

**441. Tissue Mechanics**  
Spring of odd-numbered years. 3(3-0) Interdepartmental with Materials Science and Mechanics.  
P: MSM 211.  
Application of solid mechanics to understanding mechanical responses of biological tissues. Microstructure and biological function for soft and hard connective tissues and muscle.

**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.  
P: BME 311.  
Special topics in biomedical engineering or bioengineering such as biochemical design, occupational biomechanics, biological surface science, or low temperature biotechnology.

## BIOSYSTEMS ENGINEERING

BE

### Department of Agricultural Engineering College of Agriculture and Natural Resources College of Engineering

**180. Current Issues in Biosystems**  
Fall, Spring. 2(2-0)  
P: MTH 110 or MTH 116. R: Open only to freshmen or sophomores.  
The relationship of biosystems engineering to current problems in food production and processing. Environment, natural resources, harvesting, handling, safety, and water quality.

**230. Principles of Biosystems Engineering**  
Fall. 3(3-0)  
P: MTH 132. R: Open only to sophomores or juniors in College of Agriculture and Natural Resources, College of Engineering, or College of Natural Science.  
Concepts of biosystems. Hard and soft systems. Conceptual and computer modeling of components of biosystems.

**232. Food Production and Processing Systems**  
Fall. 1 credit.  
R: Open only to students in College of Agriculture and Natural Resources or College of Engineering.  
Crop and animal production systems. Food processing systems. Field trips required.

**336. Machinery Systems for Food Production**  
Fall. 3(3-0)  
P: MTH 235.  
Processes performed by agricultural production machines. Power systems, tillage mechanics, traction, metering, distribution, conveying, fluidization, mixing, separation, and atomization. Machinery management.  
SA: AE 336

**337. Machinery Systems for Food Processing**  
Spring. 3(3-0)  
P: MTH 235.  
Principles of design, operation, and performance of equipment for processing raw materials into finished or intermediate products.  
SA: AE 338, FE 338

**350. Heat Transfer in Biosystems**  
Spring. 2(2-0)  
P: MTH 235; CPS 101 or CPS 131. R: Not open to students with credit in CHE 311 or ME 410.  
Steady state and transient heat conduction. Radiation and convection heat transfer. Heat exchangers. Application problems in biosystems engineering.

**351. Environmental Thermodynamics**  
Spring. 3(3-0)  
P: MTH 235. R: 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.

**403. Microclimate and Its Measurement**  
Fall of odd-numbered years. 4(3-3) Interdepartmental with Geography.  
P: MTH 116 R: Not open to freshmen or sophomores.  
The 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.  
SA: ATM 836

**430. Power and Control Hydraulics**  
Spring. 3(2-2)  
P: CE 321 or CHE 311 or ME 332. R: Open only to majors in College of Engineering.  
Hydraulic fluid properties. Pump and motor performance parameters. Control valves and hydraulic circuitry components. Analysis and design of hydraulic systems.  
SA: AE 430

**431. Resource Optimization**  
Spring. 3(2-2)  
P: BE 230, MTH 235 R: 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: MSM 211. R: Open only to majors in College of Engineering. 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.  
SA: AE 438

**453. Engineering Principles of the Plant Environment**  
Fall. 3(3-0)  
P: BOT 105 or BS 110 or BS 111; CEM 141, BE 350, BE 351. R: Open only to majors in College of Engineering.  
Analysis of the soil-plant-atmosphere continuum. Thermodynamics effects on plant environment: water, soil heat flow, radiation, and soil water movement.  
SA: AE 353

**456. Electric Power and Control**  
Spring. 3(2-2)  
P: EE 200 or EE 345. R: Open only to majors in College of Engineering.  
Alternating current circuits, power distribution, electrical machines, protection, and programmable motor controllers. Design project related to food and agricultural industries.  
SA: AE 356

**457. Postharvest Engineering**  
Fall. 3(3-0)  
P: BE 350 or CHE 311 or ME 410. R: Open only to majors in College of Agriculture and Natural Resources or College of Engineering.  
Engineering principles involved with the storage and handling of grains and horticultural crops between harvest and processing.  
SA: FE 460

**460. Resource and Environmental Economics**  
Spring. 3(3-0) Interdepartmental with Public Resource Management; Resource Development; and Park, Recreation and Tourism Resources. Administered by Resource Development.  
P: RD 200; EC 201 or EC 202 or PRM 201 or RD 302.  
Economics of land and related environmental resources. Production and consumption processes. Resource allocations and scarcity. Market failure and externalities. Market and institutional remedial approaches.

**481. Agricultural and Small Watershed Hydrology**  
Spring. 3(2-2)  
P: CPS 101 or CPS 131; CE 321 or CHE 311 or BE 350; BE 453 or CE 312. R: Open only to seniors in College of Engineering or graduate students.  
Runoff, infiltration, surface and subsurface drainage and soil erosion.  
SA: AE 481

**486. Biosystems Design Fundamentals**  
Fall. 3(3-0)  
P: BE 350 or BE 336 or BE 453. R: Open only to seniors in College of Engineering or graduate students.  
Concepts, methods, and procedures of the total design process from problem identification to final specifications.  
SA: AE 486

**487. Biosystems Design Project (W)**  
Spring. 3 credits.  
P: BE 486. R: Open only to seniors in College of Engineering. Completion of Tier I writing requirement.  
Individual or team design project selected in BE 486. Information expansion, development of alternatives, and evaluation, selection, and completion of a design project.  
SA: AE 488

**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: BE 230 or BE 336 or BE 350 or BE 453. R: Open only to majors in College of Engineering. Approval of department; application required.  
Supervised individual student research and study in biosystems engineering.  
SA: AE 490

**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: BE 230, BE 336 or BE 350 or BE 453. R: Open only to majors in College of Engineering. Approval of department.  
Special topics in biosystems engineering.  
SA: AE 491

**802. Computational Methods in Biosystems Engineering**  
Summer of odd-numbered years. 3(3-0)  
R: Open only to graduate students in the College of Agriculture and Natural Resources or College of Engineering.  
Formulation and solution of mathematical equations in biosystems engineering. Constitutive equations. Linear and nonlinear problems. Steady state and transient problems. Computer solutions.  
SA: AE 802

**Descriptions — Biosystems Engineering  
of  
Courses**

**809. Finite Element Method**  
Fall, Spring, 3 credits. Interdepartmental with Materials Science and Mechanics, Civil Engineering, and Mechanical Engineering. Administered by 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-numbered years. 3(3-0)  
R: Open only to graduate students in the College of Engineering.  
Thermodynamics, heat and mass transfer, fluid flow, dehydration. Handling and storage of biological products.  
SA: AE 812

**815. Instrumentation for Biosystems Engineering**  
Fall. 3(3-0)  
R: Open only to graduate students in the College of Engineering.  
Theory and techniques of measuring temperature, pressure, flow, humidity, and moisture in biological materials.  
SA: AE 815

**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.  
Procedures and methods for designing and executing research projects.  
SA: AE 820

**831. Biosystems Analysis**  
Fall. 3(2-2)  
P: MTH 132. R: 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: 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: BE 431 or BE 831  
Neural network algorithms and their application to biological systems.

**837. Food Rheology**  
Fall. 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.  
SA: AE 837

**850. Dimensional Analysis and Theory of Models**  
Fall of odd-numbered years. 3(2-2)  
R: Open only to graduate students in the College of Agriculture and Natural Resources or College of Engineering.  
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.  
SA: AE 850

**882. Irrigation and Water Management Engineering**  
Spring of even-numbered years. 3(3-0)  
P: BE 481, CE 321.  
Design and management of systems for supplemental irrigation. Water supply and transport. Economic and engineering optimization of irrigation design.  
SA: AE 882

**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.  
Individual study in biosystems engineering.  
SA: AE 890

**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.  
Biosystems engineering topics not covered in regular courses.  
SA: AE 891

**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.  
Current topics in biosystems engineering.  
SA: AE 892

**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

**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

**BOTANY AND PLANT  
PATHOLOGY BOT**

**Department of Botany and Plant  
Pathology  
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 credit.  
P: 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 credits. Interdepartmental with Biological Science, Microbiology, and Zoology. Administered by Biological Science.  
P: BS 111 or concurrently  
Principles and applications of common techniques used in cell and molecular biology.

**202. The Plant Kingdom**  
Spring. 3(2-3)  
P: BS 110 or BOT 105 or LBS 144.  
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 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: BS 110 or BOT 105 or LBS 144.  
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: CEM 141 or CEM 151; CEM 161; BOT 105 or BS 111 or LBS 145. R: Completion of Tier 1 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 credits. Interdepartmental with Entomology, Geological Sciences, Zoology, and Sociology. Administered by Entomology.  
P: 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-numbered years. 3(3-0) Interdepartmental with Geological Sciences.  
P: BS 110 or BOT 105 or GLG 201 or LBS 144. R: Juniors and above.  
Evolutionary history of plants, the development of ecosystems, and the use of plant fossils in the reconstruction of ancient environments and climate.

**336. Useful Plants**  
Fall of odd-numbered years. 3(3-0)  
P: CEM 142 or CEM 143 or CEM 152; BOT 105 or BS 110, BS 111 or LBS 144, LBS 145.  
Ways in which plants are used for myriad purposes from food and construction materials to medicines and perfumes. The potential for expanding the uses of plants through biotechnology will be explored.

**341. Fundamental Genetics**  
Fall, Spring, Summer. 4 credits. Interdepartmental with Zoology. Administered by Zoology.  
P: BS 111 or LBS 145.  
Principles of heredity in animals, plants and microorganisms. Formal and molecular methods in the study of gene structure, transmission, expression and evolution.

**355. Ecology**  
Fall. 3(3-0) Summer. 3 credits. Given only at W.K. Kellogg Biological Station. Interdepartmental with Zoology. Administered by Zoology.  
P: BS 110 or LBS 144. R: Completion of Tier I writing requirement.  
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.  
SA: ZOL 250