

Biomedical Engineering–BME

- 445 Biomechanical Design**
Spring. 3(3-0) Interdepartmental with Materials Science and Mechanics. Administered by Department of Materials Science and Mechanics. R: Open only to juniors or seniors in the College of Engineering. SA: BME 491A

Biomechanical product design with application to people or animals. Synthesis, prototyping, and analysis of designs. Project management. Market research.

- 490 Independent Study (MTC)**
Fall, Spring. 3 to 12 credits. A student may earn a maximum of 12 credits in all enrollments for this course. R: Approval of department.

Individualized reading and research in biomedical engineering or bioengineering such as clinical biomechanics, biomaterials, tissue biomechanics, etc.

- 491 Special Topics (MTC)**
Fall, Spring. 3 to 12 credits. A student may earn a maximum of 12 credits in all enrollments for this course.

Special topics in biomedical engineering or bioengineering such as biochemical design, occupational biomechanics, biological surface science, or low temperature biotechnology.

- 331 Machinery Principles in Biosystems Engineering**
Fall. 3(3-0) P:M: (MTH 235 or MTH 255H or LBS 220) and (MSM 206 or MSM 211 or concurrently) and (CE 321) RB: Upper division standing in the College of Engineering

Functional processes of machines used in biosystems engineering, including pumping, blowing, conveying, mixing separation, atomization, size reduction and mobility. Power requirements, efficiency and failure modes

- 333 Biosystems Engineering Laboratory**
Fall. 1(0-3) P:M: (BS 110 or BS 111 or BOT 105 or ENT 205 or MIC 205 or MIC 301 or PSL 250 or ZOL141) R: Open only to students in the Biosystems Engineering major.

Measurement of physical, chemical and biological parameters and properties that characterize engineered biosystems. Data collection and analysis. Experiment design.

- 337 Machinery Systems for Food Processing**
Spring. 3(3-0) P:M: (BE 230) and (LBS 220 or concurrently or MTH 235 or concurrently or MTH 255H or concurrently) SA: AE 338, FE 338

Principles of design, operation, and performance of equipment for processing raw materials into finished or intermediate products.

- 350 Heat and Mass Transfer in Biosystems**
Spring. 3(3-0) P:M: (MTH 235 or MTH 255H or LBS 220) and (CSE 131 or LBS 127) and (CE 321 or concurrently or CHE 311 or concurrently or ME 332 or concurrently) P:NM: (CEM 143) Not open to students with credit in ME 410.

Steady state and transient heat conduction. Radiation and convection heat transfer. Heat exchangers. Mass transfer application problems in biosystems engineering.

- 351 Environmental Thermodynamics**
Fall. 3(3-0) P:M: (MTH 235 or MTH 255H or LBS 220) Not open to students with credit in CHE 321 or ME 201.

First and Second Laws of Thermodynamics with applications in food, biosystems, and environmental engineering. Refrigeration cycles. Entropy. Thermodynamic aspects of fluid flow. Psychrometrics.

- 402 Agricultural Climatology**
Fall of even years. 3(3-0) Interdepartmental with Geography. Administered by Department of Geography. P:M: (MTH 104 or MTH 110 or MTH 116) R: Not open to freshmen or sophomores. SA: AE 402

Relationships between climate and agriculture in resource assessment, water budget analysis, meteorological hazards, pests, crop-yield modeling, and impacts of global climate change.

- 403 Microclimate and Its Measurement**
Fall of odd years. 4(3-3) Interdepartmental with Geography. P:M: (MTH 116 or MTH 124 or MTH 132 or LBS 118)

Climate near the earth's surface. Energy balance, thermal radiation exchange, heat fluxes, temperature sensors, wind speed and direction, humidity and evapotranspiration and their measurement.

- 418 Comprehensive Nutrient Management Planning**
Fall. 3(2-2) Interdepartmental with Animal Science. Administered by Department of Animal Science. P:M: (ANS 110 or BE 230)

Comprehensive nutrient management plans (CNMP) for animal feeding operations. Trends in animal production, environmental issues, and diet formulation and their impact on manure production. Development of CNMP for a specific animal feeding operation.

- 419 Applications of Geographic Information Systems to Natural Resources Management**

Spring. 4(2-4) Interdepartmental with Fisheries and Wildlife; Forestry; Geography; Park, Recreation and Tourism Resources; Resource Development. Administered by Department of Fisheries and Wildlife. P:NM: (GEO 221)

The application of geographic information systems, remote sensing, and global positioning systems to integrated planning and management for fish, wildlife, and related resources.

- 430 Power and Control Hydraulics**
Fall. 3(2-2) P:M: (CE 321 or CHE 311 or ME 332) SA: AE 430

Hydraulic fluid properties. Pump and motor performance parameters. Control valves and hydraulic circuitry components. Analysis and design of hydraulic systems.

- 431 Resource Optimization**
Spring. 3(2-2) P:M: (BE 230) and (MTH 235 or MTH 255H or LBS 220) Not open to students with credit in BE 831.

Optimal solutions to problems with multiple and conflicting objectives and constraints. Applications to natural and manufactured biological systems.

- 438 Design of Machinery Structures**
Fall. 3(3-0) P:M: (MSM 211) SA: AE 438 Not open to students with credit in ME 471.

Design of structural components and systems in machines. Tension, compression, torsion, bending and combined loadings. Joint connections.

- 443 Restoration Ecology**
Spring. 3(2-2) Interdepartmental with Fisheries and Wildlife; Zoology. Administered by Department of Fisheries and Wildlife. P:NM: (CSS 210 or BE 230) and (FOR 404 or FW 364 or ZOL 355)

Principles of ecological restoration of disturbed or damaged ecosystems. Design, implementation, and presentation of restoration plans. Field trips required.

- 452 Watershed Concepts**
Fall, Spring, Summer. 3(3-0) Interdepartmental with Resource Development; Crop and Soil Sciences; Forestry; Fisheries and Wildlife. Administered by Department of Resource Development. P:M: (RD 324 and ZOL 355) RB: organic chemistry

Watershed hydrology and management. The hydrologic cycle, water quality, aquatic ecosystems and social systems. Laws and institutions for managing water resources.

BIOSYSTEMS ENGINEERING

BE

Department of Agricultural Engineering College of Agriculture and Natural Resources

- 130 Engineering Design Fundamentals for Biological Systems**
Fall. 2(1-2) P:M: (MTH 132 or concurrently or MTH 114 or concurrently or MTH 116 or concurrently or LBS 117 or concurrently or LBS 118 or concurrently or MTH 152H)

Professional and fundamental methods of biosystems engineering. Basic engineering methods. Analysis and design. Interdisciplinary design.

- 230 Principles of Biosystems Engineering**
Fall. 3(3-0) P:M: (MTH 132 or MTH 152H or LBS 118)

Concepts of biosystems. Hard and soft systems. Conceptual and computer modeling of components of biosystems.

- 232 Food Production and Processing Systems**
Fall. 1(0-2)

Crop and animal production systems. Food processing systems. Field trips required.

- 329 Fundamentals of Food Engineering**
Spring. 3(3-0) Interdepartmental with Food Science. P:M: (FSC 229) and (MTH 126 or LBS 118) and (PHY 231 or LBS 164) P:NM: (FSC 211) SA: FE 329

Unit operations in food industry: fluid mechanics, heat transfer, rate processes, refrigeration, freezing, and dehydration. Thermal process calculations.

- 453 Engineering Principles of the Plant Environment**
Fall. 3(3-0) P:M: (BOT 105 or BS 110 or BS 111 or LBS 144 or LBS 145 or LBS 149H) and (BE 350 or concurrently) and (BE 351) SA: AE 353
Analysis of the soil-plant-atmosphere continuum. Thermodynamics effects on plant environment: water, soil heat flow, radiation, and soil water movement.
- 456 Electric Power and Control**
Spring. 3(2-2) P:M: (ECE 200 or ECE 345) SA: AE 356
Alternating current circuits, power distribution, electrical machines, protection, and programmable motor controllers. Design project related to food and agricultural industries.
- 457 Postharvest Engineering**
Fall. 3(3-0) P:M: (BE 350 or CHE 311 or ME 410) and (ME 332 or CHE 311 or CE 321) and (BE 351 or CHE 321 or ME 201) SA: FE 460
Engineering principles involved with the storage and handling of grains and horticultural crops between harvest and processing.
- 460 Resource and Environmental Economics**
Spring. 3(3-0) Interdepartmental with Resource Development; Public Resource Management; Park, Recreation and Tourism Resources. Administered by Department of Resource Development. P:M: (EC 201) P:NM: (RD 302 or PRM 255)
Economics of land and related environmental resources. Production and consumption processes. Resource allocations and scarcity. Market failure and externalities. Market and institutional remedial approaches.
- 477 Food Engineering**
Fall. 3(2-2) Interdepartmental with Food Science. P:M: (BE 350 and BE 351 and CE 321) SA: FE 465
Unit operations, process engineering, equipment, and industrial practices of the food industry. Manufactured dairy products: thermal processing, pipeline design, heat exchange, evaporation, dehydration, aseptic processing, membrane separation, cleaning, and sanitation.
- 481 Agricultural and Small Watershed Hydrology**
Spring. 3(2-2) P:M: (CSE 131 or LBS 127) and (CE 321 or CHE 311) and (CE 312) SA: AE 481
Runoff, infiltration, surface and subsurface drainage and soil erosion.
- 485 Biosystems Design Techniques**
Fall. 2(2-0) P:M: (BE 130) and (BE 331 or BE 350 or BE 351) SA: BE 486
The engineering design process. Problem identification, analysis, design, modeling, materials, cost estimation, final specifications. Safety, environmental and ethical considerations.
- 486 Biosystems Design Fundamentals**
Fall. 3(3-0) P:M: (BE 230 and BE 350) SA: AE 486
Concepts, methods, and procedures of the total design process from problem identification to final specifications.
- 487 Biosystems Design Project (W)**
Spring. 3(0-6) P:M: (BE 486) and completion of Tier I writing requirement. R: Open only to seniors in the College of Engineering. SA: AE 488
Individual or team design project selected in BE 486. Information expansion, development of alternatives, and evaluation, selection, and completion of a design project.
- 490 Independent Study**
Fall, Spring, Summer. 1 to 5 credits. A student may earn a maximum of 5 credits in all enrollments for this course. P:M: (BE 230 or BE 350) R: Approval of department; application required. SA: AE 490
Supervised individual student research and study in biosystems engineering.
- 491 Special Topics in Biosystems Engineering**
Fall, Spring, Summer. 1 to 4 credits. A student may earn a maximum of 12 credits in all enrollments for this course. P:M: (BE 230 or BE 336 or BE 350) R: Approval of department. SA: AE 491
Special topics in biosystems engineering.
- 802 Computational Methods in Biosystems Engineering**
Summer of odd years. 3(3-0) R: Open only to graduate students in the College of Agriculture and Natural Resources or College of Engineering. SA: AE 802
Formulation and solution of mathematical equations in biosystems engineering. Constitutive equations. Linear and nonlinear problems. Steady state and transient problems. Computer solutions.
- 809 Finite Element Method**
Fall, Spring. 3(3-0) Interdepartmental with Materials Science and Mechanics; Civil Engineering; Mechanical Engineering. Administered by Department of Materials Science and Mechanics.
Theory and application of the finite element method to the solution of continuum type problems in heat transfer, fluid mechanics, and stress analysis.
- 812 Bio-Process Engineering**
Spring of odd years. 3(3-0) R: Open only to graduate students in the College of Engineering. SA: AE 812
Thermodynamics, heat and mass transfer, fluid flow, dehydration. Handling and storage of biological products.
- 815 Instrumentation for Biosystems Engineering**
Fall. 3(3-0) R: Open only to graduate students in the College of Engineering. SA: AE 815
Theory and techniques of measuring temperature, pressure, flow, humidity, and moisture in biological materials.
- 820 Research Methods in Biosystems Engineering**
Fall. 1(1-0) R: Open only to graduate students in the College of Agriculture and Natural Resources or College of Engineering. SA: AE 820
Procedures and methods for designing and executing research projects.
- 831 Biosystems Analysis**
Fall. 3(2-2) P:NM: (MTH 132) Not open to students with credit in BE 431.
Systems concepts. Properties of biological systems. Effect of environmental, technological, and economic factors on biological systems.
- 832 Network Design and Optimization of Biological Systems**
Spring. 3(2-2) P:NM: (BE 431 or BE 831)
Techniques of process network theory and multi-criteria optimization for designing environmentally sound and economically beneficial biosystems.
- 833 Artificial Neural Network Applications in Biological Systems**
Fall. 3(2-2) P:NM: (BE 431 or BE 831)
Neural network algorithms and their application to biological systems.
- 837 Food Rheology**
Spring of even years. 3(3-0) Interdepartmental with Food Science.
Definition, analysis, and measurement of rheological properties to describe the steady shear, dynamic, viscoelastic, extensional, and solid behavior of biological materials. Industrial applications of rheological methods with emphasis on fluid and semi-solid foods.
- 850 Dimensional Analysis and Theory of Models**
Fall of odd years. 3(2-2) R: Open only to graduate students in the College of Agriculture and Natural Resources or College of Engineering. SA: AE 850
Dimensional concepts, systems of measurements and transformation of units, and formation of dimensionless groups. Development of prediction equations, concepts of similarity, and scaling laws. Distortion.
- 852 Systems Modeling and Simulation**
Fall of even years. 3(3-0) Interdepartmental with Fisheries and Wildlife; Forestry; Resource Development. Administered by Department of Fisheries and Wildlife. P:NM: (STT 422 or STT 442 or STT 464 or GEO 463)
General systems theory and concepts. Modeling and simulation methods. Applications of systems approach and techniques to natural resource management, and to ecological and agricultural research.
- 853 Applied Systems Modeling and Simulation for Natural Resource Management**
Spring of odd years. 3(2-2) Interdepartmental with Fisheries and Wildlife; Forestry; Resource Development; Zoology. Administered by Department of Fisheries and Wildlife. P:NM: (FW 820 or BE 486 or ZOL 851) or approval of department. R: Open only to seniors and graduate students
Mathematical models for evaluating resource management strategies. Stochastic and deterministic simulation for optimization. System control structures. Team modelling approach.
- 882 Irrigation and Water Management Engineering**
Spring of even years. 3(3-0) P:NM: (BE 481 and CE 321) SA: AE 882
Design and management of systems for supplemental irrigation. Water supply and transport. Economic and engineering optimization of irrigation design.

Biosystems Engineering–BE

890 Special Problems
Fall, Spring, Summer. 1 to 3 credits. A student may earn a maximum of 6 credits in all enrollments for this course. R: Approval of department; application required. SA: AE 890
Individual study in biosystems engineering.

891 Advanced Topics in Biosystems Engineering
Fall, Spring, Summer. 1 to 3 credits. A student may earn a maximum of 6 credits in all enrollments for this course. R: Open only to graduate students in the College of Engineering. Approval of department. SA: AE 891
Biosystems engineering topics not covered in regular courses.

892 Biosystems Engineering Seminar
Spring. 1(1-0) R: Open only to graduate students in the College of Agriculture and Natural Resources or College of Engineering. SA: AE 892
Current topics in biosystems engineering.

899 Master's Thesis Research
Fall, Spring, Summer. 1 to 10 credits. A student may earn a maximum of 99 credits in all enrollments for this course. R: Open only to master's students in the Biosystems Engineering major. SA: AE 899
Master's thesis research.

999 Doctoral Dissertation Research
Fall, Spring, Summer. 1 to 24 credits. A student may earn a maximum of 99 credits in all enrollments for this course. R: Open only to doctoral students in the Biosystems Engineering major. SA: AE 999
Doctoral dissertation research.

202 The Plant Kingdom
Spring. 3(2-3) P:M: (BS 110 or BS 111 or BOT 105 or LBS 144 or LBS 148H or LBS 149H)
Morphology of the major plant groups with an emphasis on structure, reproduction and evolution. Field trips required.

205 Pests, Society and Environment
Fall, Spring. 3(3-0) Interdepartmental with Entomology. Administered by Department of Entomology.
Nature of pests and their impact on society. Principles of integrated pest management in relation to environmental quality and sustainable development.

218 Plants of Michigan
Fall. 3(2-3) P:M: (BS 110 or BOT 105 or LBS 144 or LBS 148H)
Plant taxa of Michigan and the Great Lakes region and the major habitats in which they occur. Principles and rationale of classification. Relationships between life histories, morphology and environment. Field trips required.

301 Introductory Plant Physiology
Fall, Spring. 3(2-3) P:M: (CEM 141 or CEM 151 or LBS 171 or CEM 181H) and (CEM 161 or LBS 171L) and (BOT 105 or BS 111 or LBS 145 or LBS 149H) and completion of Tier I writing requirement.
General principles of plant physiology relating plant structure to function. Cell physiology, water relations, effects of light and temperature, respiration, photosynthesis, mineral nutrition, and hormone action.

319 Introduction to Earth System Science
Fall. 3(3-0) Interdepartmental with Entomology; Geological Sciences; Zoology; Sociology. Administered by Department of Entomology. RB: Completion of one course in biological or physical science.
Systems approach to Earth as an integration of geochemical, geophysical, biological and social components. Global dynamics at a variety of spatio-temporal scales. Sustainability of the Earth system.

335 Plants Through Time
Spring of odd years. 3(3-0) Interdepartmental with Geological Sciences. P:M: (BS 110 or BOT 105 or GLG 201 or LBS 144 or LBS 148H) R: Open only to juniors or seniors.
Evolutionary history of plants, development of ecosystems, and use of plant fossils in the reconstruction of ancient environments and climate.

336 Useful Plants
Fall of odd years. 3(3-0) P:M: (CEM 142 or CEM 143 or CEM 152 or CEM 182H) and (BOT 105 or LBS 145) or (BS 110 and BS 111 and BS 111L) or (LBS 148H and LBS 149H)
Ways in which plants are used for myriad purposes from food and construction materials to medicines and perfumes. Potential for expanding the uses of plants through biotechnology.

341 Fundamental Genetics
Fall, Spring, Summer. 4(4-0) Interdepartmental with Zoology. Administered by Department of Zoology. P:M: (BS 111 or LBS 145 or LBS 149H)
Principles of heredity in animals, plants and microorganisms. Classical and molecular methods in the study of gene structure, transmission, expression and evolution.

355 Ecology
Fall, Summer. 3(3-0) Interdepartmental with Zoology. Administered by Department of Zoology. P:M: (BS 110 or LBS 144 or LBS 148H) SA: ZOL 250
Plant and animal ecology. Interrelationships of plants and animals with the environment. Principles of population, community, and ecosystem ecology. Application of ecological principles to global sustainability.

355L Ecology Laboratory
Fall, Summer. 1(0-3) Interdepartmental with Zoology. Administered by Department of Zoology. P:M: (ZOL 355 or concurrently or BOT 355 or concurrently) and completion of Tier I writing requirement.
Population, community and ecosystem ecology utilizing plant and animal examples to demonstrate general field principles.

362 Management of Turfgrass Pests
Fall. 4(3-2) Interdepartmental with Crop and Soil Sciences; Entomology. Administered by Department of Crop and Soil Sciences. P:M: (CSS 232)
Chemical, biological, and cultural methods of managing weeds, diseases, and insect pests of turfgrass. Environmental considerations in pest management.

402 Biology of Fungi
Fall. 3(2-3) P:M: (BS 110 or BS 111 or BOT 105 or LBS 145 or LBS 148H or LBS 149H)
Major groups of fungi: characteristics, habitats and diversity. Significance of fungi in nature and their economic importance.

405 Introductory Plant Pathology
Spring. 4(2-4) P:M: (BS 110 and BS 111) or (BOT 105 and BOT 106) or (LBS 144 and LBS 145) or (LBS 148 H and LBS 149H) and completion of Tier I writing requirement. Not open to students with credit in BOT 407.
Important plant diseases and the organisms that cause them. Principles of disease management including application of chemicals, plant breeding, biological control, and genetic engineering.

407 Diseases and Insects of Forest and Shade Trees
Spring. 4(3-3) Interdepartmental with Entomology. P:M: (BOT 105 or BS 110 or LBS 144 or LBS 148H) and (BOT 218 or FOR 204 or HRT 211) and completion of Tier I writing requirement. Not open to students with credit in BOT 405.
Diseases, insects, and environmental problems affecting trees in forests, parks, suburbs, and nurseries. Methods of control.

412 Environmental Plant Physiology
Fall. 3(3-0) P:M: (BOT 105 or BS 111 or LBS 145 or LBS 149H) and (CEM 141 or CEM 152) and (CEM 161)
General concepts underlying interactions between plants and the environment. Light sensing and utilization. Energy budgets. Water uptake and utilization. Mineral nutrition.

413 Virology
Spring. 3(3-0) Interdepartmental with Microbiology and Molecular Genetics. Administered by Department of Microbiology and Molecular Genetics. P:M: (BMB 462 or concurrently) RB: (MIC 409) SA: BOT 413, MIC 403, MPH 403
Viruses and modern molecular biology. Viral replication and gene expression of the major classes of viruses. Virus-cell interactions and viral diseases.

BOTANY AND PLANT PATHOLOGY BOT

Department of Botany
and Plant Pathology
College of Agriculture and
Natural Resources
College of Natural Science

105 Plant Biology
Fall, Spring. 3(3-0)
Plant structure, function, development, genetics, diversity and ecology.

106 Plant Biology Laboratory
Fall, Spring. 1(0-3) P:M: (BOT 105 or concurrently)
Cell structure, anatomy, physiology, growth and development, and diversity of plants.

111L Cell and Molecular Biology Laboratory
Fall, Spring, Summer. 2(1-3) Interdepartmental with Biological Science; Microbiology and Molecular Genetics; Zoology. Administered by Natural Science. P:M: (BS111 or concurrently) Not open to students with credit in LBS 159H.
Principles and applications of common techniques used in cell and molecular biology.