Agricultural Engineering

Administered by the Department of Agricultural and Biosystems Engineering

Undergraduate Study

For the undergraduate curriculum in agricultural engineering leading to the degree bachelor of science. This curriculum is accredited under the General Criteria and Program Criteria for Agricultural Engineering Programs by the Engineering Accreditation Commission of ABET, http://www.abet.org/ .

Curriculum Educational Goal, Objectives, and Learning Outcomes:

Goal: To educate students in the analysis and design of machinery, animal housing, and environmental systems for the production, processing, storage, handling, distribution, and use of food, feed, fiber and other biomaterials, and the management of related natural resources, by integrating basic physical and biological sciences with engineering design principles.

Program Educational Objectives: Three to five years after graduation, our graduates will be using the knowledge, skills, and abilities from their agricultural engineering degree to improve the human condition through successful careers in a wide variety of fields. They will be effective leaders, collaborators, and innovators who address environmental, social, technical, and business challenges. They will be engaged in life-long learning and professional development through self-study, continuing education, or graduate/professional school.

Student Outcomes: At graduation, students will have developed and demonstrated these outcomes:

(a) an ability to apply knowledge of mathematics, science, and engineering;

(b) an ability to design and conduct experiments, as well as to analyze and interpret data;

(c) an ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability;

(d) an ability to function on multidisciplinary teams;

(e) an ability to identify, formulate, and solve engineering problems;

(f) an understanding of professional and ethical responsibility;

(g) an ability to communicate effectively;

(h) the broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context;

(i) a recognition of the need for, and an ability to engage in life-long learning;

(j) a knowledge of contemporary issues;

(k) an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.

Graduates find employment in diverse ag- and bio-related industries and government agencies dealing with agricultural machines and buildings, animal and environmental control, grain processing and handling, soil and water resources, food, biorenewables, and biotechnology. Their work involves engineering design, development, testing, research, manufacturing, consulting, sales, and service. Students are highly encouraged to participate in either cooperative education or internship programs.

The department also offers a bachelor of science curriculum in biological systems engineering. Additionally, the department offers bachelor of science curricula in agricultural systems technology and in industrial technology.

Well-qualified juniors and seniors in agricultural engineering who are interested in graduate study may apply for concurrent enrollment in the Graduate College to simultaneously pursue a bachelor of science degree in agricultural engineering and a master of science degree in agricultural engineering. A concurrent bachelor of science and master of business administration program is also offered by the department. Refer to Graduate Study for more information.

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Graduate Study

The department offers master of science, master of engineering, and doctor of philosophy degrees with a major in agricultural engineering. Within the agricultural engineering major the student may specialize in advanced machinery engineering, animal production systems engineering, biological and process engineering, occupational safety engineering, or water and environmental stewardship engineering. Details on current research programs available at http://www.abe.iastate.edu/.

For the master of science program, at least 30 credits of acceptable graduate work must be completed with a minimum of 22 credits of course work; corresponding numbers for the master of engineering program are 32 and 27. For the doctor of philosophy degree, at least 72 credits of acceptable graduate work must be completed with a minimum of 42 credits of course work. All Ph.D. students must complete a teaching/extension experience prior to graduation.

The department also offers both master of science and doctor of philosophy degrees in industrial and agricultural technology.

The department also participates in interdepartmental majors in environmental science, sustainable agriculture, biorenewable resources and technology, human computer interaction, and toxicology (see Index).

Curriculum in Agricultural Engineering

Administered by the Department of Agricultural and Biosystems Engineering.

Leading to the degree bachelor of science.

Total credits required: 128 cr. Any transfer credit courses applied to the degree program require a grade of C or better. See also Basic Program and Special Programs.

International Perspectives: 3 cr. [1]

U.S. Diversity: 3 cr. [1]

Communication Proficiency/Library requirement:

ENGL 150	Critical Thinking and Communication (minimum grade of C)	3
ENGL 250	Written, Oral, Visual, and Electronic Composition (minimum grade of C)	3
LIB 160	Information Literacy	1
One of the following (minimum grade of C)		3
AGEDS 311	Presentation and Sales Strategies for Agricultural Audiences	
ENGL 309	Report and Proposal Writing	
ENGL 314	Technical Communication	
SP CM 212	Fundamentals of Public Speaking	
MKT 343	Personal Sales	

Social Sciences and Humanities: 12 cr. [2]

3 credits from international perspectives	3
3 credits from U.S. diversity university-approved list	3
6 additional credits from Social Sciences and Humanities courses	6
Total Credits	12

Basic Program: 27 cr. [3, 4]

CHEM 167	General Chemistry for Engineering Students	4
or CHEM 177	General Chemistry I	
and		
CHEM 178	General Chemistry II	
ENGL 150	Critical Thinking and Communication *	3
ENGL 250	Written, Oral, Visual, and Electronic Composition *	3
ENGR 101	Engineering Orientation	R
ENGR 160	Engineering Problems with Computer Applications Laboratory [3]	3
LIB 160	Information Literacy	1
MATH 165	Calculus I	4
MATH 166	Calculus II	4
PHYS 221	Introduction to Classical Physics I	5
Total Credits		27

* see above for grade requirements

Math and Physical Science: 12 cr.

CHEM 167L	Laboratory in General Chemistry for Engineering	1
or CHEM 177L	Laboratory in General Chemistry I	
MATH 266	Elementary Differential Equations	3
PHYS 222	Introduction to Classical Physics II	5
STAT 305	Engineering Statistics	3
Total Credits		12

Ag Engineering Core: 29 cr. [4]

A E 216	Fundamentals of Agricultural and Biosystems Engineering	3
A E 218	Project Management & Design in Agricultural and Biosystems Engineering	2
A E 316	Applied Numerical Methods for Agricultural and Biosystems Engineering	3
A E 363	Agri-Industrial Applications of Electric Power and Electronics	4
A E 404	Instrumentation for Agricultural and Biosystems Engineering	3
A E 415	Agricultural Engineering Design I	2
A E 416	Agricultural Engineering Design II	2
E M 274	Statics of Engineering	3
E M 324	Mechanics of Materials	3
E M 327	Mechanics of Materials Laboratory	1
M E 231	Engineering Thermodynamics I	3
Total Credits		29

Other Remaining Courses: 8 cr.

A E 110	Experiencing Agricultural and Biosystems Engineering	1
A E 170	Engineering Graphics and Introductory Design	3
A E 201	Preparing for Workplace Seminar	1
One of the following (minimum grade of C)		3
AGEDS 311	Presentation and Sales Strategies for Agricultural Audiences	
ENGL 309	Report and Proposal Writing	
ENGL 314	Technical Communication	
SP CM 212	Fundamentals of Public Speaking	
MKT 343	Personal Sales	
Total Credits		8

Elect remaining courses from one of the following options:

Land and Water Resources Engineering Option: 40 cr.

BIOL 211	Principles of Biology I	3
GEOL 201	Geology for Engineers and Environmental Scientists	3
E M 378	Mechanics of Fluids	3
MICRO 201	Introduction to Microbiology	2
MICRO 201L	Introductory Microbiology Laboratory	1
AGRON 154	Fundamentals of Soil Science	3
C E 326	Principles of Environmental Engineering (ABE Breadth Elective or SSH)	3
A E 431	Design and Evaluation of Soil and Water Conservation Systems	3
A E 408	GIS and Natural Resources Management	3
C E 372	Engineering Hydrology and Hydraulics	3
Computer Graphics		1
A E 271	Engineering Applications of Parametric Solid Modeling	
or A E 272	Parametric Solid Models, Drawings, and Assemblies Using Pro/ENGINEER	
ABE Elective		3
A E 340	Functional Analysis and Design of Agricultural Field Machinery	
A E 424	Air Pollution	
BSE 480	Engineering Analysis of Biological Systems	
A E 469	Grain Processing and Handling	
AE Water Quality Elective		3
A E 436	Design and Evaluation of Soil and Water Monitoring Systems	
A E 432	Nonpoint Source Pollution and Control	
A E 537	Total Maximum Daily Load (TMDL) Development and Implementation	
AE Structures Elective		3
A E 472	Design of Environmental Modification Systems for Animal Housing	
A E 478	Wood Frame Structural Design	
Subsurface Systems Elective		3
C E 360	Geotechnical Engineering	
C E 473	Groundwater Hydrology	
Total Credits		40

Power and Machinery Engineering Option: 40 cr.

A E 271	Engineering Applications of Parametric Solid Modeling	1
or A E 272	Parametric Solid Models, Drawings, and Assemblies Using Pro/ENGINEER	
A E 340	Functional Analysis and Design of Agricultural Field Machinery	3
A E 342	Agricultural Tractor Power	3
A E 413	Fluid Power Engineering	3
AGRON 154	Fundamentals of Soil Science	3
BIOL 211	Principles of Biology I	3
E M 345	Dynamics	3
E M 378	Mechanics of Fluids	3
M E 324	Manufacturing Engineering	3
M E 324L	Manufacturing Engineering Laboratory	1
M E 325	Machine Design	3
MAT E 273	Principles of Materials Science and Engineering	3
One of the following		3
A E 431	Design and Evaluation of Soil and Water Conservation Systems	
A E 469	Grain Processing and Handling	
A E 472	Design of Environmental Modification Systems for Animal Housing	
A E 478	Wood Frame Structural Design	
BSE 480	Engineering Analysis of Biological Systems	
Electives [2]		5
Total Credits		40

Animal Production Systems Engineering Option: 40 cr.

BIOL 211	Principles of Biology I	3
Ag, Biol, Nat Res Elective from approved list		3
Graphic Design		1
A E 271	Engineering Applications of Parametric Solid Modeling	
or		
A E 272	Parametric Solid Models, Drawings, and Assemblies Using Pro/ENGINEER	
A E 472	Design of Environmental Modification Systems for Animal Housing	3
A E 469	Grain Processing and Handling	3
E M 378	Mechanics of Fluids	3
A E 424A	Air Pollution: Air quality and effects of pollutants	1
A E 424B	Air Pollution: Climate change and causes	1
A E 424E	Air Pollution: Agricultural sources of pollution	1
C E 332	Structural Analysis I	3
C E 333	Structural Steel Design I	3
C E 334	Reinforced Concrete Design I	3
M E 436	Heat Transfer	4
A E 478	Wood Frame Structural Design	3
ABE Elective [2]		3

Technical Elective	2
Total Credits	40

Co-op/Internships (Optional)

1. These university requirements will add to the minimum credits of the program unless the university-approved courses are also approved by the department to meet other course requirements within the degree program. U.S. diversity and international perspectives courses may not be taken Pass/Not Pass.
2. Choose from department approved list.
3. See Basic Program for Professional Engineering Curricula for accepted substitutions for curriculum designated courses in the Basic Program.
4. 2.00 required including transfer courses.

See also: A 4-year plan of study grid showing course template by semester for an agricultural power and machinery option in Agricultural Engineering. (https://nextcatalog.registrar.iastate.edu/planofstudy/engineering/#agriculturalengineeringbs-agpowermachineryoption)

See also: A 4-year plan of study grid showing course template by semester for a land and water resources engineering option in Agricultural Engineering. (https://nextcatalog.registrar.iastate.edu/planofstudy/engineering)

See also: A 4-year plan of study grid showing course template by semester for an animal production systems engineering option in Agricultural Engineering. (https://nextcatalog.registrar.iastate.edu/planofstudy/engineering)

Courses primarily for undergraduates:

A E 110. Experiencing Agricultural and Biosystems Engineering.
(0-2) Cr. 1. S.
Laboratory-based, team-oriented experiences in a spectrum of topics common to the practice of agricultural and biosystems engineering. Report writing, co-ops, internships, careers, registration planning.

A E 170. Engineering Graphics and Introductory Design.
(Cross-listed with BSE). (2-2) Cr. 3. F.S. *Prereq: Satisfactory scores in math placement assessments; credit or enrollment in MATH 142.*
Applications of multi-view drawings and dimensioning. Techniques for visualizing, analyzing, and communicating 3-D geometries. Application of the design process including written and oral reports.

A E 201. Preparing for Workplace Seminar.
(Cross-listed with BSE, TSM). (1-0) Cr. 1. F.S. *Prereq: Sophomore classification in A E, AST, BSE or ITec*
8 week course. Professionalism in the context of the engineering/technical workplace. Development and demonstration of key workplace competencies: teamwork, initiative, communication, and engineering/technical knowledge. Resumes, interviewing, preparation for internship experiences, professional portfolios.

A E 216. Fundamentals of Agricultural and Biosystems Engineering.
(Cross-listed with BSE). (2-2) Cr. 3. F. *Prereq: A E 110, ENGR 160, credit or enrollment in MATH 166*
Application of mathematics and engineering sciences to mass and energy balances in agricultural and biological systems. Emphasis is on solving engineering problems in the areas of heat and mass transfer, air and water vapor systems; animal production systems, grain systems; food systems, hydrologic systems, and bioprocessing.

A E 218. Project Management & Design in Agricultural and Biosystems Engineering.
(Cross-listed with BSE). (1-2) Cr. 2. S. *Prereq: A E 216*
Project management - critical path, Gantt charts, resource allocations, basic project budgeting, and project management software. Engineering design approaches. Open-ended design projects to demonstrate the preceding principles through application of technical concepts taught in prerequisite coursework.

A E 271. Engineering Applications of Parametric Solid Modeling.
(1-2) Cr. 1. F.S. *Prereq: ENGR 170 or TSM 116 or equivalent*
8 week-course. Creating, editing, and documenting part and assembly models using Solidworks.

A E 272. Parametric Solid Models, Drawings, and Assemblies Using Pro/ENGINEER.
(1-2) Cr. 1. F.S. *Prereq: ENGR 170 or TSM 116 or equivalent*
8 week-course. Applications of Pro/ENGINEER software. Create solid models of parts and assemblies. Utilize the solid models to create design documentation: standard drawing views, dimensions, and notes.

A E 298. Cooperative Education.
Cr. R. F.S.SS. *Prereq: Permission of department and Engineering Career Services*
First professional work period in the cooperative education program. Students must register for this course before commencing work.

A E 316. Applied Numerical Methods for Agricultural and Biosystems Engineering.
(Cross-listed with BSE). (2-2) Cr. 3. F. *Prereq: ENGR 160, Math 266*
Computer aided solution of agricultural engineering problems by use of numerical techniques and mathematical models. Systems analysis and optimization applicable to agricultural and biological systems.

A E 325. Biorenewable Systems.
(Cross-listed with TSM, AGRON, AN S, BSE, BUSAD, ECON). (3-0) Cr. 3. F. *Prereq: ECON 101, CHEM 163 or higher, MATH 140 or higher*
Converting biorenewable resources into bioenergy and biobased products. Biorenewable concepts as they relate to drivers of change, feedstock production, processes, products, co-products, economics, and transportation/logistics.

A E 340. Functional Analysis and Design of Agricultural Field Machinery.
(2-2) Cr. 3. F. *Prereq: A E 110, A E 216, A E 316*
Principles of operation, design, selection, testing and evaluation of agricultural field machinery and systems. Functional and mechanical performances. Crop and soil interaction with machines. Machine systems, including land preparation, crop establishment, crop protection, harvesting and post-harvest, materials handling systems.

A E 342. Agricultural Tractor Power.
(2-3) Cr. 3. S. *Prereq: Ch E 381 or M E 231*
Thermodynamic principles and construction of tractor engines. Fuels, combustion, and lubrication. Kinematics and dynamics of tractor power applications; drawbar, power take-off and traction mechanisms. Nonmajor graduate credit.

A E 363. Agri-Industrial Applications of Electric Power and Electronics.
(3-2) Cr. 4. F. *Prereq: PHYS 222*
Single phase and three phase circuit design. Electrical safety. Electric motors and controls. Programmable logic controllers. Digital logic, instrumentation and sensors. Nonmajor graduate credit.

A E 388. Sustainable Engineering and International Development.
(Cross-listed with C E, E E, M E, MAT E, BSE). (2-2) Cr. 3. F. *Prereq: Junior classification in engineering*
Multi-disciplinary approach to sustainable engineering and international development, sustainable development, appropriate design and engineering, feasibility analysis, international aid, business development, philosophy and politics of technology, and ethics in engineering. Engineering-based projects from problem formulation through implementation. Interactions with partner community organizations or international partners such as nongovernment organizations (NGOs). Course readings, final project/design report.
Meets International Perspectives Requirement.

A E 396. Summer Internship.
Cr. R. Repeatable. SS. *Prereq: Permission of department and Engineering Career Services*
Summer professional work period.

A E 397. Engineering Internship.
Cr. R. Repeatable. F.S. *Prereq: Permission of department and Engineering Career Services*
One semester maximum per academic year professional work period.

A E 398. Cooperative Education.
Cr. R. F.S.SS. *Prereq: A E 298, permission of department and Engineering Career Services*
Second professional work period in the cooperative education program. Students must register for this course before commencing work.

A E 403. Modeling and Controls for Agricultural Systems.
(Dual-listed with A E 503). (Cross-listed with BSE). (2-2) Cr. 3. Alt. S., offered 2013. *Prereq: A E 363, MATH 266*
Modeling dynamic systems with ordinary differential equations. Introduction to state variable methods of system analysis. Analysis of mechanical, electrical, and fluid power systems. Analytical and numerical solutions of differential equations. Introduction to classical control theory. Feedback and stability examined in the s domain. Frequency response as an analytical and experimental tool. MATLAB will be used throughout the course for modeling.

A E 404. Instrumentation for Agricultural and Biosystems Engineering.
(Dual-listed with A E 504). (2-2) Cr. 3. F. *Prereq: A E 363 or CPR E 281*
Interfacing techniques for computer-based data acquisition and control systems. Basic interfacing components including A/D and D/A conversion, signal filtering, multiplexing, and process control. Sensors and theory of operation applied to practical monitoring and control problems.

A E 408. GIS and Natural Resources Management.
(Dual-listed with A E 508). (Cross-listed with ENSCI). (2-2) Cr. 3. F. *Prereq: Working knowledge of computers and Windows environment*
Introduction to fundamental concepts and applications of GIS in natural resources management with specific focus on watersheds. Topics include: basic GIS technology, data structures, database management, spatial analysis, and modeling; visualization and display of natural resource data. Case studies in watershed and natural resource management using ArcView GIS.

A E 410. Electronic Systems Integration for Agricultural Machinery & Production Systems.
(Dual-listed with A E 510). Cr. 3. S. *Prereq: A E 363 or equivalent.*
System architecture and design of electronics used in agricultural machinery and production systems. Emphasis on information technology and systems integration for automated agriculture processes. Design of Controller Area Network (CAN BUS) communication systems and discussion of relevant standards (ISO 11783 and SAE J1939). Application of technologies for sensing, distribution control, and automation of agricultural machinery will be emphasized.

A E 411. Bioprocessing and Bioproducts.
(Dual-listed with A E 511). (Cross-listed with C E, BIOE, BSE). (3-0) Cr. 3. F. *Prereq: A E 216, C E 326 or equivalent, MATH 160 or MATH 165, CHEM 167 or higher, BIOL 173 or BIOL 211 or higher, senior or graduate classification*
Sustainability, cleaner production. Taxonomy, kinetics, metabolism, microbial cultivation, aerobic and anaerobic fermentation. Antibiotics, food supplements, fermented foods, vitamin production. Biofuels, bioenergy and coproducts. Mass/energy balances, process integration, pretreatment, separation. Membrane reactors, bioelectrolysis, microbial fuel cells, nanotechnology, genetic engineering, mutagenesis.

A E 413. Fluid Power Engineering.
(Cross-listed with M E). (2-2) Cr. 3. F. *Prereq: Credit or enrollment in E M 378 or M E 335, A E 216 or M E 270*
Properties of hydraulic fluids. Performance parameters of fixed and variable displacement pumps and motors. Hydraulic circuits and systems. Hydrostatic transmissions. Characteristics of control valves. Analysis and design of hydraulic systems for power and control functions. Nonmajor graduate credit.

A E 415. Agricultural Engineering Design I.
(Cross-listed with BSE). (1-2) Cr. 2. F.S. *Prereq: A E 271 or A E 272, E M 324*
Identification of current design problems in agricultural engineering. Development of alternate solutions using creativity and engineering analysis and synthesis techniques. Nonmajor graduate credit.

A E 416. Agricultural Engineering Design II.
(Cross-listed with BSE). (1-2) Cr. 2. F.S. *Prereq: A E 415*
Selection of promising solutions to design problems identified in 415 for development by design teams. Presentation of designs through oral and written reports and prototypes. Nonmajor graduate credit.

A E 424. Air Pollution.
(Dual-listed with A E 524). (Cross-listed with ENSCI, C E). (1-0) Cr. 1. *Prereq: Either PHYS 221 or CHEM 178 and either MATH 166 or 3 credits in statistics. Senior classification or above*
1 cr. per module. Module A prereq for all modules; module B prereq for D and E.

A E 424A. Air Pollution: Air quality and effects of pollutants.
(Dual-listed with A E 524A). (Cross-listed with ENSCI, C E). (1-0) Cr. 1. *Prereq: Either PHYS 221 or CHEM 178 and either MATH 166 or 3 credits in statistics. Senior classification or above*
1 cr. per module. Module A prereq for all modules; module B prereq for D and E.

A E 424B. Air Pollution: Climate change and causes.
(Dual-listed with A E 524B). (Cross-listed with ENSCI, C E). (1-0) Cr. 1. *Prereq: Either PHYS 221 or CHEM 178 and either MATH 166 or 3 credits in statistics. Senior classification or above*
1 cr. per module. Module A prereq for all modules; module B prereq for D and E.

A E 424C. Air Pollution: Transportation constraints.
(Dual-listed with A E 524C). (Cross-listed with ENSCI, C E). (1-0) Cr. 1. *Prereq: Either PHYS 221 or CHEM 178 and either MATH 166 or 3 credits in statistics. Senior classification or above*
1 cr. per module. Module A prereq for all modules; module B prereq for D and E.

A E 424D. Air Pollution: Off-gas treatment technology.
(Dual-listed with A E 524D). (Cross-listed with ENSCI, C E). (1-0) Cr. 1. *Prereq: Either PHYS 221 or CHEM 178 and either MATH 166 or 3 credits in statistics. Senior classification or above*
1 cr. per module. Module A prereq for all modules; module B prereq for D and E.

A E 424E. Air Pollution: Agricultural sources of pollution.
(Dual-listed with A E 524E). (Cross-listed with ENSCI, C E). (1-0) Cr. 1. *Prereq: Either PHYS 221 or CHEM 178 and either MATH 166 or 3 credits in statistics. Senior classification or above*
1 cr. per module. Module A prereq for all modules; module B prereq for D and E.

A E 431. Design and Evaluation of Soil and Water Conservation Systems.
(Dual-listed with A E 531). (2-3) Cr. 3. F. *Prereq: E M 378 or CH E 356*
Hydrology and hydraulics in agricultural and urbanizing watersheds. Design and evaluation of systems for the conservation and quality preservation of soil and water resources. Use and analysis of hydrologic data in engineering design; relationship of topography, soils, crops, climate, and cultural practices in conservation and quality preservation of soil and water for agriculture. Small watershed hydrology, water movement and utilization in the soil-plant-atmosphere system, agricultural water management, best management practices, and agricultural water quality.

A E 432. Nonpoint Source Pollution and Control.
(Dual-listed with A E 532). (3-0) Cr. 3. *Prereq: E M 378 or CH E 356 or M E 335*
Characteristics and courses of non-point source (NPS) pollution in agricultural and urban watersheds, computer modeling and NPS pollution for terrestrial and aquatic systems, strategies to control and manage NPS pollution of water bodies, total maximum daily loads (TMDLs) and integrated watershed management. Graduate students are required to review research papers and develop/deliver lecture models on assigned topics.

A E 436. Design and Evaluation of Soil and Water Monitoring Systems.
(Dual-listed with A E 536). (3-0) Cr. 3. Alt. S., offered 2014. *Prereq: A E 431 or permission of the instructor*
Development of monitoring systems that support effective planning, performance evaluation, modeling, or environmental impact assessment of soil-, water-, and waste-management systems. Typical soil and water pollutants and physical, chemical, and biological characteristics that affect sample location and timing. Sample collection, documentation, chain-of-custody, and quality assurance procedures.

A E 451. Food and Bioprocess Engineering.
(Dual-listed with A E 551). (3-0) Cr. 3. F. *Prereq: A E 216 and M E 436 or CH E 357, or FS HN 351 and MATH 266 or MATH 267*
Application of engineering principles and mathematical modeling to the quantitative analysis of food and bioprocessing systems. Physical/chemical characteristics of foods and biological systems, flow processes, thermal processes and separation processes.

A E 466. Multidisciplinary Engineering Design.
(Cross-listed with AER E, CPR E, ENGR, E E, I E, M E, MAT E). (1-4) Cr. 3. Repeatable. F.S. *Prereq: Student must be within two semesters of graduation and receive permission of the instructor*
Application of team design concepts to projects of a multidisciplinary nature. Concurrent treatment of design, manufacturing and life cycle considerations. Application of design tools such as CAD, CAM, and FEM. Design methodologies, project scheduling, cost estimating, quality control, manufacturing processes. Development of a prototype and appropriate documentation in the form of written reports, oral presentations, computer models and engineering drawings.

A E 469. Grain Processing and Handling.
(Dual-listed with A E 569). (Cross-listed with BSE). (2-3) Cr. 3. S. *Prereq: A E 216*
Cereal grain and oilseed properties, quality measurement, processing, and end-use value. Design of drying systems using computer simulation. Corn wet and dry milling. Soybean oil extraction. Grain handling systems.

A E 472. Design of Environmental Modification Systems for Animal Housing.
(Dual-listed with A E 572). (3-0) Cr. 3. Alt. S., offered 2012. *Prereq: A E 216, M E 231*
Principles and design of animal environmental control systems. Insulation, heat and mass transfer, fans, ventilation, air distribution, heating and cooling equipment, energy use, control strategies.

A E 478. Wood Frame Structural Design.
(Dual-listed with A E 578). (3-0) Cr. 3. Alt. S., offered 2013. *Prereq: A E 216, E M 324*
Design of light-framed wood structures using LRFD and ASD design procedures. Includes analysis of wind, snow, dead, and live loads. Applications include animal housing and machine storage. Fasteners, laminated posts, truss design and use of National Design Specifications.

A E 490. Agricultural Engineering Independent Study.
Cr. 1-4. Repeatable.

A E 490C. Agricultural Engineering Independent Study: Computer-aided Design.
Cr. 1-4. Repeatable.
Guided instruction in computer-aided design.

A E 490H. Agricultural Engineering Independent Study: Honors.
Cr. 1-4. Repeatable.
Guided instruction in agricultural engineering topics for honors students.

A E 490O. Agricultural Engineering Independent Study: Occupational Safety.
Cr. 1-4. Repeatable.
Guided instruction in occupational safety.

A E 490P. Agricultural Engineering Independent Study: Power and Machinery Engineering.
Cr. 1-4. Repeatable.
Guided instruction in power and machinery engineering.

A E 490Q. Agricultural Engineering Independent Study: Structures.
Cr. 1-4. Repeatable.
Guided instruction in structures.

A E 490R. Process Engineering.
Cr. 1-4. Repeatable.

A E 490S. Agricultural Engineering Independent Study: Environmental and Natural Resources Systems.
Cr. 1-4. Repeatable.
Guided instruction in environmental and natural resourses systems.

A E 490W. Agricultural Engineering Independent Study: Waste Management.
Cr. 1-4. Repeatable.

A E 496. Agricultural and Biosystems Engineering Travel Course.
(Cross-listed with BSE). Cr. 1-4. Repeatable. F.S.SS. *Prereq: Permission of instructor*
Limited enrollment. Tour and study of international agricultural and biosystems engineering as applied to biorenewable and food systems. Location and duration of tours will vary. Travel expenses paid by students. Course requires completion of options A, B, and C or option D.
Meets International Perspectives Requirement.

A E 496A. Agricultural and Biosystems Engineering Travel Course: Pre-departure.
(Cross-listed with BSE). Cr. 1-4. Repeatable. F.S.SS. *Prereq: Permission of instructor*
Limited enrollment. Tour and study of international agricultural and biosystems engineering as applied to biorenewable and food systems. Location and duration of tours will vary. Travel expenses paid by students. Course requires completion of options A, B, and C or option D.
Meets International Perspectives Requirement.

A E 496B. Agricultural and Biosystems Engineering Travel Course: Travel (R credit).
(Cross-listed with BSE). Cr. 1-4. Repeatable. F.S.SS. *Prereq: Permission of instructor*
Limited enrollment. Tour and study of international agricultural and biosystems engineering as applied to biorenewable and food systems. Location and duration of tours will vary. Travel expenses paid by students. Course requires completion of options A, B, and C or option D.

A E 496C. Agricultural and Biosystems Engineering Travel Course: Post-travel.
(Cross-listed with BSE). Cr. 1-4. Repeatable. F.S.SS. *Prereq: Permission of instructor*
Limited enrollment. Tour and study of international agricultural and biosystems engineering as applied to biorenewable and food systems. Location and duration of tours will vary. Travel expenses paid by students. Course requires completion of options A, B, and C or option D.
Meets International Perspectives Requirement.

A E 496D. Agricultural and Biosystems Engineering Travel Course: Combination (A/B/C).
(Cross-listed with BSE). Cr. 1-4. Repeatable. F.S.SS. *Prereq: Permission of instructor*
Limited enrollment. Tour and study of international agricultural and biosystems engineering as applied to biorenewable and food systems. Location and duration of tours will vary. Travel expenses paid by students. Course requires completion of options A, B, and C or option D.
Meets International Perspectives Requirement.

A E 498. Cooperative Education.
Cr. R. Repeatable. F.S.SS. *Prereq: A E 398, permission of department and Engineering Career Services*
Third and subsequent professional work periods in the cooperative education program. Students must register for this course before commencing work.

Courses primarily for graduate students, open to qualified undergraduates:

A E 501. Fundamentals of Biorenewable Resources.
(Cross-listed with BRT). (3-0) Cr. 3. S. *Prereq: Undergraduate training in an engineering or physical or biological discipline or degrees in agriculture or economics*
Introduction to the science and engineering of converting biorenewable resources into bioenergy and biobased products. Survey of biorenewable resource base and properties; description of biobased products; methods of biorenewable resource production; processing technologies for fuels, chemicals, materials, and energy; environmental impacts; economics of biobased products and bioenergy.

A E 503. Modeling and Controls for Agricultural Systems.
(Dual-listed with A E 403). (Cross-listed with BSE). (2-2) Cr. 3. Alt. S., offered 2013. *Prereq: A E 363, MATH 266*
Modeling dynamic systems with ordinary differential equations. Introduction to state variable methods of system analysis. Analysis of mechanical, electrical, and fluid power systems. Analytical and numerical solutions of differential equations. Introduction to classical control theory. Feedback and stability examined in the s domain. Frequency response as an analytical and experimental tool. MATLAB will be used throughout the course for modeling.

A E 504. Instrumentation for Agricultural and Biosystems Engineering.
(Dual-listed with A E 404). (2-2) Cr. 3. F. *Prereq: A E 363 or CPR E 281*
Interfacing techniques for computer-based data acquisition and control systems. Basic interfacing components including A/D and D/A conversion, signal filtering, multiplexing, and process control. Sensors and theory of operation applied to practical monitoring and control problems.

A E 506. Applied Computational Intelligence.
(2-2) Cr. 3. Alt. F., offered 2012. *Prereq: A E 316 or equivalent, MATH 166, STAT 305*
Applications of biologically inspired computational intelligence tools for data mining, system modeling, and optimization for agricultural, biological and other engineered systems. Introduction to Artificial Neural Networks, Support Vector Machines, Fuzzy Logic, Genetic Algorithms, Bayesian and Decision Tree learning. Fundamental Machine Vision techniques will be introduced in the first part of course and be integrated into the lab exercises for learning different computational intelligence techniques. MATLAB will be used throughout the course for algorithm implementation.

A E 508. GIS and Natural Resources Management.
(Dual-listed with A E 408). (Cross-listed with ENSCI). (2-2) Cr. 3. F. *Prereq: Working knowledge of computers and Windows environment*
Introduction to fundamental concepts and applications of GIS in natural resources management with specific focus on watersheds. Topics include: basic GIS technology, data structures, database management, spatial analysis, and modeling; visualization and display of natural resource data. Case studies in watershed and natural resource management using ArcView GIS. In addition to other assignments, graduate students will prepare research literature reviews on topics covered in class and develop enterprise applications.

A E 510. Electronic Systems Integration for Agricultural Machinery & Production Systems.
(Dual-listed with A E 410). Cr. 3. S. *Prereq: A E 363 or equivalent.*
System architecture and design of electronics used in agricultural machinery and production systems. Emphasis on information technology and systems integration for automated agriculture processes. Design of Controller Area Network (CAN BUS) communication systems and discussion of relevant standards (ISO 11783 and SAE J1939). Application of technologies for sensing, distribution control, and automation of agricultural machinery will be emphasized.

A E 511. Bioprocessing and Bioproducts.
(Dual-listed with A E 411). (Cross-listed with C E, BIOE, BSE). (3-0) Cr. 3. F. *Prereq: A E 216, C E 326 or equivalent, MATH 160 or MATH 165, CHEM 167 or higher, BIOL 173 or BIOL 211 or higher, senior or graduate classification*
Sustainability, cleaner production. Taxonomy, kinetics, metabolism, microbial cultivation, aerobic and anaerobic fermentation. Antibiotics, food supplements, fermented foods, vitamin production. Biofuels, bioenergy and coproducts. Mass/energy balances, process integration, pretreatment, separation. Membrane reactors, bioelectrolysis, microbial fuel cells, nanotechnology, genetic engineering, mutagenesis.

A E 515. Integrated Crop and Livestock Production Systems.
(Cross-listed with SUSAG, AGRON, AN S). (3-0) Cr. 3. Alt. F., offered 2011. *Prereq: SUSAG 509*
Methods to maintain productivity and minimize the negative ecological effects of agricultural systems by understanding nutrient cycles, managing manure and crop residue, and utilizing multispecies interactions. Crop and livestock production within landscapes and watersheds is also considered. Course includes a significant field component, with student teams analyzing Iowa farms.

A E 524. Air Pollution.
(Dual-listed with A E 424). (Cross-listed with ENSCI, C E). (1-0) Cr. 1. *Prereq: Either PHYS 221 or CHEM 178 and either MATH 166 or 3 credits in statistics. Senior classification or above*
1 cr. per module. Module A prereq for all modules; module B prereq for D and E.

A E 524A. Air Pollution: Air quality and effects of pollutants.
(Dual-listed with A E 424A). (Cross-listed with ENSCI, C E). (1-0) Cr. 1. *Prereq: Either PHYS 221 or CHEM 178 and either MATH 166 or 3 credits in statistics. Senior classification or above*
1 cr. per module. Module A prereq for all modules; module B prereq for D and E.

A E 524B. Air Pollution: Climate change and causes.
(Dual-listed with A E 424B). (Cross-listed with ENSCI, C E). (1-0) Cr. 1. *Prereq: Either PHYS 221 or CHEM 178 and either MATH 166 or 3 credits in statistics. Senior classification or above*
1 cr. per module. Module A prereq for all modules; module B prereq for D and E.

A E 524C. Air Pollution: Transportation constraints.
(Dual-listed with A E 424C). (Cross-listed with ENSCI, C E). (1-0) Cr. 1. *Prereq: Either PHYS 221 or CHEM 178 and either MATH 166 or 3 credits in statistics. Senior classification or above*
1 cr. per module. Module A prereq for all modules; module B prereq for D and E.

A E 524D. Air Pollution: Off-gas treatment technology.
(Dual-listed with A E 424D). (Cross-listed with ENSCI, C E). (1-0) Cr. 1. *Prereq: Either PHYS 221 or CHEM 178 and either MATH 166 or 3 credits in statistics. Senior classification or above*
1 cr. per module. Module A prereq for all modules; module B prereq for D and E.

A E 524E. Air Pollution: Agricultural sources of pollution.
(Dual-listed with A E 424E). (Cross-listed with ENSCI, C E). (1-0) Cr. 1. *Prereq: Either PHYS 221 or CHEM 178 and either MATH 166 or 3 credits in statistics. Senior classification or above*
1 cr. per module. Module A prereq for all modules; module B prereq for D and E.

A E 531. Design and Evaluation of Soil and Water Conservation Systems.
(Dual-listed with A E 431). (2-3) Cr. 3. F. *Prereq: E M 378 or CH E 356*
Hydrology and hydraulics in agricultural and urbanizing watersheds. Design and evaluation of systems for the conservation and quality preservation of soil and water resources. Use and analysis of hydrologic data in engineering design; relationship of topography, soils, crops, climate, and cultural practices in conservation and quality preservation of soil and water for agriculture. Small watershed hydrology, water movement and utilization in the soil-plant-atmosphere system, agricultural water management, best management practices, and agricultural water quality. Graduate students will prepare several research literature reviews on topics covered in the class in addition to the other assignments.

A E 532. Nonpoint Source Pollution and Control.
(Dual-listed with A E 432). (3-0) Cr. 3. *Prereq: E M 378 or CH E 356 or M E 335*
Characteristics and courses of non-point source (NPS) pollution in agricultural and urban watersheds, computer modeling and NPS pollution for terrestrial and aquatic systems, strategies to control and manage NPS pollution of water bodies, total maximum daily loads (TMDLs) and integrated watershed management. Graduate students are required to review research papers and develop/deliver lecture models on assigned topics.

A E 533. Erosion and Sediment Transport.
(Cross-listed with ENSCI). (3-0) Cr. 3. Alt. F., offered 2012. *Prereq: A E 422 or C E 372, MATH 266*
Soil erosion processes, modified universal soil loss equation and its application to conservation planning, sediment properties, initiation of sediment motion and over land flow, flow in alluvial channels and theory of sediment transport, channel stability, reserves sedimentation, wind erosion, BMPs for controlling erosion.

A E 536. Design and Evaluation of Soil and Water Monitoring Systems.
(Dual-listed with A E 436). (3-0) Cr. 3. Alt. S., offered 2014. *Prereq: A E 431 or permission of the instructor*
Development of monitoring systems that support effective planning, performance evaluation, modeling, or environmental impact assessment of soil-, water-, and waste-management systems. Typical soil and water pollutants and physical, chemical, and biological characteristics that affect sample location and timing. Sample collection, documentation, chain-of-custody, and quality assurance procedures.

A E 537. Total Maximum Daily Load (TMDL) Development and Implementation.
(2-2) Cr. 3. Alt. F., offered 2011. *Prereq: CE 372 or equivalent*
A project-based course to develop a water quality improvement plan. The legislative and judicial basis of the Total Maximum Daily Load (TMDL) program, different approaches for TMDL development, data needs and sources, SWAT modeling, and principles and techniques for implementation of water quality improvement plans.

A E 551. Food and Bioprocess Engineering.
(Dual-listed with A E 451). (3-0) Cr. 3. F. *Prereq: A E 216 and M E 436 or CH E 357, or FS HN 351 and MATH 266 or MATH 267*
Application of engineering principles and mathematical modeling to the quantitative analysis of food and bioprocessing systems. Physical/chemical characteristics of foods and biological systems, flow processes, thermal processes and separation processes.

A E 568. Pretreatment of Biomass.
(1-2) Cr. 2. S. *Prereq: A E 216 or equivalent*
Review of lignocellulosic chemistry; chemical and physical impacts of pretreatment; impact of pretreatment on downstream processing; pretreatment economics. Lab experiments using current and novel pretreatment methods.

A E 569. Grain Processing and Handling.
(Dual-listed with A E 469). (Cross-listed with BSE). (2-3) Cr. 3. S. *Prereq: A E 216*
Cereal grain and oilseed properties, quality measurement, processing, and end-use value. Design of drying systems using computer simulation. Corn wet and dry milling. Soybean oil extraction. Grain handling systems.

A E 572. Design of Environmental Modification Systems for Animal Housing.
(Dual-listed with A E 472). (3-0) Cr. 3. Alt. S., offered 2012. *Prereq: A E 216, M E 231*
Principles and design of animal environmental control systems. Insulation, heat and mass transfer, fans, ventilation, air distribution, heating and cooling equipment, energy use, control strategies.

A E 578. Wood Frame Structural Design.
(Dual-listed with A E 478). (3-0) Cr. 3. Alt. S., offered 2013. *Prereq: A E 216, E M 324*
Design of light-framed wood structures using LRFD and ASD design procedures. Includes analysis of wind, snow, dead, and live loads. Applications include animal housing and machine storage. Fasteners, laminated posts, truss design and use of National Design Specifications.

A E 580. Engineering Analysis of Biological Systems.
(3-0) Cr. 3. F. *Prereq: A E 216; MATH 266; BIOL 211 or BIOL 212; M E231*
Systems-level engineering analysis of biological systems. Economic and life-cycle analysis of bioresource production and conversion systems. Global energy and resource issues and the role of biologically derived materials in addressing these issues. Students enrolled in AE 580 will be required to answer additional exam questions and report on two journal articles.

A E 590. Special Topics in Agricultural & Biosystems Engineering.
Cr. 1-3. Repeatable.
Guided instruction and self-study on special topics relevant to agricultural and biosystems engineering.

A E 598. Technical Communications for a Master's Degree.
(Cross-listed with TSM). Cr. 1. F.S.SS.
A technical paper draft based on the M.S. thesis or creative component is required of all master's students. This paper must be in a form that satisfies the requirements of some specific journal and be ready for submission. A technical presentation based on M.S. thesis or creative component is required of all master's students. This presentation must be in a form that satisfies the normal presentation requirements of a professional society. The presentation itself (oral or poster) may be made at a professional society meeting or at any international, regional, state, or university conference/event as long as the presentation content and form conforms to normal expectations. Offered on a satisfactory-fail basis only.

A E 599. Creative Component.
Cr. arr. Repeatable.

Courses for graduate students:

A E 601. Graduate Seminar.
(Cross-listed with TSM). (1-0) Cr. 1. F.
Keys to writing a good MS thesis or PhD dissertation. How to begin formulating research problems. Discussion of research problems and broader impacts, review of literature, identifying knowledge gaps and needs, long-term goals, research hypotheses, objectives, rationale and significance, methods, procedures, data analysis, and reporting results. Presentation of research proposal in different formats. Using peer review and responding to feedback.

A E 610. Foundations of Sustainable Agriculture.
(Cross-listed with AGRON, SUSAG, ANTHR, SOC). (3-0) Cr. 3. F. *Prereq: Graduate classification, permission of instructor*
Historical, biophysical, socioeconomic, and ethical dimensions of agricultural sustainability. Strategies for evaluating existing and emerging agricultural systems in terms of the core concepts of sustainability and their theoretical contexts.

A E 690. Advanced Topics.
Cr. arr. Repeatable.

A E 694. Teaching Practicum.
(Cross-listed with TSM). Cr. 1-3. Repeatable. F.S.SS. *Prereq: Graduate classification and permission of instructor*
Graduate student experience in the agricultural and biosystems engineering departmental teaching program.

A E 697. Engineering Internship.
Cr. R. Repeatable. *Prereq: Permission of department chair, graduate classification*
One semester and one summer maximum per academic year professional work period.

A E 698. Technical Communications for a Doctoral Degree.
(Cross-listed with TSM). Cr. 1. F.S.SS.
A technical paper draft based on the dissertation is required of all Ph.D. students. This paper must be in a form that satisfies the requirements of some specific journal and be ready for submission. A technical presentation based on the dissertation is required of all Ph.D. students. This presentation must be in a form that satisfies the normal presentation requirements of a professional society. The presentation itself (oral or poster) may be made at a professional society meeting or at any international, regional, state, or university conference/event as long as the presentation content and form conforms to normal expectations. Offered on a satisfactory-fail basis only.

A E 699. Research.
Cr. arr. Repeatable.

A E 699B. Research: Biosystems Engineering.
Cr. arr. Repeatable.
Guided graduate research in biosystems engineering.

A E 699C. Research: Computer-aided Design.
Cr. arr. Repeatable.
Guided graduate research in computer-aided design.

A E 699E. Research: Environmental Systems.
Cr. arr. Repeatable.
Guided graduate research in environmental systems.

A E 699F. Research: Food Engineering.
Cr. arr. Repeatable.
Guided graduate research in food engineering.

A E 699O. Research: Occupational Safety.
Cr. arr. Repeatable.
Guided graduate research in occupational safety.

A E 699P. Research: Power and Machinery Engineering.
Cr. arr. Repeatable.
Guided graduate research in power and machingery engineering.

A E 699Q. Research: Structures.
Cr. arr. Repeatable.
Guided graduate research in structures.

A E 699R. Research: Process Engineering.
Cr. arr. Repeatable.
Guided graduate research in process engineering.

A E 699S. Research: Environment and Natural Resources.
Cr. arr. Repeatable.
Guided graduate research in environment and natural resources.

A E 699U. Research: Waste Management.
Cr. arr. Repeatable.
Guided graduate research in waste management.