

## Biological Science—BS

**111L Cell and Molecular Biology Laboratory**  
Fall, Spring, Summer. 2(1-3)  
Interdepartmental with Microbiology and  
Molecular Genetics; Plant Biology; Zoology.  
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.

**148H Honors Organismal Biology**  
Fall. 3(3-0) Interdepartmental with Lyman  
Briggs School. Administered by Lyman  
Briggs School. R: Honors College student or  
approval of school. Not open to students  
with credit in BS 110 or LBS 144.

Diversity and basic properties of organisms, with  
emphasis on genetic principles, ecological  
interactions, and the evolutionary process. Historical  
approach to knowledge discovery.

**149H Honors Cell and Molecular Biology**  
Spring. 3(3-0) Interdepartmental with  
Lyman Briggs School. Administered by  
Lyman Briggs School. P:M: (CEM 141 or  
concurrently or CEM 151 or concurrently or  
CEM 181H or concurrently or LBS 171 or  
concurrently) R: Honors College student or  
approval of school. Not open to students  
with credit in BS 111 or LBS 145.

Exploration of the physicochemical and molecular  
organization of cells as the unifying framework for  
genetics, evolution, and the social relevance of  
biology.

**158H Honors Organismal Biology Laboratory**  
Fall. 2(1-3) Interdepartmental with Lyman  
Briggs School. Administered by Lyman  
Briggs School. Not open to students with  
credit in BS 110 or LBS 144. C: LBS 148H  
concurrently.

Basic procedures used by organismal biologists,  
including experimental design and statistical  
methods. Development and implementation of  
research projects to test hypotheses in genetics,  
ecology, and evolution.

**159H Honors Cell and Molecular Biology  
Laboratory**  
Spring. 2(1-3) Interdepartmental with  
Lyman Briggs School. Administered by  
Lyman Briggs School. Not open to students  
with credit in BS 111L or LBS 145. C: LBS  
149H concurrently.

Basic techniques of cellular and molecular biology  
including experimental design and hypothesis  
formulation. Student-initiated projects to test  
hypothesis-driven projects in biochemistry,  
molecular biology or genetics.

## BIOMEDICAL ENGINEERING

## BME

### College of Engineering

**424 Biomaterials and Biocompatibility**  
Spring. 3(3-0) Interdepartmental with  
Materials Science and Engineering.  
Administered by Department of Chemical  
Engineering and Materials Science. P:M:  
(PSL 250 and MSE 250) SA: MSM 424

Materials science of human implants. Design  
requirements imposed by the body's milieu and the  
need to protect the body.

**441 Tissue Mechanics**  
Spring of odd years. 3(3-0)  
Interdepartmental with Materials Science  
and Mechanics. Administered by  
Department of Materials Science and  
Mechanics. P:M: (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.

**490 Independent Study**  
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.

**490A Independent Study in Clinical  
Biomechanics**  
Fall. 1 to 3 credits. A student may earn a  
maximum of 6 credits in all enrollments for  
this course. R: Approval of department.

Individualized reading and research in the  
application of biomechanics to clinical cases.

**490B Independent Study in Biomaterials**  
Spring. 1 to 3 credits. A student may earn a  
maximum of 6 credits in all enrollments for  
this course. R: Approval of department.

Individualized reading and research in the  
application of biomaterials.

**491 Special Topics**  
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.

**491B Occupational Biomechanics**  
Fall. 3(3-0)  
Special topics in occupational biomechanics of  
current interest and importance.

**491C Biological Surface Science**  
Spring of even years. 3(3-0)  
Special topics in biological surface science of  
current interest and importance.

**491D Low Temperature Biotechnology**  
Spring of odd years. 3(3-0)  
Special topics in low temperature biotechnology of  
current interest and importance.

**496 Biodynamics**  
Fall. 3(2-2) Interdepartmental with  
Mechanical Engineering. Administered by  
Department of Mechanical Engineering.  
P:M: (ME 361) R: Open only to students in  
the Engineering Mechanics major.

Fundamentals of motion analysis of human  
movement and its application to the study of function  
and dysfunction of the musculoskeletal system.  
Solution methods of the inverse dynamics problem.

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

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

## 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) RB:  
(FSC 211) SA: FE 329

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

**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 MMG 205 or MMG 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) RB: (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.
- 418 Comprehensive Nutrient Management Planning**  
 Fall. 3(2-2) Interdepartmental with Animal Science. Administered by Department of Animal Science. P:M: (CSS 210)  
 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. RB: (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. RB: (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.
- 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 Natural Resource 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) and (RD 302 or EEP 255)  
 Economic framework for analyzing natural resource management decisions. Spatial and inter-temporal allocation of renewable and nonrenewable resources. Special emphasis on institutions, externalities, and public interests in resource management.
- 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.
- 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.

## Biosystems Engineering—BE

- 818 Comprehensive Nutrient Management Planning**  
Fall. 3(2-2) Interdepartmental with Animal Science. Administered by Department of Animal Science.  
Development of 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.
- 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) RB: (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) RB: (BE 431 or BE 831)  
Techniques of process network theory and multi-criteria optimization for designing environmentally sound and economically beneficial biosystems.
- 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. RB: (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. RB: (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) RB: (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.
- 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.

## BUILDING CONSTRUCTION MANAGEMENT

## BCM

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

- 101 Principles of Building Construction Management**  
Fall. 2(2-0)  
Historical developments and current issues and trends in commercial and residential construction industries.

- 124 Residential Construction Materials and Methods**  
Spring. 3(3-0) RB: (BCM 101) SA: BCM 126  
Properties of construction materials and their application in residential construction.
- 210 Commercial Construction Methods**  
Fall. 3(3-0) P:M: (BCM 101 or concurrently and BCM 124)  
Commercial construction: principles, materials, assemblies and commercial blueprints.
- 211 Building Codes**  
Fall. 3(3-0) P:M: (BCM 210 or concurrently) SA: BCM 227  
Construction codes: structural, mechanical, electrical and plumbing. Building safety and accessibility.
- 222 Statics and Strengths of Materials**  
Spring. 3(3-0) P:M: (MTH 124 and PHY 231 and BCM 210) Not open to students with credit in MSM 205 or MSM 211.  
Equilibrium of forces. Free body diagrams. Force components. Bending moments. Stress and strain. Mechanical properties of materials. Beams and trusses. Computer applications. Indeterminate structures.
- 230 Utility Systems**  
Spring. 4(4-0) P:M: (BCM 210) R: Open only to sophomores or juniors or seniors in the Building Construction Management or Civil Engineering major.  
Heating, cooling, ventilating, electrical, gas, lighting, water, waste water, telecommunications, fire protection, safety security and sound control systems in residential and commercial construction. Applicable codes.
- 305 Site Construction and Measurement**  
Fall. 3(2-2) P:M: (BCM 230)  
Site construction methods, materials and equipment for buildings, soil, foundation, erosion and storm water. Layout, leveling, surveying and underground utilities.
- 315 Construction Quantity Surveying**  
Spring. 3(2-2) P:M: (BCM 305 or concurrently and CSE 101) R: Open only to students in the Building Construction Management or Civil Engineering major. SA: BCM 324  
Measurement of quantities for construction projects. Work breakdown structure. Industry standards.
- 322 Structural Systems**  
Fall. 3(3-0) P:M: (BCM 211) and (BCM 222 or MSM 205 or MSM 211) Not open to students with credit in CE 406.  
Structural design using wood, steel and concrete. Beams, columns, footings, and foundation walls. Loading, soils.
- 324 Construction Estimation**  
Fall, Spring. 4(3-2) P:M: (BCM 230 or concurrently and BCM 322) R: Open only to juniors or seniors in the Building Construction Management or Civil Engineering major. C: BCM 311 concurrently.  
Estimating construction projects: labor, material, overhead, and profit in unit and detailed formats. Job cost accounting and control. Estimation software.