BIORESOURCE & AGRICULTURAL ENGINEERING

BioResource & Agricultural Engineering Bldg. (08), Room 101
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Department Head: Peter Livingston

Academic Programs

Program name	Program type
Agricultural Systems Management	BS
BioResource and Agricultural Engineering	BS

The department offers two programs leading to a Bachelor of Science degree: BioResource and Agricultural Engineering and Agricultural Systems Management.

The BioResource and Agricultural Engineering Department is an engineering-based educational organization consisting of professionals whose mission is the study, teaching, and practice of engineering and systems management support for agriculture. The department is nationally recognized as a leader in this field, and for balancing theory with application and principle with practice.

Department facilities include well-equipped laboratories for hydraulic systems, evaluation and testing of power units, fabrication of agricultural machinery, agricultural electrical systems, design and construction of agricultural structures, photogrammetry, microcomputers and controllers.

Outdoor facilities include a water resources center with multiple pumping systems and operational canals, a field for evaluation of various irrigation systems including an operating linear move and land for experience in the mechanical production of farm products and safe operation of agricultural machinery.

Students are encouraged to participate in the student clubs of the department. The Agricultural Engineering Society is involved in a broad range of activities and services including Open House displays. The student branch of the American Society of Agricultural and Biological Engineers offers professional and co-curricular activities.

Undergraduate Programs

BS Agricultural Systems Management

The mission of the Agricultural Systems Management (ASM) program is to provide a "learn by doing" undergraduate educational experience that prepares students for systems management practice in support of agriculture and related industries throughout the West. The ASM program is ABET accredited by the Engineering Technology Accreditation Commission.

Students receive broad agricultural training with a business and management emphasis in one of the following areas: project management, construction management, plant production, livestock production, food and fiber processing, environmental information management, water/irrigation, and processing and manufacturing. Students have the opportunity to develop management expertise through interdisciplinary experiences in agricultural technology and business-oriented coursework.

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

- Individuals that are successful in technical, business, or management positions within agriculture or related industries
- Adapting to new challenges and opportunities through the application of acquire knowledge in agricultural systems management
- Actively pursuing professional development such as a degree in an advanced degree program, professional license, or technical certification

Agricultural Systems Management graduates demonstrate a knowledge and understanding of basic agricultural technologies and agribusiness principles necessary for technical operations and business management careers in agriculture and related industries; an understanding of modern science and practice within a specialized agricultural area of interest; and ability to apply quantitative, analytical processes for developing solutions to technological, business or management problems associated with production, processing, or the distribution of products and support services in agriculture and related industries; an understanding of the interconnected "systems" of agriculture; and ability to safely and properly handle the materials, machines, sensors, tools and techniques of modern agricultural or technical operations; and an ability to communicate and perform as effective agricultural systems management professionals in the solution of problems crossing discipline or cultural boundaries.

Career opportunities are available in the manufacturing, sales, service of agricultural equipment and machinery; construction management, management and production of animals and crops; processing of food and fiber; and management of water/irrigation facilities. The program is recognized by the American Society of Agricultural and Biological Engineers and is ABET accredited.

BS BioResource and Agricultural Engineering

The bioresource and agricultural engineering program develops one of the most versatile types 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 prepares 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 professional development such as a degree in an advanced degree program, professional license, or technical certification

- Applying unique engineering problem-solving skills and principles within a career outside traditional engineering environments, such as management, teaching, research, or other professional fields

BioResource and Agricultural Engineering graduates demonstrate a knowledge and understanding of the basic mathematics, physical and engineering sciences necessary for modern agricultural engineering practice; the ability to design components, systems or processes to meet specified objectives, including prudent use of resources; an understanding of their professional and ethical responsibilities as agricultural engineers, including the societal impact of engineering solutions and the need to engage in life-long learning; the ability to plan, design, execute and evaluate engineering solutions to problems/projects that are real, practical and of a complexity representative of projects encountered in beginning professional practice; and the ability to communicate and perform as effective engineering professionals in both individual and team-based project environments.

Cal Poly's "learn by doing" philosophy is emphasized by the numerous design-centered laboratories and the senior project. In the senior design project, which is completed in a three-quarter set of capstone courses, students demonstrate their understanding of engineering knowledge and their ability to apply that knowledge creatively to practical problems.

Consistent with program accreditation requirements regarding a graduate's ability to function on teams, the BioResource and Agricultural Engineering program has adopted an explicit graduation requirement in this area. This provides students an opportunity to practice team skills. Such experience is important for practicing engineers given the ever-increasing diversity of engineering science and applications. Methods to fulfill this requirement include items such as:

- Team design project
- CO-OP or internship employment
- Certain club activities
- Working with faculty on a sponsored project
- Project embedded in curriculum
- Taking certain technical electives
- Service learning project

Career opportunities exist in the design, evaluation and management of systems – water resources, irrigation, drainage, groundwater, pumps, soil conservation; agricultural power and machinery; food processing; energy; and agricultural environments. The program is accredited by the Engineering Accreditation Commission of ABET (http://www.abet.org).

Minors

The department participates in offering interdisciplinary minors in Water Science and Geographic Information Systems. Please see College of Agriculture, Food and Environmental Sciences (https://catalog.calpoly.edu/collegesandprograms/collegeofagriculturefoodenvironmentalsciences/) section for more information.

Graduate Program

Cal Poly offers the MS in Agriculture with specializations in BioResource and Agricultural Systems and in Irrigation, and Water Engineering. Please see College of Agriculture, Food and Environmental Sciences (https://catalog.calpoly.edu/collegesandprograms/collegeofagriculturefoodenvironmentalsciences/) section for more information.

BRAE Courses

BRAE 121. Agricultural Mechanics. 2 units
Term Typically Offered: F, W
Identification and use of tools and materials; shop safety; tool sharpening and care; concrete mixes and materials; simple electric wiring; metal work; pipe fitting; basic woodworking; estimating quantities and costs. Students are required to meet safety regulations in laboratory work. 1 lecture, 1 laboratory.

BRAE 128. Careers in Bioresource and Agricultural Engineering. 2 units
Term Typically Offered: F
Introduction to careers associated with BioResource and Agricultural Engineering, and Agricultural Systems Management. Professional engineering registration process. Engineering problem solution and report format. Design procedures. Engineering fundamentals. Laboratory includes visits to facilities relating to career opportunities. 1 lecture, 1 laboratory.

BRAE 129. Laboratory Skills and Safety. 1 unit
Term Typically Offered: F, W
Prerequisite: BRAE and ASM majors only.

Introduction to fabrication and construction materials used in the field of Agricultural Engineering. Fabrication skills in the development of wood, metal, concrete projects, and creative design. Strength tests of wood, fasteners, concrete, and student design projects. 1 laboratory.

BRAE 141. Agricultural Machinery Safety. 3 units
Term Typically Offered: F, SP
Evaluation of safe tractor and equipment operation. Supervised field operation emphasizing the safe and efficient performance of modern farm and utility-industrial equipment. 2 lectures, 1 laboratory.

BRAE 142. Agricultural Power and Machinery Management. 4 units
Term Typically Offered: F
Prerequisite: MATH 116 or equivalent.

Evaluation of agricultural machinery and tractor power performance. Equipment studied includes primary and secondary tillage tools, grain drills, row crop planters, sprayers, grain and forage harvesters, and specialty crop harvesters. Emphasis on management, selection, cost analysis using computers and efficient operation of agricultural machinery. 3 lectures, 1 laboratory.

BRAE 150. Design Graphics and CAD for Agricultural Engineering. 2 units
Term Typically Offered: F, W
Visual communication in engineering design and problem solving. Principles of freehand sketching, and computer-aided-drafting. Computer aided drafting using CAD software. 2-D projections including automatic dimensioning and hatching. Plan set development and external references. Land grading design, using 3-D drawing software. Not open to students with credit in BRAE 133 and BRAE 151. 2 laboratories.

BRAE 152. 3-D Solids Modeling. 1 unit
Term Typically Offered: W, SP
Prerequisite: BRAE 133 and BRAE 151; or BRAE 150.

Introduction to 3-dimensional solids modeling using state-of-the-art software. Model generation and modification of associative properties, assembly modeling, extrusions and revolutions. 1 laboratory.

BRAE 200. Special Problems for Undergraduates. 1-4 units
Term Typically Offered: F, W, SP
Prerequisite: Consent of department head.

Individual investigation, research, studies or surveys of selected problems. Total credit limited to 8 units, with a maximum of 4 units per quarter.

BRAE 203. Agricultural Systems Analysis. 4 units
Term Typically Offered: W
Prerequisite: MATH 118 or equivalent.

Agricultural Systems Analysis investigates the interrelationships between sub-components in an overall system. Problem solving algorithms, network analysis, project planning techniques, and optimization. 2 lectures, 2 activities.

BRAE 213. Bioengineering Fundamentals. 2 units
Term Typically Offered: F, W, SP
2020-21 or later catalog: GE Area B2
2019-20 or earlier catalog: GE Area B2
Sustainability Related
Prerequisite: MATH 142; for engineering students only. Corequisite: BIO 213. Recommended: CHEM 124.

Treatment of the engineering applications of biology. Genetic engineering and the industrial application of microbiology. Systems physiology with engineering applications. Structure and function relationships in biological systems. The impact of life on its environment. Course may be offered in classroom-based or online format. 2 lectures. Crosslisted as BMED/BRAE 213. Fulfills GE B2.

BRAE 216. Fundamentals of Electricity. 4 units
Term Typically Offered: F
Prerequisite: BRAE 129; MATH 142; and PHYS 131 or PHYS 141.

Application of electricity in BioResource and Agricultural Engineering, including basic electric circuits. Will include wiring materials, code regulations, electrical measurements, R-L-C circuit fundamentals, system planning, motors, basic electronics, and an introduction to computer usage. 3 lectures, 1 laboratory.

BRAE 220. Introduction to Biological Systems. 4 units
Term Typically Offered: F, W
2020-21 or later catalog: GE Area B2
2020-21 or later catalog: GE Area B3
2019-20 or earlier catalog: GE Area B2
2019-20 or earlier catalog: GE Area B4
Sustainability Focused
Prerequisite: MATH 141, MATH 161, or MATH 221. Recommended. Corequisite: CHEM 124 or CHEM 127.

Systems approach to introductory life science that focuses on patterns and cycles in biology. Introductory modeling and quantitative measurement of life science parameters. Emphasis on the interaction between organisms and their environment. Course may be offered in classroom-based or hybrid format. 3 lectures, 1 laboratory. Fulfills GE Areas B2 and B3 (GE Areas B2 and B4 for students on the 2019-20 or earlier catalogs).

BRAE 232. Agricultural Structures Planning. 4 units
Term Typically Offered: SP
Prerequisite: BRAE 129; BRAE 150 or BRAE 151; and PHYS 132 or PHYS 142.

Planning of facilities required in production systems. Materials and processes used in construction of agricultural structures. Environmental factors affecting crop storage structures and animal housing. Design of structural environments to meet the needs of commodities, animals, and plants. 3 lectures, 1 laboratory.

BRAE 234. Introduction to Mechanical Systems in Agriculture. 4 units
Term Typically Offered: SP
Prerequisite: BRAE 152; and PHYS 131 or PHYS 141.

Introduction to elements used in the mechanical transmission of power and force in agricultural systems. Power transmission using v-belts. roller chain, gear and shaft drives, hydraulic actuators. Linear and nonlinear actuation devices including linkages, cams, and hydraulic/pneumatic cylinders. 3 lectures, 1 laboratory.

BRAE 236. Principles of Irrigation. 4 units
Term Typically Offered: F
Prerequisite: MATH 141.

Land grading design, operation, management, and evaluation of irrigation methods. 3 lectures, 1 laboratory.

BRAE 237. Introduction to Engineering Surveying. 2 units
Term Typically Offered: F, W, SP
Prerequisite: MATH 119.

Introduction to field measurement using automatic levels, total stations, robotic stations, GNSS RTK receivers and field data collectors. Field procedures for differential and profile leveling, directional measurement, traversing and construction surveying. An understanding in direction, elevation and earthwork volume computations. 1 lecture, 1 laboratory.

BRAE 239. Engineering Surveying. 4 units
Term Typically Offered: F, W, SP
Prerequisite: MATH 119.

Field measurement using levels, robotic stations, RTK receivers, data collectors. Leveling, profiles, traverses, traverse adjustment, triangulation, earthwork volumes and curve alignment computations. Topographic surveys, topographic mapping, building layout, road design. Topics as geodetic survey, licensing, aerial mapping, GIS, and remote sensing. 2 lectures, 2 laboratories.

BRAE 240. Agricultural Engineering Laboratory. 1 unit
Term Typically Offered: TBD
Prerequisite: Consent of instructor.

Individual projects. Total credit limited to 4 units. 1 laboratory.

BRAE 244. Precision Farming. 4 units
Term Typically Offered: W
Prerequisite: One of the following: PLSC 133, PLSC 190, PLSC 260, BRAE 237, or BRAE 239.

Precision agriculture applications. Integrating GIS, GPS, and remote sensing technologies with site-specific farming practices to optimize agricultural productivity. Field trip required. 3 lectures, 1 laboratory. Crosslisted as BRAE/PLSC 244.

BRAE 247. Forest Surveying. 2 units
Term Typically Offered: TBD
Prerequisite: NR 215.

Use and care of tapes, staff compass, abney levels, total stations, and GPS receivers. Keeping field notes, measurements by tape. Closed and open traverse by compass and total stations. Turning angles and determining directions of lines. Map reading and public land description. GPS measurements. Weekend field trips required. 1 lecture, 1 laboratory. Crosslisted as BRAE/NR 247.

BRAE 270. Selected Topics. 1-4 units
Term Typically Offered: TBD
Prerequisite: Open to undergraduate students and consent of instructor.

Directed group study of selected topics. The Class Schedule will list topic selected. Total credit limited to 8 units. 1 to 4 lectures.

BRAE 301. Hydraulic and Mechanical Power Systems. 4 units
Term Typically Offered: SP
Prerequisite: BRAE 152; and PHYS 121 or PHYS 141.

Selection, application and use of hydraulic components and mechanical power transmission equipment. Use of standardized circuit design procedures. 3 lectures, 1 laboratory.

BRAE 302. Servo Hydraulics. 4 units
Term Typically Offered: W
Prerequisite: BRAE 216 or BRAE 324 and BRAE 234 or BRAE 301.

Application of microcomputers and programmable logic controllers to hydraulic, pneumatic and mechanical systems. Theory, instrumentation and sensors used in process and control systems used in agricultural equipment. 3 lectures, 1 laboratory.

BRAE 312. Hydraulics. 4 units
Term Typically Offered: F
Prerequisite: PHYS 132 or PHYS 142, ME 211.

Static and dynamic characteristics of liquids, flow in open and closed channels, uniform and nonuniform flow, flow measurement, pumps. 3 lectures, 1 laboratory.

BRAE 317. Agricultural Systems Management Theory. 4 units
Term Typically Offered: W
Prerequisite: BRAE 203.

Introduction to systems and technical management with application in agricultural business settings, including logistics, reliability, system behavior, causal loops, feedback and delay. Data analysis, systematic decision-making, and simulation. Field trip required. 4 lectures.

BRAE 320. Principles of Bioresource Engineering. 4 units
Term Typically Offered: SP
Prerequisite: BRAE 232; BRAE 236; CHEM 125; and PHYS 132 or PHYS 142.

Theory and applications of bioprocess technology in biological and agricultural systems. Engineering properties of biological materials and organisms. Basic unit operations, fluid mechanics and heat/mass transfer as applied to bioprocess technology. Special requirements of agricultural and biological processes. 3 lectures, 1 laboratory.

BRAE 321. Agricultural Safety. 3 units
Term Typically Offered: W
Prerequisite: Junior standing.

Principles of agricultural safety. Accident causation and prevention, hazard identification and abatement, laws and regulations. Machinery, electrical, chemical, livestock, shop and fire safety. Safety program development. 2 lectures, 1 activity.

BRAE 324. Principles of Agricultural Electrification. 4 units
Term Typically Offered: W
Prerequisite: MATH 119, PHYS 121.

Applications of DC/AC electricity in agriculture. National Electric Code regulations. The wiring of agricultural structures and electrical distribution. Series, parallel and series-parallel circuits, R-L-C circuits, electric motors, electronics. 3 lectures, 1 laboratory.

BRAE 328. Measurements and Computer Interfacing. 4 units
Term Typically Offered: W
Prerequisite: EE 321; EE 361; and CSC 231 or CSC 232 or CSC 234.

Transducers and engineering measurements in agricultural engineering. Covering transducer characteristics, signal processors and controllers, instrumentation techniques, and the use of the computer in the measurement and control of typical engineering problems. 3 lectures, 1 laboratory.

BRAE 331. Irrigation Theory. 3 units
Term Typically Offered: W
Prerequisite: BRAE 236 or BRAE 340; MATH 141.

Plant-water-soil relations examining evapotranspiration, plant stress, soil moisture depletion, irrigation frequency and depth, salinity management, infiltration, drainage and climate control. 3 lectures.

BRAE 332. Environmental Controls for Agricultural Structures. 4 units
Term Typically Offered: SP
Prerequisite: BRAE 232.

Design of internal environments to meet the needs of commodities, animals, and plants. Thermodynamic and psychrometric principles for agricultural structures. Heat transfer, insulation and refrigeration. Sensing, monitoring and controlling environmental factors affecting crop storage structures and animal housing. 2 lectures, 2 activities.

BRAE 333. Aquacultural Engineering. 3 units
Term Typically Offered: F
Prerequisite: Junior standing and MATH 118.

Application of aquacultural engineering principles for freshwater and marine food-production systems. Examination of system design constraints for maximizing productivity and minimizing environmental impacts, nutrient management, gas exchange and animal husbandry. Field trip required. 2 lectures, 1 laboratory.

BRAE 335. Internal Combustion Engines. 4 units
Term Typically Offered: W
Prerequisite: Junior standing.

Principles of operation of internal combustion engines. Theory of operation and diagnosis evaluation and repair of small engines, gasoline and diesel engines and economics of operation, use and repair. Power analysis and application. 3 lectures, 1 laboratory.

BRAE 337. Landscape Irrigation. 4 units
Term Typically Offered: W
Prerequisite: MATH 118.

Design of sprinkler and drip irrigation systems including: site characteristics, soil variables affecting water storage and infiltration rate, plant selection and hydrozones, hydraulics, nozzle spacing, selection of system components, back flow prevention, plumbing codes and cost estimating. Irrigation system evaluation and audit irrigation scheduling, and water budget. 3 lectures, 1 laboratory.

BRAE 339. Internship in Bioresource and Agricultural Engineering. 1-12 units
Term Typically Offered: F, W, SP
CR/NC
Prerequisite: Consent of internship instructor.

Students will spend up to 12 weeks with an approved agricultural firm engaged in production or related business. Time will be spent applying and developing production and managerial skills and abilities. One unit of credit may be allowed for each full week of completed and reported internship. Degree credit limited to 6 units. Credit/No Credit grading only.

BRAE 340. Irrigation Water Management. 4 units
Term Typically Offered: F, W, SP
2020-21 or later: Upper-Div GE Area B
2019-20 or earlier catalog: GE Area B5, B6, or B7
Prerequisite: Junior standing; completion of GE Area A with grades of C- or better; completion of one course in GE Area B4 with a grade of C- or better (GE Area B1 for students on the 2019-20 or earlier catalogs).

California water supply and budget; water rights and issues. Local, state and federal water institutions. Water measurement; basic hydraulics; irrigation systems; distribution uniformity and efficiency. Soil-plant-water relationships; soil moisture measurement; evapotranspiration; irrigation schedules; practical constraints affecting scheduling; salinity and drainage. Course may be offered in classroom-based, online, or hybrid format. 3 lectures, 1 laboratory. Fulfills GE Area Upper-Division B (GE Areas B5, B6, or B7 for students on the 2019-20 catalog).

BRAE 342. Agricultural Materials. 4 units
Term Typically Offered: F
Prerequisite: PHYS 121; SS 120 or SS 121; and MATH 119.

Physical properties of agricultural materials and their measurement. Strength of materials, material flow and transport, material deformation, shape and size classification, moisture relationships and biological interactions. Interactions between agricultural materials, the environment and equipment used to handle them. 3 lectures, 1 laboratory.

BRAE 343. Mechanical Systems Analysis. 4 units
Term Typically Offered: W
Prerequisite: BRAE 342.

Use of statics and dynamics to make original calculations, plans, sketches, graphics, drawings, schemes and layouts for the fabrication and construction of machines. 3 lectures, 1 laboratory.

BRAE 344. Fabrication Systems. 4 units
Term Typically Offered: SP
Prerequisite: BRAE 343.

Fabrication systems including cutting, sawing, shearing, bending, welding, grinding, cleaning, painting and proper safety procedures. Experimental projects to include team design and construction, presentation, organization, and evaluation. 2 lectures, 2 laboratories.

BRAE 345. Aerial Photogrammetry and Remote Sensing. 3 units
Term Typically Offered: F, W
Prerequisite: MATH 118.

Concepts of photogrammetry and remote sensing. Object recognition, stereoscopic viewing, elevation determination, and scale. State-of-the-art techniques for collecting, processing, and interpreting remote sensing data. Digital image analysis techniques such as image enhancement, change detection, unsupervised and supervised classifications. 2 lectures, 1 laboratory.

BRAE 348. Energy for a Sustainable Society. 4 units
Term Typically Offered: F, W, SP
2020-21 or later: Upper-Div GE Area B
2019-20 or earlier catalog: GE Area B5, B6, or B7
Sustainability Focused
Prerequisite: Junior standing; completion of GE Area A with grades of C- or better; completion of one course in GE Area B4 with a grade of C- or better (GE Area B1 for students on the 2019-20 or earlier catalogs).

Study of how the transition can be made from fossil fuels to renewable energy sources including hydro, biomass, solar, wind, and energy conservation. Environmental, economic, and political consequences of a renewable energy-based sustainable society. 3 lectures, 1 activity. Fulfills GE Area Upper-Division B (GE Areas B5, B6, or B7 for students on the 2019-20 catalog).

BRAE 349. Water for a Sustainable Society. 4 units
Term Typically Offered: F, W, SP
2020-21 or later: Upper-Div GE Area D
2019-20 or earlier catalog: GE Area D5
Prerequisite: Junior standing; completion of GE Area A with grades of C- or better; one course in GE Area B4 with a grade of C- or better (GE Area B1 for students on the 2019-20 or earlier catalogs); and two lower-division courses in GE Area D.

Historical, political, economic, socio-technical, and cultural dimensions of water sustainability. Overview of complex systems with an emphasis on individual choices and their impact on water sustainability. Exploration of core sustainability concepts; practices, barriers and goals related to water resources. Course offered online only. 4 lectures. Crosslisted BRAE/NR 349. Fulfills GE Upper-Division D (GE Area D5 for students on the 2019-20 or earlier catalogs).

BRAE 355. Drone Assisted Surveying. 4 units
Term Typically Offered: F, SP
Prerequisite: BRAE 237 or BRAE 239.

Integration of remote sensing, surveying, natural resource management, applied drone technology. Understanding laws, regulations, measurement concepts, and big data. Field applications using Unmanned Aerial Systems and Global Navigation Satellite Systems. Creation of maps and supporting documents for use in GIS. 2 lectures, 2 laboratories. Crosslisted as BRAE/NR 355.

BRAE 400. Special Problems. 1-4 units
Term Typically Offered: F, W, SP
Prerequisite: Consent of department head.

Individual investigation, research, studies, or surveys of selected problems in agriculture. Total credit limited to 8 units, with a maximum of 4 units per quarter.

BRAE 403. Agricultural Systems Engineering. 4 units
Term Typically Offered: SP
Prerequisite: MATH 242 or MATH 244. Corequisite: STAT 312.

Engineering and economic principles combined with mathematical optimization techniques to evaluate parameters in agricultural production and processing systems. Project planning techniques, linear and nonlinear modeling, response surface methodology. Professional responsibilities in Agricultural Engineering including ethics, patents, copyrights, liability. 3 lectures, 1 laboratory.

BRAE 405. Chemigation. 1 unit
Term Typically Offered: F
Prerequisite: BRAE 236 or BRAE 340; or graduate standing.

Fertilizer and chemical injection through irrigation systems. Hardware, fertilizer compounds, and distribution uniformity. Matching chemicals and equipment to specific irrigation methods. Safety. 1 laboratory.

BRAE 414. Irrigation Engineering. 4 units
Term Typically Offered: SP
Prerequisite: BRAE 331 or BRAE 340; BRAE 312 with a grade of C or better; or graduate standing.

Design of on-farm irrigation systems; micro, surface, and sprinkler irrigation systems; canals and pumps; economic and strategies of pipe design; pipeline protection. 3 lectures, 1 laboratory.

BRAE 418. Agricultural Systems Management I. 4 units
Term Typically Offered: F
Prerequisite: BRAE 203; AGB 310; and completion of GE Area A3 with a grade of C- or better; or graduate standing.

Project management of agricultural systems. Emphasis placed on a team approach to problem solution. Case studies and student projects used to explore the following topics: project leadership, project organization, communication, needs assessment, feasibility studies, cost analysis, decision making, solution implementation, and evaluation. 3 lectures, 1 laboratory.

BRAE 419. Agricultural Systems Management II. 4 units
Term Typically Offered: W
Prerequisite: BRAE 418.

Project management of agricultural systems. Emphasis placed on a team approach to problem solution. Case studies and student projects used to explore the following topics: project leadership, project organization, communication, needs assessment, feasibility studies, cost analysis, decision making, solution implementation, and evaluation. 2 lectures, 2 laboratories.

BRAE 421. Equipment Engineering I. 4 units
Term Typically Offered: F
Prerequisite: BRAE 152; CE 204; and ME 212.

Design of specialized agricultural components and equipment. 3 lectures, 1 laboratory.

BRAE 422. Equipment Engineering II. 4 units
Term Typically Offered: W
Prerequisite: BRAE 421.

Fabrication and construction of specialized agricultural components and equipment. 2 lectures, 2 laboratories.

BRAE 425. Computer Controls for Agriculture. 3 units
Term Typically Offered: SP
Prerequisite: BRAE 324.

Computer activated controls as applied to agricultural machinery, agricultural structures, processing and irrigation industries. Encompassing control logic to evaluate stability behavior of systems of computer interfacing, data input and control output. 2 lectures, 1 laboratory.

BRAE 428. Agricultural Robotics and Automation. 4 units
Term Typically Offered: SP
Prerequisite: BRAE 328.

Agricultural applications of signal processing, control theories, machine vision and robot basics for agricultural production and processing. Approaches and constraints related to agricultural automation and the use of robotics in field applications. Engineering approach to problem-solving and experimental data analysis. Field trip required. 3 lectures, 1 laboratory.

BRAE 432. Agricultural Buildings. 4 units
Term Typically Offered: SP
Prerequisite: PHYS 121, BRAE 342, BRAE 343.

Selection of buildings, storage units, and related equipment for production agriculture. Economics and functionality of various designs and construction materials. Environmental factors affecting crop storage and animal housing. 3 lectures, 1 laboratory.

BRAE 433. Agricultural Structures Design. 4 units
Term Typically Offered: F
Prerequisite: BRAE 232, CE 204.

Structural analysis and design of agricultural service and processing buildings. Emphasis on use of wood, metals, and reinforced concrete in light construction. 3 lectures, 1 laboratory.

BRAE 434. Automotive Engineering for a Sustainable Future. 4 units
Term Typically Offered: W
Prerequisite: Junior standing in any engineering or physical science major.

Multidisciplinary investigation of automotive renewable fuels and electric/hybrid vehicles. Analyze and design related technologies and systems. Methods for complete-cycle energy and GHG analysis. Comparative emissions, efficiency, power output, and infrastructure requirements. Laboratory projects converting engines and vehicles to operate on alternative fuels or electric propulsion. 3 lectures, 1 laboratory. Crosslisted as BRAE/EE 434.

BRAE 435. Drainage. 4 units
Term Typically Offered: TBD
Prerequisite: BRAE 312 or BRAE 340; or graduate standing.

Relevant principles of hydrology and porous media flow. Flow nets, wells and ground water, design of simple surface and sub-surface drains. 3 lectures, 1 laboratory.

BRAE 436. Food and Agriculture Process Water Engineering. 4 units
Term Typically Offered: W
Prerequisite: one of the following: BIO 111, BIO 161, BOT 121, BRAE 213, or MCRO 221; and CHEM 125 or CHEM 128.

Theory and design of facilities for physical and chemical treatment of water used in agricultural practices to sanitize crops as they are harvested, and water used while processing the commodities. This course also includes the design of chemical and biological reactors. 3 lectures, 1 activity.

BRAE 438. Drip/Micro Irrigation. 4 units
Term Typically Offered: W
Prerequisite: BRAE 236 or BRAE 340; or graduate standing.

Drip/micro irrigation hardware and management. Emphasizes agricultural drip/micro irrigation with some landscape application. Filtration, emitters, chemical injection, agronomic constraints, and scheduling. Field trip(s) included. 3 lectures, 1 laboratory.

BRAE 440. Agricultural Irrigation Systems. 4 units
Term Typically Offered: SP
Prerequisite: BRAE 340 or graduate standing.

On-farm irrigation system evaluation and management. Drip, micro-spray, furrow, border strip, sprinkler systems. Irrigation efficiency and uniformity. Pumping costs. For non-BRAE majors only. 3 lectures, 1 laboratory.

BRAE 447. Advanced Surveying with GIS Applications. 4 units
Term Typically Offered: SP
Prerequisite: BRAE 239.

Field skills in precise mapping, high order control and terrestrial imagery. CAD mapping and design. Work with large datasets on regional surface models. Collect, manipulate data for GIS. Basics of boundary law and limitations of using land boundaries in GIS. 2 lectures, 2 laboratories.

BRAE 448. Bioconversion. 4 units
Term Typically Offered: TBD
Prerequisite: MATH 118 or equivalent.

Biological, thermal and physical techniques for converting biomass into useful energy forms for agriculture and industry. Laboratory exercises include experiments with anaerobic digestion of animal wastes into methane, ethanol fermentation of grains and composting of agricultural residues. Technical and economic feasibility of biofuels. 3 lectures, 1 laboratory.

BRAE 450. Solar Photovoltaic System Engineering. 4 units
Term Typically Offered: SP
Prerequisite: one of the following: PHYS 104; PHYS 118; PHYS 121; or PHYS 141; and junior standing.

Engineering principles, design, and installation of solar photovoltaic power systems including grid-tie and off-grid systems. Photonic energy conversion, solar module engineering, solar power electronics, photovoltaic site planning, mechanical and structural considerations, permit processes, government incentives, and analysis of financial and investment issues. Field trips required. 3 lectures, 1 laboratory. Crosslisted as BRAE/EE/HNRS 450.

BRAE 460. Senior Project Organization. 1 unit
Term Typically Offered: F
Prerequisite: Completion of GE Area A3 with a grade of C- or better.

Selection and organization of senior project. Involves time management, research techniques, budgeting and project presentation. Documentation of multidisciplinary team experience. 1 laboratory.

BRAE 461. Senior Project I. 2 units
Term Typically Offered: SP
Prerequisite: BRAE 460.

Solution of an engineering or systems management problem in agriculture. May involve research methodology, problem statement, analysis, synthesis, project design, construction, and evaluation. Project requires 150 hours with a minimum of faculty supervision.

BRAE 462. Senior Project II. 2 units
Term Typically Offered: TBD
Prerequisite: BRAE 461.

Solution of an engineering or systems management problem in agriculture. May involve research methodology, problem statement, analysis, synthesis, project design, construction, and evaluation. Project requires 150 hours with a minimum of faculty supervision.

BRAE 465. Senior Project Operation, Testing, and Safety. 2 units
Term Typically Offered: SP
Prerequisite: BRAE 419 or BRAE 422; and BRAE 460.

Final course in the senior design series. Preparation of an Operation, Maintenance and Safety manual for projects fabricated in the earlier courses. Develop a memorandum and video documenting the design, fabrication, and testing phases. Final oral presentation for each group. 1 lecture, 1 laboratory.

BRAE 470. Selected Advanced Topics. 1-4 units
Term Typically Offered: TBD
Prerequisite: Consent of instructor.

Directed group study of selected topics for advanced students. Open to undergraduate and graduate students. Class Schedule will list topic selected. Total credit limited to 8 units. 1-4 lectures.

BRAE 471. Selected Advanced Laboratory. 1-4 units
Term Typically Offered: TBD
Prerequisite: Consent of instructor.

Directed group laboratory study of selected topics for advanced students. Open to undergraduate and graduate students. The Class Schedule will list topic selected. Total credit limited to 8 units. 1 to 4 laboratories.

BRAE 481. Advanced Agricultural Mechanics. 2 units
Term Typically Offered: SP
Prerequisite: Agricultural teacher candidates starting/returning from student teaching, senior or graduate standing or consent of instructor.

Advanced shop skills. Carpentry, electricity, plumbing, surveying, power mechanics, tractor equipment operation and maintenance. 1 lecture, 1 laboratory.

BRAE 485. Cooperative Education Experience in BioResource and Agricultural Engineering. 6 units
Term Typically Offered: SP
CR/NC
Prerequisite: Sophomore standing and consent of instructor.

Part-time work experience with an approved BioResource and Agricultural Engineering firm engaged in production or related business, industry or governmental agency. Positions are paid and usually require relocation and registration in course for two consecutive quarters. Formal report and evaluation by work supervisor required. Major credit limited to 4 units; total credit limited to 12 units. Credit/No Credit grading only.

BRAE 495. Cooperative Education Experience in BioResource and Agricultural Engineering. 12 units
Term Typically Offered: TBD
CR/NC
Prerequisite: Sophomore standing and consent of instructor.

Full time work experience with an approved BioResource and Agricultural Engineering firm engaged in production or related business, industry or governmental agency. Positions are paid and usually require relocation and registration in course for two consecutive quarters. Formal report and evaluation by work supervisor required. Major credit limited to 4 units; total credit limited to 12 units. Credit/No Credit grading only.

BRAE 500. Individual Study. 1-3 units
Term Typically Offered: F, W, SP
Prerequisite: Consent of instructor.

Advanced study planned and completed under the direction of a member of the department faculty. Open only to graduate students who have demonstrated ability to do independent work. Enrollment by petition. Total credit limited to 6 units, repeatable in same term.

BRAE 532. Water Wells and Pumps. 4 units
Term Typically Offered: SP
Prerequisite: BRAE 312 or BRAE 340 or CE 336 or ME 341.

Water well drilling, design, and development. Pump characteristics and system head. Series and parallel operation. Design of pump intakes. Variable speed electric drives and engines. Pump testing. 3 lectures, 1 laboratory.

BRAE 533. Irrigation Project Design. 4 units
Term Typically Offered: W
Prerequisite: BRAE 312, BRAE 340 or equivalent (hydraulics/fluid mechanics course).

Advanced open channel and pipeline controls for unsteady flow. Social aspects of improved water delivery to customers. Engineering solutions for modernizing irrigation projects, including open-channel flow measurement, advanced control structure design, determining capacities, and Supervisory Control and Data Acquisition (SCADA) systems. 3 lectures, 1 laboratory.

BRAE 570. Selected Advanced Topics in BioResource and Agricultural Engineering. 1-4 units
Term Typically Offered: TBD
Prerequisite: Graduate standing or consent of instructor.

Directed group study of selected topics for advanced students. Open to undergraduate and graduate students. The Class Schedule will list topic selected. Total credit limited to 12 units. 1 to 4 seminars.

BRAE 571. Selected Advanced Laboratory in Bioresources and Agricultural Engineering. 1-4 units
Term Typically Offered: TBD
Prerequisite: Consent of instructor.

Directed group laboratory study of selected topics for advanced students. Open to undergraduate and graduate students. The Class Schedule will list topic selected. Total credit limited to 8 units. 1 to 4 laboratories.

BRAE 599. Thesis in BioResource and Agricultural Engineering. 1-9 units
Term Typically Offered: F, W, SP
Prerequisite: Graduate standing and consent of instructor.

Systematic research of a significant problem in bioresource and agricultural engineering. Thesis will include problem identification, significance, methods, data analysis, and conclusion. Students must enroll every quarter in which facilities are used or advisement is received. Degree credit limited to 6 units.