BIOLOGICAL SYSTEMS ENGINEERING

Description

Website: http://bsen.unl.edu/

Biological systems engineering (BSEN) is one of two engineering degree programs offered in the Department of Biological Systems Engineering. BSEN students emphasize engineering course work in one of three areas: biomedical engineering, bioenergy and food engineering, or environmental and water resources engineering. A biological systems engineer could work on systems to micropropagate tissue culture, develop biomaterials and biofibers, design equipment and processes for producing foods and biofuels, or design devices for performing minimally invasive surgery. Still another could be responsible for developing biological sensors and imaging devices for detecting diseases in humans, for measuring plant and animal stress, or for controlling the environment of greenhouses and animal facilities. Biological systems engineers could also be involved in resolving environmental issues associated with waste management, water quality and sustainable energy production. Job opportunities for graduates are available in industry, public agencies, consulting, and private practice. A significant number of graduates pursue graduate school or studies in medical or law school.

By two to six years after graduation, BSEN alumni will share the attribute of improving the organization for which they work, and the community and country in which they live. They will do this whether they are involved in biomedical engineering, environmental or water resources engineering, bioenergy and food engineering, or other professional endeavors such as business, law or medicine. In doing so, they will:

• provide innovative and effective solutions to problems in a variety of work environments through the use of their unique background in biological systems engineering and the biological sciences;
• look beyond components in isolation thereby providing holistic solutions to complex issues involving (for example) interactions at the ecosystem, organism, organ, cellular or subcellular level;
• think logically using appropriate elements of mathematics, science, and engineering to develop, manage, and interpret data, to correctly interpret new research findings, and to design new systems for the benefit of society;
• successfully integrate technical knowledge with organizational, listening, communication, and interpersonal skills to lead and work effectively in teams, and to respectfully articulate the role of engineering decisions in the workplace, community, and world;
• responsibly address issues such as health and safety, personal and professional ethics, cultural diversity, as well as the social, environmental, and global impacts of their work; and
• continue their personal growth, professional development, and professional and community service through various opportunities provided by institutions, professional organizations and other venues.

The Department of Biological Systems Engineering is located in Chase Hall on East Campus. BSEN students participate in classes and laboratories on both the East and City Campuses. BSEN courses are offered on the East Campus. Basic courses in math, chemistry, physics, engineering sciences, computers, and electives in mechanical, civil, electrical, and chemical engineering are taken on the City Campus. Convenient bus transportation is available between campuses.

Students benefit from small classes and personal acquaintances with faculty. In consultation with their advisor, students select electives that permit specialization in an emphasis area applicable to their career aspirations. Many students work part-time on departmental research projects, gaining valuable experience for employment in industry and for graduate or professional studies. Students also benefit from summer jobs, internships and co-op programs. These opportunities give students practical experience to learn about careers in engineering. Students also gain valuable experience through participation in professional organizations such as the American Society of Agricultural and Biological Engineers, the Water and Environmental Federation, the Soil and Water Resources Club, the Biomedical Engineering Society, the Nebraska Society of Professional Engineers and the Society for Women Engineers.

Major Department Admission

Pre-professionally admitted COE students majoring in biological systems engineering (BSEN) have their records examined for advancement to professionally admitted status during the Fall, Spring, and Summer immediately following the term in which 43 or more credits applicable to the BSEN degree have been completed. Students must be professionally admitted in order to enroll in AGEN 470/BSEN 470 Design I in Agricultural and Biological Systems Engineering.

To be professionally admitted to BSEN, the student must first meet the general Professional Admission criteria of the College of Engineering (i.e., completion of at least one semester in the College, a cumulative GPA of 2.5 or greater, and not having been already declined admission by two other engineering majors). BSEN Professional Admission criteria require consistent grades of C or better in calculus, calculus-based physics, chemistry, communications, and engineering science courses. Specifically, the student must have completed MECH 223 Engineering Statics and AGEN 225/BSEN 225 Engineering Properties of Biological Materials or BSEN 244 Thermodynamics of Living Systems with grades of a C or better to gain Professional Admission to BSEN. In addition, the student must complete the AGEN/BSEN Writing Assessment Exam (i.e., Grammar Slammer) before Professional Admission is granted.

Students who meet the above criteria with a cumulative GPA of 3.0 or greater with all grades above a C in UNL mathematics, science, engineering, and communications courses, and scoring 70 percent or higher on the AGEN/BSEN Writing Assessment Exam may be professionally admitted without further review by Department faculty. Students scoring less than 70 percent on the AGEN/BSEN Writing Assessment Exam must agree to a writing improvement plan with their academic advisor in order to be granted Professional Admission. Students not meeting the 3.0 GPA standard, or having grades below a C in the listed areas, will have their record reviewed by Department faculty for evidence of ability to succeed in BSEN. Under special circumstances, the Department may elect to defer Professional Admission for an additional term.

The Department faculty may recommend provisional admission and specify deficiencies and performance criteria to transition out of provisional status. If a student has not met the admission criteria and has not, in the opinion of the Department faculty demonstrated a minimum standard of good professional judgment in the pursuit of their academic program as expected of degree engineers, they may be denied Professional Admission to the degree program. The student may appeal.
this decision to the BSE Department Head and then, if necessary, to the College of Engineering Curriculum and Academic Standards Committee.

College Requirements

College Admission

College Entrance Requirements

Students must have high school credit for (one unit is equal to one high school year):

1. 4 units of mathematics: 2 of algebra, 1 of geometry, 1 of precalculus and trigonometry.
2. 4 units of English.
3. 3 units of natural science that must include 1 unit of physics and 1 unit of chemistry (chemistry requirement waived for students in construction management).
4. 2 units of a single foreign language.
5. 3 units of social studies.
6. Students having a composite ACT score of 28 or greater (or equivalent SAT score) will be admitted to the College of Engineering even if they lack any one of the following: trigonometry, chemistry, or physics.
7. Students having an ACT score of 19 or less in English (or equivalent SAT score) must take ENGL 151 Writing and Inquiry or ENGL 151 Writing and Argument.

A total of 16 units is required for admission.

Students must have an ACT (enhanced) score of 24 or greater (or equivalent SAT). Students who lack entrance requirements may be admitted based on ACT scores, high school rank and credits, or may be admitted to pre-engineering status in the Exploratory and Pre-Professional Advising Center. Pre-engineering students are advised within the College of Engineering.

Students for whom English is not their language of nurture must meet the minimum English proficiency requirements of the University.

Students who lack entrance units may complete precollege training by Independent Study through the UNL Office of On-line and Distance Education, in summer courses, or as a part of their first or second semester course loads while in the Exploratory and Pre-Professional Advising Center or other Colleges at UNL.

Students should consult their advisor, their department chair, or Engineering Student Services if they have questions on current policies.

Other Admission Requirements

Students who transfer to the University of Nebraska–Lincoln from other accredited colleges or universities and wish to be admitted to the College of Engineering (COE) must meet COE freshman entrance requirements and have a minimum cumulative GPA of 2.5 for Nebraska residents or 3.0 for non-residents, and be calculus-ready. Students not meeting either of these requirements must enroll in the Explore Center or another UNL college until they meet COE admission requirements.

The COE accepts courses for transfer for which a C or better grade was received. Although UNL accepts D grades from the University of Nebraska at Kearney and at Omaha, not all majors in the COE accept such low grades. Students must conform to the requirements of their intended major and, in any case, are strongly encouraged to repeat courses with a grade of C- or less.

All transfer students must adopt the curricular requirements of the undergraduate catalog current at the time of transfer to the COE—not that in use when they entered UNL. Upon admission to UNL, students wishing to pursue degree programs in the COE will be classified and subject to the policies defined in the subsequent section.

College Degree Requirements

Grade Rules

Grade Appeals

In the event of a dispute involving any college policies or grades, the student should appeal to his/her instructor, and appropriate department chair or school director (in that order). If a satisfactory solution is not achieved, the student may appeal his/her case through the College Academic Appeals Committee on his/her campus.

Catalog Rule

Students must fulfill the requirements stated in the catalog for the academic year in which they are first admitted at UNL. In consultation with advisors, a student may choose to follow a subsequent catalog for any academic year in which they are admitted to and enrolled as a degree-seeking student at UNL in the College of Engineering. Students must complete all degree requirements from a single catalog year. The catalog which a student follows for degree requirements may not be more than 10 years old at the time of graduation.

Learning Outcomes

Majors in biological systems engineering will be able to:

1. Apply knowledge of mathematics, physics, and the engineering sciences. (a)
2. Apply knowledge of the chemical and biological sciences, and biological systems engineering. (a)
3. Design and conduct experiments, utilize probability and statistics, as well as to analyze and interpret data. (b)
4. Design a system, component, or process to meet desired needs. (c)
5. Function on teams, including multi-disciplinary teams. (d)
6. Identify, formulate, and solve engineering problems. (e)
7. Understand professional and ethical responsibility. (f)
8. Communicate effectively. (g)
9. Understand the impact of engineering solutions in a global and societal context. (h)
10. Recognize the need for, and an ability to engage in, life-long learning. (i)
11. Have knowledge of contemporary issues. (j)
12. Use the techniques, skills, and modern engineering tools necessary for engineering practice. (k)

NOTE: Letters are references to ABET Engineering Accreditation Commission outcomes (a through k).

Major Requirements

Specific Major Requirements

First Semester

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>BSEN 100</td>
<td>Introduction to Biological Engineering and Agricultural Engineering</td>
<td>1</td>
</tr>
<tr>
<td>AGEN 100</td>
<td>Fundamental Chemistry I</td>
<td>4</td>
</tr>
<tr>
<td>CHEM 113</td>
<td>Freshman Engineering Seminar</td>
<td>0</td>
</tr>
<tr>
<td>MATH 106</td>
<td>Calculus I</td>
<td>5</td>
</tr>
</tbody>
</table>
### ACE Electives
Select one course from not yet satisfied ACE outcomes 5, 6, 7, or 9.

| Credit Hours Subtotal: | 16 |

### Second Semester

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>BSEN 112</td>
<td>Computer-Aided Problem-Solving</td>
<td>2</td>
</tr>
<tr>
<td>AGEN 112</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CHEM 114</td>
<td>Fundamental Chemistry II</td>
<td>3</td>
</tr>
<tr>
<td>MATH 107</td>
<td>Calculus II</td>
<td>4</td>
</tr>
<tr>
<td>PHYS 211</td>
<td>General Physics I</td>
<td>4</td>
</tr>
</tbody>
</table>

### Organizational Skills Elective
Select from a list of 40+ courses available from advisor.

| Credit Hours Subtotal: | 16 |

### Third Semester

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>BSEN 225</td>
<td>Engineering Properties of Biological Materials</td>
<td>3</td>
</tr>
<tr>
<td>AGEN 225</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Select one of the following:

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>CHEM 251</td>
<td>Organic Chemistry I</td>
<td>4</td>
</tr>
<tr>
<td>&amp; CHEM 253</td>
<td>and Organic Chemistry I Laboratory</td>
<td></td>
</tr>
<tr>
<td>CHEM 255</td>
<td>Biological Organic Chemistry</td>
<td>3</td>
</tr>
<tr>
<td>&amp; CHEM 257</td>
<td>and Biological Organic Chemistry Laboratory</td>
<td></td>
</tr>
<tr>
<td>CHEM 261</td>
<td>Organic Chemistry</td>
<td>3</td>
</tr>
<tr>
<td>&amp; CHEM 263</td>
<td>and Organic Chemistry Laboratory</td>
<td></td>
</tr>
<tr>
<td>ENGR 20</td>
<td>Sophomore Engineering Seminar</td>
<td>0</td>
</tr>
<tr>
<td>JGEN 200</td>
<td>Technical Communication I</td>
<td>3</td>
</tr>
<tr>
<td>MATH 208</td>
<td>Calculus III</td>
<td>4</td>
</tr>
<tr>
<td>MECH 223</td>
<td>Engineering Statics</td>
<td>3</td>
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</table>

| Credit Hours Subtotal: | 17 |

### Fourth Semester

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credit Hours</th>
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<tbody>
<tr>
<td>BSEN 130</td>
<td>Computer-Aided Design</td>
<td>2</td>
</tr>
<tr>
<td>CIVE 130</td>
<td></td>
<td></td>
</tr>
<tr>
<td>BSEN 244</td>
<td>Thermodynamics of Living Systems</td>
<td>3</td>
</tr>
<tr>
<td>LIFE 120</td>
<td>Fundamentals of Biology I</td>
<td>4</td>
</tr>
<tr>
<td>&amp; LIFE 120L</td>
<td>and Fundamentals of Biology I Laboratory</td>
<td></td>
</tr>
<tr>
<td>MATH 221</td>
<td>Differential Equations</td>
<td>3</td>
</tr>
<tr>
<td>MECH 373</td>
<td>Engineering Dynamics</td>
<td>3</td>
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</table>

### Computer Programming Elective
Select one of the following:

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>BSEN 212A</td>
<td>Computational Tools &amp; Modeling for Agricultural &amp; Biological Systems Eng: MATLAB</td>
<td>1</td>
</tr>
<tr>
<td>BSEN 212B</td>
<td>Computational Tools &amp; Modeling for Ag &amp; Biological Sys Engr: Control Systems</td>
<td></td>
</tr>
<tr>
<td>BSEN 212E</td>
<td>Computational Tools &amp; Modeling for Agricultural &amp; Biological Systems Eng: LabVIEW</td>
<td></td>
</tr>
</tbody>
</table>

| Credit Hours Subtotal: | 16 |

### Fifth Semester

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>LIFE 121</td>
<td>Fundamentals of Biology II</td>
<td>4</td>
</tr>
<tr>
<td>&amp; LIFE 121L</td>
<td>and Fundamentals of Biology II Laboratory</td>
<td></td>
</tr>
<tr>
<td>MECH 310</td>
<td>Fluid Mechanics</td>
<td>3</td>
</tr>
<tr>
<td>or CHME 332</td>
<td>Transport Operations I</td>
<td></td>
</tr>
<tr>
<td>MECH 321</td>
<td>Engineering Statistics and Data Analysis</td>
<td>3</td>
</tr>
</tbody>
</table>

### Sixth Semester

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credit Hours</th>
</tr>
</thead>
</table>

Select 3 hours

| Credit Hours Subtotal: | 17 |

### Seventh Semester

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>BSEN 206</td>
<td>Engineering Economics</td>
<td>3</td>
</tr>
<tr>
<td>CONE 206</td>
<td></td>
<td></td>
</tr>
<tr>
<td>BSEN 460</td>
<td>Instrumentation and Controls</td>
<td>3</td>
</tr>
<tr>
<td>AGEN 460</td>
<td></td>
<td></td>
</tr>
<tr>
<td>BSEN 470</td>
<td>Design I in Agricultural and Biological Systems Engineering</td>
<td>1</td>
</tr>
<tr>
<td>AGEN 470</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### ACE Elective
Select one course from not yet satisfied ACE outcomes 5, 6, 7, or 9

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credit Hours</th>
</tr>
</thead>
</table>

Select 3 hours

| Credit Hours Subtotal: | 16 |

### Eighth Semester

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>BSEN 480</td>
<td>Design II in Agricultural and Biological Systems Engineering</td>
<td>3</td>
</tr>
<tr>
<td>AGEN 480</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ENGR 400</td>
<td>Professional Ethics and Social Responsibilities</td>
<td>1</td>
</tr>
</tbody>
</table>

| Credit Hours Subtotal: | 16 |

### Biological Science Electives
Select 4 hours

**BSEN Emphasis Elective**
Select 3 hours

**Engineering or Science Emphasis Elective**
Select 3 hours

**Engineering Emphasis Elective**
Select 3 hours

Credit Hours Subtotal: 17

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>CHEM 109</td>
<td>General Chemistry I</td>
<td>may be substituted with permission of advisor.</td>
</tr>
<tr>
<td>CHEM 110</td>
<td>General Chemistry II</td>
<td>may be substituted with permission of advisor.</td>
</tr>
<tr>
<td>BIOS 203</td>
<td>Bioethics</td>
<td>is not acceptable; a minimum of two BIOS, BIOC or equivalent laboratory courses, or two courses with laboratories, is required within the 15 hrs of biological sciences and biochemistry courses.</td>
</tr>
</tbody>
</table>

**Additional Major Requirements**

**Grade Rules**
A grade of C- or better is required for all Biological Systems Engineering required courses and electives that are to count toward graduation, with the exception of ACE 5, 6, 7, and 9 electives.

**Bulletin to Use**
In addition to the "Bulletin Rule" of the College of Engineering, students transferring into the Department of Biological Systems Engineering must follow the bulletin in effect at the time of their transfer into the department.

**BSEN 100 Introduction to Biological Engineering and Agricultural Engineering**
Crosslisted with: AGEN 100
Description: Description of careers in biomedical, environmental, water resources, food and bioproducts, and agricultural engineering. The human, economic and environmental impacts of engineering in society. Communication, design, teamwork, and the role of ethics and professionalism in engineering work.
Credit Hours: 1
Max credits per semester: 1
Max credits per degree: 1
Format: LEC
Prerequisite for: AGEN 112, BSEN 112

**BSEN 112 Computer-Aided Problem-Solving**
Crosslisted with: AGEN 112
Prerequisites: BSEN 100/AGEN 100 and high school physics, or permission
Description: Problem solving techniques and procedures through the use of Excel, MATLAB, and graphical methods. Emphasis on problem/solution communications with topics and problems from agricultural engineering and biological systems engineering.
Credit Hours: 2
Max credits per semester: 2
Max credits per degree: 2
Format: LEC
Prerequisite for: BSEN 212A, AGEN 212A; BSEN 212B, AGEN 212B; BSEN 212E, AGEN 212E

Select two of the following:

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>BSEN 303</td>
<td>Principles of Process Engineering</td>
<td>3</td>
</tr>
<tr>
<td>AGEN 303</td>
<td></td>
<td></td>
</tr>
<tr>
<td>BSEN 446</td>
<td>Unit Operations of Biological Processing</td>
<td>3</td>
</tr>
<tr>
<td>AGEN 446</td>
<td></td>
<td></td>
</tr>
<tr>
<td>BSEN 444</td>
<td>Biomass and Bioenergy Engineering</td>
<td>3</td>
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</tbody>
</table>

**BSEN Primary Emphasis Area Courses**

**Bioenergy and Food**

<table>
<thead>
<tr>
<th>Course Code</th>
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<th>Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>BSEN 303</td>
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<td>3</td>
</tr>
<tr>
<td>AGEN 303</td>
<td></td>
<td></td>
</tr>
<tr>
<td>BSEN 446</td>
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</tr>
<tr>
<td>AGEN 446</td>
<td></td>
<td></td>
</tr>
<tr>
<td>BSEN 444</td>
<td>Biomass and Bioenergy Engineering</td>
<td>3</td>
</tr>
</tbody>
</table>

Total Credit Hours: 9

**Biomedical**

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>BSEN 317</td>
<td>Introduction to Biomedical Engineering</td>
<td>3</td>
</tr>
</tbody>
</table>

Select two of the following:

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>BSEN 311</td>
<td>Biomedical Signal and System Analysis</td>
<td>3</td>
</tr>
<tr>
<td>BSEN 414</td>
<td>Medical Imaging Systems</td>
<td></td>
</tr>
<tr>
<td>BSEN 416</td>
<td>Introduction to Biomaterials</td>
<td></td>
</tr>
<tr>
<td>BSEN 418</td>
<td>Tissue Engineering</td>
<td></td>
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</tbody>
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Total Credit Hours: 9

**Water and Environment**

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Hours</th>
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</thead>
<tbody>
<tr>
<td>BSEN 350</td>
<td>Soil and Water Resources Engineering</td>
<td>3</td>
</tr>
<tr>
<td>AGEN 350</td>
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Select one of the following:

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>BSEN 326</td>
<td>Introduction to Environmental Engineering</td>
<td>3</td>
</tr>
<tr>
<td>CIVE 326</td>
<td></td>
<td></td>
</tr>
<tr>
<td>BSEN 355</td>
<td>Introduction to Ecological Engineering</td>
<td>3</td>
</tr>
<tr>
<td>BSEN 441</td>
<td>Animal Waste Management</td>
<td>3</td>
</tr>
<tr>
<td>AGEN 441</td>
<td></td>
<td></td>
</tr>
<tr>
<td>BSEN 453</td>
<td>Irrigation and Drainage Systems</td>
<td>3</td>
</tr>
<tr>
<td>AGEN 453</td>
<td>Engineering</td>
<td></td>
</tr>
<tr>
<td>BSEN 455</td>
<td>Nonpoint Source Pollution Control</td>
<td>3</td>
</tr>
<tr>
<td>CIVE 455</td>
<td>Engineering</td>
<td></td>
</tr>
<tr>
<td>BSEN 458</td>
<td>Groundwater Engineering</td>
<td>3</td>
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Total Credit Hours: 9

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>BSEN 100</td>
<td>Introduction to Biological and Agricultural Engineering</td>
<td>1</td>
</tr>
<tr>
<td>AGEN 100</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CHEM 109</td>
<td>General Chemistry I</td>
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<td>AGEN 446</td>
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<td></td>
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<tr>
<td>BSEN 444</td>
<td>Biomass and Bioenergy Engineering</td>
<td>3</td>
</tr>
<tr>
<td>BSEN 317</td>
<td>Introduction to Biomedical Engineering</td>
<td>3</td>
</tr>
</tbody>
</table>

Total Credit Hours: 133
BSEN 130 Computer-Aided Design
Crosslisted with: CIVE 130
Description: Use of computer-aided design software to communicate engineering ideas. Specifications, dimensioning, tolerancing, 2- and 3-D model development, topographic mapping, and process layout with environmental, bioprocess, and biomedical emphases.
Credit Hours: 2
Max credits per semester: 2
Max credits per degree: 2
Format: LEC
Prerequisite for: AGEN 470, BSEN 470

BSEN 206 Engineering Economics
Crosslisted with: CONE 206
Prerequisites: Sophomore standing
Description: Introduction to methods of economic comparisons of engineering alternatives: time value of money, depreciation, taxes, concepts of accounting, activity-based costing, ethical principles, civics and stewardship, and their importance to society.
Credit Hours: 3
Max credits per semester: 3
Max credits per degree: 3
Format: LEC
Prerequisite for: MECH 343
ACE: ACE 8 Civic/Ethics/Stewardship

BSEN 212A Computational Tools & Modeling for Agricultural & Biological Systems Eng: MATLAB
Crosslisted with: AGEN 212A
Prerequisites: AGEN or BSEN 112/112H; or permission
Description: Introduction to tools needed to develop computation-intensive solutions for a wide variety of problems relevant to agricultural and biological systems engineering. Advanced problem solving techniques are illustrated using examples of scripts.
Credit Hours: 1
Max credits per semester: 1
Max credits per degree: 1
Format: LEC
Prerequisite for: BSEN 311; MECH 350

BSEN 212B Computational Tools & Modeling for Ag & Biological Sys Engr: Control Systems
Crosslisted with: AGEN 212B
Prerequisites: AGEN or BSEN 112/112H; ELEC 211 or ELEC 213 or PHYS 212, or parallel, or permission
Notes: This is a 5-week mini-course in which the lab time entails a combination of a 2nd lecture and followup laboratory applications.
Description: Introduction to microcontroller based embedded systems for agricultural and biological applications. Fundamental principles of microcontrollers and embedded systems through binary and hexadecimal number systems, digital logic, programming in integrated development environment, and microcontroller peripherals. Common agricultural and biological microcontroller input and output devices.
Credit Hours: 1
Max credits per semester: 1
Max credits per degree: 1
Format: LEC

BSEN 212E Computational Tools & Modeling for Agricultural & Biological Systems Eng: LabVIEW
Crosslisted with: AGEN 212E
Prerequisites: AGEN or BSEN 112/112H; or permission
Description: Introduction to tools needed to develop computation-intensive solutions for a wide variety of problems relevant to agricultural and biological systems engineering. Advanced problem solving techniques are illustrated using examples of scripts, simulation methods, graphical programming, and their combination.
Credit Hours: 1
Max credits per semester: 1
Max credits per degree: 1
Format: LEC

BSEN 225 Engineering Properties of Biological Materials
Crosslisted with: AGEN 225
Prerequisites: MATH 106
Description: Physical properties important to the design of harvesting, storage, and processing systems for agricultural crops; principles and techniques for measurement of properties including frictional effects, particle size, strength, moisture content, specific heat, and thermal conductivity.
Credit Hours: 3
Max credits per semester: 3
Max credits per degree: 3
Format: LEC
Prerequisite for: AGEN 324, BSEN 324

BSEN 244 Thermodynamics of Living Systems
Prerequisites: BIOS 101 and 101L, or BIOS 102, CHEM 110 or 114, MATH 208 and PHYS 211.
Description: Introduction to the laws of thermodynamics and their application to biological and environmental systems. Zeroth, first, second, and third laws; open and closed systems; enthalpy and specific heat; and Gibb's free energy and chemical potential for biological and environmental systems. Applications to biochemical potentials, water potential, absorption, osmosis, radiation, membranes, surface tension, and fugacity. Thermodynamic cycles as they apply to living systems.
Credit Hours: 3
Max credits per semester: 3
Max credits per degree: 3
Format: LEC
Prerequisite for: AGEN 344, BSEN 344

BSEN 303 Principles of Process Engineering
Crosslisted with: AGEN 303
Prerequisites: MATH 221 or permission.
Description: Introduction to performance parameters and characteristics of pumps, fans, presses, and solids handling, size reduction, separation and agitation equipment. Application of the various technologies studied with analysis of example systems.
Credit Hours: 3
Max credits per semester: 3
Max credits per degree: 3
Format: LEC
BSEN 311 Biomedical Signal and System Analysis
Prerequisites: MATH 221; and BSEN212A or equivalent
Credit Hours: 3
Max credits per semester: 3
Max credits per degree: 3
Format: LEC

BSEN 317 Introduction to Biomedical Engineering
Prerequisites: PHYS 211; MATH 221 or parallel and one semester of biology
Description: Research areas and applications related to biomedical engineering including bioelectricity, biosensors, biomechanics, cardiovascular mechanics, tissue engineering, biotechnology, and medical imaging. Identifying engineering methods used to develop biomedical technologies and communicating technical knowledge to a wide variety of audiences.
Credit Hours: 3
Max credits per semester: 3
Max credits per degree: 3
Format: LEC

BSEN 324 Mechanics of Materials for Agricultural and Biological Systems Engineering
Crosslisted with: AGEN 324
Prerequisites: AGEN/BSEN 225, MECH 223
Description: Development of the concepts of stress and strain relevant to agricultural and biological systems. Stress analysis of axial, torsional, and bending stresses, combined loading analysis, deflection evaluation, static and dynamic failure theory. Practical applications in agricultural and biological systems will be discussed.
Credit Hours: 3
Max credits per semester: 3
Max credits per degree: 3
Format: LEC

BSEN 326 Introduction to Environmental Engineering
Crosslisted with: CIVE 326
Prerequisites: CHEM 110 or 111 or 113 and MATH 221
Description: Introduction to principles of environmental engineering including water quality, atmospheric quality, pollution prevention, and solid and hazardous wastes engineering. Design of water, air, and waste management systems.
Credit Hours: 3
Max credits per semester: 3
Max credits per degree: 3
Format: LEC
Prerequisite for: BSEN 425, CIVE 425

BSEN 326H Honors: Introduction to Environmental Engineering
Crosslisted with: CIVE 326H
Prerequisites: Good standing in the University Honors Program or by invitation: CHEM 110 or 111 or 113, MATH 221.
Description: Introduction to principles of environmental engineering including water quality, atmospheric quality, pollution prevention, and solid and hazardous wastes engineering. Design of water, air, and waste management systems.
Credit Hours: 3
Max credits per semester: 3
Max credits per degree: 3
Format: LEC

BSEN 327 Environmental Engineering Laboratory
Crosslisted with: CIVE 327
Prerequisites: CHEM 110 or 111 or 113, and MATH 221.
Description: Environmental engineering experiments, demonstrations, field trips, and projects. Experiments include the measurement and determination of environmental quality parameters such as solids, dissolved oxygen, biochemical and chemical oxygen demand, and alkalinity.
Credit Hours: 1
Max credits per semester: 1
Max credits per degree: 1
Format: LAB

BSEN 325 Power Systems Design
Crosslisted with: AGEN 325
Prerequisites: PHYS 212 or ELEC 211, and MECH/CIVE 310 or CHME 332 or parallel or permission.
Description: Fundamentals of Power systems for machines. Introduction to fluid power (hydraulics, pneumatics), pumps, motors, cylinders, control devices and system design. Selection of electric motors as power sources, operating characteristics and circuits. Selection of internal combustion engines as power sources.
Credit Hours: 3
Max credits per semester: 3
Max credits per degree: 3
Format: LEC

BSEN 344 Biological and Environmental Transport Processes
Crosslisted with: AGEN 344
Prerequisites: BSEN 244 or MECH 200; MATH 221; MECH/CIVE 310 or CHME 332 or parallel; or permission
Description: Introduction to concurrent transport of energy and mass in biological and environmental processes. Modes of heat transfer, steady and non-steady state heat conduction, convective heat transfer, radiative heat transfer, and heat transfer with phase change. Equilibrium, kinetics, and modes of mass transfer, diffusion, dispersion, and convective mass transfer. Soil freezing and thawing, energy and mass balances of crops, diffusivities of membranes, photosynthesis, human and animal energy balances, and respiration.
Credit Hours: 3
Max credits per semester: 3
Max credits per degree: 3
Format: LEC
Prerequisite for: AGEN 470, BSEN 470
BSEN 350 Soil and Water Resources Engineering
Crosslisted with: AGEN 350
Prerequisites: MATH 221 and parallel: MECH/CIVE 310 or CHME 332.
Description: Introduction to soil and water resources and the engineering processes used to analyze watersheds. Soil water relations, evapotranspiration, precipitation, runoff, erosion, flow in natural waterways and through reservoirs, wetland and groundwater hydrology, and water quality. Geographic information system utilized to develop maps and analyze watershed characteristics. A selected watershed is investigated.
Credit Hours: 3
Max credits per semester: 3
Max credits per degree: 3
Format: LEC
Prerequisite for: AGEN 957, BSEN 957, CIVE 957, GEOL 957

BSEN 355 Introduction to Ecological Engineering
Prerequisites: CHEM 110 or CHEM 111 or CHEM 114; and MATH 104 or MATH 106.
Notes: Recommended: AGEN/BSEN 350 or CIVE 352 or CIVE 353 or MSYM/WATS 354; and BIOS 101 or LIFE 121 or NRES 220.
Description: Introduction to principles of ecological engineering including ecosystems ecology, river restoration, constructed wetlands, green infrastructure stormwater management, and environmental restoration. Ecological design of water and land protection practices. Includes introduction to water pollution and contaminant fate and remediation.
Credit Hours: 3
Max credits per semester: 3
Max credits per degree: 3
Format: LEC

BSEN 395 Internship in Agricultural and Biological Systems Engineering
Crosslisted with: AGEN 395
Prerequisites: Permission
Notes: Completion of internship approval form is required. The internship proposal is subject to approval by the Department of Biological Systems Engineering.
Description: Practical experience, directed learning, and career exploration and development in a selected business, industry, agency, or educational institution. Activities must include a significant engineering component.
Credit Hours: 1-3
Min credits per semester: 1
Max credits per semester: 3
Max credits per degree: 3
Format: FLFD

BSEN 414 Medical Imaging Systems
Crosslisted with: BSEN 814
Prerequisites: BSEN 311 or ELEC 304
Description: Underlying physics, instrumentation, and signal analysis of biomedical and biological imaging modalities. MRI, X-ray, CT, ultrasound, nuclear medicine, and the human visual system. Energy-tissue interactions. Resolution, point spread function, contrast, diffraction, comparisons. Information content in images for biological systems.
Credit Hours: 3
Max credits per semester: 3
Max credits per degree: 3
Format: LEC

BSEN 416 Introduction to Biomaterials
Crosslisted with: BSEN 816
Prerequisites: BSEN/AGEN 225; BIOC 321 or BIOC/BIOS/CHM 431/831.
Notes: BSEN 416/816 requires the evaluation of current primary literature in the field.
Description: Introduction to all types of bio-materials, metals, ceramics, polymers, and natural materials. Characterization of biomaterials, mechanical and physical properties, cell-biomaterials interactions, degradation, and host reaction to biomaterials. FDA testing and applications of biomaterials, implants, tissue engineering scaffolds, artificial organs, drug delivery, and adhesives.
Credit Hours: 3
Max credits per semester: 3
Max credits per degree: 3
Format: LEC
Prerequisite for: BSEN 418, BSEN 818

BSEN 418 Tissue Engineering
Crosslisted with: BSEN 818
Prerequisites: BSEN 416/816 or equivalent
Notes: BSEN 418/818 uses case studies to demonstrate clinical implementation of engineered tissues.
Description: Introduction to engineering biological substitutes that can restore, maintain or improve organ function in therapy of diseases. Engineering methods and principles to design tissues and organs, cell and tissue biology, tissue growth and development, biomaterial scaffolds, growth factor and drug delivery, scaffold-cell interactions, and bioreactors.
Credit Hours: 3
Max credits per semester: 3
Max credits per degree: 3
Format: LEC

BSEN 422 Pollution Prevention: Principles and Practices
Crosslisted with: BSEN 822, CIVE 422, CIVE 822
Prerequisites: Permission
Description: Introduction to pollution prevention (P2) and waste minimization methods. Practical applications to small businesses and industries. Legislative and historical development of P2 systems analysis, waste estimation, P2 methods, P2 economics, and sources of P2 information.
Credit Hours: 3
Max credits per semester: 3
Max credits per degree: 3
Format: LEC

BSEN 425 Process Design in Water Supply and Wastewater Treatment
Crosslisted with: CIVE 425
Prerequisites: CIVE/BSEN 326 and CIVE/MECH 310.
Description: Design of unit operations and processes associated with drinking water and wastewater treatment facilities.
Credit Hours: 3
Max credits per semester: 3
Max credits per degree: 3
Format: LEC
BSEN 441 Animal Waste Management
Crosslisted with: AGEN 441, AGEN 841, BSEN 841
Prerequisites: Senior standing.
Description: Characterization of wastes from animal production. Specification and design of collection, transport, storage, treatment, and land application systems. Air and water pollution, regulatory and management aspects.
Credit Hours: 3
Max credits per semester: 3
Max credits per degree: 3
Format: LEC

BSEN 444 Biomass and Bioenergy Engineering
Crosslisted with: BSEN 844
Prerequisites: Senior/graduate standing in engineering; BIOC 321 or 431; or permission
Description: Engineering processes for biomass conversion and bioenergy production. Topics include biomass chemistry, conversion reactions, current and emerging bioenergy technologies, feedstock logistics, life cycle assessment. Analysis of primary research literature required for graduate credit.
Credit Hours: 3
Max credits per semester: 3
Max credits per degree: 3
Format: LEC

BSEN 446 Unit Operations of Biological Processing
Crosslisted with: BSEN 846, AGEN 446, AGEN 846
Prerequisites: AGEN 225 or BSEN 225 and CHEM 332 or equivalent.
Description: Application of heat, mass, and moment transport in analysis and design of unit operations for biological and agricultural materials. Evaporation, drying, distillation, extraction, leaching, thermal processing, membrane separation, centrifugation, and filtration.
Credit Hours: 3
Max credits per semester: 3
Max credits per degree: 3
Format: LEC

BSEN 453 Irrigation and Drainage Systems Engineering
Crosslisted with: AGEN 453, AGEN 853, BSEN 853
Prerequisites: CIVE 310 or MECH 310; AGEN 344 or BSEN 344; or permission.
Description: Analytical and design consideration of evapotranspiration, soil moisture, and water movement as related to irrigation and drainage systems; analysis and design of components of irrigation and drainage systems including water supplies, pumping plants, sprinkler systems, and center pivots.
Credit Hours: 3
Max credits per semester: 3
Max credits per degree: 3
Format: LEC

BSEN 455 Nonpoint Source Pollution Control Engineering
Crosslisted with: BSEN 855, CIVE 455, CIVE 855
Prerequisites: BSEN 326 or CIVE 326; BSEN 350 or AGEN 350 or CIVE 352.
Description: Identification, characterization, and assessment of nonpoint source pollutants; transport mechanisms and remediation technologies; design methodologies and case studies.
Credit Hours: 3
Max credits per semester: 3
Max credits per degree: 3
Format: LEC

BSEN 458 Groundwater Engineering
Crosslisted with: BSEN 858, CIVE 458, CIVE 858
Prerequisites: CIVE 352 or AGEN 350 or BSEN 350 or equivalent.
Description: Application of engineering principles to the movement of groundwater. Analysis and design of wells, well fields, and artificial recharge. Analysis of pollutant movement.
Credit Hours: 3
Max credits per semester: 3
Max credits per degree: 3
Format: LEC

BSEN 460 Instrumentation and Controls
Crosslisted with: AGEN 460, AGEN 860, BSEN 860
Prerequisites: ELEC 211 or ELEC 215; or permission
Description: Analysis and design of instrumentation and controls for agricultural and biological production, management and processing. Theory of basic sensors and transducers, analog and digital electrical control circuits, and the interfacing of computers with instruments and controls. Emphasis on signal analysis and interpretation for improving system performance.
Credit Hours: 3
Max credits per semester: 3
Max credits per degree: 3
Format: LEC

BSEN 470 Design I in Agricultural and Biological Systems Engineering
Crosslisted with: AGEN 470
Prerequisites: BSEN or MECH 130 and AGEN or BSEN 344; Prereq or Parallel: AGEN or BSEN 460 and at least two courses from primary emphasis area; or permission
Description: Definition, scope, analysis, and synthesis of a comprehensive design problem within the areas of emphasis in the Department of Biological Systems Engineering. Identification of a client's engineering problem to solve, and development of objectives and anticipated results.
Credit Hours: 1
Max credits per semester: 1
Max credits per degree: 1
Format: LEC
Prerequisite for: AGEN 480, BSEN 480

BSEN 479 Hydroclimatology
Crosslisted with: NRES 479, METR 479, WATS 479, NRES 879, METR 879, BSEN 879
Prerequisites: NRES 208 or METR 100 or METR/NRES 370.
Notes: Offered spring semester of even-numbered calendar years.
Credit Hours: 3
Max credits per semester: 3
Max credits per degree: 3
Format: LEC
BSEN 480 Design II in Agricultural and Biological Systems Engineering
Crosslisted with: AGEN 480
Prerequisites: BSEN/AGEN 470
Description: Definition, scope, analysis, and synthesis of a comprehensive engineering problem in an engineering area of emphasis within the Department of Biological Systems Engineering. Design activity using the team approach to develop a solution.
Credit Hours: 3
Max credits per semester: 3
Max credits per degree: 3
Format: LAB
ACE: ACE 10 Integrated Product

BSEN 492 Special Topics
Crosslisted with: BSEN 892
Prerequisites: Permission
Description: Subject matter in emerging areas of Biological Systems Engineering not covered in other courses within the curriculum. Topics, activities, and delivery methods vary.
Credit Hours: 1-6
Min credits per semester: 1
Max credits per semester: 6
Max credits per degree: 6
Format: LEC

BSEN 496 Independent Study
Crosslisted with: AGEN 496
Prerequisites: Permission
Notes: Topics vary.
Description: Investigation and written report on engineering problems not covered in sufficient depth through existing courses.
Credit Hours: 1-6
Min credits per semester: 1
Max credits per semester: 6
Max credits per degree: 6
Format: IND

BSEN 499H Honors Thesis
Crosslisted with: AGEN 499H
Prerequisites: Senior or junior standing, admission to the University Honors Program.
Description: Independent project which meets the requirements of the University Honors Program, conducted under the guidance of a faculty member in the Department of Biological Systems Engineering. The project should contribute to the advancement of knowledge in the field. Written thesis and formal presentation required.
Credit Hours: 1-6
Min credits per semester: 1
Max credits per semester: 6
Max credits per degree: 6
Format: IND

PLEASE NOTE
This document represents a sample 4-year plan for degree completion with this major. Actual course selection and sequence may vary and should be discussed individually with your college or department academic advisor. Advisors also can help you plan other experiences to enrich your undergraduate education such as internships, education abroad, undergraduate research, learning communities, and service learning and community-based learning.

Icon Legend: Critical

16 HR TERM 1

Engineering
complete BSEN 100
1hr
C-

ACE 4 Chemistry

complete either CHEM 113 or CHEM 109
4hr
C-

Freshman Seminar
complete ENGR10#
0hr
ENGR 10 becomes critical to your success in the major if not completed by the end of the first term of enrollment.

Math/Science
complete MATH 106
5hr
C

ACE 5 Humanities
complete 1 from ACE5
3hr
Complete an ACE 5, 6, 7, or 9 requirement this term.

ACE 6 Social Sciences
complete 1 from ACE6
3hr
Complete an ACE 5, 6, 7, or 9 requirement this term.

17 HR TERM 2

Engineering
complete BSEN 112
2hr
C-

BSEN 112 becomes critical to your success in the major if not completed by the end of the second term of enrollment.
complete either CHEM 114 or CHEM 110

Math/Science
complete MATH 107, PHYS 211

MATH 107 and PHYS 211 both become critical to your success in the major if not completed by the end of the third term of enrollment.

Biological Sci Labs
recommend 1 or more courses

See advisor for list.

17 HR TERM 3

Engineering
complete BSEN 225

BSEN 225 becomes critical to your success in the major if not completed by the end of the third term of enrollment.

Engineering Statics
complete MECH 223

MECH 223 becomes critical to your success in the major if not completed by the end of the fourth term of enrollment.

Organic Chemistry Reqd
complete 2 from CHEM 251, CHEM 253, CHEM 255, CHEM 257, CHEM 261, CHEM 263

Complete one set - lecture and lab.

Sophomore Seminar

16 HR TERM 4

Engineering
complete 3 from BSEN 130, MECH 373, BSEN 212E, BSEN 212B, BSEN 212A

Complete both BSEN 130 and MECH 373 and choose one between BSEN 212A, 212B, or 212E.

Engineering
complete BSEN 244

BSEN 244 becomes critical to your success in the major if not completed by the end of the fifth term of enrollment.

ACE 4 Biological Science
complete LIFE 120, LIFE 120L

Complete one set - lecture and lab.

Math/Physics
complete MATH 221
17 HR TERM 5

ACE 4 Biological Science
complete either LIFE 121 or LIFE 121L

Engineering
complete 1 from CIVE 310, CHME 332, MECH 310

CIVE 310 or MECH 310 becomes critical to your success in the major if not completed by the end of the sixth term of enrollment.

Math/Physics
complete 2 from MECH 321, MATH 380, PHYS 212

Complete PHYS 212 and either MECH 321 or MATH 380.

BSEN Courses 12 Hrs
recommend 1 or more courses

Select a course towards an Emphasis Elective.

ACE 7 Arts
complete 1 from ACE7

Complete an ACE 5, 6, 7, or 9 requirement this term.

BSEN Courses 12 Hrs
recommend 1 or more courses

Select a course towards an Emphasis Elective.

ACE 2 Communication Skill
complete 1 from ALEC 102, COMM 209, COMM 283, COMM 286, ENGR 100, GERM 303, JAPN 202, JGEN 300, RUSS 304, SPAN 303

Engineering
complete ECEN 211

Select a course towards an Emphasis Elective.

Milestones
1. Professional Admission into College.

18 HR TERM 6

Biochemistry
complete either BIOC321# or BIOC 431

Engineering
complete BSEN 344

BSEN 344 becomes critical to your success in the major if not completed by the end of the sixth term of enrollment.

ACE 9 Global/Human Divers
complete 1 from ACE9

Complete an ACE 5, 6, 7, or 9 requirement this term.

BSEN Courses 12 Hrs
recommend 1 or more courses

Select a course towards an Emphasis Elective.
Suggested Engineering
recommend 1 or more courses

Select a course towards an Engineering or Science Emphasis Elective.

16 HR TERM 8

Professional Ethics
complete ENGR 400

Engineering
complete BSEN 480

BSEN 480 will fulfill the ACE 10 requirement.

Biological Sci Electives
complete 1 from ENGBSEN-B

BSEN Courses 12 Hrs
recommend 1 or more courses

Select a course towards an Emphasis Elective.

Suggested Science
recommend 1 or more courses

Select two courses towards an Engineering or Science Emphasis Electives.

Graduation Requirements
1. 133 hours required for graduation.
2. 2.40 GPA required for graduation.
3. 30 of the last 36 hours must be taken at UNL/UNO.

Career Information
The following represents a sample of the internships, jobs and graduate school programs that current students and recent graduates have reported.

Jobs of Recent Graduates
- Civil Design Engineer, US Army Corps of Engineers - Kansas City KS
- Environmental Engineer, Koch Industries - Enid OK
- Process Engineer, Novozymes, Inc. - Blair NE
- Environmental Sales Associate, LI-COR Biosciences, Inc. - Lincoln NE
- Applications Engineer, National Instruments - Austin TX
- Environmental Engineering Volunteer, Peace Corps - Panama City, Panama
- Project Engineer, Becton Dickinson - Columbus NE
- Water Resource Engineer, HDR - Denver CO
- Production Management Engineer, Cargill - Raleigh NC
- Project Management, Epic Systems Corporation - Madison WI

Internships
- BSEN Co-op, NASA - Johnson Space Center - Houston TX
- R&D Hematology Intern, Streck - Omaha NE
- Water Resources Intern, Olsson Associates - Lincoln NE
- Environmental Intern, Kiewitt - Omaha NE
- BSE Co-op, ConAgra Foods - Omaha NE
- Microbiology Intern, Becton Dickinson - Broken Bow NE
- Ecology Intern, Auckland University of Technology - Auckland, New Zealand
- Biomedical Engineering Summer Associate, Medtronic - Minneapolis MN
- Commercial Product Training Specialist Intern, Case New Holland Industrial - Racine WI
- Hydrologic Student Intern, United States Geological Survey - Lincoln NE

Grad Schools
- Doctor of Medicine, UNMC College of Medicine - Omaha NE
- Masters in Prosthetics and Orthotics, University of Texas Southwestern Medical Center - Dallas TX
- Medical Scientist Training Program/M.D. and Ph.D., University of Wisconsin-Madison - Madison WI
- Biological Engineering, Ph.D., UNL - Lincoln NE
- Pharmacy, University of Nebraska Medical Center - Omaha NE
- Dental School, UNMC Dental School - Lincoln NE
- Juris Doctor, George Washington University Law School - Washington DC
- Bioengineering PhD, University of California-Berkeley - Berkeley CA
- Veterinary School, Iowa State University - Ames IA
- Biomedical Engineering PhD, University of Minnesota - Minneapolis MN