BIOLOGICAL ENGINEERING (BE)

BE AG499: Foreign Studies
1-12 Credits/Maximum of 12
Courses offered in foreign countries by individual or group instruction.
International Cultures (IL)
BE 1: Growing Your Future–First-Year Seminar
1 Credits

First-year seminar to introduce students to the breadth of the agricultural and biological engineering profession, including bioprocessing, machinery, and natural resources. B E 001S Growing Your Future–First-Year Seminar (1) This first-year seminar introduces students to the university in general and to the breadth of the agricultural and biological engineering profession. Students participate in hands-on lab activities in the focus areas of the profession, including machinery systems, food and biological processing, and natural resource engineering. Through these lab activities and a group project, students learn how the profession is critical to providing a growing world population with food, fiber, fuel, and water under increasing environmental constraints. In addition to being introduced to Penn State as an academic community, students also become familiar with the resources, tools, and opportunities available to them. Through the lab activities and in-class discussions on research, internship, and international opportunities, students meet and establish relationships with faculty, graduate students, and undergraduate students affiliated with the Biological Engineering and BioRenewable Systems programs.

First-Year Seminar
BE 297: Special Topics
1-9 Credits/Maximum of 9

Formal courses given infrequently to explore, in depth, a comparatively narrow subject which may be topical or of special interest.

BE 299: Foreign Studies
1-12 Credits/Maximum of 12
Course offered in foreign countries by individual or group instruction
International Cultures (IL)
BE 301: Mathematical Modeling of Biological and Physical Systems
3 Credits

The ability to quantify relationships into mathematical models, and implement the models into the computer to find solutions, is essential for engineering analysis and design. This course provides the student with tools for modeling biological and physical systems. Upon completion of this course, the student will be able to: identify a process/system and represent that process/system mathematically; solve the mathematically-represented system using computer-based modeling tools, such as Excel and MATLAB; describe the emphasis areas offered in the Biological Engineering major; and be able to develop a systems model related to each area. The course includes engineering economics, matrix operations, curve fitting, numerical integration and differentiation, linear and non-linear systems of equations, and applications of these methods to biological and agricultural systems.

Prerequisite: MATH 251

BE 302: Heat and Mass Transfer in Biological Systems
4 Credits

Engineering applications of the fundamentals of heat and mass transfer to natural and engineered biological systems. B E 302 Heat and Mass Transfer in Biological Systems (4) This course applies the principles of heat and mass transfer to the engineering of biological systems, ranging from soil/water ecosystems to animal, plant, and microbial production systems. Heat transfer mechanisms (conduction, convection, and radiation) are covered, as well as analysis techniques for steady state and transient cases. Mass transfer mechanisms (diffusion, dispersion, and convection) are also covered followed by simultaneous heat and mass transfer, including psychrometrics, ventilation, and drying. Applications of heat and mass transfer to agricultural and biological engineering are interwoven throughout the course. These applications may include heat exchangers for hydraulic systems, flow through porous media, soil freezing and thawing, bioreactor design, post-harvest product storage, animal housing, and greenhouses.

Prerequisite: MATH 231, MATH 251, BE 301, M E 300. Prerequisite or concurrent: C E 360 or M E 320; Concurrent: C E 360 or M E 320

BE 303: Structural Systems in Agriculture
3 Credits

Engineering analysis and design of structural systems in agriculture; topics: loads, connectors, analysis and design of structural members and systems. B E 303 Structural Systems in Agriculture (3) The objective of this course is to provide the student with the essential skills necessary to engage in practical agricultural structure analysis and design. Topics include a review of shear, moment and deflection concepts; loading in agricultural structures including earth loads, grain loads and livestock loads; methods for the analysis of determinate and indeterminate beams, trusses and frames; the material properties of wood including impact of species, grain orientation, degree of hydration, etc., on member adequacy. The nano and molecular structure of wood is also discussed and how it impacts material properties. A lecture is also presented including ethics in the workplace including issues related to new materials technologies. Lectures are focused on the practical application of basic engineering principles with examples. The lab period contains a substantial design analysis project where a student team analyzes an industrially designed structure (typically a post-frame building containing a truss roof system), which has been designed for a specific area. The team then redesigns the structure for a different location with different snow and wind loadings as well as intended usage, and optimizes the structure for efficient design of the structural members. The design and analysis uses a common industrial software package. There are also field trips near the end of the class to tie everything together. The course will serve as a prerequisite for senior-level structural design courses.

Prerequisite: E MCH210 or E MCH213
BE 304: Engineering Properties of Food and Biological Materials

3 Credits

Engineering properties play a crucial role during the analysis, design, and synthesis phases of problem solving. The accurate knowledge of properties is essential to the precise determination of the overall system and component responses. Due to the time-dependent and environmentally-sensitive nature of properties of the agricultural, food, and biological materials, the theory and measurement systems are different from those used for conventional engineering materials and their systems. Therefore, the focus of this course is to provide the students with sound bases of the theory and measurement methods that are used to quantify physical, mechanical, thermal, biological, and chemical properties of products and their systems. In addition, the significance and importance of the inherent variation in the property values of agricultural, food, and biological materials is emphasized.

Prerequisite: (EMCH 210; EMCH 213), MATH 251 CONCURRENT: BE 301, (CE 360; ME 320)

BE 305: Agricultural Measurements and Control Systems

3 Credits

Principles of measurements, instruments, controls, and data acquisition systems, with emphasis on agricultural applications. B E 305 Agricultural Measurements and Control Systems (3) Engineers and scientists are routinely required to measure or control parameters of physical systems. Frequently, these parameters are quantified electronically. This course prepares the student to solve fundamental engineering instrumentation and control problems with emphasis on agricultural and biological systems. Upon completion of this course, the student will be able to: select and apply electronic devices to solve basic engineering measurement and control problems; apply interference (noise) reduction techniques using sound engineering principles; demonstrate correct use of common electronic measurement tools including multimeters, oscilloscopes and others; demonstrate electrical construction techniques including cable preparation, soldering, crimping, circuit board fabrication, and others; explain simple measurement and control circuits represented by schematics or ladder diagrams; demonstrate the application of dataloggers, microcontrollers, programmable logic controllers, and computer software to collect data and/or control basic processes; explain the function of common circuit components such as resistors, capacitors, inductors, diodes, transistors, op-amps, and transformers in simple circuits. Students are evaluated on homework and lab worksheets, quizzes, an oral presentation, and a final project.

Prerequisite: PHYS 212

BE 306: Machines for Agricultural and Biological Processing

3 Credits

Application of machine systems to agricultural production and biological processing machinery. Functional design and analysis of equipment. B E 306 Machines for Agricultural and Biological Processing (3) This course is designed to provide a broad foundation for understanding machine system design for biological engineering students. In addition, this course serves as a foundation for those wishing to develop a more focused understanding of agricultural and general machine systems, and is a prerequisite for B E 400 level courses. Machine systems are an integral part of many agricultural operations from field production to post-harvest processing, storage, transportation, and bio-based processing. Biomass feedstock logistics and bioenergy production systems are heavily relying on machine systems. Biological engineers will likely encounter a wide range of powered and automated equipment in their careers. This course consists of lectures, labs, and open-ended design projects. The lab activities will focus on testing and evaluating of machine performance using prototype machines and instruments. Lab activities and design projects will be completed in the format of small groups. This course equips the students to: (1) describe operating characteristics of engines and motors and properly select models for different applications; (2) design machine elements and mechanical power transmission systems to accomplish a machine task; (3) apply basic physics and engineering principles in a variety of machine-product interaction situations; and (4) practice technical report writing and oral presentation.

Prerequisite: E MCH212; E MCH210 or E MCH213

BE 307: Principles of Soil and Water Engineering

3 Credits

Utilization and engineering of soil-water resources; including rainfall-runoff, soil-water movement, erosion/sediment transport and flow processes. B E 307 Principles of Soil and Water Engineering (3) The two 50-minute class periods will focus on exploration of the underlying principles, equations, and importance of each of the topics to be covered. The two-period lab sessions will be used to explore each topic in a practical and experiential mode, with class participants sharing in discussions, lab activities, and explanations/presentations of project items. Weekly quizzes and periodic exams (somewhat evenly distributed during the semester) will be given during the lab period at appropriate stages of the course (likely after each major topic). The lab activities will focus on using representative soil profiles, cropping-management systems, and watershed-scale settings common to the immediate Centre County region as the basis for the experiential learning. Lab activities will sequentially build from one lab period to the next, showing how each stage of soil and water engineering is used to develop a more complete watershed-type project. Labs will involve in-class activities and field trips including map use, problem formulation, team problem solving, discussions, and reports/presentations by class participants. Participants will be expected to gather information and conduct some analyses outside of the class meeting times so as to complete the required lab projects. As appropriate, field trips will be scheduled so as to show course participants the practical settings in which basic soil and water engineering principles can be applied. The course will serve as a course preceding the senior-level soil and water engineering design courses in the Natural Resources Engineering Option of the Biological Engineering (B E) major.

Prerequisite: C E 360 or M E 320; Concurrent: C E 360 or M E 320

BE 308: Engineering Elements of Biochemistry and Microbiology

3 Credits

Introduction to basic biochemistry and microbiology as well as industrial and environmental applications. B E 308 Engineering Elements of Biochemistry and Microbiology (3) B E 308 provides an introduction to microbiology, biochemistry, and major organic compounds found in living systems such as carbohydrates, lipids, proteins, and vitamins, as a package to engineering students. Energy calculations in microbial bioenergetics will be covered. Examples of industrial and environmental applications that build on the basic principles will be presented.
Prerequisite: CHEM 110

BE 391: Contextual Integration of Communication Skills for the Technical Workplace
2 Credits
To develop corporate communication skills in technically focused students in a contextual manner. AS M (A B E) 391 Contextual Integration of Communication Skills for the Technical Workplace (2) A B E/A S M 391 is the first half of a two-semester capstone experience in corporate focused leadership and communication skills training. The sequence is formatted into two 2-credit courses (second semester Junior for A B E/A S M 391 and first semester senior for the companion A B E/A S M 392 course). A key facet of this training is the contextual approach taken. All course modules are focused around the needs of industry and corresponding technical course content &mdash; a complete contextual approach. To meet the needs of the student, the course will reflect clear understanding of leadership and communication but also appreciate critical aspects of the technical content of student’s work and of the industries within which the students will ultimately work. The primary focus for 391 is communication skills (oral and written) with a secondary focus on leadership and career skills. The course provides the student with interaction with individuals from industry (company visitors, industry trips, and recruiting opportunities). Students will be evaluated through writing and speaking projects, professional presentations, written worksheets in class and out, creation of portfolios and reports, in class group and individual exercises, computer graphics presentation assignments, library assignments, interaction with industry executives (reports), and leadership journals.

Prerequisite: Junior level standing in B E or BRS
Cross-listed with: BRS 391
General Education: Writing/Speaking (GWS)

BE 392: Contextual Integration of Leadership Skills for the Technical Workplace
2 Credits
B E/BRS 392 is the second half of a two-semester experience in corporate-focused leadership and communication skills training. The sequence is formatted into two 2-credit courses (second semester junior for B E/BRS 391 and first semester senior for the B E/BRS 392 course). A key facet of this training is the contextual approach taken. All course modules focus on leadership and communication needs of industry within its corresponding technical content - thereby representing a complete contextual approach. To meet the needs of the student, the course will reflect clear understanding of leadership and communication but also appreciate critical aspects of the technical content of student’s work and of the industries within which the students will ultimately work. The primary focus of BE/BRS 392 is on leadership, with communication, ethics, sustainability and career issues the secondary focus. The course provides students with interactions with individuals from industry (company visitors, industry trips, and recruiting opportunities). Topics developed for B E/BRS 392 include personal development, ethical decision-making, corporate social responsibility, strategic group management, facilitation, and diversity. Students may be evaluated through writing and speaking projects, professional presentations, written worksheets in class and out, creation of portfolios and reports, in-class group and individual exercises, interaction with industry executives (reports), and leadership journals.

Prerequisite: B E 301; B E 391; 7th semester standing
Writing Across the Curriculum

BE 460: Design of Fluid Power Systems
3 Credits
Hydraulic systems, hydrostatic transmissions, electro-hydraulic systems in application to agricultural production and processing systems. BE 461 Design of Fluid Power Systems (3)This course is designed to provide a solid foundation for understanding hydraulic and pneumatic systems for power transmission and motion control. Applications include mobile and stationary equipment. Biological Systems Engineers (and other engineers as well) will likely encounter a wide range of powered and automated equipment in their careers. This course equips the students to: (1) understand the key operating characteristics of most fluid power system components including compressors, pumps, valves, cylinders, and motors, (2) design fluid power circuits, (3) mathematically model the steady state operation of fluid power systems, and (4) have sufficient knowledge to obtain the Hydraulic Specialist Certification offered by the Fluid Power Society. The course includes a hands-on laboratory offering the chance for students to construct circuits, see component cutaways, experience component and system performance demonstrations, and work with electronic control of hydraulic systems. Prerequisite
knowledge includes fluid mechanics and familiarity with mechanical power transmission systems. The course grade is based on homework assignments, laboratory reports, a design project, and exams.

**Prerequisite:** B E 306 or M E 360; C E 360 or M E 320

**BE 462: Design of Wood Structures**

3 Credits

Structural properties of wood; design of wood structural elements; design of wood structural systems; design of post-frame buildings. B E 462 Design of Wood Structures (3) This course begins by defining the structural loads applicable to wood framed building systems. The course then introduces students to the unique physical and structural characteristics of solid lumber and other wood products, such as plywood and other panel products and structural composite lumber, including laminated veneer lumber, parallel strand lumber and composite wood I-joists. The engineering principles and specifications for designing wood structural members, including tension members, beams, columns, and beam-columns are presented in detail using the National Design Specification for Wood Design. Design specifications for designing wood structural connections using dowels, such as nails, bolts and lag-screws, are presented. Design procedures for designing selected wood-frame systems, such as floors, trusses, structural diaphragms and shear walls, are also presented. Students are introduced to a computer program which is an invaluable aid for analyzing and designing wood framed structural systems. At the conclusion of the course students will be able to specify structural loads for wood framing systems and analyze and design wood beams, columns, beam-columns, typical wood diaphragms and shear walls, simple wood structural systems, and a range of wood structural connections. The course builds on engineering students' prior knowledge from strength of materials and elementary structural analysis. Students are evaluated based on homework assignments, exams and a semester project.

**Prerequisite:** B E 303, A E 308, or C E 340

**BE 464: Bioenergy Systems Engineering**

3 Credits

Fundamental theories and applied technologies for production and conversion of biomass into energy and co-products. Students may take only one course from B E 464 and A B E 884 for credit. B E 464 Bioenergy Systems Engineering (3) In the coming decades biomass will play an increasing role in satisfying society's energy and material needs, providing a renewable alternative to fossil fuels. This course will cover the fundamental theories and applied technologies used in production and conversion of biomass into transportation fuels, heat, power, electricity, chemicals and other value-added products. Production strategies focus on sustainable cropping systems, harvest, storage, and pretreatment for diverse biomass feedstocks. Conversion technologies covered include ethanol fermentation, biodiesel catalysis, combustion, pyrolysis, gasification, anaerobic digestion, and emerging processes. System analysis will address worker safety and health, environmental impacts, policy, and economics. The course is recommended for students in engineering and science majors with a background in thermodynamics, chemistry, and biochemistry or microbiology. Evaluation will be based on class participation, homework, quizzes, exams, and a team design project.

**Prerequisite:** EME 301 or M E 201 or M E 300 or CH E 220; Prerequisite or concurrent: B E 308 or CH E 340 or C E 479

**BE 465: Food and Biological Process Engineering**

3 Credits

Reactor design, kinetics, fluid flow, thermal processes, and other topics applied to the design of systems for the food and biological process industry. B E 465 Food and Biological Process Engineering (3) Learning objectives. At the end of this course students will be able to: 1. Use and convert units and dimensions applicable to food processing 2. Apply laws of conservation of mass and energy 3. Evaluate time and temperature profiles for food pasteurization and sterilization 4. Design an aseptic processing system 5. Describe operation of mechanical refrigeration systems 6. Calculate freezing times 7. Compute the energy requirements in single and multiple effect evaporators 8. Use the psychrometric chart in relation to drying processes Engineering principles of reactors, fluid flow, thermal processes and other topics will be applied to the design of systems for the food and biological process industry. The examples used will be applicable to bioreactor production, food processing, pharmaceutical manufacture, etc.

**Prerequisite:** B E 302

**BE 466W: Biological Engineering Design II**

2 Credits

BE 466 is part two of a two course sequence that provides a culminating design experience for students in the Biological Engineering major. Students will develop skills and techniques for managing and executing engineering design projects in the following fields: agricultural engineering, food and biological processing engineering, and/or natural resource engineering. Projects are sponsored by faculty, industry, or community initiatives and are structured to span two semesters. In the Fall semester, the emphasis is on classroom lectures, preliminary analyses, and project proposal development. In the Spring semester, the emphasis is on hands-on laboratory activities, project execution, and report preparation. Project teams perform all facets of the design process. This includes problem identification, planning of the project, formulation of design specifications, development and evaluation of alternative conceptual designs, development of detailed designs, consideration of safety and design optimization, design implementation, design testing, and analysis and documentation of results. Students improve their writing skills through preparation and refinement of various documents including a design notebook, proposal, statement of work, design specification report, status reports, and a final report. Students also present their results in other formats, including poster and oral presentations for both technical and non-technical audiences.

**Prerequisite:** BE 460W

**Writing Across the Curriculum**

**BE 467: Design of Stormwater and Erosion Control Facilities**

3 Credits

Design of best management practices for stormwater management, erosion and sediment control as applied to the agriculture-urban interface. BE 467 Design of Stormwater and Erosion Control Facilities (3) This course equips seniors agricultural and biological engineers with the ability to design sediment and stormwater impoundments and erosion control structures used in agriculture and the development of the agricultural-urban interface. Predictive hydrology is presented along
with an introduction to several hydrology-based models used in the land-
development industry. Basins are presented as fundamental structures
used to attenuate stormwater peaks as well as holding ponds to
facilitate gravitational sediment removal from stormwater runoff. Various
sediment traps are also included. Flood routing is developed so students
understand and can design for flood peak attenuation. Low Impact
Development (LID) practices such as green roofs, bioretention areas and
vegetated filter strips are presented as infiltration-based alternatives to
traditional stormwater management. Open channel design procedures
including maximum permissible velocity and tractive force are reviewed.
The Revised Universal Soil Loss Equation (RUSLE) is introduced and the
latest version of the RUSLE software package is available for student use.
Stream corridor restoration procedures, especially many of the structural
practices, are introduced. The course includes a major design project
executed in groups of 3 to 5 students. Students are assigned a land
parcel and the proposed development. Students are expected to develop
a Stormwater Management Plan, including several LIDs, and an Erosion
and Sedimentation Control Plan, including a sediment basin. Students
must present their final designs in oral and written format to their peers
and a lay audience. This project makes up about 30% of their course
grade. The remainder of the grade is from two take-home exams and daily
homework. The majority of those taking this course are A B E seniors or
graduate students. Civil and Environmental Engineers often elect this
course.

Prerequisite: B E 307 or C E 461

BE 468: Microbiological Engineering

3 Credits

Application of basic engineering principles and designs in biochemical
and biological processes. B E 468 Microbiological Engineering (3)
Microbial engineering is a combination of biochemistry and microbiology
applied to engineering. The purpose of this course is to provide an
understanding of conversions of raw agricultural materials into value-
added products via microbial fermentation. This course presents all steps
in this type of bioprocessing such as mutagenesis, genetic modification
for microbial manipulation, enzyme and microbial kinetics, aeration,
agitation for bioreactor design, and scale-up strategies, as well as various
recovery methods for downstream processing.

Prerequisite: B E 308 or both MICRB201 and B M B211; Concurrent: B E 302

BE 477: Land-Based Waste Disposal

3 Credits

Analysis, design, and management of land-based systems for recycling
and disposal of municipal, industrial, and agricultural wastes. B E 477
Land-Based Waste Disposal (3) The course focuses on exploration of
the fundamental principles and processes that determine the fate of
nutrients and pollutants in liquid and semi-solid wastes that are applied
to the soil for recycling and disposal. These principles then serve as
the basis for design of systems for application of livestock manures,
biosolids, septage, wastewater effluents, and other residual materials.
Relevant state and federal regulations will be covered to illustrate the
impact of regulations and policies on engineering practice. The course
culminates in a project for which students design a system to dispose of
municipal, agricultural, or industrial byproduct or wastewater. Principles
will be reinforced with several homework sets. Field trips will expose
students to land-based waste disposal processes and systems. The
course will serve as a senior-level engineering science/design course in
Agricultural and Biological Engineering (A B E).

Prerequisite: B E 307 or C E 370 or A S M327

BE 487: Watershed Modeling for Water Quality Design

3 Credits

Application of common watershed models used to investigate design
alternatives for flow and quality effects. B E 487 Watershed Modeling
for Water Quality Design (3) This course will explore the use of several
commonly-available watershed simulation models for investigating
water quality (WQ) and water quantity issues. The models will serve
as a base from which students can investigate the effects of different
management design scenarios on watershed system responses. Spring
Creek Watershed in Centre County, and subwatersheds within Spring
Creek, will serve as case study watersheds to be investigated for all
modeling applications. The ArcView Generalized Watershed Loading
Function (AVGWLF) model will be used as an initial exploration of
modeling for the entire watershed and to show the hydrologic and WQ
responses for various subwatersheds (agriculturally dominated vs. urban
dominated). The StormWater Management Model (SWMM) model will
be used to explore more in-depth modeling for an urban watershed, with
the Fox Hollow Watershed serving as the primary case study. Extensive
flow and WQ monitoring data are available and will serve to assist in
parameterizing and calibrating the model. The Soil Water Assessment
Tool (SWAT) model will be used to explore flow and constituent response
from a more agriculturally-dominated Cedar Run watershed, also located
within Spring Creek. The potential impact of urban low impact design
(LID) practices and agricultural best management practices (BMPs) will
be investigated for urban and rural watersheds, respectively.

Prerequisite: B E 307 or C E 461

BE 494: Senior Thesis

1-9 Credits/Maximum of 9

Students must have approval of a thesis adviser before scheduling this
course.

BE 494H: Senior Honors Thesis

1-6 Credits/Maximum of 999

Senior honors thesis.

Prerequisite: junior or senior status in the University Scholar's program
Honors

BE 495: Agricultural Engineering Internship

1-6 Credits/Maximum of 6

Independent study and supervised cooperative education experience
related to the student's career objective.

BE 496: Independent Studies

1-18 Credits/Maximum of 18

Creative projects, including research and design, which are supervised on
an individual basis and which fall outside the scope of formal courses.
BE 497: Special Topics

1-9 Credits/Maximum of 9

Formal courses given infrequently to explore, in depth, a comparatively narrow subject which may be topical or of special interest.