

BIOLOGICAL ENGINEERING UNDERGRADUATE HANDBOOK

(Revised: May 2021)

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Biological Engineering Program Goal

Biological Engineers find the sustainable solutions needed to supply a growing world population with food, fiber, water, and fuel under increasing environmental constraints. The goal of the Biological Engineering program is to prepare graduates for careers in the application of engineering design and analysis to power and machinery systems, structures, production of food and pharmaceuticals, biomass energy systems, and protection of natural resources.

Biological Engineering Program Educational Objectives

Early career Biological Engineering graduates will be expected to:

1. Demonstrate proficiency in basic and engineering sciences related to biological processing, natural resource, and agricultural engineering fields;
2. Effectively identify, analyze and design sustainable solutions to address issues and opportunities throughout the world;
3. Work in teams and effectively communicate within and outside the profession;
4. Demonstrate strong leadership skills, ethical integrity, and professional engagement.

Biological Engineering Student Outcomes

Student outcomes describe what students are expected to know and be able to do by the time of graduation. The Biological Engineering program is designed to enable students to:

1. Identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics
2. Apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors
3. Communicate effectively with a range of audiences
4. Recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts
5. Function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives
6. Develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions
7. Acquire and apply new knowledge as needed, using appropriate learning strategies.

Introduction

Welcome to Penn State and the Department of Agricultural and Biological Engineering! The faculty and staff are committed to enabling you to have enriching, rewarding, and professional experiences at Penn State.

This manual has been prepared to guide Biological Engineering (BE) majors through their academic programs at Penn State, help students understand the requirements for the Biological Engineering major, and give guidance for selecting various elective courses. The program check sheets should be kept up-to-date and checked periodically against the one in your advisor's file.

Each BE student is assigned an academic advisor when they arrive as a first-year student (in the College of Agricultural Sciences), declare BE as their major in the entrance-to-major process, or transfer to the program from another university. Your advisor will counsel you on the academic requirements of the major and serve as a resource to answer other academic questions. Your advisor will assist in developing your career goals and objectives. It is also hoped that your advisor will become a friend and listener as well as a source of information concerning non-academic matters if the need arises. Normally the same academic advisor is retained until graduation. **Generally, advisors will not search for the students; it is the responsibility of each student to meet with their advisor at least once each semester for counsel, guidance, and career development information.** Any specific interests or concerns you have in Biological Engineering should be discussed with your advisor.

The Agricultural and Biological Engineering Department is committed to providing a stimulating educational environment for all students. Please inform the Department Head immediately of any barriers--real or perceived--that create problems or limitations in the educational opportunities for you or other students in the Department.

For further information about the Biological Engineering major, please contact:

Dr. Megan Marshall
Associate Teaching Professor & BE Program Coordinator
305 Agricultural Engineering Building
814-865-3392
mnm11@psu.edu

What is Biological Engineering?

Biological Engineering is the application of engineering principles to biological systems; each of which greatly impact our food and fiber supply. A college education in Biological Engineering prepares students for many exciting career opportunities in the diverse areas of production of food and other biological materials, processing systems, and management of land and water resources. Employment opportunities for Biological Engineers are undoubtedly going to continue to increase as the world's population demands more abundant supplies of nutritious, high quality food at affordable prices.

Courses in the Biological Engineering curriculum provide thorough training in mathematics, physics and the engineering sciences common to all engineering disciplines. In addition, students receive specialized training in biological, environmental, and/or agricultural sciences. Through the selection of an option, electives, and possibly a minor, a Biological Engineering student can specialize. Each student is required to select the **Agricultural Engineering Option**, the **Food and Biological Processing Engineering Option** or the **Natural Resources Engineering Option** at the time that they declare the BE major. **However, a student can switch options at any time after declaring the major.** Please see your advisor to discuss a change in option, as it may extend expected time to graduation.

Agricultural Engineering

- Machinery design and systems management, including off-road equipment for agricultural production, construction, forestry, and food processing
- Structural design and environmental control with a focus on design of wood structures

Food and Biological Processing Engineering

- Engineering of microbiological systems for pharmaceuticals, renewable energy, and vitamin and food supplements
- Food processing, handling, and storage from the time food is produced until it reaches consumers

Natural Resources Engineering

- Engineering for the protection of the environment from non-point source pollution, including sediment loss and nutrient/chemical runoff
- Designing solutions for stormwater management and sustainable land development

There are many exciting job opportunities available for Biological Engineering graduates, with specific responsibilities such as engineering design, analysis, field testing, research, development, systems management, sales, consulting and applications engineering. Biological Engineers are uniquely qualified to cope with the various engineering aspects of production and processing of food and other biological materials within the constraints of environmental protection and natural resources conservation.

About 20% of our graduates continue their education by enrolling in the graduate program at Penn State or other leading universities for advanced study in a particular area of Biological Engineering or in a related engineering discipline.

The best way for students to learn more about the Biological Engineering profession is to participate in the Penn State Student Branch of ASABE, the society for engineering in agricultural, food, and biological systems (see page 43), and company visits sponsored by the Department.

The student-advisor relationship: roles and expectations

Biological Engineering students should establish a working relationship with their advisors for a productive and efficient college experience. The following lists provide guidance on the roles and expectations of both the student and the advisor:

Responsibilities and Expectations of Students

- Ensuring that proper courses are selected
- Ensuring that courses are taken in the appropriate sequence, adhering to prerequisites
- Ensuring that graduation requirements are met
- Completing petitions for degree requirement substitutions prior to the graduation semester
- Developing course schedule for each semester

Responsibilities and Expectations of Advisor

- Keeping advisee records up to date each semester
- Providing guidance on selection of courses
- Providing career guidance
- Encouraging students to engage in co-curricular activities
- Promoting summer job, internships and co-op opportunities
- Help inform student of minors and how minors might fit with career plans

AGRICULTURAL ENGINEERING OPTION –

GRADUATION CHECKLIST, **FLOW CHART,** **AND SELECTION LISTS**

(SEE THE [UNDERGRADUATE BULLETIN](#) FOR SUGGESTED ACADEMIC PLAN)

BIOLOGICAL ENGINEERING GRADUATION CHECKLIST (before SU18)
AGRICULTURAL ENGINEERING OPTION

Student Name _____

Student ID/e-mail _____

Cr. Completed Petition?
 First Year Seminar (1 cr)

_____ 1 _____

Communications (GWS - 10 cr)

ENGL 15 3 _____

CAS 100A/B 3 _____

BE 391 2 _____

BE 392 2 _____

Quantification (GQ - 14 cr)

MATH 140 4 _____*

MATH 141 4 _____*

MATH 231 2 _____

MATH 251 4 _____*

Natural Science (GN - 12 cr)

CHEM 110 3 _____*

CHEM 111 1 _____

PHYS 211 4 _____*

PHYS 212 4 _____*

Social Science (GS - 6 cr)

ECON 102, ECON 104, or AGBM 3 _____

Humanities (GH - 6 cr)

_____ _____

Art (GA - 6 cr)

_____ _____

Health & Wellness (GHW - 3 cr)

_____ _____

US Cultures (US - 3 cr)

International Cultures (IL - 3 cr)

World Language Admissions

Engineering (21 cr)

EDSGN 100 3 _____

EMCH 211 3 _____*

EMCH 212 3 _____*

EMCH 213 3 _____*

ME 300 3 _____*

CE 360 or ME 320 3 _____*

IE 424 or STAT 401 3 _____

Biological Engineering (32 cr)

BE 301 3 _____*

BE 302 4 _____*

BE 304 3 _____*

BE 305 3 _____*

BE 308 3 _____*

BE 460 2 _____

BE 466 2 _____

Two BE 30X courses (BE 303/306/307):

_____ 3 _____*

_____ 3 _____*

Two BE 4XX courses:

_____ 3 _____

_____ 3 _____

Math/Basic Science (3 cr)

_____ _____

Biological/Agricultural Science (3 cr)

_____ _____

Engineering Science/Design (6 cr)

_____ _____

_____ _____

Technical Requirement (6 cr)

_____ _____

_____ _____

Total required credits for graduation = 129

* courses require C or better

**BIOLOGICAL ENGINEERING GRADUATION CHECKLIST (SU18 or later)
AGRICULTURAL ENGINEERING OPTION**

Student Name _____

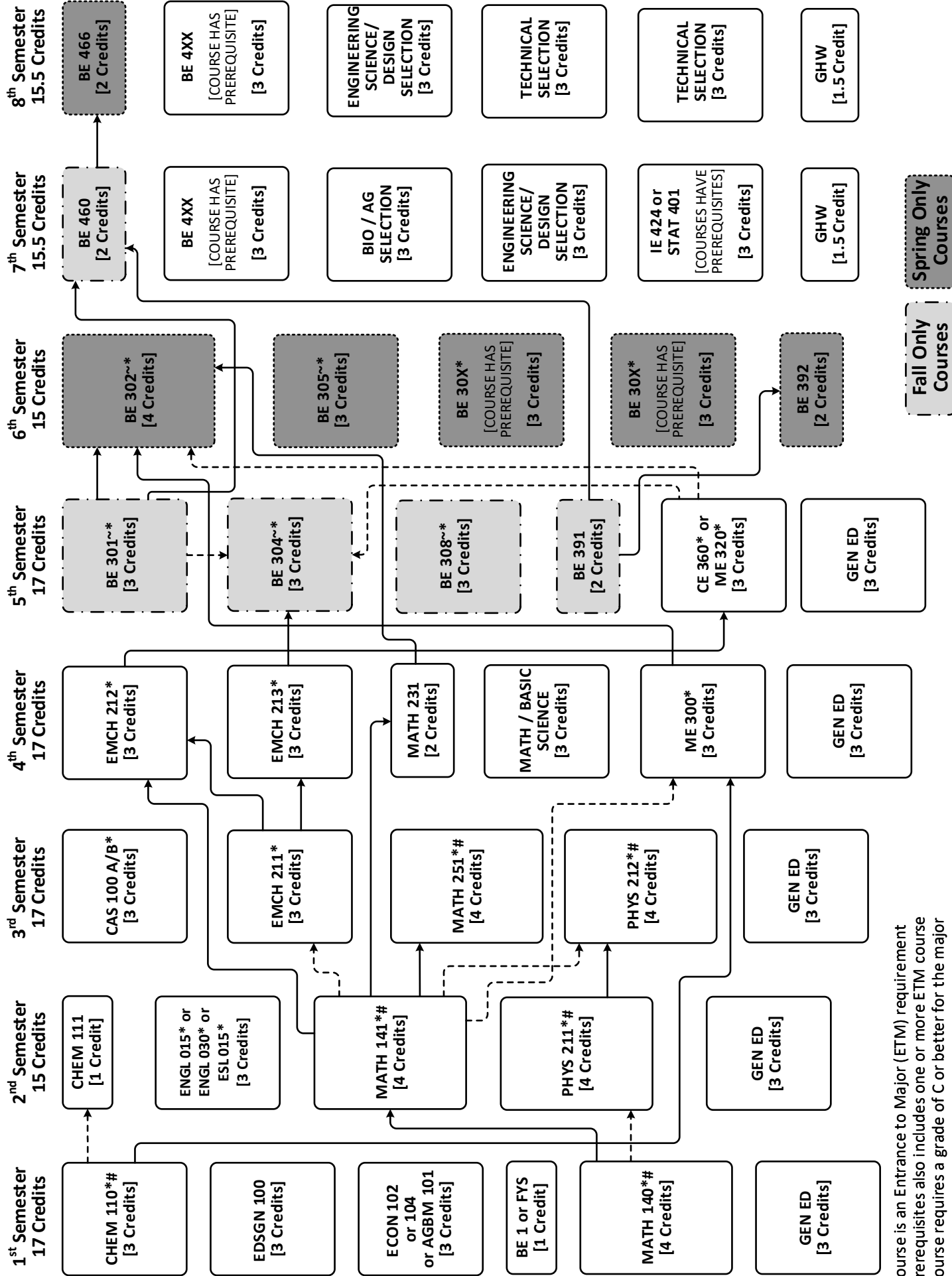
Student ID/e-mail _____

- | | Cr. | Completed | Petition? |
|---|-----|-----------|-----------|
| <input type="checkbox"/> First Year Seminar (1 cr) | | | |
| _____ 1 _____ | | | |
| <input type="checkbox"/> Communications (GWS - 10 cr) | | | |
| ENGL 15 | 3 | _____ | * |
| CAS 100A/B | 3 | _____ | * |
| BE 391 | 2 | _____ | * |
| BE 392 | 2 | _____ | * |
| <input type="checkbox"/> Quantification (GQ - 14 cr) | | | |
| MATH 140 | 4 | _____ | * |
| MATH 141 | 4 | _____ | * |
| MATH 231 | 2 | _____ | |
| MATH 251 | 4 | _____ | * |
| <input type="checkbox"/> Natural Science (GN - 12 cr) | | | |
| CHEM 110 | 3 | _____ | * |
| CHEM 111 | 1 | _____ | |
| PHYS 211 | 4 | _____ | * |
| PHYS 212 | 4 | _____ | * |
| <input type="checkbox"/> Social Science (GS - 6 cr) | | | |
| single domain ECON 102, ECON 104, or AGBM | 3 | _____ | |
| _____ | | _____ | |
| <input type="checkbox"/> Humanities (GH - 6 cr) | | | |
| single domain _____ | 3 | _____ | |
| _____ | | _____ | |
| <input type="checkbox"/> Art (GA - 6 cr) | | | |
| single domain _____ | 3 | _____ | |
| _____ | | _____ | |
| <input type="checkbox"/> Health & Wellness (GHW - 3 cr) | | | |
| single domain _____ | | _____ | |
| _____ | | _____ | |
| <input type="checkbox"/> US Cultures (US - 3 cr) | | | |
| <input type="checkbox"/> International Cultures (IL - 3 cr) | | | |
| <input type="checkbox"/> Integrative Studies (N,Q,Z - 3 cr) | | | |
| <input type="checkbox"/> Integrative Studies (N,Q,Z - 3 cr) | | | |
| <input type="checkbox"/> GN, GS, GH, GA, GHW (30 cr) | | | |
| <input type="checkbox"/> World Language Admissions | | | |

- | | Cr. | Completed | Petition? |
|---|-----|-----------|-----------|
| <input type="checkbox"/> Engineering (21 cr) | | | |
| EDSGN 100 | 3 | _____ | |
| EMCH 211 | 3 | _____ | * |
| EMCH 212 | 3 | _____ | * |
| EMCH 213 | 3 | _____ | * |
| ME 300 | 3 | _____ | * |
| CE 360 or ME 320 | 3 | _____ | * |
| IE 424 or STAT 401 | 3 | _____ | |
| <input type="checkbox"/> Biological Engineering (32 cr) | | | |
| BE 301 | 3 | _____ | * |
| BE 302 | 4 | _____ | * |
| BE 304 | 3 | _____ | * |
| BE 305 | 3 | _____ | * |
| BE 308 | 3 | _____ | * |
| BE 460 | 2 | _____ | |
| BE 466 | 2 | _____ | |
| Two BE 30X courses (BE 303/306/307): | | | |
| _____ 3 _____ | | _____ | * |
| _____ 3 _____ | | _____ | * |
| Two BE 4XX courses: | | | |
| _____ 3 _____ | | _____ | |
| _____ 3 _____ | | _____ | |
| <input type="checkbox"/> Math/Basic Science (3 cr) | | | |
| _____ _____ | | _____ | |
| <input type="checkbox"/> Biological/Agricultural Science (3 cr) | | | |
| _____ _____ | | _____ | |
| <input type="checkbox"/> Engineering Science/Design (6 cr) | | | |
| _____ _____ | | _____ | |
| _____ _____ | | _____ | |
| <input type="checkbox"/> Technical Requirement (6 cr) | | | |
| _____ _____ | | _____ | |
| _____ _____ | | _____ | |

Total required credits for graduation = 129
** courses require C or better*

BIOLOGICAL ENGINEERING [AGRICULTURAL OPTION]



Course is an Entrance to Major (ETM) requirement
 ~ Prerequisites also includes one or more ETM course
 * Course requires a grade of C or better for the major
 → = Prerequisite
 - - - - - = Prerequisite or Concurrent

Fall Only Courses
 Spring Only Courses

AGRICULTURAL ENGINEERING OPTION SELECTION LISTS

COURSES THAT MEET THE MATH/BASIC SCIENCE REQUIREMENT*

AGRO 28	Principles of Crop Management (3) Prerequisite: 6 credits of biological science. Offered: FA
AN SC 201	Animal Science (4) Offered: FA/SP
BIOL 11	Introductory Biology I (3)
BIOL 110	Biology: Basic Concepts and Biodiversity (4) Offered: FA/SP/SU
BIOL 127	Introduction to Plant Biology (3) Offered: FA
BIOL 141	Introductory Physiology (3) Offered: FA/SP/SU
BMB 211	Elementary Biochemistry (3) Prerequisite: CHEM 110; CHEM 202 or CHEM 210. Offered: FA/SP/SU
CHEM 112	Chemical Principles II (3) Prerequisite: CHEM 110 or CHEM 106. Offered: FA/SP/SU
CHEM 202	Fundamentals of Organic Chemistry I (3) Prerequisite: CHEM 101 or CHEM 110 or CHEM 106. Offered: FA/SP/SU
GEO SC 1	Physical Geology (3) Offered: FA/SP
HORT 101	Horticultural Science (3) Offered: FA/SP
MATH 220	Matrices (2-3) Prerequisite: MATH 110 or MATH 140 or MATH 140H. Offered: FA/SP/SU
MICRB 201	Introductory Microbiology (3) Prerequisite: CHEM 110. Offered: FA/SP
PHYS 213	General Physics: Fluids and Thermal Physics (2) Prerequisite: MATH 140, PHYS 211; Concurrent: MATH 141. Offered: FA/SP/SU
PHYS 214	General Physics: Wave Motion and Quantum Physics (2) Prerequisite: MATH 141, PHYS 211 and PHYS 212. Offered: FA/SP/SU
PHYS 237	Introduction to Modern Physics (3) Prerequisite: PHYS 212; Concurrent: PHYS 214. Offered: FA/SP
SOILS 101	Introductory Soil Science (3) Offered: FA/SP

COURSES THAT MEET THE ENGINEERING SCIENCE/DESIGN REQUIREMENT*

AE 308	Introduction to Structural Analysis (4) Prerequisite: EMCH 211, EMCH 213. Offered: FA
AE 310	Fundamentals of Heating, Ventilating, and Air Conditioning (3) Prerequisite: ME 201. Prerequisite or concurrent: AE 202. Offered: SP
AE 402	Design of Concrete Structures for Buildings (3) Prerequisite: AE 221, AE 222, AE 308. Offered: FA
AE 403	Advanced Steel Design for Buildings (3) Prerequisite: AE 401, AE 430. Offered: SP
AE 444	Micro CADD Applications for Buildings (3) Prerequisite: AE 222; CMPSC 201 or CMPSC 202. Offered: FA/SP
AE 470	Residential Building Design and Construction (3) Prerequisite: AE 372 or CE 332. Offered: FA
BE 461	Design of Fluid Power Systems (3) Prerequisite: BE 306 or ME 360; and CE 360 or ME 320. Offered: FA
BE 462	Design of Wood Structures (3) Prerequisite: BE 303, AE 308, or CE 340. Offered: FA
BE 464	Bioenergy Systems Engineering (3) Prerequisite: EME 301, ME 201, ME 300, or CHE 220. Prerequisite or concurrent: BE 308, CHE 340, or CE 479. Offered: FA
BE 465	Food and Biological Process Engineering (3) Prerequisite: BE 302. Offered: FA
BE 467	Design of Stormwater and Erosion Control Facilities (3) Prerequisite: BE 307 or CE 461. Offered: FA
BE 468	Microbiological Engineering (3) Prerequisite: BE 308 or both BMB 211 and MICRB 201. Prerequisite or concurrent: BE 302. Offered: SP
BE 477	Land-Based Waste Disposal (3) Prerequisite: BE 307 or CE 370 or ASM 327. Offered: SP
BE 487	Watershed Modeling for Water Quality Design (3) Prerequisite: BE 307 or CE 461. Offered: SP
CE 310	Surveying (3) Prerequisite: EDSGN 100, MATH 141. Offered: FA/SP
CE 335	Engineering Mechanics of Soils (3) Prerequisite: EMCH 213; AE 221 or GEO SC 1. Offered: FA/SP

- CE 340 Structural Analysis (3) Prerequisite: EMCH 213. Prerequisite or concurrent: CMPSC 201 or CMPSC 202. Offered: FA/SP
- CE 341 Design of Concrete Structures (3) Prerequisite: CE 340, Prerequisite or concurrent: CE 336. Offered: FA/SP
- CE 342 Design of Steel Structures (3) Prerequisite: CE 336, CE 340. Offered: FA/SP
- CE 370 Introduction to Environmental Engineering (3) Prerequisite: CHEM 110; MATH 111 or MATH 141. Offered: FA/SP
- CE 410 Sustainable Residential Subdivision Design (3) Prerequisite: AE 372 or CE 332. Offered: FA
- CE 435 Foundation Engineering (3) Prerequisite: CE 335. Prerequisite or concurrent: CE 341. Offered: FA/SP
- CE 461 Water-resource Engineering (3) Prerequisite: CE 360. Offered: FA/SP
- CE 462 Open Channel Hydraulics (3) Prerequisite: CE 360. Offered: FA/SP
- CE 465 Water Resources Capstone Course (3) Prerequisite: CE 461. Prerequisite or concurrent: CE 462. Offered: SP
- CE 475 Water Quality Chemistry (4) Prerequisite: CE 370, CHEM 110, CHEM 111. Offered: SP
- CE 476 Solid and Hazardous Wastes (3) Prerequisite: CE 370, CE 371. Offered: SP
- EDSGN 468 Engineering Design and Analysis with CAD (3) Prerequisite: EMCH 210 or EMCH 211. Offered: FA/SP (only 3 credits can be used toward electives; Solidworks section recommended)
- EDSGN 452 Projects in Humanitarian Engineering (2) Prerequisite: 5th semester standing. Concurrent: EDSGN 453. Offered: SP
- EDSGN 453 Design for Developing Communities (1) Prerequisite: 5th semester standing. Offered: SP
- EMCH 315 Mechanical Response of Engineering Materials (2) Prerequisite: EMCH 213, EMCH 210H, or EMCH 210. Offered: FA/SP
- EMCH 316 Experimental Determination of Mechanical Response of Materials (1) Prerequisite or concurrent: EMCH 315. Offered: FA/SP
- EMCH 416 Failure and Failure Analysis of Solids (3) Prerequisite: EMCH 213 or EMCH 210. Offered: SP
- IE 312 Product Design and Manufacturing Processes (3) Prerequisite: EMCH 213, EMCH 210H, or EMCH 210; Prerequisite or concurrent: ESC 414M or MATSE 259. Offered: FA/SP/SU
- MATSE 259 Properties and Processing of Engineering Materials (3) Prerequisite: EMCH 213 or EMCH 210. Offered: FA/SP/SU
- ME 405 Indoor Air Quality Engineering (3) Prerequisite: ME 320 or equivalent. Offered: FA
- ME 370 Vibration of Mechanical Systems (3) Prerequisite: EMCH 212, CMPSC 200, MATH 220, MATH 251. Offered: FA/SP
- ME 411 Heat-Exchanger Design (3) Prerequisite: ME 410. Offered: SP
- ME 410 Heat Transfer (3) Prerequisite: ME 320 or BME 409, CMPSC 200 or CMPSC 201, MATH 220 or NUCE 309. Offered: FA/SP/SU
- ME 431 Internal Combustion Engines (3) Prerequisite: ME 302. Offered: SP
- ME 433 Fundamentals of Air Pollution (3) Prerequisite: ME 201 or ME 300. Offered: SP
- ME 444 Engineering Optimization (3) Prerequisite: MATH 220; MATH 230 or MATH 231; CMPSC 201 or CMPSC 202 or CMPSC 200. Offered: SP
- ME 450 Modeling of Dynamic Systems (3) Prerequisite: ME 370, ME 345. Offered: FA/SP
- ME 452 Vehicle Road Dynamics (3) Prerequisite or concurrent: ME 450. Offered: SP
- ME 456 (IE 456) Industrial Robot Applications (3) Prerequisite: MATH 220; MATH 250 or MATH 251; IE 305 or ME 360; CMPSC 200 or CMPSC 201. Offered: FA
- ME 462 Lubrication in Machine Design (3) Prerequisite: MATH 251, ME 360. Offered: FA

AGE students with an interest in machinery systems are strongly encouraged to take EDSGN 468, Engineering Design and Analysis with CAD (3), as an Engineering Science/Design or Technical Selection (look for Solidworks section taught by Randall Bock).

COURSES THAT MEET THE BIOLOGICAL/AGRICULTURAL SCIENCE REQUIREMENT⁺

AGRO 28	Principles of Crop Management (3) Prerequisite: 6 credits in biological science. Offered: FA
AGRO 423	Forage Crop Management (3) Prerequisite: AGRO 28. Offered: FA
AGRO 425	Field Crop Management (3) Prerequisite: AGRO 28. Offered: SP
ANSC 201	Animal Science (4) Offered: FA/SP
ANSC 309	Beef Cattle Production and Management (4) Prerequisite: ANSC 201. Offered: SP
ANSC 310	Dairy Cattle Production and Management (3) Prerequisite: AN SC 201. Offered: SP
ANSC 311	Poultry Production and Management (3) Prerequisite: ANSC 201. Offered: FA
ASM 309	(ERM 309) Measurement & Monitoring of Hydrologic Systems (3) Prerequisite: PHYS 211 or PHYS 250, CHEM 110. Offered: FA
ASM 320	Combustion Engines for Mobile Equipment (3) Prerequisite: BE 306 or ASM 310 or ME 360. Offered: SP
ASM 420	Principles of Off-Road Machines (3) Prerequisite: BE 306 or ASM 310 or ME 360. Offered: SP
ASM 424	Selection and Management of Agricultural Machinery (3) Prerequisite: BE 306 or ASM 310 or ME 360. Offered: FA
BIOL 110	Biology: Basic Concepts and Biodiversity (4) Offered: FA/SP/SU
BIOL 141	Introductory Physiology (3) Offered: FA/SP/SU
BIOL 220W	Biology: Populations and Communities (4) Prerequisite: BIOL 110. Offered: SP
BIOL 240W	Biology: Function and Development of Organisms (4) Prerequisite: BIOL 110, CHEM 110. Offered: SP
BRS 411	Biobased Fiber Science (4) Prerequisite: CHEM 110, BRS 300. Offered: SP
BRS 417	Processing and Manufacturing Systems for Bioproducts (4) Prerequisite: BRS 221 and BRS 300. Offered: SP
BRS 423	Deterioration and Protection of Bioproducts (3) Prerequisite: BRS 300. Concurrent: BRS 411. Offered: SP
BRS 426	Safety and Health in Agriculture and Biorenewable Industries (3) Prerequisite: BRS 393. Offered: SP
ERM 402	Foundations of Sustainable Business (3) Prerequisite: AGBM 101 or ECON 102 or ECON 104. Offered: FA
ERM 412	Resource Systems Analysis (3) Prerequisite: BIOL 220W, ERM 151, ERM 300 and STAT 240; MATH 111 or MATH 141. Offered: FA/SP
ERM 430	(PPEM 430) Air Pollution Impacts to Terrestrial Ecosystems (3) Prerequisite: BIOL 220W or FOR 308. Offered: SP
ERM 431	(VBSC 431) Environmental Toxicology (3) Prerequisite: BIOL 110, CHEM 110, CHEM 112. Offered: FA
ERM 435	(WFS 435) Limnology (3) Prerequisite: BIOL 110, BIOL 220W, CHEM 110. Offered: FA
ERM 447	Stream Restoration (3) Prerequisite: ASM 327 or BE 307 or CE 461. Offered: FA
ERM 448	Rural Road Ecology and Maintenance (3) Prerequisite: MATH 140. Prerequisite or concurrent: BE 307 or CE 370. Offered: FA
ERM 450	(WFS 450) Wetland Conservation (3) Prerequisite: ERM 300 or WFS 209. Offered: FA
FOR 455	Remote Sensing and Spatial Data Handling (3) Prerequisite: MATH 110, 3 credits in computer science, 6 credits in ecological and/or geological sciences. Offered: SP
FOR 470	Watershed Management (3) Prerequisite: 3 credits in Soils. Offered: SP
HORT 101	Horticultural Science (3) Offered: FA/SP
HORT 315	Environmental Effects on Horticultural Crops (3) Prerequisite: HORT 101, HORT 202. Offered: SP
HORT 402	Plant Nutrition (3) Prerequisite: HORT 315 or BIOL 441, SOILS 101. Offered: SP
HORT 412	Post-Harvest Physiology (3) Prerequisite: 6 credits in horticulture or other plant sciences. Offered: SP
PLANT 426	Nutrient Management Specialist Preparation (1) Prerequisite: SOILS 101 and SOILS 102. Offered: FA
SOILS 101	Introductory Soil Science (3) Offered: FA/SP
SOILS 401	Soil Composition and Physical Properties (3) Prerequisite: SOILS 101. Offered: SP

- SOILS 404 Urban Soils (3) Prerequisite: SOILS 101. Offered: SP
 SOILS 416 Soil Genesis, Classification, and Mapping (4) Prerequisite: SOILS 101. Offered: FA
 SOILS 418 (AGECO 418, AN SC 418) Nutrient Management in Agricultural Systems (3) Prerequisite:
 BIOL 110 or (BIOL 11 and BIOL 12) or BISC 3. Offered: FA
 TURF 235 The Turfgrass (3) Offered: FA

COURSES THAT MEET THE TECHNICAL SELECTION REQUIREMENT*

Any course acceptable as a Basic Math/Science, Engineering Science/Design OR Biological/Agricultural Science Requirement may be taken as a Technical Selection, plus CMPSC 121, CMPSC 131, CMPSC 200, CMPSC 201, ENGR 310, ENGR 407, ENGR 408, ENGR 451, ENGR 455, MGMT 215, GEOSC 452.

COURSES THAT MEET THE BIOLOGICAL ENGINEERING REQUIREMENT

- BE 461 Design of Fluid Power Systems (3) Prerequisite: BE 306 or ME 360; CE 360 or ME 320. Offered: FA
 BE 462 Design of Wood Structures (3) Prerequisite: BE 303, AE 308, or CE 340. Offered: FA
 BE 464 Bioenergy Systems Engineering (3) Prerequisite: EME 301, ME 201, ME 300, or CHE 220. Prerequisite or concurrent: BE 308, CHE 340, or CE 479. Offered: FA
 BE 465 Food and Biological Process Engineering (3) Prerequisite: BE 302. Offered: FA
 BE 467 Design of Stormwater and Erosion Control Facilities (3) Prerequisite: BE 307 or CE 461. Offered: FA
 BE 468 Microbiological Engineering (3) Prerequisite: BE 308 or both MICRB 201 and BMB 211. Prerequisite or concurrent: BE 302. Offered: SP
 BE 477 Land-Based Waste Disposal (3) Prerequisite: BE 307 or CE 370 or ASM 327. Offered: FA
 BE 487 Watershed Modeling for Water Quality Design (3) Prerequisite: BE 307 or CE 461. Offered: SP
 BE 497 Design Principles for Bio-Mechatronic Systems (3) Prerequisite: BE 305. Offered: SP (being offered with a temporary course number for the first time in Spring 2019, will require a petition until it has a permanent course number)

*Other courses may be taken to meet the engineering science/design, biological/agricultural science, and technical requirements if the student submits a petition approved by the Department of Agricultural and Biological Engineering. All petitions must be submitted and approved prior to the student's graduation semester, however earlier is preferred to ensure adequate progress towards completing degree requirements.

**Recommended electives for students in the Agricultural Engineering option desiring to specialize in
STRUCTURAL DESIGN**

(See pages 9-12 for complete listing of approved courses)

BIOLOGICAL ENGINEERING JUNIOR SELECTION (6 credits required)

- BE 303 Structural Systems in Agriculture (3) Prerequisite: EMCH 210 or EMCH 213. Offered: SP
BE 307 Soil and Water Engineering (3) Prerequisite or concurrent: CE 360 or ME 320. Offered: SP

BIOLOGICAL ENGINEERING Requirement (6 credits required)

- BE 462 Design of Wood Structures (3) Prerequisite: BE 303, AE 308, or CE 340. Offered: FA
BE 467 Design of Stormwater and Erosion Control Facilities (3) Prerequisite: BE 307 or CE 461.
Offered: FA

MATH/BASIC SCIENCE Requirement (3 credits required)

- ANSC 201 Animal Science (4) Offered: FA/SP
HORT 101 Horticultural Science (3) Offered: FA/SP

BIOLOGICAL/AGRICULTURAL SCIENCE Requirement (3 credits required)

- BRS 417 Processing and Manufacturing Systems for Bioproducts (4) Prerequisite: BRS 221 and
BRS 300. Offered: SP
BRS 411 Biobased Fiber Science (4) Prerequisite: CHEM 110, BRS 300. Offered: SP
BRS 423 Deterioration and Protection of Bioproducts (3) Prerequisite: BRS 300. Concurrent: BRS
411. Offered: SP

ENGINEERING SCIENCE/DESIGN Requirement (6 credits required)

- AE 308 Introduction to Structural Analysis (4) Prerequisite: EMCH 211, EMCH 213. Offered: FA
AE 470 Residential Building Design and Construction (3) Prerequisite: AE 372 or CE 332. Offered:
FA
CE 340 Structural Analysis (3) Prerequisite: EMCH 213. Prerequisite or concurrent: CMPSC 201 or
CMPSC 202. Offered: FA/SP
CE 341 Design of Concrete Structures (3) Prerequisite: CE 340, Prerequisite or concurrent:
CE 336. Offered: FA/SP
CE 342 Design of Steel Structures (3) Prerequisite: CE 336, CE 340. Offered: FA/SP
CE 410 Sustainable Residential Subdivision Design (3) Prerequisite: AE 372 or CE 332. Offered:
FA
ME 405 Indoor Air Quality Engineering (3) Prerequisite: ME 320 or equivalent. Offered: FA
ME 410 Heat Transfer (3) Prerequisite: ME 320 or BME 409, CMPSC 200 or CMPSC 201,
MATH 220 or NUCE 309. Offered: FA/SP/SU

TECHNICAL SELECTION Requirement (6 credits required)

Any additional 6 credits from the Biological/Agricultural Science or Engineering Science/ Design courses listed above.

**Recommended electives for students in the Agricultural Engineering option desiring to specialize in
MACHINERY SYSTEMS**

(See pages 9-12 for complete listing of approved courses)

BIOLOGICAL ENGINEERING JUNIOR SELECTION (6 credits required)

BE 306* Machines for Agricultural and Biological Processing (3) Prerequisite: E MCH 212; E MCH 210 or E MCH 213. Offered: SP

BIOLOGICAL ENGINEERING Requirement (6 credits required)

BE 461* Design of Fluid Power Systems (3) Prerequisite: BE 306 or ME 360; CE 360 or ME 320. Offered: FA

BE 497 Design Principles for Bio-Mechatronic Systems (3) Prerequisite: BE 305. Offered: SP (being offered with a temporary course number for the first time in Spring 2019, will require a petition until it has a permanent course number)

MATH/BASIC SCIENCE Requirement (3 credits required)

AGRO 28 Principles of Crop Management (3) Prerequisite: 6 credits in biological science. Offered: FA

BIOLOGICAL/AGRICULTURAL SCIENCE Requirement (3 credits required)

AGRO 423* Forage Crop Management (3) Prerequisite: AGRO 28. Offered: FA

AGRO 425* Field Crop Management (3) Prerequisite: AGRO 28. Offered: SP

ASM 320* Combustion Engines for Mobile Equipment (3) Prerequisite: BE 306 or ASM 310 or ME 360. Offered: SP

ASM 420* Principles of Off-Road Machines (3) Prerequisite: BE 306 or ASM 310 or ME 360. Offered: SP

ASM 424* Selection and Management of Agricultural Machinery (3) Prerequisite: BE 306 or ASM 310 or ME 360. Offered: FA

ENGINEERING SCIENCE/DESIGN Requirement (6 credits required)

EDSGN 468 Engineering Design and Analysis with CAD (3) Prerequisite: EMCH 210 or EMCH 211. Offered: FA/SP (only 3 credits can be used toward electives; Solidworks section recommended)

EMCH 315 Mechanical Response of Engineering Materials (2) Prerequisite: EMCH 213, EMCH 210H, or EMCH 210. Offered: FA/SP

EMCH 316 Experimental Determination of Mechanical Response of Materials (1) Prerequisite or concurrent: EMCH 315. Offered: FA/SP

IE 312 Product Design and Manufacturing Processes (3) Prerequisite: EMCH 213, EMCH 210H, or EMCH 210; Prerequisite or concurrent: ESC 414M or MATSE 259. Offered: FA/SP/SU

MATSE 259 Properties and Processing of Engineering Materials (3) Prerequisite: EMCH 213 or EMCH 210. Offered: FA/SP/SU

ME 431* Internal Combustion Engines (3) Prerequisite: ME 302. Offered: SP

ME 450 Modeling of Dynamic Systems (3) Prerequisite: ME 370, ME 345. Offered: FA/SP

ME 456 (IE 456) Industrial Robot Applications (3) Prerequisite: MATH 220; MATH 250 or MATH 251; IE 305 or ME 360; CMPSC 200 or CMPSC 201. Offered: FA

ME 462 Lubrication in Machine Design (3) Prerequisite: MATH 251, ME 360. Offered: FA

TECHNICAL SELECTION Requirement (6 credits required)

Any additional 6 credits from the Biological/Agricultural Science or Engineering Science/Design courses listed above.

*Applies toward Off-Road Equipment Minor (<http://abe.psu.edu/majors/minors/off-road-equipment>).

FOOD AND BIOLOGICAL PROCESSING
ENGINEERING OPTION –

GRADUATION CHECKLIST,
FLOW CHART,
AND SELECTION LISTS

(SEE THE [UNDERGRADUATE BULLETIN](#) FOR SUGGESTED ACADEMIC PLAN)

BIOLOGICAL ENGINEERING GRADUATION CHECKLIST (before SU18)
FOOD AND BIOLOGICAL PROCESSING ENGINEERING OPTION

Student Name _____

Student ID/e-mail _____

Cr. Completed Petition?

Cr. Completed Petition?

First Year Seminar (1 cr)
 _____ 1 _____

Engineering (21 cr)
 EDSGN 100 3 _____

Communications (GWS - 10 cr)
 ENGL 15 3 _____
 CAS 100A/B 3 _____
 BE 391 2 _____
 BE 392 2 _____

EMCH 211 3 _____*

EMCH 212 3 _____*

EMCH 213 3 _____*

ME 300 3 _____*

CE 360 or ME 320 3 _____*

+ IE 424 3 _____

Quantification (GQ - 14 cr)
 MATH 140 4 _____*
 MATH 141 4 _____*
 MATH 231 2 _____
 MATH 251 4 _____*

Biological Engineering (26 cr)
 BE 301 3 _____*
 BE 302 4 _____*
 BE 304 3 _____*
 BE 305 3 _____*
 BE 308 3 _____*
 BE 460 2 _____
 BE 465 3 _____
 BE 466 2 _____
 BE 468 3 _____

Natural Science (GN - 18 cr)
 CHEM 110 3 _____*
 CHEM 111 1 _____
 CHEM 202 3 _____
 PHYS 211 4 _____*
 PHYS 212 4 _____*
 BMB 211 3 _____

Emphasis Technical Electives (6 cr)

Social Science (GS - 6 cr)
 ECON 102, ECON 104, or AGBM 101 3 _____

Engineering Science/Design (6 cr)

Humanities (GH - 6 cr)

Technical Requirement (6 cr)

Art (GA - 6 cr)

Health & Wellness (GHW - 3 cr)
 NUTR 100 1.5 _____

US Cultures (US - 3 cr)
 International Cultures (IL - 3 cr)
 World Language Admissions

+ *STAT 401 only acceptable for IE 424 if 3 cr of technical selections are engineering science/design*

Total required credits for graduation = 129

* courses require C or better

BIOLOGICAL ENGINEERING GRADUATION CHECKLIST (SU18 or later)
FOOD AND BIOLOGICAL PROCESSING ENGINEERING OPTION

Student Name _____

Student ID/e-mail _____

Cr. Completed Petition?
 First Year Seminar (1 cr)

_____ 1 _____

Communications (GWS - 10 cr)

ENGL 15 3 _____*

CAS 100A/B 3 _____*

BE 391 2 _____*

BE 392 2 _____*

Quantification (GQ - 14 cr)

MATH 140 4 _____*

MATH 141 4 _____*

MATH 231 2 _____

MATH 251 4 _____*

Natural Science (GN - 18 cr)

CHEM 110 3 _____*

CHEM 111 1 _____

CHEM 202 3 _____

PHYS 211 4 _____*

PHYS 212 4 _____*

BMB 211 3 _____

Social Science (GS - 6 cr)

single domain ECON 102, ECON 104, or AGBM 101 3 _____

Humanities (GH - 6 cr)

single domain _____

Art (GA - 6 cr)

single domain _____

Health & Wellness (GHW - 3 cr)

single domain NUTR 100 1.5 _____

Cr. Completed Petition?
 Engineering (21 cr)

EDSGN 100 3 _____

EMCH 211 3 _____*

EMCH 212 3 _____*

EMCH 213 3 _____*

ME 300 3 _____*

CE 360 or ME 320 3 _____*

+ IE 424 3 _____

Biological Engineering (26 cr)

BE 301 3 _____*

BE 302 4 _____*

BE 304 3 _____*

BE 305 3 _____*

BE 308 3 _____*

BE 460 2 _____

BE 465 3 _____

BE 466 2 _____

BE 468 3 _____

Emphasis Technical Electives (6 cr)

Engineering Science/Design (6 cr)

Technical Requirement (6 cr)

US Cultures (US - 3 cr)

International Cultures (IL - 3 cr)

Integrative Studies (N,Q,Z - 3 cr)

Integrative Studies (N,Q,Z - 3 cr)

GN, GS, GH, GA, GHW (30 cr)

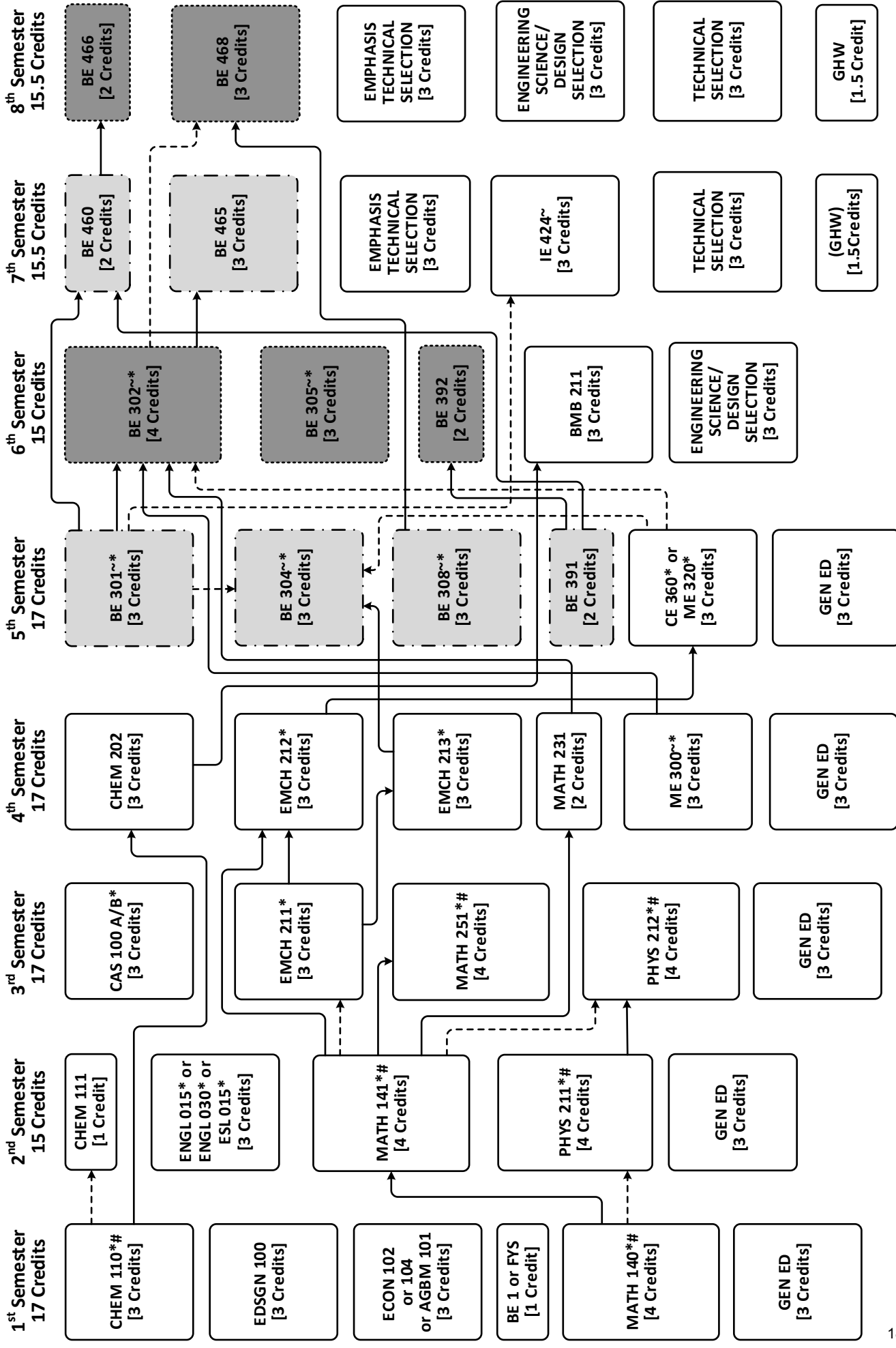
World Language Admissions

Total required credits for graduation = 129

* courses require C or better

+ STAT 401 only acceptable for IE 424 if 3 cr of technical selections are engineering science/design

BIOLOGICAL ENGINEERING [FOOD AND BIOLOGICAL PROCESS OPTION]



18

Course is an Entrance to Major (ETM) requirement
 ~ Prerequisites also includes one or more ETM course
 * Course requires a grade of C or better for the major

Fall Only Courses
 Spring Only Courses

→ = Prerequisite
 -----> = Prerequisite or Concurrent

FOOD AND BIOLOGICAL PROCESS ENGINEERING OPTION SELECTION LISTS

COURSES THAT MEET THE EMPHASIS TECHNICAL ELECTIVES REQUIREMENT *

ANSC 300	Integrated Animal Biology (3) Prerequisite: BIOL 11 and BIOL 12, or BIOL 110; at least third-semester standing. Offered: SP
BE 306	Machines for Agricultural and Biological Processing (3) Prerequisite: EMCH 212; EMCH 210 or EMCH 213. Offered: SP
BMB 212	Elementary Biochemistry Laboratory (1) Prerequisite or concurrent: BMB 211. Offered: FA/SP
BMB 251	(MICRB 251) Molecular and Cell Biology I (3) Prerequisite: CHEM 112. Offered: FA/SP
BMB 428	Physical Chemistry with Biological Applications (3) Prerequisite: CHEM 203 or CHEM 212, PHYS 203 or PHYS 251; 3 credits in cell biology. Offered: FA
BMB 442	Laboratory in Proteins, Nucleic Acids, and Molecular Cloning (3) Prerequisite: BMB 251, BIOL 230W, or MICRB 201; CHEM 202 or CHEM 210. Prerequisite or concurrent: BMB 211 or BMB 401. Offered: FA/SP
BMB 460	(MICRB 460) Cell Growth and Differentiation (3) Prerequisite: BMB 252. Offered: SP
BIOL 110	Biology: Basic Concepts and Biodiversity (4) Offered: FA/SP/SU
BIOL 220W	Biology: Populations and Communities (4) Prerequisite: BIOL 110. Offered: SP
BIOL 222	Genetics (3) Prerequisite: BIOL 110 or MICRB 201 or BIOL 141 or BIOL 133 or BMB 251. Offered: FA
BIOL 230W	Biology: Molecules and Cells (4) Prerequisite: BIOL 110, CHEM 110. Offered: FA
BIOL 240W	Biology: Function and Development of Organisms (4) Prerequisite: BIOL 110, CHEM 110. Offered: SP
BIOL 141	Introductory Physiology (3) Offered: FA/SP/SU
BIOL 142	Physiology Laboratory (1) Prerequisite or concurrent: BIOL 141. Offered: FA19 (for the last time)
BIOL 161	Human Anatomy and Physiology I (3) Offered: FA (<u>only 3 credits from either BIOL 141 or BIOL 161 can be used toward electives</u>)
BIOL 162	Human Anatomy and Physiology I - Laboratory (1) Prerequisite or concurrent: BIOL 161. Offered: FA
BIOL 163	Human Anatomy and Physiology II (3) Prerequisite: BIOL 161. Offered: SP
BIOL 164	Human Anatomy and Physiology II - Laboratory (1) Prerequisite or concurrent: BIOL 163. Offered: SP
BIOTC 416	(MICRB 416) Microbial Biotechnology (2) Prerequisite: MICRB 201, MICRB 202, BMB 442. Offered: FA
BIOTC 459	(HORT 459, BIOL 459) Plant Tissue Culture and Biotechnology (3) Prerequisite: BIOL 230W; or BMB 251, BMB 252. Offered; SP
BIOTC 479	Methods in Biofermentations (3) Prerequisite: MICRB 201, MICRB 202; BMB 251, BMB 252, BMB 442. Offered: FA/SP
BIOTC 489	Animal Cell Culture Methods (3) Prerequisite: MICRB 201, MICRB 202; BIOL 230W or BMB 251. Offered; FA
BME 201	Fundamentals of Cells and Molecules (3) Prerequisite: BIOL 141 or BIOL 240W, CHEM 112, MATH 141. Prerequisite or concurrent: PHYS 212, CMPSC 200. Offered: SP
CHEM 112	Chemical Principles II (3) Prerequisite: CHEM 110 or CHEM 106. Offered: FA/SP/SU
CHEM 113	Experimental Chemistry II (1) Prerequisite: CHEM 111. Prerequisite or concurrent: CHEM 112. Offered: FA/SP
CHEM 203	Fundamentals of Organic Chemistry II (3) Prerequisite: CHEM 202. Offered: FA/SP
FDSC 200	Introductory Food Science (3) Prerequisite: CHEM 110. Offered: SP
FDSC 207	(ANSC 207) Animal Products Technology (2) Offered: FA
FDSC 208	(ANSC 208) Animal Products Technology Laboratory (1) Prerequisite or concurrent: ANSC 207. Offered: FA/SP
FDSC 233	The Science of Winemaking (3) Prerequisite: CHEM 110 or BIOL 110. Offered: SP
FDSC 400	Food Chemistry (4) Prerequisite: CHEM 202. Prerequisite or concurrent: BMB 211, BMB 212, FDSC 200, FDSC 201. Offered: FA

FDSC 404	Sensory Evaluation of Foods (3) Prerequisite: STAT 250, Junior standing. Offered: SP
FDSC 406	Physiology of Nutrition (3) Prerequisite: BMB 211. Prerequisite or concurrent: FDSC 200, FDSC 201. Offered: SP
FDSC 407	Food Toxins (2) Prerequisite: senior standing in food science or related majors. Offered: FA
FDSC 408	Food Microbiology (3) Prerequisite: MICRB 201. Prerequisite or concurrent: FDSC 200, FDSC 201. Offered: FA
FDSC 409	Laboratory in Food Microbiology (2) Prerequisite: MICRB 202, FDSC 200, FDSC 201. Prerequisite or concurrent: FDSC 408. Offered: FA/SP
FDSC 410	Chemical Methods of Food Analysis (3) Prerequisite: BMB 212, FDSC 400. Prerequisite or concurrent: FDSC 200, FDSC 201. Offered: SP
FDSC 411	Managing Food Quality (3) Prerequisite: FDSC 200, FDSC 201, FDSC 408, STAT 250. Offered: FA
FDSC 413	Science and Technology of Plant Foods (3) Prerequisite: FDSC 200, FDSC 201, and at least 2 of the following 400 level courses (FDSC 400, FDSC 405, FDSC 408, FDSC 410). Offered: FA
FDSC 414	Science and Technology of Dairy Foods (3) Prerequisite: FDSC 200, FDSC 201, and at least 2 of the following 400 level courses (FDSC 400, FDSC 405, FDSC 408, FDSC 410). Offered: SP
FDSC 415	Science and Technology of Muscle Foods (3) Prerequisite: FDSC 200, FDSC 201, and at least 2 of the following 400 level courses (FDSC 400, FDSC 405, FDSC 408, FDSC 410). Offered: SP
FDSC 430	Unit Operations in Food Processing (3) Prerequisite: FDSC 400, FDSC 405, FDSC 408
HORT 101	Horticultural Science (3) Offered: FA/SP
HORT 402	Plant Nutrition (3) Prerequisite: HORT 315 or BIOL 441, SOILS 101. Offered: SP
HORT 412	Post-Harvest Physiology (3) Prerequisite: 6 credits in horticulture or other plant sciences. Offered: SP
HORT 420	Plant Growth Regulators (3) Prerequisite: BIOL 110 or HORT 101. Offered: FA

FDSC 405 (Food Engineering Principles) is not accepted as an elective due to overlap in content with engineering fundamentals and B E 465.

COURSES THAT MEET THE ENGINEERING SCIENCE/DESIGN REQUIREMENT*

BE 306	Machines for Agricultural and Biological Processing (3) Prerequisite: EMCH 212; EMCH 210 or EMCH 213. Offered: SP
BE 461	Design of Fluid Power Systems (3) Prerequisite: BE 306 or ME 360; CE 360 or ME 320. Offered: FA
BE 464	Bioenergy Systems Engineering (3) Prerequisite: EME 301, ME 201, ME 300, or CHE 220. Prerequisite or concurrent: BE 308, CHE 340, or CE 479. Offered: FA
BE 477	Land-Based Waste Disposal (3) Prerequisite: BE 307 or CE 370 or ASM 327. Offered: FA
BE 497	Design Principles for Bio-Mechatronic Systems (3) Prerequisite: BE 305. Offered: SP (being offered with a temporary course number for the first time in Spring 2019, will require a petition until it has a permanent course number)
BME 301	Analysis of Physiological Systems (4) Prerequisite: BIOL 141 or BIOL 240W; PHYS 212; MATH 250 or MATH 251; CMPSC 200. Offered: FA
BME 303	Bio-Continuum Mechanics (3) Prerequisite: BIOL 141 or BIOL 240W; EMCH 210 or EMCH 211 and EMCH 213; MATH 230 or MATH 231 and MATH 232; MATH 251. Offered: FA
BME 406	Medical Imaging (3) Prerequisite: PHYS 212; CMPSC 200 or CMPSC 201. Offered: FA
BME 410	Biomedical Applications of Microfluidics (3) Prerequisite: CHEM 112; PHYS 211. Prerequisite or concurrent: BME 303, ME 320, CHE 330, AERSP 308, or PHYS 213. Offered: FA

BME 413	Mass Transport in Biological Systems (3) Prerequisite: BME 313 or ME 300 or ME 302 or CHE 220 or PHYS 213 and MATH 250 or MATH 251 and BIOL 141 or BIOL 240W. Offered: SP
BME 419	Artificial Organs and Prosthetic Devices (3) Prerequisite: BIOL 141 or BIOL 240W or BIOL 472 and CMPSC 200 or CMPSC 201 or CMPSC 121. Offered: SP
BME 423	Reaction Kinetics of Biological Systems (3) Prerequisite: BIOL 141 or BIOL 240W, CHEM 112, MATH 250 or MATH 251, BME 313 or CHE 210 or ME 300. Concurrent or prerequisite: BME 413 or CHE 410 or BE 302. Offered: SP
BME 433	Drug Delivery (3) Prerequisite: CHEM 112; BME 201 or BIOL 230W or BMB 251; BME 413 or BE 302 or CHE 410. Offered: FA
BME 443	(MATSE 403) Biomedical Materials (3) Prerequisite: MATSE 201 or CHEM 112; MATH 230 or MATH 231. Offered: FA
BME 444	(IL) (MATSE 404) Surfaces and the Biological Response to Materials (3) Prerequisite: CHEM 112 or MATSE 112. Offered: SP
BME 445	Tissue Engineering: Concepts, Calculations and Applications (3) Prerequisite: CHEM 112; BME 201, BIOL 230W, or BMB 251; PHYS 211. Offered: FA
BME 446	Polymers in Biomedical Engineering (3) Prerequisite: CHEM 112, CHEM 113, CHEM 202 or CHEM 210, EMCH 210 or EMCH 211 and EMCH 213. Offered: FA
CHE 340	Introduction to Biomolecular Engineering (3) Prerequisite: CHE 210 with "C" or better, BMB 251, CHEM 212. Offered: FA/SP
CHE 449	Bioseparations (3) Prerequisite: CHE 410. Offered: SP
CHE 455	Drug Delivery, Pharmacokinetics, and Artificial Organs (3) Prerequisite: CHE 350, BME 409, BME 413, or BE 302. Recommended Preparation: CHE 410. Offered: SP
CE 370	Introduction to Environmental Engineering (3) Prerequisite: CHEM 110; MATH 111 or MATH 141. Offered: FA/SP/SU
CE 371	Water and Wastewater Treatment (3) Prerequisite: CE 360, CE 370. Offered: FA/SP/SU
EDSGN 452	Projects in Humanitarian Engineering (2) Prerequisite: 5 th semester standing. Concurrent: EDSGN 453. Offered: SP
EDSGN 453	Design for Developing Communities (1) Prerequisite: 5 th semester standing. Offered: SP
EDSGN 468	Engineering Design and Analysis with CAD (3) Prerequisite: EMCH 210 or EMCH 211. Offered: FA/SP (only 3 credits can be used toward electives)
ENVSE 400	Safety Engineering (3) Prerequisite: CHEM 110, PHYS 211, MATH 141. Offered: FA
IE 312	Product Design and Manufacturing Processes (3) Prerequisite: EMCH 213, EMCH 210H, or EMCH 210; Prerequisite or concurrent: ESC 414M or MATSE 259. Offered: FA/SP/SU
IE 327	Introduction to Work Design (3) Prerequisite: MATH 141; Prerequisite or concurrent: EMCH 211 or E MCH 210. Offered: FA/SP/SU
IE 405	Deterministic Models in Operations Research (3) Prerequisite: MATH 220. Offered: FA/SP/SU
IE 425	Stochastic Models in Operations Research (3) Prerequisite: MATH 220 and IE 322. Concurrent: IE 405. Offered: FA/SP/SU
IE 467	Facility Layout and Location (3) Prerequisite: IE 322, IE 405. Offered: SP
ME 410	Heat Transfer (3) Prerequisite: ME 320 or BME 409, CMPSC 200 or CMPSC 201, MATH 220 or NUCE 309. Offered: FA/SP/SU
ME 411	Heat-Exchanger Design (3) Prerequisite: ME 410. Offered: SP
ME 420	Compressible Flow I (3) Prerequisite: ME 320. Offered: SP

FBP students with an interest in careers in food or pharmaceutical manufacturing are strongly encouraged to consider the Six Sigma minor. See section on "Minors" (page 38) for how Six Sigma minor courses can be petitioned as electives.

COURSES THAT MEET THE TECHNICAL SELECTION REQUIREMENT*

Any course acceptable as Engineering/Science Design or Emphasis Technical Elective may be taken as a Technical Selection, plus CMPSC 121, CMPSC 131, CMPSC 200, CMPSC 201, ENGR 310, ENGR 407, ENGR 408, ENGR 451, ENGR 455, ERM 402, MATH 220 and MGMT 215.

*Other courses may be taken to meet the engineering science/design, biological/agricultural science, and technical requirements if the student submits a petition approved by the Department of Agricultural and Biological Engineering. All petitions must be submitted and approved prior to the student's graduation semester, however earlier is preferred to ensure adequate progress towards completing degree requirements.

**Recommended electives for students in the Food and Biological Process Engineering option
desiring to specialize in BIOLOGICAL PROCESS ENGINEERING**

(See pages 19-22 for complete listing of approved courses)

EMPHASIS TECHNICAL ELECTIVE Requirement (6 credits required)

BIOL 141	Introductory Physiology (3) Offered: FA/SP/SU
BMB 251*	(MICRB 251) Molecular and Cell Biology I (3) Prerequisite: CHEM 112. Offered: FA/SP
BMB 442	Laboratory in Proteins, Nucleic Acids, and Molecular Cloning (3) Prerequisite: BMB 251, BIOL 230W, or MICRB 201; CHEM 202 or CHEM 210. Prerequisite or concurrent: BMB 211 or BMB 401. Offered: FA/SP
BIOL 110	Biology: Basic Concepts and Biodiversity (4) Offered: FA/SP/SU
BIOL 230W*	Biology: Molecules and Cells (4) Prerequisite: BIOL 110, CHEM 110. Offered: FA
BIOTC 416	(MICRB 416) Microbial Biotechnology (2) Prerequisite: MICRB 201, MICRB 202, BMB 442. Offered: FA
BIOTC 459	(HORT 459, BIOL 459) Plant Tissue Culture and Biotechnology (3) Prerequisite: BIOL 230W; or BMB 251, BMB 252. Offered; SP
BIOTC 479	Methods in Biofermentations (3) Prerequisite: MICRB 201, MICRB 202; BMB 251, BMB 252, BMB 442. Offered: FA/SP
BIOTC 489	Animal Cell Culture Methods (3) Prerequisite: MICRB 201, MICRB 202; BIOL 230W or BMB 251. Offered; FA
BME 201*	Fundamentals of Cells and Molecules (3) Prerequisite: BIOL 141 or BIOL 240W; CHEM 112; MATH 141. Prerequisite or concurrent: PHYS 212; CMPSC 200. Offered: SP
CHEM 112	Chemical Principles II (3) Prerequisite: CHEM 110 or CHEM 106. Offered: FA/SP/SU

ENGINEERING SCIENCE/DESIGN Requirement (6 credits required)

BE 464	Bioenergy Systems Engineering (3) Prerequisite: EME 301, ME 201, ME 300, or CHE 220. Prerequisite or concurrent: BE 308, CHE 340, or CE 479. Offered: FA
BME 413	Mass Transport in Biological Systems (3) Prerequisite: BME 313 or ME 300 or ME 302 or CHE 220 or PHYS 213 and MATH 250 or MATH 251 and BIOL 141 or BIOL 240W. Offered: SP
BME 423	Reaction Kinetics of Biological Systems (3) Prerequisite: BIOL 141 or BIOL 240W, CHEM 112, MATH 250 or MATH 251, BME 313 or CHE 210 or ME 300. Concurrent or prerequisite: BME 413 or CHE 410 or BE 302. Offered: SP
BME 433	Drug Delivery (3) Prerequisite: CHEM 112; BME 201 or BIOL 230W or BMB 251; BME 413 or BE 302 or CHE 410. Offered: FA
CHE 340	Introduction to Biomolecular Engineering (3) Prerequisite: CHE 210 with "C" or better, BMB 251, CHEM 212. Offered: FA/SP
CHE 449	Bioseparations (3) Prerequisite: CHE 410. Offered: SP
CHE 455	Drug Delivery, Pharmacokinetics, and Artificial Organs (3) Prerequisite: CHE 350, BME 409, BME 413, or BE 302. Recommended Preparation: CHE 410. Offered: SP

TECHNICAL SELECTION Requirement (6 credits required)

Any additional 6 credits from the Emphasis Technical Elective or Engineering Science/Design courses listed above.

*BMB 251, BME 201, or BIOL 230W can be petitioned as substitute for BMB 211

Recommended electives for students in the Food and Biological Process Engineering option desiring to specialize in **FOOD PROCESS ENGINEERING**

(See pages 19-22 for complete listing of approved courses)

EMPHASIS TECHNICAL ELECTIVE Requirement (6 credits required)

BE 306	Machines for Agricultural and Biological Processing (3) Prerequisite: EMCH 212; EMCH 210 or EMCH 213. Offered: SP
FDSC 400	Food Chemistry (4) Prerequisite: CHEM 202. Prerequisite or concurrent: BMB 211, BMB 212, FDSC 200, FDSC 201. Offered: FA
FDSC 408	Food Microbiology (3) Prerequisite: MICRB 201. Prerequisite or concurrent: FDSC 200, FDSC 201. Offered: FA
FDSC 409	Laboratory in Food Microbiology (2) Prerequisite: MICRB 202, FDSC 200, FDSC 201. Prerequisite or concurrent: FDSC 408. Offered: FA/SP
FDSC 411	Managing Food Quality (3) Prerequisite: FDSC 200, FDSC 201, FDSC 408, STAT 250. Offered: FA
HORT 101	Horticultural Science (3) Offered: FA/SP
HORT 412	Post-Harvest Physiology (3) Prerequisite: 6 credits in horticulture or other plant sciences. Offered: SP

ENGINEERING SCIENCE/DESIGN Requirement (6 credits required)

BE 306	Machines for Agricultural and Biological Processing (3) Prerequisite: EMCH 212; EMCH 210 or EMCH 213. Offered: SP
BE 461	Design of Fluid Power Systems (3) Prerequisite: BE 306 or ME 360; CE 360 or ME 320. Offered: FA
BE 464	Bioenergy Systems Engineering (3) Prerequisite: EME 301, ME 201, ME 300, or CHE 220. Prerequisite or concurrent: BE 308, CHE 340, or CE 479. Offered: FA13
BE 497	Design Principles for Bio-Mechatronic Systems (3) Prerequisite: BE 305. Offered: SP (being offered with a temporary course number for the first time in Spring 2019, will require a petition until it has a permanent course number)
CHE 449	Bioseparations (3) Prerequisite: CHE 410. Offered: SP
ENVSE 400	Safety Engineering (3) Prerequisite: CHEM 110, PHYS 211, MATH 141. Offered: FA
IE 405	Deterministic Models in Operations Research (3) Prerequisite: MATH 220. Offered: FA/SP/SU
IE 425	Stochastic Models in Operations Research (3) Prerequisite: MATH 220 and IE 322. Concurrent: IE 405. Offered: FA/SP/SU
ME 410	Heat Transfer (3) Prerequisite: ME 320 or BME 409, CMPSC 200 or CMPSC 201, MATH 220 or NUCE 309. Offered: FA/SP/SU
ME 411	Heat-Exchanger Design (3) Prerequisite: ME 410. Offered: SP

TECHNICAL SELECTION Requirement (6 credits required)

Any additional 6 credits from the Emphasis Technical Elective or Engineering Science/Design courses listed above.

NATURAL RESOURCES ENGINEERING OPTION –

GRADUATION CHECKLIST, **FLOW CHART,** **AND SELECTION LISTS**

(SEE THE [UNDERGRADUATE BULLETIN](#) FOR SUGGESTED ACADEMIC PLAN)

BIOLOGICAL ENGINEERING GRADUATION CHECKLIST (before SU18)
NATURAL RESOURCES ENGINEERING OPTION

Student Name _____

Student ID/e-mail _____

First Year Seminar (1 cr)
 _____ Cr. Completed _____ Petition?

_____ 1 _____

Communications (GWS - 10 cr)

ENGL 15 3 _____

CAS 100A/B 3 _____

BE 391 2 _____

BE 392 2 _____

Quantification (GQ - 14 cr)

MATH 140 4 _____*

MATH 141 4 _____*

MATH 231 2 _____

MATH 251 4 _____*

Natural Science (GN - 15 cr)

CHEM 110 3 _____*

CHEM 111 1 _____

PHYS 211 4 _____*

PHYS 212 4 _____*

SOILS 101 3 _____

Social Science (GS - 6 cr)

ECON 102, ECON 104, or AGBM 101 3 _____

Humanities (GH - 6 cr)

Art (GA - 6 cr)

US Cultures (US - 3 cr)

International Cultures (IL - 3 cr)

World Language Admissions

Engineering (21 cr)
 _____ Cr. Completed _____ Petition?

EDSGN 100 3 _____

EMCH 211 3 _____*

EMCH 212 3 _____*

EMCH 213 3 _____*

ME 300 3 _____*

CE 360 3 _____*

IE 424 or STAT 401 3 _____

Biological Engineering (35 cr)

ASM 309 3 _____*

BE 301 3 _____*

BE 302 4 _____*

BE 304 3 _____*

BE 305 3 _____*

BE 307 3 _____*

BE 308 3 _____*

BE 460 2 _____

BE 466 2 _____

BE 467 3 _____

BE 477 3 _____

BE 487 3 _____

Biological/Environmental Science (3)

Engineering Science/Design (6 cr)

Technical Requirement (3 cr)

Health & Wellness (GHW - 3 cr)

Total required credits for graduation = 129

* courses require C or better

BIOLOGICAL ENGINEERING GRADUATION CHECKLIST (SU18 or later)
NATURAL RESOURCES ENGINEERING OPTION

Student Name _____

Student ID/e-mail _____

Cr. Completed Petition?
 First Year Seminar (1 cr)

_____ 1 _____

Communications (GWS - 10 cr)

ENGL 15 3 _____ *
 CAS 100A/B 3 _____ *
 BE 391 2 _____ *
 BE 392 2 _____ *

Quantification (GQ - 14 cr)

MATH 140 4 _____ *
 MATH 141 4 _____ *
 MATH 231 2 _____
 MATH 251 4 _____ *

Natural Science (GN - 15 cr)

CHEM 110 3 _____ *
 CHEM 111 1 _____
 PHYS 211 4 _____ *
 PHYS 212 4 _____ *
 SOILS 101 3 _____

Social Science (GS - 6 cr)

single domain ECON 102, ECON
 104, or AGBM 101 3 _____

Humanities (GH - 6 cr)

single domain _____ 3 _____

Art (GA - 6 cr)

single domain _____ 3 _____

Health & Wellness (GHW - 3 cr)

single domain _____ _____

Cr. Completed Petition?
 Engineering (21 cr)

EDSGN 100 3 _____

EMCH 211 3 _____ *

EMCH 212 3 _____ *

EMCH 213 3 _____ *

ME 300 3 _____ *

CE 360 3 _____ *

IE 424 or STAT 401 3 _____

Biological Engineering (35 cr)

ASM 309 3 _____ *

BE 301 3 _____ *

BE 302 4 _____ *

BE 304 3 _____ *

BE 305 3 _____ *

BE 307 3 _____ *

BE 308 3 _____ *

BE 460 2 _____

BE 466 2 _____

BE 467 3 _____

BE 477 3 _____

BE 487 3 _____

Biological/Environmental Science (3 cr)

Engineering Science/Design (6 cr)

Technical Requirement (3 cr)

US Cultures (US - 3 cr)

International Cultures (IL - 3 cr)

Integrative Studies (N,Q,Z - 3 cr)

Integrative Studies (N,Q,Z - 3 cr)

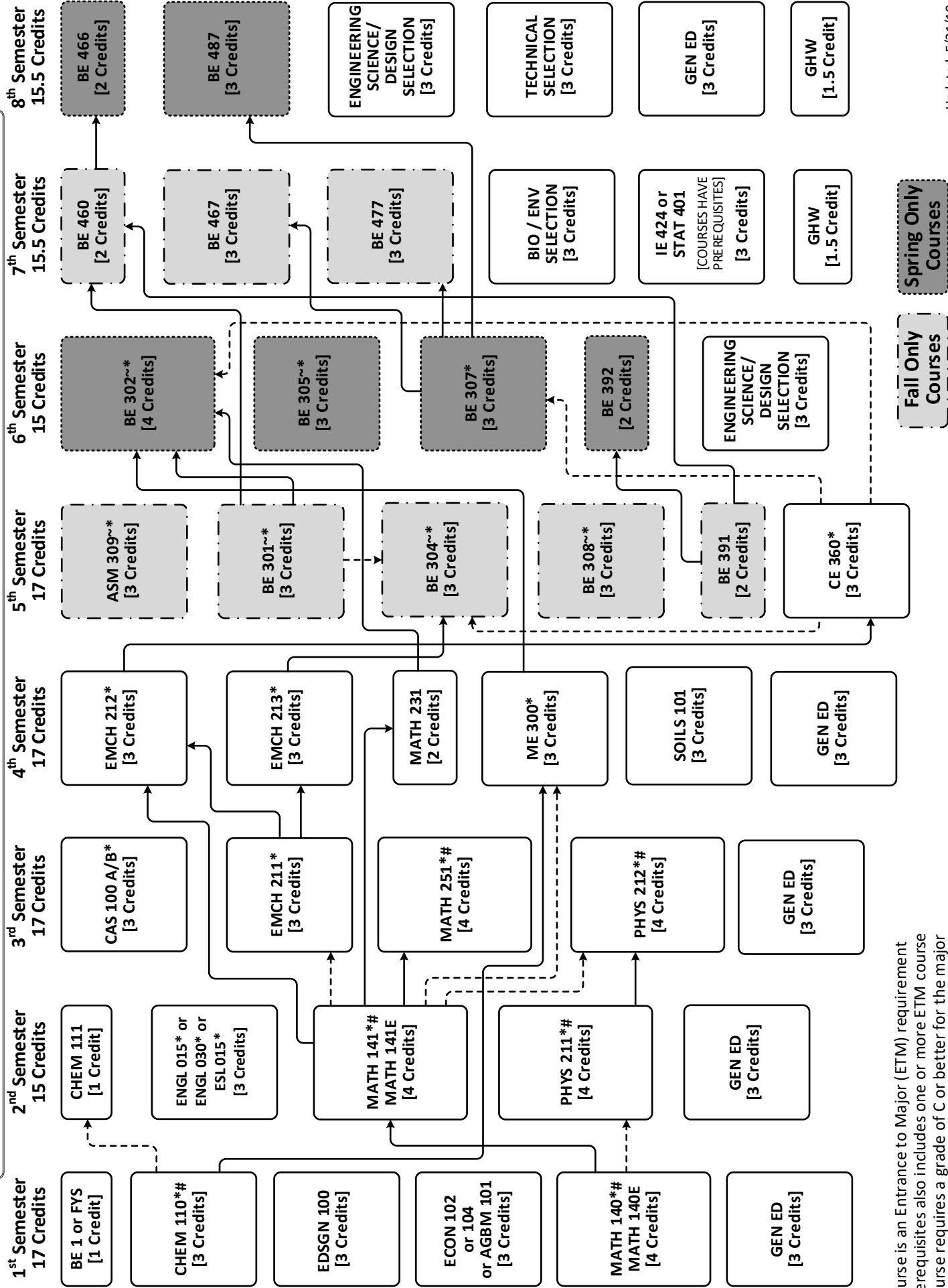
GN, GS, GH, GA, GHW (30 cr)

World Language Admissions

Total required credits for graduation = 129

* courses require C or better

BIOLOGICAL ENGINEERING [NATURAL RESOURCE OPTION]



Course is an Entrance to Major (ETM) requirement
 ~ Prerequisites also includes one or more ETM course
 * Course requires a grade of C or better for the major
 -----> = Prerequisite or Concurrent

NATURAL RESOURCES ENGINEERING OPTION SELECTION LISTS

COURSES THAT MEET THE BIOLOGICAL/ENVIRONMENTAL SCIENCE REQUIREMENT +

AGRO 28	Principles of Crop Management (3) Prerequisite: 6 credits in biological science. Offered: FA
BIOL 110	Biology: Basic Concepts and Biodiversity (4) Offered: FA/SP/SU
BIOL 220W	Biology: Populations and Communities (4) Prerequisite: BIOL 110. Offered: SP
BIOL 240W	Biology: Function and Development of Organisms (4) Prerequisite: BIOL 110, CHEM 110. Offered: SP
CE 370	Introduction to Environmental Engineering (3) Prerequisite: CHEM 110; MATH 111 or MATH 141. Offered: FA/SP/SU
ENT 425	Freshwater Entomology (3) Offered: FA
ERM 402	Foundations of Sustainable Business (3) Prerequisite: AGBM 101 or ECON 102 or ECON 104. Offered: FA
ERM 411	Legal Aspects of Resource Management (3) Prerequisite: ECON 102 or AGBM 101. Prerequisite or concurrent: ERM 151, CED 152, or EBF 200. Offered: FA
ERM 435	(WFS 435) Limnology (3) Prerequisite: BIOL 110, BIOL 220W, CHEM 110. Offered: FA
ERM 447	Stream Restoration (3) Prerequisite: ASM 327 or BE 307 or CE 461. Offered: FA
ERM 448	Rural Road Ecology and Maintenance (3) Prerequisite: MATH 140. Prerequisite or concurrent: BE 307 or CE 370. Offered: FA
ERM 449	Sustainable Water Management: Economics and Policy (3) Prerequisite: MATH 22 or MATH 110 or MATH 140; AGBM 101 or ECON 102. Recommended Preparation: CED 201 or EBF 200. Offered: SP
ERM 450	(WFS 450) Wetland Conservation (3) Prerequisite: ERM 300 or WFS 209. Offered: FA
FOR 203	Field Dendrology (3) Concurrent: FOR 200W or WP 200W and WP 203. Offered: FA
FOR 455	Remote Sensing and Spatial Data Handling (3) Prerequisite: MATH 110, 3 credits in computer science, 6 credits in ecological and/or geological sciences. Offered: SP
GEOSC 1	Physical Geology (3) Offered; FA/SP
GEOSC 452	Hydrogeology (3) Prerequisite: CHEM 112; GEOSC 1, GEOSC 20 or GEOSC 71; MATH 140 or MATH 110. Offered: FA/SP
HORT 101	Horticultural Science (3) Offered: FA/SP
HORT 131	Herbaceous Perennial and Annual Identification (3) Prerequisite: BIOL 127, BIOL 110 or HORT 101. Offered: FA
PLANT 426	Nutrient Management Specialist Preparation (1) Prerequisite: SOILS 101 and SOILS 102. Offered: FA
SOILS 102	Introductory Soil Science Laboratory (1) Prerequisite or concurrent: SOILS 101. Offered: FA/SP
SOILS 401	Soil Composition and Physical Properties (3) Prerequisite: SOILS 101. Offered: SP
SOILS 402	Soil Nutrient Behavior and Management (3) Prerequisite: CHEM 112, SOILS 101. Offered: SP
SOILS 404	Urban Soils (3) Prerequisite: SOILS 101. Offered: SP
SOILS 405	(GEOSC 405) Hydropedology (3) Prerequisite: SOILS 101. Offered: FA
SOILS 416	Soil Genesis, Classification, and Mapping (4) Prerequisite: SOILS 101. Offered: FA
SOILS 418	(AGECO 418, AN SC 418) Nutrient Management in Agricultural Systems (3) Prerequisite: BIOL 110 or (BIOL 11 and BIOL 12) or BISC 3. Offered: FA
SOILS 420	Remediation of Contaminated Soils (3) Prerequisite: SOILS 101. Offered: FA
SOILS 450	Environmental Geographic Information Systems (3) Prerequisite: SOILS 101. Offered: FA

COURSES THAT MEET THE ENGINEERING SCIENCE/DESIGN REQUIREMENT +

AE 444	Micro CADD Applications for Buildings (3) Prerequisite: AE 222; CMPSC 201 or CMPSC 202. Offered: FA/SP
BE 303	Structural Systems in Agriculture (3) Prerequisite: EMCH 210 or EMCH 213. Offered: SP

BE 462	Design of Wood Structures (3) Prerequisite: BE 303, AE 308, or CE 340. Offered: FA
BE 464	Bioenergy Systems Engineering (3) Prerequisite: EME 301, ME 201, ME 300, or CHE 220. Prerequisite or concurrent: BE 308, CHE 340, or CE 479. Offered: FA
BE 468	Microbiological Engineering (3) Prerequisite: BE 308 or both MICRB 201 and BMB 211 Prerequisite or concurrent: BE 302. Offered: SP
CE 310	Surveying (3) Prerequisite: EDSGN 100, MATH 141. Offered: FA/SP
CE 335	Engineering Mechanics of Soils (3) Prerequisite: EMCH 213; AE 221 or GEOSC 1. Offered: FA/SP
CE 340	Structural Analysis (3) Prerequisite: EMCH 213. Prerequisite or concurrent: CMPSC 201 or CMPSC 202. Offered: FA/SP
CE 370	Introduction to Environmental Engineering (3) Prerequisite: CHEM 110; MATH 111 or MATH 141. Offered: FA/SP/SU
CE 371	Water and Wastewater Treatment (3) Prerequisite: CE 360, CE 370. Offered: FA/SP/SU
CE 410	Sustainable Residential Subdivision Design (3) Prerequisite: AE 372 or CE 332. Offered: FA
CE 461	Water-resource Engineering (3) Prerequisite: CE 360. Offered: FA/SP
CE 462	Open Channel Hydraulics (3) Prerequisite: E 360. Offered FA/SP
CE 465	Water Resources Capstone Course (3) Prerequisite: CE 461. Prerequisite or concurrent: CE 462. Offered: SP
CE 472	Environmental Engineering Capstone Design (3) Prerequisite: CE 370, CE 371. Offered: SP
CE 475	Water Quality Chemistry (4) Prerequisite: CE 370, CHEM 110, CHEM 111. Offered: SP
CE 476	Solid and Hazardous Wastes (3) Prerequisite: CE 370, CE 371. Offered: SP
EDSGN 452	Projects in Humanitarian Engineering (2) Prerequisite: 5 th semester standing. Concurrent: EDSGN 453. Offered: SP
EDSGN 453	Design for Developing Communities (1) Prerequisite: 5 th semester standing. Offered: SP
EDSGN 468	Engineering Design and Analysis with CAD (3) Prerequisite: EMCH 210 or EMCH 211. Offered: FA/SP (only 3 credits can be used toward electives; AutoCAD section recommended)

NRE students are strongly encouraged to take EDSGN 468 as an Engineering Science/Design or Technical Selection (look for AutoCAD section, taught by Benjamin Fehl). Students interested in learning AutoCAD Civil 3D should also consider taking CE 410 as an Engineering Science/Design or Technical Selection.

COURSES THAT MEET THE TECHNICAL SELECTION REQUIREMENT *

Any course acceptable as Engineering/Science Design or Biological/Environmental Science may be taken as a Technical Selection, plus CHEM 112, CHEM 202, CMPSC 121, CMPSC 131, CMPSC 200, CMPSC 201, ENGR 310, ENGR 407, ENGR 408, ENGR 451, ENGR 455, MATH 220, and MGMT 215

*Other courses may be taken to meet the engineering science/design, biological/agricultural science, and technical requirements if the student submits a petition approved by the Department of Agricultural and Biological Engineering. All petitions must be submitted and approved prior to the student's graduation semester, however earlier is preferred to ensure adequate progress towards completing degree requirements.

General Education

Two sets of degree checklists are provided in this handbook based on General Education requirements – checklists for students who started at Penn State prior to summer 2018 and checklists for students who started in summer 2018 or later. For details on General Education requirements for students starting summer 2018 or later, please refer to the Undergraduate Bulletin (<http://undergraduate.bulletins.psu.edu/undergraduate/general-education/baccalaureate-degree-general-education-program/>) and the General Education Planning Tool (<https://genedplan.psu.edu>). Students who started prior to summer 2018 should refer to the Bulletin Archive for details on General Education requirements (<https://bulletins.psu.edu/undergraduate/archive/>).

Diversity, Equity, and Inclusion in General Education

It is well documented that diversity enhances excellence and innovation. Teams that include thinkers of different backgrounds outperform homogeneous groups on complex tasks, including improved problem-solving, increased innovation and more accurate predictions¹⁻³. There is also a statistically significant correlation between a more diverse leadership team and financial performance⁴. We encourage Biological Engineering majors to take courses which broaden exposure to ways of thinking and how to understand diverse perspectives to open possibilities for meaningful communication across social boundaries.

Following is a selection of courses that 1) are directly related to topics of diversity, equity, and inclusion, including a historical perspective of structural racism and challenges to it can increase awareness and inclusiveness and 2) will fulfill general education requirements not prescribed by the BE major.

Course Number	Course Title	General Education Attributes
AFAM 100	Black Freedom Struggles	US, GS
AFAM 105N	Afro-Latin America: Race and Revolution	IL, GH, GS, Interdomain
AFAM 152	African American History	US, GH
AFAM 114N	Race, Gender, and Sport	US, GH, GS, Interdomain
AFAM 136/ LER 136/ WMNST 303	Race, Gender, and Employment	US, GS
SOC 119	Race and Ethnic Relations	US, GS
CMLIT 101	Race, Gender, and Identity in World Literature	IL, US, GH
PHIL 9	Race, Racism, and Diversity	US, GH
AED 225	Diversity, Pedagogy, and Visual Culture	US, GA
ANTH 45N	Cultural Diversity: A Global Perspective	IL, US, GH, GS, Interdomain
WMNST 105N	Living in a Diverse World	US, GH, GS, Interdomain

¹Page SE, Lewis E, Cantor N. *The diversity bonus: how great teams pay off in the knowledge economy*. Princeton, NJ: Princeton University Press, 2017.

²Freeman RB, Huang W. Collaboration: strength in diversity. *Nature* 2014; 513:305.

³AlShebli BK, Rahwan T, Woon WL. The preeminence of ethnic diversity in scientific collaboration. *Nat Commun* 2018; 9:5163.

⁴Hunt, V., Layton, D. and Prince, S., 2015. Diversity matters. McKinsey & Company, 1(1), pp.15-29.

Reserve Officers' Training Corps (ROTC) Credits

Students who complete the courses required to remain in the ROTC program can use six ROTC credits toward degree requirements. At the completion of the ROTC program, students can substitute 3 ROTC credits for the General Education – Health and Wellness (GHW) requirement and 3 ROTC credits for a technical selection.

Registering for Courses Under Departmental Control

If you wish to register for a course and can not because the course is under Departmental Control, please consider the following procedures. These procedures should be supervised by your academic advisor, who may assist your efforts. Presently, most of these courses are in the CE, BME, CHE, IE, and ME Departments, but others may also apply. These are generally over-enrolled majors where classes are large and often over subscribed.

1. If the course is a required course (not an elective or selection), you should contact the scheduling officer in the department offering the controlled course. The department scheduling office will generally honor the request; assuming there is actually room left in the section. The Registrar maintains a list of department contacts for scheduling (<http://www.registrar.psu.edu/departments/index.cfm#universitypark>).
2. If this does not work, or the course is an elective, continue trying to register for the course until the first day of classes. BME typically maintains a wait list for full or controlled classes and you can contact the scheduling officer to be added to the list. CE follows a similar procedure for classes like CE 370. Other departments (such as CE, ME, and IE) will often add you to a controlled class, if there is space and you have the listed or equivalent prerequisites, after their students have completed registration.
3. If by the first day of classes you have not been able to register for the restricted course, go to and sit through the first class of the course. At the end of this first class period, politely ask the instructor if there is room and may you please be added to the course. [In almost every case, this has resulted in the student being added to the class, if there was room in the section.]

Course Descriptions in Biological Engineering

BE 301 MATHEMATICAL MODELING OF BIOLOGICAL AND PHYSICAL SYSTEMS (3) Modeling tools, quantification of processes, linear and non-linear systems of equations, numerical methods, matrix operations, applied to bio-physical systems. Prerequisite: MATH 250 or 251. Offered each **Fall** Semester.

BE 302 HEAT AND MASS TRANSFER IN BIOLOGICAL SYSTEMS (4) Engineering applications of the fundamentals of heat and mass transfer to natural and engineered biological systems. Prerequisite: BE 301 and (MATH 251 or (MATH 250 and MATH 252)) and (ME 201 or ME 300 or CHE 220 or EMCH 302H). Concurrent: CE 360 or ME 320. Offered each **Spring** Semester.

BE 303 STRUCTURAL SYSTEMS IN AGRICULTURE (3) Engineering analysis and design of structural systems in agriculture. Topics: reliability, loads, components and system design. Prerequisite: E MCH 210 or E MCH 213. Offered each **Spring** Semester.

BE 304 ENGINEERING PROPERTIES OF FOOD AND BIOLOGICAL MATERIALS (3) Composition, structure, and properties relationships. Measurement of mechanical, thermal, chemical, and biological properties, their variability, and use in engineering calculations. Prerequisite: (E MCH 210 or E MCH 213). Concurrent: BE 301 and (CE 360 or ME 320) and (MATH 251 or MATH 252). Offered each **Fall** Semester.

BE 305 AGRICULTURAL MEASUREMENTS AND CONTROL SYSTEMS (3) Principles of measurements, instruments, controls, and data acquisition systems, with emphasis on agricultural applications. Prerequisite: PHYS 212. Offered each **Spring** Semester.

BE 306 MACHINES FOR AGRICULTURAL AND BIOLOGICAL PROCESSING (3) Application of engines, motors, and power transmission systems to agricultural production and processing machinery. Functional design and analysis of equipment. Prerequisite: EMCH 212 and (EMCH 210 or EMCH 213). Offered each **Spring** Semester.

BE 307 PRINCIPLES OF SOIL AND WATER ENGINEERING (3) Utilization and engineering of soil-water resources; including rainfall-runoff, soil-water movement, erosion/sediment transport and flow processes. Concurrent: CE 360 or ME 320. Offered each **Spring** Semester.

BE 308 ENGINEERING ELEMENTS BIOCHEMISTRY AND MICROBIOLOGY (3) Introduction of basic biochemistry and microbiology as well as industrial and environmental applications. Prerequisite: CHEM 110. Offered each **Fall** Semester.

BE 391 COMMUNICATION SKILLS FOR BE AND BRS STUDENTS (2) To develop corporate communication skills in technically focused students in a contextual manner. Prerequisite: 5th semester standing or higher. Offered each **Fall** Semester.

BE 392 LEADERSHIP SKILLS FOR BE AND BRS STUDENTS (2) To develop corporate leadership skills in technically focused students in a contextual manner. Prerequisite: 5th semester standing or higher. Offered each **Spring** Semester.

BE 460W BIOLOGICAL ENGINEERING DESIGN I (2) Part one of a two course sequence; culminating design experience with projects in agricultural, food and biological processing, and natural resource engineering. Prerequisite: (BE 391 or BRS 391 or ENGL 202C) and (at least 9 credits in BE) and (7th semester standing or higher). Offered each **Fall** Semester.

BE 461 DESIGN OF FLUID POWER SYSTEMS (3) Hydraulic power systems, hydrostatic transmission, and electro-hydraulic control systems with applications in agricultural production and processing systems; integrated design projects. Prerequisite: (BE 306 or ME 360), (CE 360 or ME 320). Offered each **Fall** Semester.

BE 462 DESIGN OF WOOD STRUCTURES (3) Structural properties of wood; design of wood structural elements; design of wood systems; design of post-frame buildings. Prerequisite: AE 308 or BE 303 or CE 340. Offered each **Fall** Semester.

BE 463 DESIGN PRINCIPLES OF MECHATRONICS FOR BIOSYSTEMS (3) Application of mechatronic systems, such as controllers, sensors, and actuators, to agricultural and biological systems. Prerequisite: BE 305 or EE 210 or EE 211 or EE 212. Offered each **Spring** Semester.

BE 464 BIOENERGY SYSTEMS ENGINEERING (3) Fundamental theories and applied technologies for production and conversion of biomass into energy and co-products. Prerequisite: EME 301 or ME 201 or ME 300 or CHE 220. Prerequisite or concurrent: BE 308 or CHE 340 or CE 479. Offered each **Spring** Semester.

BE 465 FOOD AND BIOLOGICAL PROCESS ENGINEERING (3) Reactor design, kinetics, fluid flow, thermal processes, and other topics applied to the design of systems for the food and biological process industry. Prerequisite: BE 302. Offered each **Fall** Semester.

BE 466W BIOLOGICAL ENGINEERING DESIGN II (2) Part two of a two course sequence; culminating design experience with projects in agricultural, food and biological processing, and natural resource engineering. Satisfies writing across the curriculum requirement. Prerequisite: BE 460W. Offered each **Spring** Semester.

BE 467 DESIGN OF STORMWATER AND EROSION CONTROL FACILITIES (3) Design of best management practices for stormwater management, erosion and sediment control as applied to the agriculture-urban interface. Prerequisite: BE 307 or CE 461. Offered each **Fall** Semester.

BE 468 MICROBIOLOGICAL ENGINEERING (3) Application of basic engineering principles and designs in biochemical and biological processes. Prerequisite: BE 308 or (MICRB 201 and BMB 211). Concurrent: BE 302. Offered each **Spring** Semester.

BE 477 LAND-BASED WASTE DISPOSAL (3) Analysis, design, and management of land-based systems for recycling and disposal of municipal, industrial, and agricultural wastes. Prerequisite: BE 307 or CE 370. Offered each **Fall** Semester.

BE 487 SIMULATION MODELING FOR WATER RESOURCES MANAGEMENT (3) Application of common simulation models to investigate water resources-related issues. Prerequisite: BE 307 or CE 461. Offered each **Spring** Semester.

BE 495 BIOLOGICAL ENGINEERING INTERNSHIP (1-6) Independent study and supervised cooperative education experience related to the student's career objective.

BE 496 INDEPENDENT STUDIES (1-18)

Any senior with a 3.50 grade-point average or a Schreyer's Honor Scholar may be admitted to 500-level courses with the consent of the instructor and Graduate Enrollment Services; other seniors with a B average or better may be admitted to graduate courses with the consent of the instructor, the student's academic advisor, and Graduate Enrollment Services. The form for this request is available here: <https://gradschool.psu.edu/forms-and-documents/ges-owned-forms-and-documents/undergraduate-500-or-800-level-courses/>

Minors and Certificates

A minor or certificate is a good way to focus elective selections in a particular specialization area. A minor can be declared after a student reaches third semester standing or has been accepted into a major. In order to successfully complete a minor, a **C or better** must be earned in every class that counts for the minor. Furthermore, as stated in policy 59-10, **at least six credits of the minor must be unique from the Prescribed Courses required by the student's major program(s)**. In other words, as long as at least six credits of courses being used for a minor are in Additional or Supporting Courses for the major, this policy is satisfied (e.g., Engineering Science/Design Electives, Technical Selections, Biological/Environmental Science Elective, Biological/Agricultural Science Elective, Emphasis Technical Electives).

ENVIRONMENTAL ENGINEERING MINOR

The Environmental Engineering Minor is designed to provide students in engineering, science and other majors with a comprehensive study of environmental issues and the skills to solve problems associated with environmental pollution. For entrance into this minor, students must have completed CHEM 110, MATH 141, and PHYS 211 with a C or higher in each course and have a minimum GPA of 2.0.

Requirements for the Minor: The minor consists of 18 credits, at least 6 of which must be at the 400 level. A grade of C or better is required in all courses in the minor.

Introduction to Environmental Engineering (3 credits) CE 370(3)

Chemistry & Biological Sciences (Select 3 credits)

BE 308 (3), CE 479(3), CHEM 202(3), CHEM 210(3)

Process Engineering (Select 0-3 credits)

BE 302 (4), CHE 210(3), EGEE 302(3), MNPR 301(3), NUCE 430(3)

Applied Fluid Mechanics (Select 3 credits)

AERSP 308(3), **BE 467(3)**, CE 371(3), CE 462(3), CHE 330(3), EME 303(3), ME 320(3), METEO 454(3), NUCE 431(4)

Environmental Sciences & Design (Select 6-9 credits)

BE 468(3), **BE 477(3)**, CE 472(3), CE 475(3), CE 476(3), CHEM 402(3), ERM 411(3), ERM 412(3), ERM 413(3), ERM 447(3), ERM 450(3), EGEE/ME 430(3), EGEE 470(3), ENVSE 408(3), ENVSE 427(3), FSC 431(3), GEOSC 452(3), ME 405(3), ME 433(3), NUCE 405(3), NUCE 420(3), NUCE 428(3), SOILS 420(3)

For more information: <http://www.cee.psu.edu/academics/undergraduate/majors-minors-and-certificates.aspx#EnviroMinor>

Notes for BE students: In addition to the selection lists above, BE students have used **BE 467(3)** and **BE 487(3)** in the Environmental Sciences & Design category with the approval of the minor coordinator. However, as stated in policy 59-10, “**at least six credits of the minor must be unique from the Prescribed Courses required by the student's major program(s)**.”

WATERSHEDS & WATER RESOURCES MINOR

Watersheds are important landscape features that control the biogeochemistry of natural waters. This interdisciplinary minor enables students to learn the fundamental processes governing the transport and chemical evolution of surface and subsurface waters. It provides a complement to elective and required coursework in earth sciences, resource management, wastewater treatment, and/or environmental

planning. Students in this program will learn to apply fundamental concepts of chemistry, biology, geoscience, and landscape evolution to processes operating at the watershed scale. Learning objectives for the minor include excellence in written and oral expression, the ability to collect and interpret data from dynamic natural systems, and rigor in scientific thought.

A grade of C or better is required for all courses in the minor.

Requirements for the Minor: Select 18 credits from the WWR committee's approved list of courses, which includes but is not limited to courses listed below (at least 6 credits must be taken at the 400 level): **BE 307(3), BE 467(3)**, ASM 327(3), CE 370(3), CE 371(3), CE 461(3), CE 475(4), CHEM 202(3), CHEM 402(3), ERM 411(3), ERM 435(3), ERM 450(3), ENVE 411(3), ENVE 415(3), ENVSE 408(3), FOR 470(3), FOR 471(1), GEOG 431(3), GEOSC 201(4), GEOSC 340(3), GEOSC 412(3), GEOSC 413W(3), GEOSC 419(3), GEOSC 452(3), PLANT 217(3), SOILS 405(3), SOILS 418(3), WFS 410(3), WFS 422(3)

Notes for BE students: In addition to the courses listed above, the minor coordinator has indicated that **ASM 309 (3), BE 487 (3)**, CE 462 (3), and ERM 447 (3) would be approved as selections.

BIOMEDICAL ENGINEERING MINOR

This interdisciplinary minor is designed for students interested in the application of engineering principles to medical and biological problems. The minor is particularly suitable for students pursuing an undergraduate degree in a different engineering major, physics, or other applied science who are seeking careers in health-related professions. PHYS 211 GN(4), PHYS 212 GN(4), and calculus through differential equations (MATH 250 or 251) are required for entrance to minor. Additional prerequisites for prescribed and supporting courses may be required and should be researched prior to applying for the minor (e.g. CHEM 112 GN(3) and CMPSC 200 GQ(3)).

Requirements for the Minor: The minor consists of 18-20 credits. A grade of C or better is required for all courses in the minor.

Physiology (Select 3-4 credits)*

BIOL 141(3), BIOL 240W(4), BIOL 472(3)

Molecular/Cell Biology (Select 3-4 credits)*

BMB 251(3), BME 201(3), BIOL 230W(4)

Biomedical Engineering (Select 9-12 credits)

BME courses at the 400 or 500 level (*BME 406(3), BME 410(3), BME 413(3), BME 419(3), BME 423(3), BME 433(3), BME 443(3), BME 444(3), BME 445(3), and BME 446(3)* are good options for BE students. You might have suitable equivalent prerequisites, including ME 300, ME 320, BE 301, BE 302, BE 304, and BE 305.)

Biomedical Engineering-related courses (Select 0-3 credits)

MATSE 403(3)/BME 443(3), MATSE 404(3)/BME 444(3), IE 327(3), **BE 308(3), BE 468(3)**, CHE 340(3), CHE 438(3), NUCE 420(3), EE 455(3)/CMPEN 455(3), EE 453(3), PHYS 472(3)

For more information: <http://www.bme.psu.edu/students/undergraduate/undergraduate-majors-and-minors.aspx>

**Notes for BE students:* If a BE student takes both BIOL 161(3) and BIOL 163(3), these courses can be petitioned to fulfill the Physiology requirement for the BME minor. BE students in the Food and Biological Processing Option may choose to substitute BMB 251(3), BME 201(3), or BIOL 230W(4) for BMB 211(3), which is required for the Food and Biological Processing Option.

OFF-ROAD EQUIPMENT MINOR

From apple harvesters to zambonis, all off-road equipment have some things in common: engines, drive trains, safety needs, electronics, operator interfaces, power transmission, hydraulics. The Off-Road Equipment minor focuses on these topics. This technical minor is a great complement to majors such as Mechanical Engineering, Mining Engineering, Plant Sciences, Turfgrass Science, BE, and BioRenewable Systems.

Requirements for the Minor: The minor consists of 18 credits. A grade of C or better is required for all courses in the minor.

Prescribed Courses (3 credits): ASM 420(3)

Select 3 credits: ASM 320(3), ME 431(3)

Select 3 credits: **BE 306(3)**, ASM 310(3), ME 360(3)

Select 3-4 credits: **BE 305(3)**, BRS 428(3), ME 345(4)

Select 3-4 credits: ASM 424(3), AGRO 423(3), AGRO 425(3), HORT 408(4), TURF 425(3)

Select 3 credits: **BE 461(3)**, BRS 426(3)

For more information: <http://abe.psu.edu/majors/minors/off-road-equipment>

ENTREPRENEURSHIP & INNOVATION MINOR (ENTI)

The ENTI minor uses problem-based learning pedagogy to prepare students to create value and be agents of positive change in their discipline and their careers. There are different clusters to meet the students' broad range of entrepreneurship and innovation interests. The following clusters are especially of interest to BE students: Food and Bio-innovation, Social Entrepreneurship, and Technology Based Entrepreneurship.

Requirements for the Minor: The minor consists of 18-19 credits. A grade of C or better is required in all classes in the minor.

Prescribed Courses (9 credits): MGMT 215 (3), ENGR 310(3), ENGR 425(3)

Additional Courses (9 credits): Select 9 or more credits from one of the following clusters.

Food and Bio-innovation Cluster

Select up to 6 credits of the following 200-300 courses in the College of Agricultural Sciences: **BRS 391(2)**, **BRS 392(2)**, AEE 201(3), AEE 311(3), AGBM 308W(3), AGBM 338(3), ANSC 201(4), ANSC 306(3), ANSC 308(4), ANSC 309(4), ANSC 310(3), ANSC 311(3), ANSC 324(3), ANSC 327(3), ANSC 350(2), CED 375(3), ERM 300(3), FDSC 200(3), FDSC 206(3), HORT 250(3)

Select at least 3 credits of the following 400 level courses in the College of Agricultural Sciences: AGBM 407(3), AGBM 408(3), AGBM 440(3), AGBM/HORT 455(3), AGBM 460(3), ANSC 410(4), ANSC 429(3), ANSC 450(3), BRS/ERM 402(3), BRS 429(3), BRS 437(4), CED 417(3), CED 425(3), CED 430(3), CEDEV 452(3), ERM 411(3), ERM 412(3), ERM 413(3), FDSC 411(3), FDSC 430(3), FDSC 444(3), FDSC 460(1), FOR 440(3), HORT 410(3), HORT 453(3), TURF 436(3) (Sem:1-8)

Social Entrepreneurship Cluster

Required courses to be taken in the following order: ENGR 451(3), EDSGN 452(2) and EDSGN 453(1) concurrent, EDSGN 454(0.5), and ENGR 455(3)

Technology Based Entrepreneurship Cluster

Required courses: ENGR 411(3), ENGR 407(3) in sequence or concurrent, and ENGR 415(3)

For more information: <http://www.enti.psu.edu>

ENGINEERING AND COMMUNITY ENGAGEMENT CERTIFICATE

Engineering and Community Engagement (or Humanitarian Engineering and Social Entrepreneurship) is for students who are looking to gain proficiency in design, research, and implementation of appropriate technologies for use in serving communities in the U.S. and abroad while stressing an awareness of the cultural context of such activities.

Required courses to be taken in the following order: ENGR 451(3), EDSGN 452(2) and EDSGN 453(1) concurrent, EDSGN 454(0.5), and ENGR 455(3)

Select one community and culture elective (3) agreed upon with the director (John Gershenson, gersh@psu.edu)

For more information: <https://sites.psu.edu/hese/certificate-minor/>

ENGINEERING LEADERSHIP DEVELOPMENT MINOR

The Engineering Leadership Development Minor is an interdisciplinary minor designed to enable engineering undergraduate students to develop the practical leadership skills that they will need throughout their careers.

Requirements for the Minor: The minor consists of 18 credits. A grade of C or better is required in all classes in the minor. For admission to the minor, students must have completed ENGR 408(3).

Prescribed Courses (6 credits): ENGR 408(3), ENGR 407(3)

Additional Courses (6 credits): Select 6 credits from ENGR 405(3), ENGR 409(3) or ENGR 422(3), or ENGR 496(3)

Supporting Courses (6 credits): Select from approved list

BE 391 and **392** can be used toward 6-credit supporting course requirement, by petition. For BE students pursuing this minor, prescribed courses can be petitioned for technical selections in BE degree requirements. Please consult with your BE advisor.

For more information: <https://www.sedtapp.psu.edu/eld/undergraduate-minor.aspx>

SUSTAINABILITY LEADERSHIP MINOR

The Intercollege Minor in Sustainability Leadership has been designed for students who wish to promote environmental, social, and economic sustainability in their personal and professional lives. Through a combination of coursework and immersive experiences in sustainability, students develop the knowledge, skills, and attitudes required to become sustainability leaders in their respective fields.

Requirements for the Minor: The minor consists of 18 credits. Students may apply toward the minor no more than six credits from their major requirements and no more than six credits from their other minor requirements. The Sustainability Leadership Capstone credits may not be used simultaneously to fulfill capstone or thesis requirements for any other degree program. All minor programs must include at least six credits at the 400 level. A grade of C or better is required in all classes in the minor.

Prescribed Courses (3 credits): SUST 200 GS(3)

Additional Courses (6 credits):

Take the following 6 credits, or approved substitutions, in consultation with the minor advisor:
SUST 295 or 495, or approved substitution that provides an immersive sustainability experience (3)
SUST 496 or approved substitution that offers a capstone project in sustainability leadership (3)

Supporting and Related Course Area (9 credits):

Allowable courses in this area vary by Sustainability Leadership Thematic Track (**Design for Sustainable Communities**, Educating for Sustainability, **Humanistic Understanding of Sustainability**, and **Sustainability and Food Systems**). See more details at the website below.

For more information: <http://sustainability.psu.edu/learn/students/minor-sustainability-leadership>

SIX SIGMA MINOR

This minor is designed for students who are interested in the Six Sigma statistical methodology for increasing productivity and enhancing quality. Six Sigma has been increasingly internalized by companies involved in manufacturing, health care, and service industries. It has also been used to address environmental concerns such as water quality and energy conservation. The minor focuses on problem solving in business operations, lean manufacturing/business practices, and improving industry efficiencies.

Requirements for the Minor: 18 credits. A grade of C or better is required for all courses in the minor.

Prescribed Courses (18 credits)

IE 305(3), IE 322(3), IE 323(3), IE 433(3), IE 434(3), IE 436(3)

For more information: <https://www.ime.psu.edu/students/undergraduate/six-sigma-minor.aspx>

*As noted at the website above, there are some alternatives to four of the prescribed courses for students not in the Industrial Engineering major. A recommended pathway for BE students in the Food and Biological Processing Engineering Option interested in the Six Sigma minor is summarized below:

Six Sigma Minor Requirement	How Class Can Be Used in BE Major
Take IE 327(3) in place of IE 305(3)	IE 327 is offered online in the summer and is already on the approved Engineering Science/Design list
Take STAT 318(3) in place of IE 322(3)	
Take STAT 319(3) in place of IE 323(3)	Petition STAT 319 to substitute for IE 424 in the BE major
Take STAT 460(3), STAT 462(3) or IE 433(3,FA)	Petition as Technical Selection
Take IE 434(3,FA)	Petition as Technical Selection
Take IE 436(3,SP)	Petition as Engineering Science/Design

INTERNATIONAL AGRICULTURE MINOR

This minor is an interdisciplinary program of study designed so students can (1) gain an appreciation for the interrelationship and interdependency of the nations of the world for their food and fiber; (2) gain an awareness of problems in international agriculture and sustainability of alternative solutions; (3) understand global impacts of technology; and (4) understand systems of learning across cultures.

Requirements for the Minor: 18 credits. A grade of C or better is required for all courses in the minor. Students must have six credits of 400 level course work for the minor.

Prescribed Courses (6 credits)

INTAG 100 GS;IL(3), INTAG 490(3)

Additional Courses* (12 credits. Select three courses from the first two categories (9 credits) and one internationally-oriented experience from the third category (3 credits)):

Category 1: Social Sciences

AEE 400(3), AGBM 338 IL(3), ANTH 120 GS;IL (3), ANTH 472 (3), BBH 305 IL(3), BBH 402 IL(3), BBH 407 IL(3), CED 230(3), CED 420 US;IL(3), CED 425(3), CED 450(3), GEOG 3N GS/GN(3), GEOG 30N GS/GN;US/IL(3), GEOG 123 GS;IL(3), GEOG 126 GS;US/IL(3), GEOG 220(3) GS;US/IL, GEOG 430(3), GEOG 444(3), NUTR 421 US;IL(3), NUTR 425 IL(3), NUTR 430 IL(3), WMNST 420 US;IL(3), SPAN 105(4), SPAN 106(4), any university language skill development course

Category 2: Natural Sciences

AFR 105 GN;IL(3), AGEKO 3(3), AGEKO 457(3), EARTH 2(3), ENT 202(3), ENT 222(3), ENT 457(3), ERM 210(3), FDSC 105 GHW(3), FOR201(3), FOR 418 US;IL(3), FOR 488(3), GEOG 210(3), INTAG 300 IL(3), PPEM 405(3), SOILS 71(3)

Category 3: International Experience

AGBM 470A, AGBM 470B, AGEKO 499, ANSC 499, CED 499, ERM 499, FDSC 460, FDSC 499, HORT 499, INTAG 199, INTAG 470A, INTAG 470B, INTAG 499, SOILS 499, VBSC 499

*Students have the option of participating in a semester study abroad program that would be discussed and approved by the INTAG coordinator and the student's academic advisor. Twelve credits maximum can count toward the minor and the study abroad program needs to focus on courses within the food, agriculture, or natural resource areas.

For more information: <http://agsci.psu.edu/international/intag>

ENGINEERING MECHANICS MINOR

Engineering mechanics is the engineering science that deals with the effects of forces and torques on particles, rigid bodies, or deformable media. The Engineering Mechanics minor helps students prepare to analyze and/or design simple structures that are efficient and safe under foreseen loading conditions.

Requirements for the Minor: 18 credits. A grade of C or better is required for all courses in the minor. Students must have six credits of 400 level course work for the minor.

Select 12 credits of EMCH courses: **EMCH 211(3), EMCH 212(3), EMCH 213(3)**, EMCH 315(2), EMCH 316(1)

Select 6 credits from 400-level EMCH courses

INTERNATIONAL ENGINEERING CERTIFICATE PROGRAM

The International Engineering Certificate is intended to recognize the completion of course work, language study, and international experiences that will contribute toward the attainment of a global perspective of engineering. Requirements to be eligible for the certificate are:

- Three (3) credits of study in a second language at the 003 level (third-semester or 12th credit) or higher as a Penn State student.
- Six (6) credits (typically two courses) of study in courses approved to meet the International Cultures requirement (IL) of General Education.
- One to three (1-3) credits of approved study or work abroad, of at least six weeks duration.
- Completion of all degree requirements for a College of Engineering baccalaureate program.

For more information: <https://global.engr.psu.edu/students/international-engineering-certificate.aspx>

HOUSING CERTIFICATE

This program is designed to provide undergraduate students with a means of developing some basic knowledge of housing and preparing for a career in the housing industry. The certificate requires 12

credits. Students must earn a C grade or better in each required course. For entrance to the certificate program, students must be at least 5th semester and maintain good academic standing (GPA minimum of 2.00).

Residential Building Design and Construction (3 credits): AE 470

Selection List (choose 9 credits)*:

AE 432(3), **BE 462(3)**, CE 410(3), CE/AE 542(3), RM 303(3)

*With the approval of the Hankin Chair, one housing-related course of at least 3 credits not included in the list of recommended additional courses (e.g., demographics, urban geography, social housing, etc.) can be substituted for one of the three additional courses.

For more information: <http://www.cee.psu.edu/academics/undergraduate/majors-minors-and-certificates.aspx#HousingCert>

RESIDENTIAL CONSTRUCTION MINOR

The objective of the Residential Construction Minor is to provide an opportunity for students to gain an understanding of the residential building construction topics and issues with emphasis on sustainable land development, design and construction of residential buildings, as well as construction management of residential projects. The Intercollege Minor in Sustainability Leadership has been designed for students who wish to promote environmental, social, and economic sustainability in their personal and professional lives. Through a combination of coursework and immersive experiences in sustainability, students develop the knowledge, skills, and attitudes required to become sustainability leaders in their respective fields.

Requirements for the Minor: The minor consists of 22 credits (10 required credits and 12 additional credits). A grade of C or better is required in all classes in the minor.

Prescribed Courses (10 credits): AE 470(3), AE 471(3), ARCH 412(3), CE 411(1)

Additional Courses – Other Majors (select 12 credits from the following list): ARCH 100 GA(3), ARCH 481(3), AE 202(3), AE 372(3), BA 301(3), BE 303(3), RM 303(3)

For more information: <https://www.phrc.psu.edu/Student-Education/Educational-Opportunities/Residential-Construction-Minor.aspx>

Diversity, Equity, and Inclusion in Minors and Certificates

It is well documented that diversity enhances excellence and innovation. Teams that include thinkers of different backgrounds outperform homogeneous groups on complex tasks, including improved problem-solving increased innovation and more accurate predictions¹⁻³. There is also a statistically significant correlation between a more diverse leadership team and financial performance⁴. We encourage Biological Engineering majors to consider minors and certificates which broaden exposure to ways of thinking and how to understand diverse perspectives to open possibilities for meaningful communication across social boundaries.

¹Page SE, Lewis E, Cantor N. *The diversity bonus: how great teams pay off in the knowledge economy*. Princeton, NJ: Princeton University Press, 2017.

²Freeman RB, Huang W. Collaboration: strength in diversity. *Nature* 2014; 513:305.

³AlShebli BK, Rahwan T, Woon WL. The preeminence of ethnic diversity in scientific collaboration. *Nat Commun* 2018; 9:5163.

⁴Hunt, V., Layton, D. and Prince, S., 2015. Diversity matters. McKinsey & Company, 1(1), pp.15-29.

ETHICS MINOR

This interdisciplinary minor, housed in the Department of Philosophy, is designed to provide students with training in ethical reasoning, frameworks, and methods, as well as offer the opportunity to work in various fields of applied ethics. In addition to the requirements for the student's major department the minor consists of 18 credits selected from a wide range of disciplines (e.g., philosophy, communication, engineering, law, psychology, sociology, anthropology, public policy, international studies, and environmental studies). Courses deal with ethics from various perspectives, for example research ethics, media ethics, environmental ethics, bioethics, and business ethics.

Students in the minor will choose from a broad range of 0-, 100-, and 400-level ethics-related courses offered in the Philosophy Department, and will have the chance to take up to two ethics-related courses outside the department. Some Philosophy ethics-related courses cover prominent and powerful historical and contemporary approaches to ethical decision-making and leadership; others cover specific problems in ethical thinking or applications to concrete areas of life. The minor will be suitable for students in almost any major, especially students going on to further academic work or careers in medicine, teaching and education, communication, business, law, the health or life sciences, health administration, public policy, politics, computer science, or engineering.

For more information: <https://philosophy.la.psu.edu/undergraduate/ethics-minor/>

BIOETHICS AND MEDICAL HUMANITIES MINOR

The tremendous current activity in the biomedical sciences affects both the public and private sectors, including medical care, the pharmaceutical industry, genetics, environmental epidemiology, agricultural science, the insurance industry, occupational health, forensic sciences, and behavioral variation. All these areas go beyond the science itself, with varied impact on people in different age, sex, ethnic, geographic, or economic segments of society. For that reason, life and health sciences research has major social implications that bear on humanities disciplines ranging from ethics and history to religious studies and literature, affecting clinical practice, agricultural practice and research, public policy and private investment. Understanding these issues is important for an informed citizenry. Students electing the BMH minor will start with a basic background of biology coursework, and will take a curriculum that includes 18 credit hours, beginning with an introductory course on basic ideas of bioethics, followed by a choice of other relevant humanities courses, and capped with an integrative course involving original research by the student. The minor will be suitable for students in almost any major, especially students going on to further academic work or careers in health, the life sciences, informatics, forensic or legal professions.

For more information: <https://bulletins.psu.edu/undergraduate/colleges/intercollege/bioethics-medical-humanities-minor/>

AFRICAN AMERICAN STUDIES MINOR

The Department of African American Studies awards a certificate to students who, in addition to meeting the requirements for a major, complete 18 credits in the African American Studies minor. This minor is designed for students interested in African American culture and the educational, social, political, and economic development of people of African descent in the United States. In particular, it provides students with the opportunity to explore the experiences of African Americans using theories and methods originating in the field. Students are made aware of the potential to apply such knowledge to the solution of social, political, and economic problems. The minor also promotes greater understanding of the relationship between African Americans and other ethnic groups.

For more information: <https://afam.la.psu.edu/undergraduate/african-american-studies-minor/>

WOMEN'S STUDIES MINOR

This interdisciplinary minor is designed to develop a broad understanding of the study of women and women's perspectives in all areas of academic scholarship. The primary focus is on feminist analyses of

women's lives, women's social, cultural, and scientific contributions, and the structure of sex/gender systems. The interdisciplinary and inclusive nature of the field is reflected in a curriculum that includes courses cross-listed with a wide variety of departments, courses that deal with aspects of women's lives throughout history, and courses that recognize the diversities of culture, race, religion, ethnicity, age, disability, and sexual orientation. The Women's Studies minor emphasizes the development of critical and analytical skills, creative approaches to problem solving, and the ability to articulate productive alternatives.

For more information: <https://wgss.la.psu.edu/undergraduate/majors-and-minors/womens-studies-minor/>

SEXUALITY AND GENDER STUDIES MINOR

The undergraduate minor in Sexuality and Gender Studies addresses human sexuality and gender as they have been conceptualized and investigated by diverse disciplines: humanities (including history and cultural studies), behavioral and social sciences, biological sciences, and visual and performance arts. This minor helps students interrogate how gender identity and sexuality intersect with race, ethnicity, nationality, class, disability, age, religion, and other identities to create structural, institutional, and ideological inequalities and oppressions. Courses in the minor require students to explore scholarship and research on sexuality, sexual orientation, and gender across the lifespan, across cultures, and throughout history. Developing students' critical skills in a variety of disciplines, courses in the minor cover theories of sexuality and gender, sexual orientation, gender identity, lesbian, gay, bisexual, and transgender movements, the history of sexual norms, queer theory, transgender theory, gender identities and erotic orientations in the arts, among other classes.

For more information: <https://wgss.la.psu.edu/undergraduate/majors-and-minors/sexuality-and-gender-studies-minor/>

DISABILITIES STUDIES MINOR

Disability Studies is not the study of disabilities. It is a broad interdisciplinary field grounded in the rich perspectives, histories, and cultures of people with disabilities. Students in the Disability Studies minor will have wide exposure to both the lived experiences of disability, past and present, and to the unstable cultural norms that have traditionally stigmatized disability. The minor explores valuable varieties of human embodiment and mindedness; it also asks central questions about what counts as "normal," and who gets to say why. The DS minor is designed for students interested in expansive intellectual, political, and artistic approaches to disability.

For more information: <https://disabilitystudiesminor.psu.edu/about-the-minor/>

JUSTICE, ETHICS, DIVERSITY IN SPACE (JEDIS) CERTIFICATE

The 12-credit Justice, Ethics, Diversity in Space (JEDIS) certificate helps students to cultivate a diverse set of theoretical and methodological skills that geographers use to engage in a diverse and changing planet. Increasingly as students enter the workforce they will be challenged to not only interact with diverse populations, but will also have to understand the way diverse populations are impacted by a range of economic, political, and environmental challenges. They will also need to be exposed to ethical frameworks that can be productively leveraged within non-academic environments. Students who undertake a JEDIS certificate will take courses across the broad spectrum of human geography and will cultivate the intellectual capacity to address issues of inequality and diversity from an ethically informed perspective.

For more information: <https://bulletins.psu.edu/undergraduate/colleges/earth-mineral-sciences/justice-ethics-diversity-space-certificate/>

DIVERSITY STUDIES CERTIFICATE

The Diversity Studies certificate is an interdisciplinary and online program of study that explores social difference and inequality related to gender, race, ethnicity, sexuality, class, aging, religion, and disability. How we experience and view the world around us, the opportunities presented to us, and even the people that we surround ourselves with are constrained by invisible and unconscious systems of power. These systems organize our schools, workplaces, healthcare systems, criminal justice system, and media, and reproduce inequality rooted in ignoring or downplaying diversity. The Diversity Studies certificate will encourage students to take an intersectional approach to expose, critique, and confront historical and contemporary sources of social inequality. This certificate will enable students to complement their existing course portfolio by providing an opportunity to deepen their knowledge around issues of difference through a broad range of interdisciplinary coursework. An interdisciplinary approach will make it easier for students to see connections across disciplines and allow them to cluster their coursework in a meaningful and related way. The Diversity Studies certificate is designed to encourage reflection on the ethical challenges that arise when we become aware of how privilege, power, and difference are embedded in our world and daily lives. The aim is to move the discourse away from mere tolerance, celebration or appreciation to a deeper understanding and critique of discrimination, intolerance, and inequality in the historical and contemporary global society.

The certificate will provide students with skills vital to careers in fields such as human resources, non-profit agencies, social welfare, education, and health and medicine. We have designed the certificate around an intersectional perspective that invites students to see the ways that race, class, gender, disability, sexuality, etc. operate together in overlapping and conflicting ways to affect all aspects of human experience.

For more information: <https://wgss.la.psu.edu/undergraduate/majors-and-minors/diversity-studies-certificate-program/>

Opportunities for International Experiences

One of the characteristics of a world-class engineer is knowledge and appreciation for the international challenges and opportunities now and anticipated in future years. Probably the best way to gain global experiences is through participation in an international activity while you are still a student. Fortunately there are numerous opportunities for gaining international experiences and perspectives through activities such as study abroad programs (for a semester or academic year), international co-ops and internships, and short-term embedded courses (Penn State courses that include an international travel experience).

Financial support for international activities

There are scholarships available through the College of Ag Sciences and College of Engineering specifically for students who are gaining international experiences. Undergraduate students in BE have obtained significant amounts of financial support from both Colleges to participate in international programs of various formats. BE students planning to study abroad should set up a meeting with the Department Head (Dr. Paul Heinemann, hzh@psu.edu) to discuss possible department contribution toward program costs. Active members of the ASABE Student Branch can also request support for study abroad programs from the Karl Snyder Endowment (typical awards are < \$500).

The deadline dates to apply for awards from College of Ag Sciences for programs are typically:

- Fall Semester programs: March 15
- Spring Semester programs: September 30 of previous year
- Summer programs (not associated with a spring semester class): March 15
- Short Term programs embedded in a fall class and traveling during fall or winter break: September 30
- Short Term programs embedded in a spring class and traveling during spring break or directly after the end of the semester: January 31

Students who apply after the above deadline dates might be considered for awards, depending on whether all the funds have been awarded or not. For additional information, please contact Ms. Ketja Lingenfelter at ketja@psu.edu or 814-863-4164 or through Starfish to schedule a meeting and refer to the following website: <http://agsci.psu.edu/international/study-abroad/funding/funding-application>

The Penn State Office of Global Programs offers Whole-World scholarships. Whole-World scholarships provide recognition and financial incentives to undergraduate students from PSU who are enrolled or planning to enroll in select Education Abroad study abroad programs in non-traditional locations. Scholarships are given in amounts of \$2,000 for full-year, \$1,000 for one semester and \$500 for summer programs in such areas as Eastern Europe, Latin America, Africa, Asia, and the Middle East. Refer to <https://global.psu.edu/category/penn-state-managed-scholarships> for more information about Whole-World scholarships, Embedded Programs scholarships, and other funding opportunities.

Penn State tuition when participating in an international program

If the program is during the summer, you may be required to register for summer session. For instance, if you participate in a PSU/international tour combination, you may register for a 2.5-credit course on campus during the Spring Semester and then a 0.5-credit course during the international travel during May. The College of Agricultural Sciences offers several courses with embedded travel experience, as shown on this website: <http://agsci.psu.edu/international/study-abroad/study-abroad/current/short-term-agsci-ieee>

Semester programs through the Office of Global Programs assess Penn State tuition. Each program on the Global Programs website has a budget sheet, which clearly shows tuition costs as well as additional program fees and expected expenses.

International opportunities in a particular country of interest

The College of Engineering has created a web site about International Programs. The site contains a searchable database of study abroad programs for engineering majors, checklists for how to prepare for international experiences, information about program deadlines and application procedures, and useful resources for going abroad. A good place to start on the College of Engineering website is the program matrix: <http://www.engr.psu.edu/Global/Students/programmatrix.aspx>. While this matrix is a useful tool, it does not contain every possible study abroad program for students in Biological Engineering. Another resource is the program search on the Office of Global Programs website: <http://gpgglobalea.gp.psu.edu/index.cfm?FuseAction=Programs.SimpleSearch>. You can easily search by country, semester, and other requirements (such as semester standing and GPA). Programs that offer science and engineering coursework may be suitable for BE students.

Engineers without Borders, Engineers for a Sustainable World, Bridges to Prosperity, and Global Brigades are organizations that foster engineering projects in developing countries.

There are many NGOs (non-governmental organizations) such as churches, civic and fraternal groups, and humanitarian organizations that sponsor various types of short-term trips to a wide variety of countries, where they seek to build buildings (schools, clinics, orphanages, etc.), develop clean water supplies, build effective waste facilities, provide basic health education, introduce basic agricultural production practices, and more.

Be sure to read the weekly news e-mails from College of Ag Sciences and College of Engineering. These frequently identify numerous opportunities for various international activities.

Answers to other questions related to gaining international experiences

- University Office of Global Programs, 410 Boucke Bldg., 814-865-6348, global.psu.edu
- Office of International Programs, College of Ag. Sciences, 106 Ag. Admin. Bldg., 814-863-0249, <http://agsci.psu.edu/international/undergraduates>
- Global Engineering Education, www.engr.psu.edu/Global

Co-ops/Internships

The BE major does not have a formal Internship program. Students are encouraged to participate in the Engineering Co-op program or to seek summer employment to develop career related experiences. Typically, when the work experience is only during the summer, students say that the value is in the experience not in obtaining credit. However, a student can register for ENGR 195 (Engineering Internship) through the College of Engineering Career Resources & Employee Relations Office. ENGR 195 is an add-on course and does not apply toward degree requirements.

In contrast to a summer internship, a co-op is a rotational experience working with one company or organization for two or three semesters. Most co-op experiences include at least one spring or fall semester in addition to summers. There are benefits to being registered for a co-op course (ENGR 295, 395, and 495 – Engineering Co-op Work Experience I, II, and III). These benefits include maintaining your student status (not necessary to take leave of absence), not being asked to begin student loan payments, maintaining access to Penn State Library resources, etc. For more details: <https://career.engr.psu.edu/students/undergraduate/intern-coop/credit-options/index.aspx>. A BE student can choose to register for 1 credit of each co-op course (ENGR 295, 395, and 495) during subsequent rotations. Up to three credits of co-op courses can be petitioned as a Technical Selection.

Student Organizations

The Penn State Student Branch of ASABE is a professional organization that all BE students should join (<http://abe.psu.edu/students/clubs-and-organizations>). The meetings are generally held every other week. Organization activities included guest speakers, field trips, fundraising events, and social activities. Through active participation in this organization, students have an excellent opportunity to learn more about the Agricultural and Biological Engineering profession, to develop leadership and organizational skills, and to establish important leads on potential career opportunities. Furthermore, active members of the ASABE Student Branch are eligible to request funds from the Karl Snyder Endowment to support professional development activities (e.g., study abroad program, travel to conference, registration fee to take the Fundamentals of Engineering exam).

Scholarships

Biological Engineering students are eligible for scholarships awarded through both the College of Agricultural Sciences and College of Engineering. To apply for scholarships, a student needs to complete an online form through the College of Agricultural Sciences Scholarship Application site, usually by April 30. To be eligible for scholarships that require financial need, you must complete the online FAFSA application. Only when a student completes the College of Agricultural Sciences form will they be considered for scholarships from the College of Agricultural Sciences. More than \$80,000 in Departmental scholarships were awarded to BE and BRS students for the 2019-20 academic year. For a complete list of Departmental scholarships, please see <http://agsci.psu.edu/students/scholarships>

Admission to Graduate School

Undergraduate students looking forward to graduation frequently consider applying to graduate school.

Competitive applicants for admission to graduate study in the Agricultural and Biological Engineering (ABENG) program typically have the following credentials:

1. A baccalaureate degree in engineering,
2. A 3rd-4th year grade point average of at least 3.00,
3. A record of participation in professional and/or co-curricular activities, and
4. Some undergraduate research experience.

Most students enrolled in graduate study in the ABENG program receive graduate research assistantships, which include a stipend plus full waiver of tuition and fees. Specific inquiries concerning the opportunities for graduate study in Agricultural and Biological Engineering should be addressed to Dr. Jeffrey Catchmark, Director of Graduate Studies (jmc102@psu.edu).

Searching for Employment

"Self-directed" Job Searches

- Use targeted contacts rather than a mass e-mail.
- Target a company and conduct research on the company before sending cover letter and resume.
- Sell yourself in the cover letter.
- Gain experiences via co-op and other employment programs.
- Focus upon what you want to do in your professional career.
- Send resume and other materials to Chief Engineer, not Human Resources Division. Find the name of the Chief Engineer.
- Assemble a portfolio of accomplishments related to career goals.

- Network. Become actively involved with trade groups, professional societies, civic organizations, the ASABE Student Branch, etc.
- Be willing to start as a volunteer if necessary.
- Persist with follow-up.
- Explore non-standard job opportunities.
- Be assertive, but not to the extent of becoming obnoxious.

How Do Employers Evaluate Job Applicants?

- Neatness of cover letter and resume. Two or three misspelled words are a "knock out."
- Resume that is easy to read, neat, and in logical order.
- Well-written cover letter and resume that are targeted to the interests and needs of the employer.
- Specifics in letters from professional references. Avoid use of personal references (friends, neighbors, relatives, etc.).
- Junior and senior academic performance.
- Performance in certain courses specific to the company's interests.
- Experiences from summer jobs, co-ops, internships.
- Percentage of school expenses earned by working.
- Participation in campus activities and/or work activities (particularly leadership roles).
- Geographic mobility. For some companies, this is absolutely essential.
- Competence with a foreign language.
- Follow-up by the applicant.
- Interest shown in the company or organization.

Online Resources

There are many resources at Penn State to help you with your job search:

Penn State	Bank of America Career Services Center https://studentaffairs.psu.edu/career/resources
	Nittany Lion Careers (single system for Penn State students and alumni – view job postings, apply for jobs, see on-campus interview opportunities) nittanylioncareers.psu.edu
College of Ag Sciences	Center for Experiential Learning and Career Services, 110 Ag Admin http://agsci.psu.edu/students/opportunities
College of Engineering	Engineering Career Resources, 117 Hammond Bldg https://career.engr.psu.edu/
ABE Department	http://www.abe.psu.edu/students/job-postings
ASABE	https://asabe.org/Careers

There are also many general job resources online:

General Sites with Job Postings	http://www.indeed.com/ http://www.careerbuilder.com/ https://www.agcareers.com/
Career-Specific Sites with Job Postings	https://www.agcareers.com/ http://www.ift.org/careercenter.aspx (Institute of Food Technologist) https://environmentalcareer.com/ for complete list, see Agriculture and Environment headings at

<https://studentaffairs.psu.edu/career/resources/explore/career-specific>

**Company
Information**

<http://www.hoovers.com>

<http://www.thomasregister.com>

**State and Local
Information**

<https://www.cwds.state.pa.us/cwdsonline/>

Salary Information

<https://www.jobsearchintelligence.com/salary-calculator-intro-etc>

<https://career.engr.psu.edu/students/undergraduate/salary.aspx>

<https://www.salary.com/> (enter job title and location, once you make selection you can update education and years of experience – results include median salary and typical responsibilities)

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Important Phone Numbers

Emergency (Police--Fire--Ambulance)	911
Police Services (Non-Emergency)	3-1111
Department of Environmental Health and Safety (General Safety Information)	5-6491
Physical Plant Service Desk (Structural, Plumbing, Electrical Problems)	5-4731
PSU Escort Service	5-WALK

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