td>Physics 132 (Electricity &amp; Magnetism) 5</td>
<td>Phys 211 (Organic Chem) 3</td>
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<td>FABE 325 (Intro to FABE) 3</td>
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<td>Math 254.OX (Calc &amp; Analytic Geo) 5</td>
<td>FABE 415 (Org. and Engr Math) 4</td>
<td>FABE 373 (Materials of Eng) 3</td>
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<td>ME 410 (Statics) 4</td>
<td>ME 430 (Dynamics) 4</td>
<td>Physics 133 (for Bio Engs) 5</td>
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<td></td>
<td>^Biochem 511 (Intro to BioChem) 5</td>
<td>^Chem 231 or 251 (Organic Chem) 3</td>
<td>or (Ecol Engs take* EEOB 503.01 4</td>
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<tr>
<td></td>
<td>CE 413 (Fluid Mechanics) 4</td>
<td>^Chem 421 or 251 (Organic Chem) 3</td>
<td>Phys 211 (Organic Chem) 3</td>
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<td>FABE 545 (Agr Structures) 4</td>
<td>FABE 425 (Intro to FABE) 4</td>
<td>**EnGraph 410 (Comp Graph) 3</td>
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<td>3</td>
<td>OR FABE 645 (See Spring) 2</td>
<td>FABE 650 (Desig &amp; Manage Sys) 4</td>
<td>FABE 645 (Env Cntrg for Agr Struct) 4</td>
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<td>FABE 724 (Capstone Design II) 2</td>
<td>FABE 725 (Capstone Design II) 2</td>
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**Chem 251 recommended only for students in pre-Health options**

**Substitutes available – see advisor**

+ Students may choose either FABE 645 or FABE 773

* Ecological Engineering students must take EEOB 503.01 (Intro to Ecology)

**Preferred, but EnGraph 410 accepted**

** HOURS REQUIRED **

<table>
<thead>
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<td>General Education</td>
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<td><strong>TOTAL REQUIRED HOURS</strong></td>
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B22. Undergraduate Agricultural and Biological Engineering (The Pennsylvania State University)

Agricultural Engineering

Students pursuing Agricultural Engineering take courses that expose them to the breadth of the discipline, and also provide focus in a specialty area. We guarantee hands-on laboratory experiences in just about every major course! Specific major course topics include:

- environmental influences on biological systems
- modeling of biological and physical systems
- transport phenomena in biosystems
- soil and water conservation engineering
- off-road machines
- fluid power systems
- wood structures
- properties of biological materials
- engineering elements of biochemistry and microbiology
- natural resource conservation and protection
- instrumentation and measurement
- systems optimization

A student pursuing Agricultural Engineering will take courses in the basic sciences, engineering sciences, communications, and liberal arts. Specific course topics include:

- calculus
- physics
- chemistry
- static and dynamic forces
- strength of materials
- fluid mechanics
- thermodynamics
- statistics
- economics
- arts, humanities, and social sciences
- speech communications
- English
- courses of the student's choosing in engineering science and design, agricultural or biological sciences, and other technical electives.

Biological Engineering (B E)

B E 001S Growing Your Future—First-Year Seminar (1) Introduce students to University life, the agricultural/biological/engineering program and profession; prepare them to succeed in academic life at Penn State. Effective: Fall 2008
Prerequisite: first-year status
**B E 097 Special Topics** (1-9) Formal courses given infrequently to explore, in depth, a comparatively narrow subject that may be topical or of special interest. Effective: Fall 2008

**B E 296 Independent Studies** (1-18) Creative projects, including research and design, which are supervised on an individual basis and which fall outside the scope of formal courses. Effective: Fall 2008

**B E 297 Special Topics** (1-9) Formal courses given infrequently to explore, in depth, a comparatively narrow subject which may be topical or of special interest. Effective: Fall 2008

**B E 299 (IL) Foreign Studies** (1-12) Courses offered in foreign countries by individual or group instruction. Effective: Fall 2010 Future: Fall 2010

**B E 300 Biological Systems** (3) Structure, function, and energy transformation of biological systems that affect solutions to engineering problems. Effects of engineering activities on ecosystems. Effective: Fall 2008 Prerequisite: CHEM 110 and PHYS 211

**B E 301 Mathematical Modeling of Biological and Physical Systems** (3) Modeling tools, quantification of processes, linear and non-linear systems of equations, numerical methods, matrix operations, applied to biological and physical systems. Effective: Fall 2008 Prerequisite: or concurrent: MATH 251

**B E 302 Transport Processes for Biological Systems** (3) Engineering applications of the fundamentals of fluid mechanics, heat transfer, and diffusion, to biological systems at scales ranging from microbial to ecological. Effective: Fall 2008 Prerequisite: B E 300, B E 301, M E 300, C E 360 or M E 320

**B E 303 Structural Systems in Agriculture** (2) Engineering analysis and design of structural systems in agriculture; topics: loads, connectors, analysis and design of structural members and systems. Effective: Fall 2008 Ending: Fall 2010 Prerequisite: B E 301, E MCH 213

**B E 303 Structural Systems in Agriculture** (3) Engineering analysis and design of structural systems in agriculture; topics: loads, connectors, analysis and design of structural members and systems. Effective: Spring 2011 Future: Spring 2011 Prerequisite: B E 301, E MCH 213
B E 304 Engineering Properties of Food and Biological Materials (3) Composition, structure, and properties relationships. Measurement of mechanical thermal, chemical and biological properties, their variability, and use in engineering calculations. Effective: Fall 2008 Prerequisite: E MCH 213. Prerequisite or concurrent: B E 300; C E 360 or M E 320; MATH 251

B E 305 Agricultural Measurements and Control Systems (3) Principles of measurements, instruments, controls, and data acquisition systems, with emphasis on agricultural applications. Effective: Fall 2008 Prerequisite: PHYS 212

B E 306 Engineering Principles of Agricultural Machines (2) Application of engines, motors, and power transmission systems to agricultural production and processing machinery. Functional design and analysis of equipment. Effective: Spring 2010 Ending: Fall 2010 Prerequisite: B E 301, E MCH 212, E MCH 213

B E 306 Machines for Agricultural and Biological Processing (3) Application of machine systems to agricultural production and biological processing machinery. Functional design and analysis of equipment. Effective: Spring 2011 Future: Spring 2011 Prerequisite: B E 301, E MCH 212, E MCH 213

B E 307 Principles of Soil and Water Engineering (2) Utilization and engineering of soil-water resources; including rainfall-runoff, soil-water movement, erosion/sediment transport and flow processes. Effective: Fall 2008 Ending: Fall 2010 Prerequisite: C E 360 or M E 320

B E 307 Principles of Soil and Water Engineering (3) Utilization and engineering of soil-water resources; including rainfall-runoff, soil-water movement, erosion/sediment transport and flow processes. Effective: Spring 2011 Future: Spring 2011 Prerequisite: C E 360 or M E 320

B E 308 Engineering Elements of Biochemistry and Microbiology (3) Introduction to basic biochemistry and microbiology as well as industrial and environmental applications. Effective: Fall 2008 Prerequisite: CHEM 110

B E 391 (GWS) (A S M 391) Contextual Integration of Communication Skills for the Technical Workplace (2) To develop corporate communication skills in technically focused students in a contextual manner. Effective: Fall 2008 Prerequisite: Junior level standing in B E or A S M
**B E 392** (GWS) (A S M 392) *Contextual Integration of Leadership Skills for the Technical Workplace* (2) To develop corporate leadership skills in technically focused students in a contextual manner.
Effective: Fall 2008
Prerequisite: B E 391 junior level standing in B E or A S M

**B E 399** (IL) *Foreign Studies* (1-12) Courses offered in foreign countries by individual or group instruction.
Effective: Fall 2010 Future: Fall 2010

**B E 461** *Design of Fluid Power Systems* (3) Hydraulic systems, hydrostatic transmissions, electro-hydraulic systems in application to agricultural production and processing systems.
Effective: Fall 2008
Prerequisite: B E 306 or M E 360; C E 360 or M E 320

**B E 462** *Design of Wood Structures* (3) Structural properties of wood; design of wood structural elements; design of wood structural systems; design of post-frame buildings.
Effective: Fall 2008
Prerequisite: B E 303, A E 308 or C E 340

**B E 465** *Food and Biological Process Engineering* (3) Reactor design, kinetics, fluid flow, thermal processes, and other topics applied to the design of systems for the food and biological process industry.
Effective: Fall 2008
Prerequisite: B E 302

**B E 466W** *Biological Engineering Design* (3) This course focuses on a industry sponsored design project offered in conjunction with the College of Engineering Learning Factory.
Effective: Summer 2010
Prerequisite: B E 391; senior level standing in B E

**B E 467** *Design of Stormwater and Erosion Control Facilities* (3) Design of best management practices for stormwater management, erosion and sediment control as applied to the agriculture-urban interface.
Effective: Fall 2008
Prerequisite: B E 307 or C E 361

**B E 468** *Microbiological Engineering* (3) Application of basic engineering principles and designs in biochemical and biological processes.
Effective: Fall 2008
Prerequisite: B E 308 or B M B 211 and MICRB 201; PHYS 211 or PHYS 250

**B E 469W** *Optimization of Biological Production and Processing Systems* (3) Engineering and biological principles combined with economics and mathematical techniques to evaluate and optimize biological production and processing systems.
Effective: Fall 2008  
Prerequisite: B.E. 302 and one B.E. 460 level course

**B.E. 475 Food Engineering Equipment Design** (3) Engineering analysis and operation of pilot-plant equipment, i.e., spray, freeze and deep bed dryers, evaporators, freezing tunnels, distillation columns.  
Effective: Fall 2008  
Prerequisite: B.E. 465

**B.E. 477 Land-Based Waste Disposal** (3) Analysis, design, and management of land-based systems for recycling and disposal of municipal, industrial, and agricultural wastes.  
Effective: Fall 2008  
Prerequisite: B.E. 307 or C.E. 370 or A.S.M. 327

**B.E. 487 Watershed Modeling for Water Quality Design** (3) Application of common watershed models used to investigate design alternatives for flow and quality effects.  
Effective: Summer 2010  
Prerequisite: B.E. 307 or C.E. 361

**B.E. 490W Agricultural and Biological Engineering Colloquium** (1) Identification and analysis of the opportunities for professional development in the agricultural and biological engineering profession.  
Effective: Fall 2008  
Prerequisite: sixth-semester or higher standing in Agricultural and Biological Engineering

**B.E. 494 Senior Thesis** (1-9) Students must have approval of a thesis adviser before scheduling this course.  
Effective: Fall 2008

**B.E. 494H Senior Honors Thesis** (1-6) Senior honors thesis.  
Effective: Fall 2008  
Prerequisite: junior or senior status in the University Scholar's program

**B.E. 495 Agricultural Engineering Internship** (1-6) Independent study and supervised cooperative education experience related to the student's career objective.  
Effective: Fall 2008

**B.E. 496 Independent Studies** (1-18) Creative projects, including research and design, which are supervised on an individual basis and which fall outside the scope of formal courses.  
Effective: Fall 2008

**B.E. 497 Special Topics** (1-9) Formal courses given infrequently to explore, in depth, a comparatively narrow subject which may be topical or of special interest.
Effective: Fall 2008

**B E 497A Biological Engineering Design Project** (3) Engineering design groups with industry representative to conceptualize, design, build and demonstrate a solution to a posed problem.
Effective: Fall 2010 Ending: Fall 2010 Future: Fall 2010

**B E 497B Biomass Energy Systems** (3) Discuss fundamental theories, applied technologies used in production and conservation of biomass into fuels, power, heat and other valued products.
Effective: Fall 2010 Ending: Fall 2010 Future: Fall 2010

**B E 499 (IL) Foreign Studies** (1-12) Courses offered in foreign countries by individual or group instruction.
Effective: Fall 2010 Future: Fall 2010

**Biological Engineering**

Students take courses that provide a solid engineering foundation, with applications to biological systems. We guarantee hands-on laboratory experiences in just about every major course! Specific major course topics include:

- environmental influences on biological systems
- modeling of biological and physical systems
- transport phenomena in biosystems
- properties of biological materials
- engineering elements of biochemistry and microbiology
- food engineering
- microbiological engineering
- instrumentation and measurement
- systems optimization

Students will take courses in the basic sciences, engineering sciences, communications, and liberal arts. Specific course topics include:

- calculus
- physics
- chemistry
- biomolecular biology
- organic chemistry
- engineering mechanics: static forces, dynamic forces, strength of materials
- fluid mechanics
- thermodynamics
- plant and animal biotechnology
• statistics
• economics
• arts, humanities, and social sciences
• speech communications
• English
• courses of the student's choosing in engineering science and design, biological sciences, and other technical electives.

Course Descriptions in

Biological Engineering

B E 300 BIOLOGICAL SYSTEMS (3) Structural, function and energy transformations of biological systems that affect solutions to engineering problems. Effects of engineering activities on ecosystems. Prerequisite: PHYS 211 and CHEM 110. Offered each Fall Semester.

B E 301 MATHEMATICAL MODELING OF BIOLOGICAL AND PHYSICAL SYSTEMS (3) Modeling tools, quantification of processes, linear and non-linear systems of equations, numerical methods, matrix operations, applied to bio-physical systems. Prerequisite or concurrent: MATH 251. Offered each Fall Semester.

B E 302 TRANSPORT PROCESSES FOR BIOLOGICAL PRODUCTION AND PROCESSING (3) Engineering applications of the fundamentals of fluid mechanics, heat transfer, and diffusion, to biological systems at scales ranging from microbial to ecological. Prerequisite: B E 301, M E 201 or 300, C E 360 or M E 320. Offered each Spring Semester.

B E 303 STRUCTURAL SYSTEMS IN AGRICULTURE (2) Engineering analysis and design of structural systems in agriculture. Topics: reliability, loads, components and system design. Prerequisites: E MCH 213; B E 301. Offered each Spring Semester.

B E 304 ENGINEERING PROPERTIES OF FOOD AND BIOLOGICAL MATERIALS (3) Composition, structure, and properties relationships. Measurement of mechanical, thermal, chemical, and biological properties, their variability, and use in engineering calculations. Prerequisite or concurrent: MATH 251,

C E 360 or M E 320, B E 300. Prerequisite: E MCH 213. Offered each Fall Semester.

B E 305 AGRICULTURAL MEASUREMENTS AND CONTROL SYSTEMS (3) Principles of measurements, instruments, controls, and data acquisition systems, with emphasis on agricultural applications. Prerequisite: PHYS 212. Offered each Spring Semester.

B E 306 ENGINEERING PRINCIPLES OF AGRICULTURAL MACHINES (2) Application of engines, motors, and power transmission systems to agricultural production and processing machinery. Functional design and analysis of equipment. Prerequisite: B E 301, E MCH 212. Offered each Spring Semester.

B E 307 PRINCIPLES OF SOIL AND WATER ENGINEERING (2) Utilization and engineering of soil-water resources; including rainfall-runoff, soil-water movement, erosion/sediment transport and flow processes. Prerequisite: C E 360 or M E 320. Offered each Spring Semester.
B E 308  ENGINEERING ELEMENTS BIOCHEMISTRY AND MICROBIOLOGY (3)  
Introduction of basic biochemistry and microbiology as well as industrial and environmental applications. Prerequisite: CHEM 110. Offered each Fall Semester.

B E 391  CONTEXTUAL INTEGRATION OF COMMUNICATION SKILLS FOR THE TECHNICAL WORKPLACE (2)  
To develop corporate communication skills in technically focused students in a contextual manner. Prerequisite: Junior level standing in B E or ASM. Offered each Spring Semester.

B E 392  CONTEXTUAL INTEGRATION OF LEADERSHIP SKILLS FOR THE TECHNICAL WORKPLACE (2)  
To develop corporate leadership skills in technically focused students in a contextual manner. Prerequisites: B E 391, Junior level standing in B E or ASM. Offered each Fall Semester.

B E 461  DESIGN OF FLUID POWER SYSTEMS (3)  
Hydraulic power systems, hydrostatic transmission, and electro-hydraulic control systems with applications in agricultural production and processing systems; integrated design projects. Prerequisite: B E 306 or M E 360; C E 360 or M E 320. Offered each Fall Semester.

B E 462  DESIGN OF WOOD STRUCTURES (3)  
Structural properties of wood; design of wood structural elements; design of wood systems; design of post-frame buildings. Prerequisites: A E 308; or B E 303; or C E 340. Offered each Spring Semester.

B E 465  FOOD AND BIOLOGICAL PROCESS ENGINEERING (3)  
Reactor design, kinetics, fluid flow, thermal processes, and other topics applied to the design of systems for the food and biological process industry. Prerequisite: B E 302. Offered each Fall Semester.

B E 467  DESIGN OF STORMWATER AND EROSION CONTROL FACILITIES (3)  
Design of best management practices for stormwater management, erosion and sediment control as applied to the agriculture-urban interface. Prerequisite: B E 307 or C E 361. Offered each Fall Semester.

B E 468  MICROBIOLOGICAL ENGINEERING (3)  
Application of basic engineering principles and designs in biochemical and biological processes. Prerequisites: PHYS 211 or 250; B E 308 or MICRB 201 and BMB 211. Offered each Spring Semester.

B E 469W  OPTIMIZATION OF BIOLOGICAL PRODUCTION AND PROCESSING SYSTEMS (3)  
Engineering and biological principles combined with economics and mathematical techniques to evaluate and optimize biological production and processing systems. Prerequisites: B E 302 and one B E 46X course. Offered each Spring Semester.

B E 477 LAND-BASED WASTE DISPOSAL (3)  
Analysis, design, and management of land-based systems for recycling and disposal of municipal, industrial, and agricultural wastes. Prerequisites: B E 307 or C E 370 or ASM 327.

B E 495  BIOLOGICAL ENGINEERING INTERNSHIP (1-6)  
Independent study and supervised cooperative education experience related to the student's career objective.

B E 496  INDEPENDENT STUDIES (1-18)

B E 497  SPECIAL TOPICS (1-9)
B23. Undergraduate Bioenvironmental Engineering (State University of New Jersey)

Bioenvironmental Engineering Course Descriptions


11:117:413. UNIT PROCESSES IN BIOENVIRONMENTAL ENGINEERING I (3) Prerequisites: 01:640:244, 11:375:202, 11:375:203, and 14:180:387 Physical and chemical processes and operations commonly applied for water and wastewater treatment, including coagulation, flocculation, sedimentation, filtration, adsorption, ion exchange, membrane separation, precipitation, oxidation, and disinfection; principles of chemical reaction kinetics, modeling of ideal and non-ideal batch and flow-through reactors.

11:117:414. UNIT PROCESSES IN BIOENVIRONMENTAL ENGINEERING II (3) Prerequisites: 11:117:413 or permission of instructor. Biological principles and operations for wastewater treatment, bioremediation and energy production including: microbial ecology; energetics, stoichiometry and kinetics of microbial growth; kinetics of pollutant degradation; modeling ideal bioreactors; design criteria for specific wastewater treatment processes; and new developments in use of microorganisms in bioenvironmental engineering.


11:117:424. BIOENVIRONMENTAL ENGINEERING UNIT PROCESSES LAB II (1) Prerequisite: 01:160:171 or equivalent. Corequisite: 11:117:414 Demonstration and investigation of biological processes used in the treatment of wastewater, including: natural biological processes in biotreatment ponds; biodegradability and biodegradation kinetics; activated sludge reactors; anaerobic digestion for bioenergy production; use of laboratory methods and analytical equipment to assess biological processes; and introduction to activated sludge simulation software.

11:117:462. DESIGN OF SOLID WASTE TREATMENT SYSTEMS (3) Prerequisite: Open only to junior and senior engineering students. Analysis and design of integrated solid waste management systems, including waste minimization, quantity estimates, waste characteristics, collection, composting, materials recovery, recycling, incineration, and landfilling.

11:117:468. HAZARDOUS WASTE TREATMENT ENGINEERING (3) Prerequisites: 11:117:413 or permission of instructor. Engineering and process design aspects of hazardous waste management and remediation of hazardous waste sites, waste reduction and recovery, regulatory process, case studies and engineering solutions to model hazardous waste problems.

11:117:488. BIORESOURCE ENGINEERING DESIGN I (2) Open only to seniors in bioresource engineering. Design morphology. Case studies and special design problems. Solutions developed using creative design processes that include analysis, synthesis, and iterative decision making. Safety and professional ethics.


11:117:497, 498. SPECIAL PROBLEMS IN BIORESOURCE ENGINEERING (BA, BA.) Prerequisite: Permission of department. Studies of special interest in some selected area of bioresource engineering.
B24. Undergraduate Agricultural & Biosystems Engineering (University of Arizona)

The Department of Agricultural and Biosystems Engineering offers a Bachelor of Science in Biosystems Engineering under the auspices of the College of Engineering and a Bachelor of Science in Agricultural Systems Management under the auspices of the College of Agriculture and Life Sciences.

ABET accredited Biosystems engineers use engineering, math, and biology to design systems to manage soil and water resources and to design and develop biological and biomedical products. They work on projects involving wise use of energy, materials, biochemicals, and recyclable wastes. They combine technical knowledge, computer techniques, and control systems for a deeper understanding of agriculture and biology -- knowledge which someday may be used to design life support systems for colonies on other planets. Students may specialize in water resource engineering or biological engineering.
**Curriculum Schedule**

Bachelor of Science in Biosystems Engineering (ABET Accredited)

2008-2009

Biosystems engineers integrate mathematics, the biological, physical and engineering sciences with engineering design principles for producing and processing biological and agricultural products. These principles are applied to the design, analysis and construction of equipment, systems, and facilities for the efficient utilization of food, fiber and biochemical products. All programs utilize the latest in computer applications, sensor control systems, and biotechnology developments in their design objectives.

Required Curriculum:

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<th></th>
<th>First Semester</th>
<th>Freshman Year (2008-2009)</th>
<th>Second Semester</th>
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<tr>
<td>Course</td>
<td>Units</td>
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<td>Units</td>
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<tr>
<td>ENGR 102 (Intro to engineering)</td>
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<td>MATH 125 (Calculus with applications I)</td>
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<td>MATH 121 (Calculus with applications I)</td>
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<td>CHEM 152 (General Chemistry II)</td>
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<td>CHEM 151 (General Chemistry I)</td>
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<td>PHYS 141 (Introductory mechanics)</td>
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<td>ENGL 101 (First Year Composition I)</td>
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<td>ENGL 102 (First Year Composition II)</td>
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<td>INDV/TRAQ*</td>
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**Sophomore Year (2009-2010)**

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<td>ABE 296a (Seminar in BE)</td>
<td>ABE 205 (Biosys Engr. Anah Skills Workshop)</td>
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<tr>
<td>CE 114 (Statics)</td>
<td>AME 250 (Dynamics)</td>
<td>3</td>
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<tr>
<td>MATH 223 (Vector calculus)</td>
<td>MATH 254 (Ordinary Differential Eqns)</td>
<td>3</td>
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<tr>
<td>ABE 284 (Biosystems Transport Phen)</td>
<td>PHYS 241 (Intro, electricity and magnetism)</td>
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<tr>
<td>MCB 331 &amp; MCB 332</td>
<td>MCB 216 or MCB 205A &amp; MCB 206</td>
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**Junior Year (2010-2011)**

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<td>ABE 320 (Computer aided design)</td>
<td>ABE 423 (Dynamics of biological systems)</td>
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<tr>
<td>ABE 447 (Sensor and controls)</td>
<td>ABE 484 (Advanced biosystems transport)</td>
<td>3</td>
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<tr>
<td>CE 212 or ABE 331 (Hydr. or Fl. mech.)</td>
<td>ABE Elective**</td>
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<tr>
<td>CE 115 or ABE 324 (Mech of materials)</td>
<td>ENGL 308 (Technical writing)</td>
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<td>SE 305 (Engin. Probability and Statistics)</td>
<td>ABE 393 (Internship)</td>
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<td>ENGR 211P (Engineering economics)</td>
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**Senior Year (2011-2012)**

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<tr>
<td>ABE 495a (Seminar in Engr. Careers &amp; Prof.)</td>
<td>ABE 495b (Biosystems Engineering Design I)</td>
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<tr>
<td>ABE 498a (Biosystems Engineering Design I)</td>
<td>ABE Elective**</td>
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<td>INDV/TRAQ*</td>
<td>INDV/TRAQ</td>
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<td>INDV/TRAQ*</td>
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* INDV/TRAQ course must meet University general education requirements. One course must be taken in the university as focusing on non-western culture, race, gender, or ethnicity. Tier 1 & 2 in Soc. & Sec., Tra. & Cul., and GRE. course requirements are detailed on page 10.
** ABE Elective must contain elements of engineering design. See the following pages for a list of suitable courses.
***Individual electives depend upon area of emphasis and advisor's approval. Suggested technical electives are listed on following pages.
### Curriculum Schedule – Pre-Med Track

**Bachelor of Science in Biosystems Engineering (ABET Accredited) 2008-2009**

This track, in addition to satisfying ABET requirements for engineering accreditation, satisfies the standard requirements for entry into the pre-health field (medical or dental school). The major deviation from the standard curriculum is inclusion of organic chemistry (8 units including laboratories) as technical elective units.

#### Required Curriculum:

<table>
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<tr>
<th>Course</th>
<th>First Semester</th>
<th>Second Semester</th>
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<tr>
<td>ENGR 102 (Intro to engineering)</td>
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<tr>
<td>MATH 125 (Calculus with applications)</td>
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<tr>
<td>CHEM 151 (General Chemistry I)</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>PHYS 181 (Introductions mechanics)</td>
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<td>4</td>
</tr>
<tr>
<td>ENGL 101 (First Year Composition I)</td>
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<td>3</td>
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<td>INDIV/TRAD*</td>
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<td><strong>Total</strong></td>
<td><strong>16</strong></td>
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<th>Course</th>
<th>Freshman Year (2008-2009)</th>
<th>Second Semester</th>
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<tr>
<td>ABE 295a (Seminar in Bi)</td>
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<td>CE 214 (Statics)</td>
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<td>MATH 123 (Vector calculus)</td>
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<td>ABE 204 (Biosystems Transport Phen)</td>
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<td>MCI 313/318L or PLS 130</td>
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<td><strong>Total</strong></td>
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#### Sophomore Year (2009-2010)

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<thead>
<tr>
<th>Course</th>
<th>Freshman Year (2008-2009)</th>
<th>Second Semester</th>
</tr>
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<tbody>
<tr>
<td>ABE 201 (BioSys Engin. Anat. Skills Workshop)</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>AME 250 (Dynamics)</td>
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<tr>
<td>MATH 254 (Ordinary Differential Eqns)</td>
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<tr>
<td>PHYS 241 (Intro, electricity and magnetism)</td>
<td>4</td>
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<tr>
<td>MCI 181 or MCI256AB/L or 950 201</td>
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<tr>
<td><strong>Total</strong></td>
<td><strong>15</strong></td>
<td><strong>17</strong></td>
</tr>
</tbody>
</table>

#### Junior Year (2010-2011)

<table>
<thead>
<tr>
<th>Course</th>
<th>Freshman Year (2008-2009)</th>
<th>Second Semester</th>
</tr>
</thead>
<tbody>
<tr>
<td>ABE 320 (Computer aided design)</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>CE 210 or AME 333A (Hyd. or Fu. mech.)</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>CHEM 341 (Mechanics of Materials)</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>SIE 305 (Engin. Probability and Statistics)</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>CHEM 243b (Organic Chemistry)</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>CHEM 243a (Organic Chemistry Lab)</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>15</strong></td>
<td><strong>16</strong></td>
</tr>
</tbody>
</table>

**Note – MCIT normally taken this semester.**

#### Senior Year (2011-2012)

<table>
<thead>
<tr>
<th>Course</th>
<th>Freshman Year (2008-2009)</th>
<th>Second Semester</th>
</tr>
</thead>
<tbody>
<tr>
<td>ABE 496a [Seminar in Expr. Careers &amp; Prof.]</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>ABE 489b (Biosystems Engineering Design 2)</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>ABE 447 (Sensors and controls)</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>ABE Elective**</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>INDIV/TRAD*</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>15</strong></td>
<td><strong>15</strong></td>
</tr>
</tbody>
</table>

* INDIV/TRAD courses must meet university general education requirements. One course must be recognized by the university as focusing on non-western culture, race, gender, or ethnicity. 
**ABE Electives must contain elements of engineering design. See the following pages for a list of suitable courses. 
***Technical electives depend upon area of emphasis and advisor’s approval. Suggested technical electives are listed on following pages.
Classes that satisfy ABE Design Electives

This list will evolve. Check with your advisor.

- ABE / BMIE / CHEE 481A – Engineering of Biological Processes  
  Fall 2008
- ABE / CHEE 481B – Cellular and Tissue Engineering  
  Spring 2009
- ABE / AME 481b, h, i – Micro / nano technology courses  
  Spring 2010
- ABE / CHEE 482 - Simulation of Biological Systems  
  Summer 2008
- ABE AME 488 - Micro and Nano Transducer Physics and Design  
  Spring 2010
- ABE / PLS 483 – Controlled Environment Systems  
  Fall 2008
- ABE / MSE 486 – Cell / Tissue Interactions with Biomaterials  
  Spring 2009
- ABE 426 - Soil and Water Conservation Engineering  
  Fall 2008
- ABE 455 - Soil and Water Resources Engineering  
  Fall 2008
- ABE 456 - Irrigation Systems Design  
  Fall 2008
- ABE 458 - Agricultural Drainage and Effluent Treatment  
  Spring 2009
- ABE 459 - Design of Onsite Wastewater Treatment and Disposal Systems  
  Fall 2008
- ABE / WKM 451 - Advanced Watershed Hydrology  
  Fall 2008

Technical Electives

Below is a list of suitable technical electives. Check with your advisor before taking any electives to make sure these courses meet your academic objectives.

- ABE / PLS 475A - Physiology of Plant Production under Controlled Environment  
  Spring 2009
- ABE 457C - Greenhouse Pest Management: Methods and Practice  
  Spring 2009
- CHEM 241a/243a Organic Chemistry 1
- CHEM 241b/243b Organic Chemistry 2
- BIOG 441 - General Protein and Gen Metabolic Biochemistry  
  Spring 2009
- BIOG 441a General Nucleic Acid Biochemistry  
  Spring 2009
- BIOG 471A - Applied Molecular Genetics  
  Spring 2009
- BIOG 473 - Recombinant DNA Methods and Applications  
  Spring 2009
- BME 510 - Biotechnology: Methods and Practice  
  Fall 2008
- BME 511 - Physiol. For Biomed. Engin.  
  Spring 2009
- BME 516 - Principles of Biomedical Engineering  
  Fall 2008
- BME 517 Data Analysis Biomed. Engin.  
  Spring 2009
- MSE 451 - Biol. & Synthetic Materials  
  Spring 2009
- ABE 481 - Material Selection  
  Spring 2009
- ABE 485 - Renewable Energy Systems  
  Spring 2009
- ABE 486 - Biomechanical Engineering  
  Spring 2009
- ABE 488 - Biomedical Engineering  
  Fall 2008
- ABE 489 - Microbiologic Techniques  
  Spring 2009
- ABE 490 - Microbiological Techniques  
  Fall 2008
- SWES 200 Soils  
  Fall 2008
- SWES 440 Biodegradation of pollutants in soil  
  Spring 2009
- CHEE 379 Water Sup. & Wastewater  
  Fall 2008
- CHEE 370 Water & Wastewater Treat.  
  Spring 2009
- HWR 401 Subsurface Hydrology  
  Spring 2009
- SWES 470 Soil Physics  
  Fall 2008
- SWES 488 Remote Sensing Applications  
  Fall 2008
- SWES 330 Intro to Remote Sensing  
  Fall 2008
  Fall 2008
- CE 352 - Water Resources Engineering  
  Fall 2008
- CE 352 - Hydraulic Engineering and Design  
  Fall 2008
- CE 416 - Introduction to Hazardous Waste Management  
  Fall 2008
- CE 465 - Fundamentals of Industrial and Environmental Health  
  Fall 2008
- PLS 456 - Crop Science and Production  
  Fall 2008
- PLS 312 - Plant Genetics  
  Fall 2008
- PLS 340 Intro. to Biotechnology  
  Fall 2008
Undergraduate Biological Engineering (University of Arkansas)

Areas of Concentration

The three areas of concentration in biological engineering are as follows:

Biomedical Engineering – nanomedicine, tissue engineering, organ regeneration and its clinical application, bioinstrumentation, biosensing/medical imaging, medical electronics, physiological modeling, biomechanics, and rehabilitation engineering. This area is excellent preparation for medical, veterinary or dental school as well as for graduate programs in biomedical engineering.

Biotechnology Engineering – biotechnology at the micro- and nanoscale, food processing, food safety and security, developing new products from biomaterials, and biotransformation to synthesize industrial and pharmaceutical products.

Ecological Engineering – integrates ecological principles into the design of sustainable systems to treat, remediate, and prevent pollution to the environment. Applications include stream restoration, atershed management, water and wastewater treatment design, ecological services management, urban greenway design and enclosed ecosystem design. Each student is required to complete 18 semester hours of approved electives in his or her area of concentration. Six hours must be from the biological engineering design elective courses (listed below) from a single area of concentration. The remaining 12 hours are classified as technical electives and consist mainly of upper-division courses in engineering, mathematics, and the sciences as approved by the student’s adviser. The selected technical electives must include at least six hours of upper-level engineering courses, either within BENG or from other engineering departments. The department maintains a list of approved electives. The areas of technical concentration and the recommended elective courses for each are listed here.

Curriculum

<table>
<thead>
<tr>
<th>Biological Engineering Program</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Freshman Year</strong></td>
</tr>
<tr>
<td>First Semester</td>
</tr>
<tr>
<td>1 GNEG 1111 Introduction to Engineering I</td>
</tr>
<tr>
<td>3 ENGL 1013 Composition I</td>
</tr>
<tr>
<td>3 CHEM 1103 University Chemistry I</td>
</tr>
<tr>
<td>4 MATH 2554 Calculus I</td>
</tr>
<tr>
<td>4 PHYS 2054 University Physics I</td>
</tr>
<tr>
<td><strong>15 Semester hours</strong></td>
</tr>
<tr>
<td></td>
</tr>
</tbody>
</table>

| Sophomore Year                 |
| First Semester                 | Second Semester               |
|                                |                               |

Note: The curriculum includes a mix of foundational and specialized courses, with a particular focus on developing skills and knowledge in areas relevant to biomedical, biotechnology, and ecological engineering. Elective courses are chosen to complement the student’s core areas of concentration, ensuring a well-rounded education in the field of biological engineering.
<table>
<thead>
<tr>
<th>Junior Year</th>
<th>Senior Year</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>First Semester</strong></td>
<td><strong>Second Semester</strong></td>
</tr>
<tr>
<td>2 BENG 2612 Biological Engr Design Studio II</td>
<td>2 BENG 2622 Biological Engineering Design Studio III</td>
</tr>
<tr>
<td>4 Sophomore Science Elective**</td>
<td>4 MATH 3404 Differential Equations</td>
</tr>
<tr>
<td>4 MATH 2574 Calculus III</td>
<td>3 CHEM 3613 Organic Chemistry II</td>
</tr>
<tr>
<td>3 CHEM 3603 Organic Chemistry I</td>
<td>1 CHEM 3611L Organic Chemistry II Lab</td>
</tr>
<tr>
<td>1 CHEM 3601L Organic Chemistry I Lab</td>
<td>3 MEEG 2003 Statics</td>
</tr>
<tr>
<td>2 GNEG 1122 Introduction to CAD</td>
<td>3 BIOL 2013 General Microbiology</td>
</tr>
<tr>
<td><strong>16 Semester hours</strong></td>
<td>1 BIOL 2011L General Microbiology Lab</td>
</tr>
<tr>
<td><strong>Second Semester</strong></td>
<td><strong>Senior Year</strong></td>
</tr>
<tr>
<td>2 BENG 3712 Engineering Properties of Biological Materials</td>
<td><strong>First Semester</strong></td>
</tr>
<tr>
<td>3 CHEM 3813 Introduction to Biochemistry</td>
<td>3 BENG 4813 Senior Biological Engr Design I</td>
</tr>
<tr>
<td>3 MEEG 2403 Thermodynamics, or CHEG 2313 Thermodynamics of Single Component Systems</td>
<td>3 BENG 3733 Transport Phenomena in Biological Systems</td>
</tr>
<tr>
<td>3 MEEG 3013 Mechanics of Materials</td>
<td>3 BENG Design Elective</td>
</tr>
<tr>
<td>3 CVEG 3213 Hydraulics, or MEEG 3503 Mechanics of Fluids, or CHEG 2133 Fluid Mechanics</td>
<td>3 Technical Elective</td>
</tr>
<tr>
<td>3 Technical Elective</td>
<td>6 Humanities/Social Science Elective</td>
</tr>
<tr>
<td><strong>17 Semester hours</strong></td>
<td><strong>14 Semester hours</strong></td>
</tr>
</tbody>
</table>

128 Total hours required
B26. Undergraduate Biological & Agricultural Engineering (University of California)

Undergraduate Program
Biological Systems Engineering

The Biological Systems Engineering program is accredited by the Engineering Accreditation Commission of the Accreditation Board for Engineering and Technology (ABET), 111 Market Place, Suite 1050, Baltimore, MD 21202-4012 - telephone: (410) 347-7700.

Program Objectives

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

- apply life sciences in engineering at the biochemical, cellular, organismal, and macro levels, solve biological systems engineering problems while employed in the private or public sector, consider the environmental 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.

Program Educational Outcomes

Graduates with a B.S. degree in Biological Systems Engineering from UC Davis should have:

- an ability to apply knowledge of mathematics, science, and engineering
- an ability to design and conduct experiments, as well as to analyze and interpret data
- an ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability
- an ability to function on multi-disciplinary teams
- an ability to identify, formulate, and solve engineering problems
- an understanding of professional and ethical responsibility
- an ability to communicate effectively
- the broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context
- a recognition of the need for, and an ability to engage in life-long learning
- a knowledge of contemporary issues
- an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.

Biological Systems Engineering

Agricultural Engineering Specialization

Students specializing in agricultural engineering integrate engineering analysis and design with applied biology to solve problems in production, transportation and processing of agricultural products. Agricultural engineers design machinery, processes and systems for managing the environment, nutrients and waste associated with productive plant and animal culture. Suggested courses in the specialization provide students with the fundamental principles of agricultural production and a broad background in engineering. Agricultural engineers are employed as engineers...
and managers with large and small agricultural producers, equipment manufacturers, food processors, consulting engineering firms and government agencies.

Recommended Biological Science Electives

### Plant Emphasis

<table>
<thead>
<tr>
<th>Quarter Offered</th>
<th>Course &amp; Number</th>
<th>Units</th>
<th>Course Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>PLB 111</td>
<td>3</td>
<td>Plant Physiology</td>
</tr>
<tr>
<td>I</td>
<td>SSC 100</td>
<td>4</td>
<td>Principles of Soil Science</td>
</tr>
</tbody>
</table>

(select one course)

<table>
<thead>
<tr>
<th>Quarter Offered</th>
<th>Course &amp; Number</th>
<th>Units</th>
<th>Course Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>ENT 100</td>
<td>3</td>
<td>General Entomology</td>
</tr>
<tr>
<td>III</td>
<td>PLB 174</td>
<td>2</td>
<td>Biological Applications in Fruit Production</td>
</tr>
<tr>
<td>II</td>
<td>AMR 110A</td>
<td>3</td>
<td>Principles of Agronomic Crop Production in Temperate and Tropical Systems</td>
</tr>
<tr>
<td>III</td>
<td>ENH 102</td>
<td>4</td>
<td>Physiological Principles in Environmental Horticulture</td>
</tr>
</tbody>
</table>

### Animal Emphasis

<table>
<thead>
<tr>
<th>Quarter Offered</th>
<th>Course &amp; Number</th>
<th>Units</th>
<th>Course Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>I,II,III</td>
<td>NPB 101</td>
<td>5</td>
<td>Systemic Physiology</td>
</tr>
<tr>
<td>I</td>
<td>SSC 100</td>
<td>4</td>
<td>Principles of Soil Science</td>
</tr>
</tbody>
</table>

(select one course)

<table>
<thead>
<tr>
<th>Quarter Offered</th>
<th>Course &amp; Number</th>
<th>Units</th>
<th>Course Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>AVS 100</td>
<td>3</td>
<td>Avian Biology</td>
</tr>
<tr>
<td>I</td>
<td>ANS 143</td>
<td>4</td>
<td>Pig and Poultry Care and Management</td>
</tr>
<tr>
<td>I</td>
<td>ANS 144</td>
<td>4</td>
<td>Beef Cattle and Sheep Production</td>
</tr>
<tr>
<td>III</td>
<td>ANS 146</td>
<td>4</td>
<td>Dairy Cattle Production</td>
</tr>
</tbody>
</table>

### Recommended Engineering Electives

<table>
<thead>
<tr>
<th>Quarter Offered</th>
<th>Course &amp; Number</th>
<th>Units</th>
<th>Course Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>III</td>
<td>EBS 114</td>
<td>3</td>
<td>Principles of Field Machinery Design</td>
</tr>
<tr>
<td>III</td>
<td>EBS 132</td>
<td>4</td>
<td>Unit Operations in Food Engineering</td>
</tr>
<tr>
<td>II</td>
<td>EBS 145</td>
<td>4</td>
<td>Irrigation and Drainage Systems</td>
</tr>
<tr>
<td>I,II,III</td>
<td>ECI 141</td>
<td>3</td>
<td>Engineering Hydraulics</td>
</tr>
<tr>
<td>I,II,III</td>
<td>ECI 141L</td>
<td>1</td>
<td>Engineering Hydraulics Laboratory</td>
</tr>
<tr>
<td>I,II,III</td>
<td>ENG 180</td>
<td>3</td>
<td>Engineering Analysis</td>
</tr>
</tbody>
</table>

### Biological Systems Engineering

#### Aquaculture Engineering Specialization

Aquacultural engineers design, build and manage equipment and systems for the production of aquatic plants and animals. Aquacultural engineers need to have a solid understanding of biology, especially processes related to water quality changes, to be able to work with the wide variety of systems used for aquaculture production (systems range from low input earthen ponds, to indoor systems with water treatment and recirculation). The elective courses recommended for the specialization, therefore, include fish biology and production as well as water quality and treatment. In general, employment opportunities for aquacultural engineers are with engineering consulting companies and with government agencies.
### Recommended Biological Science Electives

<table>
<thead>
<tr>
<th>Quarter Offered</th>
<th>Course &amp; Number</th>
<th>Units</th>
<th>Course Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>II</td>
<td>ABT 161</td>
<td>3</td>
<td>Water Quality Management for Aquaculture</td>
</tr>
<tr>
<td>II</td>
<td>ANS 118</td>
<td>4</td>
<td>Fish Production</td>
</tr>
<tr>
<td>II</td>
<td>WFB 121</td>
<td>4</td>
<td>Physiology of Fishes</td>
</tr>
</tbody>
</table>

### Recommended Engineering Electives

<table>
<thead>
<tr>
<th>Quarter Offered</th>
<th>Course &amp; Number</th>
<th>Units</th>
<th>Course Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>III</td>
<td>ABT 163</td>
<td>3</td>
<td>Aquaculture Systems Engineering</td>
</tr>
<tr>
<td>I</td>
<td>ECI 140</td>
<td>3</td>
<td>Environmental Analysis of Aqueous Systems</td>
</tr>
<tr>
<td>I</td>
<td>ECI 140L</td>
<td>1</td>
<td>Environmental Analysis of Aqueous Systems Lab</td>
</tr>
<tr>
<td>I,III</td>
<td>ECI 141</td>
<td>3</td>
<td>Engineering Hydraulics</td>
</tr>
<tr>
<td>I,III</td>
<td>ECI 141L</td>
<td>1</td>
<td>Engineering Hydraulics Lab</td>
</tr>
<tr>
<td>II,III</td>
<td>ECI 148A</td>
<td>3</td>
<td>Water Quality Management</td>
</tr>
<tr>
<td>III</td>
<td>ECI 148B</td>
<td>3</td>
<td>Water Quality Management System Design</td>
</tr>
</tbody>
</table>
B27. Undergraduate Bioresources Engineering (University of Delaware)

UNIVERSITY REQUIREMENTS
ENGL 110 Critical Reading and Writing 3
First Year Experience (FYE) 0-4
Discovery Learning Experience (DLE) 3
Multi-cultural Courses 3
Three credits in an approved course or courses stressing multi-cultural, ethnic, and/or gender-related course content

MAJOR REQUIREMENTS
BREG 165 New Student Seminar 0

Communications
A second writing course selected from: 3
ENGL 301 Expository Writing
ENGL 302 Advanced Composition
ENGL 307 News Writing and Editing
ENGL 312 Written Communications in Business
ENGL 410 Technical Writing
An oral communications course selected from: 3
AGRI 212 Oral Communications in Agriculture and Natural Resources
COMM 212 Oral Communication in Business
COMM 255 Fundamentals of Communication
COMM 350 Public Speaking

Social Sciences and Humanities
ECON 151 Introduction to Microeconomics 3
ECON 152 Introduction to Macroeconomics 3
Six additional credits to be selected from Anthropology, Art, Art History, Black American Studies, Criminal Justice, Economics, Education, English, Foreign Language, Geography, History, Music, Philosophy, Political Science, Psychology, Sociology, Theatre, Women's Studies, or courses cross-listed in these departments. 6

Basic Sciences and Mathematics
Biology/Life Science course 3 or 4
CHEM 103/CHEM 104 General Chemistry 8
PHYS 201/PHYS 202 Introductory Physics I and II
or
PHYS 207/PHYS 208 Fundamentals of Physics I and II (recommended) 8
MATH 117 Precalculus for Scientists and Engineers 4
MATH 221/MATH 222 Calculus I and II (with permission of advisor)
or
MATH 241/MATH 242 Calculus A and B 6 or 8
Additional MATH course to bring total MATH credits at 201 level and above to 12 credits 4 or 6

Technical Skills
BREG 115 Introduction to Computer Based Problem Solving 4
BREG 209 Technical and Computer Aided Drafting 3
Technical Skills elective 3
Technical Sciences
BREG 215 Applied Fluid Mechanics 4
BREG 231 Fundamentals of Statics and Strength of Materials 4
BREG 244 Electricity for Engineering Technology 4
BREG 311 Fundamentals of Thermodynamics 3

Technical Specialization 25 to 31
25 to 31 credits of BREG or engineering courses at the 300 or 400 level from a departmental approved list, including a 3 credit capstone experience selected from BREG 450, BREG 451, BREG 466 or UNIV 401/402. At least 15 credits must be BREG courses. A minor in a technical or business subject area is strongly encouraged. With a minor, the requirements for a technical specialization are a minimum of 25 credits

Technical Support 9 to 15
9 to 15 credits of course work selected to support the student's career objectives. Subject to approval of the faculty.

CREDITS TO TOTAL A MINIMUM OF 124
Students must earn at least a C- in all prerequisite courses to qualify for admission to the next course. Enrollment in BREG 300 and 400 level courses is limited to majors with Junior or Senior standing, or by permission of the instructor.

To graduate with a major in engineering technology, a student must attain at least a 2.0 average in BREG courses. This requirement is in addition to the University requirement of an overall 2.0 grade point average. A student must complete a minimum of 48 semester hours in technical sciences, technical skills and technical specialization.
B28. Undergraduate Agricultural & Biological Engineering (University of Florida)

Agricultural and Biological Engineering

Agricultural and biological engineering (ABE) applies engineering principles to the biological sciences to produce biofuels, food and fiber products and other agricultural commodities from renewable bio-resources. It also aims to protect the environment and conserve and replenish our natural resources.

About This Major

- **Colleges:** Engineering and Agricultural and Life Sciences cooperatively
- **Degree:** Bachelor of Science in Agricultural and Biological Engineering
- **Hours for Degree:** 128
- **Specializations:** Agrisystems Engineering, Biological Engineering, Land and Water Resources Engineering
- **Minor:** No
- **Combined-Degree Program:** Yes
- **Website:** [www.abe.ufl.edu](http://www.abe.ufl.edu)

Overview

Agricultural and biological engineers pioneer new techniques in areas such as agricultural robotics, remote sensing, bioprocessing, precision agriculture and plant space biology.

Graduates are educated in the biological and environmental sciences, as well as in engineering. They will address critical problems involving land and water resources, biological systems and production agriculture. Individual selection of electives allows the student to focus on academic and career interests.

In addition to abundant job opportunities in Florida's large agricultural industry, graduates have career opportunities in biotechnology and those related to Florida's water quality and water resources, including water management districts, environmental companies, consulting firms, equipment manufacturers, bio-energy and food engineering.

The ABE curriculum can fulfill requirements for admission to pre-professional programs, as well as graduate programs such as biomedical engineering, civil engineering and mechanical engineering.

Educational Objectives

Graduates from the University of Florida's undergraduate degree program in Agricultural and Biological Engineering will be prepared for at least one of the following:
• Successful careers in practicing the profession of agricultural and biological engineering within an increasingly complex, global and multidisciplinary setting;
• Gaining admission to and completing a graduate and/or professional degree program at competitive graduate and professional schools of their choice; and
• Effectively contributing to society by engaging in ethical or professional engineering practice, and communicating a sense of professional and societal responsibility with an awareness of related contemporary issues.

Goals

To develop agricultural and biological engineering professionals with technical proficiency and societal responsibility.

Mission

The department will develop professionals, create and disseminate knowledge, and promote the application of engineering and management principles to meet societal needs with respect to agricultural, biological, and land and water resource systems.

To graduate with this major, students must complete all university, college and major requirements.

Critical Tracking and Recommended Semester Plan

Equivalent critical tracking courses as determined by the State of Florida Common Course Prerequisites may be used for transfer students

Semester 1

• 2.0 UF GPA required for semesters 1-5
• 2.5 GPA on all critical-tracking coursework for semesters 1-5
• Complete 1 of 8 tracking courses with a minimum grade of C within two attempts:
  CHM 2045 or CHM 2095, CHM 2045L, CHM 2046 or CHM 2096, MAC 2311,
  MAC 2312, MAC 2313, MAP 2302, PHY 2048/2048L, PHY 2049/2049L

Semester 2

• Complete 1 additional tracking course with a minimum grade of C within two attempts

Semester 3

• Complete 2 additional tracking courses with minimum grades of C within two attempts

Semester 4
- Complete 2 additional tracking courses with minimum grades of C within two attempts

**Semester 5**

- Complete all 8 critical-tracking courses with minimum grades of C in each course within two attempts

To remain on track, students must complete the appropriate critical-tracking courses, which appear in bold.

**Recommended semester plan**

<table>
<thead>
<tr>
<th>Semester 1</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>CHM 2045 and 2095 General Chemistry 1 (GE-P) or CHM 2095 Chemistry for Engineers 1</td>
<td>4</td>
</tr>
<tr>
<td>CHM 2045L General Chemistry 1 Laboratory (GE-P)</td>
<td>1</td>
</tr>
<tr>
<td>MAC 2311 Analytic Geometry and Calculus 1 (GE-M)</td>
<td>4</td>
</tr>
<tr>
<td>Humanities (GE-H)</td>
<td>3</td>
</tr>
<tr>
<td>Social and Behavioral Sciences (GE-S)</td>
<td>3</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>14</strong></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Semester 2</th>
<th>Credits</th>
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</thead>
<tbody>
<tr>
<td>CHM 2046 or 2096 General Chemistry 2 (3) or CHM 2096 Chemistry for Engineers 2 (3) (biological engineering specialization also requires CHM 2046L)</td>
<td>3-4</td>
</tr>
<tr>
<td>ENC 2210 Technical Writing (GE-C) or ENC 3254 Professional Writing in the Discipline (GE-C)</td>
<td>3</td>
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<tr>
<td>MAC 2312 Analytic Geometry and Calculus 2 (GE-M)</td>
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<tr>
<td>Humanities (GE-H)</td>
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<table>
<thead>
<tr>
<th>Semester 3</th>
<th>Credits</th>
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<tbody>
<tr>
<td>ABE 2012C Introduction to Agricultural and Biological Engineering</td>
<td>3</td>
</tr>
<tr>
<td>MAC 2313 Analytic Geometry and Calculus 3</td>
<td>4</td>
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<tr>
<td>PHY 2048 and 2048L Physics with Calculus 1 (GE-P) (3) and Physics with Calculus 1 Laboratory (1)</td>
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</tr>
<tr>
<td>Social and Behavioral Sciences (GE-S)</td>
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<th>Semester 4</th>
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<tr>
<td>EGM 2511 Engineering Mechanics: Statics</td>
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<tr>
<td>EML 3007 Elements of Thermodynamics and Heat Transfer</td>
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<tr>
<td>MAP 2302 Elementary Differential Equations (GE-M)</td>
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<tr>
<td>PHY 2049 Physics with Calculus 2 (GE-P)</td>
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<tr>
<td>PHY 2049L Physics with Calculus 2 Laboratory (GE-P)</td>
<td>1</td>
</tr>
<tr>
<td>Humanities (GE-H) or Social and Behavioral Sciences (GE-S)</td>
<td>3</td>
</tr>
</tbody>
</table>
Specialization: Agrisystems Engineering

Agrisystems Engineering focuses on areas such as structural and environmental design, energy conservation, computer modeling, equipment design and plant protection systems. Students study how to design renewable energy systems, create agricultural robotics, develop environmentally friendly pest-control methods, design environmental control systems for plant and animal facilities and apply engineering design to food production systems.

Students choose electives from an approved list.

Semester 5

<table>
<thead>
<tr>
<th>Course</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>ABE 3612C Heat and Mass Transfer in Biological Systems</td>
<td>4</td>
</tr>
<tr>
<td>CGN 3421 Computer Methods in Civil Engineering or ESI 4567C Matrix/Numerical Methods in Systems Engineering</td>
<td>4</td>
</tr>
<tr>
<td>EGM 3400 Elements of Dynamics</td>
<td>2</td>
</tr>
<tr>
<td>EGN 3353C Fluid Mechanics (3) or CWR 3201 Hydrodynamics (4)</td>
<td>3-4</td>
</tr>
<tr>
<td>Biological Science (ABE 2062, BSC 2007, BSC 2010 or BOT 2010; GE-B)</td>
<td>3</td>
</tr>
<tr>
<td><strong>Total 16-17</strong></td>
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Semester 6

<table>
<thead>
<tr>
<th>Course</th>
<th>Credits</th>
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</thead>
<tbody>
<tr>
<td>ABE 3212C Land and Water Resources Engineering</td>
<td>4</td>
</tr>
<tr>
<td>ABE 3652C Physical and Rheological Properties of Biological Materials (3) or CGN 3501C Civil Engineering Materials (4)</td>
<td>3-4</td>
</tr>
<tr>
<td>ABE 4303C Structural and Environmental Design</td>
<td>3</td>
</tr>
<tr>
<td>EML 2023 Computer Aided Graphics and Design or CGN 2328 Technical Drawing and Visualization</td>
<td>3</td>
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<tr>
<td>Technical science elective</td>
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<td><strong>Total 16-17</strong></td>
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Semester 7

<table>
<thead>
<tr>
<th>Course</th>
<th>Credits</th>
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</thead>
<tbody>
<tr>
<td>CGN 3710 Experimentation and Instrumentation in Civil Engineering or EEL 3003 Elements of Electrical Engineering</td>
<td>3</td>
</tr>
<tr>
<td>EGM 3520 Mechanics of Materials</td>
<td>3</td>
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<tr>
<td>Engineering electives</td>
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<td><strong>Total 12</strong></td>
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Semester 8

<table>
<thead>
<tr>
<th>Course</th>
<th>Credits</th>
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<tbody>
<tr>
<td>ABE 3042C Agricultural and Biological Engineering Design 1</td>
<td>2</td>
</tr>
<tr>
<td>ABE 4171C Power and Machines for Biological Systems</td>
<td>4</td>
</tr>
</tbody>
</table>
Biological Engineering

Biological engineering includes designing microbes to clean the environment, converting raw biological materials into useful products such as biofuels, evaluating gene expression of biological systems and applications to space biosystems.

In addition, this specialization provides an excellent background for advanced studies in biomedical, bioprocess, food and agricultural engineering and also fulfills requirements for admission to professional programs in UF's colleges of medicine, dentistry, veterinary medicine and pharmacy.

Students choose electives from an approved list.

Semester 5

<table>
<thead>
<tr>
<th>Course</th>
<th>Credits</th>
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</thead>
<tbody>
<tr>
<td>ABE 3612C Heat and Mass Transfer in Biological Systems</td>
<td>4</td>
</tr>
<tr>
<td>ABE 4931 Professional Issues in Agricultural and Biological Engineering</td>
<td>1</td>
</tr>
<tr>
<td>CGN 3421 Computer Methods in Civil Engineering or ESI 4567C Matrix/Numerical Methods in Systems Engineering</td>
<td>4</td>
</tr>
<tr>
<td>CHM 2210 Organic Chemistry 1</td>
<td>3</td>
</tr>
<tr>
<td>Biological Science (BSC 2010 or BSC 2011; GE-B)</td>
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<td>Total</td>
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Semester 6

<table>
<thead>
<tr>
<th>Course</th>
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<tbody>
<tr>
<td>ABE 3000C Applications in Biological Engineering</td>
<td>3</td>
</tr>
<tr>
<td>ABE 3652C Physical and Rheological Properties of Biological Materials</td>
<td>3</td>
</tr>
<tr>
<td>CHM 2211 and 2211L Organic Chemistry 2 (3) and Organic Chemistry 2 Laboratory (2)</td>
<td>5</td>
</tr>
<tr>
<td>EGM 3400 Elements of Dynamics</td>
<td>2</td>
</tr>
<tr>
<td>Engineering elective (adviser approved)</td>
<td>2</td>
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Semester 7

<table>
<thead>
<tr>
<th>Course</th>
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<tr>
<td>BCH 4024 Introduction to Biochemistry and Molecular Biology or BCH 3025 Fundamentals of Biochemistry</td>
<td>4</td>
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<tr>
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</table>
CGN 3710 Experimentation and Instrumentation in Civil Engineering 3
EGN 3353C Fluid Mechanics (3) or CWR 3201 Hydrodynamics (4) 3-4
EML 2023 Computer Graphics and Design or CGN 2328 Technical Drawing and Visualization 3

Total 13-14

<table>
<thead>
<tr>
<th>Semester 8</th>
<th>Credits</th>
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<tbody>
<tr>
<td>ABE 3042C Agricultural and Biological Engineering Design 1</td>
<td>2</td>
</tr>
<tr>
<td>ABE 4662 Quantification of Biological Processes</td>
<td>3</td>
</tr>
<tr>
<td>ABE 4812 Food and BioProcess Engineering Unit Operations</td>
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<tr>
<td>Biological science electives</td>
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Total 14

<table>
<thead>
<tr>
<th>Semester 9</th>
<th>Credits</th>
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<tbody>
<tr>
<td>ABE 4043C Agricultural and Biological Engineering Design 2</td>
<td>2</td>
</tr>
<tr>
<td>EGM 3520 Mechanics of Materials</td>
<td>3</td>
</tr>
<tr>
<td>Biological science electives</td>
<td>5</td>
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<tr>
<td>Engineering elective</td>
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</table>

Total 14

**Land and Water Resources Engineering**

Land and water resources is concerned with all aspects of water and natural resource management, including irrigation, water conservation, drainage, water control and structures, soil erosion, waste and recycling, water quality, ecosystems preservation and environmental quality.

Students choose electives from an approved list.

<table>
<thead>
<tr>
<th>Semester 5</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>ABE 3612C Heat and Mass Transfer in Biological Systems</td>
<td>4</td>
</tr>
<tr>
<td>EGM 3400 Elements of Dynamics</td>
<td>2</td>
</tr>
<tr>
<td>ENV 3040C Computer Methods in Environmental Engineering</td>
<td>3</td>
</tr>
<tr>
<td>SUR 3103C Geomatics</td>
<td>3</td>
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<tr>
<td>SWS 3022 Introduction to Soils in the Environment</td>
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Total 15

<table>
<thead>
<tr>
<th>Semester 6</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>ABE 3212C Land and Water Resources Engineering</td>
<td>4</td>
</tr>
<tr>
<td>ABE 3652C Physical and Rheological Properties of Biological Materials (3) or CGN 3501C Civil Engineering Materials (4)</td>
<td>3-4</td>
</tr>
<tr>
<td>ABE 4931 Professional Issues in Agricultural and Biological Engineering</td>
<td>1</td>
</tr>
<tr>
<td>CWR 3201 Hydrodynamics</td>
<td>4</td>
</tr>
<tr>
<td>Technical elective (adviser approved)</td>
<td>3</td>
</tr>
<tr>
<td>Semester 7</td>
<td>Total 15-16</td>
</tr>
<tr>
<td>-----------</td>
<td>-------------</td>
</tr>
<tr>
<td>CGN 3710 Experimentation and Instrumentation in Civil Engineering or EEL 3003 Elements of Electrical Engineering</td>
<td>3</td>
</tr>
<tr>
<td>EGM 3520 Mechanics of Materials</td>
<td>3</td>
</tr>
<tr>
<td>Biological science (ABE 2062, BSC 2007, BSC 2010 or BOT 2010; GE-B)</td>
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<tr>
<td>Technical science elective</td>
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<tr>
<td><strong>Total</strong></td>
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<table>
<thead>
<tr>
<th>Semester 8</th>
<th>Total 15</th>
</tr>
</thead>
<tbody>
<tr>
<td>ABE 3042C Agricultural and Biological Engineering Design 1</td>
<td>2</td>
</tr>
<tr>
<td>ABE 4231C Irrigation and Drainage</td>
<td>4</td>
</tr>
<tr>
<td>CWR 4202 Hydraulics</td>
<td>3</td>
</tr>
<tr>
<td>EML 2023 Computer Aided Graphics and Design or CGN 2328 Technical Drawing and Visualization</td>
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</tr>
<tr>
<td>Engineering elective</td>
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<tr>
<td><strong>Total</strong></td>
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<table>
<thead>
<tr>
<th>Semester 9</th>
<th>Total 14</th>
</tr>
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<tbody>
<tr>
<td>ABE 4043C Agricultural and Biological Engineering Design 2</td>
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</tr>
<tr>
<td>Engineering electives</td>
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<tr>
<td>Engineering or technical science electives</td>
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<tr>
<td><strong>Total</strong></td>
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</tr>
</tbody>
</table>
B29. Undergraduate Biological and Agricultural Engineering (University of Georgia)

Math, Chemistry, Physics and Biology Courses:

- Principles in Biology I (BIOL 1107)
- Freshman Chemistry I (CHEM 1211)
- Freshman Chemistry II (CHEM 1212)
- Analytical Geometry and Calculus (Math 2250)
- Integral Calculus (MATH 2260)
- Multivariable Calculus (MATH 2500)
- Differential Equations (MATH 2700)
- Introduction to Physics for Engineering and Scientist I (PHYS 1211)
- Introduction to Physics for Engineering and Scientist II (PHYS 1212)

Biological Engineering Majors also take:
- Biochemistry (BCMB 3100)
- Principles of Biology II (BIOL 1108)
- Organic Chemistry (CHEM 2211)
- Microbiology (MIBO 3000)

Engineering Courses:

- Engineering Graphics and Design (ENGR 1120)
- Computational Engineering Methods (ENGR 1140)
- Statics (ENGR 2120)
- Strength of Materials (ENGR 2140)
- Electrical Circuits (ENGR 2170)
- Design Methodology (ENGR 2920)
- Thermodynamics (ENGR 3140)
- Heat Transfer (ENGR 3150)
- Fluid Mechanics (ENGR 3160)
- Engineering Design Project (ENGR 4920)

Courses separated by each area of emphasis

Biochemical

Required:
- Sensors and Transducers (ENGR 4230)
- Structural Environments I (ENGR 4650)
- Biochemical Engineering (ENGR 4510)

Design of Biochemical Separations Processes (ENGR 4520)

Electives:
- Introduction To Systems Modeling (ENGR 4940)
- Physical Units Operation (ENGR 3540)

Biomedical

Required:
- Biomechanics Track
- Engineering Physiology (ENGR 3720)
Biomechanics (ENGR 3760)
Sensors and Transducers (ENGR 4230)
Biomaterials (ENGR 4740)
Instrumentation Track
Engineering Physiology (ENGR 3720)
Linear Systems (ENGR 4210)
Sensors and Transducers (ENGR 4230)
Biomaterials (ENGR 4740)
Electives:
Biomechanics Track
Structural Design (ENGR 3610)
Finite Elements (ENGR 4350)
Structural Environments I (ENGR 4650)
Instrumentation Track
Electronics (ENGR 3270)
Introduction to Microcontrollers (ENGR 4240)

Electrical/Electronic Systems
Required:
Electronics (ENGR 3270)
Linear Systems (ENGR 4210)
Feedback Controls (ENGR 4220)
Advanced Microcontrollers (ENGR 4250)
Electives:
Instrumentation for Environmental Quality (ENGR 4480)
Applied Machine Visions (ENGR 4540)
Introduction to Systems Modeling (ENGR 4140)

Environmental
Required:
Introduction to Natural Resource Engineering (ENGR 3410)
Water Management (ENGR 3440)
Environmental Engineering I (ENGR 4440)
Environmental Engineering II (ENGR 4450)
Instrumentation for Environmental Quality (ENGR 4480)
Electives:
Soil Mechanics (ENGR 3420)
Control of Structural Environments (ENGR 4650)
Introduction to Systems Modeling (ENGR 4940)
Forest Hydrology (FORS 4120) or Hydrology and Soils (CRSS 3060)

Mechanical Systems/Process Operations
Required:
Electronics I (ENGR 3270)
Mechanism Design Dynamics (ENGR 3300)
Mechanical Systems Design (ENGR 4300)
Finite Elements (ENGR 4350)
Introduction to Microcontrollers(ENGR 4240)
Electives:
Electronics (ENGR 4210)
Feedback Control Systems (ENGR 4220)
Advanced Microcontrollers (ENGR 4250)
Introduction to Systems Modeling (ENGR 4940)
Applied Machine Vision (ENGR 4540)

Natural Resource Management
Required:
Spatial Data Analysis (ENGR 3120)
Introduction to Natural Resource Engineering (ENGR 3410)
Water Management (ENGR 3440)
Control of Structural Environments I (ENGR 4650)
Electives:
Soil Mechanics (ENGR 3420)
Soils and Hydrology Field Trip (ENGR 4170)
Instrumentation for Environmental Quality (ENGR 4480)
Introduction to Systems Modeling (ENGR 4140)
Soils and Hydrology (CRSS 3060)
Soil Physics (CRSS 4600)

Process Operations
Required:
Electronics (ENGR 3270)
Physical Units Operation (ENGR 3540)
Linear Systems (ENGR 4210)
Feedback Control (ENGR 4220)
Introduction to Systems Modeling (ENGR 4140)
Electives:
Advanced Microcontrollers (ENGR 4250)
Applied Machine Vision (ENGR 4540)
Food Processing (FDST 4010)
Food Engineering Fundamentals I (FDST 4050)
Food Engineering Fundamentals II (FDST 4060)
Food Quality Control (FDST 4090)
Wood Properties and Utilization (FORS 3500)
Management of Organizations and Individuals (MGMT 3000)
Integrated Resource Management (MGMT 4000)
Quality Management (MGMT 4240)
Productivity Management (MGMT 4250)
Poultry Processing (POUL 4860)

Structural Systems
Required:
Structural Design (ENGR 3610)
Control of Structural Environments I (ENGR 4650)
Design of Light Frame Steel Structures (ENGR 4610)
Design of Residential Structures (ENGR 4630)
Electives:
Soil Mechanics (ENGR 3420)
Water Management (ENGR 3440)
Feedback Control Systems (ENGR 4220)
Advanced Microcontrollers (ENGR 4250)
Finite Elements (ENGR 4350)
Instrumentation for Environmental Quality (ENGR 4480)
**B30. Undergraduate Biological Engineering (University of Hawaii)**

The Department of Molecular Biosciences and Bioengineering features a multidisciplinary faculty having a broad spectrum of interests in biotechnology, molecular biology, biochemistry, biosystems engineering, and food science. The department's strong basic and applied research programs and its active, internationally recognized faculty combine to provide students with exciting learning opportunities.

The MBBE department offers an undergraduate program in Biological Engineering and also participates in an interdepartmental Plant & Environmental Biotechnology undergraduate program.

**Bachelor of Science**

Completing a B.S. in Biological Engineering will prepare you for a variety of careers in traditional as well as emerging biotech fields. Graduates have accepted engineering positions such as designing process equipment and systems for biological production and treatment, or implementing site preparation for construction or bioremediation of environmental contamination. They are prepared to help engineer systems to develop renewable sources of energy, and to improve the value of natural products produced in Hawaii for food and therapeutic applications. Increasing numbers of graduates from BE are meeting demands from growing biotech industries in Hawaii, for example for the production of systems for culturing human tissues for medical replacement and for screening, extracting, and producing antibiotics and other pharmaceutical compounds from Hawaii's unique natural biota. Many Bioengineers are employed with forward thinking institutions like NASA that are interested in engineering self-sustaining habitable environments in space as well as on Earth.

A degree in Biological Engineering prepares students for graduate school, not only in Biological Engineering but also in Medicine, Law, and Business which all value the versatility and analytical rigor of the field. Graduates also fill vital research and regulatory needs of state and federal governments to preserve and enhance the value of our natural resources.

The introductory part of the Biological Engineering curriculum is similar to other engineering fields, e.g., calculus, physics, chemistry, and computer programming. Students in Biological Engineering take additional courses in biological sciences such as biology, organic chemistry, and biochemistry. During the latter part of the program, students take basic engineering courses such as mechanics and thermodynamics as well as Biological Engineering courses with emphasis given to solving practical engineering problems involving biological systems. The mission of the Biological Engineering Program is to provide students a unique opportunity to study the fundamentals of engineering and biology and the application of engineering to biological systems. To fulfill this mission the BE Program has three educational objectives, each associated with several outcomes:

- Graduates enter professional careers where they apply fundamental engineering concepts to solve real-world problems;
  - a. The graduate has the ability to solve problems involving differential equations.
  - b. The graduate has the ability to solve physics problems involving mechanics, electromagnetics, and optics; chemistry problems involving inorganic and organic chemistry; problems involving general and micro-biology.
c. The graduate has the ability to solve engineering problems related to statics, dynamics, fluid mechanics, and thermodynamics.

Graduates serve the needs of the society by designing, manufacturing, evaluating, and/or operating systems in which living organisms or biological products are a significant component, and;

d. The graduate has the ability to design a system, component, or process in which biology plays a significant role.

e. The graduate has the ability to design and conduct experiments to gather information for engineering designs.

f. The graduate has the ability to use modern engineering techniques, skills, and tools to define, formulate, and solve engineering problems.

Graduates contribute to their communities by continuing to engage in professional development, ethical decision making, and thoughtful discourse on contemporary issues.

g. The graduate has the ability to function effectively on multi-disciplinary teams.

h. The graduate has the ability to identify professional and ethical responsibilities when practicing engineering.

i. The graduate has the ability to communicate effectively in large and small groups.

j. The graduate has the background to understand the impact of engineering solutions on the surrounding context.

k. The graduate recognizes the need to engage in life-long learning through participation in professional conferences, workshops, and courses, and by reading and writing in the relevant literature.

l. The graduate has the ability to intelligently discuss contemporary issues.

The Bachelor of Science in Biological Engineering is the only undergraduate degree offered by the program. Students benefit from small class size and one-on-one interactions with faculty. The program is accredited by the Accreditation Board for Engineering and Technology (ABET).

Requirements
General Education Core Requirements including the following:
ECON 120, ECON 130, or ECON 131
Social Science (One DS course outside of ECON)
Two courses on Global and Multicultural Perspectives (e.g., HIST 151 & 152)
Arts, Humanities, and Literature; (two courses DH/DA/DL from different categories)
BIOL 171 and 171L
CHEM 162, 162L, 272, and 272L
ENG 100, 100A, 101/101L, or ELI 100
MATH 241, 242, 243, and 244 (calculus)
PHYS 170, 170L, 272, and 272L

Focus Requirements:
One course with focus on Ethics
One course with focus on Hawaiian, Asian, or Pacific issues
Five courses with writing intensive focus
(Focus courses may also be used to fulfill other general education or major requirements)

**College requirements:**
NREM 310 (statistics)

**Basic Engineering requirements:**
EE 160 and 211 (engr. programming and circuit analysis)
CE 270, 271 (mechanics: statics and dynamics)
CE 320 or ME 322 (fluid mechanics)
ME 311 (thermodynamics)
Engineering mathematics elective (MATH 302, 307, 311, ME 360, or CEE 417)

**Biological Engineering requirements:**
BIOL 172 and 172L or MICR 351 and 351L and a biology elective (BIOL 275/275L, MICR 351/351L, or MICR 485/485L)
BE 260, 350, 350L, 373, 481, and 482
At least 15 credit hours from the following technical electives: BE 405, BE 411, BE 420, BE 421, BE 431, BE 437, BE 440, BE 460, or CEE 355

Students must complete a cumulative total of at least 128 credit hours and take (but not necessarily pass) the NCEES Fundamentals of Engineering exam in the semester they intend to graduate.
B31. Undergraduate Biological and Agricultural Engineering (Idaho University)

Biological and Agricultural Engineering

The Biological and Agricultural Engineering curriculum is accredited by the Engineering Accreditation Commission of the Accrediting Board of Engineering and Technology (EAC/ABET). Students in this program are eligible to take the Fundamentals of Engineering (FE) Examination prior to graduation and to become registered professional engineers after graduating and completing an experience requirement.

The five engineering options in the Biological and Agricultural Engineering program listed at the right, provide each student the opportunity to pursue a course of study suited to a particular professional engineering career goal.

Engineering: Agricultural Engineering

The Agricultural Engineering option is the curriculum that bridges the area between the two fields of applied science - engineering and agriculture. It is oriented to the design of equipment and systems for production, processing, and transportation of food, feed, natural raw fiber, and forest products and for the effective use of natural resources. Agricultural engineers have the education and interests that make them uniquely capable of developing engineering solutions for agricultural and biological systems.

The agricultural engineering program at the UI is designed to prepare students for a variety of interesting and rewarding careers.

Many graduates are employed as design or development engineers by equipment manufacturers, irrigation companies, trade associations, engineering consulting firms, and governmental agencies. Others are self-employed in farm equipment manufacturing, consulting firms, and other engineering-related enterprises.

Agricultural Engineering Courses

Required course work includes the university requirements

- BAE 142: Engineering for Living Systems (2 cr)
- BAE 143: Engineering Problem Solving or CS 112: Introduction to Problem Solving and Programming (3 cr)
- BAE 242: Agricultural Engineering Analysis and Design (2 cr)
- BAE 355: Fundamentals of Hydrologic Engineering (3 cr)
- BAE 441: Instrumentation and Measurements (3 cr)
- BAE 462: Electric Power and Controls (3 cr)
- BAE 478: Engineering Design I (2 cr)
- BAE 479: Engineering Design II (2 cr)
- BAE 491: Senior Seminar (1 cr)
- Chem 111: Principles of Chemistry I (4 cr)
- Chem 112: Principles of Chemistry II (5 cr)
- Engl 102: College Writing and Rhetoric (3 cr)
- Engr 105: Engineering Graphics (2 cr)
- Engr 210: Engineering Statics (3 cr)
- Engr 240: Introduction to Electrical Circuits (3 cr)
- Engr 320: Engineering Thermodynamics and Heat Transfer (3 cr)
Engr 335: Engineering Fluid Mechanics (3 cr)
Engr 350: Engineering Mechanics of Material (3 cr)
Engr 360: Engineering Economy (3 cr)
Math 170: Analytic Geometry and Calculus I (4 cr)
Math 175: Analytic Geometry and Calculus II (4 cr)
Math 275: Analytic Geometry and Calculus III (3 cr)
Math 310: Ordinary Differential Equations (3 cr)
Phys 211: Engineering Physics I (4 cr)
Phys 212: Engineering Physics II (4 cr)
Soil 205: The Soil Ecosystem (3 cr)
Stat 301: Probability and Statistics (3 cr)
Communications Elective (2 cr)

And Option Requirements of:
BAE 352: Soil and Water Engineering or CE 322/323: Hydraulics and Lab (3-4 cr)
BAE 372: Agricultural Power and Machines (3 cr)
BAE 459: Irrigation System Design (3 cr)
BAE 461: Agricultural Processing and Environment (3 cr)
CE 211: Engineering Measurements (3 cr)
CE 342: Theory of Structures (3 cr)
Engr 220: Engineering Dynamics (3 cr)
Biological Science Electives (3 cr)
Technical Electives (8 cr)
Electives approved by department to total 128 cr for the degree

A grade of C or better is required in each of the following courses before registration is permitted in upper-division engineering courses: BAE 143, BAE 242, Chem 111, Engr 210, Math 275, and Phys 211.

Students are required to submit a course plan and a statement of how the humanities and social science course requirements complement the technical content of the curriculum and are consistent with the program and institution objectives.

Engineering:

Biological Systems Engineering

Biological Systems Engineering option is an undergraduate curriculum designed to prepare students to solve technological problems in systems that involve plants, animals, microorganisms, and biological materials. They produce creative and effective solutions to problems in the environment, our food supply, and the interaction of living organisms in a biologically complex, interconnected and changing world. The program can be designed to prepare the student for advanced biomedical or environmental engineering studies.

A broader emphasis in biology and chemistry is made within this curriculum compared to other engineering disciplines. Depending on their electives, graduates in biological systems engineering have opportunities to work with consulting and industrial firms in design, environmental control and monitoring, non-point source pollution abatement, bioremediation, hydrology and water quality control. They may also work with food processing industries in storage, product development and quality control. Other options include governmental agencies in water resources, environmental quality, and environmental protection. This program is often used as a
pre-biomedical program to prepare students for graduate studies in the biomedical profession.

**Biological Systems Engineering Courses**

*Required course work includes the university requirements*

- BAE 142: Engineering for Living Systems (2 cr)
- BAE 143: Engineering Problem Solving or CS 112: Introduction to Problem Solving and Programming (3 cr)
- BAE 242: Agricultural Engineering Analysis and Design (2 cr)
- BAE 355: Fundamentals of Hydrologic Engineering (3 cr)
- BAE 441: Instrumentation and Measurements (3 cr)
- BAE 462: Electric Power and Controls (3 cr)
- BAE 478: Engineering Design I (2 cr)
- BAE 479: Engineering Design II (2 cr)
- BAE 491: Senior Seminar (1 cr)

- Chem 111: Principles of Chemistry I (4 cr)
- Chem 112: Principles of Chemistry II (5 cr)
- Engl 102: College Writing and Rhetoric (3 cr)
- Engr 105: Engineering Graphics (2 cr)
- Engr 210: Engineering Statics (3 cr)
- Engr 240: Introduction to Electrical Circuits (3 cr)
- Engr 320: Engineering Thermodynamics and Heat Transfer (3 cr)
- Engr 335: Engineering Fluid Mechanics (3 cr)
- Engr 350: Engineering Mechanics of Material (3 cr)
- Engr 360: Engineering Economy (3 cr)
- Math 170: Analytic Geometry and Calculus I (4 cr)
- Math 175: Analytic Geometry and Calculus II (4 cr)
- Math 275: Analytic Geometry and Calculus III (3 cr)
- Math 310: Ordinary Differential Equations (3 cr)
- Phys 211: Engineering Physics I (4 cr)
- Phys 212: Engineering Physics II (4 cr)
- Soil 205: The Soil Ecosystem (3 cr)
- Stat 301: Probability and Statistics (3 cr)
- Communications Elective (2 cr)

And Option Requirements of:

- BAE 461: Agricultural Processing and Environment (3 cr)
- Biol 115: Cells and the Evolution of Life (4 cr)
- Chem 277: Organic Chemistry I (3 cr)
- Chem 278: Organic Chemistry I: Lab (1 cr)
- MMBB 250: General Microbiology (5 cr)
- MMBB 380: Introductory Biochemistry (4 cr)
- Biological Science Electives (3 cr)
- Technical Electives (9 cr)

Electives approved by department to total 128 cr for the degree

A grade of C or better is required in each of the following courses before registration is permitted in upper-division engineering courses: BAE 143, BAE 242, Chem 111, Engr 210, Math 275, and Phys 211.
Students are required to submit a course plan and a statement of how the humanities and social science course requirements complement the technical content of the curriculum and are consistent with the program and institution objectives.
### B32. Undergraduate Agricultural and Biological Engineering (University of Illinois)

<table>
<thead>
<tr>
<th>Number</th>
<th>Name / Instructor</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>ABE 100</td>
<td>Introduction to Agricultural &amp; Biological Engineering - Hansen, A. / Danao, M. / Green, A.</td>
<td>1</td>
</tr>
<tr>
<td>ABE 199</td>
<td>Undergraduate Open Seminar</td>
<td>1 to 5</td>
</tr>
<tr>
<td>ABE 221</td>
<td>Agric &amp; Biological Engrng I - Kalita, P. / Grift, T.</td>
<td>4</td>
</tr>
<tr>
<td>ABE 361</td>
<td>Off-Road Machine Design - Hansen, A.</td>
<td>3</td>
</tr>
<tr>
<td>ABE 374</td>
<td>Environ Control for Buildings - Green, A.</td>
<td>3</td>
</tr>
<tr>
<td>ABE 396</td>
<td>Honors Independent Study</td>
<td>1 to 4</td>
</tr>
<tr>
<td>ABE 397</td>
<td>Independent Study</td>
<td>1 to 4</td>
</tr>
<tr>
<td>ABE 420</td>
<td>Kinem &amp; Dynamics of Mech Syst</td>
<td>3</td>
</tr>
<tr>
<td>ABE 430</td>
<td>Project Management - Zahos, S.</td>
<td>2</td>
</tr>
<tr>
<td>ABE 440</td>
<td>Applied Statistical Methods I</td>
<td>4</td>
</tr>
<tr>
<td>ABE 455</td>
<td>Erosion and Sediment Control - Hirschi, M.</td>
<td>2</td>
</tr>
<tr>
<td>ABE 459</td>
<td>Drainage and Water Management - Cooke, R.</td>
<td>3 or 4</td>
</tr>
<tr>
<td>ABE 466</td>
<td>Engineering Off-Road Vehicles - Hansen, A.</td>
<td>3</td>
</tr>
<tr>
<td>ABE 476</td>
<td>Indoor Air Quality Engineering - Zhang, Y.</td>
<td>4</td>
</tr>
<tr>
<td>ABE 483</td>
<td>Engineering Properties of Food and Biological Materials - Rausch, K.</td>
<td>3</td>
</tr>
<tr>
<td>ABE 489</td>
<td>Corn Milling Process Design - Eckhoff, S.</td>
<td>3</td>
</tr>
<tr>
<td>ABE 497</td>
<td>Independent Study</td>
<td>1 to 4</td>
</tr>
<tr>
<td>ABE 501</td>
<td>Graduate Research I - Zhang, Y.</td>
<td>1</td>
</tr>
<tr>
<td>ABE 594</td>
<td>Graduate Seminar - Zhang, Y. / Bode, L.</td>
<td>0</td>
</tr>
<tr>
<td>Number</td>
<td>Name / Instructor</td>
<td>Credit Hours</td>
</tr>
<tr>
<td>----------</td>
<td>--------------------------------------------</td>
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</tr>
<tr>
<td>ABE 199</td>
<td>Undergraduate Open Seminar</td>
<td>1 to 5</td>
</tr>
<tr>
<td>ABE 222</td>
<td>Agric &amp; Biological Engrg II - Rodríguez, L. / Zhang, Y.</td>
<td>4</td>
</tr>
<tr>
<td>ABE 396</td>
<td>Honors Independent Study</td>
<td>1 to 4</td>
</tr>
<tr>
<td>ABE 397</td>
<td>Independent Study</td>
<td>1 to 4</td>
</tr>
<tr>
<td>ABE 425</td>
<td>Engrg Measurement Systems - Grift, T.</td>
<td>4</td>
</tr>
<tr>
<td>ABE 436</td>
<td>Renewable Energy Systems - Wang, X.</td>
<td>3 or 4</td>
</tr>
<tr>
<td>ABE 440</td>
<td>Applied Statistical Methods I</td>
<td>4</td>
</tr>
<tr>
<td>ABE 445</td>
<td>Statistical Methods</td>
<td>4</td>
</tr>
<tr>
<td>ABE 456</td>
<td>Land &amp; Water Resources Engrg</td>
<td>3 or 4</td>
</tr>
<tr>
<td>ABE 458</td>
<td>NPS Pollution Modeling - Cooke, R.</td>
<td>2</td>
</tr>
<tr>
<td>ABE 463</td>
<td>Electrohydraulic Systems</td>
<td>3</td>
</tr>
<tr>
<td>ABE 469</td>
<td>Industry-Linked Design Project - Zahos, S.</td>
<td>4</td>
</tr>
<tr>
<td>ABE 488</td>
<td>Bioprocessing Grains for Fuels - Vijay, S.</td>
<td>3</td>
</tr>
<tr>
<td>ABE 497</td>
<td>Independent Study</td>
<td>1 to 4</td>
</tr>
<tr>
<td>ABE 498</td>
<td>Special Topics</td>
<td>1 to 4</td>
</tr>
<tr>
<td>ABE 502</td>
<td>Graduate Research I</td>
<td>1</td>
</tr>
<tr>
<td>ABE 561</td>
<td>Off-Road Vehicle Mechatronics</td>
<td>4</td>
</tr>
<tr>
<td>ABE 594</td>
<td>Graduate Seminar - Zhang, Y. / Bode, L.</td>
<td>0</td>
</tr>
<tr>
<td>ABE 597</td>
<td>Independent Study</td>
<td>1 to 4</td>
</tr>
<tr>
<td>ABE 599</td>
<td>Thesis Research</td>
<td>0 to 16</td>
</tr>
</tbody>
</table>
B33. Undergraduate Biosystems and Agricultural Engineering (University of Kentucky)

BAE 102 Introduction to Biosystems Engineering (1)
An introduction to the engineering of food and fibers, production and processing systems. Professionalism and the engineering approach to problem solving will be emphasized.

BAE 103 Energy in Biological Systems (2)
This course introduces the concepts of energy transport in biological systems including the study of thermodynamics, heat transfer, psychometrics, and fluid flow. Prereq. or concurrent: MA 113.

BAE 201 Economic Analysis for Biosystems (2)
The financial and managerial aspects of biosystems in evaluating design alternatives. Typical topics included are: concepts of present and future value, techniques of managerial economics, and biosystem design analysis in the evaluation of alternatives. Retirement/replacement policies and risk analysis. Prereq: MA 113.

BAE 202 Probability and Statistics for Biosystems (3)
Introduction to biosystems engineering; engineering problem solving; computer applications and structured programming; probability; and statistics. Emphasis on application of these skills to biosystems applications. Lecture, two hours, laboratory, two hours per week. Prereq: MA 113 and sophomore standing.

BAE 305 DC Circuits and Microelectronics (3)
An introduction to the use of digital electronics and integrated circuits in solving biosystems engineering problems. Digital circuits, microprocessor concepts, computer interfacing, transducers, signal conditioning and control applications are discussed. Lecture, two hours; laboratory, two hours per week. Prereq: EE 305 or EE 306.

BAE 400 Senior Seminar (1)
A course for senior students in biosystems and agricultural engineering with emphasis on oral communications skills. Students will do literature searches on topics related to the biosystems and agricultural engineering profession and present oral and written reports. Prereq: Senior standing in BAE and COM 199.

BAE 402 Biosystems and Agricultural Engineering Design I (2)
A design course for seniors in BAE requiring students to solve open-ended problems. Students will use previously learned engineering principles to produce actual designs which will be built and analyzed in BAE 403. Prereq: Engineering standing in BAE or consent of instructor.

BAE 403 Biosystems and Agricultural Engineering Design II (2)
Student design teams evaluate and enhance design solutions, fabricate prototypes, execute performance tests, analyze results, and develop final design specifications. Oral and written reports are required. Prereq: BAE 402.

BAE 417 Design of Machine Systems (3)
A study of the operational characteristics and design features associated with production and processing equipment for food and fiber products and an introduction
to conceptualization, analysis and design of these systems. Lecture, two hours; laboratory, two hours per week. Prereq: EM 313, ME 330, engineering standing or consent of instructor.

BAE 427 Structures and Environment Engineering (3)
This course teaches load estimate for light timber and concrete structures and introduces the design of heating, cooling, and ventilation systems in these structures. Prereq: EM 302; Prereq. or concur: ME 325.

BAE 435G Waste Management for Biosystems (3)
A study of the characteristics, treatment and utilization principles; and analysis and design of systems for managing waste from the production and processing of food and fiber. Lecture, two hours; laboratory three hours per week. Prereq: MA 214 and BIO 108.

BAE 437 Land and Water Resources Engineering (3)
The hydrologic cycle is studied and design procedures are developed for flood control structures, water table management, wetlands, irrigation, and erosion control systems. Prereq: CE 341 or ME 330.

BAE 438G Fundamentals of Groundwater Hydrology (3)
The first course in the physics of saturated flow in porous media. Topics include groundwater occurrence, Darcian flow, well hydraulics, flow nets, layered systems flow and pollutant movement. Prereq: ME 330 or CE 341 or consent of instructor. (Same as CE 460.)

BAE 447 Bioprocess Engineering Fundamentals (3)
Design principles and equipment selection for the most common processing operations are studied for the manufacturing and preservation of biological materials. Topics will include the design of fluid flow systems, transient heat transfer, heat exchangers, psychometrics, and refrigeration. Prereq: ME 225 and engineering standing.

BAE 450 Special Problems (1-3)
An intensive study of some phases of biosystems and agricultural engineering in which the student is particularly interested. Approval of instructor is required. May be repeated to a maximum of six credits.

BAE 502 Modeling of Biological Systems (3)
The course will focus on the mathematical description and computer simulation of the complex interactions involved in biological systems. Computer simulation will be used as a tool to analyze and suggest design changes to optimize performance. Prereq: Bio science elective, ME 340, and two "core" courses.

BAE 513 Soil Dynamics in Tillage and Traction (3)
A course for advanced undergraduate and graduate students which presents the principles of dynamic soil-machine interaction. The performance characteristics of tractive devices are presented along with the corresponding soil compliance. Soil response to mechanical disturbance or tillage is also presented. Lecture, two hours; laboratory, two hours per week. Prereq: EM 313, BAE 417.

BAE 515 Fluid Power Systems (3)
Analysis and design of fluid power systems used in agricultural, industrial and processing equipment. Selected topics to include: positive displacement components, control devices, actuators, fluid transmission and system dynamics. Lecture, two
hours; laboratory, two hours per week. Prereq: ME 330, ME 340 and engineering standing.

**BAE 517 Off-Road Vehicle Design (3)**
Morphology, operational characteristics, and design considerations of off-road vehicles used in agriculture, forestry and construction. This course provides an introduction to conceptualization, analysis and design of these vehicles. Topics to be addressed include: engine performance and design, vehicle testing, turbo chargers and intercoolers, drivetrains, chassis mechanics, electronic systems, hydraulic systems, and human factors.

**BAE 532 Stream Restoration (3)**
Introduction to principles of fluvial geomorphology for application in restoring impaired streams. Topics include channel formation processes (hydrology/hydraulics), stream assessment, sediment transport, in-stream structures, erosion control, habitat, and monitoring. Prereq: CE 341 and consent of instructor. (Same as CE 542.)

**BAE 536 Fluvial Hydraulics (3)**
Rainfall physics, principles of erosion on upland areas and construction sites, stable channel design in alluvial material, mechanics of sediment transport, river mechanics, reservoir sedimentation. Prereq: CE 461G, ME 330 and engineering standing. (Same as CE 546.)

**BAE 537 Irrigation and Drainage Engineering (3)**
Planning and design of irrigation system; sprinkler, traveling gun, center pivot, trickle, subirrigation and residential and commercial irrigating; pumps; water quality treatment and supply; ponds and wells; principles of water movement and plant-soil relationships; surface and subsurface drainage. Prereq: ME 330 or CE 341 or consent of instructor.

**BAE 538 GIS Applications for Water Resources (3)**
A study of the principles, methodology and analysis of geographic information systems (GIS) and spatially-referenced data with an emphasis on water resources applications and hydrologic model interfaces. Prereq: Previous coursework in hydrology or consent of instructor.

**BAE 541 Intermediate Fluid Mechanics (3)**
Application of basic fluid mechanics to problems of importance to civil engineering practice. This includes flow measuring, closed conduit flow and pipe networks, open channel flow, turbomachinery (pumps), hydraulic structures, culvert flow. Prereq: CE 341, CS programming course, and engineering standing or consent of instructor. (Same as CE 541.)

**BAE 545 Engineering Hydraulics (3)**
Analysis of flow in closed conduits and natural and artificial open channels. Design of hydraulic structures. Prereq: CE 341, CE 441 and engineering standing. (Same as CE 549.)

**BAE 549 Food and Bioprocess Engineering (3)**
An analysis of the most common unit operations utilized in the processing of food products. The principles of heat and mass transfer and reaction kinetics associated with processing operations will be used in defining process systems for drying, evaporation, refrigeration, freezing, fermentation, etc. Prereq: ME 225 or equivalent.
BAE 556 Solid and Hazardous Waste Management (3)
Study of the generation and management of solid and hazardous wastes. Application of engineering principles to the collection, transport, processing, resource recovery and ultimate disposal of these wastes. Prereq: CE 471G, CE 521 or consent of instructor and engineering standing. (Same as CE 556.)

BAE 580 Heating, Ventilating, and Air Conditioning (3)
A course emphasizing the use of thermodynamics, fluid mechanics, and heat transfer principles in thermal environmental design. Building energy requirements will be computed and thermal comfort criteria will be studied. Prereq: BAE 427 or ME 321 or consent of instructor. (Same as ME 580.)

BAE 581 Physics of Plant and Animal Environments (3)
A study of the thermal, moisture, light, and gaseous components of plant and animal environments with emphasis on interactions between these biological systems and their environments. Prereq: BAE 427 or consent of instructor.

BAE 599 Topics in Agricultural Engineering (2-3)
A detailed investigation of a topic of current significance in agricultural engineering such as: design of small earth dams, vacuum dehydration systems, small particle mechanics, environmental control in greenhouses, sprinkler irrigation, energy conversion in agriculture, bio-simulation. May be repeated to a maximum of six credits, but only three credits can be earned under the same title. A particular topic may be offered at most twice under the BAE 599 number. Prereq: Variable; given when topic identified.
B34. Undergraduate Bioengineering (University of Maryland)

Overview: Total Required Credits by Category for the B.S. in Bioengineering

<table>
<thead>
<tr>
<th>Course Category</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Bioengineering Core Courses</strong></td>
<td>39</td>
</tr>
<tr>
<td><strong>Non-Bioengineering Required Courses</strong></td>
<td>73</td>
</tr>
<tr>
<td><strong>Biological Science Elective Courses</strong></td>
<td>9</td>
</tr>
<tr>
<td><strong>Engineering Science Elective Courses</strong></td>
<td>6</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>127</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Course Number</th>
<th>Course Title/Description</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>BIOE 120</td>
<td>Biology for Engineers [For BIOE majors only.] A combination of lectures and discussions covering biology from a utilization perspective, and lectures on illustrative mathematical models that capture the essences of characteristics of living entities. The biology material will focus on: distinguishing engineering from biological science, principles form the sciences applicable to biology, typical biological responses to environmental stimuli, scaling of biological responses, and different means to utilize living entities.</td>
<td>3</td>
</tr>
<tr>
<td>BIOE 121</td>
<td>Biology for Engineers Laboratory [For BIOE majors only.] This course will build on the material covered in BIOE120. Experiments conducted in this laboratory course will cover topics such as biomechanical principles, biochemical methods, genetics and selection, scaling, microcosm interactions, human factors and imaging</td>
<td>1</td>
</tr>
<tr>
<td>BIOE 241</td>
<td>Biocomputation Methods [Prerequisite: permission of department. Application of computer technology to biological and natural resource systems considering engineering aspects. Designed to help students in the use of computer technology for problem solving. The course will cover 4-5 software packages important for later use by the student.]</td>
<td>3</td>
</tr>
<tr>
<td>BIOE 332</td>
<td>Transport Process Design [Prerequisite: MATH241 and MATH246. Fluid flow, heat transfer, and mass transfer with applications in medicine, environment, biotechnology, food, agriculture, and other biosystems. Design of solutions to current problems in biological engineering is emphasized.]</td>
<td>3</td>
</tr>
<tr>
<td>BIOE 340</td>
<td>Modeling Physiological Systems and Lab [Prerequisite: BIOE120 and BIOE121. Credit will be granted]</td>
<td>4</td>
</tr>
</tbody>
</table>
for only one of the following: BIOE340 or (BSCI440 and BSCI441). Topics covered will include cell and general physiology, membrane physiology, blood cells and clotting, circulation, metabolism, respiration, and the nervous system. A lab component will also be included.

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credits</th>
<th>Prerequisites</th>
</tr>
</thead>
<tbody>
<tr>
<td>BIOE 404</td>
<td><strong>Biomechanics</strong></td>
<td>3</td>
<td>Prerequisite: BIOE120 and BIOE121. For BIOE majors only. Introduction to the fundamentals of biomechanics including force analysis, mechanics of deformable bodies, stress and strain, multiaxial deformations, stress analysis, and viscoelasticity. Biomechanics of soft and hard tissues.</td>
</tr>
<tr>
<td>BIOE 420</td>
<td><strong>Bioimaging</strong></td>
<td>3</td>
<td>Prerequisite: BIOE120, BIOE121, and MATH246. For BIOE majors only. Examines the physical principles behind major biomedical imaging modalities and new ways of using images for bio-related applications.</td>
</tr>
<tr>
<td>BIOE 453</td>
<td><strong>Biomaterials</strong></td>
<td>3</td>
<td>Credit will be granted for only one of the following: BIOE453 or ENMA425. Examination of the structure and function of natural biomaterials, and cell-extracellular matrix interactions. Study physical properties of synthetic biomaterials for biomedical applications. Understanding molecular level interactions between biomolecules and biomaterials to design novel biomaterials with desirable characteristics. Application of biomaterials as implants, drug delivery systems, biosensors, engineered materials such as artificial skin and bone growth scaffolds will be covered. Also offered as ENMA425.</td>
</tr>
<tr>
<td>BIOE 455</td>
<td><strong>Basic Electronic Design</strong></td>
<td>3</td>
<td>Prerequisite: PHYS142 or equivalent; MATH246, and BIOE241. Familiarization with basic electronic circuits and the ability to produce simple electronic designs.</td>
</tr>
</tbody>
</table>
**Bioinstrumentation**
Prerequisite: BIOE455 or permission of department. Study of biomedical instrumentation and biomedical equipment technology. How biomedical equipment is used to measure information from the human body. Hands-on experience with representative biomedical equipment.

**Biological Systems Control**
Prerequisite: BIOE455 or permission of department. Principles of control systems designed by biological engineers and analysis of control mechanisms found in biological organisms. Apparent control strategies used by biological systems will be covered.

**Capstone Design I: Entrepreneurship, Regulatory Issues, and Ethics**
Prerequisite: BIOE455. Senior standing. For BIOE majors only. This is the first part of a two-semester senior capstone design course which covers principles involved in engineering design, design approaches, economics of design, ethics in engineering, and patent regulations. It also helps students learn team work and write design project proposals under the mentorship of a faculty advisor.

**Capstone Design II**
CORE Capstone (CS) Course. Individual Instruction course: contact department or instructor to obtain section number. Prerequisite: BIOE485 taken in the immediately preceding semester. Senior standing. For BIOE majors only. This is the second part of the senior capstone design course. This part is independent instruction where faculty mentoring each project team works with students to order supplies, fabricate their proposed design under BIOE485, test the design, write the report and present it to their fellow seniors and board of faculty mentors. Students are taught to convert the blue print of a design to actual device and test it.

**Total:** 39

### Non-Bioengineering Required Courses

<table>
<thead>
<tr>
<th>Course Number</th>
<th>Course Title/Description</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>MATH 140</td>
<td>Calculus I</td>
<td>4</td>
</tr>
<tr>
<td>MATH 141</td>
<td>Calculus II</td>
<td>4</td>
</tr>
<tr>
<td>MATH 241</td>
<td>Calculus III</td>
<td>4</td>
</tr>
<tr>
<td>MATH 246</td>
<td>Differential Equations for Scientists and Engineers</td>
<td>3</td>
</tr>
<tr>
<td>PHYS 161</td>
<td>General Physics: Mechanics and Particle Dynamics</td>
<td>3</td>
</tr>
</tbody>
</table>
### Sample Bioengineering Program, Undergraduate

The undergraduate program is designed to be completed in 4 years. It is very important to follow the sample program as closely as possible, as nearly all BIOE classes are only offered once a year. All Bioengineering majors must participate in an advising session prior to registering each semester. Students are assigned a faculty advisor at the start of their first semester in the major.

Courses appearing in **bold** are offered by the Fischell Department of Bioengineering.
Questions about the undergraduate program in bioengineering may be sent to bioe-undergrad@umd.edu.

You may also wish to consult the Bioengineering Undergraduate Student Handbook (PDF).

### Freshman Year: Fall Semester

<table>
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<tr>
<th>Course</th>
<th>Cr</th>
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<tbody>
<tr>
<td>ENES 100</td>
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<td>ENES 102</td>
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<td>MATH 140</td>
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<td>MATH 141</td>
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<tr>
<td>CHEM 135</td>
<td>3</td>
<td>PHYS 161</td>
<td>3</td>
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<tr>
<td>CHEM 136</td>
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<td>CORE I*</td>
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<tr>
<td>BIOE 120</td>
<td>3</td>
<td>ENGL 101</td>
<td>3</td>
</tr>
<tr>
<td>BIOE 121</td>
<td>1</td>
<td>Introduction to Writing</td>
<td></td>
</tr>
</tbody>
</table>

**Total 5**

* *Applied Ethics and Public Policy in Bioengineering (BIOE 150) is one option for CORE SB credit. It is offered in both the fall and spring semesters. Please note it will not be accepted as an Engineering Science or Biological Science elective.*

### Freshman Year: Spring Semester

<table>
<thead>
<tr>
<th>Course</th>
<th>Cr</th>
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<tr>
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<td>3</td>
<td></td>
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<tr>
<td>CORE I*</td>
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<td>ENME 331 Fluid Mechanics</td>
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<td>BIOE 455 Basic Electronic Design</td>
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<td>Biological Science Elective I</td>
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<td>BIOE 471 Biological Systems Control</td>
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**Senior Year: Spring Semester**

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<td>BIOE 404 Biomechanics</td>
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<td>BIOE 486 Capstone II</td>
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**TOTAL CREDITS: 127**
B35. Undergraduate Biological Engineering (University of Maine)

Program Description

The program follows the “process engineering” approach. During the first five terms the Biological Engineering (BLE) and Chemical Engineering (CHE) programs are essentially the same. The required courses cover both the scientific foundations of the subject and the relevant engineering sciences such as thermodynamics, kinetics, fluid mechanics and unit operations. The CHE and BLE programs diverge for the last three terms during which the courses are more discipline specific. A major advantage of this arrangement is that students can transfer freely between BLE and CHE until the second term of the junior year. Additional information about the program is available on the Web at [http://www.umche.maine.edu/chb/](http://www.umche.maine.edu/chb/)

The program provides a broad base of knowledge for engineering practice in today’s society. The curriculum includes core courses in engineering, mathematics and science combined with electives in engineering, humanities, and social sciences. Degrees are awarded upon satisfactory completion of 130 credits with a cumulative grade point average of not less than 2.0 in Chemical and Biological Engineering courses, including technical electives. The program in Biological Engineering is accredited by the Engineering Accreditation Commission of ABET, 111 Market Place, Suite 1050, Baltimore, MD 21202-4012 - telephone: (410) 347-7700.

The undergraduate program prepares students for immediate employment as well as graduate studies. The degree of Master of Science (Biological Engineering) is also offered in the Department. Several assistantships are available. The program is described in the University of Maine Graduate School online Catalog and on the Web at: [http://www2.umaine.edu/graduate/](http://www2.umaine.edu/graduate/)

Cooperative Work Experience Program Option in Chemical Engineering

Students with satisfactory academic standing at the end of their fourth semester may elect to participate in the “Co-Op” program. This fifteen month program involves two fourteen-week sessions of paid, supervised professional experience as a junior engineer. The Co-Op sessions are typically scheduled during alternating semesters of the third year with a semester of coursework between the sessions. Students are able to participate in the Co-Op experience and still graduate in four years by scheduling one of the third-year semesters of coursework during a summer term. Participating students must register for six credits which, in general, cannot be substituted for the courses required for the BS degree. Students who do their Co-Op work experience within the Pulp and Paper sector are strongly advised to take the introductory course PPA 264 prior to their first Co-Op term. This 200-level course is allowed to satisfy a technical elective requirement for those students.

Suggested curriculum for the B.S. in Biological Engineering

The recommended sequence of the four-year curriculum is outlined below. Copies can also be obtained in the College of Engineering office with detailed explanation of the requirements. This program can be adapted to a student’s special scheduling needs in consultation with an academic advisor.

First Year - First Semester
First Year - Second Semester

- **CHB 112 - Introduction to Chemical and Biological Engineering II** Credits: 2
- **CHY 122 - The Molecular Basis of Chemical Change** Credits: 3
- **CHY 124 - The Molecular Basis of Chemical Change Laboratory** Credits: 1
- **MAT 127 - Calculus II** Credits: 4
- **PHY 122 - Physics for Engineers and Physical Scientists II** Credits: 4
- Human Values and Social Context Elective 1. Credits: 3

Second Year - First Semester

- **BIO 100 - Basic Biology** Credits: 4
- **CHB 200 - Fundamentals of Process Engineering** Credits: 4
- **CHY 251 - Organic Chemistry I** Credits: 3
- **CHY 253 - Organic Chemistry Laboratory I** Credits: 2
- **MAT 228 - Calculus III** Credits: 4

Second Year - Second Semester

- **CHB 350 - Statistical Process Control and Analysis** Credits: 3
- **CHE 385 - Chemical Engineering Thermodynamics I** Credits: 3
- **ECE 209 - Fundamentals of Electric Circuits** Credits: 3
  - or PPA 264 - Introduction to the Pulp and Paper Industry¹
- **MAT 258 - Introduction to Differential Equations with Linear Algebra**
  - Credits: 4
- Human Values and Social Context Elective 2. Credits: 3

¹ Students who are cooping in pulp and paper related industry should take PPA 264 as a technical elective in place of ECE 209 in the fourth term of the program. They should take ECE 209 in place of one of the technical electives later in the program.

Third Year - First Semester

- **BMB 300 - General Microbiology** Credits: 3
- **BMB 305 - General Microbiology Laboratory** Credits: 2
- **CHE 352 - Process Control** Credits: 3
- **CHE 360 - Elements of Chemical Engineering I** Credits: 4
- **MEE 252 - Statics and Strength of Materials** Credits: 3
- Human Values and Social Context Elective 3. Credits: 3
Third Year - Second Semester

- BMB 322 - Biochemistry Credits: 3
- BMB 323 - Biochemistry Laboratory Credits: 1
- CHE 361 - Chemical Engineering Laboratory I Credits: 3
- CHE 362 - Elements of Chemical Engineering II Credits: 4
- CHE 368 - Kinetics and Reactor Design Credits: 3
- Technical Elective 1. Credits: 3

Fourth Year - First Semester

- BLE 492 - Design Project Credits: Ar
- CHB 460 - Biochemical Engineering Credits: 3
- CHB 493 - Chemical and Biological Engineering Seminar Credits: 0-1
- CHE 363 - Chemical Engineering Laboratory II Credits: 3
- CHE 477 - Elements of Chemical Process Design Credits: 3
- Human Values and Social Context elective 4. Credits: 3

Fourth Year - Second Semester

- BLE 492 - Design Project Credits: Ar
- CHB 493 - Chemical and Biological Engineering Seminar Credits: 0-1
- Human Values and Social Context Elective 5. Credits: 3
- Human Values and Social Context Elective 6. Credits: 3
- Technical Elective 2. Credits: 3
- Technical Elective 3. Credits: 3

Special Requirements

Approved Technical Electives (9 credits):
The program requires 9 credits of engineering elective courses. A list of preapproved electives is available at [http://www.umche.maine.edu/chb/undergrad/techelec.htm](http://www.umche.maine.edu/chb/undergrad/techelec.htm). Students may also select other courses with approval of the Chair of the Department of Chemical and Biological Engineering.

Fundamentals of Engineering Examination
Students are encouraged to take the FE examination.
B36. Undergraduate Biological Engineering (University of Missouri)

Program Description

Biological Engineering (BE) is a science-based engineering discipline that integrates engineering and biological sciences in one curriculum.

Biological engineers develop products and design systems or processes for improvement of human and animal health, use of bioresources, and protection of the environment.

BE is a broad-based curriculum that prepares students for careers in three areas:

* **Biomedical Engineering (including pre-medicine)**
  
  integrates physical, chemical or mathematical sciences and engineering principles for the study of biology, medicine and physiology. It advances fundamental concepts, creates knowledge from the molecular to the organ systems levels, and develops innovative biologics, materials, processes, implants, devices, and informatics approaches for the prevention, diagnosis, and treatment of disease, for patient rehabilitation, and for improving health.

* **Bioprocess Engineering**
  
  Involves the design and development of efficient and environmentally responsible systems to economically manufacture food, chemical and pharmaceutical products from renewable biological materials such as microbial, animal and plant cells, enzymes and appropriate by-products. The Bioprocess Engineering specialty encompasses food engineering, which covers processing, packaging and distribution of food, and is expanding into the manufacture of industrial products from renewable bio-resources. Bioprocess engineers play a key role in use of knowledge from the new biotechnology revolution to provide products that improve the quality of life, while preserving the environment through bioremediation and the abatement and proper use of wastes.

* **Bioenvironmental Engineering**
  
  The application of engineering principles with natural systems to sustain and manage environmental quality through proper system design, construction and management. The Bioenvironmental Engineering specialty integrates physical, biological and environmental sciences with engineering skills to develop economical methods for improving water and air quality, wastewater treatment, water management and soil remediation. Using their combined skills of engineering, environmental sciences and biotechnology, bioenvironmental engineers are well-qualified to address the issues that contribute to improved quality of life while preserving our environment.

Degree Program

The Bachelor of Science in Biological Engineering (BSBE) program at MU is accredited by the Accreditation Board for Engineering and Technology (ABET).

Graduates are well-prepared to take the Fundamentals of Engineering (FE) exam during their senior year, which is the first step towards obtaining a Professional Engineer (PE) license.

The curriculum encompasses basic sciences (math, physics, chemistry, biochemistry and biology), social and behavioral sciences, humanities and fine arts, engineering sciences and topics (computer science, mechanics, thermodynamics), and program core courses.

The core courses cover topics of biological engineering principles and design, including bioenergetics, biosystem modeling, biomechanics, transport phenomena in biosystems, bioelectronics and instrumentation.
A capstone design course requires students to apply the knowledge and skills they have gained by completing a design project under the direction of a faculty adviser. Technical electives allow students to have an emphasis in one of the three areas (biomedical, bioprocess or bioenvironmental engineering).

**BE Program Mission and Educational Objectives**

**BE Program Mission**

To prepare Biological Engineering graduates for productive careers characterized by continual professional growth.

**BE Program Educational Objectives**

The undergraduate program produces graduates with a Bachelor of Science degree in Biological Engineering, who will, in 3-5 years:

1. Show proficiency in engineering analysis, development and design.
2. Interact effectively with life science and other professionals.
3. Effectively integrate biological and engineering sciences in the design, innovation and development of systems and processes for improved health, bioresource utilization and environmental protection.
4. Exhibit professionalism as they continually add value to their chosen field of endeavor.
5. Succeed in advanced studies in engineering, medicine or veterinary medicine, if pursued.

**Career Opportunities**

Biological engineering is a relatively new branch of engineering education, but it has had a long history of practice in the industries of medicine, food, agriculture, environment protection, etc. In the past two decades, the advances in life sciences have led to the establishment of an entirely new industry of biotechnology, which is increasing the demand for biological engineers.

As a biological engineer, you will have engineering expertise related to biological systems. You may design systems and processes for medical applications, production of biologically derived products such as pharmaceuticals, or biological treatment of pollutants.

Or, you may develop new food and fiber products or products that efficiently use bioresources in an environmentally friendly manner. BE graduates are hired by biotechnology, medical, pharmaceutical, food, and agricultural companies and government agencies. Some attend graduate and medical schools.

**Research Opportunities**

Faculty often hire undergraduate students as research assistants. This provides hands-on experiences and broadens the education for students. Research projects are in various areas of biomedical, bioprocessing and bioenvironmental engineering.

Arrangements for research assistant positions are generally made through individual contacts between students and faculty. Students are encouraged to contact the faculty working in their areas of interest. In addition, some divisions of the University provide on-campus internships for students to participate in research activities.
Biological Engineering Curriculum
2008-2009

Mathematics & Statistics (19 cr)
  Math 1500 Calculus I (5)
  Math 1700 Calculus II (5)
  Math 2300 Calculus III (3)
  Math 4100 Differential Equations (3)
  Statistics (from approved list) (3)

Basic Science (29 cr)
  Phys 2750 University Physics I (5)
  Phys 2760 University Physics II (5)
  Chem 1320 General Chemistry II (3)
  Chem 2050/2100 Organic Chemistry (5-3)
  Biol 1500 Intro to Bio Systems (5)
  Bio Science (from approved list) (6-8)

General Education (21 cr)
  Social and Behavioral Sciences (9)
    Includes - Economics and Am History or Government
  English 1000 Exposition and Argumentation (3)
  Humanistic Studies and Fine Arts (9)

Basic Engineering (17 cr)
  Engr 1100 Engineering Design Graphics (2)
  Engr 1200 Statics (3)
  Engr 2200 Strength of Materials (3)
  BioEn 2080 Programming for Engineers (3)
  Fluid Mechanics (from approved list) (3)
  Thermodynamics (from approved list) (3)

Biological Engineering (19 cr)
  BE 1000 Intro to Biological Engineering (1)
  BE 2000 Professional Development (2)
  BE 2180 Engineering Analysis of Bioprocesses (3)
  BE 3180 Heat & Mass Transfer in Bio Systems (3)
  BE 4280 Survey of BioEngineering Techniques (3)
  BE 4380 Applied Electronic Instrumentation (4)
  BE 4980 Biological Engineering Design (3)

Technical Elective Courses (18 cr) – to develop a technical emphasis
  All must be upper-level engineering courses

Math, statistics, science, or engineering courses to make up 126 credit hours

June 3, 2008
# Universities in USA and Canada Offering Programs of Studies in Biosystems Engineering or Related Disciplines

**Biological Engineering**  
2008-2009 Sample Study Program

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<td>Chem 1320 General Chemistry II</td>
<td>Biol 1500 Intro to Biological Systems</td>
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<td>Engr 1100 Engineering Design Graphics</td>
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<td>Physics 2780 Univ Physics II</td>
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<td>BioEn 2180 Analysis of Bioprocesses</td>
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<td>Technical Elective</td>
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June 3, 2008
**Biological Engineering**
Technical Electives 2007-2008
February 28, 2008

**Bioenvironmental Emphasis**
BE 4150 Soil and Water Conservation Engineering
BE 4250 Irrigation and Drainage Engineering
BE 4350 Watershed Modeling Using GIS
CE 3230 Introduction to Water Quality
CE 3400 Soil Mechanics
CE 4210 Solid Waste Management
CE 4220 Hazardous Waste Management
CE 4230 Water and Wastewater Treatment
CE 4240 Water Quality Analysis
CE 4250 Environmental Regulatory Compliance
CE 4280 Sanitary Engineering Chemistry
CE 4700 Hydraulics of Open Channels
CE 4406 Landfills

**Bioprocessing Emphasis**
BE 3170 Biomaterials
BE 4160 Food Process Engineering I
BE 4480 Physics and Chemistry of Materials
ChE 2225 Mass and Energy Balance
ChE 3234 Principles of Chemical Engineering I
ChE 3235 Principles of Chemical Engineering II
ChE 3262 Chemical Engineering Thermodynamics II
BE/ChE 4314 Biochemical Engineering Operations
BE/ChE 4315 Introduction to Biochemical Engineering
ChE 4319 Introduction Polymer materials
ChE 4321 Introduction to Ceramic Materials
ChE 4363 Chemical Reaction Engineering and Technology

**Biomedical Emphasis**
BE 3170 Biomaterials
BE 4001s1 Orthopaedic Biomechanics
BE 4001s2 Modeling and Experiments in Neuroscience
BE 4070 Bioelectricity
BE 4170 Biomaterials Interfaces for Implantable Devices
BE 4470 Biomolecular Engineering & Nanobiotechnology
BE 4570 Biomedical Imaging
BE 4670 Photonics and Nanotech in Biosensors
BE 4770 Biomedical Optics
BE 4870 Molecular and Cell Mechanics
BE 4080 Engineering Computation
BE 4480 Physics and Chemistry of Materials
Biomechanics emphasis (choose up to 5-6 courses)

All biomedical engineering majors should take one of the following physiology courses:
- An Sci 3254 Physiology of Domestic Animals
- Bio 5700 Animal Physiology
- Physiol(MPP) 3202 Elements of Physiology

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<td>BE 3170</td>
<td>Biomaterials (WI)</td>
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<td>BE 4480</td>
<td>Chemistry/Physics of Materials</td>
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<tr>
<td>BE 4870</td>
<td>Molecular and Cell Biomechanics</td>
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<tr>
<td>BE 4570</td>
<td>Biomedical Imaging</td>
<td>3</td>
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<tr>
<td>BE 4170</td>
<td>Biomaterials Interface</td>
<td>3</td>
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<tr>
<td>BE 4080</td>
<td>Engineering Computation</td>
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<td>BE 4580</td>
<td>Mechanical Systems Engineering</td>
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<td>MAE 2600</td>
<td>Dynamics</td>
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<td>Advanced CAD</td>
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<td>MAE 3200</td>
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<td>MAE 4280</td>
<td>Finite Element Analysis</td>
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<td>MAE 4680</td>
<td>Introduction to MEMS</td>
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February 28, 2008
Biophotonics Emphasis (choose up to 5-6 engineering courses)

All biomedical engineering majors should take one of the following physiology courses:
- An Sci 3254 Physiology of Domestic Animals
- Bio3700 Animal Physiology
- Physiol(MPP) 3202 Elements of Physiology

<table>
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<td>Biomedical Optics</td>
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<td>BE 4080</td>
<td>Engineering Computations</td>
<td>3</td>
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<tr>
<td>BE 4070</td>
<td>Bioelectricity</td>
<td>3</td>
</tr>
<tr>
<td>BE 4670</td>
<td>Photonics and Nanotech in Biosensors</td>
<td>3</td>
</tr>
<tr>
<td>BE 4470</td>
<td>Biomolecular Engr &amp; Nanobiotechnology</td>
<td>3</td>
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<td>ECE-4570(NU ENG 4352)</td>
<td>Lasers and Their Applications</td>
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<td>ECE 4610</td>
<td>Physical Electronics</td>
<td>3</td>
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<td>ECE 4850</td>
<td>Introduction to Digital Image Processing</td>
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<tr>
<td>ECE-4830</td>
<td>Introduction to Digital Signal Processing</td>
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This course can be utilized as a science elective:

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<th>Course Number</th>
<th>Title</th>
<th>Credits</th>
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<tbody>
<tr>
<td>Physics 4110</td>
<td>Light and Modern Optics</td>
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February 28, 2008
Biomaterials Emphasis (choose up to 5-6 courses)

All biomedical engineering majors should take one of the following physiology courses:

- An Sci 3254  Physiology of Domestic Animals
- Bio3700  Animal Physiology
- Physiol(MPP) 3202  Elements of Physiology

<table>
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<tbody>
<tr>
<td>BE 3170</td>
<td>Biomaterials (WI)</td>
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<tr>
<td>BE 4170</td>
<td>Biomaterials Interfaces</td>
<td>3</td>
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<tr>
<td>BE 4570</td>
<td>Biomedical Imaging</td>
<td>3</td>
</tr>
<tr>
<td>BE 4480</td>
<td>Chemistry/Physics of Materials</td>
<td>3</td>
</tr>
<tr>
<td>BE 4870</td>
<td>Molecular and Cell Biomechanics</td>
<td>3</td>
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<tr>
<td>BE 4080</td>
<td>Engineering Computation</td>
<td>3</td>
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<tr>
<td>BE 4470</td>
<td>Biomolecular Engr &amp; Nanobiotechnology</td>
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<tr>
<td>ChemE 4319</td>
<td>Intro. to Polymers</td>
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<tr>
<td>ChemE 4320</td>
<td>Plasma Polymerization</td>
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<tr>
<td>ChemE 4321</td>
<td>Intro. to Ceramics</td>
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<td>MAE 3200</td>
<td>Engineering Materials</td>
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This course can be utilized as a science elective:

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<tbody>
<tr>
<td>Physics 4310</td>
<td>Physics in Cell and Developmental Biology</td>
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</table>

February 28, 2008
Bioinstrumentation or Bioelectronics Emphasis (choose up to 5-6 courses)

All biomedical engineering majors should take one of the following physiology courses:

- An Sc 3254 Physiology of Domestic Animals
- Bio3700 Animal Physiology
- Physiol(MPP) 3202 Elements of Physiology

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<thead>
<tr>
<th>Course Number</th>
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<td>BE 4770</td>
<td>Biomedical Optics</td>
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<tr>
<td>BE 4080</td>
<td>Engineering Computation</td>
<td>3</td>
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<tr>
<td>BE 4070</td>
<td>Bioelectricity</td>
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<tr>
<td>BE 3170</td>
<td>Biomaterials (WI)</td>
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<tr>
<td>ECE 2100</td>
<td>Circuit Theory I</td>
<td>3</td>
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<tr>
<td>ECE 3810</td>
<td>Circuit Theory II</td>
<td>3</td>
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<td>ECE 4570(NU ENG 4382)</td>
<td>Lasers and Their Applications</td>
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<td>ECE 4830</td>
<td>Introduction to Digital Signal Processing</td>
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<td>ECE 4850</td>
<td>Introduction to Digital Image Processing</td>
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<td>MAE 3800</td>
<td>Instrumentation and Measurements Laboratory</td>
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<td>MAE 4680</td>
<td>Introduction to MEMS</td>
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These courses can be utilized as the science electives:

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<tr>
<td>DMU 4200</td>
<td>Principles of Diagnostic Medical Ultrasound</td>
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</tr>
<tr>
<td>NUCMED 4327</td>
<td>Nuclear Medicine Instrumentation</td>
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February 28, 2008
Biological Engineering
Course Selections 2008-2009
October 27, 2008

Statistics Courses
Stat 4710 Introduction to Mathematical Statistics
Stat 2530 Statistical Methods in Natural Resources
IMSE 2110 Probability & Statistics for Engineers
BE/ChE 4270 SQC & DOE for Engineers

Biological and Related Science Courses
Bio 2200 Genetics
Bio 2300 Cell Biology
Bio 3700 Animal Physiology
Bio 4990 Histology
Bio 4976 Molecular Biology
An Sci 3254 Physiology of Domestic Animals
MPP 3202 Elements of Physiology (Human) MPP = medical pharmacology & physiology
DMU 4200 Principles of Diagnostic Medical Ultrasound
Nucmed Nuclear Medicine Instrumentation
Physics 4110 Light and Modern Optics
Physics 4310 Physics in Cell and Developmental Biology
Soil Sci 2100 Introduction to Soils
Soil Sci 2106 Soil Science Laboratory
Plt Sci 2110 Plant Growth and Culture
Plt Sci 2120 Plant Science Lab
Plt Sci 3215 Genetics of Agricultural Plants and Animals
Plt Sci 3235 Plant Environments
Plt Sci 4313 Soil Fertility and Plant Nutrition
Plt Sci 4314 Soil Fertility and Plant Nutrition (lab)
Plt Sci 4315 Crop Physiology
Plt Sci 4320 Plant Physiology
Soils 3290 Soils and the Environment
Soils 4312 Soil Microbiology
Soils 4318 Environmental Soil Chemistry
FSN 2172 Intro to Food Microbiology
FSN 4310 Food Chemistry
FSN 4370 Food Microbiology

Courses that do not count toward an engineering degree
Math numbered lower than Math 1500 Calculus I
Chemistry numbered lower than Chem 1320 General Chemistry II
Bio Sc 3100 Community Biology
Indsc 1001 FIG Proseminars

Writing Intensive Courses
All students must complete two Writing Intensive (WI) courses. At least one WI course must be at a 3000 or higher level in your major area of study.
BE 3170 Biomaterials
BE 4980 Biological Engineering Design

Biological Engineering
**Course Selections 2008-2009**

**Social and Behavioral Science Courses**
- Anthropology
- Black Studies
- Economics
- Finance
- Geography
- History
- Peace Studies
- Political Science
- Psychology
- Religious Studies
- Sociology
- Women’s and Gender Studies

**Missouri Constitution (American History or American Government) requirement**
- History 1100  Survey of American History to 1865
- History 1200  Survey of American History Since 1865
- History 1400  American History (no longer offered, but okay for AP credit)
- History 2210  Twentieth Century America
- History 2440  History of Missouri
- History 4000  Age of Jefferson
- History 4220  U.S. Society Between the Wars 1918-1945
- History 4230  Our Times: United States Since 1945
- Poli Sci 1100  American Government
- Poli Sci 2100  State Government

**Humanistic Studies and Fine Arts Courses**
- Art History
- Black Studies
- Classical Humanities
- Communications
- English Literature
- Music Appreciation
- Philosophy
- Religious Studies
- Theatre
- Women and Gender Studies

Foreign Language can meet the requirement if three courses are taken (12 or more cr hr).

**Suggested Courses:**
- Comm 1200  Speech Communications
- Phil 1150  Introduction to Bioethics
- Phil 2400  Ethics and the Professions
- Phil 4510  Medical Ethics

**Engineering Courses**

**Thermodynamics Courses**
- Engr 2300  Engineering Thermodynamics
- ChE 3261  Chem Engr Thermodynamics I

**Fluid Mechanics Courses**
- CVE 3700  Fluid Mechanics
- MAE 3400  Fluid Mechanics
- BE 3070  Biological Fluid Mechanics

**Computing and Applications Courses**
- BE 2060  Programming for Engineers (preferred)
  If transferring from another major or extenuating circumstances:
  - CECS 1040  Introduction to Problem Solving and Programming
  - CECS 1050  Algorithm Design and Programming I
  - MAE 2100  Computer Programming

October 27, 2008
B37. Undergraduate Bioengineering (Montana State University)

Bioengineering Electives

Proposed August 12, 2009, Updated: March 26, 2010

Fall Semester Options

BIOE 428 (formerly BIOL 424) Freshwater Ecology, 3 cr, Fall (pre-requisite: BIOE 370, formerly BIOL 303 Ecology)

BIOB 476 (formerly BIOL 466R) Gene Construction, 3 cr, Fall, (pre-req: BCH 380, formerly BCHM 340)

LRES 453 Soil & Environmental Physics, 3 cr, Fall (odd years) (pre-req: LRES 201 recommended, M 170 Survey of Calculus)

PSPP 423 Mycology, 3 cr, Fall (even years) (Pre-req: BIOC 170, formerly BIOL 101)

PSPP 424 Ecology of Fungi, 3 cr, Fall (odd years) (Pre-req: BIOC 170 formerly BIOL 101, and BIOC 256 formerly BIOC 213)

BIOM 450 (formerly MB 420) Microbial Physiology, 3 cr, Fall (pre-req: BCH 380 formerly BCHM 340, BIOM 360 formerly MB 301)

BCH 441 (formerly BCHM 441) Biochemistry of Macromolecules, 3 cr, Fall, (pre-req: BCH 380 formerly BCHM 340 B or higher)

Spring Semester Options

BIOB 425 (formerly BIOL 302) Advanced Cell & Molecular Biology, 3 cr, Spring (pre-req: BCH 380 formerly BCHM 340)

BIOE 370 (formerly BIOL 303 Principles of Ecology, 3 cr, Spring, (pre-req: BIOC 170 formerly BIOL 101, M 170)

BIOH 455 (formerly BIOL 467) Molecular Medicine, 3 cr, Spring (pre-req: BIOC 375 formerly BIOL 301 Genetics, BCH 380 formerly BCHM 340 Biochemistry)

LRES 452 Soil & Environmental Microbiology, 3 cr, Spring (pre-req: CHMY 143 (CHEM 132), LRES 201 Soil resource, MB 301)

LRES 460 Soil Remediation, 3 cr, Spring (pre-req: LRES 201 or permission of instructor)

BIOM 415 (formerly LRES 415/MB 415) Microbial Diversity, Ecology & Evolution, 3 cr, Spring (Pre-req: BCH 380, BIOM 360, formerly BCHM 340, MB 301)

PSPP 426 Plant Biotechnology, 3 cr, Spring (BCHM 340)

HDFN 451R Sustainable Food Systems, 3 cr, Spring (even years) (pre-req: HDFN 221 Human Nutrition or consent of instructor)

BIOM 410 (formerly MB 449) Microbial Genetics, 3 cr, Spring (pre-req: MB 301, BCHM 340)

BREN 434 Ground Water Supply and Remediation, 3 cr, Spring, (pre-req: EM 335 Fluid Mechanics)

BREN 441 Natural Treatment Systems, 3 cr, Spring, (pre-req: CE 340)
B38. Undergraduate Agricultural & Biological Engineering (University of Nebraska)

Agricultural Engineering Curriculum

130 total credit hours are required for graduation with a B.S. in Agricultural Engineering. For more detail on the department courses listed below, consult the on-line version of the Undergraduate Bulletin. Adobe Acrobat required.

Although the curriculum can be completed in eight semesters, many students take longer in order to participate in internships and co-op assignments with companies, international exchange studies, and part-time research projects in the department. These opportunities give AGEN students practical, hands-on experience to learn about careers in engineering.

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<th>Semester 1</th>
<th>Credit hours</th>
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<tbody>
<tr>
<td>AGEN 100</td>
<td>Introduction to Agricultural Engineering</td>
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<td>CHEM 109</td>
<td>General Chemistry I</td>
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<tr>
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<tr>
<td>AGEN 112</td>
<td>Engineering in AGEN and BSEN</td>
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<tr>
<td>CHEM 110</td>
<td>General Chemistry II</td>
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<td>Introduction to CAD</td>
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<td>AGEN 225</td>
<td>Engineering Properties of Biological Materials</td>
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<td>ENGM 223</td>
<td>Engineering Statics</td>
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<tr>
<td>JGEN 200</td>
<td>Technical Communication</td>
<td>3</td>
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<tr>
<td>MATH 208</td>
<td>Analytic Geometry and Calculus III</td>
<td>4</td>
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<td>PHYS/ASTR 212</td>
<td>General Physics II</td>
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<tr>
<td>ENGM 373</td>
<td>Engineering Dynamics</td>
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<td>ISME 206</td>
<td>Engineering Economy I</td>
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<td>MATH 221</td>
<td>Differential Equations</td>
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<td>MECH 200</td>
<td>Engineering Thermodynamics</td>
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<td>Fluid Mechanics</td>
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<td>ELEC 211</td>
<td>Elements of Electrical Engineering I</td>
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<tr>
<td>ENGM 325</td>
<td>Mechanics of Elastic Bodies</td>
<td>3</td>
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<td>Interpersonal Relations</td>
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<td>ACE</td>
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<td>AGEN 325</td>
<td>Power Systems</td>
<td>3</td>
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<td>AGEN 344</td>
<td>Biological &amp; Environmental Transport Processes</td>
<td>3</td>
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<td>IMSE 321 or Math 380</td>
<td>Engineering Statistics &amp; Data Analysis Statistics &amp; Applications</td>
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<tr>
<td>AGEN 424</td>
<td>Machine Design in Agricultural</td>
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Biological Systems Engineering Curriculum

134 total credit hours are required for graduation with a B.S. in Biological Systems Engineering. For more detail on the department courses listed below, consult the on-line version of the Undergraduate Bulletin. Adobe Acrobat required.

Although the curriculum can be completed in eight semesters, many students take longer in order to participate in internships and co-op assignments with companies, international exchange studies, and part-time research projects in the department. These opportunities give BSEN students practical, hands-on experience to learn about careers in engineering.

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<tr>
<th>First Year</th>
<th>Semester 1</th>
<th>Credit hours</th>
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<tr>
<td>BSEN 100</td>
<td>Introduction to Biological Systems Engineering (BSEN)</td>
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<td>BIOS 102</td>
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<td>CHEM 251/253 or 261/263</td>
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<tr>
<td>BIOS 103</td>
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**Semester 6**

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<td>Biological &amp; Environmental Transport Processes</td>
<td>3</td>
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<td>BSEN Elective*</td>
<td>Emphasis area</td>
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<td>Elective</td>
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**Fourth Year**

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<tbody>
<tr>
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**Semester 7**

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<td>Elective</td>
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**Total credit hours required for graduation:** 17 total

**Total credit hours required for graduation:** 134

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### *BSEN Emphasis Courses*

#### Food and Bioproduct Engineering

- **BSEN 303** Principles in Process Engineering | 3
- **BSEN 446** Unit Operations of Biological Processing | 3

#### Biomedical Engineering

- **BSEN 317** Introduction to Biomedical Engineering | 3
- **BSEN 414** Medical Imaging Systems | 3
- **BSEN 416** Introduction to Biomaterials | 3

#### Water and Environment Engineering

- **BSEN 326** Introduction to Environmental Engineering | 3
- **BSEN 350** Water Resources Engineering | 3
- **BSEN 453** Irrigation & Drainage Systems Engineering | 3
- **BSEN 455** Nonpoint Source Pollution Control Engineering | 3
### MECHANICAL TECHNOLOGY IN AGRICULTURE CURRICULUM

#### FIRST YEAR

**First Semester**

<table>
<thead>
<tr>
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<td>*ENGL 3---</td>
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<td>*SPAN 3101</td>
<td>Basic Course in Spanish</td>
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<td>*MATH 3171</td>
<td>Pre-Calculus I</td>
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<td>CHEM 3001</td>
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<td>BIOL 3435</td>
<td>Elementary Botany</td>
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<td>AGED 3005</td>
<td>Agricultural Orientation</td>
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**Second Semester**

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<td>*MATH 3172</td>
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<td>CHEM 3002</td>
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<td>BIOL 4015</td>
<td>General Zoology</td>
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#### SECOND YEAR

**First Semester**

<table>
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<td>ECON 3021</td>
<td>Principles of Economics I</td>
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<td>MATH 3049</td>
<td>Mathematical Analysis for Management Sciences</td>
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<td>GEEG 3011</td>
<td>Engineering Graphics I</td>
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<td>PLSC 3005</td>
<td>Fundamentals of Crop Production</td>
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<td>ELECTIVES **</td>
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**Second Semester**

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<tr>
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<tr>
<td>COMP 3057</td>
<td>Computer Fundamentals</td>
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<tr>
<td>PHCS 3091</td>
<td>Elements of Physics</td>
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<td>PHCS 3092</td>
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<td>General Soils</td>
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#### THIRD YEAR

**First Semester**

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<td>AGEC 4019</td>
<td>Introduction to Farm Management</td>
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<tr>
<td>AGMT 4009</td>
<td>Agricultural Power</td>
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<tr>
<td>SOSC ----</td>
<td>***Elective course in Social Sciences</td>
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<tr>
<td>PLSC 4005</td>
<td>Physiological Principles of</td>
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## COURSES OF INSTRUCTION

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<td>CIEG 4005</td>
<td>Crop Production</td>
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<td>AGEC 4007</td>
<td>Agricultural Surveying</td>
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<tr>
<td></td>
<td>Marketing of Agricultural Products</td>
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### Second Semester

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<tr>
<td>AGMT 4015</td>
<td>Agricultural Machinery I</td>
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<td>AGMT 4005</td>
<td>Farm Electrification</td>
<td>3</td>
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<td>SOSC ------</td>
<td>***Elective course in Social Sciences</td>
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<tr>
<td>AGMT 4028</td>
<td>Farm Service Buildings</td>
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### SUMMER SESSION

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<td>AGMT 4008</td>
<td>Summer Field Practice</td>
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<tr>
<td>AGMT 4990</td>
<td>Supervised Professional Occup. Exp. for Coop Students</td>
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### FOURTH YEAR

#### First Semester

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<tr>
<td>AGMT 4029</td>
<td>Agricultural Products Processing</td>
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<td>AGMT 4035</td>
<td>Soil and Water Management</td>
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<td>AGMT 4036</td>
<td>Seminar in Mechanized Agriculture</td>
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#### Second Semester

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<tr>
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<td>Agricultural Finance</td>
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<td>AGMT 4037</td>
<td>Seminar in Mechanized Agriculture</td>
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Total credits required for this program: 143

* Refer to the Academic Regulations section for information on Advanced Placement.

** The Program in Mechanical Technology in Agriculture requires a minimum of 24 credits in elective courses. In these 24 credits are included twelve credits in Professional electives selected from the offerings of the Department of Agricultural Engineering and related areas and with the authorization of the Director of the Agricultural Engineering Department. The other twelve credits are free electives.

*** The electives in Social Sciences and Humanities require authorization of the Director of the Agricultural Engineering Department.
DEPARTMENT OF AGRICULTURAL ENGINEERING

UNDERGRADUATE COURSES

AGEG 4045. FIELD PRACTICE IN AGRICULTURAL ENGINEERING. Three credit hours. Six weeks of practice during summer. Prerequisite: Fourth year student. Field experience in agricultural engineering during the summer session at the end of the fourth year of studies. The course will be offered in cooperation with governmental agencies or private industry. A written report is required.

AGEG 4046. SOIL AND WATER CONSERVATION ENGINEERING. Three credit hours. Two hours of lecture and one three-hour laboratory per week. Prerequisites: AGRO 3005, CIEG 4005 and GEEG 4015. Agricultural hydrology; analysis and design of erosion and flood control structures; terraces, waterways, dams, reservoirs, spillways, and drop inlets; land leveling and smoothing.

AGEG 4047. AGRICULTURAL POWER ENGINEERING. Three credit hours. Two hours of lecture and one three-hour laboratory per week. Prerequisites: GEEG 4011 and MEEG 4045. Application of mechanics and thermodynamics to problems of energy conversion and transmission in agricultural production and processing; correlation of principles of design, engine characteristics, and basic configuration of tractive and stationary power units.

AGEG 4048. AGRICULTURAL STRUCTURES DESIGN. Three credit hours. Two hours of lecture and one three-hour laboratory per week. Prerequisites: GEEG 3011, GEEG 4012 and ANIN 3005. Functional and structural design of farm buildings; materials, cost estimates, and specifications.

AGEG 4049. SEMINAR IN AGRICULTURAL ENGINEERING. One credit hour. One hour of seminar per week. Prerequisite: AGE 4045. Oral reports and general discussion of the experiences and observations gathered during the summer field practice. Revision and discussion of current research and developments in Agricultural Engineering.

AGEG 4056. AGRICULTURAL MACHINERY ENGINEERING. Three credit hours. Two hours of lecture and one three-hour laboratory per week. Prerequisites: GEEG 4012, GEEG 4015, and PLSC 3005. Design and functional, mechanical, and economic analysis of selected machines and combination of machines used in agricultural production and processing.

AGEG 4057. RURAL ELECTRIFICATION ENGINEERING. Three credit hours. Two hours of lecture and one three-hour laboratory per week. Prerequisites: ELEG 4005 and ANIN 3005. Electrical and electronic fundamentals applied to agricultural production and rural living; selection, installation, and operation of electrical equipment for agricultural applications.

AGEG 4058. AGRICULTURAL ENVIRONMENTAL ENGINEERING. Three credit hours. Two hours of lecture and one three-hour laboratory per week. Prerequisites: ANIN 3005, MEEG 4045, and ELEG 4075. Thermodynamic principles related to agricultural engineering processes and operations; properties of air and air-vapor mixtures; refrigeration; solar radiation; environmental requirements for plants, animals, and agricultural products.

AGEG 4059. AGRICULTURAL MACHINERY SYSTEMS ANALYSIS. Three credit hours. Two hours of lecture and one three-hour laboratory per week. Prerequisites: GEEG 3025 and PLSC 3005. Analysis of current agricultural machinery systems; adaptation and planning for sequential operations; machinery for unique and alternate production and harvesting systems; operational management.

AGEG 4065. AGRICULTURAL IRRIGATION AND DRAINAGE ENGINEERING. Three credit hours. Two hours of lecture and one three-hour laboratory per week. Prerequisites: AGRO 3005, CIEG 4005 and GEEG 4015.
Soil-water-plant relationships, consumptive use, application efficiencies; salinity problems, pumps and pumping. Principles of design, construction, operation, and maintenance of agricultural drainage and irrigation systems.

AGEG 4066. AGRICULTURAL PROCESS ENGINEERING. Three credit hours. Two hours of lecture and one three-hour laboratory per week. Prerequisites: ELEG 4075 and MEEG 4045. Engineering elements in agricultural products processing and materials handling; thermodynamics and mass transfer principles applied to agricultural processes.

AGEG 4990. SELECTED TOPICS. One to three credit hours. One to three hours of lecture per week. Selected topics in Agricultural Engineering. Topics will vary according to the needs and interests of the students and the faculty.

AGEG 4996. AGRICULTURAL ENGINEERING PROJECTS. Two to four credit hours. Supervised projects in areas of agricultural engineering. A written report is required.

AGMT 4005. FARM ELECTRIFICATION. Three credit hours. Two hours of lecture and one three-hour laboratory per week. Prerequisite: PHCS 3172, or PHCS 3152, or PHCS 3091. Application of electrical energy to agricultural production and rural living. Fundamentals of selection, installation, operation, and maintenance of electrical farm equipment; safety rules and regulations.

AGMT 4006. WOOD SHOP PRACTICES. Two credit hours. One hour of lecture and one three-hour laboratory per week. Selection, care and use of hand power tools, shop skills including farm carpentry pipe fitting, cold metal work, tool fitting and painting, and farm shop safety.

AGMT 4007. METALWORKING AND WELDING. Two credit hours. One hour of lecture and one three-hour laboratory per week. Shop skills including hot metal work, soldering and sheet metal work, electric arc welding, and oxyacetylene welding and cutting; organization and management of the farm shop.

AGMT 4008. SUMMER FIELD PRACTICE. Three credit hours. Six weeks duration. Prerequisite: Consent of the Director of the Department. Practical field experience in agricultural engineering activities, covering a minimum of six weeks during the Summer Session at the end of the student's Junior year. The course will be administered in cooperation with appropriate government agencies and organizations of private industry. A satisfactory written report will be required.

AGMT 4009. AGRICULTURAL POWER. Three credit hours. Two hours of lecture and one three-hour laboratory per week. Prerequisite: PHCS 3171, or PHCS 3151, or PHCS 3091. Sources, measurement, transmission, and economic application of mechanical power on the farm; principles of construction and operation of various types of farm power units, with particular emphasis on internal combustion engines; classification, selection, operation, and maintenance of farm tractors.

AGMT 4015. AGRICULTURAL MACHINERY I. Three credit hours. Two hours of lecture and one three-hour laboratory per week. Prerequisite: PHCS 3171, or PHCS 3151, or PHCS 3091. Principles of construction and operation, maintenance procedures, power relationships, and economic utilization of the main tillage, planting, cultivating, and other related agricultural machinery.

AGMT 4017. SAFETY IN AGRICULTURE. Two credit hours. Two hours of lecture per week. Principles of personnel and property protection as applied to agricultural operations and use of agricultural machinery, with emphasis on the development of a philosophy of safety as a basis for effective accident prevention; a critical review and analysis of agricultural accidents in Puerto Rico.

AGMT 4018. COMPUTER PROGRAMMING IN AGRICULTURE. Two credit hours. Two hours of lecture per week. Prerequisite: MATH 3172. Introductory course to computer technology and programming using BASIC language, with emphasis on applications to agriculture.
AGMT 4019. FARM DRAINAGE AND IRRIGATION. Three credit hours. Two hours of lecture and one three-hour laboratory per week. Prerequisite: AGRO 3005. Principles of irrigation and drainage of farm lands. Drainage systems, sources of water supply, water quality. Irrigation distribution systems: through gravity, sprinkler or trickle.

AGMT 4025. AGRICULTURAL MACHINERY II. Three credit hours. Two hours of lecture and one three-hour laboratory per week. Prerequisites: AGMT 4009 and AGMT 4015. Further study of agricultural machinery, covering fertilizing, pest control, harvesting, feed processing, and other agricultural machines, including those recently developed; principles of construction and operation, power relationships, maintenance procedures, and economic utilization.

AGMT 4026. DAIRY MECHANICS. Three credit hours. Two hours of lecture and one three-hour laboratory per week. Prerequisite: ANIN 3005 and (PHCS 3171, or PHCS 3151, or PHCS 3091). Construction, installation, operation, and management of mechanical equipment used in dairy enterprises.

AGMT 4028. FARM SERVICE BUILDINGS. Three credit hours. Two hours of lecture and one three-hour laboratory per week. Prerequisites: ANIN 3005 and GEEG 3011 and (PHCS 3091 or PHCS 3151 or PHCS 3171). Functional requirements and planning; materials of construction; construction principles and procedures, with particular reference to the major types of farm service building.

AGMT 4029. AGRICULTURAL PRODUCTS PROCESSING. Three credit hours. Two hours of lecture and one three-hour laboratory per week. Prerequisite: PHCS 3091 or PHCS 3151 or PHCS 3171. Unit operations, equipment, techniques, and processes used in handling and preparing farm products for marketing, utilization, or storage.

AGMT 4035. SOIL AND WATER MANAGEMENT. Four credit hours. Three hours of lecture and one three-hour laboratory per week. Prerequisites: AGRO 3005 and CIEG 4005. Soil-water plant relationships: principles and practice of irrigation and drainage of farm lands; land improvement by means of mechanical procedures, or structures for soil and water management and conservation.

AGMT 4036-4037. SEMINAR IN MECHANIZED AGRICULTURE. One credit hour per semester. One meeting per week each semester. Prerequisite: AGMT 4008 or consent of the Director of the Department. Oral reports and discussion concerning experiences and observations gathered during the summer field practice. During the second semester, emphasis will be on a review and discussion of current developments, in the field of agricultural engineering.

AGMT 4038. AGRICULTURAL HYDROLOGY. Three credit hours. Two hours of lecture and one three-hour laboratory per week. Prerequisite: PHCS 3171, or PHCS 3151, or PHCS 3091. The hydrologic cycle, including weather elements and climate, precipitation, evaporation, transpiration, infiltration, and run-off as related to soil and water management and control.

AGMT 4039. AGRICULTURAL WASTE MANAGEMENT. Three credit hours. Two hours of lecture and one three-hour laboratory per week. Prerequisite: AGRO 3005. Characteristics of agricultural wastes; environmental impact, biological processes; pollution problems and controls; agricultural wastes management systems; legal and economic aspects.

AGMT 4990. SUPERVISED PROFESSIONAL OCCUPATIONAL EXPERIENCE FOR COOP STUDENTS. Three to six credit hours. A minimum of two practice periods is required, one of them in a semester. Prerequisite: Consent of the Director of the Department and to be a Coop program student. Practical experience in Mechanical Technology in Agriculture in cooperation with the private sector or government. To be jointly supervised by the academic department, the Coop program coordinator, and an official from the cooperating entity. Written reports will be required upon completion of each work period.
AGMT 4991. SPECIAL PROBLEMS. One to three credit hours. One to three hours of lecture per week.
Problems pertaining to the applied and technical aspects of Agricultural Engineering related to the agriculture of Puerto Rico. Conferences, library research, laboratories, or field trips will be assigned on an individual basis.

AGMT 4992. SPECIAL PROBLEMS. One to three credit hours. One to three hours of lecture per week.
Problems pertaining to the applied and technical aspects of Agricultural Engineering related to the agriculture of Puerto Rico. Conferences, library studies, laboratories or field trips will be assigned on an individual basis.
B40. Undergraduate Biosystems Engineering (University of Tennessee)

Biosystems Engineering Major, BS in Biosystems Engineering - Pre-Professional Concentration

The College of Agricultural Sciences and Natural Resources, in cooperation with the College of Engineering, offers a four-year curriculum leading to the Bachelor of Science in Biosystems Engineering. The curriculum is accredited by the Engineering Commission of the Accreditation Board for Engineering and Technology (ABET). Overall goals of the program are emphasized in the educational objectives and program outcomes statements listed below. Program details are given in the showcase curricula and the individual course descriptions.

Career opportunities for graduates include the design, development, or management of practices that produce biofuels, minimize soil erosion and conserve water resources; biological waste treatment systems; safer machinery systems with lower environmental impact and improved food and bio-processing systems. Employment opportunities are available in a wide variety of industries, government agencies, research and testing organizations, and educational and non-profit institutions.

The mathematics requirement for freshman admission to the biosystems engineering program is 3½ units, including trigonometry and geometry. Otherwise, the general admission requirements of the university apply.

The curriculum provides instruction in the analytical and design skills needed to solve engineering problems related to biological and agricultural systems. Comprehensive design of systems and their components is emphasized in the senior year. In addition to the standard biosystems engineering curriculum, a pre-professional concentration is available. The degree program has provisions for elective courses to be taken in specified subject areas. Proper scheduling of courses is very important since prerequisite requirements must be met. Students must consult with their advisors each semester to review their scheduling plan.

Students majoring in biosystems engineering are eligible to participate in the Engineering Cooperative Scholarship Program and other student activities in the College of Engineering. Biosystems engineering majors interested in the Engineering Cooperative Scholarship Program should consult with their faculty advisor or the head of the Biosystems Engineering and Soil Science Department, (865) 974-7266; e-mail bess@utk.edu.

The biosystems engineering program at the University of Tennessee, Knoxville, has specific educational objectives that follow the objectives of the University of Tennessee Institute of Agriculture. In order to meet the Institute’s objectives, program graduates will receive the educational tools necessary to perform as entrylevel engineering professionals. Recent graduates are to be

- Competitive in seeking employment or graduate placement at the regional and national levels.
- Aware of meeting their own and societal needs consistent with the goals of life-long learning, professional ethics, and leadership.
• Performing as entry-level engineers or graduate students in a manner that positively reflects on the overall program’s reputation.

Program Outcomes

To achieve the educational objectives listed above, a series of program outcomes have been adopted. These program outcomes provide specific measures to determine the degree of success in meeting each of the educational objectives. These outcomes are as follows.

• An ability to apply knowledge of mathematics, science, and engineering.
• An ability to design and conduct experiments, as well as to analyze and interpret data.
• An ability to design a system, component, or process to meet desired needs.
• An ability to function on multi-disciplinary teams.
• An ability to identify, formulate, and solve engineering problems.
• An understanding of professional and ethical responsibility.
• An ability to communicate effectively.
• The broad education necessary to understand the impact of engineering solutions in a global and societal context.
• A recognition of the need for and an ability to engage in, life-long learning.
• A knowledge of contemporary issues.
• An ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.
• An understanding of the complexity of biological systems and the ability to apply engineering principles to those systems.

One of the primary tools engineers bring to the solution of many problems is a mastery of mathematics, so mathematical competence is a critical component of an engineering education. In order to graduate with a major in biosystems engineering, students must display this competence by achieving an average GPA of at least 2.0 in the required mathematics courses. It is the student’s responsibility to work with their academic advisor in assuring that they meet this requirement.

The pre-professional concentration provides comprehensive training in biosystems engineering while preparing the student for candidacy to medical school. While this program meets most of the general published pre-medical requirements, it is the student’s responsibility to work with an academic advisor to ensure that his or her program meets the demands of specific schools.

Requirements for the Bachelor of Science in Biosystems Engineering - Biosystems Engineering Major - Pre-Professional Concentration

<table>
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<th>Hours Credit</th>
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<tr>
<td>ME 202</td>
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<tr>
<td>CHEM 120*, CHEM 130*</td>
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<tr>
<td>Year</td>
<td>Courses</td>
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<tr>
<td>First Year</td>
<td>MATH 141 *, MATH 142 *</td>
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<td>ENGL 101 *, ENGL 102 *</td>
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<tr>
<td>Second Year</td>
<td>BSE 201 , BSE 221 , BSE 231 , BSE 321</td>
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<td>ME 231 , ME 321 , ME 331</td>
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<td></td>
<td>MATH 231 , MATH 241</td>
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<td></td>
<td>BIOL 130 *</td>
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<tr>
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<td>CHEM 350</td>
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<tr>
<td>Third Year</td>
<td>BSE 411 , BSE 431 , BSE 451</td>
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<tr>
<td></td>
<td>STAT 251</td>
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<td></td>
<td>ECE 301</td>
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<td>MATH 200</td>
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<tr>
<td></td>
<td>AE 341</td>
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<td></td>
<td>ENGL 360 *</td>
</tr>
<tr>
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<td>CHEM 360 , CHEM 369</td>
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<td></td>
<td>PHIL 241 * or PHIL 245</td>
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<tr>
<td>Fourth Year</td>
<td>BSE 401 *, BSE 402 , BSE 404 , BSE 444</td>
</tr>
<tr>
<td></td>
<td>ECON 201 (Social Sciences Elective)*</td>
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<td>Social Sciences Elective*</td>
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<td>Arts and Humanities Elective*</td>
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<tr>
<td></td>
<td>Cultures and Civilizations Electives*</td>
</tr>
<tr>
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<td>Total 128</td>
</tr>
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</table>

* Meets University General Education Requirement.
1 Or equivalent honors course.
2 If mathematics placement test does not indicate placement into at least MATH 141, discuss mathematics options with advisor.
3 Select from the corresponding University General Education list after consultation with advisor.
B.S. Biosystems Engineering  
Standard Sequence, 2010-2011

<table>
<thead>
<tr>
<th>1st Semester</th>
<th>2nd Semester</th>
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</thead>
<tbody>
<tr>
<td><strong>Freshman</strong></td>
<td><strong>Freshman</strong></td>
</tr>
<tr>
<td>CHEM120 General Chemistry I*</td>
<td>3 Gen Ed Elect.(Cultures &amp; Civilizations)*</td>
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<tr>
<td>EF105 Comp. Methods in Eng. Problem Solving</td>
<td>BS104 Design Apprenticeship</td>
</tr>
<tr>
<td>EF151 Physics for Engineers I</td>
<td>1 EF152 Physics for Engineers II</td>
</tr>
<tr>
<td>ENGL101 English Composition I*</td>
<td>1 ENGL102 English Composition II*</td>
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<tr>
<td>MA141 Calculus I*</td>
<td>4 MA142 Calculus II*</td>
</tr>
<tr>
<td><strong>Sophomore</strong></td>
<td><strong>Sophomore</strong></td>
</tr>
<tr>
<td>BSE201 Career Opportunities</td>
<td>BS231 Biothermalodynamics, Heat &amp; Mass Transfer</td>
</tr>
<tr>
<td>BSE221 Mass and Energy in Biosystems</td>
<td>Introduction to Soil Science</td>
</tr>
<tr>
<td>BSE231 Biochemistry for Engineers</td>
<td>MA231 Differential Equations I</td>
</tr>
<tr>
<td>MA241 Calculus III</td>
<td>ME321 Mechanics of Materials</td>
</tr>
<tr>
<td>ME231 Rigid Body Dynamics</td>
<td>MICR210 Microbiology*</td>
</tr>
<tr>
<td>ME331 Thermodynamics I</td>
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<tr>
<td><strong>Junior</strong></td>
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</tr>
<tr>
<td>Phil241 Eng. Ethics or Phil245 Env. Ethics (Arts &amp; Humanities)*</td>
<td>4 Technical Elective</td>
</tr>
<tr>
<td>AE341 Fluid Mechanics</td>
<td>BS411 Mechanical Systems Engineering</td>
</tr>
<tr>
<td>ECE301 Electrical &amp; Electronic Circuits</td>
<td>BS416 Hydrology</td>
</tr>
<tr>
<td>ENGL360 Technical Writing (WC)*</td>
<td>BS431 Bioprocess Engineering</td>
</tr>
<tr>
<td>MA200 Matrix Computations</td>
<td>BS451 Instrumentation &amp; Control</td>
</tr>
<tr>
<td>STAT251 Prob. &amp; Stat. for Sci. &amp; Engrs.</td>
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<tr>
<td><strong>Senior</strong></td>
<td><strong>Senior</strong></td>
</tr>
<tr>
<td>Economics 201* or Agr. Economics 201*</td>
<td>3 Gen Ed Elective (Social Sciences)*</td>
</tr>
<tr>
<td>4 Technical Elective</td>
<td>3 Gen Ed Elect.(Cultures &amp; Civilizations)*</td>
</tr>
<tr>
<td>BSE401 Biosystems Engineering Design I*(OC)</td>
<td>3 Gen Ed Elective (Arts &amp; Humanities)*</td>
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<tr>
<td>BSE404 Engineering Project Management</td>
<td>BS402 Biosystems Engineering Design II</td>
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<tr>
<td>BSE444 Practicum in Engineering</td>
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</table>

128 Hours Total

*Meets University General Education Requirement  
1Or equivalent honors course  
2If Math placement test does not indicate placement into at least MA141, discuss options with advisor  
3Select from the corresponding University General Education list after consultation with advisor  
4Select from list in Catalog, or other courses with consent of advisor
(BSE) Biosystems Engineering (196)

BSE 104 - Design Apprenticeship

Exposure to design in biosystems engineering through apprenticeship with senior design teams in Biosystems Engineering 402. Apprentices will assist with design, construction, testing, analysis, and presentation of project. Will also include background in engineering design, engineering project management, and engineering design tools. 1 Credit Hours

(RE) Prerequisite(s): Engineering Fundamentals 151.

BSE 201 - Career Opportunities

Activities and opportunities in the fields of specialization; required training for each area; projected career activities 1 Credit Hours

BSE 221 - Mass and Energy in Biosystems

Introduction to thermodynamic concepts for biological systems (energy, mass and energy balances, processes and cycles); psychrometrics and psychrometric processes; biological systems and the biosphere (bioenergetics, hydrologic cycle, global energy cycle). 3 Credit Hours

Contact Hour Distribution: 2 hours and 1 lab.

(RE) Prerequisite(s): Chemistry 120.

(RE) Corequisite(s): Engineering Fundamentals 152.

BSE 231 - Biochemistry for Engineers

Fundamentals of biochemistry presented from an engineering point of view and applied to solve engineering-related problems. Topics to be covered include fundamental organic chemistry of amino acids, carbohydrates, lipids and other important biochemicals; the role and control of pH in biological solutions; fundamental biochemistry of proteins and enzymes; introduction to bioenergetics and metabolic pathways, and the replication, transcription, and translation of DNA. 3 Credit Hours

(RE) Prerequisite(s): Chemistry 120 and Mathematics 141.

BSE 321 - Biothermodynamics, Heat and Mass Transfer

Application of thermodynamics to biological systems; heat transfer with emphasis upon conduction and convection applications; introduction to diffusion mass transfer. 3 Credit Hours

Contact Hour Distribution: 2 hours and 1 lab.

(RE) Prerequisite(s): 221.

BSE 401 - Biosystems Engineering Design I

First course of a capstone design sequence. Review of fundamental engineering principles and design proposal generation. Design proposals will include preliminary
engineering analyses, extensive documentation, and multiple individual and group presentations. 2 Credit Hours
(RE) Prerequisite(s): 431 and 451.
(RE) Corequisite(s): 404.

BSE 402 - Biosystems Engineering Design II

Culmination of capstone design sequence. Intensive design experience on project chosen and approved in 401. Analysis, construction, testing, evaluation, and reporting required. Periodic oral and written reports and submission of design to external engineering design competition or display required. 6 Credit Hours
Contact Hour Distribution: 2-hour lecture, 2-hour recitation, 4-hour lab.
(RE) Prerequisite(s): 401 and 444.
(RE) Corequisite(s): 404.

BSE 404 - Engineering Project Management

Fundamentals and theory of engineering design and engineering project management, use of computerized project management tools, ethical responsibilities and contemporary issues in biosystems engineering, incorporation of economic considerations in engineering design, individual professional and portfolio development. 3 Credit Hours
(RE) Corequisite(s): 401.

BSE 411 - Mechanical Systems Engineering

Fundamentals of power delivery systems and simple mechanisms; selection and design of mechanical, hydraulic, and tractive power transmission systems. Emphasis on off-road vehicles and bioprocessing systems. 3 Credit Hours
Contact Hour Distribution: 2 hours and 1 lab.
(RE) Prerequisite(s): Mechanical Engineering 231 and Mechanical Engineering 321.

BSE 416 - Environmental Hydrology

An introduction to hydrology and associated environmental implications including: the hydrologic cycle, evapotranspiration, runoff, erosion, unit hydrograph operations, routing, open channel flow, groundwater, infiltration, and urban stormwater. 3 Credit Hours
Contact Hour Distribution: 2 hours and 1 lab.
(RE) Prerequisite(s): Aerospace Engineering 341.

BSE 431 - Bioprocess Engineering

Development of interdisciplinary bioprocess engineering; basics of biology in an engineering perspective; enzymatic reaction kinetics; metabolism and bioenergetics; cell growth kinetics and product formation; engineering principles applied to bioprocess engineering including mass balance, energy balance, and reaction kinetics; reactor design and systems; introduction to bioseparations; practical aspects of bioprocess engineers and process development. 3 Credit Hours
**Contact Hour Distribution:** 2 hours and 1 lab.

(RE) **Prerequisite(s):** 321.

**BSE 444 - Practicum**

Applications of engineering theory and design in selecting, sizing, and fabricating engineering materials, and in developing processes and systems typically used in biosystems engineering. 3 Credit Hours

**Contact Hour Distribution:** 1 hour and 2 labs.

(RE) **Corequisite(s):** 401 and 404.

**BSE 451 - Electronic Systems**

Basic electronics with biological applications. Analog and digital electronics; sensing and controlling physical and environmental parameters; sensor selection and interfacing; signal conditioning; process control. Includes laboratory experiments and design projects. 4 Credit Hours

**Contact Hour Distribution:** 3 hours and 1 lab. Design content — 1 hour.

(RE) **Prerequisite(s):** Electrical and Computer Engineering 301.

**BSE 470 - Special Problems in Biosystems Engineering**

Selection, analysis solution, and report of problem. 1-3 Credit Hours

**Repeatability:** May be repeated. Maximum 6 hours.

**Registration Permission:** Consent of instructor.

**BSE 480 - Selected Topics in Biosystems Engineering**

Current trends and problems in biosystems engineering. 1-3 Credit Hours

**Repeatability:** May be repeated. Maximum 6 hours.
Undergraduate Bioenvironmental Engineering (University of Wisconsin)

General Education Requirements

As listed under General Education with the following exceptions:

Ethical Citizenship: ESM 105 Introduction to Environmental Studies, required for Environmental Engineering Technology Option

Sciences: 8-9 cr. hrs.
BIOL 100 or BIOL 150 or GEOL 101, CHEM 121, PHYS 151 or PHYS 161 required.

Mathematics: MATH 156 or MATH 166 required 3 cr. hrs.

Foundation Courses in Agriculture 12 cr. hrs.
AGEN 150 Agricultural and Environmental Engineering Technology 3 cr.
SOIL 210 Introductory Soil Science 3 cr.
AGEC 230 Agricultural Economics I 3 cr.
Choose one of the following: 3 cr.
ANSC 111 Introduction to Animal Science
FDSC 110 The Science of Food
CROP 161 Introduction to Plant Science
HORT 161 Introduction to Plant Science

Agricultural Engineering Technology Major

Major Requirements 55-60 Total Credits

Core Courses: 29 cr. hrs.
AGEN 185 Agricultural Engineering Technology Professional Seminar I 1 cr.
AGEN 240 Structures 3 cr.
AGEN 285 Agricultural Engineering Technology Professional Seminar II 1 cr.
AGEN 350 Applied Electricity 3 cr.
AGEN 352 Food and Process Engineering 3 cr.
AGEN 355 Irrigation and Drainage (writing intensive) 3 cr.
AGEN 385 Agricultural Engineering Technology Professional Seminar III 1 cr.
AGEN 485 Agricultural Engineering Technology Professional Seminar IV 1 cr.
GENG 121 Engineering Drawing 3 cr.
GENG 245 Materials Design Requirements 3 cr.
GENG 265 Engineering Graphics 3 cr.
GENG 450 Engineering Project Management 3 cr.
PHYS 156 General Physics Laboratory 1 cr.

Choose one of the following three options:
Agricultural Engineering Technology Option 26-29 cr. hrs.
AGEN 320 Internal Combustion Engines 3 cr.
AGEN 361 Machinery and Power Mechanics 4 cr.
AGEN 363 Precision Agriculture Technology 3 cr.
AGEN 451 Agricultural Instrumentation and Electronics (writing intensive) 2 cr.
GENG 235 Surveying 3 cr.
Choose two from:
AGEN 425 Environmental Engineering Technology 4 cr.
AGEN 443 Controlled Environment Systems 3 cr.
AFES 492 Experiential Learning in Agriculture, Food, and Environmental Science 3 cr.
Choose one from:
AGEN 365 Waste Management Systems (writing intensive) 3 cr.
AGEN 389 Agricultural Engineering Technology: 1/4 Scale Tractor 3 cr.
Choose one from:
AGEN 255 Welding and Metal Manufacturing 3 cr.
GENG 201 Industrial Safety 2 cr.
GENG 236 Advanced Surveying 3 cr.
GENG 251 Static Strength of Materials 3 cr.
GENG 252 Dynamics 3 cr.
PHYS 152 Algebra-Based Physics II 4 cr.
or PHYS 162 Calculus-Based Physics II

Environmental Engineering Technology Option 27-28 cr. hrs.
CHEM 122 General Chemistry II 5 cr.
CHEM 230 General Organic Chemistry 3 cr.
BIOL 324 Microbiology 4 cr.
AGEN 365 Waste Management Systems (writing intensive) 3 cr.
AGEN 425 Environmental Engineering Technology 4 cr.
AGEN 451 Agricultural Instrumentation and Electronics (writing intensive) 2 cr.
GENG 235 Surveying 3 cr.
Choose one from:
GEOL 445 Hydrogeology 3 cr.
AGEC 450 Introduction to Natural Resource Economics 3 cr.
ESM 360 Applied Hydrology and Water Quality 4 cr.

Mechanized Systems Management Option 28-31 cr. hrs.
GENG 201 Industrial Safety 2 cr.
ENGL 367 Technical Writing 3 cr.
AGEC 305 Agricultural Accounting 3 cr.
AGEC 320 Statistical Methods 3 cr.
AGEC 360 Farm Management 3 cr.
AGEC 410 Professional Selling (writing intensive) 3 cr.
AGEC 460 Agribusiness Firm Management (writing intensive) 3 cr.

Choose one from:
AGEN 425 Environmental Engineering Technology 4 cr.
AGEN 443 Controlled Environment Systems 3 cr.
AGEN 451 Agricultural Instrumentation and Electronics (writing intensive) 2 cr.
AFES 492 Experiential Learning in Agriculture, Food, and Environmental Science

Choose two from:
AGEN 320 Internal Combustion Engines 3 cr.
AGEN 361 Machinery and Power Mechanics 4 cr.
AGEN 363 Precision Agriculture Technology
AGEN 365 Waste Management Systems (writing intensive) 3 cr.

Required Supporting Courses: 4-14 cr. hrs.
Computer Literacy - students who are not prepared to use word processing and spreadsheet
programs to complete assignments in Agricultural Engineering Technology courses should elect
CSIS 105 in their freshman year.

Agricultural Engineering Technology Minor

Minor Requirements 22 Total Credits
Required Courses: 6 cr. hrs.
AGEN 150 Introduction to Agricultural Engineering 3
GENG 265 Engineering Graphics 3
Complete one of the following sets of courses: 7-10 cr. hrs.
1 AGEN 320 Internal Combustion Engines 3
AGEN 361 Machinery and Power Mechanics 4
AGEN 465 Fluid Power Systems 2
2 AGEN 350 Applied Electricity 3
AGEN 451 Agricultural Instrumentation and Electronics (writing intensive) 2
GENG 368 CAD Applications 3
3 AGEN 352 Food and Process Engineering 3
AGEN 455 Advanced Food and Process Engineering 3
GENG 368 CAD Applications 3
4 AGEN 240 Structures 3
AGEN 333 Landscape Construction 3
GENG 450 Engineering Project Management 3
5 AGEN 355 Irrigation and Drainage (writing intensive) 3
AGEN 365 Waste Management Systems (writing intensive) 3
AGEN 425 Environmental Engineering Technology 4
Directed electives in Agricultural Engineering Technology or General Engineering: 6-9 cr. hrs.
Overview

The Biological Systems Engineering (BSE) program provides students with an opportunity to combine their interests in biological sciences and engineering. While there are many specialty areas within the discipline, the undergraduate program in BSE focuses primarily in two areas: Bioprocess Engineering and Land and Water Resources Engineering. Bioprocess Engineering focuses on the design and development of processes for environmentally responsible manufacturing of food and industrial products from biological materials. Areas of interest include bioenergy, renewable materials, protein recovery, byproduct utilization, bioresidue management and utilization, systems biology, food safety, food engineering, biopharmaceuticals, and enzymes. Land and Water Resources Engineering focuses on environmental protection and natural resources management. Areas of interest include nonpoint source pollution (water pollution caused by rainfall and runoff from land surfaces such as parking lots, golf courses, urban areas, agricultural fields, and construction sites), stream wetland restoration, low impact development, and watershed management.

The program offers many opportunities for professional development outside of classes, including undergraduate research, study abroad, and professional organizations. Most students also participate in internships or other work experience.

Educational Objectives

The overall educational goal of the BSE program is to graduate biological systems engineers to support sustainable production, processing, and utilization of biological materials and to protect natural resources. The BSE program seeks to prepare its graduates to become successful in the practice of biological systems engineering or in the pursuit of advanced degrees in BSE or other complementary disciplines. Specifically, the BSE program seeks to prepare its graduates:

- to solve engineering problems using the fundamental principles of science, mathematics, and engineering;
- to engage in life-long learning and professional development;
- to be effective communicators and team members; and
- to function in a professional and ethical manner.

**Biological Systems Engineering Program (BSE)**

(This program applies to students graduating in 2009.)

| First Year |
|------------|------------|-------|-------|
| **First Semester** | **Credits** | **Second Semester** | **Credits** |
| CHEM 1035: General Chemistry | 3 | EF 1016: Intro. to Eng. or ENGE 1114: Exploration Eng. Design or ENGE 1104: Exploration Digital Future | 2 |
| CHEM 1045: General Chemistry Lab | 1 | ENGL 1106: Freshman English | 3 |
| EF 1015: Intro. to Eng. or ENGE 1024 Eng. Exploration | 2 | MATH 1206: Calculus II | 3 |
ENGL 1105: Freshman English | 3 | MATH 1224: Vector Geometry | 2
MATH 1205: Calculus I | 3 | PHYS 2305: Foundations of Physics I | 4
MATH 1114: Elementary Linear Algebra | 2 | Electives | 3
Electives | 3 | 17

**Second Year**

<table>
<thead>
<tr>
<th><strong>First Semester</strong></th>
<th><strong>Credits</strong></th>
<th><strong>Second Semester</strong></th>
<th><strong>Credits</strong></th>
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<tbody>
<tr>
<td>ESM 2104: Statics</td>
<td>3</td>
<td>ESM 2304: Dynamics</td>
<td>3</td>
</tr>
<tr>
<td>Math 2224: Multivariable Calculus</td>
<td>3</td>
<td>Math 2214: Differential Equations</td>
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<tr>
<td>BSE 2105: Introduction to BSE</td>
<td>2</td>
<td>BSE 2106: Introduction to BSE</td>
<td>2</td>
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<tr>
<td>ISE 2014: Engineering Economy</td>
<td>2</td>
<td>CHEM 2514 or 2535 or 2565: Organic Chemistry</td>
<td>3</td>
</tr>
<tr>
<td>ENGE 2344: Computer-Aided Drafting</td>
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<tr>
<th><strong>Third Year</strong></th>
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<th><strong>Second Semester</strong></th>
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<tbody>
<tr>
<td>BSE 3134: Biological Systems Eng. Seminar</td>
<td>1</td>
<td>BSE 3504: Transport Processes in BSE</td>
<td>3</td>
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<tr>
<td>BSE 3154: Thermodynamics of Biological Sys.</td>
<td>3</td>
<td>BSE 3144: Engr Analysis for Biol Systems</td>
<td>2</td>
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<tr>
<td>ESM 3024: Fluid Mechanics</td>
<td>3</td>
<td>BSE 4004: Instrumentation &amp; Exp. Mechanics</td>
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<tr>
<td>ECE 3054: Electrical Theory</td>
<td>3</td>
<td>BSE 3524: Unit Operations in BSE</td>
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<tr>
<td>BIOL 2604&amp;2614: General Microbiology &amp; Lab</td>
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<td>Technical elective</td>
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<tr>
<td>or CSES 3114&amp;3124: Soils &amp; Soils Lab</td>
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<td>Technical elective</td>
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<td>Electives</td>
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<tr>
<th><strong>Fourth Year</strong></th>
<th><strong>Credits</strong></th>
<th><strong>Second Semester</strong></th>
<th><strong>Credits</strong></th>
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<tbody>
<tr>
<td>BSE 4125: Comprehensive Design Project</td>
<td>2</td>
<td>BSE 4126: Comprehensive Design Project</td>
<td>2</td>
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<tr>
<td>Engineering topics elective</td>
<td>3</td>
<td>BSE elective</td>
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<tr>
<td>BSE elective</td>
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<td>Technical elective</td>
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<tr>
<td>STAT 4604: Stat. Meth. for Engrs.</td>
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<td>Engineering topics elective</td>
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<tr>
<td>or STAT 4705: Probability &amp; Statistics for Engrs.</td>
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<tr>
<td>Technical elective</td>
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<td>Electives</td>
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<td>17</td>
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</table>

1 These electives must include six credits each from Liberal Education Areas 2 and 3; one credit from Liberal Education Area 6; and three credits from Liberal Education Area 7 (the Area 7 course may double count with Area 2 or Area 3, or with a qualifying technical elective).
In addition to university policy, for graduation, a student must complete 134 credits with a minimum overall GPA of 2.0 and a minimum in-major GPA of 2.0. The in-major GPA calculation uses the following courses: BSE 2105, 2106, 3134, 3154, 3504, 3524, 4004, 4125, 4126, and the 6 hours of required BSE electives.

**Eligibility for continued enrollment:** upon having attempted 72 hours (including transfer, advanced placement, advanced standing, and credit by examination), "satisfactory progress" toward a B.S. degree will include the following minimum criteria: having a GPA of at least 2.0; passing BSE 2106, Phys 2306, Math 2224, 2214.

**Undergraduate Course Descriptions (BSE)**

**Courses for Engineering Students**
(See College of Agriculture and Life Sciences for courses for non-engineering students)

2105-2106: INTRODUCTION TO BIOLOGICAL SYSTEMS ENGINEERING
Introduction to the Biological Systems Engineering profession, overall goals and components of the undergraduate degree program, engineering design process, engineering problem-solving tools and techniques, development of oral and written communication skills, and the importance of professionalism and ethics in Biological Systems Engineering. Pre: ENGE 1016 or ENGE 1104 or ENGE 1114 for 2105; 2105 for 2106. Co: BIOL 1105 for 2105; BIOL 1106 for 2106. (1H,3L,2C).

2984: SPECIAL STUDY
Variable credit course.

3134: BIOLOGICAL SYSTEMS ENGINEERING SEMINAR

3144: ENGINEERING ANALYSIS FOR BIOLOGICAL SYSTEMS USING NUMERICAL METHODS
Solving engineering problems related to biological systems using numerical analysis including root finding, numerical integration, differentiation, interpolation and numerical solution of ordinary differential equations. Error analysis and programming with engineering software. Pre: 2106, MATH 2214. (2H,2C).

3154: THERMODYNAMICS OF BIOLOGICAL SYSTEMS
Fundamental concepts, first and second laws, psychrometrics applied to plant and animal environments, introduction to Gibbs energy, and application of calorimetry to gain basic understanding of energy flow in a biological system. Pre: MATH 2214. (3H,3C).

3305-3306: LAND AND WATER RESOURCES ENGINEERING
3305: Surface and groundwater hydrology, soil physics, irrigation principles, nonpoint source pollution control, land surveying. 3306: Erosion and sediment transport; transport and fate of nutrients, pesticides and pathogens; design of wetlands, detention facilities and other management practices for rural and urban nonpoint source pollution control; design of small dams and reservoirs. Pre: 2106. Co: CSES 3114, ESM 3024 for 3305. (2H,3L,3C).

3314: COMPUTER-AIDED DESIGN AND DRAFTING FOR LAND AND WATER RESOURCES ENGINEERING
Introduction to computer-aided design and drafting for land and water resources engineering. Representation of features in two and three dimensions for documentation and visualization of land and water resources engineering projects. Create plans, cross sections, detail drawings, and three dimensional visualizations using computer-aided design and drafting.

3414 (CEE 3414): DESIGN OF WOOD STRUCTURES
Wood as an engineering material, loads, structural lumber, glulam, plywood, design of single structural elements, combined stress design, fastener design, truss design, pole and post-frame structures, shear wall, and diaphragm design. Pre: CEE 3404. (3H,3C). I.

3494: ADVANCED WELDING TECHNOLOGY
Techniques in welding that include gas, submerged metal arc, metal inert gas, pulsed arc, and tungsten inert gas welding. Design of welding structures, fundamentals of heat treatment, and plasma arc cutting. Consent required. I. Pre: ISE 2214. (3L,1C).

3504: TRANSPORT PROCESSES IN BIOLOGICAL SYSTEMS
Introduction to material and energy balances in biological systems. Fundamentals of heat and mass transfer in biological systems. One and two dimensional conduction, convection, and diffusion of thermal energy and mass. Heat and mass transfer rates, steady and unsteady state conduction, convection, diffusion; design of simple heat exchangers. Application of these topics and fluid mechanics to fluid handling, bacterial growth, plant nutrient uptake, enzymatic reactions. Pre: 3154, ESM 3024. (3H,3C).

3514: PHYSICAL PROPERTIES OF BIOLOGICAL MATERIALS
Physical characteristics and physical properties to include mechanical, thermal, and electromagnetic properties of whole and processed biological products are studied. Laboratory methods for measuring physical properties are included. II. Pre: ESM 3024. (2H,3L,3C).

3524: UNIT OPERATIONS IN BIOLOGICAL SYSTEMS ENGINEERING
Unit operations for processing biological materials including heat exchangers, evaporation, drying, mixing, homogenization, extrusion, phase and multi-phase separation, and size reduction. Laboratory hands-on experience in various unit operations. Co: 3504. (2H,3L,3C).

4125-4126: COMPREHENSIVE DESIGN PROJECT
4125: Identify and develop an engineering design project using the team approach; use of literature resources to define project objectives and approach; present project proposal in a professional written and oral manner; engineering ethics, professionalism and contemporary issues. 4126: Complete a comprehensive design project using the team approach and make professional presentations of the final design. Completion of 96 hours and overall GPA of 2.0 or better. Pre: (3306 or 3414 or 3524). 4125: (1H,3L,2C) 4126: (6L,2C).

4144: BIOLOGICAL SYSTEMS SIMULATION
Study of modeling techniques and application of these techniques to reaction kinetics, crop growth, and systems analysis. Emphasis is on development of basic understanding of methods for defining and evaluating interrelationships between parameters in a biological system. Pre: 3504. (3H,3C). I.

4304: NONPOINT SOURCE POLLUTION MODELING AND MANAGEMENT

4324: NONPOINT SOURCE POLLUTION
Engineering aspects of the sources and magnitudes of nonpoint source pollution, major causative factors, and control techniques. Emphasis on hydrologic factors, erosion, atmospheric deposition, adsorption and degradation of pollutants in soil, disposal of agricultural wastes, and management for the control of urban and agricultural nonpoint source pollution. Pre: CEE 3104. (3H,3C).
4344: GEOGRAPHIC INFORMATION SYSTEMS FOR ENGINEERS
Conceptual, technical, and operational aspects of geographic information systems as a tool for storage, analysis, and presentation of spatial information. Focus on engineering applications in resource management, site selection, and network analysis. Laboratory work and senior standing required. II. (2H,3L,3C).

4394: WATER SUPPLY AND SANITATION IN DEVELOPING COUNTRIES
Social, economic and engineering principles of water supply and sanitation in developing countries as affected by climate, cultural and sociological factors, and material and financial resources. II. Pre: CEE 3104. (3H,3C).

4404: DESIGN OF MACHINERY SYSTEMS
Functional analysis and engineering design and selection of machinery components and systems for agricultural, food, and processing applications. Design, sizing, and selection of components, power units (internal combustion engines and electronic motors), transmission devices (belts, chains, gears, hydraulics, and drivelines), material handling devices, (pumps, fans, and conveyors), and agricultural equipment (tillage, planting and chemical applications). Pre: ESM 2204, ESM 2304, ESM 3024, BSE 3154. (2H,3L,3C).

4424 (ME 4434): FLUID POWER SYSTEMS AND CONTROLS
Design and analysis of industrial and mobile hydraulic systems. Hydrostatic transmissions. Electrohydraulic servovalve characteristics and use in precise position and speed control application. Characteristics of pumps, motors, valves, and activators illustrated in laboratory exercises. Pre: ESM 3024 or ME 3404. (2H,3L,3C).

4504: BIOPROCESS ENGINEERING
Study of the engineering concepts for biological conversion of raw materials to food, pharmaceuticals, fuels, and chemicals. Emphasis is placed on enzyme kinetics and technology, bioreaction kinetics, analysis, and control of bioreactors and fermenters, and downstream processing of bioreaction products. II. Pre: 3504, BIOL 2604, (CHEM 2514 or CHEM 2535 or CHEM 2565 or CHEM 2565H), (CHEM 3615 or CHEM 3615H or CHEM 4615). (3H,3C).

4514: INDUSTRIAL PROCESSING OF BIOLOGICAL MATERIALS
Principles of industrial processing of biological materials. Surveys the major food processing and biopharmaceutical industries and the major processing steps involved in the production of vegetable oils, starch, corn sweeteners, biofuels, protein, dairy products, meat and poultry, seafood, fruits and vegetables, and biopharmaceuticals. Economics, safety, environmental, and quality control factors involved in the processing of biological materials. Pre: (3524, 4604). (3H,3C).

4524: BIOLOGICAL PROCESS PLANT DESIGN

4544 (CHE 4544): PROTEIN SEPARATION ENGINEERING
Concepts, principles and applications of various unit operations used in protein separations. Properties of biological materials, such as cells and proteins, and their influences on process design. Design of processes for protein purification based on the impurities to be eliminated. Concepts and principles of scale-up of unit operations. Case studies in practical protein recovery and purification issues, with a focus on enhanced protein purification by genetic engineering. Protein purification process simulation and optimization using process simulation software. Pre: 3504 or CHE 3144. (3H,3C).

4604: FOOD PROCESS ENGINEERING
Analysis and design of food processing operations including thermal pasteurization and sterilization, freezing, extrusion, texturization, and mechanical separation. Pre: 3504, 3524. (3H,3C).
4974: INDEPENDENT STUDY
Variable credit course.

4984: SPECIAL STUDY
Variable credit course.

4994: UNDERGRADUATE RESEARCH
Variable credit course.
### B43. Undergraduate Bioenvironmental Engineering (Washington State University)

**Bioengineering**

**Bioengineering General Schedule of Study**

**Schedule of Study #1**

<table>
<thead>
<tr>
<th>Fall Freshman</th>
<th>Spring Freshman</th>
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</thead>
<tbody>
<tr>
<td>Engr 120 Innovation and Design</td>
<td>BE 140 Intro to Bioengineering</td>
</tr>
<tr>
<td>Chem 105 Principles of Chemistry I [P]</td>
<td>Biol 107 Intro to Biology [B] [L]</td>
</tr>
<tr>
<td>Gen Ed 110 World Civilizations I [A]</td>
<td>Gen Ed 111 World Civilizations II [A]</td>
</tr>
<tr>
<td>Math 171 Calculus I [N]</td>
<td>Math 172 Calculus II</td>
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<table>
<thead>
<tr>
<th>Fall Sophomore</th>
<th>Spring Sophomore</th>
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<tbody>
<tr>
<td>BE 205 Bioengineering Prof Prep &amp; Ethics</td>
<td>Arts &amp; Humanities [H] or [G]</td>
</tr>
<tr>
<td>ChE 201 Chemical Process Principles</td>
<td>BE 210 Bioengineering Analysis</td>
</tr>
<tr>
<td>Chem 345 Organic Chemistry I</td>
<td>CE 211 Statics</td>
</tr>
<tr>
<td>Math 220 Linear Algebra</td>
<td>Math 315 Differential Equations</td>
</tr>
<tr>
<td>Math 273 Calculus III</td>
<td>Math 370 Intro Statistics for Engineers</td>
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<table>
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<tr>
<th>Fall Junior</th>
<th>Spring Junior</th>
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<tbody>
<tr>
<td>BE 321 Mechanics of Biomaterials</td>
<td>BE 330 Bioinstrumentation</td>
</tr>
<tr>
<td>BE 350 Intro to Cellular Bioengineering</td>
<td>Bioengineering Elective</td>
</tr>
<tr>
<td>ChE 310 Transport Processes</td>
<td>EconS 101/102 Micro/Macro Economics [S]</td>
</tr>
<tr>
<td>EE 261 Electrical Circuits</td>
<td>Intercultural Studies [I], [G] or [K]</td>
</tr>
<tr>
<td>MBioS 303 Intro to Biochemistry</td>
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<table>
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<tr>
<th>Fall Senior</th>
<th>Spring Senior</th>
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287
<table>
<thead>
<tr>
<th>Course</th>
<th>Credits</th>
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</thead>
<tbody>
<tr>
<td>BE 410 Bioengineering Capstone Project I [M]</td>
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</tr>
<tr>
<td>BE 411 Bioengineering Capstone Project II</td>
<td>3</td>
</tr>
<tr>
<td>BE 440 Unified Systems Bioengineering II</td>
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<tr>
<td>Bioengineering Elective</td>
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<td>Bioengineering Elective</td>
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<td>Bioengineering Elective</td>
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<td>Bioengineering Elective</td>
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<td>Bioengineering Elective</td>
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<tr>
<td>Bioengineering Elective</td>
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<tr>
<td>Engl 402 Technical &amp; Professional Writing [W]</td>
<td>3</td>
</tr>
<tr>
<td>Tier III Humanities or Social Sci [H] or [S]</td>
<td>3</td>
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<tr>
<td>NOTES:</td>
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<tr>
<td>• For certification, a grade of &quot;C&quot; or better is required in the BLUE courses.</td>
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<tr>
<td>• A grade of &quot;C&quot; or better is required in all Mathematics courses before continuing on to the next level.</td>
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<tr>
<td>• Overall GPA must be 2.0</td>
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<tr>
<td>• Tier III GER must satisfy Humanities or Social Science designation.</td>
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<tr>
<td>• Diversity designation can be selected with the Arts &amp; Humanities, Social Science, or the Tier III.</td>
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</tr>
<tr>
<td>• Bioengineering electives must have (6) engineering credits.</td>
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</tr>
<tr>
<td>Bioengineering electives must have (6) 400-level credits.</td>
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</tbody>
</table>
B44. Undergraduate Biological System Engineering (Virginia Tech)

The Biological Systems Engineering (BSE) program provides students with an opportunity to combine their interests in biological sciences and engineering. While there are many specialty areas within the discipline, the undergraduate program in BSE focuses primarily in two areas: Bioprocess Engineering and Land and Water Resources Engineering. Bioprocess Engineering focuses on the design and development of processes for environmentally responsible manufacturing of food and industrial products from biological materials. Areas of interest include bioenergy, renewable materials, protein recovery, byproduct utilization, bioresidue management and utilization, systems biology, food safety, food engineering, biopharmaceuticals, and enzymes. Land and Water Resources Engineering focuses on environmental protection and natural resources management. Areas of interest include nonpoint source pollution (water pollution caused by rainfall and runoff from land surfaces such as parking lots, golf courses, urban areas, agricultural fields, and construction sites), stream wetland restoration, low impact development, and watershed management.

The program offers many opportunities for professional development outside of classes, including undergraduate research, study abroad, and professional organizations. Most students also participate in internships or other work experience.

The B.S. program in Biological Systems Engineering is accredited by the Engineering Accreditation Commission of ABET, 111 Market Place, Suite 1050, Baltimore, MD 21202-4012 - telephone: (410) 347-7700.
Biological Systems Engineering

Overview

The Biological Systems Engineering program integrates biology, chemistry, and physics with engineering to solve engineering problems associated with the environmentally sound production, processing, and utilization of renewable resources. The curriculum differs from other engineering programs in that it focuses on the sustainable production and management of natural resources and biological materials. The curriculum prepares graduates for a variety of engineering careers. Biological systems engineering graduates are typically employed by environmental consulting firms, state and federal agencies, universities, and food processing, pharmaceutical, and biotechnology industries.

The overall educational goal of the Biological Systems Engineering (BSE) program is to graduate biological systems engineers to support sustainable production, processing, and utilization of biological materials and to protect natural resources. The BSE Program seeks to prepare its graduates to become successful in the practice of biological systems engineering or in the pursuit of advanced degrees in BSE or other complementary disciplines. Specifically, the BSE Program seeks to prepare its graduate:

1. to solve engineering problems using the fundamental principles of science, mathematics, and engineering;
2. to engage in life-long learning and professional development;
3. to be effective communicators and team members; and
4. to function in a professional and ethical manner.

The Biological Systems Engineering program at Virginia Tech is designed to provide a strong, broad-based engineering education with opportunity for limited specialization utilizing the 23 credits of technical electives available in the curriculum. Using these electives, BSE students may specialize in one of the two formal options offered by the department: Land and Water Resources Engineering or Bioprocess Engineering. In addition, the program may also be used as a pre-med or pre-vet program.

The Land and Water Resources Engineering Option is designed for students interested in a career in environmental protection and natural resources management. Biological, chemical, and engineering principles are applied to the wise use, conservation, and management of natural resources, particularly land and water. The option is unique in that it addresses nonpoint sources of pollution (water pollution caused by rainfall and runoff from land surfaces such as parking lots, golf courses, agricultural fields, construction sites) that are now responsible for more than half of the water quality problems in the United States. To pursue the Land and Water Resources Engineering Option, students must have junior standing and have completed BSE 2105, 2106. Students must receive a grade of C- or better in each course comprising the required 19 hours of the Land and Water Resources Engineering Option and an overall average of 2.0 or better in these courses. The required courses for the Land and Water Resources Engineering Option include:

- BSE 3305: Land & Water Resources Engineering
- BSE 3306: Land & Water Resources Engineering
- BSE 4304: NPS Pollution Modeling & Management
- BSE 4344: Geographic Information Systems for Engineers
- CEE 3104: Introduction to Environmental Engineering
- CSES 3114: Soils
- CSES 3124: Soils Lab

Those who complete the requirements of this option will have Land and Water Resources Engineering Option noted on their transcript.

The Bioprocess Engineering Option is tailored for students interested in the design and development of equipment and processes for environmentally responsible manufacturing of value-added products such as food, feed, fuel, pharmaceuticals, nutraceuticals, chemicals, polymers, and other biological products from renewable biological materials. To pursue the Bioprocess Engineering Option, students must have junior standing and have completed BSE 2105, 2106. Students must receive a grade of C- or better in each course comprising the
required 25 hours of the Bioprocess Engineering Option and an overall average of 2.0 or better in these courses. The required courses for the Bioprocess Engineering Option include:

- BIOL 2604: General Microbiology
- BIOL 2614: General Microbiology Lab
- BSE 3524: Unit Operations in Biological Systems Engineering
- BSE 4524: Biological Process Plant Design
- BSE 4504: Bioprocess Engineering
- BSE 4514: Industrial Processing of Biological Materials
- BSE 4544: Protein Separation Engineering
- BSE 4604: Food Process Engineering
- CHEM 3615: Physical Chemistry

Those who complete the requirements of this option will have Bioprocess Engineering Option noted on their transcript.

Recognizing the importance of "hands-on" experience in engineering education, instructional laboratories are included in over half the courses in Biological Systems Engineering. These laboratory courses are designed to enhance understanding of theoretical concepts through hands-on activities. In addition to providing a strong and broad-based engineering education, the program emphasizes communication, team work skills, and design experience. The department participates in the Cooperative Education Program, which gives qualified students valuable work experience while pursuing an undergraduate degree. Students are also encouraged to participate in undergraduate research and study abroad programs.

Design and teamwork experiences are integral parts of the program. In the second year, students are required to complete a yearlong design project. Students work in teams to design, build, and test a solution to an assigned design problem. Throughout the junior year, students acquire knowledge and analysis skills required for successful and professional engineering design through course assignments. The senior year design sequence gives students a comprehensive design experience in which they utilize much of the knowledge they have acquired through their other courses. Students work in teams to solve "real-life" engineering problems.

The relatively small class sizes in Biological Systems Engineering promote excellent interaction between faculty and students. Mentoring begins early in the second year when each student is assigned a faculty advisor who follows the student's progress through graduation.

The bachelor of science in biological systems engineering is offered through the College of Engineering and is accredited by the Engineering Accreditation Commission of ABET, 111 Market Place, Suite 1050, Baltimore, MD 21202-4012 – telephone: (410) 347-7700. The department offers over 20 endowed scholarships to students enrolled in Biological Systems Engineering; students are also eligible for College of Engineering and other university scholarships.

In addition to the undergraduate degree program, programs of study leading to master of engineering, master of science, and Ph.D. degrees are available in the department. The BSE department also participates in the Five-Year Bachelor/Master's Degree program. Through this program, undergraduate students with a GPA of 3.5 or above can apply for admission to the Graduate School upon completion of 75 hours of undergraduate study. If admitted, students may apply up to 12 hours of graduate coursework to both their graduate and undergraduate degree requirements. This program provides students an opportunity to complete both a bachelors and master's degree in BSE within five years.
### Biological Systems Engineering Program (BSE)

(This program applies to students graduating in 2009.)

<table>
<thead>
<tr>
<th>First Year</th>
<th>Credits</th>
<th>Second Semester</th>
<th>Credits</th>
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<tbody>
<tr>
<td><strong>First Semester</strong></td>
<td>Credits</td>
<td><strong>Second Semester</strong></td>
<td>Credits</td>
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<tr>
<td>CHEM 1035: General Chemistry</td>
<td>3</td>
<td>EF 1016: Intro. to Eng. or ENGE 1114: Exploration Eng. Design or ENGE 1104: Exploration Digital Future</td>
<td>2</td>
</tr>
<tr>
<td>CHEM 1045: General Chemistry Lab</td>
<td>1</td>
<td>ENGL 1106: Freshman English</td>
<td>3</td>
</tr>
<tr>
<td>EF 1015: Intro. to Eng. or ENGE 1024 Eng. Exploration</td>
<td>2</td>
<td>MATH 1206: Calculus II</td>
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<tr>
<td>ENGL 1105: Freshman English</td>
<td>3</td>
<td>MATH 1224: Vector Geometry</td>
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<tr>
<td>MATH 1205: Calculus I</td>
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<td>PHYS 2305: Foundations of Physics I</td>
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<td>MATH 1114: Elementary Linear Algebra</td>
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<td>Electives</td>
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<tr>
<td><strong>Second Year</strong></td>
<td>Credits</td>
<td><strong>Second Semester</strong></td>
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<td><strong>First Semester</strong></td>
<td>Credits</td>
<td><strong>Second Semester</strong></td>
<td>Credits</td>
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<tr>
<td>ESM 2104: Statics</td>
<td>3</td>
<td>ESM 2304: Dynamics</td>
<td>3</td>
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<tr>
<td>Math 2224: Multivariable Calculus</td>
<td>3</td>
<td>Math 2214: Differential Equations</td>
<td>3</td>
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<tr>
<td>BSE 2105: Introduction to BSE</td>
<td>2</td>
<td>BSE 2106: Introduction to BSE</td>
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<tr>
<td>ISE 2014: Engineering Economy</td>
<td>2</td>
<td>CHEM 2514 or 2535 or 2565: Organic Chemistry</td>
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<tr>
<td>ENGE 2344: Computer-Aided Drafting</td>
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<td><strong>Third Year</strong></td>
<td>Credits</td>
<td><strong>Second Semester</strong></td>
<td>Credits</td>
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<tr>
<td><strong>First Semester</strong></td>
<td>Credits</td>
<td><strong>Second Semester</strong></td>
<td>Credits</td>
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<tr>
<td>BSE 3134: Biological Systems Eng. Seminar</td>
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<td>BSE 3504: Transport Processes in BSE</td>
<td>3</td>
</tr>
<tr>
<td>BSE 3154: Thermodynamics of Biological Sys.</td>
<td>3</td>
<td>BSE 3144: Engr Analysis for Biol Systems</td>
<td>2</td>
</tr>
<tr>
<td>ESM 3024: Fluid Mechanics</td>
<td>3</td>
<td>BSE 4004: Instrumentation &amp; Exp. Mechanics</td>
<td>3</td>
</tr>
<tr>
<td>ECE 3054: Electrical Theory</td>
<td>3</td>
<td>BSE 3524: Unit Operations in BSE</td>
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<tr>
<td>BIOL 2604&amp;2614: General Microbiology &amp; Lab or CSES 3114&amp;3124: Soils &amp; Soils Lab</td>
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<td>Technical elective</td>
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<tr>
<td>Technical elective</td>
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<td>Electives</td>
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<td><strong>Fourth Year</strong></td>
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<td><strong>First Semester</strong></td>
<td>Credits</td>
<td><strong>Second Semester</strong></td>
<td>Credits</td>
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<tr>
<td>BSE 4125: Comprehensive Design Project</td>
<td>2</td>
<td>BSE 4126: Comprehensive Design Project</td>
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<tr>
<td>Engineering topics elective</td>
<td>3</td>
<td>BSE elective</td>
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<tr>
<td>BSE elective</td>
<td>3</td>
<td>Technical elective</td>
<td>2</td>
</tr>
<tr>
<td>STAT 4604: Stat. Meth. for Engrs. or STAT 4705: Probability &amp; Statistics for Engrs.</td>
<td>3</td>
<td>Engineering topics elective</td>
<td>3</td>
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<td>Technical elective</td>
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<td>Electives</td>
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</table>
These electives must include six credits each from Liberal Education Areas 2 and 3; one credit from Liberal Education Area 6; and three credits from Liberal Education Area 7 (the Area 7 course may double count with Area 2 or Area 3, or with a qualifying technical elective).

In addition to university policy, for graduation, a student must complete 134 credits with a minimum overall GPA of 2.0 and a minimum in-major GPA of 2.0. The in-major GPA calculation uses the following courses: BSE 2105, 2106, 3134, 3154, 3504, 3524, 4004, 4125, 4126, and the 6 hours of required BSE electives.

Eligibility for continued enrollment: upon having attempted 72 hours (including transfer, advanced placement, advanced standing, and credit by examination), "satisfactory progress" toward a B.S. degree will include the following minimum criteria: having a GPA of at least 2.0; passing BSE 2106, Phys 2306, Math 2224, 2214.

Undergraduate Course Descriptions (BSE)

Courses for Engineering Students
(See College of Agriculture and Life Sciences for courses for non-engineering students)

2105-2106: INTRODUCTION TO BIOLOGICAL SYSTEMS ENGINEERING
Introduction to the Biological Systems Engineering profession, overall goals and components of the undergraduate degree program, engineering design process, engineering problem-solving tools and techniques, development of oral and written communication skills, and the importance of professionalism and ethics in Biological Systems Engineering. Pre: ENGE 1016 or ENGE 1104 or ENGE 1114 for 2105; 2105 for 2106. Co: BIOL 1105 for 2105; BIOL 1106 for 2106. (1H,3L,2C).

2984: SPECIAL STUDY
Variable credit course.

3134: BIOLOGICAL SYSTEMS ENGINEERING SEMINAR

3144: ENGINEERING ANALYSIS FOR BIOLOGICAL SYSTEMS USING NUMERICAL METHODS
Solving engineering problems related to biological systems using numerical analysis including root finding, numerical integration, differentiation, interpolation and numerical solution of ordinary differential equations. Error analysis and programming with engineering software. Pre: 2106, MATH 2214. (2H,2C).

3154: THERMODYNAMICS OF BIOLOGICAL SYSTEMS
Fundamental concepts, first and second laws, psychrometrics applied to plant and animal environments, introduction to Gibbs energy, and application of calorigraphy to gain basic understanding of energy flow in a biological system. Pre: MATH 2214. (3H,3C).

3305-3306: LAND AND WATER RESOURCES ENGINEERING
3305: Surface and groundwater hydrology, soil physics, irrigation principles, nonpoint source pollution control, land surveying. 3306: Erosion and sediment transport; transport and fate of nutrients, pesticides and pathogens; design of wetlands, detention facilities and other management practices for rural and urban nonpoint source pollution control; design of small dams and reservoirs. Pre: 2106. Co: CSES 3114, ESM 3024 for 3305. (2H,3L,3C).

3314: COMPUTER-AIDED DESIGN AND DRAFTING FOR LAND AND WATER RESOURCES ENGINEERING
Introduction to computer-aided design and drafting for land and water resources engineering. Representation of features in two and three dimensions for documentation and visualization of land and water resources engineering projects. Create plans, cross sections, detail drawings, and three dimensional visualizations using computer-aided design and drafting tools. Partial duplication of ENGE 2344. Pre: 3305. (3H,2L,2C).

3414 (CEE 3414): DESIGN OF WOOD STRUCTURES
Wood as an engineering material, loads, structural lumber, glulam, plywood, design of single structural elements, combined stress design, fastener design, truss design, pole and post-frame structures, shear wall, and diaphragm design. Pre: CEE 3404. (3H,3C). I.
3494: ADVANCED WELDING TECHNOLOGY
Techniques in welding that include gas, submerged metal arc, metal inert gas, pulsed arc, and tungsten inert gas welding. Design of welding structures, fundamentals of heat treatment, and plasma arc cutting. Consent required. I. Pre: ISE 2214. (3L,1C).

3504: TRANSPORT PROCESSES IN BIOLOGICAL SYSTEMS
Introduction to material and energy balances in biological systems. Fundamentals of heat and mass transfer in biological systems. One and two dimensional conduction, convection, and diffusion of thermal energy and mass. Heat and mass transfer rates, steady and unsteady state conduction, convection, diffusion; design of simple heat exchangers. Application of these topics and fluid mechanics to fluid handling, bacterial growth, plant nutrient uptake, enzymatic reactions. Pre: 3154, ESM 3024. (3H,3C).

3514: PHYSICAL PROPERTIES OF BIOLOGICAL MATERIALS
Physical characteristics and physical properties to include mechanical, thermal, and electromagnetic properties of whole and processed biological products are studied. Laboratory methods for measuring physical properties are included. II. Pre: ESM 3024. (2H,3L,3C).

3524: UNIT OPERATIONS IN BIOLOGICAL SYSTEMS ENGINEERING
Unit operations for processing biological materials including heat exchangers, evaporation, drying, mixing, homogenization, extrusion, phase and multi-phase separation, and size reduction. Laboratory hands-on experience in various unit operations. Co: 3504. (2H,3L,3C).

4125-4126: COMPREHENSIVE DESIGN PROJECT
4125: Identify and develop an engineering design project using the team approach; use of literature resources to define project objectives and approach; present project proposal in a professional written and oral manner; engineering ethics, professionalism and contemporary issues. 4126: Complete a comprehensive design project using the team approach and make professional presentations of the final design. Completion of 96 hours and overall GPA of 2.0 or better. Pre: (3306 or 3414 or 3524). 4125: (1H,3L,2C) 4126: (6L,2C).

4144: BIOLOGICAL SYSTEMS SIMULATION
Study of modeling techniques and application of these techniques to reaction kinetics, crop growth, and systems analysis. Emphasis is on development of basic understanding of methods for defining and evaluating interrelationships between parameters in a biological system. Pre: 3504. (3H,3C). I.

4304: NONPOINT SOURCE POLLUTION MODELING AND MANAGEMENT

4324: NONPOINT SOURCE POLLUTION
Engineering aspects of the sources and magnitudes of nonpoint source pollution, major causative factors, and control techniques. Emphasis on hydrologic factors, erosion, atmospheric deposition, adsorption and degradation of pollutants in soil, disposal of agricultural wastes, and management for the control of urban and agricultural nonpoint source pollution. Pre: CEE 3104. (3H,3C).

4344: GEOGRAPHIC INFORMATION SYSTEMS FOR ENGINEERS
Conceptual, technical, and operational aspects of geographic information systems as a tool for storage, analysis, and presentation of spatial information. Focus on engineering applications in resource management, site selection, and network analysis. Laboratory work and senior standing required. II. (2H,3L,3C).

4394: WATER SUPPLY AND SANITATION IN DEVELOPING COUNTRIES
Social, economic and engineering principles of water supply and sanitation in developing countries as affected by climate, cultural and sociological factors, and material and financial resources. II. Pre: CEE 3104. (3H,3C).

4404: DESIGN OF MACHINERY SYSTEMS
Functional analysis and engineering design and selection of machinery components and systems for agricultural, food, and processing applications. Design, sizing, and selection of components, power units (internal combustion engines and electronic motors), transmission devices (belts, chains, gears, hydraulics, and drivelines), material handling devices, (pumps, fans, and conveyors), and agricultural equipment (tillage, planting and chemical applications). Pre: ESM 2204, ESM 2304, ESM 3024, BSE
3154. (2H,3L,3C).

4424 (ME 4434): FLUID POWER SYSTEMS AND CONTROLS
Design and analysis of industrial and mobile hydraulic systems. Hydrostatic transmissions. Electrohydraulic servovalve characteristics and use in precise position and speed control application. Characteristics of pumps, motors, valves, and activators illustrated in laboratory exercises. Pre: ESM 3024 or ME 3404. (2H,3L,3C).

4504: BIOPROCESS ENGINEERING
Study of the engineering concepts for biological conversion of raw materials to food, pharmaceuticals, fuels, and chemicals. Emphasis is placed on enzyme kinetics and technology, bioreaction kinetics, analysis, and control of bioreactors and fermenters, and downstream processing of bioreaction products. Pre: 3504, BIOL 2604, (CHEM 2514 or CHEM 2535 or CHEM 2565 or CHEM 2565H), (CHEM 3615 or CHEM 3615H or CHEM 4615). (3H,3C).

4514: INDUSTRIAL PROCESSING OF BIOLOGICAL MATERIALS
Principles of industrial processing of biological materials. Surveys the major food processing and biopharmaceutical industries and the major processing steps involved in the production of vegetable oils, starch, corn sweeteners, biofuels, protein, dairy products, meat and poultry, seafood, fruits and vegetables, and biopharmaceuticals. Economics, safety, environmental, and quality control factors involved in the processing of biological materials. Pre: (3524, 4604). (3H,3C).

4524: BIOLOGICAL PROCESS PLANT DESIGN

4544 (CHE 4544): PROTEIN SEPARATION ENGINEERING
Concepts, principles and applications of various unit operations used in protein separations. Properties of biological materials, such as cells and proteins, and their influences on process design. Design of processes for protein purification based on the impurities to be eliminated. Concepts and principles of scale-up of unit operations. Case studies in practical protein recovery and purification issues, with a focus on enhanced protein purification by genetic engineering. Protein purification process simulation and optimization using process simulation software. Pre: 3504 or CHE 3144. (3H,3C).

4604: FOOD PROCESS ENGINEERING
Analysis and design of food processing operations including thermal pasteurization and sterilization, freezing, extrusion, texturization, and mechanical separation. Pre: 3504, 3524. (3H,3C).

4974: INDEPENDENT STUDY
Variable credit course.

4984: SPECIAL STUDY
Variable credit course.

4994: UNDERGRADUATE RESEARCH
Variable credit course.
B45. Undergraduate Biological Engineering (Dalhousie University)

The first two terms of the Biological Engineering Program follow Year 1 of the common program outlined in the Engineering section of the calendar.

TERM 3
General Biology I
Electric Circuits
Differential Equations
Computer Programming
Mechanics of Materials
Humanities Elective

TERM 4
General Biology II
Organic Biological Chemistry
Applied Probability and Statistics
Fluid Mechanics
Mechanics
Engineering Economics

TERM 5
Vector Calculus and Partial Differential Equations
Environmental and Industrial Microbiology
Applied Thermodynamics
Measurement and Control
Fundamentals of Environmental Engineering
Technical Communications

TERM 6
Numerical Methods and Linear Algebra
Heat and Mass Transfer
Microcomputer Interfacing
Properties of Biomaterials
Mechanical Design
Engineering in Society I
TERM 7
Design Project for Biological Engineers I
4 Technical Electives

TERM 8
Design Project for Biological Engineers II
Operation Research Methods of Systems
Industrial Biotechnology
2 Technical Electives

Suggested Technical Electives
Industrial Biomechanics
Biomechanical Engineering
Biomedical Engineering
CAD/CAM
Robotics
Design of Biomachnies
Bioprocess Engineering
Food Engineering
Food Science for Engineers
B46. Undergraduate Biosystems Engineering (Manitoba University)

Undergraduate courses offered by the Department of Biosystems Engineering 2007-08

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credit Hours</th>
<th>Prerequisites</th>
</tr>
</thead>
<tbody>
<tr>
<td>BIOE 2110</td>
<td>Transport Phenomena</td>
<td>J. Morrison</td>
<td></td>
</tr>
<tr>
<td>BIOE 2580</td>
<td>Biosystems Engineering Design Trilogy 1</td>
<td>D. Petkau</td>
<td></td>
</tr>
<tr>
<td>BIOE 2590</td>
<td>Biology for Engineers</td>
<td>D. Levin</td>
<td></td>
</tr>
<tr>
<td>BIOE 2CAD</td>
<td>Computer Aided Design</td>
<td>K. Laing</td>
<td></td>
</tr>
<tr>
<td>BIOE 3270</td>
<td>Instrumentation and Measurement for Biosystems</td>
<td>J. Paliwak</td>
<td></td>
</tr>
<tr>
<td>BIOE 3320</td>
<td>Engineering Properties of Biological Materials</td>
<td>S. Cenkowski</td>
<td></td>
</tr>
<tr>
<td>BIOE 3580</td>
<td>Biosystems Engineering Design Trilogy 2</td>
<td>D.D. Mann</td>
<td></td>
</tr>
<tr>
<td>BIOE 3590</td>
<td>Mechanics of Biological Materials</td>
<td>K. Dick</td>
<td></td>
</tr>
<tr>
<td>BIOE 4240</td>
<td>Graduation Project</td>
<td>Q. Zhang</td>
<td></td>
</tr>
<tr>
<td>BIOE 4390</td>
<td>Unit Operations I</td>
<td>Y. Chen</td>
<td></td>
</tr>
<tr>
<td>BIOE 4580</td>
<td>Biosystems Engineering Design Trilogy 3</td>
<td>K. Dick</td>
<td></td>
</tr>
<tr>
<td>AGRI 2200</td>
<td>Principles of Plant &amp; Animal Physiology for Engineers</td>
<td>D. Ingles</td>
<td></td>
</tr>
</tbody>
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**Technical Electives — Engineering Design**

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credit Hours</th>
<th>Prerequisites</th>
</tr>
</thead>
<tbody>
<tr>
<td>BIOE 4400(F)</td>
<td>Unit Operations II</td>
<td>Not offered in 2007-08 (SC)</td>
<td></td>
</tr>
<tr>
<td>BIOE 4412(E)</td>
<td>Design of Light-Frame Building Systems</td>
<td>Q. Zhang &amp; K. Dick</td>
<td></td>
</tr>
<tr>
<td>BIOE 4414(M)</td>
<td>Imaging and Spectroscopy for Biosystems</td>
<td>J. Paliwak</td>
<td></td>
</tr>
<tr>
<td>BIOE 4420(F)</td>
<td>Crop Preservation</td>
<td>Not offered in 2007-08 (JP)</td>
<td></td>
</tr>
<tr>
<td>BIOE 4460(E)</td>
<td>Air Pollution Assessment and Management</td>
<td>Not offered in 2007-08 (CZ)</td>
<td></td>
</tr>
<tr>
<td>BIOE 4480(E)</td>
<td>Environmental Impact Assessment</td>
<td>Not offered in 2007-08 (DDM)</td>
<td></td>
</tr>
<tr>
<td>BIOE 4530</td>
<td>Analysis and Design of Biomachinery</td>
<td>Y. Chen</td>
<td></td>
</tr>
<tr>
<td>BIOE 4560</td>
<td>Design with Wood</td>
<td>Not offered in 2007-08 (KO)</td>
<td></td>
</tr>
<tr>
<td>BIOE 4590(E)</td>
<td>Management of By-Products from Animal Production</td>
<td>Y. Chen</td>
<td></td>
</tr>
<tr>
<td>BIOE 4600(E)</td>
<td>Design of Water Management Systems</td>
<td>R. Sri Ranjan</td>
<td></td>
</tr>
<tr>
<td>BIOE 4610(M)</td>
<td>Design of Assistive Technology Devices</td>
<td>D.D. Mann</td>
<td></td>
</tr>
<tr>
<td>BIOE 4620(E)</td>
<td>Remediation Engineering</td>
<td>Not offered in 2007-08 (RSR)</td>
<td></td>
</tr>
<tr>
<td>BIOE 4630(E)</td>
<td>Pollution Prevention Practices</td>
<td>Not offered in 2007-08 (NC)</td>
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</tbody>
</table>

**Technical Electives — Engineering Science**

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credit Hours</th>
<th>Prerequisites</th>
</tr>
</thead>
<tbody>
<tr>
<td>BIOE 2080</td>
<td>Agricultural Survey Systems</td>
<td>Not offered in 2007-08 (DI)</td>
<td></td>
</tr>
<tr>
<td>BIOE 4450</td>
<td>Radiation Process of Food &amp; Other Agric. Commodities</td>
<td>Not offered in 2007-08</td>
<td></td>
</tr>
</tbody>
</table>

**Co-op Courses**

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Instructor(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>BIOE 3550</td>
<td>Biosystems Engineering Work Study I</td>
<td>N. Cicak (January - August)</td>
</tr>
<tr>
<td>BIOE 4550</td>
<td>Biosystems Engineering Work Study II</td>
<td>N. Cicak (May - December)</td>
</tr>
</tbody>
</table>

**BIOE 2080 Agricultural Survey Systems Cr.Hrs.3 (Lab Required)**


**BIOE 2110 Transport Phenomena Cr.Hrs.3**

Principles of heat transfer, solar radiation, psychometrics, molecular diffusion, mass transfer and refrigeration and their application to biosystems. *Prerequisite:* ENG 1120 (or 130.112).

**BIOE 2580 Biosystems Engineering Design Trilogy 1 Cr.Hrs.4 (Lab Required)**

Biosystems Engineering and its place in the professions of engineering and agrology. Design concepts, with an emphasis on team building and technical communication skills. Philosophy of project planning. Preparation of a conceptual design by teams in response to design assignment submitted by industry. Written report presented orally. *Prerequisite:* ENG 1400 (or 130.140). Not to be held with the former 034.214.

**BIOE 2590 Biology for Engineers Cr.Hrs.3 (Lab Required)**

Provide theories and principles of Biology to engineering students and present applications of biological principles to engineering problems. Fundamental theories
involved in cell structure and function, metabolism, genetics and heredity, bacteria and virus structure and function, plant and animal structure and function are covered. An introduction to animal and plant physiology is also provided. Laboratory sessions and term assignments focus on the engineering applications of these basic theories and principles to provide a good understanding of the role of Biology in Engineering. **Prerequisite:** CHEM 1300 (or 002.130). Not be held with the former 071.201.

**BIOE 3270 Instrumentation and Measurement for Biosystems**

Cr.Hrs.4 (Lab Required)

Basic instrumentation for measuring electrical and nonelectrical quantities associated with biosystems engineering and industry; transducers for automatic control. **Prerequisites:** 006.261 or MATH 2110 (or 136.211), ENG 1180 (or 130.118).

**BIOE 3320 Engineering Properties of Biological Materials**

Cr.Hrs.4 (Lab Required)

Engineering properties of biological and interacting materials within the system. Relationship between composition, structure, and properties of plant, animal, and human tissues. Definition and measurement of mechanical, thermal, electromagnetic, chemical and biological properties and their variability. Use of these properties in engineering calculations. **Prerequisites:** MATH 2100 (or 136.210 or 006.260), CIVL 2800 (or 023.280) or MECH 2220 (or 025.222), BIOE 2580 (or 034.258 or 034.214). Not to be held with the former 034.323.

**BBIOE 3550 Cooperative Work Study 1**

Cr.Hrs.1

Work assignment in business, industry, or government for Cooperative education students in Biosystems Engineering. Requires a written report covering the work completed during a minimum 25-week work period. Available from January to August. (Pass/Fail grade only)

**BIOE 3580 Biosystems Engineering Design Trilogy 2**

Cr.Hrs.4 (Lab Required)

Advanced design concepts associated with Biosystems Engineering, with emphasis on the principles of safety and human factors engineering. Theory of project planning. Preparation of a preliminary design by design teams in response to a design assignment submitted by industry. Written report with engineering drawings presented orally. **Prerequisites:** BIOE 2580 (or 034.258 or 034.214). Not to be held with the former 034.326.

**BIOE 3590 Mechanics of Materials in Biosystems**

Cr.Hrs.4 (Lab Required)

In this course students will be exposed to both the theory and physical behaviour of materials when subjected to loads. The course will be delivered using a combination of lectures and hands-on labs. The materials presented include a wide range of design biosystems engineers may be involved with, including plastics, bone, wood, concrete, steel, other biological materials and composites. **Prerequisite:** CIVL 2800 (or 023.280), or consent of instructor. Not to be with the former 034.324

**BIOE 4240 Graduation Project**

Cr.Hrs.3

Either an independent or a directed study including at least one of: a comprehensive literature review, an experimental research project, or an engineering design problem. The project is to be concluded by a formal report or thesis. **Prerequisites:** BIOE 3580 (034.358) or approval of department. (Pass/Fail grade only).
BIOE 4390 Unit Operations 1 Cr.Hrs.4 (Lab Re(quired)
Equipment and systems used in handling, mixing, size reduction, separation and size enlargement of value-added food products. Prerequisites: CIVL 2790 (or 023.279) or MECH 2260 (or 025.226), BIOE 3270 (or 034.327). Corequisites: BIOE 3320 (or 034.332 or 034.323), BIOE 3580 (or 034.358 or 034.326).

BIOE 4400 Unit Operations 2 Cr.Hrs.4 (Lab Required)
Physical and mechanical operations for process and equipment design for handling, processing, and distribution of foods and food products. Prerequisites: BIOE 2110 (or 034.211), BIOE 3320 (or 034.332 or 034.323). Not offered in 2007-2008.

BIOE 4412 Design of Light-Frame Building Systems Cr.Hrs.4 (Lab Required)
Light-frame buildings as a structural and environmental system; structural loads in building systems; energy (heat), moisture and air contaminants in building systems; built-environment for building occupants. Hands-on labs of constructing small-scale structures for students to gain an understanding of building construction techniques. Prerequisites: BIOE 2110 (034.211) and BIOE 3590 (034.359). Offered in 2007-2008 and alternate years after.

BIOE 4414 Imaging and Spectroscopy for Biosystems Cr.Hrs.4 (Lab Required)
The purpose of this course is to familiarize senior Biosystems Engineering students with the fundamentals of imaging and spectroscopy for biosystems. Techniques of image acquisition, storage, processing, and pattern recognition will be taught. Various spectroscopy techniques and their applicability to biological materials will be discussed. Analysis of data using statistical, artificial neural networks and chemometric methods will be covered. Offered in alternate years. Prerequisite: BIOE 3270 (034.327). Offered in 2007-2008 and alternate years after.

BIOE 4420 Crop Preservation Cr.Hrs.4 (Lab Required)
Biological and physical deterioration during storage. Methods of preserving and storing cereals, oilseeds, and other agricultural crops. Prerequisite: BIOE 2110 (or 034.211). Not offered in 2007-2008.

BIOE 4450 Radiation Processing of Food and Other Agricultural Commodities Cr.Hrs.4
An introduction to the scientific principles underlying the radiation processing of food and other agricultural commodities; its development and implementation within the context of societal needs and concerns. Prerequisites: BIOE 2590 (or 034.259) or 071.201 or BIOL 1020 and BIOL 1030 or the former 071.125 (C) and CHEM 1300 (or 002.130) or the former 002.123 or 002.127. Not offered in 2007-2008.

BIOE 4460 Air Pollution Assessment and Management Cr.Hrs.4 (Lab Required)
Air pollutant sources and characteristics, their impact on the environment, their behaviour in the atmosphere. Methods of sampling and measurement and the basic technological alternatives available for separation/removal and control. Particular problems of regional interest are discussed. Corequisites: CIVL 2790 (or 023.279) or CIVL 3610 (023.361) or MECH 2260 (or 025.226). Not offered in 2007-2008.

BIOE 4480 Environmental Impact Assessment Cr.Hrs.4 (Lab Required)
Basic methodologies for conducting impact assessments, including physical, chemical and ecological impacts. **Prerequisites:** approval of department. Not offered in 2007-2008.

**BIOE 4530 Analysis and Design of Biomachinery** Cr.Hrs.4 (Lab Required)
Design of machines for bioprocessing; traction mechanics and tractor chassis mechanics; power transmission components; functional requirements for field and process machines; fluid power hydraulics. **Prerequisite:** BIOE 3580 (or 034.358) or 034.326. Offered in 2007-2008 and alternate years after.

**BIOE 4550 Cooperative Work Study** 2 Cr.Hrs.1
Work assignment in business, industry, or government for Cooperative education students in Biosystems Engineering. Requires a written report covering the work completed during a minimum 25 week work period. Available from May to December. (Pass-Fail grade only)

**BIOE 4560 Structural Design in Wood** Cr.Hrs.4 (Lab Required)
Design using wood as a structural material in light-frame buildings. Consideration of design constraints associated with sawn lumber as well as based composite materials. Emphasis on use of computer based design aids. **Prerequisites:** CIVL 3770 (or 023.377) or BIOE 3590 (034.359) or 034.324. Not offered in 2007-2008.

**BIOE 4580 Biosystems Engineering Design Trilogy** 3 Cr.Hrs.4 (Lab Required)
Advanced design concepts, with emphasis on the principle of quality control. Application of project planning techniques. Principles of owning and operating an engineering consulting company. Preparation of a final design by design teams in response to a design assignment submitted by industry. Written report with cost of services rendered, presented orally. **Prerequisite:** BIOE 3580 (or 034.358) or 034.326.

**BIOE 4590 Management of By-Products from Animal Production** Cr.Hrs.4 (Lab Required)
Topics covered include solid and liquid manure, manure characteristics, manure collection, storage, land application and utilization, biological treatment, design of equipment and facilities for manure handling. Environment issues, such as odour and water pollution associated with manure management will also be discussed. **Prerequisites:** CIVL 2790 (or 023.279) or MECH 2260 (or 025.226). Offered in 2007-2008 and alternate years after.

**BIOE 4600 Design of Water Management Systems** Cr.Hrs.4 (Lab Required)
To introduce the basic theoretical principles in the design of irrigation and drainage systems. Topics covered include the determination of irrigation depth and interval, evapotranspiration, measurement and analysis of precipitation, design of sprinkler and drip irrigation systems, selection of pumps, surface and subsurface drainage design, water quality issues, salinity management, and the environmental impact of water management practices. Corequisite: SOIL 4060 (or 040.406) or CIVL 3730 (or 023.373) or consent of instructor. Not to be held with the former 034 412 or 034.418. Offered in 2007-2008 and alternate years after.

**BIOE 4610 Design of Assistive Technology Devices** Cr.Hrs.4 (Lab Required)
Application and design of technology for individuals with disabilities; emphasizing the development of the requisite knowledge, skills, and attitudes to evaluate, design,
and implement client-centred assistive technology. A multi-disciplinary approach to learning and applying knowledge will be emphasized with engineering and medical rehabilitation students collaborating on a design project. Prerequisite: AGRI 2200 (or 065.220). Offered in 2007-2008 and alternate years after.

**BIOE 4620 Remediation Engineering Cr.Hrs.4 (Lab Required)**

The theoretical basis for the engineering design of different remediation technologies to treat contaminated soil and groundwater will be introduced. Methods for site characterization, monitoring of progress in remediation, and modeling of the remediation process will be presented. Different methods such as soil washing, air sparging, bioremediation, phytoremediation, constructed wetlands, electrokinetic remediation, reactive barriers will be discussed. Prerequisite: CIVL 2790 (or 023.279) or MECH 2260 (or 025.226). Not offered in 2007-2008.

**BIOE 4630 Pollution Prevention Practices Cr.Hrs.4 (Lab Required)**

To give students an understanding of pollution prevention as it relates to solids and hazardous waste management, air and water pollution, energy usage, and resource depletion. To evaluate practices on improved manufacturing operations, present fundamentals of pollution prevention economics, examine waste minimization incentives, design improvements to existing systems, and investigate overall sustainability of industrial practices. Prerequisite: CIVL 2790 (or 023.279) or MECH 2260 (or 025.226). Not offered in 2007-2008.
Undergraduate Biosystems & Bioresource Engineering (McGill University)

Overview:

The Bioresource Engineering program is a Major program and upon graduation you will obtain a Bachelor of Engineering degree (B.Eng.).

In Québec, the university years are called U0, U1, U2, and U3 (known elsewhere as the Freshman, Sophomore, Junior and Senior Years, respectively). Students who come to McGill directly from high schools outside of the province of Québec (for example, other Canadian provinces, the US, or overseas), typically enter the university in their Freshman Year (U0). Such students, as well as those who transfer from another degree program, or university, will often need to take some introductory science and math (freshman) courses. If you are unsure of your status, please discuss your situation and degree requirements with your academic advisor and/or the Freshman Advisor, who will be happy to assist.

See the freshman website (McGill University Macdonald Campus Freshman Program) for those courses.

Minor Program:

While you are working to obtain your (B.Eng.) Major degree, you can also complete a Minor program. This usually adds about one term to your total studies at McGill. However, it will increase your expertise substantially in that specific area, such as Environmental Engineering. Academic Minors

Entrance Levels:

You can enter the Bioresource Engineering program at several levels. The requirements for admission depend on your educational background.

U0 Level – Freshman Year: Students coming from Canadian provinces outside Québec or other countries may enter the program at this level, and complete a 30-credit "freshman year" before proceeding with their U1 (Undergraduate) courses.

Freshman Year information can be found here: McGill University Macdonald Campus Freshman Program

U1 Level – University Year 1: Most students will enter at this level after completing a CEGEP 2-year DEC in Quebec, after finishing Grade 11 in high school.

Advanced Standing: Students may wish to enter our program with advanced standing because they have courses from another engineering program, either at McGill, another university, or equivalent educational institution. These students can then enter either at the U0, U1, U2, or even the U3 level.
Completion of B.Eng.:

U0 Level – Freshman Year: 143 credits in four years and a half years

If you come from outside Québec you may be admitted on the basis of a high school diploma or equivalent education. In that case you can apply for and register for the B.Eng. (Bioresource) degree but start the engineering program at the U0 level or "Freshman Year". Depending on the details of your educational background you may be given advanced standing for work done at other universities. Your total credit requirement will then be 113+30=143 credits (two years of Québec CEGEP are accorded the equivalent of 30 credits at the university level).

Freshman Year information can be found here: McGill University Macdonald Campus Freshman Program

U1 Level – University Year 1: 113 credits in three and a half years

This is based on the student entering the program with a Québec DEC in Science with all the appropriate science and mathematics courses. If you enter the program with another type of Quebec DEC from, for instance, a technical college special conditions apply, but you can often enter the program with advanced standing.

Advanced Standing

If you come from outside Québec, and have qualifications in addition to high school (e.g., International Baccalaureate, French Baccalaureate, or results from Advanced Placement Tests), you may be granted admission to the Freshman program with advanced standing, or admission to the Bioresource Engineering program, perhaps with some entrance requirements outstanding. These details are resolved by the Admissions office after you apply to McGill.

Accreditation:

Our program is accredited by:

- The Canadian Engineering Accreditation Board (CEAB): graduates automatically qualify for membership in the Ordre des Ingénieurs du Québec (after meeting various conditions such as passing the French language test, paying some appropriate fees, etc.). This corresponds directly to "Professional Engineer" status in other Canadian provinces and Territories, as well as various states of the US.
- The Ordre des Agronomes du Québec: graduates qualify to become members of this order and officially become "agronomes".

Five Optional Streams of Focus:

The undergraduate program was designed to give you a balanced education, allowing the student to move, as a professional, into a number of different sub-disciplines, without being over-stretched. Thus, in the program the student can concentrate on a particular area of focus.

- BioEnvironmental Engineering
- Soil and Water Engineering
- Ecological Engineering
• Food and Bioprocess Engineering
• Agricultural Engineering

In each stream the main set of courses is devoted to the engineering sciences, design, and synthesis. They are combined with mathematics, and science courses that are specifically oriented to the stream. As well, the student follows a number of courses in the humanities/management/social sciences fields. For all streams a typical engineering approach is followed: there is heavy stress on the relationship between decision-making and option evaluation during the design stage, and the resultant performance of the unit or effect of the decision once implemented. This approach is followed whether the subject of discussion is a simple cultivation tool or an entire ecosystem.

Please note: All courses at McGill are taught in English. However, students always have the option of submitting assignments and writing exams in either English or French.

BEng in Bioresource Engineering
Streams offered in the BEng include:
Bioresource Engineering

Bioenvironmental Engineering
BioEnvironmental Engineering

The BioEnvironmental Engineering stream focuses on the interface between the agro-ecosystem and the environment.

In this stream you will concentrate on the following:
Conservation of soil and water resources and quality
Geomatics and the use of Geographic Information System (GIS) for biosystem management
Organic Waste Treatment with various technologies including:
Composting
Environmental Remediation
Land Protection and Development (within an overall ecosystem-design approach)
Remote Sensing Applications of Artificial Intelligence
Complex System Simulation (to attain the overall objectives of long-term sustainability and environmental protection)

Course Sets:
Required Courses, 53 credits
Complementary Course Set A, 6 credits
Complementary Course Set B, 9 credits
Complementary Course Set C, minimum 9 credits
Complementary Course Set D, 36 credits
Complementary Courses, set A - 6 credits:
AEMA 310 Statistical Methods 1
or
CIVE 302 Probabilistic Systems
or

**MATH 323** Probability

**CHEE 315** Heat and Mass Transfer
or
**MECH 346** Heat Transfer

Complementary Courses, set B - 9 credits:
* **AEBI 211** Organisms 2
* **FDSC 211** Biochemistry 1
* **LSCI 230** Introductory Microbiology

Complementary Courses, set C - min. 9 credits: (with at least 3 credits from subset marked with *)
* **MIME 308** Social Impact of Technology

The two other courses needed in this set may be taken from humanities, social sciences, administrative studies, law, or language.

**Note:** This may be any language course which is deemed, by the academic advisor, to have a sufficient cultural component or, in the case of the student who is not proficient in a specific language, program credit will be given for the second of two successfully completed, academically approved 3-credit language courses.

Complementary Courses, set D - min. 36 credits: (including the following courses)
**BREE 214** Geomatics
**BREE 217** Hydrology and Water Resources
**BREE 322** Organic Waste Management
**BREE 518** Bio-Treatment of Wastes
**BREE 525** Climate Control for Buildings

**Optional for this stream:**
**BREE 416** Eng for Land Development
**BREE 501** Simulation and Modelling
**BREE 502** Drainage/Irrigation Eng.
**BREE 504** Instrumentation and Control
**BREE 509** Hydrologic Systems&Modelling
**BREE 515** Soil Hydrologic Modelling

**Ecological Engineering**
Ecological Engineering
Ecological Engineering is the application of engineering and ecological principles to the design, creation, maintenance and operation of ecological systems. Ecosystems are complex adaptive systems - a community of organisms and their surroundings, including technological components. Ecological Engineering involves design methods that preserves and utilizes natural ecological processes.

Course Sets:
- **Required Courses**, 53 credits
- **Complementary Course Set A**, 6 credits
- **Complementary Course Set B**, 9 credits
- **Complementary Course Set C**, minimum 9 credits
- **Complementary Course Set D**, 36 credits

Complementary Courses, set A - 6 credits:
- **AEMA 310** Statistical Methods 1
  - or
- **MATH 323** Probability
  - or
- **CIVE 302** Probabilistic Systems

- **MECH 346** Heat Transfer
  - or
- **CHEE 315** Heat and Mass Transfer

Complementary Courses, set B - 9 credits:
- **ENVB 210** The Biophysical Environment
- **SOIL 331** Soil Physics

Optional for this stream:
* **LSCI 230** Introductory Microbiology

Complementary Courses, set C - min. 9 credits: (with at least 3 credits from subset marked with *)

Optional for this stream:
* **CHEE 230** Envrnmntl Aspects of Technol

The two other courses needed in this set may be taken from humanities, social sciences, administrative studies, law, or language.

Note: This may be any language course which is deemed, by the academic advisor, to have a sufficient cultural component or, in the case of the student who is not proficient in a specific language, program credit will be given for the second of two successfully completed, academically approved 3-credit language courses.

Complementary Courses, set D - min. 36 credits: (including the following courses)
COMING SOON...

Optional for this stream:
COMING SOON...

Food and Bioprocess Engineering

The Food and Bioprocess Engineering stream focuses on the storage of agricultural products and related biological materials, their processing into value-added foods and various other industrial commodities. Traditional food processing methods such as size reduction / heating / cooling / drying are studied, as well as modern methods such as microwave processing and bio-processing with enzymes. In this stream you will concentrate on the following:
Food Processing and Food Engineering
Post-Harvest Storage and Food Preservation
Organic Waste Treatment
Physical Properties of Biological Material
Fermentation and Bio-Processing
You will also be exposed to industrial control techniques, and to some applications of artificial intelligence and complex system simulation for design and control. You will take some courses in biochemistry, food chemistry and food science.

Course Sets:
Required Courses, 53 credits
Complementary Course Set A, 6 credits
Complementary Course Set B, 9 credits
Complementary Course Set C, minimum 9 credits
Complementary Course Set D, 36 credits
Complementary Courses, set A - 6 credits:
AEMA 310 Statistical Methods 1
or
CIVE 302 Probabilistic Systems
or
MATH 323 Probability

CHEE 315 Heat and Mass Transfer
or
MECH 346 Heat Transfer

Complementary Courses, set B - 9 credits:
FDSC 200 Introduction to Food Science
Optional for this stream:
* FDSC 211 Biochemistry 1
* LSCI 230 Introductory Microbiology
Complementary Courses, set C - min. 9 credits: (with at least 3 credits from subset marked with *)

**Optional for this stream:**
* CHEE 230 Envrmntl Aspects of Technol

The two other courses needed in this set may be taken from humanities, social sciences, administrative studies, law, or language.  
**Note:** This may be any language course which is deemed, by the academic advisor, to have a sufficient cultural component or, in the case of the student who is not proficient in a specific language, program credit will be given for the second of two successfully completed, academically approved 3-credit language courses.

Complementary Courses, set D - min. 36 credits:
  - BREE 325 Food Process Engineering
  - BREE 519 Advanced Food Engineering
  - BREE 530 Fermentation Engineering
  - BREE 531 Post-Harvest Drying
  - BREE 532 Post-Harvest Storage

**Optional for this stream:**
  - BREE 314 Agri-Food Buildings
  - BREE 315 Design of Machines
  - BREE 322 Organic Waste Management
  - BREE 501 Simulation and Modelling
  - BREE 504 Instrumentation and Control
  - BREE 518 Bio-Treatment of Wastes
  - BREE 525 Climate Control for Buildings

**Soil and Water Engineering**

Soil and Water Engineering

The Soil and Water Engineering stream focuses on the soil/water interface and how to manage it for maximum productivity within the environmental requirements of long-term sustainability and overall ecosystem health.

In this stream you will concentrate on the following topics:
- Hydrology
- Irrigation and Drainage
- Soil Mechanics
- Soil and Water Management
- Surface and Groundwater Flow
- Remote Sensing and Geographic Information System (GIS)
- Environmental Quality
- Land Development
Complex System Simulation Applications

Course Sets:
- **Required Courses**, 53 credits
- **Complementary Course Set A**, 6 credits
- **Complementary Course Set B**, 9 credits
- **Complementary Course Set C**, minimum 9 credits
- **Complementary Course Set D**, 36 credits

Complementary Courses, set A - 6 credits:
- **AEMA 310** Statistical Methods 1
  or
- **CIVE 302** Probabilistic Systems
  or
- **MATH 323** Probability

**CHEE 315** Heat and Mass Transfer
  or
**MECH 346** Heat Transfer

Complementary Courses, set B - 9 credits:
- **ENVB 210** The Biophysical Environment
- **SOIL 331** Soil Physics

**Optional for this stream:**
- * **LSCI 230** Introductory Microbiology

Complementary Courses, set C - min. 9 credits: (with at least 3 credits from subset marked with *)

**Optional for this stream:**
- * **CHEE 230** Envrnmntl Aspects of Technol

The two other courses needed in this set may be taken from humanities, social sciences, administrative studies, law, or language.

**Note:** This may be any language course which is deemed, by the academic advisor, to have a sufficient cultural component or, in the case of the student who is not proficient in a specific language, program credit will be given for the second of two successfully completed, academically approved 3-credit language courses.

Complementary Courses, set D - min. 36 credits: (including the following courses)
- **BREE 214** Geomatics
- **BREE 217** Hydrology and Water Resources
- **BREE 416** Eng for Land Development
- **BREE 418** Soil Mechanics & Foundations
Optional for this stream:

BREE 322 Organic Waste Management
BREE 419 Structural Design
BREE 502 Drainage/Irrigation Eng.
BREE 504 Instrumentation and Control
BREE 509 Hydrologic Systems & Modelling
BREE 512 Soil Cutting and Tillage
BREE 515 Soil Hydrologic Modelling

Agricultural Engineering

The Agricultural Engineering stream is the closest to our traditional Agricultural Engineering program. It is also referred to as the "Food Production Machinery and Buildings" stream. This stream focuses on providing engineering support for agricultural industries and agricultural enterprises. This includes the design, construction, functioning, etc. of agricultural machines, structures, and other infrastructure such as waste treatment facilities, irrigation and drainage systems, and storage buildings and methods.
In this stream you will concentrate on the following topics:
Agricultural Machinery
Agricultural Structures
Organic Waste Treatment
Hydrology
Irrigation
Drainage
Animal and Plant Production
Post-Harvest Storage

Course Sets:
- **Required Courses**, 53 credits
- **Complementary Course Set A**, 6 credits
- **Complementary Course Set B**, 9 credits
- **Complementary Course Set C**, minimum 9 credits
- **Complementary Course Set D**, 36 credits
Complementary Courses, set A - 6 credits:
- **AEMA 310** Statistical Methods 1
  or
- **CIVE 302** Probabilistic Systems
  or
- **MATH 323** Probability

**CHEE 315** Heat and Mass Transfer
or
MECH 346 Heat Transfer

Complementary Courses, set B - 9 credits:
ENVB 210 The Biophysical Environment
PLNT 211 Principles of Plant Science

Optional for this stream:
* ENVB 305 Population & Community Ecology

Complementary Courses, set C - min. 9 credits: (with at least 3 credits from subset marked with *)

Optional for this stream:
* MIME 308 Social Impact of Technology

The two other courses needed in this set may be taken from humanities, social sciences, administrative studies, law, or language.

Note: This may be any language course which is deemed, by the academic advisor, to have a sufficient cultural component or, in the case of the student who is not proficient in a specific language, program credit will be given for the second of two successfully completed, academically approved 3-credit language courses.

Complementary Courses, set D - min. 36 credits, including the following courses:
BREE 214 Geomatics
BREE 314 Agri-Food Buildings
BREE 315 Design of Machines
BREE 412 Machinery Systems Engineering
BREE 418 Soil Mechanics & Foundations

Optional for this stream:
BREE 217 Hydrology and Water Resources
BREE 322 Organic Waste Management
BREE 419 Structural Design
BREE 504 Instrumentation and Control
BREE 525 Climate Control for Buildings

The following program(s) lead toward eligibility for professional accreditation:
Bioresource Engineering: Professional Engineer accreditation in any province of Canada; Ordre des agronomes du Québec
C. GRADUATE STUDIES
C1. Graduate Biosystems Engineering (Auburn University)

Graduate Students

The biosystems engineering graduate programs are designed to prepare graduates for leadership, creative accomplishment and continued professional learning, and to prepare graduates to effectively conduct independent scientific research.

Students may be accepted with backgrounds in quantitative-based scientific fields relating to chemistry, mathematics, physics, biology or any branch of engineering. A number of undergraduate prerequisite or corequisite courses may be required for applicants who have undergraduate degrees in nonengineering disciplines.

Each degree program is planned individually to augment the student's previous engineering and science background with adequate breadth in engineering and specialization in an area of biosystems engineering. In addition to biosystems engineering, course work includes mathematics, physics, chemistry, statistics, and biological and engineering sciences.

Candidates for the Master of Science (M.S.) degree are required to complete a minimum of 24 hours of course work plus an additional six hours of thesis research and submit an acceptable thesis.

Candidates for the Ph.D. degree are required to complete an additional 36 semesters hours of course work beyond the M.S. degree. Students must also complete 18 hours of dissertation research and submit an acceptable dissertation.

Graduate School Application
Graduate Courses
BIOSYSTEMS ENGINEERING 2008 - 2009

B E (CSENV) 608 Land Treatment of Wastewater and Sludges 3(3,0)
See CSENV 608.

B E 612 Heat and Mass Transport in Biosystems Engineering 3(3,0)
Fundamentals of heat and mass transport used in engineering design and analysis of biological systems; principles of steady state and transient energy and mass balances including chemical and biological generation terms. Preq: B E 312, MTHSC 208. Coreq: M E 310.

B E 614 Biosystems Engineering Unit Operation 3(2,3)
Applies the basic principles of statics, dynamics, and thermodynamics to design of mechanical and electrical systems supporting biological operations and processes. Preq: B E 314, M E 310.

B E 615 Instrumentation and Control for Biosystems Engineers 4(3,3)
Overview of modern instrumentation techniques and digital electronic components and subsystems to integrate them into digital data acquisition and control systems for biosystems. Emphasizes laboratory use of equipment. Topics include characteristics of instruments, signal conditioning, transducer theory and applications, programmable logic controllers, and digital data acquisition and control. Preq: E C E 307.

B E 617 Applied Instrumentation and Control for Biosystems 2(1,3)
Study of hardware and software implementation of digital data acquisition and control systems for application to agriculture, aquaculture, biotechnology, and other biosystems. Topics include digital electronic circuits and components, microcomputer architecture, interfacing, and programming. Preq: B E 415 or consent of instructor.

B E 622 Hydrologic Modeling of Small Watersheds (3,0)
Design of structures and development of best management practices for runoff, flood, and sediment control from rural and urban areas, including natural and disturbed watersheds. Topics include modeling of prismatic and non-prismatic channels, culverts, and detention/retention ponds. Preq: B E 322 or consent of instructor.

B E (CH E) 628 Biochemical Engineering 3(3,0)
Use of microorganisms and enzymes for the production of chemical feedstocks, single-cell protein, antibiotics, and other fermentation products. Topics include kinetics and energetics of microbial metabolism, design and analysis of reactors for microbial growth and enzyme-catalyzed reactions, and considerations of scale-up, mass transfer, and sterilization during reactor design. Preq: B E 312, MICRO 305; Coreq: (for Biosystems Engineering majors) BIOCH 301 or 305; (for Chemical Engineering majors) CH E 330, 450.

B E 635 Applications in Biotechnology Engineering 3(2,3)
Bioengineering principles applied to the expanding fields of agricultural biotechnology, ecotechnology, and biomedical technology. Special applications include waste treatment and ecological engineering, bioreactor propagation of plant
and animal cells and tissues, applied genomics and synthetic seed production, biosensors and biomonitoring, biological implants and materials biocompatibility. Preq: B E (CH E) 428.

**B E 638 Bioprocess Engineering Design 3(2,2)**
Design and analysis of systems for processing materials. Topics include biotechnology, thermodynamics, transport processes, and biological properties related to bioprocess design and computational simulation. Unit operations include basic bioreactor operation, bioseparations, and preservation techniques. Preq: B E 428.

**B E 640 Renewable Energy Resource Engineering 3(2,2)**
Investigation into merging renewable energy resources, including detailed study of solar, wind, and bioenergy alternatives. Also includes principles, technologies, and performance evaluation of components for these technologies and an introduction to tidal, hydro, geothermal, and other energy; energy conservation; cogeneration; financial, economical, and other issues related to alternative energy sources. Preq: Science or engineering major, consent of instructor.

**B E 642 Properties and Processing of Biological Products 2(1,3)**
Study of engineering properties of biological materials and their uniqueness as design restraints on systems for handling, processing, and preserving biological products. Preq: B E 333, C E 341, M E 302, 310.

**B E (EE&S, FOR) 651 Newman Seminar and Lecture Series in Natural Resources Engineering 1(0,2)**
Topics dealing with development and protection of land, air, water, and related resources are covered by seminar with instructor and invited lecturers. Current environmental and/or resource conservation issues are addressed. Preq: Senior standing, consent of instructor.

**B E 664 Non-Point Source Management in Engineered Ecosystems 3(2,3)**
Fundamentals of nonpoint source pollution including quantification of environmental impact and ecosystem management related to contaminants and nutrients and to planning and design of ecological systems. Preq: MICRO 305, senior standing in engineering, or consent of instructor.

**B E (EE&S) 684 Municipal Solid Waste Management 3(3,0)**
See EE&S 684.

**B E 781 Special Problems 1-3(1-3,0)**
Students select subjects and conduct library, laboratory, and/or field research. A technical report documenting the study is required. May be repeated for a maximum of six credits. Preq: Master’s degree candidate in Engineering.

**B E 835 Industrial Biotechnology Techniques 4(3,3)**
Introduces industrial biotechnology techniques with emphasis on bioproduction, pilot bioprocessing equipment operation, biopharmaceutical storage, process simulation and economics, project management, good laboratory practice (GLP), and current good manufacturing practice (cGMP) geared toward the biotechnology industry. Preq: B E 638 or BIOCH 633, GEN (BIOSC) 616, or consent of instructor.
B E 838 Advanced Bioprocess Engineering 3(3,0)
Advanced bioprocessing techniques with emphasis on processing and modeling aspects of eukaryotic systems and associated bioproducts. Modules include thermal processing, supercritical fluid extraction, and advanced biological thermodynamics, chromatography, and spectroscopy. Preq: B E 438/638 or consent of instructor.

B E 865 Advanced Biological Transport Processes 3(3,0)
Study of transient transport processes in biological materials and systems. Incorporates mathematics describing active and passive cellular transport. Emphasizes numerical solution techniques for coupled transport relationships in nonideal, heterogeneous systems, including biological kinetic and thermodynamic considerations. Preq: BIOCH 305, CH E 601, MTHSC 634, or consent of instructor.

B E 871 Selected Topics in Biosystems Engineering 1-3(1-3,0)
Supervised, in-depth study of an area related to biosystems engineering not covered in other courses. May be repeated for a maximum of six credits.

B E 891 Master’s Thesis Research 1-12

B E 901 Special Problems in Agricultural Engineering 3(3,0)
Library and/or laboratory research on one of the following subjects, depending on student’s field of study or interests: power and machinery, soil and water resources, farm structures, electric power and processing, food engineering, forest engineering or waste management. A technical report is required.

B E 991 Doctoral Dissertation Research 1-12
C2. Graduate BioResource & Agricultural Engineering (California Polytechnic State University)

Masters Programs

- **MS Engineering, Specialization in Water Engineering**
- **MS Agriculture, Specialization in Irrigation**
- **MS Agriculture, Specialization in Agricultural Engineering Technology**

Masters of Science Engineering

Specialization in Water Engineering

**Required Courses**

- Analytical methods for engineering: 6 units
- Advanced Mathematics: 3 units
- ECON 410 Public Finance/Cost-Benefit Analysis: 4 units
- BRAE 435/BRAE 414/BRAE 440: 3 units
- BRAE 533 Irrigation Project Design: 4 units
- CE 533 Adv Water Resources Engineering: 3 units
- CE 573 Public Works Administration: 3 units
- BRAE/CE 599 Design Project (Thesis) or 9 units of approved technical electives *and* written comprehensive examination: 2/2/5 units

**Approved Elective Courses**

Select 10 units from the following:

- BRAE 414, 437, 440, 533;
- CE 434, 440;
- ENVE 438, 439, 535

**Total**

45 units

For a list of classes required of students who do not have a BS from an ABET-accredited program in Agricultural or Civil or Environmental Engineering, click here.

A description of paperwork and other requirements for the BRAE MS in Engineering can be found here. For advisor information and other forms, please click here.

**General Characteristics**

The Master of Science degree program in Engineering has the following objectives:

- Provide preparation for further study in engineering, leading to the Doctor of Engineering or Ph.D. degree.
- Provide an empowering terminal professional degree for students who intend to become practicing engineers, a degree that not only retains the strong laboratory emphasis and industrial interaction found in the BS curriculum, but which also provides an attractive, efficient educational option to undergraduate students.
- Provide job-entry education for the more complex and evolving interdisciplinary areas of engineering, such as research and development,
innovative design, systems analysis and design, bio-engineering, biomedical engineering, manufacturing, mechatronics, and engineering management.

- Update and upgrade opportunities for practicing engineers.
- Allows graduates to maintain currency in their fields.

**Prerequisites**

For admission as a classified graduate student, an applicant should hold a bachelor's degree in engineering or a closely related physical science with a minimum grade point average of 2.5 in the last 90 quarter units (60 semester units) attempted. Applicants for graduate engineering programs are required to submit scores for the General Test of the Graduate Record Examination. An applicant who meets these standards but lacks prerequisite coursework may be admitted as a conditionally classified student and must make up any deficiencies before advancement to classified graduate standing.

**Program of Study**

Graduate students must file formal study plans with their advisor, department, college, and university graduate studies office no later than the end of the quarter in which the 12th unit of approved courses is completed.

The formal program of study must include a minimum of 45 units (at least 23 of which must be at the 500 level) with a specialization in one of the following areas: Biochemical Engineering, Bioengineering, Biomedical Engineering, Industrial Engineering, Integrated Technology Management, Materials Engineering, or Water Engineering.

**Requirements**

The broad curriculum requirements for the Master of Science degree in Engineering are:

- a minimum of 24 units in the field of specialization, with at least 18 units at the 500 level;
- a minimum of 9 units from an approved list of mathematics, statistics, computer science, or analytic engineering courses, with at least 3 units at the 500 level;
- remaining units taken from a list of approved electives;
- at least 23 units of the 45 unit program at the 500 level.

In some specializations, two program options are available: a thesis program which requires coursework, a thesis and oral defense of thesis; or a non-thesis option which involves additional coursework and a comprehensive examination. The non-thesis option is normally allowed only for those students who have completed a senior project or have had significant engineering project experience.

**Masters of Science Agriculture**
Specialization in Irrigation

**Required Courses**

<table>
<thead>
<tr>
<th>Course Description</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>BRAE 405 Chemigation</td>
<td>1</td>
</tr>
<tr>
<td>BRAE 414 Irrigation Engineering</td>
<td>4</td>
</tr>
<tr>
<td>BRAE 435 Drainage</td>
<td>4</td>
</tr>
<tr>
<td>BRAE 440 Agricultural Irrigation Systems</td>
<td>4</td>
</tr>
<tr>
<td>BRAE 438 Drip/Micro Irrigation or BRAE 439 Vineyard Irrigation</td>
<td>4</td>
</tr>
<tr>
<td>BRAE 532 Water Wells and Pumps</td>
<td>4</td>
</tr>
<tr>
<td>BRAE 500 Individual Study</td>
<td>3</td>
</tr>
<tr>
<td>BRAE 533 Irrigation Project Design</td>
<td>4</td>
</tr>
<tr>
<td>BRAE 599 Thesis</td>
<td>6</td>
</tr>
<tr>
<td>400-500 level research methods or statistics course</td>
<td>3</td>
</tr>
<tr>
<td>Electives (400-500 level courses approved by the student's graduate committee)</td>
<td>8</td>
</tr>
<tr>
<td>At least 4 units required by the committee as reflected on the formal study plan must be at the 500 level.</td>
<td></td>
</tr>
</tbody>
</table>

**Total** 45 units

**Prerequisite**

BS in a technical field of agriculture, or a BA with proficiency in basic chemistry, advanced algebra and trigonometry. All students must have had at least one undergraduate class in general irrigation, soil science, and crop science, plus be familiar with computer spreadsheet usage. Students may complete prerequisite courses at Cal Poly if necessary.

A description of paperwork and other requirements for the BRAE MS in Agriculture can be found [here](#).

*For advisor information and other forms, please click here.*

**General Characteristics**

Graduate studies in the College of Agriculture allow the student to pursue either a professional program designed to enhance the competencies of agricultural educators, or an academic program of graduate-level scholarly activities and research in one of several specializations. Graduates are prepared for:

- professional-level positions with business and industry, government, and foreign service in agriculture and related fields;
- agricultural teaching in secondary schools or community colleges; or
- continued graduate work at other institutions.

**When to Apply**

Application filing periods are given in the Cal Poly catalog. To ensure adequate processing and full consideration, all application materials should be filed with the
Cal Poly Admission's Office before the dates given below; nevertheless, applicants are encouraged to file during the initial filing period.

Fall Quarter - July 1  
Winter Quarter - November 1  
Spring Quarter - March 1  
Summer Quarter - April 1

**Prerequisites**

Consideration for admission to this program as a classified graduate student requires a minimum grade point average of 2.75 in the last 90 quarter units attempted. An applicant not meeting these academic standards, but who meets the basic university standard of a grade point average of 2.5 in the last 90 quarter units attempted may be considered for admission as a postbaccalaureate student; such admission does not constitute admission to graduate degree standing. A change from postbaccalaureate status to graduate status requires application and additional processing through the university's admissions office.

An applicant meeting the grade point requirement for classified graduate status, but who is deficient in background courses in agriculture, natural resources and/or related support disciplines may be considered for admission as a conditionally classified graduate student. Before such a student is advanced to classified graduate status, deficiencies in prerequisites must be removed and satisfactory academic performance in a graduate program must be demonstrated by the completion of no fewer than 12 units of specified courses with a minimum grade point average of 3.0. Courses taken to remove deficiencies in prerequisites will not count toward the unit requirement for the degree.

All applicants who do not speak and write English as their primary language are required to complete the Test of English as a Foreign Language (TOEFL), with a minimum score of 550, and the Test of Written English (TWE), with a minimum score of 4.5.

**Programs of Study**

There are three MS degrees in the College of Agriculture: MS in Agribusiness, MS in Forestry Sciences, and the MS in Agriculture. The MS Agriculture program includes the following specializations: Agricultural Education, Agricultural Engineering Technology, Animal Science, Crop Science, Dairy Products Technology, Environmental Horticultural Science, Food Science and Nutrition, Irrigation, Plant Protection Science, Recreation, Parks, and Tourism Management, and Soil Science. Although the program offers several specializations, there is a single degree; students may not earn more than one Master of Science degree in the College of Agriculture.

**The Thesis**

The thesis is based on independent, supervised research; students should contact individual departments to determine the availability of funding support for their research. The final copy of the thesis must meet the standards explained in the
"Manual of Instructions for the Preparation and Submission of the Master's Thesis or Master's Project" available from the Cal Poly Research and Graduate Programs Office. At least one course in statistical methods and/or experimental design is required of students in a thesis curriculum.

**Formal Study Plan**

Graduate students must file the formal study plan for the degree with the Graduate Coordinator of the College of Agriculture no later than the end of the quarter in which the 12th unit of approved courses is completed. The formal program of study must include at least 45 units of committee-approved graduate coursework; at least 23 units required must be at the 500 level.

Students should refer to the course descriptions in this catalog for credit limitations of individual courses; for example, total credit for AG 500, Individual Study, is limited to six units. At least one course in statistical methods and/or experimental design is required of students in a thesis curriculum.

All candidates must meet the current Graduation Writing Requirement. All students are required to pass an oral comprehensive examination which is normally given during the final quarter of the program of study. A written comprehensive exam may also be required by the master's degree committee, but this is optional. For students in a thesis program, the final oral comprehensive examination will include, but not necessarily be limited to, a defense of the thesis.

**Masters of Science Agriculture**

**Specialization in Agricultural Engineering Technology**

<table>
<thead>
<tr>
<th>Required Courses</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>BRAE 599 Thesis</td>
<td>6</td>
</tr>
<tr>
<td>AG 581/BRAE 581 Graduate Seminar</td>
<td>1</td>
</tr>
<tr>
<td>SS 501 Research Planning</td>
<td>4</td>
</tr>
<tr>
<td>STAT 512 Statistical Methods</td>
<td>4</td>
</tr>
<tr>
<td>STAT 513 Applied Experimental Design and Regression Models</td>
<td>4</td>
</tr>
<tr>
<td>BRAE 521 Systems Analysis of Ag Systems</td>
<td>4</td>
</tr>
<tr>
<td>Restricted electives (Any 400 and 500 level courses approved by the student's graduate committee. At least 11 units must be at the 500 level)</td>
<td>22</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>45</strong></td>
</tr>
</tbody>
</table>

**Objectives**

Students have the opportunity to focus their program on the application of engineering technologies and management to solve agriculturally related problems.

A description of paperwork and other requirements for the BRAE MS in Agriculture can be found [here](#). *For advisor information and other forms, please click here.*

**General Characteristics**
Graduate studies in the College of Agriculture allow the student to pursue either a professional program designed to enhance the competencies of agricultural educators, or an academic program of graduate-level scholarly activities and research in one of several specializations. Graduates are prepared for:

- professional-level positions with business and industry, government, and foreign service in agriculture and related fields;
- agricultural teaching in secondary schools or community colleges; or
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**Prerequisites**

Consideration for admission to this program as a classified graduate student requires a minimum grade point average of 2.75 in the last 90 quarter units attempted. An applicant not meeting these academic standards, but who meets the basic university standard of a grade point average of 2.5 in the last 90 quarter units attempted may be considered for admission as a postbaccalaureate student; such admission does not constitute admission to graduate degree standing (refer to page 85). A change from postbaccalaureate status to graduate status requires application and additional processing through the university's admissions office.

An applicant meeting the grade point requirement for classified graduate status, but who is deficient in background courses in agriculture, natural resources and/or related support disciplines may be considered for admission as a conditionally classified graduate student. Before such a student is advanced to classified graduate status, deficiencies in prerequisites must be removed and satisfactory academic performance in a graduate program must be demonstrated by the completion of no fewer than 12 units of specified courses with a minimum grade point average of 3.0. Courses taken to remove deficiencies in prerequisites will not count toward the unit requirement for the degree.

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The thesis is based on independent, supervised research; students should contact individual departments to determine the availability of funding support for their research. The final copy of the thesis must meet the standards explained in the "Manual of Instructions for the Preparation and Submission of the Master's Thesis or Master's Project" available from the Cal Poly Research and Graduate Programs Office. At least one course in statistical methods and/or experimental design is required of students in a thesis curriculum.

Formal Study Plan

Graduate students must file the formal study plan for the degree with the Graduate Coordinator of the College of Agriculture no later than the end of the quarter in which the 12th unit of approved courses is completed. The formal program of study must include at least 45 units of committee-approved graduate coursework; at least 23 units required must be at the 500 level.

Students should refer to the course descriptions in the Cal Poly catalog for credit limitations of individual courses; for example, total credit for AG 500, Individual Study, is limited to six units. At least one course in statistical methods and/or experimental design is required of students in a thesis curriculum.

All candidates must meet the current Graduation Writing Requirement. All students are required to pass an oral comprehensive examination which is normally given during the final quarter of the program of study. A written comprehensive exam may also be required by the master's degree committee, but this is optional. For students in a thesis program, the final oral comprehensive examination will include, but not necessarily be limited to, a defense of the thesis.
C3. Graduate Biosystems Engineering (Clemson University)

The biosystems engineering graduate programs are designed to prepare graduates for leadership, creative accomplishment and continued professional learning, and to prepare graduates to effectively conduct independent scientific research.

Students may be accepted with backgrounds in quantitative-based scientific fields relating to chemistry, mathematics, physics, biology or any branch of engineering. A number of undergraduate prerequisite or corequisite courses may be required for applicants who have undergraduate degrees in nonengineering disciplines.

Each degree program is planned individually to augment the student's previous engineering and science background with adequate breadth in engineering and specialization in an area of biosystems engineering. In addition to biosystems engineering, course work includes mathematics, physics, chemistry, statistics, and biological and engineering sciences.

Candidates for the Master of Science (M.S.) degree are required to complete a minimum of 24 hours of course work plus an additional six hours of thesis research and submit an acceptable thesis.

Candidates for the Ph.D. degree are required to complete an additional 36 semesters hours of course work beyond the M.S. degree. Students must also complete 18 hours of dissertation research and submit an acceptable dissertation.

Graduate School Application
Graduate Courses

BIOSYSTEMS ENGINEERING 2008 - 2009

B E (CSENV) 608 Land Treatment of Wastewater and Sludges 3(3,0)
See CSENV 608.

B E 612 Heat and Mass Transport in Biosystems Engineering 3(3,0)
Fundamentals of heat and mass transport used in engineering design and analysis of biological systems; principles of steady state and transient energy and mass balances including chemical and biological generation terms. Preq: B E 312, MTHSC 208. Coreq: M E 310.

B E 614 Biosystems Engineering Unit Operation 3(2,3)
Applies the basic principles of statics, dynamics, and thermodynamics to design of mechanical and electrical systems supporting biological operations and processes. Preq: B E 314, M E 310.

B E 615 Instrumentation and Control for Biosystems Engineers 4(3,3)
Overview of modern instrumentation techniques and digital electronic components and subsystems to integrate them into digital data acquisition and control systems for biosystems. Emphasizes laboratory use of equipment. Topics include characteristics of instruments, signal conditioning, transducer theory and applications, programmable logic controllers, and digital data acquisition and control. Preq: E C E 307.

B E 617 Applied Instrumentation and Control for Biosystems 2(1,3)
Study of hardware and software implementation of digital data acquisition and control systems for application to agriculture, aquaculture, biotechnology, and other biosystems. Topics include digital electronic circuits and components, microcomputer architecture, interfacing, and programming. Preq: B E 415 or consent of instructor.

B E 622 Hydrologic Modeling of Small Watersheds (3,0)
Design of structures and development of best management practices for runoff, flood, and sediment control from rural and urban areas, including natural and disturbed watersheds. Topics include modeling of prismatic and non-prismatic channels, culverts, and detention/retention ponds. Preq: B E 322 or consent of instructor.

B E (CH E) 628 Biochemical Engineering 3(3,0)
Use of microorganisms and enzymes for the production of chemical feedstocks, single-cell protein, antibiotics, and other fermentation products. Topics include kinetics and energetics of microbial metabolism, design and analysis of reactors for microbial growth and enzyme-catalyzed reactions, and considerations of scale-up, mass transfer, and sterilization during reactor design. Preq: B E 312, MICRO 305; Coreq: (for Biosystems Engineering majors) BIOCH 301 or 305; (for Chemical Engineering majors) CH E 330, 450.

B E 635 Applications in Biotechnology Engineering 3(2,3)
Bioengineering principles applied to the expanding fields of agricultural biotechnology, ecotechnology, and biomedical technology. Special applications include waste treatment and ecological engineering, bioreactor propagation of plant
and animal cells and tissues, applied genomics and synthetic seed production, biosensors and biomonitoring, biological implants and materials biocompatibility. Preq: B E (CH E) 428.

**B E 638 Bioprocess Engineering Design 3(2,2)**
Design and analysis of systems for processing materials. Topics include biotechnology, thermodynamics, transport processes, and biological properties related to bioprocess design and computational simulation. Unit operations include basic bioreactor operation, bioseparations, and preservation techniques. Preq: B E 428.

**B E 640 Renewable Energy Resource Engineering 3(2,2)**
Investigation into merging renewable energy resources, including detailed study of solar, wind, and bioenergy alternatives. Also includes principles, technologies, and performance evaluation of components for these technologies and an introduction to tidal, hydro, geothermal, and other energy; energy conservation; cogeneration; financial, economical, and other issues related to alternative energy sources. Preq: Science or engineering major, consent of instructor.

**B E 642 Properties and Processing of Biological Products 2(1,3)**
Study of engineering properties of biological materials and their uniqueness as design restraints on systems for handling, processing, and preserving biological products. Preq: B E 333, C E 341, M E 302, 310.

**B E (EE&S, FOR) 651 Newman Seminar and Lecture Series in Natural Resources Engineering 1(0,2)**
Topics dealing with development and protection of land, air, water, and related resources are covered by seminar with instructor and invited lecturers. Current environmental and/or resource conservation issues are addressed. Preq: Senior standing, consent of instructor.

**B E 664 Non-Point Source Management in Engineered Ecosystems 3(2,3)**
Fundamentals of nonpoint source pollution including quantification of environmental impact and ecosystem management related to contaminants and nutrients and to planning and design of ecological systems. Preq: MICRO 305, senior standing in engineering, or consent of instructor.

**B E (EE&S) 684 Municipal Solid Waste Management 3(3,0)**
See EE&S 684.

**B E 781 Special Problems 1-3(1-3,0)**
Students select subjects and conduct library, laboratory, and/or field research. A technical report documenting the study is required. May be repeated for a maximum of six credits. Preq: Master’s degree candidate in Engineering.

**B E 835 Industrial Biotechnology Techniques 4(3,3)**
Introduces industrial biotechnology techniques with emphasis on bioproduction, pilot bioprocessing equipment operation, biopharmaceutical storage, process simulation and economics, project management, good laboratory practice (GLP), and current good manufacturing practice (cGMP) geared toward the biotechnology industry. Preq: B E 638 or BIOCH 633, GEN (BIOSC) 616, or consent of instructor.
B E 838 Advanced Bioprocess Engineering 3(3,0)
Advanced bioprocessing techniques with emphasis on processing and modeling aspects of eukaryotic systems and associated bioproducts. Modules include thermal processing, supercritical fluid extraction, and advanced biological thermodynamics, chromatography, and spectroscopy. Preq: B E 438/638 or consent of instructor.

B E 865 Advanced Biological Transport Processes 3(3,0)
Study of transient transport processes in biological materials and systems. Incorporates mathematics describing active and passive cellular transport. Emphasizes numerical solution techniques for coupled transport relationships in nonideal, heterogeneous systems, including biological kinetic and thermodynamic considerations. Preq: BIOCH 305, CH E 601, MTHSC 634, or consent of instructor.

B E 871 Selected Topics in Biosystems Engineering 1-3(1-3,0)
Supervised, in-depth study of an area related to biosystems engineering not covered in other courses. May be repeated for a maximum of six credits.

B E 891 Master's Thesis Research 1-12

B E 901 Special Problems in Agricultural Engineering 3(3,0)
Library and/or laboratory research on one of the following subjects, depending on student’s field of study or interests: power and machinery, soil and water resources, farm structures, electric power and processing, food engineering, forest engineering or waste management. A technical report is required.

B E 991 Doctoral Dissertation Research 1-12
C4. Graduate Chemical and Biological Engineering (Colorado State University)

Graduate Program

The graduate program in the Department of Chemical and Biological Engineering (CBE) offers students a broad range of cutting-edge research areas led by faculty who are world renowned experts in their respective fields. Research areas are broken into five main categories: Polymer Science, Biological Engineering, Mathematical Modeling, Environmental Engineering and Transport Phenomena. More detail about each of the areas is provided through the link to Research Areas below. The laboratories available to CBE students are state of the art facilities. Opportunities for collaboration with many other department across the university are abundant - examples are Chemistry, Mechanical Engineering, Microbiology, and many more!

Located in Fort Collins, Colorado State University is perfectly positioned as a gateway to the Rocky Mountains; with its superb climate (over 300 days of sunshine per year), there are exceptional opportunities for outdoor pursuits including hiking, biking, skiing and rafting. Fort Collins offers a wealth of cultural opportunities and great restaurants to be enjoyed in a beautiful setting.

Graduate Degree Requirements

Graduate Program Course Listing

CH 501, Chemical Engineering Thermodynamics
CH 502, Advanced Reactor Design
CH 503, Transport Phenomena Fundamentals
CH 504, Fundamentals of Biochemical Engineering
CH 514, Polymer Science and Engineering
CH 521, Mathematical Modeling for Chemical Engineers
CH 523, Separation Processes
CH 524, Environmental Biotechnology
CH 525 Tissue Engineering
CH 603, Advanced Mass Transfer
CH 621, Advanced Process Control
CH 693, Seminar I
CH 705, Enzyme Technology
CH 723, Bioseparation Processes
CH 793, Seminar II (Graduate Seminar Series)

Degree Requirements

Doctor of Philosophy Degree

A Ph.D. degree is normally required for a career in university teaching and research as well as for research management in industry. Candidates for the Ph.D. must have a firm understanding of the fundamental principles of mathematics, physical and
biological sciences, and engineering. They must be able to synthesize information from a variety of disciplines in formulating new and effective approaches to specific problems of interest. Furthermore, the Ph.D. candidate must possess the ability to plan and execute a creative research program that results in new knowledge. Ideally, breadth as well as depth of learning distinguishes the holder of a Ph.D. degree.

All candidates for the Ph.D. degree are therefore required to demonstrate their ability to apply information from a variety of disciplines to problems encountered in their field of specialization. This is accomplished through a preliminary examination conducted at least two semesters prior to submission of the dissertation. Typically, the preliminary examination is given within the first year of formal course work on the Ph.D. A final oral examination in defense of the dissertation is also required.

Summary of Requirements for the Ph.D., Degree:

1. At least 72 semester credits of course work and research approved for graduate credit by the student's advisory committee. The following restrictions apply:
   a. At least 32 semester credits must be earned at Colorado State University. (A suitable M.S. degree may be substituted for 30 semester credits and up to 10 credits of course work after completion of the M.S. degree may be accepted for transfer.)
   b. At least 40 semester credits beyond the B.S. must be at the 500 level or above.
   c. Not more than 30 semester credits of research beyond the M.S. may be counted toward the minimum requirements listed above.
   d. Courses must include: CH 693 Seminar I CH 793 Seminar II and at least two advanced courses in applied mathematics or statistics.

2. Satisfactory performance on a preliminary examination normally taken in the first year of the program.


4. Satisfactory performance on a final comprehensive examination, which includes a defense of the dissertation.

5. Satisfactory completion of any additional University requirements as listed in the Graduate and Professional Bulletin.

Master of Science Degree

The basic purposes of the program leading to the M.S. degree are (1) to develop the student's ability to conduct research and (2) to develop proficiency in a specialized area of chemical engineering. Thus, the M.S. degree is an appropriate step toward a Ph.D. degree (described later) or a means to train engineers capable of applied research and technical leadership in industry or government. The M.S. degree is an excellent way for qualified students to gain a deeper insight into a specific subject and
to expand the general engineering knowledge obtained during undergraduate education.

To meet the needs of students with different goals, two programs are offered: Plan A, in which a research investigation culminating in a thesis is required; and Plan B, a program of advanced study culminating in a technical report and a general examination by a committee of the graduate faculty. Plan A is normally selected by those envisioning a career in applied research or as an intermediate step toward the Ph.D. degree. Students who want to develop technical proficiency in a particular area of specialization but do not contemplate a career in research or university teaching usually choose Plan B. Individual programs of study are determined by students in consultation with their advisory committees. Typical selections are described in the section on programs of study.

Summary of Requirements for the M.S. Degree:

1. At least 30 semester credits in course work and research approved for graduate credit by the student's advisory committee. The following restrictions apply:

   a. Twenty-four of the 30 semester credits must be earned at Colorado State University (may include credits from videotaped classes taken through SURGE), 21 of which must be earned after admission to the Graduate School.

   b. At least 16 semester credits at Colorado State University must be earned in courses numbered 500 or above, of which 12 must be in regular course work.

   c. Not more than six credits for thesis research may be counted toward the minimum requirements listed above.

   d. Courses must include: CH 693 Seminar I CH 793 Seminar 11 and at least one advanced course in applied mathematics or statistics.

2. An acceptable thesis (Plan A) or technical report (Plan B).

3. Satisfactory performance in a final comprehensive examination.

4. Satisfactory completion of any additional University requirements as listed in the Graduate and Professional Bulletin.
C5. Graduate Biological Environmental Engineering (Cornell University)

The biological revolution continues to mature and impact all of us. Human-based gene manipulation affects nearly all North American food supplies. Plants and animals are already being defined on a molecular basis. Living organisms can now be analyzed, measured and "engineered" as never before. Hundred million-dollar pharmaceutical plants can be replaced by a small herd of genetically altered goats through "pharmaceutical engineering". Designer "bugs" are being produced to enhance biological processes. These changes continue to redefine our graduate program that continues to emphasize biological, environmental and food and fiber engineering. Our connections to agriculture and food systems remain, but modern agriculture is greatly influenced by biotechnology, and our connections to agriculture reflect this fact.

Graduate study in BEE covers a broad range of work and study. It continues a long tradition of integrating engineering with the physical and biological sciences. The web pages of our faculty describe the following projects:

- trace-metal detoxification by aquatic algae;
- controlled environment agriculture;
- image spectroscopy of fruits and vegetables;
- electrochemical and optical biosensors;
- controlled-atmosphere storage;
- stomatal control of gas exchange;
- heat and mass transport in food processing;
- thermal environment of animals;
- mathematical models for solid-waste management;
- fermentor design, enzyme technology, and genetic engineering as applied to food processing;
- new pollution control processes involving living systems;
- integrating single molecule biological motors with nanoscale silicon devices;
- application of mathematics to agricultural and environmental problems;
- sustainable development;
- management of soil and water resources;
- design of the microclimate affecting farm animals and fish;
- enzymes, microorganisms, and plants as active components of bio-industries;
- hydrology and water quality, with a focus on rural watersheds

Thesis research can range from entirely theoretical to primarily experimental. The emphasis of graduate study at Cornell is a challenging and rewarding educational experience tailored to the needs and interests of each individual student. Biological and Environmental engineering researchers are actively incorporating cutting edge technology and science into their own research programs.

The number of graduate students in Biological and Environmental Engineering averages between fifty and sixty (graduate students). Students come from a variety of undergraduate and graduate programs, including other fields of engineering, physics, applied mathematics, biological sciences and the physical sciences. Approximately half are enrolled in doctoral study, a third in the Master of Science program and the remaining in the Master of Engineering and Masters of Professional Studies programs.
Approximately a third of our graduate students are female and third are international students. The Department of Biological and Environmental Engineering focuses on four distinct programs:

- Biological Engineering
- Environmental Engineering
- Food and Bioprocessing Engineering
- Industrial Biotechnology
C6. Graduate Biological Systems Engineering (Kansas State University)

Graduate study demands a high degree of intellectual aptitude. It presupposes a broad preparation and involves the acquisition of specialized knowledge. These facts should be reflected in the graduate student's program of study. Credits that were earned more than six years prior to the semester in which the program of study is approved cannot be accepted.

1 Course Levels and Programs

Master's students should earn a significant majority of their credit hours in courses numbered 700 or above. Therefore, of the 30 to 32 credit hours normally required for the master's program of study at least 18 hours should be at the 700 level and above, including the thesis/research and the report/problems hours required by the thesis and report options (see Chapter 2.A). Courses at the 600-level may be included, but 500-level courses in the student's major area are expected to have been completed as undergraduate prerequisites to graduate study or as undergraduate deficiency courses assigned upon admission. The use of 500-level supporting courses in master's programs is therefore restricted as follows: (1) No course in the student's major area may be at the 500 level, and (2) normally no more than 6 credit hours may be at the 500 level.

2 Problems Courses

No more than 3 hours in problems or other individualized courses may be applied to the master's degree.

3 Short Courses and Workshops

A student enrolled in a short course or workshop during the summer session may also take regularly scheduled courses but must be able to attend all sessions of both. Enrollment in a short course or workshop does not affect enrollment in research or problems. In no case may a student enroll for more than nine credit hours during the summer session.

4 S Courses

Departments may choose to offer certain courses or course sections that are primarily intended to teach or provide practice in skills and principles deemed important to a particular profession or discipline but that may not be applied to a master's degree program. Such courses or course sections are designated by the letter S.

5 Courses Applied Toward Two Degrees

No graduate student may use credit from the same course in meeting the requirements for both an undergraduate and a graduate degree, except as described in the concurrent B.S./master/graduate certificate programs approved by Graduate Council.

Transferring graduate credit

a. Students who take two master’s degrees may apply up to six hours of graduate credit from the first degree to the program of the second.

b. Students who wish to earn a master’s degree after earning a doctorate may apply a maximum of 10 credit hours of doctoral work from the first degree toward the master’s degree.

Master's Students in the College of Veterinary Medicine
a. A maximum of 12 graduate credit hours may be granted a student with a bachelor's degree while enrolled in the College of Veterinary Medicine;

b. A maximum of 12 graduate credit hours may be granted to a student without a bachelor’s degree while enrolled in the College of Veterinary Medicine; however, the MS degree must be awarded concurrently with the DVM degree;

c. A maximum of 12 graduate credit hours or the equivalent may be granted to graduates of other colleges of veterinary medicine;

d. For a master's degree, a minimum of one summer school enrollment or the equivalent in the Graduate School, for at least 8 hours of graduate credit, is required, and preferably a student should have 2 summer school enrollments or the equivalent in the Graduate School.

6 Transfer of Credit

Kansas State University accepts graduate credit from another institution only under the following conditions:

a. The other institution is accredited by the cognizant regional accrediting association to offer graduate degree programs appropriate to the level of the credit to be transferred;

b. The credit is fully acceptable to the other institution in satisfaction of its own advanced degree requirements; and

c. The credit is applicable to the student's program of study for an advanced degree at Kansas State University.

The program of study should consist solely of courses directly related to the master's degree.

Under normal circumstances, graduate credit transferred from other institutions may not exceed 10 credit hours for the master's degree, and then only for courses graded B or better. Credits that were earned more than six years prior to the semester in which the program of study is approved cannot be transferred. Research conducted outside an academic program cannot be accepted for credit as part of a program of study.

7 Off-Campus Programs

A student who has satisfied requirements for admission to the Graduate School may receive credit toward a master's degree for off-campus courses taught by regular members of the Kansas State University graduate faculty or by others approved by specific action of the Graduate Council and the Faculty Senate. The department offering the course must obtain approval in advance from the Dean of the Graduate School and from the Graduate Council. The request for approval must include documentation sufficient to demonstrate that the quality of instruction will be equivalent to that of on-campus offerings.

8 Off-Campus Research

Special difficulties arise in guiding graduate students when they are engaged in protracted off-campus research, whether that research is in the field, in the laboratory, or in the library. Therefore, supervisory committees must take adequate steps to ensure appropriate guidance. As a minimal requirement, the student must submit to the supervisory committee a well formulated research plan, including objectives and methodology, and the committee must review and approve the plan before the student departs for the research site and indicate approval on the program of study. In addition, the supervisory committee may require:
a. That the major professor and/or a competent local authority who can reliably guide the student provide continuing on-site supervision.

b. That the student provide the supervisory committee with frequent, periodic estimates of performance and progress. The committee may also require that these be authenticated by a competent local authority.

c. That the major professor carry out local inspections of the student's activities.

Regardless of the location at which the research is conducted, the final oral examination will normally be given on the Manhattan campus. Exceptions can be made if requested by the student, recommended by the supervisory committee, and approved by the Department Head or Graduate Program Director and the Dean of the Graduate School. In the case of an examination in which the participants are not all in the same location, any technology used to conduct the examination must support simultaneous oral interaction between the student and all members of the examining committee. When unusual circumstances arise in the guidance of off-campus students, supervisory committees should consult with the Dean of the Graduate School.
C7. Graduate Biological and Agricultural Engineering (Louisiana State University)

The LSU Department of Biological and Agricultural Engineering offers graduate programs at the master's and Ph.D. levels. The Master of Science in Biological and Agricultural Engineering is a departmental program. The department cooperates with the College of Engineering in offering interdisciplinary master's and Ph.D. degrees in Engineering Science with Biological and Agricultural Engineering as the major area of study.

Program Highlights

The Master of Science Degree Programs:

Two master's degree programs leading to the Master of Science in Biological and Agricultural Engineering or the Master of Science in Engineering Science are offered in both thesis and non-thesis options. Eighteen months is the usual time required for completion of the M.S. degree. Thesis options require 30 hours of course work beyond the bachelor's and a publishable thesis. Non-thesis options require 36 hours beyond the bachelor's and a project. A guide for students pursuing master's degrees that describes the detailed requirements and a chronological guide is available.

The Ph.D. Program:

The program typically requires three years of work beyond the master's degree, including a minimum of 54 hours of approved course work beyond the bachelor's degree, 27 hours of which must be engineering courses, and a dissertation based on original research. Student programs are guided by a major professor from the department and a committee of four or five other graduate faculty members. Ph.D. students (with the help of a major professor) are expected to make most of the decisions concerning course work, research, and selection of committee members. A guide for students pursuing a doctoral program describing the detailed requirements and a chronological guide are also available.

To assure breadth in the program, two minor areas of concentration must be included in the course work. Minors may be from a degree-granting department (such as mechanical engineering, mathematics, or statistics) or from a recognized area of study (robotics, CAD, fluid dynamics, or aquacultural engineering). A representative from each minor area must be a member of the student's advisory committee. Usually the minors are used to support the student's total program -- a minor in statistics could be helpful in planning experiments; one in CAD could support a program requiring machine design; and one in hydrology could apply to a program in soil and water.

Admission Requirements:

Admission to the graduate program requires graduation from an accredited undergraduate institution, acceptable grades on all undergraduate and graduate work, satisfactory scores on the verbal and quantitative portions of the Graduate Record Examination (GRE), and three letters of recommendation from faculty with whom the
prospective student has studied. Applicants who lack these qualifications may, under special circumstances, be admitted on a provisional or probationary basis. An undergraduate grade-point average of 3.0 and GRE score of 1000 are the minimum basic requirements.

The undergraduate records of international students will be evaluated by the Graduate School on the same basis as U.S. citizens. International students (if English is not their native language) must also take the Test of English as a Foreign Language (TOEFL). A score of 213/525 on the TOEFL is required for admission and 215/550 for consideration for an assistantship.

The Master of Science programs in Biological and Agricultural Engineering require a bachelor's degree from an ABET-accredited engineering program or the equivalent of the required engineering courses in the undergraduate Biological and Agricultural Engineering curriculum. The Master of Science in Engineering Science allows entry from other engineering or science programs, although additional work may have to be taken to support the student's program, and half of the student's course work must be taken in the College of Engineering.

The Ph.D. program in Engineering Science will accept qualified students who have a bachelor's or master's degree in any of the engineering disciplines or who have a science degree and have also taken the basic engineering courses. In the latter case, the student must plan appropriate supporting course work with the aid of his or her committee.

Financial Assistance:

Research and teaching assistantships are available to qualified students on a competitive basis. Doctoral students may compete for Alumni Association or Board of Regents Graduate Fellowships paying $17,000 per year for four years. When available, half-time graduate assistantships for M.S. and Ph.D. students start at $14,000 for 12 months.
C8. Graduate Biosystems and Agricultural Engineering (Iowa State University)

Graduate Study

The department offers work for the degrees in master of science, master of engineering, and doctor of philosophy with a major in agricultural engineering and minor work to students taking major work in other departments. Within the major the student may specialize in:

- advanced machinery engineering (agricultural safety and health, sensors and artificial intelligence, controls and automation, precision agriculture, and biorenewables)

- animal and plant production engineering (air emissions measurement and abatement, animal welfare, environmental control in animal housing, manure treatment, crop modeling, plant stress physiology, precision agriculture, and decision support systems)

- environmental stewardship engineering (erosion control, drainage/water management, pollutant fate and transport, nutrients management, wetlands, vegetated filter/buffer strips, hydrological/ water quality/crop modeling, geographic information science (GIS)

- remote sensing, water quality, and watershed management, or

- process engineering for food safety and value addition (processing technologies and systems for adding value, quality management systems, agricultural product, marketing practices and standards, instrumentation for grain, seed, and food quality enhancement).

A prerequisite to graduate work is the completion of an undergraduate curriculum substantially equivalent to that required of agricultural engineering undergraduate students at this institution. However, because of the diversity of interests within the graduate programs in agricultural engineering, a student may qualify for graduate study even though the undergraduate training has been in a discipline other than agricultural engineering. Supporting work will be required depending on the student's background and area of interest with requirements defined by departmental graduate student guidelines: [www.iastate.edu/grad_students.asp](http://www.iastate.edu/grad_students.asp)

Well-qualified juniors or seniors in agricultural engineering who are interested in graduate study may apply for concurrent enrollment in the Graduate College to simultaneously pursue both B.S. and M.S. degrees. Under concurrent enrollment, students are eligible for assistantships and simultaneously take undergraduate and graduate courses.

For the master of science program at least 30 credits of acceptable graduate work must be completed with a minimum of 22 credits of course work; corresponding numbers for the master of engineering program are 32 and 27. For the doctor of philosophy degree at least 72 credits of acceptable graduate work must be completed.
with a minimum of 42 credits of course work. All PhD graduates are also expected to have completed some teaching/extension experience prior to graduation.

The departments also offers a masters of science and doctor of philosophy in industrial and agricultural technology, see College of Agriculture, Curricula.

The department also participates in the interdepartmental majors in environmental science, sustainable agriculture, biorenewable resources and technology, human and computer interaction, and toxicology (see Index).

Courses open for nonmajor graduate credit: 342, 363, 413, 415, 416.

Courses primarily for graduate students, open to qualified undergraduate students

**A E 503. Modeling and Controls for Agricultural Systems.** (Dual-listed with 403). (2-2) Cr. 3. F. Prereq: 363, Math 267. Modeling dynamic systems with ordinary differential equations. Introduction to state variable methods of system analysis. Analysis of mechanical, electrical, and fluid power systems. Analytical and numerical solutions of differential equations. Introduction to classical control theory. Feedback and stability examined in the s domain. Frequency response as an analytical and experimental tool. MATLAB will be used throughout the course for modeling. Individual and/or group projects required for graduate credit.

**A E 504. Instrumentation for Agricultural and Biosystems Engineering.** (Dual-listed with 404). (2-2) Cr. 3. S. Prereq: 363 or Cpr E 210. Interfacing techniques for computer-based data acquisition and control systems. Basic interfacing components including A/D and D/A conversion, signal filtering, multiplexing, and process control. Sensors and theory of operation applied to practical monitoring and control problems. Individual and group projects required for graduate credit.

**A E 505I. Watershed Modeling and GIS.** (Cross-listed with Ia LL, EnSci). Cr. 4. Alt. SS., offered 2008. GIS techniques for watershed hydrology and water quality modeling and water resource management, including various approaches to watershed analysis, modeling and management; analytical tools for modeling watershed hydrology and water quality; and case studies in modeling and managing rural and urban watersheds.

**A E 506. Applied Computational Intelligence for Agricultural and Biological Systems.** (Dual-listed with 406). (2-2) Cr. 3. Alt. F., offered 2008. Prereq: Math 166, Stat 305, AE 203, or equivalent. Applications of biologically inspired computational intelligence tools to solve problems in agricultural and biological systems. Introduction to Artificial Neural Networks, Support Vector Machines, Fuzzy Logic, Genetic Algorithms, Bayesian and Decision Tree Learning. Fundamental machine vision techniques will be introduced in the first part of course and integrated into the lab exercises for learning different computational intelligence techniques. MATLAB will be used throughout the course for algorithm implementation. Individual and/or group projects required for graduate credit.
A E 508. GIS and Natural Resources Management. (Dual-listed with 408). (Cross-listed with EnSci). (2-2) Cr. 3. F. Prereq: Working knowledge of computers and Windows environment. Introduction to fundamental concepts and applications of GIS in natural resources management with specific focus on watersheds. Topics include: basic GIS technology, data structures, database management, spatial analysis, and modeling; visualization and display of natural resource data. Case studies in watershed and natural resource management using ArcView GIS. In addition to other assignments, graduate students will prepare research literature reviews on topics covered in class and develop enterprise applications.

A E 515. Integrated Crop and Livestock Production Systems. (Cross-listed with Agron, An S, SusAg). (3-0) Cr. 3. Alt. F., offered 2007. Prereq: SusAg 509. Methods to maintain productivity and minimize the negative ecological effects of agricultural systems by understanding nutrient cycles, managing manure and crop residue, and utilizing multispecies interactions. Crop and livestock production within landscapes and watersheds is also considered. Course includes a significant field component, with student teams analyzing Iowa farms.


A E 532. Modeling Agricultural Watersheds. (Dual-listed with 432). (2-3) Cr. 3. Alt. S., offered 2009. Prereq: A E 431/531, A E 408/508. Understanding and modeling the processes affecting delivery of sediment and chemical/biological pollutants to surface water resources in natural and intensively managed watersheds. Application of state-of-the-art ecolhydrologic and water quality models. Development and application of watershed decision support systems. Model parameter estimation and uncertainty analysis. Modeling for policy decisions. Case studies involving Iowa watersheds. In addition to other assigned course activities, graduate students are required to undertake and complete a modeling project for an intensively managed watershed. The project will provide students the opportunity to use a model to examine different aspects of climate, hydrology, nutrient cycles and land use/land cover change and their interactions at the landscape level.

A E 536. Design and Evaluation of Soil and Water Monitoring Systems. (Dual-listed with 436). (2-3) Cr. 3. Alt. S., offered 2008. Prereq: A E 431/531. Development of monitoring systems that support effective planning, performance evaluation, modeling, or environmental impact assessment of soil-, water-, and waste-management systems. Typical soil and water pollutants and physical, chemical, and biological characteristics that affect sample location and timing. Sample collection, documentation, chain-of-custody, and quality assurance procedures. In addition to other assignments, graduate students will prepare several research literature reviews on topics covered in the class and develop monitoring plans.


A E 572. Design of Environmental Modification Systems for Animal Housing. (Dual-listed with 472). (3-0) Cr. 3. S. Prereq: 216, M E 330. Principles and design of animal environmental control systems. Insulation, heat and mass transfer, fans, ventilation, air distribution, heating and cooling equipment, duct design, and controls. Individual and group projects required for graduate credit.


A E 580. Engineering Analysis of Biological Systems. (Dual-listed with 480). (Cross-listed with EnSci). (2-2) Cr. 3. F. Prereq: 216; Math 266; Biol 211 or 212; M E 330. Systems-level engineering analysis of biological systems. Economic and life-cycle analysis of bioresource production and conversion systems. Global energy and resource issues and the role of biologically derived materials in addressing these issues. Students enrolled in A E 580 will be required to answer additional exam questions and report on two journal articles.

B. Biosystems Engineering
F. Food Engineering
O. Occupational Safety
P. Power and Machinery Engineering
Q. Structures and Environment
R. Process Engineering
S. Water and Environment
U. Waste Management

F.S.SS. A technical paper draft based on M.S. thesis or creative component is required of all master's students. This paper must be in a form that satisfies the requirements of some specific journal. Satisfactory-fail only.


Courses for graduate students

A E 601. Graduate Seminar. (Cross-listed with TSM). (1-0) Cr. 1. F. Discussion of research problems, methods, procedures, and reports.

A E 610. Foundations of Sustainable Agriculture. (Cross-listed with Anthr, Soc, SusAg, Agron). (3-0) Cr. 3. F. Prereq: Graduate classification, permission of instructor. Historical, biophysical, socioeconomic, and ethical dimensions of agricultural sustainability. Strategies for evaluating existing and emerging systems of agriculture in terms of core concepts of sustainability and their theoretical contexts.


A E 697. Engineering Internship. Cr. R. Repeatable. Prereq: Permission of department chair, graduate classification. One semester and one summer maximum per academic year professional work period.

A E 698. Technical Paper for a Doctoral Degree. (Cross-listed with TSM). Cr. 1. F.S.SS. A technical paper draft based on dissertation is required of all Ph.D. students. This paper must be in a form that satisfies the requirements of some specific journal. Satisfactory-fail only.


B. Biosystems Engineering
C. Computer-aided Design
E. Environmental Systems
F. Food Engineering
O. Occupational Safety
P. Power and Machinery Engineering
Q. Structures
R. Process Engineering
S. Environment and Natural Resources
U. Waste Management
B.Briassoulis  UNIVERSITIES IN USA AND CANADA OFFERING PROGRAMS OF STUDIES IN BIOSYSTEMS ENGINEERING OR RELATED DISCIPLINES

C9. Graduate Bioproducts and Biosystems Science, Engineering and Management (BBSEM) (Minnesota University)

BBE offers a new multi-disciplinary graduate program - Bioproducts and Biosystems Science, Engineering and Management (BBSEM). The program is designed to educate the next-generation of scientists and engineers with the cross-disciplinary training necessary to develop solutions to the complex problems specific to the 21st century bioeconomy while addressing environmental sustainability.

The Bioproducts and Biosystems Science Engineering and Management (BBSEM) graduate program provides a strong foundation in the basic sciences, engineering and management in support of the renewable bio-resources utilization, environmental quality, and national security while improving our global competitiveness.

Depending on the area of research and related course work, students can specialize in broad areas including Bioproducts Science and Engineering, Biosystems Science and Engineering, Bioproducts Marketing and Management, Environmental and Ecological Engineering and Management.

Exciting areas of cutting-edge graduate research include:

- Biodeteroration and Biodegradation
- Lignocellulose Biocatalysis
- Bioproducts Engineering
- Biosystems Engineering
- Environmental and Ecological Engineering
- Building Science
- Industrial Ecology
- Corporate Environmental Management
- Bioproducts Marketing and Management
- Water and Soil Management and Protection
- Livestock Environment
- Food Engineering/Value Added Processing
- Machinery Systems Design
- Grain Quality
- Safety, Health, and Risk Management
- Waste Management

The BBSEM graduate program offers master’s (M.S.), plan A or plan B, and doctorate (Ph.D) degrees. Students seeking a master’s degree should have a bachelor’s degree in engineering, mathematics or the physical or biological sciences or a related field from a recognized U.S. or international university and have a preferred performance level of at least a 3.0 grade point average (on a 4.0 grading scale). Students seeking a Ph.D. should have a master’s degree in mathematical, physical, biological or social sciences and should have a preferred performance level of at least a 3.0 grade point average (on a 4.0 grading scale). The areas of specialization include

- Bioproducts Science and Engineering,
• Biosystems Science and Engineering,
• Bioproducts Marketing and Management.

The department often has funds available for half-time assistantships. Currently, students on assistantships receive a stipend, health benefits, and 14 credits of tuition per semester. You should indicate whether you are seeking an assistantship when you apply for admission at the University of Minnesota Graduate School.

**BIOPRODUCTS AND BIOSYSTEMS ENGINEERING (BBE)**
College of Food, Agricultural and Natural Resource Sciences; Institute of Technology
Bioproducts and Biosystems Engineering

**BBE 4023W - Process Control and Instrumentation (WI)**
(3.0 cr; = [BBE 5023]; Prereq-Upper div IT or grad student; A-F or Aud, fall, every year)
Measurement of motion, force, pressure, flow, temperature, size, shape, color, texture, rheology, moisture, water mobility, fat, and pH. Linking physical and biological control systems.

**BBE 4733 - Renewable Energy Technologies**
(3.0 cr; = [BBE 5733]; Prereq-Upper div IT or grad student or #; A-F or Aud, spring, every year)

**BBE 5001 - Chemistry of Plant Materials**
(4.0 cr; = [BBE 4001]; Prereq-Grad student or #; A-F or Aud, fall, every year)
Chemical principles underlying structure, properties, processing, and performance of plant materials.

**BBE 5023 - Process Control and Instrumentation**
(3.0 cr; = [BBE 4023W]; Prereq-Grad student or #; fall, every year)
Fundamental principles in system dynamics/control. Emphasizes process systems and problems faced by process engineers.

**BBE 5095 - Special Problems**
(1.0 - 5.0 cr [max 5.0 cr]; Prereq-#; fall, spring, summer, every year)
Advanced individual-study project. Application of engineering principles to specific problem.

**BBE 5102 - Residential Indoor Air Quality**
(3.0 cr; = [BBE 3102]; Prereq-Grad student or #; A-F or Aud, fall, every year)
Indoor air pollution issues found in residential structures, especially in the north central region of the United States. Pollutant descriptions, including measurement techniques and typical ranges of concentrations. Health effects. Pathways, transport mechanisms. Control strategies including mitigation and prevention.
BBE 5212 - Safety and Environmental Health Issues in Plant and Animal Production and Processing
(3.0 cr; Prereq-grad student or sr or #; Credit will not be granted if credit has been received for AGET 5212.; A-F or Aud, fall, spring, summer, every year)
Safety/health issues in food production, processing and horticultural work environments using public health, injury control, and health promotion frameworks: regulation, engineering, education. Traumatic injury, occupational illness, ergonomics, pesticide health effects, biotechnology, air contaminants.

BBE 5301 - Surface and Colloid Science in Bio-based Products Manufacturing
(3.0 cr; = [BBE 4301]; Prereq-Grad student or #; spring, every year)
Principles of surface and colloid science, their application to manufacturing/performance of bio-based products.

BBE 5302 - Organisms Impacting Bio-based Products
(3.0 cr; = [BBE 4302]; Prereq-Grad student or #; spring, every year)
Organisms and their importance to bio-based products: deterioration, control, bioprocesses for benefit.

BBE 5303 - Introduction to Bio-based Materials Science
(3.0 cr; = [BBE 4303]; Prereq-Grad student or #; spring, every year)
Principles of materials science, their application to bio-based materials. Project required.

BBE 5305 - Pulp and Paper Technology
(3.0 cr; Prereq-Grad student or #; fall, every year)

BBE 5312 - Pulp and Paper Unit Operations
(4.0 cr; Prereq-Grad student or #; fall, every year)
Application of principles of momentum, heat, and mass transfer to unit operations in pulp/paper industry. Fluid transport, filtration, sheet formation, sedimentation, drainage, pressing, heat exchange, evaporation, washing, bleaching, humidification/drying, chemical/energy recovery. Computer simulation of multiple-stage systems. Online course.

BBE 5314 - Papermaking Processes and Process Engineering Laboratory
(3.0 cr; Prereq-Grad student or #; spring, every year)

(3.0 cr; Prereq-Grad student or #; spring, every year)
Presented through the Internet. Basic concepts and most frequently used methods in
statistical process control, analysis of variances, experiment design, and regression analysis. Online course.

**BBE 5362 - Pulping and Bleaching (WI)**
(4.0 cr; Prereq-Grad student or #; spring, every year)
Chemistry/technologies in producing paper-making raw material. Focuses on wood pulping/bleaching, including non-wood fibers and recycled fiber materials. Online course.

**BBE 5401 - Bioproducts Engineering**
(3.0 cr; = [01294]; Prereq-Grad student or #; A-F or Aud, fall, every year)
Unit operations of bioproducts engineering/manufacture. Project required.

**BBE 5402 - Bio-based Products Engineering Lab I**
(1.0 cr; = [BBE 4402]; Prereq-Grad student or #; A-F or Aud, spring, every year)
Laboratory exercises in bio-based products engineering.

**BBE 5403 - Bio-based Products Engineering Lab II**
(1.0 cr; = [BBE 4403]; Prereq-Grad student or #; A-F or Aud, fall, every year)
Laboratory exercises in bio-based products engineering.

**BBE 5404 - Bio-based Composites Engineering**
(3.0 cr; = [BBE 4404]; Prereq-Grad student or #; A-F or Aud, spring, every year)
Properties of bio-based composites.

**BBE 5407 - Bio-based Products Manufacturing and Applications I**
(3.0 cr; = [BBE 4407]; Prereq-Grad student or #; fall, every year)

**BBE 5412 - Manufacturing and Applications of Bio-based Products**
(4.0 cr; = [BBE 4412W]; Prereq-Grad student or #; spring, every year)
Manufacturing processes, end-use applications of bio-based products.

**BBE 5413 - A Systems Approach to Residential Construction**
(4.0 cr; = [HSG 4413, BBE 4413]; Prereq-Grad student or #; spring, every year)
Dynamic/interrelated issues of energy, moisture control, indoor air quality in residential bldgs. Emphasizes design, construction, and operational aspects to provide an energy efficient, durable structure, and healthy living environment. Interaction between moisture and wood products within building system.

**BBE 5414 - Advanced Residential Building Science**
(3.0 cr; = [BBE 4414]; Prereq-Grad student or #; fall, every year)
Building science theory, advanced applications for residential buildings. Focuses on heat/mass transfer.

**BBE 5415 - Advanced Residential Building Science Lab**
(1.0 cr; = [BBE 4415]; Prereq-Grad student or #; A-F or Aud, fall, every year)
Concurrent with 4334. Exercises on advanced applications of heat/mass transfer to predict performance of residential buildings.
BBE 5416 - Building Testing & Diagnostics
(2.0 cr; = [BBE 4416]; Prereq-Grad student or #; spring, every year)
Theoretical basis for performance testing. Diagnostics applications for residential structures. Focuses on existing structures and retrofit/remedial applications. Digital differential pressure gauges, blower doors, airflow hoods/grids, duct pressure testing, infrared thermography. Hands-on sessions for equipment use, problem solving.

BBE 5480 - Special Topics
(3.0 - 4.0 cr [max 12.0 cr]; = [BBE 3480]; Prereq-Sr or grad student; fall, spring, every year)
Topics specified in Class Schedule.

BBE 5503 - Marketing of Bio-based Products
(4.0 cr; = [BBE 3503]; Prereq-Grad student or #; A-F or Aud, fall, every year)
Introduction to marketing function as it relates to current/emerging bio-based products industries (building materials, paper, fuels, etc.). Product positioning, pricing, promotion, and channel management within strategic planning and environmental marketing management.

BBE 5504 - Bio-based Products Development and Management
(3.0 cr; Prereq-Grad student or #; A-F or Aud, spring, every year)
Concepts of new product development and product management and their application to bio-based products.

BBE 5535 - Assessment and Diagnosis of Impaired Waters
(3.0 cr; = [BBE 4535]; Prereq-Grad student or #; A-F only, fall, every year)
Assessing impaired waters and developing TMDL for conventional pollutants. Preparing/communicating legal, social and policy aspects. TMDL analysis of real-world impaired waters problem. Field trip to impaired waters site.

BBE 5713 - Biological Process Engineering
(3.0 cr; = [BBE 4713]; Prereq-[3033, [4013 or &4013], [upper div IT or grad student]] or #; A-F only, spring, every year)

BBE 5723 - Food Process Engineering
(3.0 cr; = [BBE 4723]; Prereq-[[4013 or &4013], [upper div IT or grad student]] or #; A-F only, spring, every year)
Food processing engineering. Applications of material balance, energy balance, fluid dynamics, and heat/mass transfer to refrigeration, freezing, psychometrics, dehydration, evaporation, non-thermal processing, and separation. Development/control for food products.

BBE 5733 - Renewable Energy Technologies
(3.0 cr; = [BBE 4733]; Prereq-Upper div IT or grad student or #; A-F only, fall, every year)
Solar thermal energy, solar photovoltaics, biomass energy, wind energy, hydroelectricity, tidal power, and geothermal energy. Sustainable development: energy security, environmental, economic, and societal considerations.

BBE 8306 - Graduate Seminar
(2.0 cr [max 6.0 cr]; spring, offered periodically)
Communication of scientific knowledge related to wood and paper science through the media of poster sessions, oral presentations, and the Internet.

BBE 8333 - FTE: Master's
(1.0 cr; Prereq-Master's student, adviser and DGS consent; No Grade, fall, spring, summer, every year)
(No description)

BBE 8444 - FTE: Doctoral
(1.0 cr; Prereq-Doctoral student, adviser and DGS consent; No Grade, fall, spring, summer, every year)
(No description)

BBE 8513 - Hydrologic Modeling of Small Watersheds
(3.0 cr; Prereq-CE 3502, hydrology course)
Study and representation of hydrologic processes by mathematical models: stochastic meteorological variables, infiltration, overland flow, return flow, evapotranspiration, and channel flows. Approaches for model calibration and evaluation.

BBE 8523 - Coupled Heat, Moisture, and Chemical Transport in Porous Media
(3.0 cr; Prereq-[CSci 5301 or equiv], [[Math 5512, Math 5513] or equiv], [Soil 5232 or equiv], computer programming; A-F or Aud)
Mathematical study of coupled heat, moisture, and chemical transport in porous media. Derivation of governing equations for coupled heat, moisture, and chemical transport. Derivation of numerical solution techniques to solve coupled equations. Comparison of numerical solutions to analytical solutions.

BBE 8666 - Doctoral Pre-Thesis Credits
(1.0 - 6.0 cr [max 12.0 cr]; Prereq-Doctoral student who has not passed prelim oral; no required consent for 1st/2nd registrations, up to 12 combined cr; % for 3rd/4th registrations, up to 24 combined cr; doctoral student admitted before summer 2007 may register up to four times, up to 60 combined cr; No Grade, fall, spring, summer, every year)

BBE 8703 - Managing Water in Food and Biological Systems
(3.0 cr; Prereq-Chem 3501 or FScN 5451 or MatS 3011 or #)
Qualitative and quantitative analysis of water in foods and biological materials using NMR and MRI. Water and chemical reactivity, microbial activity, physiochemical properties and changes, and structural properties and changes in foods and biological materials.

BBE 8777 - Thesis Credits: Master's
(1.0 - 18.0 cr [max 50.0 cr]; Prereq-Max 18 cr per semester or summer; 10 cr total required [Plan A only]; No Grade, fall, spring, summer, every year)
(No description)

**BBE 8888 - Thesis Credit: Doctoral**

(1.0 - 24.0 cr [max 100.0 cr]; Prereq-Max 18 cr per semester or summer; 24 cr required; No Grade, fall, spring, summer, every year)

(No description)
C10. Graduate Biosystems Engineering (Michigan State University)

Graduate Study in Biosystems Engineering
Department of Biosystems and Agricultural Engineering
Michigan State University

Biosystems Engineering (BE) faculty and graduate students are engaged in exciting research in three overall areas: food quality, safety and biosecurity; sustainable ecosystems; and renewable bioenergy systems. Many BE graduate students are given financial support in the form of graduate assistantships that are funded from research grants obtained by the faculty. Graduate assistantships are awarded on a competitive basis, and all applicants are considered as part of the evaluation process.

Our graduate programs in Biosystems Engineering are excellent, and the faculty are eager to have outstanding students join us in our academic pursuits.

Two graduate degree programs in Biosystems Engineering are offered:

- **Master of Science (MS)** thesis option, plan A; and non-thesis option, plan B. The MS with thesis option (plan A) is suited for students planning to work in research and development, or for those who hope to continue toward a PhD degree. Plan B, the non-thesis option, is intended for students who want to broaden their knowledge of the field through course work alone. Most MS students follow the Plan A tract.

- **Doctor of Philosophy (PhD)** The PhD program is designed for students who want a career in teaching and/or research in the universities, the private sector, or government organizations. Feel free to contact us for additional information.

**MS Degree Requirements**

The program is available under both Plan A (with thesis) and Plan B (without thesis).

**Requirements for Master of Science Degree in Biosystems Engineering***

Requirements for both Plan A and Plan B

- A total of 30 credits in 400, 800, and 900 level courses. At least 20 of the 30 credits must be at the 800-900 level.
- **BE 815, BE 820, BE 825, BE 835, and BE 892**.

Additional Requirements for Plan A

- Complete at least 6 (and no more than 8) credits of the 30 credit total requirement with **BE 899** (Master's Thesis Research) credits.
- Pass a final oral examination over the written thesis.
• Provide to the major professor, and to the department, a hard-bound copy of the thesis.
• Provide to the major professor a manuscript (based on the MS thesis) suitable for submission to a refereed journal for publication.

Additional Requirement for Plan B

• The student must pass the final examination over the course work in the student's approved program of study.

PhD Degree Requirements

Requirements for the Doctor of Philosophy Degree*

• Complete a minimum total of 24 credits in BE 999 (Doctoral Dissertation Research).
• Complete a minimum of 38 additional course credits (excluding BE 899) past the BS degree. These 38 credits must include (unless previously taken) the following: BE 815, BE 820, BE 825, BE 835, and BE 892.
• Complete one course in a biological science at the 400 level or above. An approved list of courses will be maintained by the department.
• Complete one course in quantitative analysis or mathematics at the 400 level or above. An approved list of courses will be maintained by the department.
• Complete one course in statistics at the 400 level or above. An approved list of courses will be maintained by the department.
• Pass the doctoral qualifying examination.
• Pass the doctoral comprehensive examination.
• Submit at least two papers to refereed journals before scheduling the oral examination in defense of the dissertation.
• Pass the oral examination in defense of the dissertation.
• Provide to the major professor, and to the department, a hard-bound copy of the dissertation made from the original unbound manuscript submitted to the Office of The Graduate School.
C11. Graduate Biological and Agricultural Engineering (Mississippi State University)

Graduate study is offered in the Department of Agricultural and Biological Engineering leading to the degree of Master of Science in Biological Engineering or a Doctor of Philosophy in Engineering. The department has several major research laboratories including: Renewable Energy Laboratory, water quality and environmental engineering, and cotton ginning (the MAFES/ABE Mini-Gin, a fully operational cotton gin). A limited number of Graduate research and teaching assistantships are available.

RESEARCH AREAS INCLUDE:

- Watershed and Climatology Modeling
- Precision agriculture
- Animal waste management
- Sustainable design
- Renewable Energy
- Bioenvironmental systems
- Seed processing and storage
- Aquacultural systems
- Agricultural modeling
C12. Graduate Agricultural Engineering (NC A&T SU)

Graduate Advisor and Graduate Advisory Committee

All students in master’s programs must have a graduate advisor who is a member of the Graduate Faculty in the student’s major department or program. The graduate advisor is appointed by the Coordinator of Graduate Programs. In addition, all students must have a graduate advisory committee. The advisory committee is composed of at least three members of the Graduate Faculty. The graduate advisor serves as chair or co-chair of the committee. The graduate advisory committee is appointed by the Coordinator of Graduate Programs in the student’s department or program. At the time of the request for a permit to schedule the final oral examination, the School of Graduate Studies verifies that the committee is properly constituted.

Plan of Graduate Work

The master’s degree candidate must submit an approved Plan of Graduate Work to the School of Graduate Studies during the term in which the candidate will complete 15 or more credits toward the degree sought. If the 15 credits will be completed at the end of a regular semester, the Plan of Graduate Work must be submitted to the School of Graduate Studies Office five working days before registration for the following semester. If the 15 credits will be completed at the end of the summer session, the Plan of Graduate Work should be filed in the School of Graduate Studies within five working days following fall registration. The Plan of Graduate Work lists the committee chairperson, other committee members, and a sequence of courses required for the degree and approved by the student’s advisor. Each committee member’s signature indicates approval of the Plan of Graduate Work. Upon approval by the School of Graduate Studies, the Plan becomes the student’s official guide to completing his/her program. Any changes in the Plan of Graduate Work or exceptions to the schedule for submission of the Plan must be approved by the committee and the Dean of the School of Graduate Studies.

Declaration of Major

A graduate student shall declare and complete the requirements of one master’s degree program before declaring another major. This does not prevent a student from changing a declaration of major.

Time Limitation

The master’s degree program must be completed within six successive calendar years. Programs remaining incomplete after this time interval are subject to cancellation, revision, or special examination for out-dated work. Students enrolled in doctoral programs (Electrical, Industrial and Systems, and Mechanical Engineering) should see the appropriate section of the Graduate Catalog for details regarding the maximum time allowed to complete the degree programs. When the program of study is interrupted because the student has been drafted into the armed services, the time limit shall be extended for the length of time the student shall have been on active duty, if the candidate resumes graduate work no later than one year following his/her release from military service.
Course Levels

At the University, the department prefix, followed by a three-digit number, is used to designate all course offerings. The first digit indicates the classification level of the course. Courses numbered 600 through 699 are open to seniors and to graduate students. Courses numbered 700 and above are open only to graduate students. At least 50% of the courses counted in the work towards a master’s degree must be those open only to graduate students; that is, numbered 700 and above. The University uses the department prefix, followed by a three-digit number, to designate all course offerings. The first digit indicates the classification level of the course. The numbering system is as follows:

- 100-399 - lower level courses primarily for freshmen and sophomores
- 400-599 - upper level courses primarily for juniors and seniors
- 600-699 - courses for undergraduate seniors and graduate students
- 700-799 - courses for graduate students and appropriate professional students’ special programs
- 800-899 - courses for doctoral students
- 900-999 - courses for graduate students (999 continuation of thesis courses)

Credits

A minimum of 30 semester credit hours is required for most master’s degrees; however, some programs require more than 30. Also, in order to gain the breadth desired in their program or to make up deficits in their undergraduate degree, many students will actually take more credit hours than the minimum required by the program.

Residence Requirements

A minimum of three-fourths of the hours required for the master’s degree must be earned in residence study at the University.

Language Requirements

A reading knowledge of one foreign language is required by some programs for the Master of Arts and the Master of Science degrees. Other departments may designate that the language requirement be fulfilled from among those languages in which the Department of Foreign Languages conducts testing. Students should contact the major department for specific language requirements.

Thesis

Theses prepared by candidates for the Master of Science and Master of Arts degrees, in programs requiring the thesis, must present an original investigation into a subject which has been approved by the student’s advisory committee and the Coordinator of Graduate Programs in the student’s major. Four copies of the thesis in final form as approved by the advisory committee, each signed by the members of the advisory committee, must be submitted to the School of Graduate Studies by a specific deadline in the semester or summer session in which the degree is to be conferred.
Final Comprehensive Examination

Students enrolled in a master’s degree program or a doctoral degree program may be tested by a comprehensive examination to determine the student’s knowledge and skills in a general subject area of concentration. The comprehensive examination date will be announced by the departmental graduate committee chairperson at the beginning of the semester. This examination will be administered to the enrolled student by an examining committee of the department. Eligibility to sit for the examination will be determined by the departmental graduate committee and the results of the examination will be forwarded to the School of Graduate Studies no later than 30 days prior to the end of the semester. Students may only take the comprehensive examination twice. After a second failure, the student must petition the Coordinator of Graduate Programs and the Dean of the School of Graduate Studies for approval to take the exam a third time. If the student is unsuccessful after the third attempt, the student is dismissed from the Graduate Program.

Comprehensive Final Oral Examination

Candidates for master’s degrees must pass a comprehensive oral examination to demonstrate to the advisory committee that he/she possesses a reasonable mastery of the subject matter of the major and supporting fields and that this knowledge can be used with promptness and accuracy. This examination may not be held until all other requirements, except completion of the course work in current registration during the final semester, are satisfied. A request for a permit to schedule the examination may be filed with the Dean of the School of Graduate Studies after the above conditions are met. The School of Graduate Studies will check to determine that the advisory committee and the courses taken by the student meet the requirements.

If all requirements are met, the permit to schedule the final examination will be forwarded to the Director of Graduate Programs within 20 days of receipt of the request. Upon receipt of the permit, the student may proceed to schedule the exam at a time that is convenient to all members of the advisory committee. In those programs that require the thesis, the thesis must be submitted in complete form, except for such revisions necessary as a result of the final exam, to all members of the advisory committee at least two weeks prior to the exam.

A unanimous vote of approval of the advisory committee is required to pass the oral examination.

Approval of the examination may be conditional, however, upon completion of additional work to the satisfaction of the advisory committee. A formal reexamination will not be required in this case. Failure of a student to pass the oral examination terminates the student’s graduate work at North Carolina A&T State University, unless the graduate advisory committee unanimously recommends a reexamination. Only one reexamination will be given. A form giving the date that the exam was
conducted and the result of the examination, signed by all members of the advisory committee, is forwarded to the Dean of the School of Graduate Studies by the Coordinator of Graduate programs in the student’s department or program. A student may appeal all committee actions by written application to the Dean of the School of Graduate Studies.

Oral examinations for master’s degree candidates are open to the Graduate Faculty by right and to the University community by unanimous consent of the advisory committee and the student being examined. Discussions and decisions regarding the student’s performance are private to the advisory committee.

Summary of Procedures for Master’s Degrees

ALL STUDENTS

• Application materials and required fees must be received.
• Application materials must be reviewed by department or program.
• The department or program must forward its recommendation regarding applicant’s admissibility to the Dean of the School of Graduate Studies.
• The School of Graduate Studies must review the recommendation and the student is notified of the action taken on the request for admission.
• The student must report to the department or program, be assigned a graduate advisor, and develop a roster of courses and credits with the advisor.
• The student must comply with requests from the School of Graduate Studies for updated copies of transcripts from previous colleges or universities.
• The student must sign a patent agreement and file with the School of Graduate Studies.
• The student is subject to continuous registration policy until graduation.
• The student must pass a language examination, if required.
• The student must pass a written examination, if required.
• The student must submit a diploma order form by end of the sixth week of the semester or summer session of anticipated graduation.
• An overall grade point average of at least 3.0 must be maintained for all graduate coursework taken at North Carolina A&T State University to graduate.

All degree requirements must be completed within six calendar years, beginning with the date the student commences courses carrying graduate credit applicable to the degree program, unless a more restrictive time limit has been established by the department/program or academic college/school.

Students in Non-Thesis Programs

• A graduate advisory committee of three or more Graduate Faculty members must be appointed by the Coordinator of Graduate Programs.
• A Plan of Graduate Work must be prepared by the student, in consultation with and with the approval of his/her graduate advisory committee. This plan must be approved by the Coordinator of Graduate Programs prior to completion of one-half the credits on the plan.
• When all requirements except completion of the course work in the final semester are satisfied, the Coordinator of Graduate Programs must request that the School of Graduate Studies issue a permit to schedule the final oral examination.
• If the School of Graduate Studies requirements are met, a permit to schedule the final examination will be issued within 20 working days of receipt of the request.
• The final examination must be scheduled and conducted.
• The final examination report, including date and result of the examination, must be submitted to the School of Graduate Studies by the Coordinator of Graduate Programs. This report should be received within five working days of the examination.

Students in Thesis Programs

• graduate advisory committee of three or more Graduate Faculty members must be appointed by the Coordinator of Graduate Programs.
• A Plan of Graduate Work must be prepared by the student, in consultation with and with the approval of his/her graduate advisory committee. This plan must be approved by the Coordinator of Graduate Programs prior to completion of one-half the credits on the plan.
• A copy of a preliminary draft of the thesis, if required, must be submitted to the chair of the student’s advisory committee.
• When all requirements except completion of the course work in the final semester are satisfied and after the thesis is complete except for such revisions as may be necessary as a result of the exam, the Coordinator of Graduate Programs will request that the School of Graduate Studies issue a permit to schedule the final oral examination.
• If all requirements are met, a permit to schedule the final examination is issued by the School of Graduate Studies within 20 working days of receipt of the request.
• At least two weeks prior to the final oral examination, the chair of the student’s advisory committee must submit the thesis to the other members of the advisory committee for review.
• The final examination must be scheduled and conducted.
• The final examination report, including the date and result of the examination, must be submitted to the School of Graduate Studies by the Coordinator of Graduate Programs. The report should be received by the School of Graduate Studies within five working days after the examination.
• The student must submit four copies of the thesis, signed by each member of his/her advisory committee, to the School of Graduate Studies.
• The deadline date for submitting four copies of the thesis to the School of Graduate Studies for the student to graduate in a given semester or summer session appears in The Academic Calendar in this catalog as well as in other School of Graduate Studies calendars.
• The defended thesis is reviewed by the School of Graduate Studies to ensure that the format conforms with the specifications prescribed in the Thesis and Dissertation Manual.
C13. Graduate Biosystems and Agricultural Engineering (North Dakota State University)

The department offers M.S. & Ph. D degrees in Agricultural and Biosystems Engineering in the College of Engineering and Architecture. Ph. D in Engineering is also offered where a student can choose an appropriate research area & obtain a Ph. D in Engineering.

Our Research Program focuses on designing, developing & testing engineering solutions for problems associated with agricultural, food, & biological systems.

<table>
<thead>
<tr>
<th>Course Number</th>
<th>Courses</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>644</td>
<td><strong>Transport Processes in Biological and Environmental Systems</strong></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Energy and mass transport principles applied to biological and environmental systems. 3 lectures. Prereq. Math 266 and CE 309 or MEAM 352.</td>
<td></td>
</tr>
<tr>
<td>652</td>
<td><strong>Bioenvironmental Systems Design</strong></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Study of Psychrometrics, heat and mass transfer, and physiological requirements for livestock and bioproducts. Design of environmental modifications, livestock wastes, and control systems. 3 lectures. Prereq. CE 309, ME 350.</td>
<td></td>
</tr>
<tr>
<td>658</td>
<td><strong>Food Process Engineering</strong></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Analysis and design of food processing equipment and plants. Emphasis is on application of fluid flow, thermodynamics, and heat and mass transfer principles. 3 lectures.</td>
<td></td>
</tr>
<tr>
<td>664</td>
<td><strong>Resource Conservation and Irrigation Engineering</strong></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Resource principles and design of systems for soil and water resources management and environmental protection. 3 lectures, 1 three-hour lab. Prereq. CE 309.</td>
<td></td>
</tr>
<tr>
<td>673</td>
<td><strong>Agricultural Power</strong></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Theory, analysis, and testing of internal combustion engines, traction, power trains, hydraulic systems, vehicle dynamics, stability, and ergonomics in tractor design. Electrical power units including motors. Alternative energy systems. 2 lectures, 1 three-hour lab. Prereq. ME 350.</td>
<td></td>
</tr>
<tr>
<td>678</td>
<td><strong>Machinery Analysis and Design</strong></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Principles of design, development, and testing of agricultural machines and machine systems. Applications of computer-aided design and FMEA. 2 lectures. Prereq. ME 442.</td>
<td></td>
</tr>
<tr>
<td>682</td>
<td><strong>Instrumentation and Measurements</strong></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Application of instrumentation and sensor concepts to measurement and control of environmental, biological, and mechanical parameters. Including sensor principles, signal conditioning, data collection, and data analysis methods. 2 lectures, 1 three-hour lab. Prereq. ME 223, PHYS 252.</td>
<td></td>
</tr>
<tr>
<td>758</td>
<td><strong>Applied Computer Imaging &amp; Sensing Techniques for BioSystems</strong></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Sensors and non-destructive principles (e.g., computer vision, spectroscopy, imaging, fiber optic sensing) for bioproduction and processing applications. Data/signal acquisition, signal conditioning/analysis, signal interpretation, and pattern recognition using statistical, neural networks, and fuzzy logic techniques. 3 lectures. Prereq. Graduate standing.</td>
<td></td>
</tr>
<tr>
<td>763</td>
<td><strong>Theory of Drying Biological Products</strong></td>
<td></td>
</tr>
</tbody>
</table>

361
<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Description</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>765</td>
<td>Theory used to describe the drying processes of biological products. 3 lectures.</td>
<td>Prereq. Graduate standing.</td>
<td></td>
</tr>
<tr>
<td>773</td>
<td>Advanced Agricultural Power and Machinery</td>
<td>Theory and design of agricultural power units and field machines. 3 lectures. Prereq. ABEN 473/673.</td>
<td>3</td>
</tr>
<tr>
<td>783</td>
<td>Advanced Structures and Environmental Systems</td>
<td>Detailed analysis of building components and advanced design problems relating to agricultural and environmental systems. 3 lectures. Prereq. ABEN 383.</td>
<td>3</td>
</tr>
<tr>
<td>791</td>
<td>Bioprocess Engineering</td>
<td>Biological, biochemical, and engineering fundamentals of industrial bioprocessing. Topics include bioprocessing kinetics (enzymes, cell growth, substrate utilization, and product formation); bioreactor selection, scale-up and control; and product recovery. 2 lectures. Prereq. Graduate standing.</td>
<td>3</td>
</tr>
</tbody>
</table>

The following variable credit courses are also offered:

- 790 Seminar 1-3
- 793 Individual Study 1-5
- 795 Field Experience 1-5
- 696/796 Special Topics 1-5
- 797 Master's Paper 1-3
- 798 Master's Thesis 1-10
- 799 Doctoral Dissertation 1-15
C14. Graduate Biosystems and Agricultural Engineering (Oklahoma State University)

Graduate Program (course from the list of courses in undergradute programs – the list includes also graduate course)

In Biosystems Engineering at OSU, each person seeking an advanced degree is treated as an individual and is encouraged to develop a program of study based on his or her personal and professional goals. Two degrees are offered, Master of Science and Doctor of Philosophy in Biosystems Engineering.

We have four general areas for study, Environmental and Natural Resources, Food, Biomechanical and Bioprocessing. None of the Department's degrees have a set curriculum requirement. Students work with their advisor to develop a plan of study that includes courses from engineering, mathematics, computer science, statistics, agriculture and related disciplines that will suit their particular needs and interests. Individual research is the most important element in our graduate program. It allows students to develop a close working relationship with the faculty, a hallmark of our program. We prided ourselves in our excellent research labs.

Graduates of the Biosystems Engineering program at Oklahoma State University find a variety of jobs and include university faculty, private companies and government agencies. Our graduates can be found in almost every state in the United States and many foreign countries.

Admission Requirements

Usually students with an BS degree from an ABET accredited Biosystems or Agricultural engineering program (most US programs) are admitted automatically if their grade point average is 3.0 or higher. Persons with a grade point average less than 3.0 will be considered, particularly if they have two or more years of professional engineering experience. Since BAE is a broad discipline, we look favorably on degrees from other engineering fields. Usually, persons with degrees in Mechanical, Civil, Environmental and Chemical engineering are admitted without condition. Electrical and Industrial engineering majors may be required to take one or more "make-up" undergraduate classes.

Students with undergraduate degrees in closely-related scientific fields such as Chemistry, Geology, Mathematics, and Physics are also invited to apply for admission to our graduate program. Such applications are evaluated on an individual basis, and specific plans of study are developed for each student. Students with a Bachelor's of Science who have already taken calculus through differential equations, physics, chemistry and biology will typically have two to four additional undergraduate engineering courses required in addition to their normal graduate work.

We are a tradition based engineering department. Person with degrees in agriculture, the life sciences and biology based biotechnology programs, who have not taken college level calculus, physics and at least some applied technology (electronics, fluid mechanics, material sciences, etc) will usually not be accepted. Graduates from three-year undergraduate programs (some forgein institutions) will not be accepted.
Students with only a BS will be considered for the MS degree program. To be considered for the Ph.D. program, a student should have a MS. **We do not generally allow a student to obtain a Ph.D. without obtaining a MS first.** It is common for students who successfully complete their MS to be admitted to the PhD program.

Teaching and research assistantships are available to qualified applicants. In the past we have provided financial support to about 90% of new graduate students with engineering degrees from American institutions. Only about 10 to 20% of students with degrees from foreign schools are offered financial aid.
C15. Graduate Biological & Ecological Engineering (Oregon State University)

**Graduate Programs**
The BEE department offers programs leading to the M.S. and Ph.D. degrees. The objective of the department's degree programs are to serve at the interface between life sciences and engineering. Biological and Ecological Engineering is the application of engineering and life-science principles and problem-solving techniques to the optimum use and sustainability of biological resources. The curriculum is engineering-based with strong emphasis on the life sciences. Courses focus on biological systems modeling, theoretical and applied aspects of bioconversion and bioseparation processes, regional hydrologic analysis, groundwater systems, irrigation, water resource optimization, remote sensing, image analysis, and instrumentation.

The Biological & Ecological Engineering Department offers the following graduate degrees:

**Biological & Ecological Engineering**
(M.S., MENG, and Ph.D degree programs)
The graduate program in Biological & Ecological Engineering deals with diverse issues in the design and analysis of a wide range of biological and hydrologic systems. Focus areas are in bioprocessing and water resource engineering/watershed analysis. The bioprocessing program encompasses quality retention in frozen seafood, thermal processing, and preservation and energy conservation in fresh fruit storages. Research topics in Water Resource Engineering include: constructed wetland treatment systems, crop growth modeling, optimum irrigation management, crop-water requirements, groundwater and subsurface contaminant transport, hydrologic modeling, image processing and artificial intelligence technologies to manage water resources, livestock production odor control, and non-point source water pollution control.

**Water Resources Graduate Program**
The New Water Resources Program at Oregon State University awards M.S. and Ph.D. degrees and brings together faculty and students from six colleges and multiple departments. The degrees are designed to allow flexibility in coursework, while insuring an outstanding foundation and specialization in your area of interest. The Program includes core requirements for all students with additional work concentrated in specific degree programs in Water Resources Engineering, Water Resources Science, or Water Resources Policy and Management. Students will draw from a set of existing OSU courses covering engineering approaches, watershed processes, and/or water resources management and policy.

**Ecosystems Informatics Graduate Minor**
A Graduate Minor in Ecosystem Informatics is available. The minor entails a series of 4 core classes, colloquia, and an ethics class totaling 18 credit hours. A student only needs to be of graduate student status in order to be eligible for the minor.
C16. Graduate Agricultural Engineering (Purdue University)

The Purdue University Department of Agricultural and Biological Engineering is consistently ranked among the top in the nation. Research focuses on the application of engineering principles to biological systems, resulting in the creation of new products and practices that improve the quality of human life.

The Department of Agricultural and Biological Engineering offers opportunity for creative endeavor in academic coursework and in fundamental and applied research in the general areas of machine systems engineering, environmental and natural resources engineering, food process engineering, biological engineering, and agricultural systems management. The Graduate Manual describes additional areas of specialization for graduate students in the ABE Department, which include fluid power, ecological sciences and engineering, biological engineering and technology, and computational sciences and engineering. Excellent facilities and internationally-known faculty support approximately 80 graduate students per year.

Both Masters and PhD degrees are offered in a variety of fields.

Funding: Prestigious fellowships are available for outstanding graduate students who plan to complete a Ph.D. Nearly all graduate students in our department are supported by fellowships or research assistantships, which fund both Ph.D. and M.S. students. Research projects that fund assistantships change each year, so contact specific faculty to determine opportunities for which you may be qualified.

Areas of Specialization

Graduate students study in all the various fields of Agricultural and Biological Engineering, including machine systems engineering, environmental and natural resources engineering, food process engineering, biological engineering, and agricultural systems management.

In addition, an Area of Specialization is used to allow a specialized area of graduate study to be reflected on a student’s final transcript. The Department of Agricultural and Biological Engineering currently has the following Areas of Specialization:

- Agricultural and Biological Engineering
- Agricultural Systems Management
- Biological and Food Process Engineering
- Biological Engineering and Technology
- Computational Science and Engineering
- Ecological Sciences and Engineering
- Fluid Power
C17. Graduate Biosystems Engineering (South Dakota State University)

Master of Science Degree in Engineering
A Master of Science Degree is offered through the College of Engineering. Primary and secondary course requirements are defined in the SDSU Graduate Bulletin. Areas of specialization for the area of Agricultural and Biosystems Engineering include machine vision, biomaterials processing, soil and water engineering, structures, and machine design.

Research

Research efforts are a valuable component of the ABE department mission to the students, faculty, state, region, and world. The research program areas of the department include natural resources (the protection and conservation of soil and water resources); biorenewable processing (the development of value-added product such as ethanol and its by-products, biomass conversion, and vegetable oils); power and machinery systems (the development of advance hydraulic systems, global information systems related to agriculture commodities, and machinery design); structures and ventilation (the analysis of building trusses and structure components, livestock housing ventilation systems, and the effect on production and animal well-being); and environment (the investigation of mitigation technologies to reduce odor and gasses from livestock facilities, modeling livestock odors, and manure handling systems).

Research is aimed at improving performance and reducing cost at all levels of production with minimal environmental impact. Research is conducted in university labs, and in the field either at four Research and Extension Centers or on producer farms. In addition to research conducted in South Dakota, several faculty members have projects involving international collaboration, for example in developing biofilter systems on livestock barns in Denmark. Research cooperation with industries that involve agricultural commodities and production has broadened the scope of agricultural engineering research, especially in the development of monitoring sensors and process control systems.
C18. Graduate Bioenvironmental Engineering (Texas A&M University)

Graduate Degree Programs

Graduate students in the top-ranked* Texas A&M University Department of Biological & Agricultural Engineering enjoy small class size and frequent one-to-one contact with professors, even though our department is among the largest of its kind. What's more, our faculty will be actively involved in helping develop your career, from advising you on the selection of your courses to helping you make contact with our many industrial partners, many of whom are among our more than 2,000 Former Students. The Agricultural Engineering Department offers these advanced degrees:

- Master of Science
- Master of Engineering
- Master of Agriculture
- Doctor of Philosophy
- Doctor of Engineering

Students entering the graduate program in the Department of Biological & Agricultural Engineering at Texas A&M University may select a research topic from a broad array of fields. The high level of funding support for agriculture and engineering in Texas, the diversity of agriculture, and the breadth of faculty expertise and research interests contribute to a large number of research programs from which to choose. The following major areas of agricultural engineering research are offered:

- Food Engineering
- Environmental & Natural Resource Engineering
- Bioprocess Engineering
- Biomaterials Science
- Machine & Energy Systems
- Systems Analysis
- Food, Feed & Fiber Processing
- Bioacoustics

The Master of Agriculture is a non-engineering degree program, primarily for students with a baccalaureate in Agricultural Systems Management, Mechanized Agriculture or a similar degree. All of the other advanced degrees are engineering degrees. An undergraduate engineering degree or its equivalent is a prerequisite for an advanced engineering degree.

If you don't have an undergraduate engineering degree, but you have a strong academic background in mathematics or science, you may still be admitted to a graduate program in engineering. The prerequisite course work required for the successful completion of the Engineering-in-Training exam, identifies by your advisor and approved by the department head, will be taken at the same time as the graduate courses. Otherwise, a second baccalaureate in agricultural engineering is recommended.
C19. Graduate Bio Engineering (Ohio University)

DEGREE OPTIONS:

The department offers exciting opportunities to work with world-class researchers in the fields of food engineering, agricultural engineering and biological engineering. One of the greatest advantages to students in the department is their ability to tailor their programs to their specific areas of interest. The low faculty-to-student ratio of approximately 1-to-6 allows a great deal of personalized interaction.

MASTER OF SCIENCE DEGREE:

The Master's degree requires 30 credit hours (based on a quarter system) of course work from disciplines that meet the needs of your research specialty, and 15 credit hours of thesis research.

In the course of your program, you will be required to prepare and orally defend a thesis based on your research. Students require approximately two years to complete the Master of Science degree.
C20. Graduate Agricultural and Biological Engineering (The Pennsylvania State University)

Graduate Program

The Department of Agricultural and Biological Engineering maintains a very active Graduate Program and we think you will find our Department to be interesting, exciting, challenging, and rewarding. The various pages and links offered here are intended to help you learn more about our Graduate Program, Faculty and Students, Research Activities, Admission/Program Requirements, and associated information. You will also find the necessary procedure (and associated forms) required for applying to our program.

Graduate students select research projects and supporting course work from a wide range of interest areas that match faculty research expertise. Research projects are available in renewable biofuels; bio-nanomaterials; bioproducts development; synthetic biological engineering; biological and food process engineering; biosensors and instrumentation; food safety engineering; natural resources engineering for sustainability of water and land use; biowaste management and utilization; ecological systems; machine systems for biomass/bioenergy production and feedstock logistics; plant, animal, and microbial production systems; agricultural safety and health; particulate materials processing and modeling; structures and controlled environments of agricultural and biological facilities; and modeling of biological systems.

Although Penn State is a large university, the atmosphere in the Department of Agricultural and Biological Engineering is typical of a small university or college. Graduate students in our Department are invited and encouraged to participate in all academic, professional, and social activities with the faculty and staff. Other features to enhance professional development for the graduate students include financial support to attend national professional meetings and clerical and technical support for assistance with research activities. M.S. and Ph.D. enrollment is typically 40-45 students. Approximately one-half of our students are of international origin and nearly sixty percent are actively seeking Ph.D. degrees.
C21. Graduate Biosystems Engineering (University of Arizona)

M.S. in Biosystems Engineering

Program Educational Objectives

The Educational Objectives of the Biosystems Engineering Program at the University of Arizona are to produce graduates:

1. Who are effective engineers within natural resources and biotechnology related industries; and
2. Who have the foundation to perform and lead engineering projects and make significant contributions; or are
3. Enrolled in an advanced engineering or medical or other professional degree program and are successful in those.

Master of Science in ABE

ADMISSION GUIDELINES

In evaluating applications sent to the Department by the Graduate College, the following criteria are followed:

1. Grade Point Average
   A minimum GPA of 3.0 (out of 4.0) is required for admission to this program. Non-technical, agricultural mechanics, lower-division, and non-lecture (except engineering laboratory) courses are excluded from the calculations.
2. Previous Degree
   A B.S. in agricultural engineering, biological engineering, a related engineering, or suitable technical discipline is required. Students who do not have such a degree may still be admitted but they may have to take a number of courses ordinarily taken by B.S. agricultural and biosystems engineering students. These will not count toward degree requirements.
3. TOEFL
   Students whose native language is other than English must meet University English language entrance requirements (TOEFL >= 550 or Computer Based Test (CBT) >= 213 or English language education).
4. GRE
   The Graduate Record Examination (GRE) is required of all applicants, and GRE scores should be submitted to the ABE Department and the Graduate College with other application materials.
5. Statement of Purpose
6. Three Letters of Recommendation

REQUIREMENTS FOR GRADUATION

Except where otherwise noted, previous work at the B.S. level may contribute to meeting the M.S. degree requirements. In addition to the following requirements,
students must meet all those for the M.S. degree which may be set by the University or the Graduate College.

A minimum of thirty units of graduate credit of which 5 are for the thesis is required. Specific requirements are:

1. A minimum of 6 units in mathematics and/or statistics and/or numerical analysis
2. A minimum of 12 units of ABE courses exclusive of seminar, thesis, dissertation, and independent studies units
3. A minimum of 15 units in the major (including thesis units)
4. ABE 696a seminar (1 unit every semester). One unit may be used to meet the 30 unit requirement
5. No. 400 level courses may be taken in the major; a maximum of six units of 400 level coursework may be taken in other areas with advisor approval
6. All ABE graduate students will be required to submit a Progress Report with the exception of first semester graduate students. However, it is recommended that new students also submit the report. Submission of the report is required to receive a passing grade in ABE 696a (seminar) except for new graduate students. Each Progress Report must include a research abstract if you have completed (2) semesters in the ABE Department. Failure to include an abstract will result in a decrease in your assigned grade by two letters (e.g. S to C).

TYPICAL A.B.E. PROGRAMS

- Biological Engineering
- Water Resource and/or Irrigation Engineering
- Sensors
- Controlled Environment Engineering
- Alternative Energy Engineering

DUAL DEGREE PROGRAM WITH ELLER COLLEGE OF MANAGEMENT

Interested graduate students have option of receiving two graduate degrees on a concurrent basis. One of these degrees will be an MBA degree from the Eller College of Management. The other will be a graduate degree from ABE. For more information regarding this program go to Eller dual degree web site.
D. Typical Programs

Biological Engineering

Typical M.S. courses:

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>ABE 547</td>
<td>Sensors and Controls</td>
</tr>
<tr>
<td>ABE 581A</td>
<td>Engineering of Biological Processes</td>
</tr>
<tr>
<td>ABE 581B</td>
<td>Bioprocess Engineering Applications</td>
</tr>
<tr>
<td>ABE 584</td>
<td>Advanced Biosystems Transport Phenomena</td>
</tr>
<tr>
<td>ABE 586</td>
<td>Biomaterial-Tissue Interactions</td>
</tr>
<tr>
<td>ABE 589B</td>
<td>Bio Micro/Nanotechnology Applications</td>
</tr>
<tr>
<td>MATH 509C</td>
<td>Statistics for Research</td>
</tr>
<tr>
<td>MATH 522</td>
<td>Advanced Applied Analysis</td>
</tr>
<tr>
<td>ABE 601</td>
<td>Research Methods in Biosystems Engineering</td>
</tr>
<tr>
<td>ABE 696A</td>
<td>Agricultural and Biosystems Engineering</td>
</tr>
<tr>
<td>ABE 910</td>
<td>Thesis</td>
</tr>
<tr>
<td>Total</td>
<td>32</td>
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Possible Alternative Courses: (Note: This list is not meant to be exhaustive)

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
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<tbody>
<tr>
<td>ABE 523</td>
<td>Biosystems Analysis and Design</td>
</tr>
<tr>
<td>ABE 582</td>
<td>Simulation of Biological Systems</td>
</tr>
<tr>
<td>ABE 583</td>
<td>Controlled Environment Systems</td>
</tr>
<tr>
<td>BME 510</td>
<td>Biology for Biomedical Engineering</td>
</tr>
<tr>
<td>BME 511</td>
<td>Physiology for Biomedical Engineering</td>
</tr>
<tr>
<td>BME 516</td>
<td>Principles of Biomedical Engineering</td>
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<tr>
<td>BME 517</td>
<td>Measurement and Data Analysis in Biomedical Engineering</td>
</tr>
<tr>
<td>CHEE 505</td>
<td>Advanced Chemical Engineering Transport Phenomena</td>
</tr>
<tr>
<td>CHEE 520</td>
<td>Chemical Reaction Engineering</td>
</tr>
<tr>
<td>CHEE 577A</td>
<td>Microbiology for Engineers</td>
</tr>
<tr>
<td>CHEE 577L</td>
<td>Microbiology for Engineers Laboratory</td>
</tr>
<tr>
<td>CHEE 577R</td>
<td>Microbiology for Engineers</td>
</tr>
<tr>
<td>MSE 561</td>
<td>Biological and Synthetic Materials</td>
</tr>
<tr>
<td>PL S 575A</td>
<td>Physiology of Plant Production under Controlled Environment</td>
</tr>
</tbody>
</table>
UNIVERSITIES IN USA AND CANADA OFFERING PROGRAMS OF STUDIES IN BIOSYSTEMS ENGINEERING OR RELATED DISCIPLINES

PL S 580  3  Medicinal Plants
SWES 525  3  Environmental Microbiology
SWES 526  2  Environmental Microbiology Laboratory
MATH 561  3  Regression and Multivariate Analysis
MATH 575A  3  Numerical Analysis

WATER RESOURCES AND/OR IRRIGATION ENGINEERING

Typical M.S. Courses:

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Credits</th>
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<tbody>
<tr>
<td>MATH 522</td>
<td>Advanced Analysis for Engineers</td>
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<tr>
<td>MATH 509C</td>
<td>Statistics for Research</td>
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</tr>
<tr>
<td>ABE 555</td>
<td>Soil and Water Conservation Engineering</td>
<td>3</td>
</tr>
<tr>
<td>ABE 547</td>
<td>Sensor and controls</td>
<td>3</td>
</tr>
<tr>
<td>ABE 556</td>
<td>Irrigation system Design</td>
<td>3</td>
</tr>
<tr>
<td>ABE 558</td>
<td>Agricultural Drainage and Effluent Treatment</td>
<td>3</td>
</tr>
<tr>
<td>ABE 601</td>
<td>Research Methods in Biosystems Engineering</td>
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<tr>
<td>ABE 650A</td>
<td>Seminar-Agricultural &amp; Biosystems Engineering</td>
<td>1</td>
</tr>
<tr>
<td>ABE 910</td>
<td>Thesis</td>
<td>5</td>
</tr>
<tr>
<td>TOTAL</td>
<td></td>
<td>32</td>
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</table>

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<thead>
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</thead>
<tbody>
<tr>
<td>C/E 522</td>
<td>Open-Channel Flow</td>
<td>3</td>
</tr>
<tr>
<td>ABE 559</td>
<td>Design of Onsite Wastewater Treatment and Dispercal Systems</td>
<td>3</td>
</tr>
<tr>
<td>ABE 567</td>
<td>Advanced Watershed Hydrology</td>
<td>3</td>
</tr>
<tr>
<td>ABE 605</td>
<td>Soil-Water Dynamics</td>
<td>3</td>
</tr>
<tr>
<td>C/E 502</td>
<td>Introduction to Finite Element Methods</td>
<td>3</td>
</tr>
<tr>
<td>C/E 504</td>
<td>Numerical Methods in Subsurface Hydrology</td>
<td>4</td>
</tr>
<tr>
<td>CE 523</td>
<td>Hydrology</td>
<td>3</td>
</tr>
<tr>
<td>C/E 527</td>
<td>Computer Applications in Hydraulics</td>
<td>3</td>
</tr>
<tr>
<td>C/E 576A</td>
<td>Water Treatment System Design</td>
<td>3</td>
</tr>
<tr>
<td>C/E 576B</td>
<td>Wastewater Treatment Design System</td>
<td>3</td>
</tr>
<tr>
<td>C/E 676</td>
<td>Advanced Water and Wastewater Treatment</td>
<td>3</td>
</tr>
<tr>
<td>SWES 501</td>
<td>Management of Arid Land and Salt-Affected Soils</td>
<td>3</td>
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<tr>
<td>SWES 520</td>
<td>Environmental Physics</td>
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<td>SWES 553</td>
<td>Remote Sensing of the Environment</td>
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</tr>
<tr>
<td>SWES 565</td>
<td>Contaminant Transport in Porous Media</td>
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<td>SWES 570</td>
<td>Soil Physics</td>
<td>3</td>
</tr>
<tr>
<td>SWES 602</td>
<td>Nutrient Dynamics in Soils</td>
<td>3</td>
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<tr>
<td>SWES 606</td>
<td>Soil Water Dynamics</td>
<td>3</td>
</tr>
<tr>
<td>WS M 560</td>
<td>Watershed Hydrology</td>
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</tr>
<tr>
<td>WS M 562</td>
<td>Watershed Management</td>
<td>3</td>
</tr>
<tr>
<td>WS M 567</td>
<td>Advanced Watershed Hydrology</td>
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</tr>
<tr>
<td>WS M 573</td>
<td>Spatial Analysis and Modeling</td>
<td>3</td>
</tr>
<tr>
<td>Course Code</td>
<td>Credits</td>
<td>Course Title</td>
</tr>
<tr>
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</tr>
<tr>
<td>WS M 605</td>
<td>3</td>
<td>Watershed Modeling</td>
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<td>RNR 503</td>
<td>3</td>
<td>Applications of Geographic Information Systems</td>
</tr>
<tr>
<td>RNR 517</td>
<td>3</td>
<td>Geographic Information Systems for Natural Resources</td>
</tr>
<tr>
<td>RNR 520</td>
<td>3</td>
<td>Advanced Geographic Information Systems</td>
</tr>
<tr>
<td>RNR 573</td>
<td>3</td>
<td>Spatial Analysis and Modeling</td>
</tr>
<tr>
<td>RNR 575</td>
<td>3</td>
<td>Economics of Natural Resource Policy</td>
</tr>
<tr>
<td>RNR 580</td>
<td>3</td>
<td>Natural Resources Policy and Law</td>
</tr>
<tr>
<td>RNR 583</td>
<td>3</td>
<td>Geographic Applications of Remote Sensing</td>
</tr>
<tr>
<td>HWR 517</td>
<td>3</td>
<td>Fundamentals of Water Quality</td>
</tr>
<tr>
<td>C E 526</td>
<td>3</td>
<td>Soil and Water Conservation Engineering</td>
</tr>
</tbody>
</table>

**SENSORS**

**Typical M.S. courses**

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Credits</th>
<th>Course Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>ABE 523</td>
<td>3</td>
<td>Biosystems Analysis and Design</td>
</tr>
<tr>
<td>ABE 547</td>
<td>3</td>
<td>Sensors and Controls</td>
</tr>
<tr>
<td>ABE 579</td>
<td>3</td>
<td>Applied Instrumentation for CFA</td>
</tr>
<tr>
<td>ABE 589B</td>
<td>3</td>
<td>Bio Micro/Nanotechnology Applications</td>
</tr>
<tr>
<td>A M E 586</td>
<td>3</td>
<td>Micro fluids</td>
</tr>
<tr>
<td>SWES 553</td>
<td>3</td>
<td>Remote Sensing of the Environment</td>
</tr>
<tr>
<td>ABE 696A</td>
<td>1</td>
<td>Agricultural and Biosystems Engineering</td>
</tr>
<tr>
<td>MATH 562</td>
<td>3</td>
<td>Time Series Analysis</td>
</tr>
<tr>
<td>MATH 575A</td>
<td>3</td>
<td>Numerical Analysis</td>
</tr>
<tr>
<td>ABE 601</td>
<td>2</td>
<td>Research Methods in Biosystems Engineering</td>
</tr>
<tr>
<td>ABE 910</td>
<td>5</td>
<td>Thesis</td>
</tr>
<tr>
<td>TOTAL</td>
<td>32</td>
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</table>

Possible Alternative Courses: (Note: This list is not meant to be exhaustive)

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Credits</th>
<th>Course Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>ABE 563</td>
<td>3</td>
<td>Controlled Environment Systems</td>
</tr>
<tr>
<td>ABE 584</td>
<td>3</td>
<td>Biosystems Transport Phenomena</td>
</tr>
<tr>
<td>BME 517</td>
<td>3</td>
<td>Measurement and Data Analysis in Biomedical Engineering</td>
</tr>
<tr>
<td>CHEE 413</td>
<td>3</td>
<td>Process Control and Simulation</td>
</tr>
<tr>
<td>CHEE 577A</td>
<td>4</td>
<td>Microbiology for Engineers</td>
</tr>
<tr>
<td>CHEE 577L</td>
<td>1</td>
<td>Microbiology for Engineers Laboratory</td>
</tr>
<tr>
<td>CHEE 577R</td>
<td>3</td>
<td>Microbiology for Engineers</td>
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<tr>
<td>ECE 563</td>
<td>3</td>
<td>Remote Sensing Instrumentation and Techniques</td>
</tr>
<tr>
<td>SWES 525</td>
<td>3</td>
<td>Environmental Microbiology</td>
</tr>
<tr>
<td>SWES 526</td>
<td>2</td>
<td>Environmental Microbiology Laboratory</td>
</tr>
<tr>
<td>MATH 509C</td>
<td>3</td>
<td>Statistics for Research</td>
</tr>
<tr>
<td>MATH 522</td>
<td>3</td>
<td>Advanced Applied Analysis</td>
</tr>
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</table>
### CONTROLLED ENVIRONMENT ENGINEERING

#### Typical M.S. Courses

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Name</th>
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</thead>
<tbody>
<tr>
<td>ABE 581A</td>
<td>Engineering of Biological Processes</td>
</tr>
<tr>
<td>ABE 582</td>
<td>Simulation of Biological Systems</td>
</tr>
<tr>
<td>ABE 583</td>
<td>Controlled Environment Systems</td>
</tr>
<tr>
<td>ABE 584</td>
<td>Biosystems Transport Phenomena</td>
</tr>
<tr>
<td>ABE/PLS 575A</td>
<td>Physiology of Plant Production under CE</td>
</tr>
<tr>
<td>ABE/PLS 579</td>
<td>Applied Instrumentation for CEA</td>
</tr>
<tr>
<td>MATH 522</td>
<td>Advanced Applied Analysis</td>
</tr>
<tr>
<td>MATH 509C</td>
<td>Statistics for Research</td>
</tr>
<tr>
<td>ABE 601</td>
<td>Research Methods in Biosystems Engineering</td>
</tr>
<tr>
<td>ABE 696A</td>
<td>Graduate Seminar</td>
</tr>
<tr>
<td>ABE 910</td>
<td>Thesis</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td><strong>38</strong></td>
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#### Possible Alternative Courses: (Note: This list is not meant to be exhaustive)

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Name</th>
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</thead>
<tbody>
<tr>
<td>ABE 553</td>
<td>Biosystems Analysis and Design</td>
</tr>
<tr>
<td>ABE 547</td>
<td>Sensors and Controls</td>
</tr>
<tr>
<td>ABE 555</td>
<td>Soil and Water Resource Engineering</td>
</tr>
<tr>
<td>ABE 556</td>
<td>Irrigation System Design</td>
</tr>
<tr>
<td>ABE 581B</td>
<td>Bioprocess Engineering Applications</td>
</tr>
<tr>
<td>ABE 587C</td>
<td>Greenhouse Pest Management Applications and Practices</td>
</tr>
<tr>
<td>CHEE 580</td>
<td>Advanced Chemical Reaction Engineering</td>
</tr>
<tr>
<td>CHEE 574</td>
<td>Environmental Transport Processes</td>
</tr>
<tr>
<td>CHEE 577A</td>
<td>Microbiology for Engineers</td>
</tr>
<tr>
<td>SIE 500A-C</td>
<td>Introduction to Systems and Industrial Engineering Methods</td>
</tr>
<tr>
<td>SIE 530</td>
<td>Engineering Statistics</td>
</tr>
<tr>
<td>SIE 531</td>
<td>Simulation Modeling and Analysis</td>
</tr>
<tr>
<td>SIE 545</td>
<td>Fundamentals of Optimization</td>
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<tr>
<td>SIE 579</td>
<td>Intelligent Control Systems &amp; Applications</td>
</tr>
<tr>
<td>SWES 520</td>
<td>Environmental Physics</td>
</tr>
<tr>
<td>SWES 555</td>
<td>Environmental Microbiology</td>
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<tr>
<td>SWES 540</td>
<td>Biodegradation of Pollutants in Soil and Groundwater</td>
</tr>
<tr>
<td>SWES 553</td>
<td>Remote Sensing of the Environment</td>
</tr>
<tr>
<td>SWES 573</td>
<td>Monitoring Biosphere Processes</td>
</tr>
<tr>
<td>PL S 508</td>
<td>Crop Ecology</td>
</tr>
<tr>
<td>PL S 540</td>
<td>Plant Growth and Development</td>
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<tr>
<td>PL S 550</td>
<td>Plant Anatomy and Morphology</td>
</tr>
<tr>
<td>PL S 560</td>
<td>Core Concepts in Plant Biology</td>
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**ALTERNATIVE ENERGY ENGINEERING**

**Typical M.S. Courses**

<table>
<thead>
<tr>
<th>Course</th>
<th>Units</th>
<th>Title</th>
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</thead>
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<tr>
<td>ABE 581A</td>
<td>3</td>
<td>Engineering of Biological Processes</td>
</tr>
<tr>
<td>AME 545</td>
<td>3</td>
<td>Renewable Energy Systems</td>
</tr>
<tr>
<td>ABE 547</td>
<td>3</td>
<td>Sensors and Controls</td>
</tr>
<tr>
<td>SWES 525</td>
<td>3</td>
<td>Environmental Microbiology</td>
</tr>
<tr>
<td>AME 540</td>
<td>3</td>
<td>Energy Utilization and Management</td>
</tr>
<tr>
<td>ABE 584</td>
<td>3</td>
<td>Biosystems Transport Phenomena</td>
</tr>
<tr>
<td>MATH 522</td>
<td>3</td>
<td>Advanced Applied Analysis</td>
</tr>
<tr>
<td>MATH 500C</td>
<td>3</td>
<td>Statistics for Research</td>
</tr>
<tr>
<td>ABE 601</td>
<td>2</td>
<td>Research Methods in Biosystems Engineering</td>
</tr>
<tr>
<td>ABE 698A</td>
<td>1</td>
<td>Agricultural and Biosystems Engineering Seminar</td>
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<tr>
<td>ABE 910</td>
<td>2</td>
<td>Thesis</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td><strong>32</strong></td>
<td><strong>TOTAL</strong></td>
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Possible Alternative Courses: (Note: This list is not meant to be exhaustive)

<table>
<thead>
<tr>
<th>Course</th>
<th>Units</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>ABE 581B</td>
<td>3</td>
<td>Bioprocess Engineering Applications</td>
</tr>
<tr>
<td>ABE 601</td>
<td>2</td>
<td>Research Methods in Biosystems Engineering</td>
</tr>
<tr>
<td>ABE 533</td>
<td>3</td>
<td>Biosystems Analysis and Design</td>
</tr>
<tr>
<td>ABE 579</td>
<td>3</td>
<td>Applied Instrumentation for CEA</td>
</tr>
<tr>
<td>ABE 582</td>
<td>3</td>
<td>Simulation of Biological Systems</td>
</tr>
<tr>
<td>ABE 583</td>
<td>3</td>
<td>Controlled Environment Systems</td>
</tr>
<tr>
<td>AME 532</td>
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<td>Convective Transport Phenomena</td>
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<tr>
<td>AME 533</td>
<td>3</td>
<td>Conduction and Radiative Heat Transfer</td>
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<td>CHEE 520</td>
<td>3</td>
<td>Chemical Reaction Engineering</td>
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<tr>
<td>CHEE 577A</td>
<td>4</td>
<td>Microbiology for Engineers</td>
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<td>CHEE 577L</td>
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<td>Microbiology for Engineers Laboratory</td>
</tr>
<tr>
<td>CHEE 577B</td>
<td>3</td>
<td>Microbiology for Engineers</td>
</tr>
<tr>
<td>SWES 526</td>
<td>2</td>
<td>Environmental Microbiology Laboratory</td>
</tr>
<tr>
<td>MATH 562</td>
<td>3</td>
<td>Time Series Analysis</td>
</tr>
<tr>
<td>MATH 575A</td>
<td>3</td>
<td>Numerical Analysis</td>
</tr>
<tr>
<td>MATH 522</td>
<td>3</td>
<td>Advanced Applied Analysis</td>
</tr>
</tbody>
</table>
C22. Graduate Biological Engineering (University of Arkansas)

The Biological and Agricultural Engineering Department offers the following graduate degrees programs

I. Master of Science in Biological Engineering (MSBE)

II. Master of Science in Biomedical Engineering (MSBME)

The MSBE and MSBME requires the student to take a minimum of 24 course hours beyond the B.S. degree; at least 10 semester hours of advanced BENG courses (5000 level or above); and at least one course in mathematics or statistics. In addition, 6 hours of master’s thesis are required. There is not a non-thesis option. Courses taken prior to acceptance for graduate study cannot be used to fulfill this requirement.

IV. PhD in Engineering

The doctoral program leads to a Ph.D. in Engineering degree and requires satisfactory completion of at least 30 course hours beyond the master’s degree, plus 18 hours of dissertation and the completion of the dissertation based on original research. All Ph.D. students must take a minimum of 13 hours of advanced BENG courses (5000 level or above). At least one course in mathematics or statistics is required in the student's graduate program.
C23. Graduate Biological & Agricultural Engineering (University of California)

Graduate Program: Biological Systems Engineering

Mission

Our program offers a wide variety of opportunities for research at the interface of engineering, biology, and agriculture and has a long tradition and respected reputation for research in biological systems engineering; we are consistently ranked as one of the top five departments in the United States by U.S. News and World Report.

With approximately 40 graduate students and 25 faculty members, we can offer you a high level of personal attention. Our faculty members bring in approximately $5 million in research funding per year, offering you opportunities to conduct research in areas such as biotechnical engineering; energy systems; food engineering; biosensors; environmental, ecological, and resource engineering; machine systems; and aquaculture.

Our students take classes in the College of Engineering, Division of Biological Sciences and the College of Agricultural and Environmental Sciences. UC Davis’ programs in these areas are some of the strongest in the country. Most of the courses taught at UC Davis are described in the General Catalog, which is available at the UC Davis home page: http://registrar.ucdavis.edu/UCDWebCatalog/.

Davis is centrally located, with easy access to the San Francisco Bay Area, Napa Valley, the Northern California coast, the Sierra Nevada and Lake Tahoe. The campus is home to both the Mondavi Performing Arts Center, with its outstanding calendar of events, and the Arts and Recreation Center (ARC), so UC Davis has all your interests covered, whether they are intellectual, cultural or physical.

To meet your specific needs, we also offer four different degree options: M.S., Master of Engineering, Ph.D. and Doctor of Engineering. If you’re interested in admission, the university strongly encourages you to apply online at: http://www.gradstudies.ucdavis.edu/b4apply.htm.

Graduate Program: Biological Systems Engineering

Graduate degree opportunities

Our program provides four graduate degrees. The Master of Science (M.S.) and Doctor of Philosophy (Ph.D.) degrees prepare students for basic scientific research in engineering. Programs for Master of Engineering (M.E.) and Doctor of Engineering (D.E.) degrees emphasize design, analysis, economics, and management useful to the professional engineer. Programs of study and related research projects are available or can be developed in the engineering facets of aquaculture, biotechnology, environment protection, food processing, forestry, and production agriculture.

MS/ME Students

M.S. Degree requirements PDF
Guide for Masters Students
M.S. Program of Study Form XLS
M.S. Program of Study Form PDF
Additional forms from Graduate Study

Ph.D./DE Students
Ph.D. Degree requirements PDF
Guide for Ph.D./DE Students
Ph.D. Program of Study Form XLS
Ph.D. Program of Study Form PDF
Dissertation presentation form PDF

Additional forms from Graduate Study
C24. Graduate Bioresources Engineering (University of Delaware)

To apply to the BREG Masters Degree program, applicants must apply through the Office of Graduate Studies. If you have any questions about how well you could fit in the Masters Degree in Bioresources Engineering, contact the Graduate Coordinator, Dr. Eric Benson (ebenson@udel.edu).

Credits

A minimum of 30 credits is required for the Master of Science degree. It is to include 24 credits of approved course work and 6 credits of thesis (BREG 869). Of the 24 credit hours of approved course work, at least 3 credits must be a statistics or advanced math course. Only graduate level courses (500 – 599), (600 - 699), (800 - 899) are applicable towards the course requirements. Selection of courses will be done in consultation with the chair of the thesis committee based upon the student’s interest and area of research.

Student Funding

Most graduate students in the Bioresources Engineering Department are supported by a combination of project funding, departmental graduate assistantships, and/or fellowships. Potential graduate fellowship or assistantships available to graduate students in the department include the Institute for Soil and Environmental Quality Fellowships, Avian Bioscience Center Fellowships, University Graduate Fellowships, and minority fellowships are also available. Students should also contact faculty to explore assistantship opportunities.

Sample Curriculum

Upon acceptance into the program, students will meet with their advisor to formalize their curriculum. They will choose approved course relevant to their area of study and research (Land and Water Resource, Plant and Animal Systems).

Graduate Program

The Master of Science in Bioresources Engineering is a new, vibrant, and diverse program that allows students to study land and water resources or plant and animal systems. A new flyer on the program is available for download (pdf). The program especially encourages interdisciplinary education and research and provides the students with a greater choice and flexibility in shaping their education. Students are encouraged to address “real world” problems and participate in “hands-on” field and laboratory experiences so that they are better prepared to take on future challenges in industry, government, and academia. The department is actively searching for suitable candidates for several graduate assistantships.

Research Areas
The BREG Masters Degree program focuses on two areas: land and water resources and plant and animal systems. Potential research areas for students concentrating on land and water resources include projects in nonpoint pollution, stormwater and watershed management, water quality modeling, bioremediation, land application of wastewater, irrigation water management and vegetative control on drainage ditches. Representative projects for students focusing on plant and animal systems include projects on vegetable harvesting, mushroom environmental management, poultry house environmental management and sensor technology.

Admissions Requirements

The Bioresources Engineering Masters degree program currently has funded openings for graduate students. Potential candidates for the BREG Masters degree program should meet the following criteria:

a. A BS in engineering or related field.
b. An undergraduate index of 2.8 overall and 3.0 in their major field of study out of 4.0 or the equivalent for students with degrees outside the US.
c. Completion of mathematics through differential equations.
d. A combined score of 1050 on the verbal and quantitative portions of the GRE.
e. A paper-based TOEFL score of at least 550 (or 213 computer-based) is required for non-native English students.

f. Three letters of recommendations that address the student’s likelihood of successfully completing graduate education. Students who do not meet all of the criteria, but are interested in graduate study, should discuss possibilities with the Graduate Coordinator, Dr. Eric Benson (ebenson@udel.edu) to discuss possible alternatives. Students may be admitted on a provisional basis and allowed to address completion of subject area deficiencies as indicated by the department Graduate Studies Committee.
C25. Graduate Agricultural & Biological Engineering (University of Florida)

GRADUATE STUDIES

The ABE graduate studies program at the University of Florida is your key to success in a world that increasingly depends on expertise in agriculture and engineering. Ranked among the top programs nationally by U.S. News & World Report, the department offers Master's and Ph.D. degrees through both the College of Engineering and the College of Agricultural and Life Sciences.

GRADUATE SPECIALIZATIONS

The ABE graduate studies program provides unique opportunities to expand your skills in engineering, management, and modeling of agricultural, biological and natural ecosystems. Learn to bring a systems-approach and precision technologies to water, nutrient, pesticide and waste management in diverse agricultural and natural ecosystems, including space-based systems. Choose from the following specializations:

- **Agricultural Production**
  Includes development and application of precision agriculture concepts and tools, pesticide application, robotics and other machine systems, and environmental control systems. Applications to space agriculture are included in cooperation with NASA at Kennedy Space Center. ([Current Research](#))

- **Biological Engineering**
  Includes post-harvest operations, plant biotechnology, process microbiology, environmental biotechnology, food and bioprocess engineering, and packaging science. ([Current Research](#))

- **Information Systems**
  Includes development and application of remote sensing, communications, mathematical modeling, environmental decision analysis and expert systems techniques to biological and agricultural systems. ([Current Research](#))

- **Land and Water Resources**
  Includes soil-water-plant relations, irrigation, water quality, watershed hydrology, BMP and TMDL studies, hydrologic modeling, ecological restoration, ecological and risk modeling, waste management, and water reuse. ([Current Research](#))

GRADUATE DEGREES
The Agricultural and Biological Engineering Department offers graduate degree programs through the College of Engineering and the College of Agricultural and Life Sciences. Please refer to the Graduate Student Manuals for requirements.

- **College of Engineering**

  The graduate programs offered through the College of Engineering for Agricultural and Biological Engineering (ABE) majors are the Master of Engineering, Master of Science, Degree of Engineer, and the Ph.D.

  The **Master of Engineering** degree is intended for students who have completed an undergraduate degree in engineering and desire to further their technical and analytical skills. The **Master of Science** degree through the College of Engineering is intended for students who do not have an undergraduate degree in engineering but desire to advance their science backgrounds within the framework of an engineering discipline. The **Degree of Engineer** is for those engineers who need additional technical depth and diversification beyond the Master's degree. The **engineering Ph.D.** degree is an advanced graduate degree for students who wish to pursue a career in education or research.

- **College of Agricultural and Life Sciences**

  For the Agricultural Operations Management (AOM) option the following degrees are offered through the College of Agricultural and Life Sciences: the Master of Science degree and the Doctor of Philosophy degree. The **Master of Science** degree in AOM is for students who desire to advance their management skills through additional course work and graduate level research. The **AOM Ph.D.** degree through the College of Agricultural and Life Sciences is an advanced degree in technical management.

  An **Applied Science Masters and Ph.D.** degree is offered for students with a basic science degree who desire advanced training in problem-solving capabilities, interdisciplinary research, and methods for applying science to real world problems and issues.

- **One-Year Master's Degree (Non-Thesis)**

  This degree program requires a total of 30 credit hours. It can be completed in two semesters and one summer term. Students may take four courses in the Fall, four courses in the Spring, and two courses in the Summer.

  Students may select an area of concentration within Agricultural and Biological Engineering, and must complete 30 hours of graduate level course work, at least 15 of which must be from Agricultural and Biological Engineering. With the approval of the supervisory committee, students may take coursework in related areas from other departments including both engineering management and technical courses.

- **Areas of Concentration**
The department offers several specialization areas including:

- Agricultural Production Engineering
- Biological Engineering
- Food Engineering
- Information Systems
- Land and Water Resources Engineering
- Post Harvest Handling and Processing
- Precision Agriculture
- Structures and Environment Modification Systems

- **Application Procedures**
  Review both university and departmental application procedures for domestic and international graduate student, with links to the UF on-line application.

- **Admission Requirements**
  Review graduate student admission requirements for Master's, Ph.D. or the combined BS/ME or BS/MS degree.

- **Graduate Student Manuals and Plan of Study Templates**
  View degree requirements and departmental policies and procedures.

- **Financial Aid and Fellowships**
  A variety of funding opportunities are available for graduate students. Apply early!

- **Interdisciplinary Programs**
  The ABE department participates in six interdisciplinary programs with other UF departments.

- **Graduate Research Projects**
  ABE faculty and graduate students are involved in a wide variety of research projects.

- **UF Resources for Graduate Students**
  Learn about information and resources for domestic and international students, community life and student services at the University of Florida. Graduate students may be eligible to participate in the UF GatorGradCare Health Plan.
C26. Graduate Biological and Agricultural (University of Georgia)

Agricultural Engineering

The MS in Agricultural Engineering degree provides an opportunity for learning advanced data analyses skills and original research presentation skills. Problem definition skills are also stressed. This degree requires twenty-four semester hours of course work, including ENGR 6910, Research Methods, and one hour of seminar (ENGR 8950). Six hours of thesis research is also required. Six hours of math and six hours of statistics are encouraged, with remaining courses related to a thesis topic.

Biological Engineering

This degree requires twenty-four semester hours of course work, including ENGR 6910, Research Methods and one hour of seminar (ENGR 8950). Six hours of thesis research is also required. Nine hours of life science courses identified by the department committee and student are highly encouraged. Math and statistics courses identified by the department committee and student are encouraged. Contact the graduate coordinator for additional details.

Research Areas:

Biochemical

Biochemical engineers develop new technologies involving the analysis and design of systems and processes using enzymes and microorganisms. The program allows students the ability to manipulate biochemical processes resulting in the creation of new products that have value in our society. Students participate in research using bioremediation, bioconversion, fermentation and metabolic engineering. By using their broad knowledge of biological interactions - whether it is at the gene expression or ecosystem level - graduates have found employment in diverse biobased products and pharmaceutical industries.

Biomedical

Biomedical engineering is the discipline of engineering that integrates physical, chemical, or mathematical sciences and engineering principles for the study of biology, medicine, behavior, or health. It advances fundamental concepts, created knowledge from the molecular to the organ systems levels; and develops innovative biologies, materials, processes, implants, devices, and informatics approaches for the prevention, diagnosis, and treatment of disease, for patient rehabilitation, and for improving health. Bioengineering prepares students for seeking a career in medical product industry, biotechnology industry, independent or federal research laboratories, or entering into a medical school, business school, or law school.

Environmental

For engineers who care about the environment, study in environmental systems allows them the capacity to change systems drastically based on the needs of mankind while understanding and implementing appropriate changes requiring environmentally sustainable engineering approaches. A significant new branch of environmental engineering is that of Ecological Engineering, which is evolving as an engineering discipline within the environmental area. Many graduates find environmental systems engineering provides skills to address water quality management with water resource models, including strategies for erosion control and management of waste materials.
Understanding environmental systems offers an opportunity for engineers seeking employment with state agencies and engineering consulting firms to design and evaluate approaches minimizing human impacts on the environment.

**Agricultural and Natural Resources**

Engineers in bioresource systems help produce and process high-quality, safe food and fiber products. Though these engineers have an understanding of agricultural products from the field to market, specialized skills optimize the methods used to grow and package our food. Some of these technologies include magnetic resonance and x-rays for sensing quality factors such as moisture content and internal quality defects in grains, seeds, or vegetables, and yield monitoring and mapping to increase economic efficiency, harvest timing, and reduce environmental impacts. An understanding of these technologies provide graduate students with ability to use their expertise in food safety, microbiology, and engineering to find solutions and provide high quality, safe, nutritious, and economic foods. Graduates with an education in bioresource systems are sought after by other research institutions as well as equipment and instrument manufacturing companies.

**Computer Systems**

The goal of the information or computer systems engineering is to learn the science of representing numerically, symbolically and graphically the information about processes and behaviors of complex systems and to use systems thinking for applying it in the design of intelligent decisions support and control systems. Decision support applications are usually positioned at discipline interfaces and thus can be incorporated into all the engineering programs of study and engineering-related disciplines.

**Sensors and Instrumentation**

In today's industries, engineers with an advanced understanding of sensors and instrumentation find a wider range of opportunities because the skills are applicable in nearly every field of engineering. Students study instrumentation and sensors to measure the electrostatic properties and its effects on natural processes. An understanding of instrumentation and knowledge of current research provides engineers the expertise to design controlled environments, process control systems, and assess air quality. The program currently enables students to evaluate novel approaches in instrumentation and techniques for assessing air quality for animal production systems and human health. Graduates use instrumentation skills to enable graduates to take position with federal or private research facilities.
C27. Graduate Biological Engineering (University of Hawaii)

Graduate studies leading to a Master of Science degree are available in nine fields: animal sciences; biological engineering; entomology; food sciences; molecular biosciences and biological engineering; natural resources and environmental management; nutritional science; tropical plant pathology; and tropical plant and soil sciences. Doctor of Philosophy programs are available in six fields: tropical plant pathology, molecular biosciences and bioengineering, entomology, natural resources and environmental management, nutrition, and tropical plant and soil sciences.

Three of CTAHR’s graduate programs in tropical agriculture (entomology, natural resources and environmental management, and tropical plant and soil sciences), have been recognized as distinctive programs by the Western Interstate Commission for Higher Education (WICHE). Qualified students from participating states may enroll in these graduate programs at Hawai‘i-resident tuition rates.

CTAHR utilizes general University facilities, including the libraries, which offer extensive collections and information services, and the computing center, which provides access to individual computers as well as large mainframes. Along with the Pacific Biomedical Research Center, CTAHR sponsors the Biotechnology-Molecular Biology Instrumentation Facility for the benefit of researchers throughout the University of Hawai‘i. The college’s facilities include a microcomputer laboratory, several research stations, and specialized laboratories with state-of-the-art equipment, all of which support research and instruction in the food and agricultural sciences. On-campus affiliations with the Hawai‘i Institute of Marine Biology, Water Resources Research Center, East-West Center, Harold L. Lyon Arboretum, Sea Grant College Program, and Hawai‘i Natural Energy Institute extend CTAHR’s resources. The college is also affiliated closely with off-campus institutions, such as the Bernice P. Bishop Museum, USDA/ARS Tropical Fruit and Vegetable Research Laboratory, Hawai‘i Agriculture Research Center, U.S. Geological Survey, National Marine Fisheries Service, and Hawai‘i State Department of Agriculture.

Students may contact individual departments, the Graduate Division (2540 Maile Way, Spalding Hall, Honolulu, HI 96822), or Financial Aid Services (2600 Campus Road, Honolulu, HI 96822) for information on grants, fellowships, assistantships, scholarships, tuition waivers, loans, work-study programs, and job opportunities.

Information on CTAHR graduate programs can be obtained from individual CTAHR departments.

The research areas in Biological Engineering open to MS students include management of wastes and wastewater; engineering for cell culture, fermentation, micropropagation, and bioconversion; engineering-intensive horticultural and aquatic biosystems; modeling and optimization of bioresource production and processing systems; engineering of systems for renewable energy production; development of processes for enhancing the value of natural products; spatial decision support systems for environmental protection and resource development; bioremediation; biological and thermochemical conversion; control, automation and mechanization of biological systems, and; biosensor development for agricultural and medical applications. Graduates of the program have entered careers in industry and public...
agencies or have undertaken further study in a PhD degree program. Intended candidates for the MS must have completed a bachelor's degree from an accredited engineering program or the equivalent.

Program Emphasis

The base of knowledge in biological science and engineering is being expanded at a rapid rate. Meeting emerging challenges in Biological Engineering requires an increasingly interdisciplinary approach where students must understand not only fundamental engineering principles but also the molecular mechanisms underlying complex biological systems. The administration of the Biological Engineering programs under the Molecular Bioscience and Biological Engineering Department of the University of Hawaii at Manoa allows unique collaborative opportunities to transform this knowledge into commercial products and useful technologies. The graduate program in Biological Engineering integrates biological science and engineering for design, fabrication, or operation of systems with a significant biological component. Some of the most notable areas where the expertise of Biological Engineering is needed include environmental protection, safe and sustainable food production, development of alternative biological energy sources, and biological processing of natural materials for medical and other high-valued applications.

Nine key program areas form the backbone of the department's graduate research and instruction. They are:

- bioenvironmental engineering
- bioprocess engineering
- development of renewable (biological) energy
- plant cell culture engineering
- post-harvest handling
- resource systems engineering
- biosensor engineering
- automation of food and crop processing
- aquacultural engineering

Typical research projects include development of plant cell and recombinant microbial processes for the production of high-value products, treatment of waste water using entrapped microbial cells, automated micropropagation of commercially important crops, development of integrated aquaculture systems for reduced environmental pollution, feed processing, natural resource management, production systems planning and management, development of rapid diagnostics for foodborne and agricultural pathogens, and modeling and simulation of crop production systems.

The M.S. program is designed to prepare students for career opportunities in the field of Biological Engineering or for further study in a Ph.D. degree program. The primary objective of the program is to provide students with training in research methods, problem analysis and solution, and with current knowledge concerning the application of Biological Engineering.
Another objective is to provide students with a sufficiently broad range of research techniques to permit them to initiate their own inquiries. Independent, critical, and imaginative thinking is an overall objective of the program.

To achieve these objectives, the program has five student learning outcomes describing specific skills and competencies that students are expected to possess by the time of graduation. These outcomes include:

a. The graduate has the ability to design a system, component, or process in which biology plays a significant role;

b. The graduate has the ability to design and conduct experiments to gather information for engineering designs;

c. The graduate has the ability to use modern engineering techniques, skills, and tools to define, formulate, and solve engineering problems;

d. The graduate has the ability to communicate effectively to a technical audience from diverse areas of expertise, and;

e. The graduate recognizes the need to engage in life-long learning through participation in professional conferences, workshops, and courses, and by reading and writing in the relevant literature.

**Admission Requirements**

The basic requirement for admission to the graduate program in Biological Engineering is a Bachelor of Science degree from an accredited engineering program or its equivalent, with at least a B grade point average. If you have an undergraduate degree in a non-engineering field of the physical or biological sciences, you may be considered for admission on the condition that you complete specific prerequisite courses in engineering and mathematics.

Applicants to University of Hawaii at Manoa graduate programs can now apply online by visiting the website at [www.hawaii.edu/graduate](http://www.hawaii.edu/graduate) and clicking on "Apply Online." Applicants may also pay by credit card via this new online application. Paper form applications continue to be an option.

Biological Engineering courses as well as courses from the related fields of engineering, agriculture, and sciences may be utilized to fulfill the minimum requirement of 30 credit hours. Both Plan A (thesis) and Plan B (non-thesis) are available.

**Plan A**

- Twenty-one (21) course credits and 9 thesis research credits.
- Directed Research (course 699) and Thesis (course 700) cannot be used to satisfy course credit requirements.
- Twelve (12) or more course credits must be at 600 level or above.
— Twelve (12) or more course credits must be in Biological Engineering courses; of these, 9 must be earned in courses numbered 600-698 Biological Engineering.

— One Graduate Seminar in Biological Engineering.

— Pass a final oral examination administered by a committee of three or more graduate faculty, chaired by the student's thesis advisor.

— Enrolled in the graduation semester. If all other course work is completed, one credit of BE 700 must be taken in the graduation semester.

### Plan B

— Twenty-seven (27) course credits and 3 credits of Directed Research (course 699) on a Design or research project.

— The Directed Research (course 699) cannot be used to satisfy course credit requirements.

— Eighteen (18) or more course credits must be at 600 level or above.

— Eighteen (18) or more course credits must be in Biological Engineering of these, 12 must be in course numbered 600-698.

— One Graduate Seminar in Biological Engineering

— Pass a final oral examination administered by a committee of three or more graduate faculty, chaired by the student's advisor.

Enrolled in the graduation semester. If all other course work is completed, one credit of BE 500 must be taken in the graduation semester.
C28. Graduate Biological and Agricultural Engineering (University of Idaho)

M.S., M.E., Ph.D. Biological and Agricultural Engineering

Specialize in water resources, bioremediation, or bioenergy. Learn to develop methods and tools to improve soil and water conditions. Understand systems for irrigation, runoff, erosion control in watersheds, stream restoration, and to protect or enhance natural and agricultural lands. Gain the skills to design and test new ways to produce biodiesel and other forms of alternative energy from feedstock such as locally grown canola oil or manufacturing waste. Use state-of-the-art software programs, GIS, and image analysis to aid in your research.

Before entering the program, determine the professor whose research interests match your own. Secure a position as an assistant in his or her lab. This professor will chair your graduate committee and guide your independent project.

Choose a program:

Master of Science: Complete a research project, and write a thesis. Coursework and thesis research generally take two years.

Master of Engineering: Complete a practical design project. Coursework and project generally take two years.

Ph.D.: Conduct research in the field of biological and agricultural engineering and produce innovative ways to advance science and engineering. Write a dissertation and publish your work. Coursework and research generally take three to four years.

Conduct an independent research or design project. Receive guidance from a graduate committee comprised of professors with valuable expertise. Present your findings in a seminar to your professors and peers. Demonstrate your work at scientific or professional meetings.

Thesis. Develop a research plan, carry out scientific data collection, and analyze your results. Example topics include studying the use of ion exchange resins to refine biodiesel from mustard and canola oil or creating nutrient loading plans for a dairy operation that reduces environmental impact. A thesis is excellent preparation for work in consulting, state and federal agencies, as well as for a Ph.D. Accomplish the goal of publishing an article of your findings.

Non-thesis project. Analyze a real-world problem and develop solutions. For example, evaluate how a waste treatment plant can produce power from methane gas or conduct a case study of a historical industrial disaster such as the one in 1984 in Bhopal, India. Put together a professional paper of your project. A project is an excellent addition to your career portfolio.

Dissertation: Write a proposal for a significant scientific study. Collect data, and carefully document your results. For example, study how Giardia cysts are transported through groundwater, investigate the relationship between atmospheric heat flux and
soil moisture for building global climate models, investigate the exhaust emissions and performance of biofuel produced from genetically optimized soybeans, or calculate the cradle-to-grave energy and pollution costs of biofuels from vegetable oils and food processing wastes.

Achieve independence in your research and accomplish the goal of publishing three articles of your research and findings in academic journals.

Work and learn in departmental laboratories and field studies. For example, you might:
• Evaluate samples from a creek to see how phosphorous contamination is partitioned between sediment and water.
• Learn state-of-the-art hydrologic sampling techniques in a special single-credit lab.
• Create models of waste-to-energy processing circuits in the computing lab.
• Assess the qualities of blends in the biodiesel and biofuel labs.
• Study how microbes break down hazardous waste in the bioremediation lab.

Help professors with research projects on topics such as thermal conversion of biomass, vadose zone hydrology, eco-hydrology, climate, and microbe transport in bioremediation. Participate in grant-funded research projects.

Prepare for Success
Candidates for this program should have:
• An undergraduate degree in civil, chemical, or biological agricultural engineering
• An interest in lab work and research
• A desire to solve problems and think critically about some of society’s most pressing problems

Your First Year
Your first year, you should expect to:
• Take specialized courses in engineering, math, statistics, or related topics
• Conduct preliminary research with your primary advising professor
• Choose professors who will serve on your graduate committee
• Work with your committee to plan the specifics of your coursework and research goals
• Select your research topic

What You Can Do
With this degree, you may become one of the following:
Research engineer/professor: Test and refine new products. Conduct hazardous-waste management studies and design sustainable irrigation, waste-handling, and energy systems. Explore solutions to problems such as contaminant transport in rivers.
Bioremediation engineer: Advise on environmental restoration. Visit sites to observe problems, consult with contractors, and monitor cleanup activities.
Regulatory engineer: Enforce environmental regulations. Advise on pollution treatment and containment.
Design engineer: Design, fabricate, and test agricultural machinery or image analysis components and equipment.

Project engineer: Plan and supervise the building of a biofuel processing plant, irrigation system, manure-to-fertilizer operation, construction of structures for crop storage, or the testing of groundwater wells to determine aquifer recharge.

Consulting engineer: Advise on issues such as pollution management and water use. Conduct technology transfer programs to help farmers plan for ground and surface water interaction.

Opportunities

Work for biotechnology companies, energy providers, or for the food and agricultural industry. Conduct research in university or government laboratories. Graduates with a Ph.D. may design and manage significant research projects, or operate their own labs. Graduates with a master’s degree generally assist in significant research projects, and manage portions of the research. Salaries start as high as 80,000.
C29. Graduate Agricultural and Biological Engineering (University of Illinois)

The Department of Agricultural and Biological Engineering offers study in many areas, but the following are some of the broad topical areas:

- Agricultural Safety
- Bioenvironmental Engineering
- Renewable Energy Engineering
- Food and Bioprocess Engineering
- Grain Quality and Milling Properties
- Indoor Air Quality Engineering
- Off-Road Equipment Engineering
- Precision or Site-Specific Agriculture
- Soil and Water Resources
- Water Quality

**Bioenvironmental Engineering**

Research involves environmental control for biological systems, indoor air quality, control of airborne contaminate emissions, environmental protection, animal response to environment, light frame structural design, and energy from biomass. A few specific projects include improving agricultural ventilation performance, reducing dust and odor emissions from livestock facilities, measuring airborne particulate distribution, providing good environments for laboratory animals, and converting swine manure into oil.

The Graduate Program is designed to provide fundamental training in basic and applied areas of Agricultural and Biological Engineering. After selecting an area of specialization, students are guided by their advisor and to some extent by their thesis committee members in designing a program of study that will develop the knowledge and skills appropriate to the student’s professional objectives and career interests. Students usually prepare for careers in basic or applied engineering in the agricultural industry, universities, governmental agencies, or engineering-consulting firms.

**Types of Graduate Status**

**Full Standing**

Full standing is the status, which all graduate students must attain in order to graduate from their degree program at the University of Illinois.

**Limited Status**

Candidates with a GPA less than 3.00/4.00 (A=4.00) from the last 60 hours of coursework, but with superior academic records or special backgrounds, abilities, and interests may be admitted on limited status. In some cases, a candidate with a B.S. engineering degree may be admitted on limited status because some additional undergraduate courses are needed in order for the B.S. degree to be considered as an “equivalent” engineering degree to the agricultural engineering degree. In this case, the additional courses would be prescribed by the Graduate Program Director at the
time of admission. These course deficiencies must be passed with a grade of B or better within the first two semesters of enrollment. In some rare cases non-native English speaking candidates who are lacking a current TOEFL score, but otherwise have superior academic records or special backgrounds, abilities, and interests may be admitted on limited status. Limited status can be removed by attaining a TOEFL over 570 (230) or by completion of the recommended ESL courses. It is the student’s responsibility to inform their advisor when all limited status requirements have been met and to show such verification to the Departmental Graduate Program Director. Then a departmental request for full standing will be sent to the Graduate College. A student must have full standing in order to graduate.

**Non-degree Status**

Non-degree status provides an opportunity for a very highly motivated student to obtain a graduate degree in agricultural engineering. Non-degree status situations usually arise when a candidate is very strong academically but has a B.S. degree in a non-engineering discipline. In this case, the Graduate Program Director prescribes a list of courses that would provide “B.S. agricultural engineering degree equivalency.” These equivalency courses would be taken under non-degree status. A candidate considering this option should review the Non-degree Status section in the *Handbook for Graduate Students and Advisers* to be aware of some important registration limitations as well.
C30. Graduate Biosystems and Agricultural Engineering (University of Kentucky)

BAE 618 Advanced Plant, Soil, and Machinery Relationships (3)

A consideration of fundamental concepts of energy and materials in the identification and mensuration of parameters need in the development of new machines for agriculture. Lecture, two hours; laboratory, two hours. Prereq: BAE 417.

BAE 625 Topics in Advanced Environment Control and Analysis (Subtitle Required) (3)

A study of current research in environment control and analysis of agricultural, commercial and residential structures. May be repeated three times for a maximum of nine credits, but not more than three credits may be earned under a particular topic. Prereq: Senior course in environment control and HVAC, BAE/ME 580, or consent of instructor.

BAE 638 Groundwater Hydrology (3)

The equations of saturated and unsaturated groundwater flow, the formulation of boundary value problems, and some analytical methods of solution. Solutions using Fourier series, solutions involving the Fourier transform and the Fourier sine and cosine transforms. The Boltzman transformation, development of the Philip solution for horizontal and vertical flow. Mathematical statement of the saturated and unsaturated groundwater pollution problem and some analytical methods of solution. The semigroup solution of the resulting evolution equation, examples of solutions using the Laplace transform and the Fourier transform, more complex solutions in two-dimensional and three-dimensional domains, solutions for distributed sources in time and im space, solutions for time-varied boundary conditions. Prereq: MA 214, CE 461G or equivalent. (Same as CE 660.)

BAE 642 Open Channel Flow (3)

The hydraulics of free surface flow including such topics as uniform flow, varied flow, unsteady flow, the hydraulic jump flow transitions, spillways and channel delivery. Prereq: CE 341. (Same as CE 642.)

BAE 643 Mechanics of Sediment Transport (3)

Fundamentals of turbulence in rivers and sediment transport will be taught including recent theory, derivation of governing equations, experimental methods, modeling, and design based on sediment thresholds. Prereq: CE 341 or consent of instructor. (Same as CE 643.)

BAE 647 System Optimization I (3)

Introduction to linear and nonlinear optimization and their use in engineering design. Emphasis on numerical approaches and use of optimization methods for engineering
systems (e.g. biological, mechanical, structural). Prereq: CS 221; one mathematics course beyond MA 214 or equivalent. (Same as ME 647.)

**BAE 648 Energy and Mass Transfer in Agricultural Processing (3)**

A comprehensive and in-depth study of the principles of energy and mass transfer as they apply to the processing of agricultural and biological materials. Prereq: BAE 548 or consent of instructor.

**BAE 653 Water Quality in Surface Waters (3)**

Water quality requirements for various beneficial uses. Analysis of dispersion, advection, evaporation, natural aeration, biological oxidation and photosynthesis; their effects on the physical, chemical and biological quality of waters in streams, lakes, reservoirs, estuaries and other surface waters. Eutrophication. Prereq: MA 214 and CE 451, or consent of instructor. (Same as CE 653.)

**BAE 658 Instrumentation for Engineering Research (3)**

Instrumentation and measuring system characteristics; transducers for engineering measurements; and data acquisition and analysis. Lecture, two hours; laboratory, two hours per week. Prereq: Consent of instructor.

**BAE 660 Similitude in Engineering (3)**

An advanced approach to engineering problems through the theory of similitude and its application to models. The use of geometrically similar, distorted and dissimilar models will be discussed. Prereq: Graduate standing.

**BAE 662 Stochastic Hydrology (3)**

Hydrologic random variables and probability distributions. Statistical measures, development and use of Monte Carlo simulations in the generation of precipitation fields. Statistical tests of hydrologic data. Point frequency and regional frequency analysis. Analysis of hydrologic time series. Long-term trend, harmonic analysis of periodicity, autocorrelation, spectral analysis. Correlation and regression analysis. Linear stochastic models. Introduction to stochastic processes in hydrology, real-time hydrologic forecast (Kalman filter), pattern recognition, and stochastic differential equations. Prereq: MA 214, CE 461G or equivalent. (Same as CE 662.)

**BAE 665 Water Resources Systems (3)**

Application of systems analysis, mathematic modeling, and optimization in water resources management and design. Solution of engineering problems found in water supply, water quality, urban drainage, and river basin development and management by use of linear, nonlinear, and dynamic programming models. Prereq. or Concur: CE 421 and CE 569 or consent of instructor. (Same as CE 665.)

**BAE 667 Stormwater Modeling (3)**
Introduction to deterministic and parametric modeling approaches for mathematically simulating stormwater runoff and quality. Emphasis on modeling concepts and model formulation. Analysis of deterministic component models and their linkage. Formulation of existing parametric models. Presentation of methods for parameter optimization and regionalization. Demonstration of linkage between the two approaches will illustrative examples. Prereq: CE 341 and CE 461G, or consent of instructor. (Same as CE 667.)

BAE 672 Landfill Design (3)

This course deals with the geotechnical aspects of the design of landfills for the disposal of municipal solid waste. Since landfill design is driven by state and federal regulations, time is taken to review these regulations. Landfills are evaluated as engineered systems consisting of multiple components. Each component is investigated individually, and methods are developed to predict and quantify the performance of these components so that appropriate materials, design criteria, and construction methods can be selected to assure that the landfill will function with minimal environmental impact. Prereq: CE 471G. (Same as CE 672.)

BAE 680 Biochemical Engineering (3)

Principles and design of processes involving biochemical reactions, including aerobic and anaerobic respirations and fermentations, and involving pure and mixed cultures. Energy considerations, heat and mass transfer, biochemical kinetics, and application to biological waste treatment. Prereq: CME 550, CME 630, CHE 440G or consent of instructor. (Same as CME 680.)

BAE 748 Masters Thesis Research (0)

Half-time to full-time work on thesis. May be repeated to a maximum of six semesters. Prereq: All course work toward the degree must be completed.

BAE 749 Dissertation Research (0)

Half-time to full-time work on dissertation. May be repeated to a maximum of six semesters. Prereq: Registration for two full-time semesters of 769 residence credit following the successful completion of the qualifying exams.

BAE 750 Special Problems in Agricultural Engineering (1-3)

Independent work on selected research problems in one of the various fields of biosystems and agricultural engineering. Consultation and laboratory by appointment. May be repeated three times for a maximum of nine credits. Prereq: Approval of chairperson of department.

BAE 767 Dissertation Residency Credit (2)

Residency credit for dissertation research after the qualifying examination. Students may register for this course in the semester of the qualifying examination. A
minimum of two semesters are required as well as continuous enrollment (Fall and Spring) until the dissertation is completed and defended.

**BAE 768 Residence Credit for Master's Degree (1-6)**

May be repeated to a maximum of 12 hours.

**BAE 769 Residence Credit for Doctor's Degree (0-12)**

May be repeated indefinitely.

**BAE 775 Seminar (0)**

Weekly meetings with members of the staff for reports and discussions on research and current trends and practices in agricultural engineering. May be repeated twice. One class hour.

**BAE 795 Thesis (0)**

May be repeated twice.
C31. Graduate Bioengineering (University of Maryland)

The Graduate Program in Bioengineering

Degree Options

The Fischell Department of Bioengineering offers a Graduate Program in Bioengineering and a special combined M.D./M.S. program for students enrolled in the University of Maryland Baltimore School of Medicine.

The Graduate Program in Bioengineering

The Graduate Program in Bioengineering offers research and educational opportunities leading to the Doctor of Philosophy degree and the M.S./M.D. Masters of Science as a dual degree program with the University of Maryland School of Medicine. The Graduate Program in Bioengineering is housed in and administered by the Fischell Department of Bioengineering. Its faculty includes all faculty holding a tenured or tenure-track appointment in the Fischell Department of Bioengineering, as well as faculty holding Affiliate and Adjunct appointments with the Department.

The program's objective is to combine the principles and applications embedded within engineering with the sciences of biology, medicine, and health. It is our belief that developments at the interface of biology and engineering will advance the efficacy of health care by developing new paradigms for the diagnosis of disease, and the development and delivery of new therapeutics. Our bioengineering students will gain the knowledge base and skill sets to quantitatively measure, and rationally manipulate cells, tissues, and integrated systems. Bioengineers must bring problem solving skills and design methodologies to the study of biology in an effort to translate the biological sciences into medical practice in an analogous manner to the transformation of chemistry into industrial practice that occurred in the 20th century.

Our program provides a basic understanding of bioengineering at the molecular and cellular level, focusing on:

- biomolecular and cellular rate processes
- cellular and tissue biomechanics
- electrophysiology of the cell
- cellular and physiological transport phenomena

In addition, we stress the application of this fundamental understanding to the development of:

- medical diagnostics systems
- bio-devices
- vaccines

Students in the Graduate Program in Bioengineering are students in the Graduate School at the University of Maryland, and are subject to the Graduate School's requirements for the conferral of graduate degrees, in addition to the Graduate Program in Bioengineering's degree requirements. Prospective and current
students are urged to refer to our BIOE Graduate Program Student Handbook (PDF) and the Graduate School’s publications and web page for additional information.

Graduate Courses in Bioengineering

Required Courses (12 credits)

**BIOE 601: Biomolecular and Cellular Rate Processes** (3 credits)
Presentation of techniques for characterizing and manipulating non-linear biochemical reaction networks. Advanced topics to include mathematical modeling of the dynamics of biological systems; separation techniques for heat sensitive biologically active materials; and rate processes in cellular and biomolecular systems. Methods are applied to current biotechnological systems, some include: recombinant bacteria; plant, insect and mammalian cells; and transformed cell lines.

**BIOE 604: Transport Phenomena in Bioengineering Systems** (3 credits)
A study of the transport processes of fluid flow, heat transfer, and mass transfer applied to biological organisms and systems, using analogical and systems approaches.

**BIOE 605/606: Laboratory Rotations** (2 credits total)
*For BioE majors only.*
Provides the opportunity to experience different laboratory environments. Students gain exposure to graduate research, learn a wide variety of laboratory and/or computational techniques, become familiar with BIOE program faculty, and develop insight on personal research interests and direction. Laboratory rotations are required in Fall and Spring of the first year of the Ph.D. Program.

**BIOE 608: Bioengineering Seminar Series** (1 credit)
A variety of topics related to Bioengineering will be presented in weekly seminars.

**BIOE 612: Physiological Evaluation of Bioengineering Designs** (3 credits)

Dissertation and Thesis Requirements (18+ Credits)

In addition to the core courses, a minimum of 18 credit hours of Dissertation Research (BIOE 899) is required of all Ph.D. students. M.S. students are required to take a minimum of 6 credit hours of Thesis Research (BIOE 799).

Other Course Requirements

- **Two restricted elective courses** (6 credits), in topics such as biology, cell biology and molecular genetics, biochemistry, and neuroscience.
- **Three unrestricted elective courses** (9 credits), in topics such as engineering, mathematics, or computer science.

Courses must be selected in consultation with the research advisor and approved by the BIOE Program Director. A partial list of courses that fulfill the elective requirements follows. Course descriptions can be found at: [www.testudo.umd.edu/](http://www.testudo.umd.edu/).
Restricted Elective Courses (2 Courses, 6 credits)

Restricted elective courses consist of topics spanning fundamental bioengineering disciplines. Courses include:

**BIOE 602: Cellular and Tissue Biomechanics** (3 credits)
Introduction to the fundamentals of biomechanics including force analysis, mechanics of deformable bodies, stress and strain, multiaxial deformations, stress analysis, and viscoelasticity. Biomechanics of soft and hard tissues.

**BIOE 603: Quantitative Cell Physiology** (3 credits)
Introduction to the electrophysiology of the cell membrane. Development of mathematical models of different types of ionic membrane currents and fluid compartment models, culminating in the development of functional whole-cell models for neurons and muscle (cardiac, skeletal and smooth muscle) cells. Characterization of volume conductor boundary value problems encountered in electrophysiology consisting of the adequate description of the bioelectric current source and the volume conductor (surrounding tissue) medium.

**BIOE 611: Tissue Engineering** (3 credits)
A review of the fundamental principles involved in the design of engineered tissues and organs. Both biological and engineering fundamentals will be considered. We recommend one advanced biology course and one advanced engineering math course prior to taking BIOE 611.

**BIOE 620: Modern Methods of Drug Delivery** (3 credits)
Basic concepts and physiochemical principles of drug delivery will be discussed. The course has three modules: orally and nasally inhaled drug products; introduction of statistical thermodynamics and its applications; novel nanomedicine; and design considerations and applications.

**BIOE 631: Biosensor Instrumentation and Techniques** (3 credits)

**BIOE 653: Biomaterials** (3 credits)

**BIOE 689C: Biomedical Optics** (3 credits)
Optical imaging, spectroscopy, and microscopy have become indispensable tools in modern biomedical research. This course will cover the principles and instrumentation of various biomedical optical techniques, including fluorescence and Raman spectroscopy, confocal and multi-photon microscopy, optical coherence tomography, and diffuse optical tomography. Biomedical applications will also be discussed.

**BIOE 689M: Cell Engineering** (3 credits)

Unrestricted Electives (3 Courses, 9 Credits)

Three more unrestricted elective courses will be selected in consultation with the student's advisor. The list below provides examples of courses taken by our students in the past.
AMSC 666: Numerical Analysis I

BCHM 676: Biological Mass Spectrometry
*Also cross-listed as BIOE 689B and CHEM 699A.*

BIOE 689: Special Topics in Bioengineering: Evolutionary Computation and Artificial Life (also offered as CMSC 828R)

BIOE 689: Special Topics in Bioengineering: Medical Imaging and Imaging Analysis (also offered as ENEE 739)

BIOE 689: Special Topics in Bioengineering: Introduction to Biomaterials (also offered as ENMA 698)

BIOE 689: Special Topics in Bioengineering: Polymers, Bio-Polymers and their Applications in Nano- and Bio-Technology

BIOE 689: Special Topics in Bioengineering: Chemical and Biological Detection (also offered as ENPM 808B)

BIOE 689N: Special Topics in Bioengineering: Bionanotechnology: Physical Principles

BIOE 689Q: Special Topics in Bioengineering: Quantitative Cell Physiology

CHEM 705: Nuclear chemistry

CMSC 828U: Advanced Topics in Information Processing: Exploiting Biological Resources

ENCH 620: Methods of Engineering Analysis

ENCH 648: Special Topics in Chemical Engineering: Advanced Biochemical Engineering

ENEE 631: Digital Imaging Processing

ENEE 719: Advanced Topics in Microelectronics: Mixed Signal VLSI Circuit Design

ENMA 620: Polymer Physics

MOCB 630: Eukaryote Molecular Genetics

MOCB 639: Advanced Cell Biology

MOCB 640: Protein Structure and Function

NACS 641: Introduction to Neurosciences

NACS 728R: Computational Neuroscience
C32. Graduate Biological Engineering (University of Maine)

The Masters of Science in Biological Engineering prepares students to conduct research involving the application of engineering to biological systems. Examples of research projects are sensors to detect specific biological molecules or pathogens in food or water, understanding cell membranes in terms of signaling and transport of molecules, imaging of cells or proteins, conformation of biological molecules at membrane surfaces as well as environmental risk assessment modeling. Alliances with several governmental agencies and other organizations, such as the Institute of Molecular Biophysics, the Jackson Laboratory and Maine Medical Center Research Institute, increase research opportunities related to genetics and biomedical issues in engineering. Cooperation with the Laboratory for Surface Science and Technology gives access to tools related to surface analysis.

Research Facilities

Standard equipment for cell growth and characterization, near IR, confocal microscope, mechanical testing of biological materials and other tools are available. Specialized equipment is also available related to individual projects.

Financial Aid

Graduate Research Assistantships are available on a competitive basis for externally funded research projects.

Applying

Applications for entry into the program for either the fall or spring semesters must be received at least three months prior to the start of the semester. For fall semester, it is recommended that applications be received by March of that year. Applications are available on line at the graduate school web site.

Requirements

Required core courses are CHE 510 (Transport Phenomena) and CHB 460 (Biochemical Engineering). One course in advanced mathematics, such as CHE 580, is required. Three technical electives, approved by the thesis committee, and two semesters of the graduate seminar course are required. A thesis and a total of 30 hours of graduate credits are needed to fulfill the master’s degree requirements.
C33. Graduate Biological Engineering (University of Missouri)

Graduate Programs

Biological Engineering confers both master's and doctoral degrees to students who satisfy the general requirements of the Graduate School and the specific requirements for the master's degree and the doctoral degree of the Biological Engineering Department.

Master of Science in Biological Engineering

A prospective M.S. student must have completed an approved course of study with a grade point average (GPA) of at least 3.0 on a four-point scale or its equivalent. This generally includes a Bachelor of Science (B.S.) degree from an accredited university or equivalent experience.

Doctoral in Biological Engineering

A prospective Ph.D. student must complete an approved course of study with a grade point average (GPA) of at least 3.0 on a four-point scale or its equivalent. This generally includes a Bachelor of Science (B.S.) degree and a Master of Science (M.S.) degree from an accredited university or equivalent experience.

Master of Engineering in Biological Engineering

An undergraduate GPA of 3.0 on the last 60 hours of course work is required for admission. Exceptions to the GPA requirements for promising students, include such factors as experience, time since completion of the undergraduate studies, standardized test scores, etc.
D. Briassoulis

UNIVERSITIES IN USA AND CANADA OFFERING PROGRAMS OF STUDIES IN BIOSYSTEMS ENGINEERING OR RELATED DISCIPLINES

C34. Graduate Agricultural and Biosystems Engineering (University of Puerto Rico)

ADVANCED UNDERGRADUATE AND GRADUATE COURSES

AGEG 5990. SELECTED TOPICS. One to three credit hours. One to three hours of lecture per week.

Selected topics in Agricultural Engineering. Topics will vary according to the needs and interest of the students and the faculty.

AGMT 5005. EQUIPMENT FOR APPLICATION OF AGRICULTURAL CHEMICALS. Three credit hours. Two hours of lecture and one three-hour laboratory per week.

A detailed study of modern techniques and equipment for the application of chemicals for pest control and other uses in agriculture.

AGMT 5006. PLANNING AND MANAGEMENT FOR POWER FARMING. Three credit hours. Two hours of lecture and one three-hour laboratory per week. Prerequisites: AGMT 4009 and AGMT 4015.

General principles of agricultural mechanization, with particular reference to the economic and managerial aspects of the application of power and machinery to modern farming; farm work simplification in agricultural systems.

AGMT 5007. ADVANCED SOIL AND WATER MANAGEMENT. Three credit hours. Two hours of lecture and one three-hour laboratory per week. Prerequisite: AGMT 4035.

Advanced topics and special problems in the field of soil and water management and control, with particular reference to drainage, irrigation, and watershed management.

AGMT 5015. DRIP IRRIGATION: PRINCIPLES AND MANAGEMENT. Three credit hours. Two hours of lecture and one three-hour laboratory per week. Prerequisite: AGRO 3005 or consent of the Director of the Department.

Principles of drip irrigation, system and components, soil and water relations, tensiometer principle and installation, chemigation, clogging and filtration, system layouts, automation, problem shooting, and field evaluation.

AGMT 5017. AGROCLIMATOLOGY. Three credit hours. Three hours of lecture per week. Prerequisite: fifth year student, or graduate, and consent of the Director of the Department.

Climatology related to environmental conservation and sustainable agricultural production in precipitation, evaporation, evapotranspiration, photosynthesis, crop production, irrigation and drainage, crop protection, agronomy, animal science, agricultural technology, and remote data acquisition systems.

AGMT 5991. SELECTED TOPICS. One to three credit hours. One to three hours of lecture per week.

Selected topics in Agricultural Engineering. Topics will vary according to the needs and interests of the students and the faculty.

AGMT 5995. PROBLEMS IN MECHANIZED AGRICULTURE. One to three credit hours. One to three research periods per week.
Problems pertaining to the applied and less technical aspects of Agricultural Engineering as related to the agriculture of Puerto Rico. Conferences, library laboratory and/or field work on an assigned problem, on an individual basis, with complete written report required.
C35.  Graduate Biosystems Engineering & Biosystems Engineering Technology (Tennessee University)

Graduate Studies

The department supports five graduate degrees in three programs of study:

In the Graduate Biosystems Engineering masters and doctoral programs, we are committed to linking engineering sciences and mathematics to real-world problems involving natural and man-made biologically-based systems. We strive to train students with the ability to serve humanity by applying engineering knowledge to solving problems facing society.

In the Graduate Biosystems Engineering Technology masters program, students from agricultural or related undergraduate fields apply engineering technology to a variety of agricultural and biological systems. Focus areas include machinery systems; environmental quality and resource conservation; instrumentation, sensor and control systems; and bioprocessing.

Biosystems Engineering Graduate Courses

BsE411 Mechanical Systems Engineering (3) Fundamentals of power delivery systems and simple mechanisms; selection and design of mechanical, hydraulic, and tractive power transmission systems. Emphasis on off-road vehicles and bioprocessing systems. Contact Hour Distribution: 2 hours and 1 lab. (RE) Prerequisite(s): Mechanical Engineering 231 and Mechanical Engineering 321.

BsE416 Hydrology (3) An introduction to hydrology and associated environmental implications including: the hydrologic cycle, evapotranspiration, runoff, erosion, unit hydrograph operations, routing, open channel flow, groundwater, infiltration, and urban stormwater. Contact Hour Distribution: 2 hours and 1 lab. (RE) Prerequisite: Aerospace Engineering 341.

BsE416x Hydrologic & Water Quality Eng. (3) An introduction to hydrology including: hydrologic variability, precipitation, evapotranspiration, infiltration, runoff, erosion, water quality and non-point pollution, energy dissipation, streamflow measurement, hydrographs, routing, open channel flow, and urban hydrology. (Same as Civil Engineering 416.) (RE) Prerequisite(s): Civil Engineering 390 or Aerospace Engineering 341.

BsE431 Bioprocess Engineering (3) Development of interdisciplinary bioprocess engineering; basics of biology in an engineering perspective; enzymatic reaction kinetics; metabolism and bioenergetics; cell growth kinetics and product formation; engineering principles applied to bioprocess engineering including mass balance, energy balance, and reaction kinetics; reactor design and systems; introduction to bioseparations; practical aspects of bioprocess engineers and process development. Contact Hour Distribution: 2 hours and 1 lab. (RE) Prerequisite(s): 321.

BsE451 Instrumentation & Control (4) Basic electronics with biological applications. Analog and digital electronics; sensing and controlling physical and environmental parameters; sensor selection and interfacing; signal conditioning; process control. Includes laboratory experiments and design projects. Contact Hour
Distribution: 3 hours and 1 lab. (RE) Prerequisite(s): Electrical and Computer Engineering 301.

**BsE500 Thesis (1-1)** Grading Restriction: P/NP only. Repeatability: May be repeated. Registration Restriction(s): Master of Science – biosystems engineering major.

**BsE502 Registration for use of facilities (1-1)** Required for the student not otherwise registered during any semester when student uses university facilities and/or faculty time before degree is completed. Grading Restriction: Satisfactory/No Credit grading only. Repeatability: May be repeated. Credit Restriction: May not be used toward degree requirements.

**BsE503 Seminar (1)** (See Environmental and Soil Sciences 503.)

**BsE519 Modeling Techniques and Applications (3)** Engineering approach to mathematical modeling of physical phenomena. Systems definitions and boundaries; types and formulation of models and solution techniques; verification and calibration techniques; model applications and case studies. Contact Hour Distribution: 2 hours and 1 lab. Comment(s): Graduate standing in engineering required.

**BsE525 Soil erosion and sediment yield (3)** (See Environmental Engineering 525.)

**BsE530 Research problems in Biosystems Engineering (1-3)** Theoretical and experimental studies relating to current problems in agricultural engineering. Repeatability: May be repeated. Maximum 6 hours.

**BsE532 On-Site Domestic Wastewater Treatment, Dispersal, and Reuse (3)** Design and management of domestic on-site wastewater treatment and dispersal systems, use of the soil as a medium for final treatment and for wastewater dispersal, concepts of the decentralization of domestic wastewater management, and reuse of treated water for irrigation. (Same as Biosystems Engineering Technology 532.) Contact Hour Distribution: 2 hours and 1 lab. (DE) Prerequisite(s): Civil Engineering 395 or consent of instructor.

**BsE543 Instrumentation and measurement (3)** Modern instrumentation techniques. Static and dynamic response of instrumentation; signal conditioning; temperature, moisture, optical radiation, displacement, strain, pressure, velocity, acceleration, and flow measurements; digital data acquisition and control. (Same as Environmental Engineering 543.) Contact Hour Distribution: 2 hours and 1 lab. (DE) Prerequisite(s): 451 or coursework in electronics and computer circuits.

**BsE545 Monitoring hydrologic phenomena (3)** Application of instrumentation theory to monitoring hydrologic phenomena; strengths and weaknesses of current equipment and strategies; equipment operation and solution of environmental monitoring problems. (Same as Environmental Engineering 545.) Contact Hour Distribution: 2 hours and 1 lab. (DE) Prerequisite(s): 416.

**BsE550 Selected topics (1-3)** Lecture/group discussion on specialized topics. Repeatability: May be repeated. Maximum 6 hours.
BsE552 Biological treatment theory (3) (See Environmental Engineering 552.)

BsE555 GIS and GPS applications to Biosystems (3) Theory and applications of Geographical Information Systems (GIS) and Global Positioning Systems (GPS); acquiring, managing, and analyzing spatially-varying data. Site-specific agriculture, environmental site assessment, natural resource management, and hydrology. (Same as Biosystems Engineering Technology 555.) Contact Hour Distribution: 2 hours and 1 lab. Comment(s): Students with graduate standing in engineering, biological or physical sciences only.

BsE562 Selected Topics in Natural Resource Engineering (3) Topics in engineering for the characterization, conservation, and protection of soil, water, and air resources in spite of human activities such as off-road vehicle use, agriculture, mining, construction and land development, or waste application. Repeatability: May be repeated. Maximum 12 hours.

BsE572 Selected Topics in Machinery, Control, and Instrumentation Systems (3) Topics in the engineering of machinery, sensors, and data collection and analysis systems, and the use of these systems in ways that enhance productivity, increase efficiency, boost economic return, and protect environmental resources. Repeatability: May be repeated. Maximum 12 hours.

BsE575 Applied microbiology and bioengineering (3) (See Chemical Engineering 575.)

BsE582 Selected Topics in Processing (3) Topics in the engineering of biological and physical processes and of biological systems, from the production of raw materials through to high-demand value-added products. Repeatability: May be repeated. Maximum 12 hours.

BsE591 Environmentally-Sensitive Spray Applications (3) Develops the concepts of spray drift causes and corrective actions to lessen the effects of pesticides in the environment. Concepts are based on factors related to dosage transfer and the competing physics of droplet delivery under a variety of atmospheric conditions. Mass balance procedures are emphasized to validate measures of spray drift. Sprayer equipment components and operation factors affecting spray drift are introduced as operator controlled measures to minimize spray drift. The role of pesticide label language is incorporated into course concepts. Best management practices are developed to ensure practical applications of course concepts are emphasized. The student will learn how to implement spray drift reduction practices as well as make objective conclusions about spray drift test data. Registration Permission: Consent of instructor.

BsE600 Doctoral research and dissertation (3-1) Grading Restriction: P/NP only. Repeatability: May be repeated. Registration Restriction(s): Doctor of Philosophy – biosystems engineering major.

BsE603 Seminar (1) (See Environmental and Soil Sciences 603.)

BsE619 Mathematical Modeling for Engineers (3) Describing physical and
biological settings with mathematical expressions. Applying dimensional analysis, linear and nonlinear ordinary differential equations, partial differential equations, systems of linear equations, linearization, moving boundary problems, and series solutions to solve mathematical expressions. (RE) Prerequisite(s): 519.

BsE636 Geospatial Methods for Environmental Research (3) Sampling and displaying the multidimensionality of environmental variables. Spatial and temporal sensing of the environment. Geostatistical mapping and interpretation; sampling theory; precision geomatic techniques for the environmental scientist and engineer. Contact Hour Distribution: 2 hours and 1 lab. (RE) Prerequisite(s): 555.

BsE650 Selected topics (1-3) Lecture, group discussion, and individual study on specialized developments. Repeatability: May be repeated. Maximum 6 hours.
Biosystems Engineering Technology Graduate Courses

BsET412 Surveying (3) Measurement of landforms using radar, remote imagery, satellite real-time kinematics, and laser-based surveying instruments. Survey methods and mapping using GIS. Precision landform measurement of distances, angles, and areas; differential and profile leveling; topographic surveying and mapping; area computation. Recommended background: college mathematics and computer literacy

BsET432 Agricultural Machinery and Tractors (3) Functions, selection, matching, and management of agricultural machinery systems. Tractor power ratings, engine and transmission systems, hydraulic systems, hitching, and ballasting. Field and material capacity, field efficiency, cost analysis, and machinery replacement strategies. Functional analyses of tillage operations, planters and drills, no-tillage systems, hay harvest systems, forage and small grain harvesting, and cotton harvesting. Crop drying processes, off-road machinery safety considerations, and operator ergonomics. Contact Hour Distribution: 2 hours and 1 lab. (RE) Prerequisite(s): Mathematics 123 or Mathematics 125.

BsET442 Agricultural Waste Management and Pollution Control (3) Waste renovation fundamentals; characteristics of animal manure, techniques for collecting, transporting, storing, and utilizing livestock waste. Contact Hour Distribution: 2 hours and 1 lab. (RE) Prerequisite(s): Mathematics 123 or Mathematics 125.

BsET452 Small Internal Combustion Engines (3) Theory, concepts and mechanics of small internal combustion engines; theoretical cycles, selection, operation, adjustment, troubleshooting and repair of single-cylinder engines. Contact Hour Distribution: 2 hours and 1 lab. (RE) Prerequisite(s): Mathematics 123 or Mathematics 151.

BsET462 Agricultural Chemical Application Technology (3) Equipment for application of liquid, solid, and gaseous agricultural chemicals; system components; operational characteristics; calibration; selection and management; safety considerations; materials handling and disposal methods. Contact Hour Distribution: 2 hours and 1 lab. (RE) Prerequisite(s): Mathematics 123 or Mathematics 151.

BsET500 Thesis (1-1) Grading Restriction: P/NP only. Repeatability: May be repeated. Registration Restriction(s): Master of Science – biosystems engineering major.

BsET502 Registration for use of facilities (1-1) Required for the student not otherwise registered during any semester when student uses university facilities and/or faculty time before degree is completed. Grading Restriction: Satisfactory/No Credit grading only. Repeatability: May be repeated. Credit Restriction: May not be used toward degree requirements.

BsET503 Seminar (1) (See Environmental and Soil Sciences 503.)

BsET506 Physical phenomena (3) Properties of materials, fundamentals of hydraulics, principles of electricity, thermal phenomena, applications in biological systems. Contact Hour Distribution: 2 hours and 1 lab.
BsET508 Special problems in Biosystems Engineering Technology (1-3)
Individual studies of current problems. Repeatability: May be repeated. Maximum 6 hours.

BsET514 CAD applications to Biosystems Engineering Technology (3) Computer Aided Drafting (CAD) applications in agriculture and environmental science. Essentials of CAD software to create drawings of components, systems, flow charts, and process diagrams. Applications in mechanical, structural, and biosystems. 2-D applications with limited exposure to 3-D applications. Computer intensive course. Hands-on experience. Contact Hour Distribution: Two 2-hour labs. Credit Restriction: Students cannot receive credit for both 414 and 514. Registration Restriction(s): Minimum student level – graduate.

BsET532 On-Site Domestic Wastewater Treatment, Dispersal, and Reuse (3)
(See Biosystems Engineering 532.)

BsET534 Production Monitoring & Automation (3) Precision technologies for monitoring and control of agricultural systems. Applications include: yield monitoring, variable rate control and sensing systems for planters, sprayers, soil applied nutrients, water management, crop health, and pest pressure; electronic information transfer; and GPS-based vehicle guidance. Contact Hour Distribution: 2 hours and 1 lab. Credit Restriction: Students cannot receive credit for both 434 and 534. Registration Restriction(s): Minimum student level – graduate.

BsET542 Simulation of agricultural systems (3) Synthesis and analysis of agricultural systems using computer simulation, philosophy of system simulation, critical path, discrete and continuous systems. Contact Hour Distribution: 2 hours and 1 lab. (RE) Prerequisite(s): 506.

BsET546 Automation devices and applications (3) Basic electronics as applied to simple automation systems, programmable controllers, data acquisition, digital logic and transducers. Contact Hour Distribution: 2 hours and 1 lab. (RE) Prerequisite(s): 506.

BsET555 GIS and GPS applications to biosystems (3) (See Biosystems Engineering 555.)

BsET562 Selected topics in Biosystems Engineering Technology (1-3)
Lecture/group discussion on specialized topics. Repeatability: May be repeated. Maximum 6 hours.

BsET574 Environmental instrumentation and monitoring (3) Equipment and techniques commonly used to measure all aspects of hydrologic cycle: precipitation, runoff, streamflow, subsurface water movement. Sampling of all flows for contaminants. Design of monitoring systems. Analysis of data. Contact Hour Distribution: 2 hours and 1 lab. Credit Restriction: Students cannot receive credit for both 474 and 574. (RE) Prerequisite(s): 506. Recommended Background: Hydrology. Registration Restriction(s): Minimum student level – graduate.
C36. Graduate Biological Systems Engineering (Virginia Tech University)

Overview and Program Areas

The Department has a strong teaching program offering graduate degrees. The program provides students with an opportunity to combine their interest in biological sciences and engineering. Even though there are many specialty areas within the discipline, the program focus in BSE is in two areas:

Bioprocess Engineering

Land and Water Resources Engineering

We offer degrees at the MS and PhD levels. The Department currently has 53 graduate students of which 27 are MS students and 26 are PhD students (as of Fall 2008).

Bioprocess Engineering

The Bioprocess Engineering option in Biological Systems Engineering deals with the design and development of processes for environmentally responsible manufacturing of food and industrial products from biological materials. Areas of interest include food safety, food engineering, functional food, biopharmaceuticals, biofuels and enzymes.

Land and Water Resources Engineering

The Land and Water Resources Engineering option in Biological Systems Engineering is designed for students interested in a career in environmental protection, natural resources management, and ecological restoration. Our main focus areas are in managing and understanding nonpoint sources of pollution and in obtaining/disseminating knowledge for use in stream and wetland restoration.

Mission & Educational Objectives

BSE MS Mission Statement

To graduate biological systems engineers to support sustainable production, processing, and utilization of biological materials and to protect natural resources. The BSE program seeks to prepare its graduates to become successful in the practice of biological systems engineering or in the pursuit of PhD degrees in BSE or other complementary disciplines.

BSE PHD Mission Statement

To graduate biological systems engineers to support sustainable production, processing, and utilization of biological materials and to protect natural resources. The BSE program seeks to prepare its graduates to become successful educators,
researchers and practitioners of biological systems engineering or other complementary disciplines.

**Biological Systems Engineering - Learning Objectives/Outcomes**

Student demonstrates technical competence in chosen area of study

Student demonstrates effective communication skills

Student demonstrates ability to synthesize prior literature on a research topic

Student demonstrates ability to contribute to scholarly research (does not apply to non-thesis Masters Degrees)

Student understands the broader technical implications of their work

Student understands the broader societal implications of their work

**Graduate Courses**

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Description</th>
<th>Credit Hours</th>
<th>Lecture Hours</th>
<th>Level(s)</th>
<th>Instruction Type</th>
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<tbody>
<tr>
<td>BSE 5114</td>
<td>Advanced Properties of Biological Materials</td>
<td>Theory and measurement of fundamental physical properties important to harvesting, handling, sorting, processing, and packaging of food and agricultural materials.</td>
<td>3</td>
<td>3</td>
<td>Graduate</td>
<td>Lecture</td>
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<tr>
<td>BSE 5134</td>
<td>Land Application of Wastes</td>
<td>Engineering concepts and design methods for land application of municipal, agricultural, and industrial wastes; waste utilization and recovery, surface and ground water pollution control; economic analysis of land application systems.</td>
<td>3</td>
<td>3</td>
<td>Graduate</td>
<td>Lecture</td>
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<tr>
<td>BSE 5214</td>
<td>Advanced Topics in Watershed Management</td>
<td>An interdisciplinary exploration of advanced topics in watershed management. Reading, discussion, summary and presentation of current research in the areas of water quality and watershed management. Topics will be built around a semester theme that will vary by semester; the course may be repeated up to three times. Graduate standing required.</td>
<td>2</td>
<td>2</td>
<td>Graduate</td>
<td>Lecture, Lecture1</td>
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<tr>
<td>BSE 5244 (CEE 5244)</td>
<td>Advanced GIS in Hydrologic Analysis</td>
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</table>
Advanced GIS course focusing on raster analysis with particular application to the issues associated with hydrologic analysis. Application and evaluation of algorithms for terrain analysis, watershed characterization, and hydrologic analysis and modeling as implemented in GIS. Digital elevation data sources and error assessment. Approaches to GIS/model integration and application.
Credit Hours: 3
Lecture Hours: 2
Level(s): Graduate
Instruction Type: Lab, Lecture

BSE 5305 - Watershed Assessment and Modeling (pending approval)
Credit Hours: 3
Lecture Hours: 2
Level(s): Graduate
Instruction Type: Lab, Lecture

BSE 5344: Geographic Information Systems for Engineers
Conceptual, technical, and operational aspects of geographic information systems as a tool for storage, analysis, and presentation of spatial information. Focus on engineering applications in resource management, site selection, and network analysis. Laboratory work required.
Credit Hours: 3
Lecture Hours: 2
Level(s): Graduate
Instruction Type: Lab, Lecture

BSE 5354 - Nonpoint Source Pollution Modeling
Examination of the fundamental structure of nonpoint source pollution models, considering components, parameters and dependent variables, governing mathematical relationships; spatial variation of inputs; upland sediment and nutrient transport; and nonpoint source pollution control planning. II
Credit Hours: 3
Lecture Hours: 3
Level(s): Graduate
Instruction Type: Lecture

BSE 5404 - Agricultural Nonpoint Source Pollution
Assessment and management of agricultural nonpoint source pollution (NPS). Precipitation, runoff, erosion, pollutant fate and transport, and best management practices. Application of Total Maximum Daily Loads and water quality standards. Pre: Background in physical, chemical, biological, and soil factors affecting the environment and in environmental regulations.
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<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Description</th>
<th>Credit Hours</th>
<th>Lecture Hours</th>
<th>Level(s): Graduate</th>
<th>Instruction Type</th>
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<tr>
<td>BSE 5544</td>
<td>Advanced Protein Separation Engineering</td>
<td>Concepts, principles and applications of various unit operations used in protein separations. Properties of biological materials, such as cells and proteins, and their influences on process design. Design of processes for protein purification based on the impurities to be eliminated. Concepts and principles of scale-up of unit operations. Case studies in practical protein recovery and purification issues, with a focus on enhanced protein purification by genetic engineering. Protein purification process simulation and optimization using process simulation software.</td>
<td>3</td>
<td>3</td>
<td>Graduate</td>
<td>Lecture, Online Course</td>
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<tr>
<td>BSE 5604</td>
<td>Advanced Food Process Engineering</td>
<td>Design of food processing operations including microwave cooking, frying, and extrusion. New food processing technologies including ohmic, radio frequency, high pressure, and pulsed electric field processing. Simulation of food processing systems. Procedures for optimizing formulations or processes. Odd years. II.</td>
<td>3</td>
<td>3</td>
<td>Graduate</td>
<td>Lecture</td>
</tr>
<tr>
<td>BSE 5614</td>
<td>Advances in Recombinant Protein Production</td>
<td>Concepts, principles and applications of various expression systems for recombinant protein production, and the principles and applications of the most current unit operations used in bioseparations. The principles and applications of various methods for protein molecular modification to facilitate its downstream processing. Design of processes for protein purification based on expression systems, protein properties, and the impurities to be eliminated. Case studies in recombinant protein expression, recovery and purification. Graduate standing required.</td>
<td>3</td>
<td>3</td>
<td>Graduate</td>
<td>Lecture</td>
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<tr>
<td>BSE 5894</td>
<td>Final Examination</td>
<td>Pass/Fail only.</td>
<td>3</td>
<td>3</td>
<td>Graduat</td>
<td>Lecture</td>
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<tr>
<td>BSE 5904</td>
<td>Project and Report</td>
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Variable credits.
Credit Hours: 1 to 19
Level(s): Graduate
Instruction Type: Research

BSE 5944 - Seminar
Selected presentations and discussions by graduate students and faculty. Pass/Fail only.
Credit Hours: 1
Lecture Hours: 1
Level(s): Graduate
Instruction Type: Lecture

BSE 5974 - Independent Study
Pass/Fail only. Variable credit course.
Credit Hours: 1 to 19
Lecture Hours: 1 to 19
Level(s): Graduate
Instruction Type: Independent Study

BSE 5984 - Special Study
Variable credit course. Recent special studies courses in the process of becoming permanent:
- Renewable Materials
- Renewable Energy
- Enzyme Engineering
- Stream Restoration
Credit Hours: 1 to 19
Lecture Hours: 1 to 10
Level(s): Graduate
Instruction Type: Lecture, Lecture 1, Lecture 2, Lecture 3

BSE 5994 - Research and Thesis
Variable credit course.
Credit Hours: 1 to 19
Level(s): Graduate
Instruction Type: Research

BSE 7994 - Research and Dissertation
Variable credit course.
Credit Hours: 1 to 19
Level(s): Graduate
Instruction Type: Research
C37. Graduate Bioprocess Engineering (Virginia Tech)

The Department has a strong teaching program offering graduate degrees. The program provides students with an opportunity to combine their interest in biological sciences and engineering. Even though there are many specialty areas within the discipline, the program focus in BSE is in two areas:
- Bioprocess Engineering
- Land and Water Resources Engineering

We offer degrees at the MS and PhD levels. The Department currently has 53 graduate students of which 27 are MS students and 26 are PhD students (as of Fall 2008).

Bioprocess Engineering
The Bioprocess Engineering option in Biological Systems Engineering deals with the design and development of processes for environmentally responsible manufacturing of food and industrial products from biological materials. Areas of interest include food safety, food engineering, functional food, biopharmaceuticals, biofuels and enzymes.

Land and Water Resources Engineering
The Land and Water Resources Engineering option in Biological Systems Engineering is designed for students interested in a career in environmental protection, natural resources management, and ecological restoration. Our main focus areas are in managing and understanding nonpoint sources of pollution and in obtaining/disseminating knowledge for use in stream and wetland restoration.
C38. Graduate Bioenvironmental Engineering (Washington State University)

Coursework for the BAE degrees

Seminar

An old humorous definition of a PhD is “someone who studies more and more about less and less until they know everything about nothing”. That degree of focus, to the exclusion of everything else, is not conducive to developing an inquisitive and exploratory view of the world. The BAE seminar series is one method to widen your viewpoint. Attendance at the seminar series is expected of every graduate student every semester while on the Pullman campus.

BAE M.S. Program Requirements
BSYE 512  Research and Teaching Methods
BSYE 541  Instrumentation and Measurements

BAE Ph.D. Program Requirements
BSYE 512  Research and Teaching Methods
BSYE 541  Instrumentation and Measurements
STAT 512  Analysis of Variance of Designed Experiments

Three credits of mathematics beyond Differential Equations. You may choose from:
MATH 540  Applied Mathematics I
MATH 548  Numerical Analysis
Or other courses approved by the advisors.

Land and Water Engineering Requirements
Core Courses
M.S. students choose two from the three core courses while Ph.D. students take all three courses
BSYE 556  Surface Hydrologic Processes and Modeling
BSYE 5XX  Nutrient Cycling and Transport (in preparation)
BSYE 595  Ground-water Flow and Contaminant Transport

Suggested Elective Courses
BSYE 555  Natural Systems for Wastewater Treatment
BSYE 557  Watershed Modeling and Management
BSYE 562  Cropping Systems Modeling (To be revised)
SOILS 513  Soil Physics
SOILS 514  Environmental Biophysics
SOILS 515  Environmental Biophysics Laboratory
SOILS 521  Environmental Soil Chemistry
SOILS 523  Advanced Vadose Zone Hydrology
CE 517  Mechanics of Sediment Transport
CE 518  Hazardous Waste Engineering
CE 527  Advanced Soil Mechanics
CE 551  Open Channel Flow
CE 552  Advanced Topics in Hydraulic Engineering
CE 571  Meteorology
GEOL 569  Hydrogeology Methods (with lab)
GEOL 579  Groundwater Geochemistry  
GEOL 584  Stable Isotope Geochemistry  
ME 521  Fundamentals of Fluids I  
ME 522  Fundamentals of Fluids II  

**Food Engineering Requirements**

Core Courses  
M.S. Program  
BSYSE 581  Advanced Physical Properties of Foods  3  
BSYSE 582  Food Process Engineering Design  3  
BSYSE 584  Thermal Processing of Foods  3  

Ph.D. Program  

**M.S. required courses plus two courses from the following list:**  
BSYSE 583  Food Separation Processes Design  3  
BSYSE 586  Food Rheology  3  
BSYSE 588  Food Powders  3  
BSYSE 587  Food Plant Design  3  
Or other food engineering graduate courses  

**Elective Courses**

MS food engineering students should take at least seven credits and Ph.D. student should take at least nine credits from the following list:

FSHN 416  Food Microbiology  2  
FSHN 417  Food Microbiology Laboratory  2  
FSHN 460  Food Chemistry  3  
FSHN 462  Food Analyses3  
FSHN 470  Advanced Food Processing Technologies  3  
ME 404  Heat Transfer  3  
ME 513  Conduction Heat Transfer  3  
ME 514  Thermal Radiation Processes  3  
ME 515  Advanced Heat Transfer  3  
ME 521  Fundamentals of Fluids I  3  
ME 522  Fundamentals of Fluids II  3  
EE 517  Numerical Solutions to EM problems3  
EE 518  Advanced Electromagnetic Theory I  3  
EE 538  EM Simulation  3  
CE 534  Finite Elements  3  
CE 556  Numeric Modeling in Fluid Mechanics  3  
ChE 441  Process Control  3  
ChE 510  Transport Processes  3  
And other graduate level courses offered in the CEA  

**Environmental Engineering Requirements**

Core Courses  
M.S. students choose two from the three core courses while Ph.D. students take all five courses
BSYSE 556 Surface Hydrologic Processes and Modeling
BSYSE 5XX Nutrient Cycling and Transport (in preparation)
BSYSE 555 Natural Systems for Wastewater Treatment
CE 541 Environmental Engineering Unit Operations
CE 542 Environmental Engineering Unit Processes

**Suggested Elective Courses**
BSYSE 595 Ground-water Flow and Contaminant Transport
BSYSE 557 Watershed Modeling and Management
CE 515 Environment Measurements
CE 517 Mechanics of Sediment Transport
CE 518 Hazardous Waste Engineering
CE 519 Hazardous Water Treatment
CE 547 Principles of Environmental Engineering
CE 571 Meteorology
SOILS 514 Environmental Biophysics
SOILS 515 Environmental Biophysics Laboratory
SOILS 521 Environmental Soil Chemistry

**Biomass Processing and Bioproduct Engineering Requirements**
Core Courses
Required for M.S. and Ph.D. students.
BSYSE 594 Advanced Topics in Bioprocessing and Biotreatment
BSYSE 5XX Biorefinery Process Analysis and Design
BSYSE 5XX Biochemical, Biofuel and Bioenergy

**Suggested Elective Courses**
BSYSE 583 Food Separation Process Design
ChE 529 Chemical Engineering Kinetics
ChE 541 Chemical Engineering Analysis
ChE 546 Mass Transfer Operations
ChE 552 Process Optimization
ChE 560 Biochemical Engineering
ChE 575 Introduction to Biochemical Engineering
MBIOS 503 Molecular Biology I
MBIOS 503 Molecular Biology II
MBIOS 506 Molecular Techniques in Microbiology
MBIOS 513 General Biochemistry I
MBIOS 513 General Biochemistry II
C39. Graduate Biological Engineering (Dalhousie University)

GRADUATE STUDIES AND RESEARCH

The Department of Biological Engineering has an active research program and opportunities exist for graduate studies leading to MEng, MASc and PhD degrees.

RESEARCH AREAS

Faculty members within the department conduct research in a number of areas including:

- Alternative Energy Sources, Storage and Conservation
- Aquacultural Engineering
- Biological Systems Analysis
- Biological Machinery & Bio-robotics
- Environmental Engineering
- Crop Production Modelling
- Food Engineering
- Instrumentation and Measurements for Plant/Animal Environments
- Waste Management
- Watershed Modelling
- Contaminant Fate and Transport

Ecological Engineering
D.Briassoulis  UNIVERSITIES IN USA AND CANADA OFFERING PROGRAMS OF STUDIES IN BIOSYSTEMS ENGINEERING OR RELATED DISCIPLINES

C40. Graduate Biosystems Engineering Program (University of Manitoba)

<table>
<thead>
<tr>
<th>COURSES common for all options</th>
<th>Cr Hr</th>
<th>VR/TAKEN</th>
<th>GRADE</th>
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<tbody>
<tr>
<td>1. MATH 2470 Tech &amp; Mat of Cas. &amp; Math (2000)</td>
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<tr>
<td>2. BIOE 2110 Transport Phenomena</td>
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<td>3. BIOE 2550 Biof. Design Trilogy 1</td>
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<td>4. BIOE 2550 Biology for Engineers</td>
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<tr>
<td>5. BIOE 3270 Inst &amp; Muc. Biosystems</td>
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<td>6. BIOE 3220 Eng Prep Biological Mat</td>
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<td>7. BIOE 3580 Biof. Design Trilogy 2</td>
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<tr>
<td>8. BIOE 3590 Math Mat Biosystems</td>
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<tr>
<td>9. BIOE 4340 Graduation Project</td>
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<td>10. BIOE 4380 Unit Operations</td>
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<tr>
<td>11. BIOE 4500 Biof. Design Trilogy 3</td>
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<tr>
<td>12. CHEM 1200 Chemistry (Shop &amp; Me)</td>
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<tr>
<td>13. CHEM 1310 U1, Physical Chemistry</td>
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<tr>
<td>14. CIVL 2700 Fluid Mechanics &amp; Heat Transfer</td>
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<td>15. CIVL 2800 Solid Mechanics I (3)</td>
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<td>16. CIVL 3750 Finite Element Analysis</td>
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<td>17. CIVL 4090 Engineering Economics</td>
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<tr>
<td>18. COMP 1010 Computer Science</td>
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<tr>
<td>19. ENGR 1400 Design in Engineering</td>
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<tr>
<td>20. ENGR 1490 Intro to Statistics</td>
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<tr>
<td>21. ENGR 1450 Intro to Elec &amp; Comp Eng Techniques</td>
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<td>22. ENGR 1470 Intro to Thermal Sciences</td>
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<td>23. ENG 2020 Eng (CAD) Tech for Biosystems</td>
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<td>24. ENGL 1310 English (004, 132; Eng. (200))</td>
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<td>25. MATH 1210 Classical/Linear Algebra</td>
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<td>26. MATH 1510 Applied Calculus I (100)</td>
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<td>27. MATH 1710 Applied Calculus II (170)</td>
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<td>28. MATH 2120 Intro to Num Meth for Engineers</td>
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<td>29. MATH 2150 Eng Math Analysis I</td>
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<td>30. MATH 2152 Eng Math Analysis II</td>
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<tr>
<td>31. MBIO 2100 General Microbiology (or MBIO 1220)</td>
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<td>32. MBIO 3452 Invertebrates &amp; Dynamics</td>
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<td>33. MBIO 3610 Critical Thinking (or equivalent)</td>
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<td>34. PHYS 1050 Physics I, Mechanics</td>
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<td>35. STAT 2220 Probability &amp; Statistics</td>
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<tr>
<td>36. BIOL 1410 Anatomy Human Body (or BIOL 1420)</td>
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<td>37. BIOL 1412 Physic Human Body (or ACTSC 2310)</td>
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<td>38. COMP Studies</td>
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<td>39. Biof. Design</td>
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<td>41. Biof. Design</td>
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<td>42. Biof. Design (must be min. 3 Cr in)</td>
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<th>OPTIONS / MINORS</th>
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<td>Regular Stream</td>
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<td>Comp Studies (EC)</td>
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<th>Environmental Option</th>
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<tr>
<td>ENGR 2750 Enviro Bio (3)</td>
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<td>Civil 3900 Enviro Analysis (3)</td>
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<td>Civil 3700 Enviro Design (3)</td>
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<th>Admission to Medicine</th>
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<tr>
<td>PHYS 2710 Organ. Chem</td>
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<td>CIVL 2200 Bio Chem 1 (3)</td>
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<td>CIVL 2200 Bio Chem 2 (3)</td>
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<td>PHYS 2740 Bio Chem 2 (3)</td>
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<th>Co-op Option</th>
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<tr>
<td>BIOL 3550 Wild Study</td>
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<tr>
<td>BIOL 4550 Wild Study</td>
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<th>Minor in Arts</th>
<th>Cr Hr</th>
<th>VR/TAKEN</th>
<th>GRADE</th>
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<tbody>
<tr>
<td>Must complete 18 Cr or 6 Hum + 6 Soc + 6 Arts</td>
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<th>Minor in Management</th>
<th>Cr Hr</th>
<th>VR/TAKEN</th>
<th>GRADE</th>
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<tbody>
<tr>
<td>Must complete 12 Cr or 6 Hum + 6 Soc + 6 Arts</td>
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<tr>
<td>Must complete 12 Cr or 6 Hum + 6 Soc + 6 Arts</td>
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<tr>
<th>Minor in Math</th>
<th>Cr Hr</th>
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<tbody>
<tr>
<td>Must complete 24 Cr or 6 Hum + 6 Soc + 6 Arts</td>
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<tr>
<td>Must complete 24 Cr or 6 Hum + 6 Soc + 6 Arts</td>
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<tr>
<th>Minor in Music</th>
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<tbody>
<tr>
<td>Must complete 18 Cr or 6 Hum + 6 Soc + 6 Arts</td>
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<tr>
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Bioresource Engineering is an interdisciplinary program that integrates engineering, design and the biological sciences. The department offers facilities for research in the areas of computer modelling and simulation, electrotechnology for biotech applications, food storage and processing, agricultural structures, plant and animal environments, hydrology, waste management, bioremediation, environmental and ecosystem design and control, artificial intelligence, irrigation, drainage, agricultural machinery, mechatronics, soil mechanics, post-harvest technology, cultivation and tillage, remote sensing, machine learning, machine vision, GIS, fermentation and brewing, heat and mass transfer, non-thermal pasteurization and bioenergy. The Department has a comprehensive inventory of well equipped laboratories for conducting research in all these areas. Also, a number of research assistantships to qualified postgraduate students with stipends up to $20,000 per year are offered. It is a unique profession that applies engineering principles to the enhancement and sustainability of the world’s natural resources.

Description of Graduate programs:

1. M.Sc. Thesis Option (46 credits)

The various areas of bioresource engineering include plant and animal environments; ecological engineering (ecosystem modelling, design, management, and remediation); water resources management (hydrology, irrigation, drainage, water quality); agricultural machinery, mechatronics and robotics; food engineering and food processing; postharvest technology; waste management and protection of the environment; artificial intelligence; bioenergy. Science and Engineering graduates with a flair for research in these areas can pursue this program and would be suitable for individuals who intend to follow a career in Bioresource Engineering.


The non-thesis option is aimed at individuals already employed in industry or seeking to improve their skills in specific areas (soil and water, structures and environment, waste management, environment protection, post-harvest technology, food process engineering, environmental engineering) in order to attain a higher level of engineering qualification. Candidates must be qualified to be members of a Canadian professional engineering association such as the Ordre des ingénieurs du Québec (OIQ) and must maintain contact with their academic advisor in the Department of Bioresource Engineering before registration to clarify objectives, investigate project possibilities, and plan a program of study.


Integrated Water Resources Management is a one year program providing an essential approach for sustainable management of our natural watershed resources. The 15-
credit internship is a central feature of this Master’s program. The degree gives students the unique opportunity to study the biophysical, environmental, legal, institutional, and socio-economic aspects of water use and management, in an integrated context. The degree is directed at practicing professionals who wish to upgrade and/or focus their skill set to address water management issues. As a graduate from this program, you will be well suited to opportunities in diverse fields of employment, such as Water Resources Consultant, International Development Project Manager, Researcher with Government or University, Public Policy and Governance Development and Climate Change Impact Assessment Officer.

4. Integrated Water Resources Management (IWRM) Graduate Certificate – Non Thesis (15 credits)

The Graduate Certificate in Integrated Water Resources Management is for practicing professionals who wish to upgrade or focus their skill-set to address water management issues. Students are trained in Water Ethics, Law and Policy of Water Management, Freshwater Ecosystems, Health and Sanitation.


This option is a joint offering between McGill University and the Smithsonian Tropical Research Institute (STRI) in Panama. This interdisciplinary option encourages and promotes ethically sound and socially significant scholarship valuable in the global context of environmental problems. Participation in the MSE-Panama Symposium presentation in Montreal is a requirement of this program. This program trains students in the socio-political aspects of the Tropical Environment.


The non-thesis option is aimed at individuals already employed in industry or seeking to improve their skills in specific areas of the Tropical Environment. Participation in the MSE-Panama Symposium presentation in Montreal is a requirement of this program.

7. M.Sc. Applied in Environmental Engineering (45 credits)

The Environmental Engineering program emphasizes interdisciplinary fundamental knowledge, practical applications in diverse environmental contexts and functional skills needed for solving environmental problems. The primary objective of the program is to train environmental professionals at the advanced level. The program is thus designed for individuals with a university undergraduate degree in engineering. Through this program, students will master specialized skills in their home disciplines and acquire a broader perspective and awareness of environmental issues.


The McGill School of Environment (MSE) Graduate Environment Option is coordinated through the McGill School of Environment (MSE). This option is intended for students who want to take an interdisciplinary approach in their graduate research on environmental issues. Students are provided with an understanding of how
knowledge is transferred into action with regard to the environment, as well as how to
develop an appreciation of the role of science, politics, economics, and ethics.


The non-thesis option is aimed at individuals already employed in industry or seeking
to improve their skills in specific areas under the coordination of the McGill School of
Environment.

10. PhD. - Standard Program (0 credits)

The course of study set out for a PhD program will depend on existing academic
qualifications of the candidate and on those needed for effective pursuit of research in
the chosen field. Candidates are encouraged to take an additional course of study of
their own choice in some field of the humanities, sciences, or engineering not directly
related to their research. The course of study will be established by consultation of the
candidate with a committee which will include the Research Director and at least one
other professor. Candidates for the PhD degree will normally register for the MSc
degree first. In cases where the research work is proceeding very satisfactorily, or
where the equivalent of the MSc degree has been completed previously, candidates
may be permitted to proceed directly to the PhD degree.

11. PhD. - Neotropical Environment (9 credits)

This is a research-based degree with a team of co-advisors from McGill and Latin
America with the requirements of a one year residency in Panama or tropical Latin
America, three interdisciplinary courses, at least two of them focusing on North-South
issues, proficiency in Spanish or Portuguese, one time off-campus (Panama) fees,
possibility of NEO specific fellowships. Only the accredited professors listed on the
NEO web site can accept students in the option.

12. PhD. Bioresource Engineering: Environment - MSE Option (9 credits)

The Ph.D. Bioresource Engineering: Environment – MSE Option is coordinated
through the McGill School of Environment (MSE). This option is intended for
students who want to take an interdisciplinary approach in their graduate research on
environmental issues. Students will learn how knowledge is transferred into action
with regards to the environment and how to develop an appreciation of the role of
science, politics, economics, and ethics.