

# Biological and Agricultural Engineering (BAE)

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## **BAE 100 Introduction to Biological Engineering** (1 credit hours)

Technical topics and career options in Biological Engineering with concentrations in Agricultural, Bioprocess, and Environmental Engineering are introduced. Information is provided about career services, internships, and study abroad and co-op opportunities in these areas. Students develop a plan of work.

*Typically offered in Spring only*

## **BAE 123 Light Equipment Technology** (3 credit hours)

Principles of operation and maintenance of powered turf, garden, and landscape equipment. Small engines, power transmission systems, equipment maintenance, and operator safety.

Requisite: Agricultural Institute Only

*Typically offered in Spring only*

## **BAE 133 Agricultural Tractors and Machinery** (4 credit hours)

Principles of tractor engines, power trains, and hydraulics. Tractor operation, service and testing. Machinery management involving tractor and implement selection based on power and field requirements and on economics of ownership and operation. Implements for crop production to include tillage, planting, chemicals and harvesting. Set-up, operation and maintenance of implements. Calibration of planting and chemical equipment. Tractor and machinery safety. VEAL

Requisite: Agricultural Institute Only

*Typically offered in Spring only*

## **BAE 200 Computer Methods in Biological Engineering** (2 credit hours)

Students develop computer-based problem solving techniques to solve introductory problems in Biological Engineering. Emphasis is on developing solution algorithms and implementing these with spreadsheets and computer programming.

Prerequisite: Grade of C or better in MA 141 and Corequisite: E 115

*Typically offered in Fall only*

## **BAE 202 Introduction to Biological and Agricultural Engineering Methods** (4 credit hours)

Introduction to experimental design methodology, basic engineering design and problem solving methodology for Biological Engineering. Visualization skills, computer-aided 3-D solid modeling of parts, 3-D assembly of solid part geometries, computation of mass properties, 2-D engineering drawings, engineering design process, safety, tools and fabrication processes and design, and hands-on shop fabrication of semester project.

Prerequisite: E 115

*Typically offered in Spring only*

## **BAE 203 Introduction to AutoCAD Civil 3D for Environmental & Ecological Engineers** (2 credit hours)

Introduction to the use of AutoCAD Civil 3D for Environmental & Ecological Engineering applications. Basic drawing, managing survey data, surfaces, alignments, profiles, corridors, grading, pipe networks, plan production, GIS interface, GIS data types and sources, importing data, creation and export of objects in GIS formats. BE majors will be given priority in enrollment.

Prerequisite: BAE 200

*Typically offered in Spring only*

## **BAE 204 Introduction to Environmental and Ecological Engineering** (2 credit hours)

Introduction to the principles and applications related to environmental and ecological engineering. Topics include watershed hydrology, nutrient cycling, sources of environmental pollution, and the impact to ecosystems. An overview of different methods employed in these two disciplines to remediate and protect natural resources. Special emphasis on how soil, water, microbial, and plant interactions occur in ecosystems and how they are used to develop treatment technologies.

Prerequisite: BAE 200 and (BIO 181 or BIO 183); Corequisite: BAE 203 and SSC 200

*Typically offered in Spring only*

## **BAE 302 Transport Phenomena** (3 credit hours)

Theory and application of heat and mass transfer in biological, food, and agricultural systems. Topics include fluid flow, conduction, convection, radiation, psychrometrics, and refrigeration.

Prerequisite: MAE 201 and MA 341 and Corequisite: BAE 200 and MAE 208 and CE 282 or MAE 308

*Typically offered in Fall only*

## **BAE 305 Biological Engineering Circuits** (4 credit hours)

Fundamentals of analog and digital circuit analysis and design as applied to biological engineering instrumentation systems. Analysis and design of AC and DC circuits using Ohms and Kirchhoff's laws, the node voltage method, Thevenin and Norton's theorem, Laplace Transforms, resistance, capacitance, inductance, operational amplifiers, and frequency response, analog filter design, diode, transistors, biological signal acquisition, binary math and logical operators, digital circuit design, circuit simulation tools and techniques. Laboratory exercises supplement the topics presented in class lectures.

Prerequisite: MA 242, PY 208

*Typically offered in Fall only*

## **BAE 321 Bioprocessing Engineering Fundamentals** (3 credit hours)

For Engineering and non-Engineering students interested in processing, biotechnology and related disciplines, it is important to have an understanding of the basic principles behind process analysis, design and scale up. This course will provide an introduction to the interdisciplinary approach and engineering concepts behind the development of useful food, chemical, energy, nutraceutical and pharmaceutical products through transformation of biological materials (bioprocessing). Some of the relevant topics covered include the fundamentals behind units, dimensions and engineering properties, stoichiometry, data analysis and statistics, mass and energy balances, rheology, mixing, heat and mass transfer, reaction kinetics and unit operations.

Prerequisite: BIO 181 or BIO 183; Corequisite: MAE 201

*Typically offered in Fall only*

**BAE 322 Introduction to Food Process Engineering** (3 credit hours)

Introductory principles and practices of handling and preserving food products. Coverage includes the design and analysis of handling systems for discrete and continuous flow material handling systems, the selection and specification of automatic controls, food preservation principles and considerations relevant to the design of food handling systems, and the principles and practices of drying and storing grain.

Prerequisite: BAE 302; MAE 308 or CE 282; MAE 301 or CHE 315

*Typically offered in Spring only*

**BAE 325 Introductory Geomatics** (3 credit hours)

Theory and practice of plane and satellite-based surveying. Includes distance measurement, differential leveling, profile leveling, topographic surveying, and record keeping. Introduction to tapes, levels, total stations, surveying software, the global positioning system, GPS receivers and methods (stand-alone, DGPS, RTK), data collection, data processing, and applications.

Prerequisite: Junior standing

*Typically offered in Fall only*

**BAE 361 Analytical Methods in Engineering Design** (3 credit hours)

Engineering problem solving through studies of topics in engineering design. Analysis of linkages, analysis and design of machine structures and components, analysis and design of power transmission components, three-dimensional modeling, and finite element analysis.

Prerequisite: BAE 202 and MAE 208 and MA 341 and Corequisite: CE 225 or MAE 214

*Typically offered in Spring only*

**BAE 371 Fundamentals of Hydrology for Engineers** (3 credit hours)

Hydrology and erosion principles. Designing structures and selecting practices to control land runoff, erosion, sediment pollution and flooding.

Prerequisite: BAE 200 and BAE 203; Corequisite: SSC 200 and CE 282 or MAE 308

*Typically offered in Fall only*

**BAE 376 Watershed Assessment and Water Quality Protection** (3 credit hours)

Application of methods to describe and protect quality. Identification of water quality problems based on physical, chemical, and biological species and intended use. Water quality sampling equipment, and sample collection strategies and methods. Macroinvertebrate sampling and interpretation. Presentation of water quality data and information. Identification of structural and non-structural best management practices (BMPs) to mitigate degradation of watersheds and ecological systems.

Prerequisite: BAE 371 Corequisite: ST 370

*Typically offered in Spring only*

**BAE 401/BAE 501 Sensors and Controls** (3 credit hours)

Basic concepts of sensors and controls for biological systems. Study of transducers and circuits utilized in biological and agricultural engineering applications. Demonstration of concepts of error, accuracy and precision, linearity and other instrument characteristics by electronic models. Provision of hands-on experience for reinforcing lecture concepts in laboratories. Credit will not be given for both BAE 401 and BAE 501.

Prerequisite: BAE 305

*Typically offered in Spring only*

**BAE 425/BAE 525 Industrial Microbiology and Bioprocessing** (3 credit hours)

Introduction to the structure and functions of microbial cells and their cultivation and utilization in Biological engineering processes. Topics covered include Fermentation systems and downstream processing methods. Enzyme kinetics, production and application. Biomanufacturing of fuels, industrial chemicals, food additives and food products such as beer, wine, cheese and yogurt, Microbial biomass production, Introduction to environmental biotechnology including wastewater treatment and bioremediation. Field trip is an essential educational component of the course and is are required. Credit will not be given for both BAE 425 and BAE 525.

Prerequisite: Junior or higher standing in CALS or COE; MB 351

*Typically offered in Spring only*

**BAE 435/BAE 535 Precision Agriculture Technology** (3 credit hours)

Overview of technology available for implementation of a comprehensive precision agriculture program. Topics include computers, GPS, sensors, mechanized soil sampling, variable rate control system, yield monitors, and postharvest processing controls. Applications of precision agriculture in crop planning, tillage, planting, chemical applications, harvesting and postharvest processing. Credit may not be received for BAE 435 and BAE 535.

Prerequisite: Junior standing or Senior standing

*Typically offered in Spring only*

*This course is offered alternate even years*

**BAE 451 Engineering Design I** (2 credit hours)

Design concepts of engineering problems are reviewed, including objectives, specifications, manufacturing, prior art and analysis. Reverse engineering, national and international standards, quality control, intellectual law and engineering ethics are covered. Team projects from agricultural, bio-processing and environmental/ecological engineering are executed through problem definition, proposal development, design, and testing. Field trips are required.

Prerequisite: (CE 225 or MAE 214) and (BAE 202 or BAE 203) and BAE 302 and BAE 401 and either (BAE 321 or BAE 322 or BAE 361 or BAE 371) Restrictive Statement: Must be within 36 credit hours of completing the BE degree.

*Typically offered in Fall only*

**BAE 452 Engineering Design II** (2 credit hours)

Continuation of BAE 451; Project analysis, design, scheduling, construction, tests, presentations and reports. Teamwork development, soft skills and the function of engineering design in society are covered. Field trips are required.

Prerequisite: BAE 451; Restrictive Statement: Must be within 36 hours of completing the BE degree.

*Typically offered in Spring only*

**BAE 455/BAE 555 R Coding for Data Management and Analysis** (3 credit hours)

This course provides students with foundational coding skills in R, an open-source statistical software environment, as well as instruction on best practices for tidying, managing, and analyzing environmental and agricultural data, including geospatial, tabular, and time series observations. As this is an introductory course, prior programming experience is not required or expected. Coding approaches taught in the course will be targeted towards developing skills needed for summarizing data, creating data visualizations, and applying simple statistical models for analysis of environmental and agricultural data.

P: ST 311, or ST 370, or ST 512, or ST 515

*Typically offered in Fall only*

**BAE 462 Machinery Design and Applications** (3 credit hours)

Machinery design for effective use of energy and labor in agricultural production. Engine cycles, power transmission, hydraulics, traction, combined stresses, finite element analysis, computer-aided-engineering, and engineering economics. Machinery design of agricultural field equipment and other agricultural machinery systems.

Prerequisite: BAE 361

*Typically offered in Fall only*

**BAE 472/BAE 572 Irrigation and Drainage** (3 credit hours)

Design, management and evaluation of irrigation and drainage systems; concepts and processes of system design. Credit will not be given for both BAE 472 and BAE 572.

Prerequisite: BAE 371

*Typically offered in Spring only*

**BAE 473/BAE 573/SSC 573/SSC 473 Introduction to Hydrologic and Water Quality Modeling** (3 credit hours)

Concepts in basic hydrologic, erosion and chemical transport used in modeling. Evaluation of typical hydrologic and water quality models on watershed systems. Project examples using state-of-the-art models. Credit will not be given for both BAE 473 and BAE 573.

Prerequisite: BAE 371

*Typically offered in Spring only*

**BAE 474 Principles and Applications of Ecological Engineering** (3 credit hours)

Governing principles of ecological engineering and the advanced biological, chemical, and physical conditions that determine the design of biological systems. Emphasis on 1) stream and wetland ecosystem restoration and 2) natural treatment systems for groundwater, stormwater, and wastewater such as riparian buffers, bioretention cells, and stormwater wetlands. A class field trip is required during non-scheduled time.

Prerequisite: BAE 203 and BAE 204 and BAE 371 and at least one of the following, MB 351 or PB 321 or PB 360 or SSC 332; Corequisite: BAE 451

*Typically offered in Fall only*

**BAE 478/BAE 578 Circular Approach to Manure Management** (3 credit hours)

This course teaches engineering principles of handling, treating, processing, and using animal and poultry manures and organic byproducts from the perspective of recovery and reuse of nitrogen, phosphorus, carbon, and components that have a negative impact on the local environment. Topics include waste characterization, descriptions of systems and technology, land application principles, biochemical/biological processes, and potential impacts to the environment. Assignments include homework, quizzes, projects, and discussions that emphasize teamwork, problem solving, and analysis.

Prerequisite: BAE 204 or AEC/PB 360 or PB 321 or SSC 332 or MB 351

*Typically offered in Fall only*

**BAE 481 Structures & Environment** (3 credit hours)

Principles of environmental control and structural analysis are combined with biological principles for the design of structures. Topics include structural analysis, load estimation, material selection, fasteners, physiological reactions of animals and plants to their environment, applications of heat transfer and psychrometrics in calculating ventilation requirements, heating or cooling loads.

Prerequisite: BAE 302; CE 225 or MAE 314

*Typically offered in Spring only*

**BAE 486/BAE 586 Aquacultural Engineering** (3 credit hours)

This course starts with a general background of aquaculture, both theoretical and practical. Based on this, engineering applications for both extensive (e.g. pond based) and intensive (e.g. recirculating aquaculture systems) culture systems are studied. Unit operations including biofiltration, aeration, degassing, sedimentation, pumps, piping and related topics, as well as mass balances provide quantitative engineering design tools. Transport, harvest, processing and food safety are discussed, and sustainability (ecological and environmental aspects of aquacultural engineering design) as well as cutting edge research in the area are covered. Field trips; guest lectures/discussion, and hands on work is included to provide practical applications and experience.

Prerequisite: CE 282 or MAE 308; Restrictive Statement: Senior Standing

*Typically offered in Spring only*

**BAE 488 Postharvest Engineering** (3 credit hours)

An introduction to the engineering aspects of the proper postharvest handling of fresh produce. Topics addressed include cleaning, grading, sorting, cooling, storing, packaging, transport, and marketing. Issues relating to food safety will be integrated throughout all the course content. A class field trip is required during non-scheduled time.

Prerequisite: BAE 302 or MAE 310

*Typically offered in Spring only*

**BAE 492 External Learning Experience** (1-6 credit hours)

A learning experience in agriculture and life sciences within an academic framework that utilizes facilities and resources which are external to the campus. Contact and arrangements with prospective employers must be initiated by student and approved by a faculty adviser, the prospective employer, the departmental teaching coordinator and the academic dean prior to the experience.

Prerequisite: Sophomore standing

*Typically offered in Fall, Spring, and Summer*

**BAE 493 Special Problems in Biological and Agricultural Engineering** (1-6 credit hours)

A learning experience in agriculture and life sciences within an academic framework that utilizes campus facilities and resources. Contact and arrangements with prospective employers must be initiated by student and approved by a faculty adviser, the prospective employer, the departmental teaching coordinator and the academic dean prior to the experience.

Prerequisite: Sophomore standing

*Typically offered in Fall, Spring, and Summer*

**BAE 495 Special Topics in Biological and Agricultural Engineering** (1-3 credit hours)

Offered as needed for presenting material not normally available in regular BAE departmental courses or for new BAE courses on a trial basis.

*Typically offered in Fall, Spring, and Summer*

**BAE 501/BAE 401 Sensors and Controls** (3 credit hours)

Basic concepts of sensors and controls for biological systems. Study of transducers and circuits utilized in biological and agricultural engineering applications. Demonstration of concepts of error, accuracy and precision, linearity and other instrument characteristics by electronic models. Provision of hands-on experience for reinforcing lecture concepts in laboratories. Credit will not be given for both BAE 401 and BAE 501.

Prerequisite: BAE 305

*Typically offered in Spring only*

**BAE 502 Instrumentation for Hydrologic Applications** (3 credit hours)

Basic theory of instruments and measurements. Physical parameters of interest, available methods and sensors for assessment. Sensor characteristics. Dataloggers and sensor-datalogger communications. Data transfer, management, and processing. Emphasis on hydrologic and water quality research applications. Course offered by Distance Education only.

Prerequisite: MA 341, BAE 401 or ECE 331, ST 370 or ST 511

*Typically offered in Spring only*

**BAE 525/BAE 425 Industrial Microbiology and Bioprocessing** (3 credit hours)

Introduction to the structure and functions of microbial cells and their cultivation and utilization in Biological engineering processes. Topics covered include Fermentation systems and downstream processing methods. Enzyme kinetics, production and application. Biomanufacturing of fuels, industrial chemicals, food additives and food products such as beer, wine, cheese and yogurt, Microbial biomass production, Introduction to environmental biotechnology including wastewater treatment and bioremediation. Field trip is an essential educational component of the course and is required. Credit will not be given for both BAE 425 and BAE 525.

Prerequisite: Junior or higher standing in CALS or COE; MB 351

*Typically offered in Spring only*

**BAE 528 Biomass to Renewable Energy Processes** (3 credit hours)

This course will introduce fundamental principles and practical applications of biomass-to-renewable energy processes, including anaerobic digestion of organic wastes for biogas and hydrogen production, bioethanol production from starch and lignocellulosic materials, biodiesel production from plant oils, and thermoconversion of biomass and waste materials. Restricted to engineering seniors and graduate standing in COE, CALS, PAMS or CNR.

Prerequisite: Introductory Organic Chemistry or Biochemistry

*Typically offered in Fall only*

**BAE 535/BAE 435 Precision Agriculture Technology** (3 credit hours)

Overview of technology available for implementation of a comprehensive precision agriculture program. Topics include computers, GPS, sensors, mechanized soil sampling, variable rate control system, yield monitors, and postharvest processing controls. Applications of precision agriculture in crop planning, tillage, planting, chemical applications, harvesting and postharvest processing. Credit may not be received for BAE 435 and BAE 535.

Prerequisite: Junior standing or Senior standing

*Typically offered in Spring only*

*This course is offered alternate even years*

**BAE 536 GIS Applications in Precision Agriculture** (1 credit hours)

Exploration of geographic information systems (GIS) and its applications in precision agriculture. Topics will include file structure and formatting, interfacing with precision agriculture equipment, georeferencing maps, merging and clipping farm data, data field calculations, designing management zones, variable rate prescriptions, and basic data analysis.

Prerequisite: GIS 410 or GIS 510 or BAE 435 or BAE 535

*Typically offered in Spring only*

**BAE 542 SAS Advanced Analytics to Agriculture, Food and Life Sciences Data** (3 credit hours)

This course introduces students to the rapidly growing field of data science and its applications in predictive modeling within Agriculture, Food, and Life Sciences. Students will learn techniques to access, explore, validate, prepare, manipulate, analyze, and report on data. They will be able to create analysis flow diagrams for both pattern discovery (segmentation, association, and sequence analyses) and predictive modeling (decision trees, ensembles of trees like forests and gradient boosting, regression, logistic regression, neural networks, and support vector machines) in an interactive and exploratory manner.

Prerequisite: ST 525 or ST 512

*Typically offered in Fall and Spring*

**BAE 555/BAE 455 R Coding for Data Management and Analysis** (3 credit hours)

This course provides students with foundational coding skills in R, an open-source statistical software environment, as well as instruction on best practices for tidying, managing, and analyzing environmental and agricultural data, including geospatial, tabular, and time series observations. As this is an introductory course, prior programming experience is not required or expected. Coding approaches taught in the course will be targeted towards developing skills needed for summarizing data, creating data visualizations, and applying simple statistical models for analysis of environmental and agricultural data.

P: ST 311, or ST 370, or ST 512, or ST 515

*Typically offered in Fall only*



**BAE 560 Aerosol Science and Engineering** (3 credit hours)

This course is designed for students who have a desire to work in the area of air quality. It will provide students with fundamental knowledge of aerosol properties, behavior and physical principles, and with hands-on experience in applying this knowledge to aerosol/PM measurements and control.

Prerequisite: MA 341

*Typically offered in Fall only*

*This course is offered alternate even years*

**BAE 561 Agricultural Air Quality** (3 credit hours)

This course will prepare students to identify agricultural air pollutants and their sources, understand the on-farm and off-farm impacts of these pollutants, measure these pollutants, characterize and model the fate of these pollutants, and select and/or design cost-effective remediation measures. This course is restricted to seniors in engineering and MEAS, and graduate students in CALS, PAMS, and CNR.

Prerequisite: MA 341

*Typically offered in Spring only*

*This course is offered alternate even years*

**BAE 565 Environmental and Agricultural Analytics and Modeling** (3 credit hours)

This course provides students with a fundamental and practical understanding of data science and modeling approaches for environmental and agricultural systems analysis. The course is organized into three modules: (1) data retrieval, management, documentation, and visualization; (2) process-based modeling; and (3) data mining through statistical analysis and machine learning. Rather than develop a strong knowledge base in a specific methodology, students will gain broad and introductory understanding of a range of contemporary quantitative approaches and learn to think critically about the use of data analytics and models.

Prerequisite: Introductory statistics (e.g. ST 515) and experience coding in R (e.g. BAE 555)

*Typically offered in Spring only*

**BAE 572/BAE 472 Irrigation and Drainage** (3 credit hours)

Design, management and evaluation of irrigation and drainage systems; concepts and processes of system design. Credit will not be given for both BAE 472 and BAE 572.

Prerequisite: BAE 371

*Typically offered in Spring only*

**BAE 573/SSC 573/SSC 473/BAE 473 Introduction to Hydrologic and Water Quality Modeling** (3 credit hours)

Concepts in basic hydrologic, erosion and chemical transport used in modeling. Evaluation of typical hydrologic and water quality models on watershed systems. Project examples using state-of-the-art models. Credit will not be given for both BAE 473 and BAE 573.

Prerequisite: BAE 371

*Typically offered in Spring only*

**BAE 575 Design of Structural Stormwater Best Management Practices** (3 credit hours)

The design of structural stormwater Best Management Practices (BMPs) used in the urban and suburban environments is reviewed, including stormwater wetlands, bio-retention areas, sand filters, innovative wet ponds, green roofs, permeable pavement, and reinforced grass swales. The course is application oriented and includes a pair of field trips.

Prerequisite: BAE 471 or CE 383

*Typically offered in Spring only*

*This course is offered alternate odd years*

**BAE 577 Wetlands Design and Restoration** (3 credit hours)

Fundamental understanding of hydrology, soils and ecology of natural wetland systems will be developed to serve as the basis for designing wetland systems for water treatment and restoring degraded natural wetland systems. Stormwater and wastewater treatment wetland design and implementation concepts will be emphasized. Wetland restoration will also be studied with emphasis on current wetland regulations, design, and implementation techniques. Engineered wetland concepts will be supplemented with relevant case studies. Basic understanding of biology, soils, hydrology, and soil and water engineering is required.

*Typically offered in Spring only*

**BAE 578/BAE 478 Circular Approach to Manure Management** (3 credit hours)

This course teaches engineering principles of handling, treating, processing, and using animal and poultry manures and organic byproducts from the perspective of recovery and reuse of nitrogen, phosphorus, carbon, and components that have a negative impact on the local environment. Topics include waste characterization, descriptions of systems and technology, land application principles, biochemical/biological processes, and potential impacts to the environment. Assignments include homework, quizzes, projects, and discussions that emphasize teamwork, problem solving, and analysis.

Prerequisite: BAE 204 or AEC/PB 360 or PB 321 or SSC 332 or MB 351

*Typically offered in Fall only*

**BAE 580 Introduction to Land and Water Engineering** (3 credit hours)

This distance course introduces students to concepts of the hydrologic cycle, water quality, precipitation, evapotranspiration, infiltration, watershed delineation, surface runoff and open channel flow. Students will apply these concepts to an engineering design problem. This course is designed for non-engineering distance graduate students and lifelong education students and students from engineering disciplines outside of BAE. It will not substitute for BAE 471. The course is only open to students with senior standing or higher.

Prerequisite: MA 241

*Typically offered in Fall only*

**BAE 581 Open Channel Hydraulics for Natural Systems** (3 credit hours)

Theory and applications of hydraulics to open channels with an emphasis on natural streams and rivers. Course will introduce and develop principles of flow regimes (subcritical/critical/supercritical), and types (uniform flow, gradually varied and rapidly varied flow). Application will include hydraulics of flow measuring devices, step-backwater analysis and rating curve development, and flood studies using hydraulic models. A lab-scale flume will be used to illustrate concepts. Laptops will be used in class to learn and apply HEC-RAS (water surface profiles model). CE 382 or equivalent required. CE 381 recommended.

Prerequisite: CE 282 or equivalent. CE 381 recommended.

*Typically offered in Fall only*

*This course is offered alternate odd years*

**BAE 582 Risk and Failure Assessment of Stream Restoration Structures** (1 credit hours)

This course defines uncertainty and risk pertaining to stream restoration structures and identifies and quantifies sources of such. Students will review various in-stream structures and, using an example study of the rock cross vane as a guide, will investigate a structure of their choice applying the concepts of risk and uncertainty. Modules include: Introduction to structures and definitions; Types and modes of failure; Uncertainty in Stream Restoration Design; Probability of failures, cost of failures; and Failure modes and effects.

Prerequisite: CE 382 or MAE 308 or equivalent

*Typically offered in Spring only*

**BAE 583 Stream Corridor 3 Es: Ecohydraulics, Engineering and Ethics** (3 credit hours)

Overview of stream ecological and functional processes that structure stream corridors. Explore human interactions with streams including stream restoration structures and watershed scale practices that impact hydraulic, hydrologic, chemical, sedimentary and biotic functions. Discuss failure and risk analysis, policy and rights, and ethical use of our freshwater resources. As we move from a microscopic study of stream benthos to global-scale water concerns, students will develop a fluency in communicating human impacts on streams. Independent visits by students to a local stream required.

Restriction: Graduate or Senior Standing

*Typically offered in Spring only*

**BAE 584 Introduction to Fluvial Geomorphology** (3 credit hours)

This distance course provides an introduction to applied fluvial geomorphology as it relates to natural physical stream processes. Students will learn about watershed hydrology, stream gage data analysis, bankfull stage identification, hydraulic geometry relationships, stream channel assessment and classification, stream stability and channel evolution.

Prerequisite: BAE 471 or BAE 580

*Typically offered in Fall only*

**BAE 586/BAE 486 Aquacultural Engineering** (3 credit hours)

This course starts with a general background of aquaculture, both theoretical and practical. Based on this, engineering applications for both extensive (e.g. pond based) and intensive (e.g. recirculating aquaculture systems) culture systems are studied. Unit operations including biofiltration, aeration, degassing, sedimentation, pumps, piping and related topics, as well as mass balances provide quantitative engineering design tools. Transport, harvest, processing and food safety are discussed, and sustainability (ecological and environmental aspects of aquacultural engineering design) as well as cutting edge research in the area are covered. Field trips; guest lectures/discussion, and hands on work is included to provide practical applications and experience.

Prerequisite: CE 282 or MAE 308; Restrictive Statement: Senior Standing

*Typically offered in Spring only*

**BAE 587 Biogeochemical processes for Ecological engineering and Environmental Sciences** (3 credit hours)

The course provides the advanced theoretical knowledge of biogeochemical processes at play in man-made and natural filter systems, such as wetlands and other buffer systems, alleviating common pollutants associated with non-point source pollution, both in rural and suburban watersheds. Particular emphasis is put on the fate of excess nitrogen in these systems. This emphasis serves as a model for describing ecological engineering principles and quantifying processes at play for all pollutants. 20 students max. This course puts together biological, chemical, biochemical, and hydrological knowledge in one ensemble. Minimum proficiency in each of these is necessary to be able to follow the class with ease.

*Typically offered in Fall only*

**BAE 588 River Mechanics and Sediment Transport** (3 credit hours)

This course focuses on the physical processes that are governed by the dynamics of water and sediment within alluvial rivers. The overarching goals of the course are to examine the hydraulics of sediment transport and to apply analytical tools for predicting the results of flow-sediment interaction. Both theory and engineering calculations are covered.

Prerequisite: CE 282 or permission of instructor.

*Typically offered in Fall only*

*This course is offered alternate odd years*

**BAE 590 Special Problems** (1-6 credit hours)

Selection of a subject by each student on which to do research and write a technical report on the results. The individual may choose a subject pertaining to his or her particular interest in any area of study in biological and agricultural engineering.

Prerequisite: Senior standing or Graduate standing in Biological and Agricultural Engineering

**BAE 591 Master's Research Methods I** (1 credit hours)

This is the first in a series of research methods courses for MS students majoring in Biological and Agricultural Engineering. Students will develop research questions to be answered by their thesis project and produce a literature review focusing on those questions. Students will also observe formal seminar presentations, providing critiques and participating in discussions of proper seminar delivery. This course is restricted to MS students majoring in BAE.

*Typically offered in Fall only*

**BAE 592 Master's Research Methods II** (1 credit hours)

This is the second in a series of research methods courses for MS students majoring in Biological and Agricultural Engineering. Students will develop a research proposal for their thesis work and will present the proposal in a final seminar. This course is restricted to MS students majoring in BAE.

Prerequisite: BAE 591

*Typically offered in Spring only*

**BAE 593 Introduction to Research Communications** (1 credit hours)

This course introduces graduate students to the process of reading, analyzing, and communicating, in writing and multiple presentation formats, the findings of scientific literature searches. Students will progress from superficial reading to critical analysis of literature and will present their analyses in written, poster, presentation, and video formats. Related issues in research and professional communication will be discussed.

Prerequisite: Graduate Students in BAE Only

*Typically offered in Fall only*

**BAE 610 Special Topics** (1-6 credit hours)

A study of topics in the special fields of interest of graduate students under the direction of the graduate faculty.

Prerequisite: Graduate standing

*Typically offered in Fall only*

**BAE 620 Special Problems** (1-6 credit hours)

Selection of a subject by each student on which to do research and write a technical report on the results. The individual may choose a subject pertaining to his or her particular interest in any area of study in biological and agricultural engineering.

Prerequisite: Senior standing or Graduate standing in Biological and Agricultural Engineering

*Typically offered in Fall only*

**BAE 685 Master's Supervised Teaching** (1-3 credit hours)

Teaching experience under the mentorship of faculty who assist the student in planning for the teaching assignment, observe and provide feedback to the student during the teaching assignment, and evaluate the student upon completion of the assignment.

Prerequisite: Master's student

*Typically offered in Fall only*

**BAE 690 Master's Examination** (1-9 credit hours)

For students in non-thesis master's programs who have completed all other requirements of the degree except preparing for and taking the final master's exam.

Prerequisite: Master's student

*Typically offered in Fall, Spring, and Summer*

**BAE 693 Master's Supervised Research** (1-9 credit hours)

Instruction in research and research under the mentorship of a member of the Graduate Faculty.

Prerequisite: Master's student

*Typically offered in Fall only*

**BAE 695 Master's Thesis Research** (1-9 credit hours)

Thesis research.

Prerequisite: Master's student

*Typically offered in Fall, Spring, and Summer*

**BAE 696 Summer Thesis Research** (1 credit hours)

For graduate students whose programs of work specify no formal course work during a summer session and who will be devoting full time to thesis research.

Prerequisite: Master's student

*Typically offered in Summer only*

**BAE 699 Master's Thesis Preparation** (1-9 credit hours)

For students who have completed all credit hour requirements and full-time enrollment for the master's degree and are writing and defending their thesis.

Prerequisite: Master's student

*Typically offered in Fall and Spring*

**BAE 790 Special Topics** (1-6 credit hours)

Special topics in BAE.

**BAE 791 Doctoral Research Methods I** (1 credit hours)

This is the first in a series of research methods courses for PhD students majoring in Biological and Agricultural Engineering. Students will develop PhD level research questions to be answered in their dissertation project and will produce a PhD level literature review on those questions. Students will also observe seminars, providing critiques and discussions of proper seminar delivery. This course is restricted to PhD students majoring in BAE

*Typically offered in Fall only*

**BAE 792 Doctoral Research Methods II** (1 credit hours)

This is the second in a series of research methods for PhD students majoring in Biological and Agricultural Engineering. Students will develop a research proposal appropriate for their dissertation project and will present the proposal in both a practice and final seminar. The course is restricted to PhD students majoring in BAE.

Prerequisite: BAE 791

*Typically offered in Spring only*

**BAE 810 Special Topics** (1-6 credit hours)

A study of topics in the special fields of interest of graduate students under the direction of the graduate faculty.

*Typically offered in Fall only*

**BAE 820 Special Problems** (1-6 credit hours)

Selection of a subject by each student on which to do research and write a technical report on the results. The individual may choose a subject pertaining to his or her particular interest in any area of study in biological and agricultural engineering.

Prerequisite: Senior standing or Graduate standing in Biological and Agricultural Engineering

*Typically offered in Spring only*

**BAE 885 Doctoral Supervised Teaching** (1-3 credit hours)

Teaching experience under the mentorship of faculty who assist the student in planning for the teaching assignment, observe and provide feedback to the student during the teaching assignment, and evaluate the student upon completion of the assignment.

Prerequisite: Doctoral student

*Typically offered in Fall and Spring*

**BAE 890 Doctoral Preliminary Examination** (1-9 credit hours)

For students who are preparing for and taking written and/or oral preliminary exams.

Prerequisite: Doctoral student

*Typically offered in Fall, Spring, and Summer*

**BAE 893 Doctoral Supervised Research** (1-9 credit hours)

Instruction in research and research under the mentorship of a member of the Graduate Faculty.

Prerequisite: Doctoral student

*Typically offered in Fall and Spring*

**BAE 895 Doctoral Dissertation Research** (1-9 credit hours)

Dissertation research

Prerequisite: Doctoral student

*Typically offered in Fall, Spring, and Summer*

**BAE 896 Summer Dissertation Research** (1 credit hours)

For graduate students whose programs of work specify no formal course work during a summer session and who will be devoting full time to thesis research.

Prerequisite: Doctoral student

*Typically offered in Summer only*

**BAE 899 Doctoral Dissertation Preparation** (1-9 credit hours)

For students who have completed all credit hours, full-time enrollment, preliminary examination, and residency requirements for the doctoral degree, and are writing and defending their dissertation.

Prerequisite: Doctoral student

*Typically offered in Fall, Spring, and Summer*