Department of Biological and Irrigation Engineering

Department Head: Ronald C. Sims
Location: Engineering 402G
Phone: (435) 797-2785
FAX: (435) 797-1248
E-mail: bieusu@cc.usu.edu
WWW: http://www.engineering.usu.edu/bie

Undergraduate Advising:
Engineering Advising Center, Engineering 314A, (435) 797-2705, isobel.roskelley@usu.edu

Degrees offered:
Bachelor of Science (BS), Master of Science (MS), and Doctor of Philosophy (PhD) in Biological Engineering; MS and PhD in Irrigation Engineering

Undergraduate options: *BS*—Biomedical; Bioprocess; Bioenvironmental; and Soil and Water Resource Systems Engineering

Graduate areas of interest: Biomedical Engineering; Biosensors; Biofuels; Sustainable Energy; Bioprocess Engineering; Biophotonics; Bioenvironmental Engineering; Irrigation Conveyance and Control Structures; Surface, Sprinkle, and Trickle Irrigation Methods; Irrigation Project Planning, Design, and Operation and Management; Agricultural Hydrology; Crop Water-Yield Analysis; Evapotranspiration; On-Farm Water Management; Remote Sensing and Geographical Information Systems; Groundwater Management and Simulation

Mission

The mission of the Department of Biological and Irrigation Engineering (BIE) is to teach students preparing to become biological engineers how to apply engineering principles and the knowledge of biological sciences to the design, control, and analysis of biological-engineered systems and to solutions of biotechnology problems. The department also prepares students for entry into other professions, including biomedical engineering, environmental engineering, medicine, and law.

Scope and Objectives

The scope of the Biological Engineering Program involves engaging students to learn to manipulate biological materials for useful purposes, to understand the biological literature, and to be able to communicate with biological scientists. Students first learn to integrate biological sciences with conventional studies in mathematics and chemistry. These skills are broadened with a liberal exposure to humanities and social sciences, then sharpened with the study of engineering topics that develop practical problem-solving abilities; expand a sensitivity to the economic, social, and legal dimensions of technical problems; provide an understanding of ethics and professional responsibility; and stimulate a desire for life-long learning. The scope involves applications in engineered biological systems, from nanoscale to watershed scale, as well as engineered life-support systems in above-earth and planetary space environments.

The objectives of the Biological Engineering Program are to:

1. Develop practical problem-solving and communication abilities that will contribute to biological engineering practice, advance knowledge, and contribute to society;

2. Expand a professional sensitivity to the economic, social, and legal dimensions of technical problems, in order that engineering solutions are more holistic and applicable; and

3. Stimulate a desire for life-long learning and adaptation as one means of extending engineering knowledge.

Outcomes

Biological Engineering Program outcomes are aligned with the program outcomes of all academic engineering programs in the U.S. that are provided by the Accreditation Board for Engineering and Technology/Engineering Accreditation Commission (ABET/EAC). Six specific outcomes are identified below.

1. Students have proven themselves to be proficient in mathematics, the sciences, and engineering.

2. Students have shown a capacity for investigation and experimentation, including the analysis and interpretation of data, as well as the ability to design an effective biological or irrigation system.

3. Students have exercised their engineering skills as part of a multi-disciplinary group, and have demonstrated the capability to communicate verbally, in writing, graphically, and through engineering media.

4. Students have demonstrated the ability to solve engineering analysis and design problems, utilizing both fundamental engineering principles and modern engineering technology and tools.

5. Students have demonstrated an understanding of the standards of professional conduct and ethical responsibility, in addition to understanding the role that an engineer plays in modern global society.

6. Students have manifested recognition of and commitment to the need for life-long learning as a professional, and have broadened the scope of their interests beyond engineering to include an awareness of the world around them.

Assessment and Evaluation

The BIE Department is committed to an assessment process aimed at evaluating the effectiveness of BIE programs in preparing graduates as productive professionals. The foundation of departmental assessment is the undergraduate accreditation by the Engineering Accreditation Commission (EAC) of ABET.

The continuing improvement processes that are documented and implemented annually as part of the accreditation activities in support of the EAC/ABET requirements provide for formal and external review of the Biological Engineering Bachelor of Science program. Internal assessment and evaluation is formally conducted annually through BIE Department committees including: (1) the Curriculum Committee, and (2) the ABET Committee. This assessment and evaluation ensures that the USU program meets an overall objective and structure consistent with similar programs in the U.S. and Canada.

The biological engineering program is continuously improved through integrating the results of this formal assessment with the day-to-day assessments obtained from both students and faculty. To ensure the overall quality of the program, the department conducts several specific assessments. These are:

1. Annual faculty self-assessment survey

2. Fundamentals of Engineering Examination performances

3. Biological and Irrigation Engineering Advisory Board activities, including employer responses and board reviews

4. Alumni survey

5. Graduating student exit interviews

6. Teaching evaluations

Undergraduate Programs

General biological engineering concepts include the properties of biological materials, electronics and bio-instrumentation, computer use and programming, engineering mechanics, thermodynamics, computer-aided drafting, bio-environmental transport phenomena, and fluid mechanics.

Students gain a strong foundation in biological, chemical, and physical sciences. Each student then selects an option within the field, based on personal interest. These areas of study are tailored for each student with 21 semester credits of technical electives and one-on-one academic advisement with a member of the faculty. Design is a major theme of both the student's general coursework and specialization, with most courses including open-ended design problems. The entire design experience is brought together in a capstone design course.

The Biological Engineering Program is accredited by the Engineering Accreditation Commission of the Accreditation Board for Engineering and Technology (EAC/ABET).

Requirements

Admission and Graduation Requirements

The student who is majoring in or planning to major in Biological Engineering needs to be aware of the College of Engineering requirements concerning admission to the college, pre-engineering, admission to the professional engineering program, general education, and other academic requirements. Additional information concerning these items is given in the College of Engineering requirements on pages 121-123. It is the responsibility of the student to be aware of these rules and regulations.

Biological Engineering Curriculum

Biological Engineering is divided into a preprofessional and a professional program involving either a four-year or a five-year schedule that will satisfy the requirements for a BS degree in Biological Engineering. Students receiving credit from the College Level Examination Program (CLEP) or from Advanced Placement (AP) may complete a BS degree program in less than four years. The academic work, particularly in the junior and senior years, is supplemented by hands-on laboratories which are required as part of the coursework. Modification in the program to meet special needs and priorities of a student may be obtained with the approval of the department head and advisor.

Preprofessional Program:

BIE 1880 Engineering Quantification of Biological Processes (Sp) 3
BIE 2330 Engineering Properties of Biological Materials (Sp) 3
CHEM 1210 Principles of Chemistry I (F,Sp) 4
CHEM 1215 Chemical Principles Laboratory I (F,Sp) 1
CHEM 2300 Principles of Organic Chemistry (F) 3
CHEM 2315 Organic Chemistry Laboratory I (F) 1
ENGR 1000 Introduction to Engineering Design (F) 2
ENGR 2010 Engineering Mechanics Statics (F,Sp) 2
ENGR 2030 Engineering Mechanics Dynamics (F,Sp) 3
ENGR 2200 Engineering Numerical Methods I (F) 3
BIOL 1610 (BLS)[1] Biology I (F) 4
ENGL 2010 (CL2) Intermediate Writing: Research Writing in a Persuasive Mode (F,Sp,Su) 3
ETE 2270 Computer Engineering Drafting (F,Sp,Su) 2
BIE 2400 Biological and Environmental Thermodynamics (Sp) 3
MATH 1210 (QL) Calculus I (F,Sp,Su) 4
MATH 1220 (QL) Calculus II (F,Sp,Su) 4
MATH 2250 (QI) Linear Algebra and Differential Equations (F,Sp,Su) .. 4
PHYS 2200 Elements of Mechanics 2
Communications Literacy 3

Professional Program:

BIE 3000 Instrumentation for Biological Systems (Sp) 2
BIE 3200 Introduction to Unit Operations in Biological Engineering (F) 3
BIE 3670 Transport Phenomena in Bio-Environmental Systems (Sp) .. 3
BIE 3870 Biological Engineering Design I (F,Sp,Su) 1
BIE 4880 (CI) Biological Engineering Design II (F,Sp,Su) 3
BIE 4890 (CI) Biological Engineering Design III (F,Sp,Su) 3
BIE 5930 Special Studies: Modeling Biological Systems (F) 3
BIOL 3300 (BLS)[1] General Microbiology (F,Sp) 4
CEE 3500 Civil and Environmental Engineering Fluid Mechanics (F,Sp) 3
CHEM 3700 Introductory Biochemistry (Sp) 3
CHEM 3710 Introductory Biochemistry Laboratory (Sp) 1
STAT 3000 (QI) Statistics for Scientists (F,Sp,Su) 3
ETE 2300 (QI) Electronic Fundamentals (F,Su) 4
Biological Engineering Electives 6-21
Engineering Electives (0-15 cr) (9-21 cr total for Biological Engineering Electives *and* Engineering Electives combined) 9-21
Technical Electives (0-12 cr) (21 cr total for Biological Engineering Electives, Engineering Electives, *and* Technical Electives combined) 0-12
University Studies (18 credits) 18

Biological Engineering Required Coursework

Suggested Semester Schedule (126 credits)

Preengineering: Freshman and Sophomore

Freshman Year (32 credits)

Fall Semester (15 credits)

BIOL 1610 (BLS)[1,3] Biology I 4
CHEM 1210[3] Principles of Chemistry I 4
CHEM 1215[3] Chemical Principles Laboratory I 1
ENGR 1000[3] Introduction to Engineering Design 2
MATH 1210 (QL)[3] Calculus I 4

Spring Semester (17 credits)

BIE 1880[3] Engineering Quantification of Biological Processes 3
ETE 2270[3] Computer Engineering Drafting 2
MATH 1220 (QL)[3] Calculus II 4
PHYS 2200[3] Elements of Mechanics 2
University Studies Breadth courses 6

Sophomore Year (33 credits)

Fall Semester (16 credits)

BIE 2330[3] Engineering Properties of Biological Materials 3
CHEM 2300[3] Principles of Organic Chemistry 3
CHEM 2315[3] Organic Chemistry Laboratory I 1
ENGR 2010[3] Engineering Mechanics Statics 2
ENGR 2200[3] Engineering Numerical Methods I 3
MATH 2250 (QI)[3] Linear Algebra and Differential Equations 4

Spring Semester (17 credits)
BIE 2400[3] Biological and Environmental Thermodynamics 3
BIOL 3300 (BLS)[1] General Microbiology 4
ENGL 2010 (CL2)[3] Intermediate Writing: Research Writing in a Persuasive Mode 3
ENGR 2030[3] Engineering Mechanics Dynamics 3
ETE 2300 (QI) Electronic Fundamentals 4

Professional Engineering: Junior and Senior

Junior Year (31 credits)

Fall Semester (15 credits)
BIE 3200 Introduction to Unit Operations in Biological Engineering 3
CEE 3500 Civil and Environmental Engineering Fluid Mechanics 3
STAT 3000 (QI) Statistics for Scientists 3
Technical Elective course[2] 3
University Studies Breadth course 3

Spring Semester (16 credits)
BIE 3000 Instrumentation for Biological Systems 2
BIE 3670 Transport Phenomena in Bio-Environmental Systems 3
BIE 3870 Biological Engineering Design I 1
CHEM 3700 Introductory Biochemistry 3
CHEM 3710 Introductory Biochemistry Laboratory 1
Technical Elective course[2,4] 3
University Studies Breadth course 3

Senior Year (32-34 credits)

Fall Semester (15-16 credits)
BIE 4880 (CI) Biological Engineering Design II 3
BIE 5930 Special Studies: Modeling Biological Systems 3
University Studies Depth Humanities and Creative Arts (DHA) course 2-3
Technical Elective courses[2] 7

Spring Semester (17-18 credits)
BIE 4890 (CI) Biological Engineering Design III 3
Technical Elective courses[2] 8
University Studies Breadth Physical Sciences (BPS) course 3-4
University Studies Depth Social Sciences (DSS) course 3

Technical Elective Courses (select 21 or more credits)

Students must select 9-21 credits from the **Biological Engineering Electives** and **Engineering Electives** categories.

Biological Engineering Electives (select 6-21 credits)
BIE 5010 Principles of Irrigation Engineering (F) 3
BIE 5110 Sprinkle and Trickle Irrigation (F) 4
BIE 5150 Surface Irrigation Design (Sp) 3
BIE 5250 Remote Sensing of Land Surfaces (Sp) 4
BIE 5300 Irrigation Conveyance and Control Systems (F) 3
BIE 5350 Drainage and Water Quality Engineering (Sp) 3
BIE 5520 Irrigation Project Operation and Maintenance (Sp) 3
BIE 5550 Groundwater Systems Engineering I (F) 3
BIE 5610 Food and Bioprocess Engineering (F) 3
BIE 5680 Soil-based Waste Management (Sp) 2
BIE 5810 Biochemical Engineering (F) 3
BIE 5830 Management and Utilization of Biological Solids and Wastewater (F) 3
BIE 5840 Introduction to Biophotonics (F) 3
BIE 5850 Biomaterials Engineering (F) 3
BIE 5890 Tissue Engineering (Sp) 3
BIE 5910 Introduction to Biosensors (F) 3
BIE 5930 Special Studies: Biophotonics (F) 3

Engineering Electives (select 0-15 credits)
CEE 3430 Engineering Hydrology (Sp) 3
CEE 3510 Civil and Environmental Engineering Hydraulics (F,Sp) 3
CEE 3640 Water and Wastewater Engineering (Sp) 4
CEE 4200 Engineering Economics (F) 2
CEE 5430 Groundwater Engineering (F) 3
CEE 5680 Soil-based Waste Management (Sp) 2
MAE 5620 Manufacturing Automation (F) 3

Technical Electives (select 0-12 credits)
AV 4200 Composite Manufacturing Processes and Repair (Sp) 3
BIE 4250 Cooperative Practice (F,Sp,Su) 3
BIOL 2320 Human Anatomy (Sp,Su) 4
BIOL 2420 Human Physiology (F,Sp,Su) 4
BIOL 3100 (CI) Bioethics (Sp) 3
BIOL 3060 (QI) Principles of Genetics (F,Sp,Su) 4
BIOL 5160 Methods in Biotechnology: Cell Culture (Sp) 3
BIOL 5210 Cell Biology (F) 3
BIOL 5230 Developmental Biology (Sp) 3
BIOL 5240 Methods in Biotechnology: Protein Purification Techniques (Sp) 3
BIOL 5260 Methods in Biotechnology: Molecular Cloning (F) 3
BIOL 5620 Medical Physiology (Sp) 3
CEE 2240 Engineering Surveying (F,Su) 3
CEE/PUBH 3610 Environmental Management (F) 3
CEE/PUBH 3870 Professional/Technical Writing in Civil and Environmental Engineering (F) 2
CHEM 2320 Organic Chemistry II (Sp) 4
CHEM 2325 Organic Chemistry Laboratory II (Sp) 1
CHEM 3070 (QI) Physical Chemistry (Sp) 3
ECE 2250 Electrical Circuits (F,Sp) 4
ECE 2700 Digital Circuits (F,Sp) 4
ENGR 2140 Strength of Materials (F,Sp) 2
ETE 3030 Computer-Integrated Manufacturing Systems (Sp) 3
MAE 2160 Material Science (F,Sp) 3
MAE 2650 Manufacturing Processes (Sp) 3
NFS 3100 (QI) Sensory Evaluation of Food (Sp) 3
NFS 4020 Advanced Nutrition (F) 3
NFS 5110 (CI) Food Microbiology (Sp) 4
PHYS 2110 The Physics of Living Systems I 4
PHYS 2120 (BPS) The Physics of Living Systems II 4
PHYS 2210 (QI) General Physics—Science and Engineering I 4
PHYS 2220 (BPS/QI) General Physics—Science and Engineering II 4
SOIL 3000 Fundamentals of Soil Science (F,Sp) 4
SOIL 5650 Environmental Soil Physics (F) 3
WATS 4490 Small Watershed Hydrology (F) 4
WATS 4500 Limnology: Ecology of Inland Waters (Sp) 3
WATS 5660 Watershed and Stream Restoration (Sp) 2

Other technical courses may be accepted with prior written approval from the Department of Biological and Irrigation Engineering.

Suggested Semester Schedule for Premedical Program

It is possible for students to combine premedical requirements with requirements for the Biological Engineering major. Some of the premedical requirements add to the total amount of credits required. This combination may be completed within five years, if the student is very diligent. Medical schools *do not* accept AP, CLEP, or ACT scores toward fulfillment of English Composition, Chemistry, or Biology requirements. The following schedule is designed to satisfy the requirements without time conflicts. Students who must deviate from this schedule should be sure to meet often with a College of Engineering advisor.

Preengineering: First Three Years

First Year (31 credits)

Fall Semester (15 credits)
BIOL 1610[1,3] Biology I 4

CHEM 1210[3] Principles of Chemistry I 4
CHEM 1215[3] Chemical Principles Laboratory I 1
ENGR 1000[3] Introduction to Engineering Design 2
MATH 1210 (QL)[3] Calculus I 4

Spring Semester (16 credits)
BIE 1880[3] Engineering Quantification of Biological Processes 3
BIOL 1620 (BLS) Biology II 4
CHEM 1220 (BPS) Principles of Chemistry II 4
CHEM 1225 Chemical Principles Laboratory II 1
MATH 1220 (QL)[3] Calculus II 4

Second Year (32 credits)
Fall Semester (15 credits)
PHYS 2210 (QI)[3] General Physics—Science and Engineering I 4
MATH 2250 (QI)[3] Linear Algebra and Differential Equations 4
ENGL 1010 (CL1)[3] Introduction to Writing: Academic Prose 3
ENGR 2010[3] Engineering Mechanics Statics 2
ETE 2270[3] Computer Engineering Drafting 2

Spring Semester (17 credits)
PHYS 2220 (BPS/QI) General Physics—Science and Engineering II 4
ENGL 2010 (CL2)[3] Intermediate Writing: Research Writing in a Persuasive Mode 3
ENGR 2030[3] Engineering Mechanics Dynamics 3
BIOL 2320 Human Anatomy 4
University Studies Breadth American Institutions (BAI) course 3

Third Year (31 credits)
Fall Semester (15 credits)
BIE 2330[3] Engineering Properties of Biological Materials 3
ENGR 2200[3] Engineering Numerical Methods I 3
CHEM 2310[3] Organic Chemistry I 4
CHEM 2315 Organic Chemistry Laboratory I 1
BIOL 2420 Human Physiology 4

Spring Semester (16 credits)
BIE 2400[3] Biological and Environmental Thermodynamics 3
CHEM 2320 Organic Chemistry II 4
CHEM 2325 Organic Chemistry Laboratory II 1
BIOL 3060 (QI) Principles of Genetics 4
ETE 2300 (QI) Electronic Fundamentals 4

Professional Engineering: Junior and Senior Years
Junior Year (30 credits)
Fall Semester (15 credits)
BIE 3200 Introduction to Unit Operations in Biological Engineering 3
CEE 3500 Civil and Environmental Engineering Fluid Mechanics 3
BIOL 5210 Cell Biology 3
University Studies Breadth Humanities (BHU) course 3
University Studies Breadth Social Sciences (BSS) course 3

Spring Semester (15 credits)
BIOL 3300 (BLS)[1,3] General Microbiology 4
BIE 3670 Transport Phenomena in Bio-Environmental Systems 3
BIE 3870 Biological Engineering Design I 1
CHEM 3700 Introductory Biochemistry 3
CHEM 3710 Introductory Biochemistry Laboratory 1
University Studies Breath Creative Arts (BCA) course 3

Students should plan to take the MCAT during summer prior to their final year.

Senior Year (29 credits)
Fall Semester (15 credits)
BIE 4880 (CI) Biological Engineering Design II 3
BIE 5850 Biomaterials Engineering 3
BIE 5930 Special Studies: Modeling Biological Systems 3
STAT 3000 (QI) Statistics for Scientists 3
BIE elective course 3

Spring Semester (14 credits)
BIE 3000 Instrumentation for Biological Systems 2
BIE 4890 (CI) Biological Engineering Design III 3
Engineering Elective 3
University Studies Depth Humanities and Creative Arts (DHA) course 3
University Studies Depth Social Sciences (DSS) course 3

[1]The Breadth Life Sciences (BLS) area in the University Studies Program is satisfied by the combination of BIOL 1610 and 3300.
[2]To emphasize irrigation, bioprocesses, premedical, etc., contact department for suggested technical electives.
[3]This course is required for admission to the Professional Engineering Program (PEP).
[4]Irrigation engineers must take CEE 3430 this semester. It is a prerequisite to all senior irrigation classes

Departmental Honors

Students who would like to experience greater academic depth within their major are encouraged to enroll in departmental honors. Through original, independent work, Honors students enjoy the benefits of close supervision and mentoring, as they work one-on-one with faculty in select upper-division departmental courses. Honors students also complete a senior project, which provides another opportunity to collaborate with faculty on a problem that is significant, both personally and in the student's discipline. Participating in departmental honors enhances students' chances for obtaining fellowships and admission to graduate school. Minimum GPA requirements for participation in departmental honors vary by department, but usually fall within the range of 3.30-3.50. Students may enter the Honors Program at almost any stage in their academic career, including at the junior (and sometimes senior) level. The campus-wide Honors Program, which is open to all qualified students regardless of major, offers a rich array of cultural and social activities, special classes, and the benefit of Honors early registration. Interested students should contact the Honors Program, Main 15, (435) 797-2715, honors@cc.usu.edu. Additional information can be found online at: **http://www.usu.edu/honors/**

Additional Information

For more information about the Bachelor of Science requirements and the sequence in which courses should be taken, see major requirement sheet, available from the Biological and Irrigation Engineering Department, or online at:
http://www.usu.edu/majorsheets/

Financial Support

Scholarships, assistantships, grants-in-aid, and work-study programs are available through the University. In addition, the department employs students to assist in engineering research and development. Cooperative education and industrial employment opportunities for students are coordinated by the University Placement Office and by the BIE Department.

Concurrent BS/Master's Program

The concurrent BS/Master's program allows engineering students to begin taking graduate-level classes during their senior year. This permits them to complete requirements for *both* the BS degree *and* the master's degree concurrently during two years. Students in this

program have a greater selection of graduate courses, since many graduate courses are taught during alternate years. In addition, the student's senior design project could be applicable to a graduate design project or thesis. After completing the BS degree coursework, students in the program can earn a master's degree in only one additional year. Both the BS and the master's degree can generally be earned with 150 total credits, although students should note that a Plan C MS requires 3 extra credits. Finally, students with a master's degree can expect a much higher starting salary following graduation. (For more information, see *College of Engineering* section of this catalog, pages 123-124.)

Graduate Programs

Admission Requirements

See general admission requirements identified in this catalog. Admission committees also consider experience, undergraduate record and curriculum, and formal recommendations. A student without an undergraduate engineering background will be required to complete selected undergraduate courses prior to or concurrently with enrollment in graduate courses.

Prerequisites for Matriculation

Students who are admitted provisionally or who have been changed from matriculated to probationary matriculated status will have their records reviewed by a faculty committee when they have completed 12 credits of coursework (among which must be formal engineering courses) or at the end of their second semester at USU. Those students who have earned a 3.0 GPA at that time and desire to be matriculated may apply to the department to have their status changed. If they meet all other academic requirements of the School of Graduate Studies and the department, they will be matriculated and admitted to the degree program. When a student is admitted as a degree candidate, the committee may allow up to 12 credits taken while on nonmatriculated status to be transferred. Nonmatriculated students may continue to study at USU but without degree candidate status. At the end of their studies, nondegree students are granted a Certificate of Completion.

Prerequisite Requirements

All students must have had **formal** courses in engineering and computer programming, as well as at least one year of calculus. Students without this background can satisfy these requirements by taking the appropriate undergraduate courses at USU. An additional year of calculus (MATH 1210, 1220, and 2250, or equivalent) is required for the MS degree in Irrigation Engineering and for all PhD programs. These background courses will not be counted toward the degree credit requirements.

MS in Biological Engineering and in Irrigation Engineering

Students must have a BS from an ABET-accredited engineering program in the U.S. or its equivalent in their home countries or must take the make-up coursework required for a BS in engineering at USU. It is assumed that the bachelor's degree mathematical training includes courses in calculus, linear analysis, and differential equations.

Three MS options are available: research (Plan A), technical practice (Plan B), and training/extension (Plan C).

Research Option

Students wishing to gain experience in research may select the research option, particularly if they have a long-term goal of PhD study. The minimum requirements for this option are 30 credits, of which 8 may be awarded for the thesis.

Technical Practice Option

Some students may not be interested in pursuing a PhD degree or in doing the research necessary for a thesis. For such students, the technical practice (Plan B) option is offered. The requirements for the degree are similar to those for the research option, with the exception of the thesis. The 8 thesis credits are replaced by 4 credits for a significant engineering report or design project and 4 additional credits of coursework. The minimum course requirement for the technical practice option is 30 approved graduate credits.

Training/Extension Option

Students expecting to terminate their graduate studies at the MS level and wishing to develop an emphasis in the training and/or extension fields of biological engineering or irrigation engineering, may choose the training/extension option (Plan C). The same engineering BS or equivalent requirements noted under the Plan A option apply. The minimum requirements for this degree are 30 approved graduate credits. No report or thesis is required. The degree requirements under this option can be met by taking courses.

Doctor of Philosophy

Two PhD programs are offered in the department: (1) **Biological Engineering** and (2) **Irrigation Engineering**. Students who have completed an MS with a thesis (Plan A or equivalent) in an engineering discipline are eligible to apply for admission to a PhD program. Admission will be based on the students' prior academic records and, if they are graduates of USU, the recommendations of their graduate committees. It is assumed that students are adequately prepared in mathematics and engineering design courses to compete at the PhD level. If such is not the case, a program of courses to make up the deficiency will be required.

In addition to any prescribed review courses and seminars, the minimum requirements for a PhD program include 60 credits of approved graduate courses beyond a master's degree, satisfactory completion of comprehensive examinations or submission of an approved manuscript to a refereed archival journal, and the writing of a dissertation based on an original research project. The degree requirements beyond a master's degree can be met by taking courses in engineering design, synthesis, and systems; mathematics; and related sciences.

Research

Graduate research projects in the BIE Department encompass two broad options: biological engineering and irrigation engineering. Specific research projects in the biological engineering option include tissue and biomedical engineering related to heart stents, biosensor design and development for biomedical and bioenvironmental applications (genetic probes), microbial fermentations, biorefining (production of biofuels and bioplastics from biological feedstocks), nanobiotechnology (quantum dots), biophotonics (interactions of light with biological materials), and land-based bioenvironmental sustainable systems (land application of industrial and municipal residuals for recycling, vegetative growth, soil improvement, and groundwater protection).

Department of Biological and Irrigation Engineering

Food engineering represents an area of emphasis under the biological engineering option. Land application of food processing wastes, extrusion of dairy-based food, multi-stage anaerobic digestion of biological materials, functional properties of foods, and biological detoxification of metals are some of the research topics supported in food engineering.

In the irrigation engineering area, USU has attained worldwide prestige through the successful professional contributions of its graduates during a period of 80 years. The BIE Department is substantially involved in overseas research and training activities, for example in the Dominican Republic, Armenia, and Tatarstan, concerned with managing irrigation systems, on-farm water management, water resource development, and soil assimilation and recycling of industrial residues. Specific research projects in the irrigation and drainage engineering option include hydraulics of surface irrigation, consumptive use, return flow quantity and quality of irrigation waters, transient flow in tile drainage systems, drain envelopes, sprinkler irrigation, trickle irrigation, crop production and water requirements, salt movement, regional groundwater modeling for optimizing sustainable yield, conveyance system modeling and control, and remote sensing.

Financial Assistance

The large and diverse departmental research programs make it possible to offer graduate financial support in the form of research assistantships, traineeships, and teaching assistantships for qualified students. Research assistantships are provided by the BIE Department and by individual research projects. Teaching assistantships are provided by the School of Graduate Studies and by the College of Engineering. Traineeships and research assistantships carry tuition waivers. It is the goal of the BIE Department to provide research and/or teaching support for all qualified students.

Additional Information

Two guides are available from the department to assist students: (1) *Report, Thesis, and Dissertation Format Guidelines and Policies*, and (2) *Policies and Procedures for Graduate Study*.

Biological and Irrigation Engineering Faculty

Professors
Conly L. Hansen, food engineering
Robert W. Hill, irrigation and water resource extension
Gary P. Merkley, conveyance systems
Christopher M. U. Neale, remote sensing
Richard C. Peralta, groundwater
Ronald C. Sims, biological process engineering
Wynn R. Walker, surface irrigation, Associate Dean of College of Engineering

Research Professors
Darwin L. Sorensen, soil microbiology
L. Humberto Yap-Salinas, drainage

Adjunct Professors
Richard Allen, irrigation
Anne J. Anderson, plant root-microbe interactions
Daryll B. DeWald, cell biology; Department Head, Biology
H. Scott Hinton, biophotonics
Lawrence E. Hipps, biometeorology
Kamal Rashid, biotechnology
Bart C. Weimer, microbiology, Director of Center for Integrated BioSystems

Professors Emeritus
George H. Hargreaves, crop water requirements
Jack Keller, sprinkle and drip irrigation
Glen E. Stringham, surface irrigation

Research Associate Professors
Joan E. McLean, soil chemistry
Judith L. Sims, soil biology

Adjunct Associate Professor
Michael J. McFarland, biosolids

Associate Professor Emeritus
Edwin C. Olsen III, international irrigation, water management

Assistant Professors
David W. Britt, biomedical engineering
Soonjo Kwon, tissue engineering
Sridhar Viamajala, bioprocess engineering
Anhong Zhou, nanobiotechnology

Adjunct Assistant Professors
David G. Chandler, soil processes
Andrew A. Keller, irrigation
Paul D. Schreuders, biomedical engineering

Adjunct Research Assistant Professors
Hui Fang Dou, electrical engineering
Arnulfo González-Meza, irrigation system transfer
Scott B. Jones, soil physics
Charles D. Miller, biology

Research Assistant Professor Emeritus
R. Kern Stutler, irrigation structures

Principal Lecturer
Timothy A. Taylor, bioprocess engineering

Course Descriptions

Biological and Irrigation Engineering (BIE), pages 574-576