BE 142 Introduction to Biological Engineering
2 credits
An introduction to biological engineering and the engineering principles used to solve biological engineering problems. Fields of study within biological engineering will be discussed including agricultural, bioenergy, biomedical, bioprocess, ecohydrological and environmental engineering. Students will work on a team-based engineering project. One lecture and one 3-hour lab a week.

BE 204 (s) Special Topics
Credit arranged.

BE 242 Biological Engineering Analysis and Design
3 credits
Methods of analyzing and solving engineering problems; introduction to elements of biological engineering design; use of computers in engineering problem solving.
Prereq: MATH 170
Coreq: MATH 175.

BE 299 (s) Directed Study
Credit arranged.

BE 355 Fundamentals of Hydrologic Engineering
3 credits
Cross-listed CE 325
Principles of hydrologic science and their application to the solution of hydraulic, hydrologic, environmental, and water resources engineering problems.
Prereq: MATH 310, STAT 301, and ENGR 335. A minimum grade of 'C' or better is required for all pre/coreqs.

BE 361 Transport Processes in Biological Systems
3 credits
The course will familiarize students with transport phenomena processes involved in bio-related fields spanning from agricultural to environmental and medical to pharmaceutical.
Prereq: ENGR 320 and ENGR 335.

BE 398 (s) Engineering Cooperative Internship
Credit arranged
Supervised internship in professional engineering settings, integrating academic study with work experience; details of the co-op to be arranged with supervising professor before the start of the co-op; requires written report. Graded P/F. Cannot be used for technical elective.
Prereq: Permission.

BE 404 (s) Special Topics
Credit arranged.

BE 411 (s) Industrial Energy Efficiency
1 credit, max 6
This course will provide students an understanding of major industrial energy consuming equipment, diagnostics of energy inefficiencies, and instrumentation for baselining energy efficiency. Students will learn energy auditing and report writing with improvement recommendations including cost analysis. Each semester will cover a specific topic such as "process heating and refrigeration" or "motors and air compressors". As topics change by semester, prerequisites may be only a subset of those listed. Contact instructor for details.
Prereq: (ENGR 320 or ME 322) and ENGR 240 or permission.

BE 421 Image Processing and Computer Vision
3 credits
Joint-listed with BE 521
Fundamentals of digital image processing, analysis, feature recognition, and computer vision applied to areas of Biological Engineering including agricultural, environmental and biomedical applications. This course covers camera model, digital image processing and image analysis techniques for computer vision. Additional project components required for graduate credit.
Prereq: (BE 242 and MATH 275) or permission.

BE 422 Tissue Biomechanics
3 credits
Joint-listed with BE 522
This course explores the structure and mechanical properties of hard and soft tissues. The main focus will be on musculoskeletal tissues and may include topics in bone, skin, cartilage, muscle, tendon and ligament. Structure-function relationships at a range of anatomical levels, from the cell to the whole tissue, will be examined. Journal articles will be used to discuss current research in tissue biomechanics. Additional projects/assignments are required for graduate credit. Recommended Preparation: Mechanics of Materials
Prereq: Junior or Senior standing; or Instructor Permission.

BE 423 Tissue Engineering and Regenerative Medicine
3 credits
Joint-listed with BE 523
This course explores the principles, strategies, and tools used in the field of tissue engineering and regenerative medicine. Topics may include the application of biomaterials, stem cells, and bioreactors for restoring, maintaining and improving tissue function. Journal articles will be used to discuss current research in tissue engineering and regenerative medicine. Additional projects/assignments are required for graduate credit.
Prereq: Junior or Senior standing or permission of instructor.

BE 425 Introduction to Biomedical Engineering
3 credits
Principles of biomedical engineering, including biomechanics, biomaterials, nano-osseointegration, tissue engineering, cardiovascular systems and artificial hearts, medical imaging, and a brief survey of biosensors and bio-signaling.
Prereq: Junior or Senior standing in the College of Engineering or the College of Science; or Permission of instructor.

BE 426 Medical Imaging Techniques and Applications
3 credits
Joint-listed with BE 526
This course studies the physical and mathematical principles of diagnostic medical imaging systems and may include: X-ray, CT, nuclear medicine (PET and SPECT), ultrasound, MRI, and others. Applications of imaging techniques will be discussed with respect to medical uses. Basic principles of image processing will be discussed and applied using computer programming software. Additional work is required for graduate credit.
Prereq: MATH 275, PHYS 212, Junior or Senior standing or permission of instructor. Math 310 recommended but not required.
BE 433 Bioremediation
3 credits
Joint-listed with BE 533
Theory and practice of bioremediation as applied to toxic and hazardous wastes, including reaction kinetics, reaction stoichiometry, microbiology, and design of ex- and in-situ processes. Graduate credit requires additional design project. One-two field trips.
Prereq: BIOL 115, BIOL 115L, and MATH 170, or Permission.

BE 441 Instrumentation and Measurements
3 credits
Joint-listed with BE 541
Sensing elements, signal conditioning, data output and control. Additional projects/assignments reqd for grad cr. Two lectures and one 3-hour lab a week. Cooperative: open to WSU degree-seeking students.
Prereq: ENGR 240
Coreq: MATH 301.

BE 450 Environmental Hydrology
3 credits
Carries no credit after BE 355 or CE 325. The objective of this course is to provide a comprehensive understanding of the hydrologic processes associated with the environmental processes. Includes components of the hydrologic cycle, analysis of precipitation and run off, evapotranspiration, routing, peak flow, infiltration, soil and water relationships, snowmelt, and frequency analysis. (Spring only)
Prereq: MATH 170.

BE 452 Environmental Water Quality
3 credits
Joint-listed with BE 552
Engineering design to monitor, evaluate, and minimize non-point pollution from agriculture, environmentally acceptable disposal of wastes, bioremediation. Graduate credit requires an additional project and report. Two lectures and one 3-hour lab a week.
Prereq: BE 355 and CHEM 112, CHEM 112L; and SOIL 205 or BIOL 250.

BE 453 Northwest Climate and Water Resources Change
3 credits
Joint-listed with BE 553
Examines the relationship between climate and water resources in the Northwest, including historical and potential changes, and comparisons with other US regions. Scientific literature is read and discussed. Quantitative tools are developed for modeling the process physics and conducting statistical analyses. Historical data are analyzed. Additional project components required for graduate credit.
Prereq: STAT 301 or permission.

BE 459 Irrigation System Design
3 credits
Crop water requirements, irrigation scheduling and water management, selection and design of irrigation systems, pump selection. Two lectures and one 3-hour lab a week; one 1-day field trip.
Prereq: ENGR 335.

BE 461 Bioprocess Engineering
3 credits
Joint-listed with BE 561
This course covers advanced applications of biological sciences, processing principles applied to the analysis and design of handling, processing, and separation of bioproducts. Students complete several hands-on laboratory modules, in addition to a bioprocess design project. Additional work is required for graduate credit.
Prereq: Permission.

BE 462 Electric Power and Controls
3 credits
Design, selection, and use of electrical equipment and electric power systems for application to biological systems; design and use of electrical, electronic, and other feedback control systems for use with biological systems. Course includes advanced biological sciences applications. Two lectures and one 3-hour lab a week.
Prereq: ENGR 240
Coreq: MATH 310.

BE 478 Engineering Design I
3 credits
Gen Ed: Senior Experience
The capstone design sequence for biological and agricultural engineering majors. Course topics include research, design, experimental methods, specifications, prototyping, and verification; report writing, documentation and oral presentations. Topics, from industrial sponsorship, are considered in the context of a major design project involving a team of students. Projects incorporate realistic engineering constraints including environmental concerns, sustainability, ethical, safety, manufacturability, social and political considerations.
Prereq: BE 242, ENGR 320, ENGR 335, and ENGR 350.

BE 479 Engineering Design II
3 credits
Gen Ed: Senior Experience
Continuation of the capstone design sequence for biological and agricultural engineering majors. Course topics include research, design, experimental methods, specifications, prototyping, and verification; report writing, documentation and oral presentations. Topics, from industrial sponsorship, are considered in the context of a major design project involving a team of students. Projects incorporate realistic engineering constraints including environmental concerns, sustainability, ethical, safety, manufacturability, social and political considerations.
Prereq: BE 478.

BE 485 Fundamentals of Bioenergy and Bioproducts
3 credits
Joint-listed with BE 585
Prereq: CHEM 111, CHEM 111L
Coreq: ENGR 320 or Permission.

BE 491 Senior Seminar
1 credit
Gen Ed: Senior Experience
Professional aspects of the field, employment opportunities and preparation of occupational inventories. Graded P/F.
Prereq: Senior standing.

BE 492 Biofuels
3 credits
Joint-listed with BE 592
Basic principles for the production and utilization of biobased fuels; processing techniques and chemistry; fuel properties and utilization. Additional projects/assignments required for graduate credit. Recommended Preparation: Organic Chemistry.
Prereq: CHEM 111, CHEM 111L
Coreq: ENGR 320 or Permission.
BE 494 Thermochemical Technologies for Biomass Conversion
3 credits
Joint-listed with BE 594
Introduce the fundamentals of biomass conversion technologies for biofuels and bioenergy. Specific topics include biomass preparation/pretreatment, pyrolysis, gasification, direct liquefaction, and economic factors in thermochemical conversion of biomass. Advances of the technologies will be brought to current through literature reviews. A semester long course project is required if taken as a graduate level course. Recommended Preparation: Organic Chemistry, Chemical Reaction Engineering, Engineering Thermodynamics.
Prereq: CHEM 277 and CHEM 278
Coreq: ENGR 320 or Permission.

BE 499 (s) Directed Study
Credit arranged.

BE 500 Master's Research and Thesis
Credit arranged.

BE 501 (s) Seminar
Credit arranged
Graded P/F.
Prereq: Permission.

BE 502 (s) Directed Study
Credit arranged.

BE 504 (s) Special Topics
Credit arranged.

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3 credits
Joint-listed with BE 421
Fundamentals of digital image processing, analysis, feature recognition, and computer vision applied to areas of Biological Engineering including agricultural, environmental and biomedical applications. This course covers camera model, digital image processing and image analysis techniques for computer vision. Additional project components required for graduate credit.
Prereq: (BE 242 and MATH 275) or permission.

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BE 526 Medical Imaging Techniques and Applications
3 credits
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This course studies the physical and mathematical principles of diagnostic medical imaging systems and may include: X-ray, CT, nuclear medicine (PET and SPECT), ultrasound, MRI, and others. Applications of imaging techniques will be discussed with respect to medical uses. Basic principles of image processing will be discussed and applied using computer programming software. Additional work is required for graduate credit.
Prereq: MATH 275, PHYS 212, Junior or Senior standing or permission of instructor. Math 310 recommended but not required.

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Theory and practice of bioremediation as applied to toxic and hazardous wastes, including reaction kinetics, reaction stoichiometry, microbiology, and design of ex- and in-situ processes. Graduate credit requires additional design project. One-two field trips.
Prereq: BIOL 115, BIOL 115L and MATH 170, or Permission.

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3 credits
Joint-listed with BE 441
Sensing elements, signal conditioning, data output and control. Additional projects/assignments reqd for grad cr. Two lectures and one 3-hour lab a week. Cooperative: open to WSU degree-seeking students.
Prereq: ENGR 240
Coreq: STAT 301.

BE 551 Advanced Hydrology
3 credits
Principles of the hydrologic cycle including precipitation, lower atmosphere, evaporation, fluid mechanics of free surface flow, overland flow, stream flow routing, water transport in porous media, infiltration, groundwater outflow and base flow, stream flow generation, and elements of frequency analysis in hydrology.
Prereq: BE 355; or BE 450 and MATH 310; or Permission.

BE 552 Environmental Water Quality
3 credits
Joint-listed with BE 452
Engineering design to monitor, evaluate, and minimize non-point pollution from agriculture, environmentally acceptable disposal of wastes, bioremediation. Graduate credit requires an additional project and report. Two lectures and one 3-hour lab a week.
Prereq: BE 355 and CHEM 112, CHEM 112L; and SOIL 205 or BIOL 250.

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3 credits
Joint-listed with BE 453
Examines the relationship between climate and water resources in the Northwest, including historical and potential changes, and comparisons with other US regions. Scientific literature is read and discussed. Quantitative tools are developed for modeling the process physics and conducting statistical analyses. Historical data are analyzed. Additional project components required for graduate credit.
Prereq: STAT 301 or permission.

BE 558 Fluid Mechanics of Porous Materials
3 credits
Statics and dynamics of multiflow systems in porous materials; properties of porous materials; steady and unsteady flow. Cooperative: open to WSU degree-seeking students.
BE 561 Bioprocess Engineering
3 credits
Joint-listed with BE 461
This course covers advanced applications of biological sciences, processing principles applied to the analysis and design of handling, processing, and separation of biomaterials. Students complete several hands-on laboratory modules, in addition to a bioprocess design project. Additional work is required for graduate credit.
Prereq: Permission.

BE 585 Fundamentals of Bioenergy and Bioproducts
3 credits
Joint-listed with BE 485
Prereq: CHEM 111, CHEM 111L
Coreq: ENGR 320 or Permission.

BE 592 Biofuels
3 credits
Joint-listed with BE 492
Basic principles for the production and utilization of biobased fuels; processing techniques and chemistry; fuel properties and utilization. Additional projects/assignments required for graduate credit. Recommended Preparation: Organic Chemistry.
Prereq: CHEM 111, CHEM 111L
Coreq: ENGR 320 or Permission.

BE 594 Thermochemical Technologies for Biomass Conversion
3 credits
Joint-listed with BE 494
Introduce the fundamentals of biomass conversion technologies for biofuels and bioenergy. Specific topics include biomass preparation/pretreatment, pyrolysis, gasification, direct liquefaction, and economic factors in thermochemical conversion of biomass. Advances of the technologies will be brought to current through literature reviews. A semester long course project is required if taken as a graduate level course. Recommended Preparation: Organic Chemistry, Chemical Reaction Engineering, Engineering Thermodynamics.
Prereq: CHEM 277 and CHEM 278
Coreq: ENGR 320 or Permission.

BE 598 (s) Internship
Credit arranged.

BE 599 (s) Non-thesis Master's Research
Credit arranged
Research not directly related to a thesis or dissertation.
Prereq: Permission.

BE 600 Doctoral Research and Dissertation
Credit arranged.