Bachelor of Science Program in Chemical and Biological Engineering

Program Notes

Fall 2016
Bachelor of Science Program in Chemical and Biological Engineering

Program Notes

CONTENTS:

- CBE Curriculum checksheet
- Typical semester-by-semester course plan – CBE majors
- Important note about math and physics courses
- Course flowchart
- Grade C minimum and grading rubric
- Course descriptions
- Bioscience elective list
- Technical elective list
- AUCC course list
- Minors and focuses
- CBE-BIOM dual degree checksheet
- Track III and Sequential Masters Degrees
# Department of Chemical and Biological Engineering

## B.S. DEGREE IN CHEMICAL AND BIOLOGICAL ENGINEERING

**Total credits:** 130  
Name: _____________________________  
Date entered dept: ___________________

Applicable to new students from Fall 2015  
Minor (optional): ___________________

### Required engineering and science courses:

<table>
<thead>
<tr>
<th>FIRST YEAR</th>
<th>SECOND YEAR</th>
</tr>
</thead>
<tbody>
<tr>
<td>CBE 101^, CBE 101^ (3) ________ OR ________</td>
<td>CBE 201, 210 (3,3) ________ ________</td>
</tr>
<tr>
<td>CBE 160^ (1) ________ OR ________</td>
<td>CBE 205 (3) ________</td>
</tr>
<tr>
<td>CO150 (3) ________ OR ________</td>
<td>CHEM 341, 343 (3,3) ________ ________</td>
</tr>
<tr>
<td>CHEM 111, 113 (4,3) ________</td>
<td>CHEM 344 (2) ________</td>
</tr>
<tr>
<td>CHEM 112, 114 (1,1) ________</td>
<td>MATH 261, 340 (4,4) ________ ________</td>
</tr>
<tr>
<td>MATH 160, 161 (4,4) ________</td>
<td>PH 142 (5) ________</td>
</tr>
<tr>
<td>PH 141 (5) ________</td>
<td>________</td>
</tr>
<tr>
<td>LIFE 102 (4) ________</td>
<td>________</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>THIRD YEAR</th>
<th>FOURTH YEAR</th>
</tr>
</thead>
<tbody>
<tr>
<td>CBE 310 (3) ________</td>
<td>CBE 430 (3) ________</td>
</tr>
<tr>
<td>CBE 320 (3) ________</td>
<td>CBE 442 (4) ________</td>
</tr>
<tr>
<td>CBE 330 (3) ________</td>
<td>CBE 443 (2) ________</td>
</tr>
<tr>
<td>CBE 331 (3) ________</td>
<td>CBE 451, 452 (3,3) ________ ________</td>
</tr>
<tr>
<td>CBE 332 (3) ________</td>
<td>CBE 333 (2) ________</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Engineering and science elective courses:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bioscience Elective (3) ________</td>
</tr>
<tr>
<td>Engineering Elective (3) ________</td>
</tr>
<tr>
<td>Technical Electives (6) (engineering or science) ________ ________</td>
</tr>
</tbody>
</table>

### AUCC – required courses that are not listed above*

<table>
<thead>
<tr>
<th><strong>AUCC 2A/B:</strong> Advanced Writing (3) _____</th>
<th><strong>AUCC 3D:</strong> Historical Perspectives (3) _____</th>
</tr>
</thead>
<tbody>
<tr>
<td>----------------------------------------</td>
<td>----------------------------------------</td>
</tr>
<tr>
<td><strong>AUCC 3B:</strong> Arts/Humanities (6) _____</td>
<td><strong>AUCC 3E:</strong> Global &amp; Cultural Awareness (3) _____</td>
</tr>
<tr>
<td>----------------------------------------</td>
<td>----------------------------------------</td>
</tr>
<tr>
<td>----------------------------------------</td>
<td>----------------------------------------</td>
</tr>
<tr>
<td><strong>AUCC 3C:</strong> Social/Behavioral Sciences (3) _____</td>
<td></td>
</tr>
</tbody>
</table>

*Note: all numbers in parenthesis indicate credits. *See All University Core Curriculum (AUCC) in the General Catalog for eligible courses.**Take CBE 101 & CBE 160 together OR CO150 ~ PLUS – College of Engineering PLI requirements**
### Suggested program plan

#### Year 1 Fall
- CBE 101* 3
- CBE 160* 1
- MATH 160 4
- CHEM 111 4
- CHEM 112 1
- LIFE 102 4

**Total:** 17

#### Year 1 Spring
- CO150* 3
- MATH 161 4
- CHEM 113 3
- CHEM 114 1
- PH 141 5

**Total:** 16

* CBE 101 and CBE 160 can be taken Fall or Spring, they are offered both semesters. Students not taking CBE 101 and CBE 160 their first semester should take CO150 in place of these.

#### Year 2 Fall
- CBE 201 3
- CBE 205 3
- Math 261 4
- CHEM 341 3
- Arts/Humanities 3

**Total:** 16

#### Year 2 Spring
- CBE 210 3
- MATH 340 4
- CHEM 343 3
- CHEM 344 2
- PH 142 5

**Total:** 17

#### Year 3 Fall
- CBE 310 3
- CBE 330 3
- CBE 331 3
- BC 351 4
- Advanced Writing 3

**Total:** 16

#### Year 3 Spring
- CBE 320 3
- CBE 332 3
- CBE 493 1
- Bioscience elective 3
- Historical Perspectives 3

**Total:** 16

#### Year 4 Fall
- CBE 333 2
- CBE 442 4
- CBE 451 3
- Arts and Humanities 3
- Technical elective 3

**Total:** 15

#### Year 4 Spring
- CBE 430 3
- CBE 443 2
- CBE 452 3
- Technical elective 3
- Engineering elective 3

**Total:** 17

* Consider a summer research experience or internship after Year 3.
Important Notes on Math and Physics Prerequisite Requirements

The CBE curriculum is designed so that the courses from one semester serve as the foundation for those taken in subsequent semesters. This relationship among courses is expressed in the course catalog as lists of prerequisites courses.

Understanding the importance of these prerequisites is important for planning which courses will be taken when, especially when one considers that CBE courses are offered only once per year (i.e., either in the fall or the spring semester).

Of particular importance in the first two years of the CBE program are the requirements for math (MATH) and physics (PH) courses. These are covered in more detail below.

Mathematics

The CBE program, like those of the other engineering programs, requires four semesters of mathematics: MATH 160 (Calculus I), MATH 161 (Calculus II), MATH 261 (Calculus III), and MATH 340 (Differential Equations). The “math mods” are viewed as remedial courses and do not count toward the 130 credits required for graduation with a BS in Chemical and Biological Engineering.

We expect that students will be enrolled in MATH 160 in the fall semester of their first year in our program. There are two critical issues is this is not the case:

a. They are unlikely to take PH 141 in the spring semester (see below)
b. They will not be on track to take the third-year, fall semester CBE courses (CBE 310, 330, and 331)

To address this, students who do not take MATH 160 until the spring semester of their first year have three options:

a. They can get back on track by taking MATH 161 in the summer following their first year in the program (this can be taken at another university or college and transferred to CSU)
b. They can get back on track by taking MATH 340 in the summer following their second year in the program (this can be taken at another university or college and transferred to CSU)
c. They can take a year away from the CBE track after their first or second year in the program to get caught up (and get ahead) in the basic science and math prerequisites.

(over)
Physics
The CBE program requires two semesters of calculus-based physics: PH 141 and PH 142. PH 141 is normally taken in the second semester of the program, since MATH 160 is highly recommended as a prerequisite for this course (officially, it is a co-requisite, but years of experience with this course have made it clear to us that students perform far better in PH 141 if they have had Calculus I first).

While PH 142 is not a prerequisite for other required courses in the CBE program, PH 141 is a prerequisite for CBE 201, Material and Energy Balances. Thus, students who do not take PH 141 in the spring of their first year in the CBE program (e.g., because they did not take MATH 160 in the fall) should plan to take PH 141 in the summer after their first year. (A course equivalent to PH 141 may be taken elsewhere and the credits transferred to CSU.)

Any student who is NOT enrolled in MATH 160 in the fall semester of their first year in the CBE program should discuss these options with their advisor as soon as possible.
C Grade Minimum Requirement for All CBE Prerequisite Courses

In order to help our students gain the necessary skills to succeed in future CBE courses and ultimately to be successful engineers upon graduation, the CBE department is implementing a minimum C grade requirement for all CBE courses that serve as a prerequisite for a future CBE course. This means that you must receive a C grade or better in the prerequisite course before you will be allowed to take future CBE courses for which the class is a prerequisite.

Starting with Spring 2014 semester, you must receive a C grade or better in the following courses which serve as prerequisites for other CBE courses...

- CBE 201 – Material and Energy Balances
- CBE 210 – Thermodynamic Process Analysis
- CBE 310 – Molecular Concepts and Applications
- CBE 320 – Chemical and Biological Reactor Design
- CBE 330 – Process Simulation
- CBE 331 – Momentum Transfer and Mechanical Separations
- CBE 332 – Heat and Mass Transfer Fundamentals
- CBE 442 – Separation Processes
- CBE 451 - Chemical Engineering Design I

Failing to receive a minimum C grade means that you must retake the course before moving on in the CBE curriculum.

In order to ensure consistency in implementation of this requirement across all courses, the CBE faculty developed the following grade interpretation statement. This statement is meant to help clarify what each letter grade represents in terms of student learning and performance in each class.

Grade Interpretation Statement

A grade of 'A' indicates excellent performance. Students receiving an 'A' demonstrate a high level of command of the relevant material with no or only a few minor weaknesses.

A grade of 'B' indicates good performance. Students receiving a 'B' demonstrate good command of the relevant material and several minor to moderate weaknesses.

A grade of 'C' indicates adequate performance. Students receiving a 'C' demonstrate a basic command of the relevant material but also some gaps or moderate weaknesses. A grade of 'C' may be given for performance meeting only the minimum requirements for progression into courses for which the course is a prerequisite.

A grade of 'D' indicates poor performance. Students receiving a 'D' demonstrate major weaknesses in multiple aspects of the relevant materials. It indicates a performance that does not meet the minimum requirements for progression into courses for which the course is a prerequisite.

A grade of 'F' indicates a performance that is unacceptable in many respects.
Notes:
In the statements above, "performance" refers to any and all aspects of a course, including homework assignments, exams, semester projects, and/or laboratory reports. Since each course element contributes to learning and provides evidence of a student's mastery of the course concepts, earning a higher grade requires both completion of the course elements and demonstration of mastery.

Depending on the instructor's preference, plus and minus grades may be used in the course to indicate gradations between grading levels.
Chemical and Biological Engineering BS Degree Curriculum
Required Course Descriptions and Prerequisites

Year 1 – Fall Semester

CBE 101 (3) Chemical and Biological Engineering I. F. (AUCC 3A).
Engineering design and problem solving; technical presentation skills; basic computer programming.

CHEM 111 (4) General Chemistry I. (AUCC 3A). F, S, SS. Prerequisite: (MATH 118 or placement out of MATH 118) or MATH 141 or MATH 155 or MATH 160 or MATH 161 or MATH 229 or MATH 261. Intended for science majors. Students should complete the sequence CHEM 111, CHEM 112, CHEM 113, and CHEM 114. Fundamental aspects of chemistry and chemical principles; emphasis on structure, bonding, and stoichiometry. (GT-SC1)

CHEM 112 (1) General Chemistry Laboratory I. (AUCC 3A). F, S, SS. Prerequisite: CHEM 111 or concurrent registration. Credit not allowed for both CHEM 112 and CHEM 108. Laboratory applications of principles covered in CHEM 111. ($)

MATH 160 (4) Calculus for Physical Scientists I. (AUCC 1B). F, S, SS. Prerequisite: MATH 124, MATH126; concurrent registration in MATH 124. Limits, continuity, differentiation, and integration of elementary functions with applications; conic sections. (GT-MA1)

LIFE 102 (4) Attributes of Living Systems. (AUCC 3A) F, S, SS. Prerequisites: High school chemistry. Levels of organization, stability, and change in living systems. ($)

Year 1 – Spring Semester

CBE 102 (3) Chemical and Biological Engineering II. S. Prerequisite: CBE 101.
Applications of engineering design and problem solving; computer programming to solve engineering problems; team project.

CHEM 113 (3) General Chemistry II. F, S, SS. Prerequisite: CHEM 107 or CHEM 111 or CHEM 117; (MATH 124 or placement out of MATH 124) or MATH 141 or MATH 155 or MATH 160 or MATH 161 or MATH 229 or MATH 261 or concurrent registration in MATH 141 or MATH 155 or MATH 160 or MATH 161 or MATH 229 or MATH 261.
Acid/base equilibria, kinetics, thermodynamics, solubility, oxidation-reduction reactions, electrochemistry, selected topics.

CHEM 114 (1) General Chemistry Laboratory II. F, S, SS. Prerequisite: CHEM 112; CHEM 113 or concurrent registration.
Laboratory applications of principles covered in CHEM 113. ($)

MATH 161 (4) Calculus for Physical Scientists II. (AUCC 1B). F, S, SS. Prerequisite: MATH 124; MATH 160. Graphing calculator required. Must register for lecture and laboratory. Transcendental functions, integration techniques, polar coordinates, sequences and series, with mathematical software.

PH 141 (5) Physics for Scientists and Engineers I. (AUCC 3A). F, S, SS. Prerequisite: (MATH 126 or concurrent registration; MATH 155 or concurrent registration) or (MATH 160 or concurrent registration). [CBE note: We have found that students who have already had Calculus I prior to PH 141 perform much better than those who have not.] Forces, energy, momentum, angular momentum, oscillations, waves, heat, thermodynamics (calculus base)
Year 2 – Fall Semester

CBE 201 (3) Material and Energy Balances. F. Prerequisite: CBE 102 or MATH 151 or concurrent registration in MATH 151; CHEM 111; LIFE 102 or concurrent registration; PH 141. Principles of chemistry, physics, and mathematics applied to development of material and energy balances; illustration of concepts.

CHEM 341 (3) Organic Chemistry I. F, S. Prerequisite: CHEM 113; Students should plan to complete the sequence, CHEM 341, CHEM 343, CHEM 344. Structure, nomenclature, dynamics, spectroscopy, reactions of organic molecules. Laboratory applications of principles presented in lecture. ($)

MATH 261 (4) Calculus for Physical Scientists III. F, S, SS. Prerequisite: MATH 161. Vector functions, partial differentiation, cylindrical and spherical coordinates, multiple integrals, line integrals, Green's theorem.

CO 150 (3) College Composition. (AUCC 1A). F, S, SS. Prerequisite: SAT critical reading score of 600 or above or ACT English score of 26 or above or composition placement/challenge exam (score of 3, 4, or 5) or CO 130. (For students registered at CSU prior to Fall 2008, SAT verbal score of 500 or above or ACT English score of 20 or above.) Understanding and writing for rhetorical situations; critical reading and response; writing source-based argument for academic and public audiences.

Year 2 – Spring Semester

CBE 210 (3) Thermodynamic Process Analysis. S. Prerequisites: CBE 201; MATH 261 or concurrent registration. Thermodynamic fundamentals and applications to ideal and non-ideal mixtures, power cycles, and chemical equilibria.

CHEM 343 (3) Organic Chemistry II. F, S, SS Prerequisite: CHEM 245 or CHEM 341 or CHEM 345. Continue studies of reactions and mechanisms of organic molecules. Laboratory applications of principles presented in lecture. ($)

CHEM 344 (2) Organic Chemistry Lab. F, S, SS Prerequisite: CHEM 343 or concurrent registration or CHEM 346 or concurrent registration. Credit not allowed for both CHEM 344 and CHEM 246. Laboratory applications of modern organic chemistry.

MATH 340 (4) Introduction to Ordinary Differential Equations. F, S, SS. Prerequisite: MATH 255 or MATH 261. Credit allowed for only one of the courses MATH 340, MATH 345, MATH 355. First and second order equations, series, Laplace transforms, linear algebra, eigenvalues, first order systems of equations, numerical techniques.

PH 142 (5) Physics for Scientists and Engineers II. (AUCC 3A). F, S. Prerequisite: PH 141, concurrent registration in MATH 161 or MATH 255. Credit not allowed for both PH 142 and PH 122. Electricity and magnetism, circuits, light, optics (calculus based).

Year 3 – Fall Semester

CBE 310 (3) Molecular Concepts and Applications F Prerequisite: CBE 202 or CBE 210; MATH 340. Application of modern molecular theory to chemical and biological engineering problems in thermodynamics, chemical kinetics, and transport phenomena.

CBE 330 (3) Process Simulation. F. Prerequisite: CBE 210; MATH 340.
Analysis of chemical engineering problems by numerical simulation.

**CBE 331 (3) Momentum Transfer and Mechanical Separations.** F. Prerequisite: CBE 202 or CBE 210 or MECH 237; MATH 340.
Fluid properties; conservation equations; compressible and incompressible flow; pumping and metering; mixing; separation of fluid-solid mixtures.

**BC 351 (4) Principles of Biochemistry.** F, S, SS. Prerequisite: CHEM 245 or CHEM 341 or CHEM 345.
Structure and function of biological molecules; biocatalysis; metabolism and energy transduction; gene expression.

**Year 3 – Spring Semester**

**CBE 320 (3) Chemical and Biological Reactor Design.** S. Prerequisite: CBE 310; CBE 330.
Mechanisms and rates of chemical reactions; design of homogeneous and heterogeneous reactors; biological reactions and reactors.

**CBE 332 (3) Heat and Mass Transfer Fundamentals.** S Prerequisite: CBE 310; CBE 330; CBE 331.
Thermal processes; steady and unsteady conduction; convective heat transfer; radiation; heat exchanger design; mass transfer by diffusion and convection.

**CBE 493 (1) Professional Development Seminar.** S
Topics in engineering professional development, including ethics, role of engineers in society, and life-long learning.

**Year 4 – Fall Semester**

**CBE 333 (2) Momentum and Heat Transfer Laboratory.** F Prerequisite: CBE 332 or concurrent registration.
Laboratory experiments involving material balances, thermodynamics, and momentum and heat transfer. Data analysis; written and oral reports.

**CBE 442 (4) Separation Processes.** F. Prerequisite: CBE 332.
Analysis of chemical and biological separations based on thermodynamics, diffusion, and convective mass transfer; design of separations equipment.

**CBE 451 (3) Chemical Engineering Design I.** F. Prerequisite: CBE 320; CBE 442 or concurrent registration.
Chemical and biological process synthesis and simulation; engineering economics principles.

**Year 4 – Spring Semester**

**CBE 430 (3) Process Control and Instrumentation.** S. Prerequisite: CBE 320; CBE 442.
Measurement and control of process variables; transient chemical and biological processes; feedback, feedforward, and computer control concepts.

**CBE 443 (2) Mass Transfer and Separation Laboratory.** F. Prerequisite: CBE 442 or concurrent registration.
Laboratory experiments involving advanced chemical and biological engineering concepts. Data analysis; written and oral reports.

**CBE 452 (3) Chemical Engineering Design II.** S. Prerequisite: CBE 451.
Projects requiring students to design a chemical and/or biological process with cost estimation and constraint analysis; written and oral reports.
Biochemistry
BC 401: Comprehensive Biochemistry I
BC 403: Comprehensive Biochemistry II (BC 401)
BC 404: Comprehensive Biochemistry Lab (BC 401)

Bioagricultural Sciences and Pest Management
BSPM 302: Applied and General Entomology
BSPM 303A: Entomology Lab (BSPM 302)
BSPM 361: Elements of Plant Pathology

Biomedical Sciences
BMS 300: Principles of Human Physiology
BMS 301: Human Gross Anatomy
BMS 302: Laboratory in Principles in Physiology (BMS 300/360)
BMS 360: Fundamentals of Physiology

Botany/Zoology
BZ 310: Cell Biology
BZ 315: Marine Ecology
BZ 346: Population and Evolutionary Genetics
BZ 350: Molecular and General Genetics

Environmental and Radiological Health Sciences
ERHS 300: Introduction to Radiation Biology
ERHS 448: Environmental Contaminants: Exposure and Fate

Life Sciences
LIFE 201B: Introductory Genetics
LIFE 202B: Introductory Genetics Recitation (LIFE 201B)
LIFE 203: Introductory Genetics Laboratory (LIFE 201B)
LIFE 210: Introductory Eukaryotic Cell Biology
LIFE 211: Eukaryotic Cell Biology Recitation (LIFE 210)
LIFE 212: Intro Cell Biology Laboratory (LIFE 210)
LIFE 320: Ecology

Microbiology
MIP 300: General Microbiology
MIP 301: Fundamental Microbiology Laboratory Techniques (MIP 300)
MIP 302: General Microbiology Laboratory (MIP 300)

Soil and Crop Sciences
SOCR 330: Principles of Genetics
SOCR 331: Genetics Laboratory (SOCR 330)
All BS CBE students are required to complete 48 credits of engineering coursework. As part of this requirement, each student must complete at least 3 credits of an engineering elective.

Eligible engineering elective courses are listed below. Students should choose the engineering elective to reinforce basic engineering concepts and to explore important engineering subjects aligned with the CBE major.

New courses appear frequently and some may be eligible for inclusion in this list. If you are interested in a course not listed below, you must have it approved as an engineering elective before the start of the semester. Engineering electives must be at the 200 level or higher and must contain significant engineering content.

Many more engineering courses are listed on the technical electives list; those shown here were selected because their prerequisites are satisfied by other courses in the CBE curriculum.

### Courses with biological engineering content

<table>
<thead>
<tr>
<th>Course number (credits)</th>
<th>Title</th>
<th>Prerequisite(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>BIOM 470 (3)</td>
<td>Biomedical Engineering</td>
<td>PH 141, MATH 160</td>
</tr>
<tr>
<td>BIOM 525 (3)</td>
<td>Cell and Tissue Engineering</td>
<td>BC 351 or BMS 300</td>
</tr>
<tr>
<td>BIOM 533 (3)</td>
<td>Biomolecular Tools for Engineers</td>
<td>BMS 300 or MIP 300</td>
</tr>
<tr>
<td>CBE 504 (3)</td>
<td>Fundamentals of Biochemical Engineering</td>
<td>MIP 300, MATH 340, CBE 320 or concurrent registration</td>
</tr>
<tr>
<td>CBE 522 (3)</td>
<td>Bioseparation Processes</td>
<td>CBE 331</td>
</tr>
<tr>
<td>CBE 524 (3)</td>
<td>Bioremediation</td>
<td></td>
</tr>
<tr>
<td>CBE 543 (3)</td>
<td>Membranes for Biotechnology and Biomedicine</td>
<td>CHEM 343, CBE 310</td>
</tr>
<tr>
<td>CIVE 536 (1)</td>
<td>Wastewater Treatment</td>
<td>Concurrent registration in CIVE 540</td>
</tr>
<tr>
<td>CBE 540 (2)</td>
<td>Fundamentals of Environmental Biotechnology</td>
<td>None (but MIP 300 would be useful)</td>
</tr>
</tbody>
</table>

### Courses with chemical engineering content

<table>
<thead>
<tr>
<th>Course number (credits)</th>
<th>Title</th>
<th>Prerequisite(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>ATS 555 (3)</td>
<td>Air Pollution</td>
<td>CHEM 113 and (MATH 261 or MATH 340) and PH 142</td>
</tr>
<tr>
<td>ATS 560 (2)</td>
<td>Air Pollution Measurement</td>
<td>CHEM 114 [additional CBE restriction: ATS 555 is a prerequisite]</td>
</tr>
<tr>
<td>CBE 406 (3)</td>
<td>Introduction to Transport Phenomena</td>
<td>CBE 332, CBE 310</td>
</tr>
<tr>
<td>Course number (credits)</td>
<td>Title</td>
<td>Prerequisite(s)</td>
</tr>
<tr>
<td>-------------------------</td>
<td>--------------------------------------------</td>
<td>------------------------------------------------------</td>
</tr>
<tr>
<td>CBE 501 (3)</td>
<td>Chemical Engineering Thermodynamics</td>
<td>MATH 340, CBE 210</td>
</tr>
<tr>
<td>CBE 502 (3)</td>
<td>Advanced Reactor Design</td>
<td>CBE 320, CBE 332</td>
</tr>
<tr>
<td>CBE 503 (3)</td>
<td>Transport Phenomena Fundamentals</td>
<td>CBE 406 (or CBE 331 and 332)</td>
</tr>
<tr>
<td>CBE 504 (3)</td>
<td>Fundamentals of Biochemical Engineering</td>
<td>CBE 320 or concurrent registration; Math 340; MIP 300</td>
</tr>
<tr>
<td>CBE 514 (3)</td>
<td>Polymer Science and Engineering</td>
<td>CHEM 343 or CHEM 346; CBE 310</td>
</tr>
<tr>
<td>CBE 521 (3)</td>
<td>Mathematical Modeling for Chemical Engineers</td>
<td>MATH 340</td>
</tr>
<tr>
<td>CIVE 538 (3)</td>
<td>Aqueous Chemistry</td>
<td>CHEM 113, MATH 340</td>
</tr>
</tbody>
</table>

**Courses with other engineering content**

<table>
<thead>
<tr>
<th>Course number (credits)</th>
<th>Title</th>
<th>Prerequisite(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>CIVE 260 (3)</td>
<td>Engineering Mechanics – Statics</td>
<td>MATH 160, PH 141 or concurrent registration</td>
</tr>
<tr>
<td>CIVE 261 (3)</td>
<td>Engineering Mechanics – Dynamics</td>
<td>CIVE 260</td>
</tr>
<tr>
<td>CIVE 322 (3)</td>
<td>Basic Hydrology</td>
<td>CBE 331*, (CIVE 202 or STAT 301 or STAT 315)**</td>
</tr>
<tr>
<td>CIVE 360 (3)</td>
<td>Mechanics of Solids</td>
<td>CIVE 260</td>
</tr>
<tr>
<td>CIVE 401 (3)</td>
<td>Hydraulic Engineering</td>
<td>CBE 331*</td>
</tr>
<tr>
<td>CIVE 413 (3)</td>
<td>Environmental River Mechanics</td>
<td>CBE 331*</td>
</tr>
<tr>
<td>CIVE 423 (3)</td>
<td>Groundwater Engineering</td>
<td>CBE 331*</td>
</tr>
<tr>
<td>CIVE 425 (3)</td>
<td>Soil and Water Engineering</td>
<td>CBE 331*</td>
</tr>
<tr>
<td>CIVE 438 (4)</td>
<td>Pollution Control Engineering</td>
<td>CHEM 113, CBE 331*</td>
</tr>
<tr>
<td>CIVE 440 (3)</td>
<td>Nonpoint Source Pollution</td>
<td>CBE 331</td>
</tr>
<tr>
<td>CIVE 450 (4)</td>
<td>Introduction to Geotechnical Engineering</td>
<td>CIVE 360</td>
</tr>
<tr>
<td>CIVE 504 (3)</td>
<td>Wind Engineering</td>
<td>CBE 331*</td>
</tr>
<tr>
<td>CIVE 520 (3)</td>
<td>Physical Hydrology</td>
<td>CIVE 322</td>
</tr>
<tr>
<td>CIVE 531 (3)</td>
<td>Groundwater Hydrology</td>
<td>CBE 331*</td>
</tr>
<tr>
<td>CIVE 560 (3)</td>
<td>Advanced Mechanics of Materials</td>
<td>CIVE 360</td>
</tr>
<tr>
<td>ECE 204 (3)</td>
<td>Introduction to Electrical Engineering</td>
<td>MATH 161, PH 142</td>
</tr>
<tr>
<td>ENGR 510 (3)</td>
<td>Linear Programming and Network Flows</td>
<td>MATH 261</td>
</tr>
<tr>
<td>ENVE 322 (3)</td>
<td>Basic Hydrology</td>
<td>Same as CIVE 322</td>
</tr>
<tr>
<td>ENVE 438 (4)</td>
<td>Pollution Control Engineering</td>
<td>Same as CIVE 438</td>
</tr>
<tr>
<td>MECH 331 (4)</td>
<td>Introduction to Engineering Materials</td>
<td>CHEM 111, CHEM 112, PH 142 (each with a C or better)</td>
</tr>
<tr>
<td>MECH 437 (3)</td>
<td>Internal Combustion Engines</td>
<td>CBE 332*</td>
</tr>
<tr>
<td>MECH 460 (3)</td>
<td>Aeronautics</td>
<td>CBE 331*</td>
</tr>
<tr>
<td>Course Code</td>
<td>Course Title</td>
<td>Corequisites</td>
</tr>
<tr>
<td>-------------</td>
<td>----------------------------------------------</td>
<td>--------------</td>
</tr>
<tr>
<td>MECH 463 (3)</td>
<td>Building Energy Systems</td>
<td>CBE 332*</td>
</tr>
<tr>
<td>MECH 558 (3)</td>
<td>Combustion</td>
<td>CBE 332*</td>
</tr>
<tr>
<td>MECH 575 (3)</td>
<td>Solar and Alternative Energies</td>
<td>CBE 331*, CBE 332*</td>
</tr>
</tbody>
</table>

*Indicates CBE version of another course; an override from the instructor/host department will be necessary.

** It may be possible to do well in CIVE 322 without these statistics requirements; interested students should meet with the course instructor to check this and to understand what background material they should cover on their own.

### Independent Study/Thesis

Independent study credits can be earned through one or more of the following courses:
- BIOM 486, Biomedical Clinical Practicum
- ENGR 298, Undergraduate Research
- ENGR 498, Undergraduate Research
- CBE 495, Independent Study
- HONR 499, Honors Thesis

Independent study credits from BIOM 486, ENGR 298/498, and CBE 495 may count toward the requirements for engineering content. However, a plan for the independent study, including the topic, activities, and outcomes (e.g., research paper), must be prepared and approved by the Director of Undergraduate Studies, Dr. Reardon, prior to the start of the semester in which the course is taken. A maximum of three credits toward the program requirements may be earned through independent study.
Notes:

1. **ALL courses on the bioscience elective list and the engineering elective list are also eligible as technical electives.**
2. *This list is not exhaustive*; other science and engineering courses may be eligible. However, they should be at the 200 level or higher and have appropriate technical content. If you are interested in a course not on this list, ask your advisor or the Director of Undergraduate Studies before taking the course.
3. **Plan ahead!** If you are interested in a particular elective course, check the catalog to find out what prerequisites are required.
4. Courses marked with the symbol @ are not offered every year.

<table>
<thead>
<tr>
<th>Course number (credits)</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Astronomy</strong></td>
<td></td>
</tr>
<tr>
<td>AA 301@ (5)</td>
<td>Astrophysics I</td>
</tr>
<tr>
<td>AA 302@ (5)</td>
<td>Astrophysics II</td>
</tr>
<tr>
<td>AA 303@ (5)</td>
<td>Astrophysics III</td>
</tr>
<tr>
<td><strong>Bioagricultural Sciences and Pest Management</strong></td>
<td></td>
</tr>
<tr>
<td>BSPM 450@ (3)</td>
<td>Molecular Plant-Microbe Interactions</td>
</tr>
<tr>
<td><strong>Biochemistry</strong></td>
<td></td>
</tr>
<tr>
<td>BC 463 (3)</td>
<td>Molecular Genetics</td>
</tr>
<tr>
<td>BC 465 (3)</td>
<td>Molecular Regulation of Cell Function</td>
</tr>
<tr>
<td><strong>Biomedical Engineering</strong></td>
<td></td>
</tr>
<tr>
<td>BIOM 531 (3)</td>
<td>Materials Engineering</td>
</tr>
<tr>
<td>BIOM 532 (3)</td>
<td>Material Issues in Mechanical Design</td>
</tr>
<tr>
<td>BIOM 570 (3)</td>
<td>Bioengineering</td>
</tr>
<tr>
<td>BIOM 571 (3)</td>
<td>Biomechanics</td>
</tr>
<tr>
<td>BIOM 573 (3)</td>
<td>Structure and Function of Biomaterials</td>
</tr>
<tr>
<td><strong>Biomedical Sciences</strong></td>
<td></td>
</tr>
<tr>
<td>BMS 410 (3)</td>
<td>Physiological Responses to the Environment</td>
</tr>
<tr>
<td>BMS 420 (3)</td>
<td>Cardiopulmonary Physiology</td>
</tr>
<tr>
<td>BMS 430 (3)</td>
<td>Endocrinology</td>
</tr>
<tr>
<td>BMS 450 (3)</td>
<td>Pharmacology</td>
</tr>
<tr>
<td>BMS 500 (4)</td>
<td>Mammalian Physiology I</td>
</tr>
<tr>
<td>BMS 501 (4)</td>
<td>Mammalian Physiology II</td>
</tr>
<tr>
<td>BMS 550 (3)</td>
<td>Electron Microscopy – TEM, SEM, and X-Ray</td>
</tr>
<tr>
<td>BMS 560@ (3)</td>
<td>Theory and Practice of Animal Biotechnology</td>
</tr>
<tr>
<td><strong>Biotechnology</strong></td>
<td></td>
</tr>
<tr>
<td>BTEC 450@ (2)</td>
<td>Topics in Biotechnology</td>
</tr>
<tr>
<td><strong>Botany/Zoology</strong></td>
<td></td>
</tr>
<tr>
<td>BZ 311 (4)</td>
<td>Developmental Biology</td>
</tr>
<tr>
<td>BZ 348 (4)</td>
<td>Theory of Population and Evolutionary Ecology</td>
</tr>
<tr>
<td>Course number (credits)</td>
<td>Title</td>
</tr>
<tr>
<td>------------------------</td>
<td>------------------------------------------------------------</td>
</tr>
<tr>
<td>BZ 440 (3)</td>
<td>Plant Physiology</td>
</tr>
<tr>
<td>BZ 441 (2)</td>
<td>Plant Physiology Laboratory</td>
</tr>
<tr>
<td>BZ 450 (4)</td>
<td>Plant Ecology</td>
</tr>
<tr>
<td>BZ 476 (3)</td>
<td>Topics in Advanced Genetics</td>
</tr>
<tr>
<td>BZ 572 (3)</td>
<td>Phytoremediation</td>
</tr>
<tr>
<td>CM 501 (4)</td>
<td>Advanced Cell Biology</td>
</tr>
<tr>
<td>CM 502 (2)</td>
<td>Techniques in Molecular &amp; Cellular Biology</td>
</tr>
<tr>
<td><strong>Chemistry</strong></td>
<td></td>
</tr>
<tr>
<td>CHEM 261 (3)</td>
<td>Fundamentals of Inorganic Chemistry</td>
</tr>
<tr>
<td>CHEM 331 (3)</td>
<td>Quantitative Analysis – Biological Sciences</td>
</tr>
<tr>
<td>CHEM 334 (1)</td>
<td>Quantitative Analysis Laboratory – Biological</td>
</tr>
<tr>
<td>CHEM 335 (3)</td>
<td>Introduction to Analytical Chemistry</td>
</tr>
<tr>
<td>CHEM 332 (2)</td>
<td>Quantitative Analysis Laboratory</td>
</tr>
<tr>
<td>CHEM 431 (4)</td>
<td>Instrumental Analysis</td>
</tr>
<tr>
<td>CHEM 433 (3)</td>
<td>Clinical Chemistry</td>
</tr>
<tr>
<td>CHEM 440 (2)</td>
<td>Advanced Organic Laboratory</td>
</tr>
<tr>
<td>CHEM 461 (3)</td>
<td>Inorganic Chemistry</td>
</tr>
<tr>
<td>CHEM 462 (2)</td>
<td>Inorganic Chemistry Laboratory</td>
</tr>
<tr>
<td>CHEM 511 (3)</td>
<td>Solid State Chemistry</td>
</tr>
<tr>
<td>CHEM 515 (3)</td>
<td>Polymer Chemistry</td>
</tr>
<tr>
<td>CHEM 517 (3)</td>
<td>Chemistry of Electronic Materials</td>
</tr>
<tr>
<td>CHEM 530 (1)</td>
<td>Advanced Topics in Chemical Analysis</td>
</tr>
<tr>
<td>CHEM 537 (3)</td>
<td>Electrochemical Methods</td>
</tr>
<tr>
<td>CHEM 539 (1)</td>
<td>Principles of NMR and MRI</td>
</tr>
<tr>
<td>CHEM 543 (3)</td>
<td>Structure/Mechanisms in Organic Chemistry</td>
</tr>
<tr>
<td>CHEM 547 (3)</td>
<td>Physical Organic Chemistry</td>
</tr>
<tr>
<td>CHEM 551 (3)</td>
<td>Organometallic Chemistry</td>
</tr>
<tr>
<td>CHEM 565 (3)</td>
<td>Inorganic Mechanisms</td>
</tr>
<tr>
<td>CHEM 569 (3)</td>
<td>Chemical Crystallography</td>
</tr>
<tr>
<td>CHEM 570 (3)</td>
<td>Chemical Bonding</td>
</tr>
<tr>
<td>CHEM 571 (3)</td>
<td>Quantum Chemistry</td>
</tr>
<tr>
<td>CHEM 575 (3)</td>
<td>Chemical Thermodynamics</td>
</tr>
<tr>
<td>CHEM 576 (3)</td>
<td>Statistical Mechanics</td>
</tr>
<tr>
<td>CHEM 577 (3)</td>
<td>Surface Chemistry</td>
</tr>
<tr>
<td>CHEM 579 (3)</td>
<td>Chemical Kinetics</td>
</tr>
<tr>
<td><strong>Computer Science</strong></td>
<td></td>
</tr>
<tr>
<td>CS 160 (4)</td>
<td>Foundations in Programming</td>
</tr>
<tr>
<td>CS 161 (4)</td>
<td>Object-Oriented Problem Solving</td>
</tr>
<tr>
<td>CS 200 (4)</td>
<td>Algorithms and Data Structures</td>
</tr>
<tr>
<td>CS 270 (4)</td>
<td>Computer Organization</td>
</tr>
<tr>
<td>CS 301 (4)</td>
<td>Foundations of Computer Science</td>
</tr>
<tr>
<td>CS 420 (4)</td>
<td>Introduction to Analysis of Algorithms</td>
</tr>
<tr>
<td><strong>Environmental Engineering</strong></td>
<td></td>
</tr>
<tr>
<td>ENVE 441 (1)</td>
<td>Water and Wastewater Characterization</td>
</tr>
<tr>
<td><strong>Environmental and Radiological Health Science</strong></td>
<td></td>
</tr>
<tr>
<td>ERHS 446 (3)</td>
<td>Environmental Toxicology</td>
</tr>
<tr>
<td>Course number (credits)</td>
<td>Title</td>
</tr>
<tr>
<td>------------------------</td>
<td>---------------------------------------------------------</td>
</tr>
<tr>
<td>ERHS 502 (3)</td>
<td>Fundamentals of Toxicology</td>
</tr>
<tr>
<td>ERHS 510 (3)</td>
<td>Cancer Biology</td>
</tr>
<tr>
<td>ERHS 547 (3)</td>
<td>Equipment and Instrumentation</td>
</tr>
<tr>
<td><strong>Forest Sciences</strong></td>
<td></td>
</tr>
<tr>
<td>F 311 (3)</td>
<td>Forest Ecology</td>
</tr>
<tr>
<td><strong>Food Technology</strong></td>
<td></td>
</tr>
<tr>
<td>FTEC 447 (2)</td>
<td>Food Chemistry</td>
</tr>
<tr>
<td>FTEC 572 (2)</td>
<td>Food Biotechnology</td>
</tr>
<tr>
<td><strong>Geoscience</strong></td>
<td></td>
</tr>
<tr>
<td>GEOL 150 (4)</td>
<td>Physical Geology for Scientists and Engineers</td>
</tr>
<tr>
<td>GEOL 454 (4)</td>
<td>Geomorphology</td>
</tr>
<tr>
<td><strong>Health and Exercise Science</strong></td>
<td></td>
</tr>
<tr>
<td>HES 307 (3)</td>
<td>Biomechanical Principles of Human Movement</td>
</tr>
<tr>
<td>HES 319 (3)</td>
<td>Neuromuscular Aspects of Human Movement</td>
</tr>
<tr>
<td>HES 403 (4)</td>
<td>Physiology of Exercise</td>
</tr>
<tr>
<td><strong>Mathematics</strong></td>
<td></td>
</tr>
<tr>
<td>MATH 317 (4)</td>
<td>Advanced Calculus of One Variable</td>
</tr>
<tr>
<td>MATH 332 (3)</td>
<td>Partial Differential Equations</td>
</tr>
<tr>
<td>MATH 348 (4)</td>
<td>Theory of Population and Evolutionary Ecology</td>
</tr>
<tr>
<td>MATH 366 (3)</td>
<td>Introduction to Abstract Algebra</td>
</tr>
<tr>
<td>MATH 369 (3)</td>
<td>Linear Algebra</td>
</tr>
<tr>
<td>MATH 405 (3)</td>
<td>Introduction to Number Theory</td>
</tr>
<tr>
<td>MATH 417 (3)</td>
<td>Advanced Calculus I</td>
</tr>
<tr>
<td>MATH 418 (3)</td>
<td>Advanced Calculus II</td>
</tr>
<tr>
<td>MATH 419 (3)</td>
<td>Introduction to Complex Variables</td>
</tr>
<tr>
<td>MATH 455 (3)</td>
<td>Mathematics in Biology and Medicine</td>
</tr>
<tr>
<td>MATH 469 (3)</td>
<td>Linear Algebra II</td>
</tr>
<tr>
<td>MATH 501 (3)</td>
<td>Combinatorics I</td>
</tr>
<tr>
<td>MATH 502 (3)</td>
<td>Combinatorics II</td>
</tr>
<tr>
<td>MATH 510 (3)</td>
<td>Linear Programming and Network Flows</td>
</tr>
<tr>
<td>MATH 520 (3)</td>
<td>Nonlinear Programming</td>
</tr>
<tr>
<td>MATH 525 (3)</td>
<td>Optimal Control</td>
</tr>
<tr>
<td>MATH 530 (4)</td>
<td>Mathematics for Scientists and Engineers</td>
</tr>
<tr>
<td>MATH 531 (3)</td>
<td>Discrete Models of Physical Systems</td>
</tr>
<tr>
<td>MATH 532 (3)</td>
<td>Mathematical Modeling of Large Data Sets</td>
</tr>
<tr>
<td>MATH 545 (3)</td>
<td>Partial Differential Equations I</td>
</tr>
<tr>
<td>MATH 546 (3)</td>
<td>Partial Differential Equations II</td>
</tr>
<tr>
<td><strong>Mechanical Engineering</strong></td>
<td></td>
</tr>
<tr>
<td>MECH 307 (4)</td>
<td>Mechatronics and Measurement Systems</td>
</tr>
<tr>
<td>MECH 431 (3)</td>
<td>Metals and Alloys</td>
</tr>
<tr>
<td>MECH 468 (3)</td>
<td>Space Propulsion and Power Engineering</td>
</tr>
<tr>
<td>MECH 530 (3)</td>
<td>Advanced Composite Materials</td>
</tr>
<tr>
<td>MECH 531 (3)</td>
<td>Materials Engineering</td>
</tr>
<tr>
<td>MECH 532 (3)</td>
<td>Material Issues in Mechanical Design</td>
</tr>
</tbody>
</table>
### Microbiology

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>MIP 334 (3)</td>
<td>Food Microbiology</td>
</tr>
<tr>
<td>MIP 335@ (2)</td>
<td>Food Microbiology Laboratory</td>
</tr>
<tr>
<td>MIP 342 (3)</td>
<td>Immunology</td>
</tr>
<tr>
<td>MIP 343 (2)</td>
<td>Immunology Laboratory</td>
</tr>
<tr>
<td>MIP 350 (3)</td>
<td>Microbial Diversity</td>
</tr>
<tr>
<td>MIP 351 (3)</td>
<td>Medical Bacteriology</td>
</tr>
<tr>
<td>MIP 352 (2)</td>
<td>Medical Bacteriology Laboratory</td>
</tr>
<tr>
<td>MIP 420 (4)</td>
<td>Medical and Molecular Virology</td>
</tr>
<tr>
<td>MIP 432@ (3)</td>
<td>Microbial Ecology</td>
</tr>
<tr>
<td>MIP 433@ (1)</td>
<td>Microbial Ecology Laboratory</td>
</tr>
<tr>
<td>MIP 436@ (4)</td>
<td>Industrial Microbiology</td>
</tr>
<tr>
<td>MIP 443 (4)</td>
<td>Microbial Physiology</td>
</tr>
<tr>
<td>MIP 450 (3)</td>
<td>Microbial Genetics</td>
</tr>
<tr>
<td>MIP 576 (3)</td>
<td>Bioinformatics</td>
</tr>
<tr>
<td>MIP 578 (4)</td>
<td>Genetics of Natural Populations</td>
</tr>
</tbody>
</table>

### Natural Resources

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>NR 300 (3)</td>
<td>Biological Diversity</td>
</tr>
<tr>
<td>NR 322 (4)</td>
<td>Introduction to Geographic Information Systems</td>
</tr>
<tr>
<td>NR 323 (3)</td>
<td>Remote Sensing of Natural Resources</td>
</tr>
</tbody>
</table>

### Natural Sciences

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>NSCI 380A2@ (3)</td>
<td>Introduction to Nanoscale Science</td>
</tr>
</tbody>
</table>

### Physics

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>PH 314 (4)</td>
<td>Introduction to Modern Physics</td>
</tr>
<tr>
<td>PH 315 (2)</td>
<td>Modern Physics Laboratory</td>
</tr>
<tr>
<td>PH 341 (4)</td>
<td>Mechanics</td>
</tr>
<tr>
<td>PH 351 (4)</td>
<td>Electricity and Magnetism</td>
</tr>
<tr>
<td>PH 353 (4)</td>
<td>Optics and Waves</td>
</tr>
<tr>
<td>PH 361 (3)</td>
<td>Physical Thermodynamics</td>
</tr>
<tr>
<td>PH 451 (3)</td>
<td>Introductory Quantum Mechanics I</td>
</tr>
<tr>
<td>PH 452 (3)</td>
<td>Introductory Quantum Mechanics II</td>
</tr>
<tr>
<td>PH 521 (3)</td>
<td>Introduction to Lasers</td>
</tr>
<tr>
<td>PH 522 (1)</td>
<td>Introductory Laser Laboratory</td>
</tr>
<tr>
<td>PH 531 (3)</td>
<td>Introductory Solid State Physics</td>
</tr>
<tr>
<td>PH 541 (3)</td>
<td>Classical Physics</td>
</tr>
<tr>
<td>PH 551 (3)</td>
<td>Modern Physics</td>
</tr>
<tr>
<td>PH 561 (3)</td>
<td>Elementary Particle Physics</td>
</tr>
<tr>
<td>PH 571 (3)</td>
<td>Mathematical Methods for Physicists I</td>
</tr>
<tr>
<td>PH 572 (3)</td>
<td>Mathematical Methods for Physicists II</td>
</tr>
</tbody>
</table>

### Soil and Crop Sciences

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>SOCR 240 (4)</td>
<td>Introductory Soil Science</td>
</tr>
<tr>
<td>SOCR 330 (3)</td>
<td>Principles of Genetics</td>
</tr>
<tr>
<td>SOCR 455 (3)</td>
<td>Soil Microbiology</td>
</tr>
<tr>
<td>SOCR 456 (1)</td>
<td>Soil Microbiology Laboratory</td>
</tr>
<tr>
<td>SOCR 467 (3)</td>
<td>Soil and Environmental Chemistry</td>
</tr>
<tr>
<td>SOCR 470 (3)</td>
<td>Soil Physics</td>
</tr>
<tr>
<td>SOCR 471 (1)</td>
<td>Soil Physics Laboratory</td>
</tr>
<tr>
<td>Course Code</td>
<td>Course Title</td>
</tr>
<tr>
<td>-------------</td>
<td>--------------------------------------------------</td>
</tr>
<tr>
<td>SOCR 478 (3)</td>
<td>Environmental Soil Sciences</td>
</tr>
<tr>
<td>SOCR 479 (1)</td>
<td>Environmental Soil Science Laboratory</td>
</tr>
<tr>
<td>SOCR 560 (3)</td>
<td>Chemical Equilibria in Soils</td>
</tr>
<tr>
<td><strong>Statistics</strong></td>
<td></td>
</tr>
<tr>
<td>STAT 305 (3)</td>
<td>Sampling Techniques</td>
</tr>
<tr>
<td>STAT 315 (3)</td>
<td>Statistics for Engineers and Scientists</td>
</tr>
<tr>
<td>STAT 340 (3)</td>
<td>Multiple Regression Analysis</td>
</tr>
<tr>
<td>STAT 350 (3)</td>
<td>Design of Experiments</td>
</tr>
<tr>
<td>STAT 372 (3)</td>
<td>Data Analysis Tools</td>
</tr>
<tr>
<td>STAT 420 (3)</td>
<td>Probability and Mathematical Statistics I</td>
</tr>
<tr>
<td>STAT 430 (3)</td>
<td>Probability and Mathematical Statistics II</td>
</tr>
<tr>
<td>STAT 511 (3)</td>
<td>Design and Data Analysis for Researchers I</td>
</tr>
<tr>
<td>STAT 512 (3)</td>
<td>Design and Data Analysis for Researchers II</td>
</tr>
</tbody>
</table>
All-University Core Curriculum

Office of Vice Provost for Undergraduate Affairs
Administration Building, Room 108
core.colostate.edu

ALL-UNIVERSITY CORE CURRICULUM (AUCC)

All Colorado State University students share a learning experience in common. Faculty from across the University contribute to that experience.

Each baccalaureate Program of Study must incorporate the following elements:

1. Basic Competencies (6 credits)
   A. Intermediate Writing\(^1\) 3
   B. Mathematics\(^1\) 3

2. Advanced Writing (3 credits)\(^2,3\)

3. Foundations and Perspectives (22 credits)
   A. Biological/Physical Sciences 7
      (At least one course will have an associated lab)
   B. Arts/Humanities 6
   C. Social/Behavioral Sciences 3
   D. Historical Perspectives 3
   E. Global and Cultural Awareness 3

4. Depth and Integration
   A. Each major must designate courses that build upon the Core Competencies of writing, speaking, and problem solving in an integrative and complementary way.
   B. Each major must designate courses that build upon the foundations of knowledge and intellectual perspectives of Core Category 3 in an integrative and complementary way.
   C. Every major must require a capstone experience at the senior level that consists of a designated course or sequence of courses that offer the opportunity for integration and reflection on students’ nearly completed baccalaureate education.

1 The composition and mathematics requirements must be completed within the first 60 credits (CSU and transfer) taken. More information on this requirement is at the end of this section of the catalog.
2 First-time students entering a college or university on or after July 1, 2008, must take an advanced writing course (category 2). Some programs of study have specific requirements. For advanced writing, see the particular program of study.
3 Students are advised to see if their preferred program of study has particular recommendations for satisfying All-University Core Curriculum requirements.

A student must earn a cumulative grade point average of 2.000 or better in the courses used to satisfy categories 1 through 3 of the All-University Core Curriculum requirements.

What follows is a brief description of each category in the All-University Core Curriculum and a list of the courses currently approved to meet that category. Note: No courses are listed in more than one category; courses listed in one category cannot be used to fulfill any other category in the AUCC.

Category 1. Basic Competencies

A. Intermediate Writing\(^1\) The ability to write correctly and effectively is necessary for success in any academic program and enhances the possibility of one’s success in personal and professional life. The objective of courses in this category is to provide instruction in the skills essential to effective written communication, extensive practice in the use of those skills, and evaluation of students’ writing aimed to guide them in improving their skills.

CO 150 College Composition (GT-CO2)\(^2\) 3
HONR 193 Honors Seminar (must be enrolled in University Honors program) 3

1 The composition requirement must be completed within the first 60 credits (CSU and transfer) taken. More information on this requirement is at the end of this section of the catalog.
2 Certain Colorado State University courses have been approved by the Colorado Department of Higher Education (CDHE) as general education courses guaranteed to transfer statewide among all public higher education institutions in Colorado. The subcode refers to the specific statewide general education category the course fulfills. For more information visit the CDHE website: highered.colorado.gov/Academics/Transfers/gtPathways/curriculum.html
3 First-time students entering a college or university on or after July 1, 2008, must take an advanced writing course (category 2). Some programs of study have specific requirements; see the particular program of study.

B. Mathematics\(^1\) The objective of the Mathematics requirement is to ensure that students develop mathematical
skill and understanding essential for describing events, experiences, and the knowledge base of other disciplines. Mathematics encourages a mode of thought that encompasses abstraction and generalization and permits careful analysis as well as explicit calculation.

MATH 117 College Algebra in Context I (GT-MA1) \(^2\) 1
MATH 118 College Algebra in Context II (GT-MA1) 1
MATH 124 Logarithmic and Exponential Function (GT-MA1)
MATH 125 Numerical Trigonometry (GT-MA1) 1
MATH 126 Analytic Trigonometry (GT-MA1) 1
MATH 130 Math in the Social Sciences (GT-MA1) 3
MATH 133 Financial Mathematics (GT-MA1) 3
MATH 135 Patterns of Phenomena I (GT-MA1) 3
MATH 141 Calculus in Management Sciences (GT-MA1)
MATH 155 Calculus for Biological Scientists I (GT-MA1) 4
MATH 160 Calculus for Physical Scientists I (GT-MA1) 4
MATH 161 Calculus for Physical Scientists II (GT-MA1) 4
MATH 255 Calculus for Biological Scientists II (GT-MA1) 4

1 The mathematics requirement must be completed within the first 60 credits (CSU and transfer) taken. More information on this requirement is at the end of this section of the catalog.
2 Certain Colorado State University courses have been approved by the Colorado Department of Higher Education (CDHE) as general education courses guaranteed to transfer statewide among all public higher education institutions in Colorado. The subcode refers to the specific statewide general education category the course fulfills. For more information visit the CDHE website: highered.colorado.gov/Academics/Transfers/gtPathways/curriculum.html

Category 2. Advanced Writing. (3 credits)\(^1\)

Building on and adapting basic skills and strategies already developed in the course in Written Communication, the objective of this requirement is enhancement of skills in written communication to extend rhetorical knowledge, to extend experience in writing processes, to extend mastery of writing convention, to demonstrate comprehension of content knowledge at the advanced level through effective communication strategies.

BUS 300 Business Writing and Communication 3
CHEM 301 Advanced Scientific Writing: Chemistry 3
CO 300 Writing Arguments (GT-CO3) 3
CO 301A Writing in the Disciplines-Arts and Humanities (GT-CO3) 3
CO 301B Writing in the Disciplines-Sciences (GT-CO3) 3
CO 301C Writing in the Disciplines-Social Sciences (GT-CO3) 3
CO 301D Writing in the Disciplines-Education (GT-CO3) 3
CO 302 Writing Online (GT-CO3) 3
JTC 300 Professional and Technical Communication (GT-CO3) 3
LB 300 Specialized Professional Writing 3

1 First-time students entering a college or university on or after July 1, 2008, must take an advanced writing course (category 2). Some programs of study have specific requirements for advanced writing, see the particular program of study.

Category 3. Foundations and Perspectives.

The Core rests on acquiring foundations of knowledge and understanding intellectual perspectives. Courses in this category of the Core are designed to bring the skills developed in Core Competencies to life and give them direction and purpose. Elements of foundation offer exemplary introductions to fields and areas of study that explore their distinctive characteristics as well as critical links within and among them. Elements of perspective promote coherence and integration of knowledge within and among fields and areas of study, often through the exploration of significant thematic issues. Foundation elements frequently will be introduced in disciplinary contexts. Perspective elements typically will be structured comparatively and enlivened through interdisciplinary contexts.

A. Biological/Physical Sciences. (7 credits) The objective of the Biological/Physical Sciences requirement is to install a clear understanding of the basic scientific viewpoint, to master scientific knowledge at a level that facilitates communication in an increasingly technological society, to employ and build on core competencies in mathematics and logical/critical thinking, to enable students to learn and use the scientific method, and to evaluate the impacts of science and technology on society.

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>AA 100</td>
<td>Introduction to Astronomy (GT-SC2)(^2)</td>
<td>3</td>
</tr>
<tr>
<td>AA 101</td>
<td>Astronomy Laboratory (GT-SC1)</td>
<td>1</td>
</tr>
<tr>
<td>ANTH 120</td>
<td>Human Origins and Variation (GT-SC2)</td>
<td>3</td>
</tr>
<tr>
<td>ANTH 121</td>
<td>Human Origins and Variation Laboratory (GT-SC1)</td>
<td>1</td>
</tr>
<tr>
<td>BSPM 102</td>
<td>Insects, Science, and Society (GT-SC2)</td>
<td>3</td>
</tr>
<tr>
<td>BZ 101</td>
<td>Humans and Other Animals (GT-SC2)</td>
<td>3</td>
</tr>
<tr>
<td>BZ 104</td>
<td>Basic Concepts of Plant Life (GT-SC2)</td>
<td>3</td>
</tr>
<tr>
<td>BZ 105</td>
<td>Basic Concepts of Plant Life Laboratory (GT-SC1)</td>
<td>1</td>
</tr>
<tr>
<td>BZ 110</td>
<td>Principles of Animal Biology (GT-SC2)</td>
<td>3</td>
</tr>
<tr>
<td>BZ 111</td>
<td>Animal Biology Laboratory (GT-SC1)</td>
<td>1</td>
</tr>
<tr>
<td>BZ 120</td>
<td>Principles of Plant Biology (GT-SC2)</td>
<td>4</td>
</tr>
<tr>
<td>CHEM 103</td>
<td>Chemistry in Context (GT-SC2)</td>
<td>3</td>
</tr>
<tr>
<td>CHEM 104</td>
<td>Chemistry in Context Laboratory (GT-SC1)</td>
<td>1</td>
</tr>
<tr>
<td>CHEM 107</td>
<td>Fundamentals of Chemistry (GT-SC2)</td>
<td>4</td>
</tr>
<tr>
<td>CHEM 108</td>
<td>Fundamentals of Chemistry Laboratory (GT-SC1)</td>
<td>1</td>
</tr>
<tr>
<td>CHEM 111</td>
<td>General Chemistry I (GT-SC2)</td>
<td>4</td>
</tr>
<tr>
<td>CHEM 112</td>
<td>General Chemistry Laboratory I (GT-SC1)</td>
<td>1</td>
</tr>
<tr>
<td>FW 104</td>
<td>Wildlife Ecology and Conservation (GT-SC2)</td>
<td>3</td>
</tr>
<tr>
<td>GEO 120</td>
<td>Exploring Earth: Physical Geology(^3)</td>
<td>3</td>
</tr>
<tr>
<td>GEO 121</td>
<td>Introductory Geology Laboratory(^3) (GT-SC1)</td>
<td>1</td>
</tr>
<tr>
<td>GEO 122</td>
<td>The Blue Planet: Geology of Our Environment(^3) (GT-SC2)</td>
<td>3</td>
</tr>
<tr>
<td>GEO 124</td>
<td>Geology of Natural Resources(^3) (GT-SC2)</td>
<td>3</td>
</tr>
<tr>
<td>HORT 100</td>
<td>Horticultural Sciences</td>
<td>4</td>
</tr>
<tr>
<td>LAND 220</td>
<td>Fundamentals of Ecology (GT-SC2)</td>
<td>3</td>
</tr>
<tr>
<td>LIFE 102</td>
<td>Attributes of Living Systems (GT-SC1)</td>
<td>4</td>
</tr>
<tr>
<td>LIFE 201A</td>
<td>Introductory Genetics-Applied Genetics(^3)</td>
<td>3</td>
</tr>
</tbody>
</table>

\(^{1}\) First-time students entering a college or university on or after July 1, 2008, must take an advanced writing course (category 2). Some programs of study have specific requirements for advanced writing, see the particular program.
### All-University Core Curriculum

<table>
<thead>
<tr>
<th>Code</th>
<th>Description</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>LIFE 201B</td>
<td>Introductory Genetics-Molecular (GT-SC2)</td>
<td>3</td>
</tr>
<tr>
<td>LIFE 220</td>
<td>Fundamentals of Ecology (GT-SC2)</td>
<td>3</td>
</tr>
<tr>
<td>MIP 101</td>
<td>Introduction to Human Disease (GT-SC2)</td>
<td>3</td>
</tr>
<tr>
<td>NR 120A</td>
<td>Environmental Conservation (GT-SC2)</td>
<td>3</td>
</tr>
<tr>
<td>NR 130</td>
<td>Global Environmental Systems (GT-SC2)</td>
<td>3</td>
</tr>
<tr>
<td>NR 150</td>
<td>Oceanography (GT-SC2)</td>
<td>3</td>
</tr>
<tr>
<td>PH 110</td>
<td>Descriptive Physics (GT-SC2)</td>
<td>3</td>
</tr>
<tr>
<td>PH 111</td>
<td>Descriptive Physics Laboratory (GT-SC1)</td>
<td>1</td>
</tr>
<tr>
<td>PH 121</td>
<td>General Physics I (GT-SC1)</td>
<td>5</td>
</tr>
<tr>
<td>PH 122</td>
<td>General Physics II (GT-SC1)</td>
<td>5</td>
</tr>
<tr>
<td>PH 141</td>
<td>Physics for Scientists and Engineers I (GT-SC1)</td>
<td>5</td>
</tr>
<tr>
<td>PH 142</td>
<td>Physics for Scientists and Engineers II (GT-SC1)</td>
<td>5</td>
</tr>
<tr>
<td>WR 304</td>
<td>Principles of Watersheds Management</td>
<td>3</td>
</tr>
</tbody>
</table>

1. At least one course must have a laboratory component. Sometimes the laboratory component is a separate course number.
2. Certain Colorado State University courses have been approved by the Colorado Department of Higher Education (CDHE) as general education courses guaranteed to transfer statewide among all public higher education institutions in Colorado. The subcode refers to the specific statewide general education category the course fulfills. For more information visit the CDHE website: [highe dụr.colorado.gov/academics/Transfers/getPathways/curriculum.html](http://www.highered.colorado.gov/academics/Transfers/getPathways/curriculum.html)
3. Credit allowed for only one of the following: GEOG 120, GEOG 122, GEOG 124, GEOG 150, G CC 130, G 140.
4. Credit allowed for only one of the following: GEOG 121, GEOG 150, G 140.
5. Credit not allowed for both LIFE 201A and LIFE 201B.
6. Credit not allowed for both NR 130 and G CC 130 and NR 130.

#### B. Arts/Humanities. (6 credits)
The arts and humanities explore expressions that are uniquely human. The objective of the Arts/Humanities requirement is to investigate the cultural character and literatures of human experiences, fundamental questions of value and meaning, and, both in word and beyond words, the symbols and creative expressions of human life.

| ART 100 | Introduction to the Visual Arts (GT-AH1) | 3 |
| D 110 | Understanding Dance (GT-AH1) | 3 |
| E 140 | The Study of Literature (GT-AH2) | 3 |
| E 232 | Introduction to Humanities (GT-AH2) | 3 |
| E 242 | Reading Shakespeare (GT-AH2) | 3 |
| E 270 | Introduction to American Literature (GT-AH2) | 3 |
| E 276 | Survey of British Literature I (GT-AH2) | 3 |
| E 277 | Survey of British Literature II (GT-AH2) | 3 |
| ETST 240 | Native American Cultural Expressions (GT-AH2) | 3 |
| HONR 392 | Seminar (must be enrolled in University Honors program) | 3 |
| LARA 200 | Second Year Arabic I (GT-AH4) | 4 |
| LARA 201 | Second Year Arabic II (GT-AH4) | 4 |
| LARA 250 | Arabic Language, Literature, and Culture in Translation (GT-AH2) | 3 |
| LCHI 200 | Second Year Chinese I (GT-AH4) | 5 |
| LCHI 201 | Second Year Chinese II (GT-AH4) | 5 |
| LCHI 250 | Chinese Language, Literature, and Culture in Translation (GT-AH2) | 3 |
| LFRE 200 | Second Year French I (GT-AH4) | 3 |
| LFRE 201 | Second Year French II (GT-AH4) | 3 |
| LFRE 250 | French Language, Literature, and Culture in Translation (GT-AH2) | 3 |
| LGER 200 | Second Year German I (GT-AH4) | 3 |
| LGER 201 | Second Year German II (GT-AH4) | 3 |
| LGER 250 | German Language, Literature, and Culture in Translation (GT-AH2) | 3 |
| LJPN 200 | Second Year Japanese I (GT-AH4) | 5 |
| LJPN 201 | Second Year Japanese II (GT-AH4) | 5 |
| LJPN 250 | Japanese Language, Literature, and Culture in Translation (GT-AH2) | 3 |
| LRUS 200 | Second Year Russian I (GT-AH4) | 3 |
| LRUS 201 | Second Year Russian II (GT-AH4) | 3 |
| LRUS 250 | Russian Language, Literature, and Culture in Translation (GT-AH2) | 3 |
| LSPA 200 | Second Year Spanish I (GT-AH4) | 3 |
| LSPA 201 | Second Year Spanish II (GT-AH4) | 3 |
| LSPA 250 | Spanish Language, Literature, and Culture in Translation (GT-AH2) | 3 |
| MU 100 | Music Appreciation (GT-AH1) | 3 |
| MU 111 | Music Theory Fundamentals (GT-AH1) | 3 |
| MU 131 | Introduction to Music History and Literature (GT-AH1) | 3 |
| PHIL 100 | Appreciation of Philosophy (GT-AH3) | 3 |
| PHIL 103 | Moral and Social Problems (GT-AH3) | 3 |
| PHIL 110 | Logic and Critical Thinking (GT-AH3) | 3 |
| PHIL 120 | History and Philosophy of Scientific Thought (GT-AH3) | 3 |
| SPCM 100 | Communication and Popular Culture (GT-AH1) | 3 |
| SPCM 201 | Rhetoric in Western Thought (GT-AH3) | 3 |
| TH 141 | Introduction to Theatre (GT-AH1) | 3 |

1. Certain Colorado State University courses have been approved by the Colorado Department of Higher Education (CDHE) as general education courses guaranteed to transfer statewide among all public higher education institutions in Colorado. The subcode refers to the specific statewide general education category the course fulfills. For more information visit the CDHE website: [highe Dudley.colorado.gov/academics/Transfers/getPathways/curriculum.html](http://www.highered.colorado.gov/academics/Transfers/getPathways/curriculum.html)
2. No more than three credits of intermediate foreign language (L** 200, L** 201) may be used toward this category.

#### C. Social/Behavioral Sciences. (3 credits)
The social/behavioral sciences use similar methods of description and analysis to study the complex behaviors of individuals and their relationships with others in families, public associations, and cultures. The objective of the Social/Behavioral Sciences requirement is to explore the forms and implications of individual and collective behaviors, their ties to formal institutions, and the methods by which they are studied.

| ANTH 100 | Introductory Cultural Anthropology (GT-S3) | 3 |
| AREC 202 | Agricultural and Resource Economics (GT-S1) | 3 |
| AREC 240 | Issues in Environmental Economics (GT-S1) | 3 |
| ECON 101 | Economics of Social Issues (GT-S1) | 3 |
| ECON 202 | Principles of Microeconomics (GT-S1) | 3 |
| ECON 204 | Principles of Macroeconomics (GT-S1) | 3 |
| ECON 212 | Racial Inequality and Discrimination (GT-S1) | 3 |
| ECON 240 | Issues in Environmental Economics (GT-S1) | 3 |
| EDUC 275 | Schooling in the U.S. (GT-S3) | 3 |
| GR 100 | Introduction to Geography (GT-S2) | 3 |
| HDFS 101 | Individual and Family Development (GT-S3) | 3 |
| HONR 492 | Senior Seminar (must be enrolled in University Honors program) | 3 |
| JTC 100 | Media in Society (GT-S3) | 3 |
D. Historical Perspectives. (3 credits) The objective of the Historical Perspectives requirement is to engage students in an analytical, chronological study of significant, multidimensional human experiences. It should also provide students with a foundation for relating beliefs about the past to aspirations for the future.

- AMST 100 Self/Community in American Culture, 1600-1877 (GT-AH2) 3
- AMST 101 Self/Community in American Culture Since 1877 (GT-AH2) 3
- ANTH 140 Introduction to Prehistory (GT-HI1) 3
- ETST 250 African American History (GT-HI1) 3
- ETST 252 Asian American History (GT-HI1) 3
- ETST 255 Native American History (GT-HI1) 3
- HIST 100 Western Civilization, Pre Modern (GT-HI1) 3
- HIST 101 Western Civilization, Modern (GT-HI1) 3
- HIST 115 Islamic World to 1500 (GT-HI1) 3
- HIST 120 Asian Civilizations I (GT-HI1) 3
- HIST 121 Asian Civilizations II (GT-HI1) 3
- HIST 150 U.S. History to 1876 (GT-HI1) 3
- HIST 151 U.S. History Since 1876 (GT-HI1) 3
- HIST 170 World History, Ancient-1500 (GT-HI1) 3
- HIST 171 World History, 1500-Present (GT-HI1) 3
- HIST 250 African American History (GT-HI1) 3
- HIST 252 Asian American History (GT-HI1) 3
- HIST 255 Native American History (GT-HI1) 3
- NR 320 Natural Resources History and Policy 3

E. Global and Cultural Awareness.1, 3 (3 credits) The objective of the Global and Cultural Awareness requirement is to engage students in the study of particular cultural identities, explore the interactions among these cultural identities, and consider the ways in which these patterns of interaction are related to the larger global context in which they take place.

- AGRI 116 Plants and Civilization (GT-SS3) 3
- AGRI 270 World Interdependence-Population and Food (GT-SS3) 3
- AM 250 Clothing, Adornment, and Human Behavior (GT-SS3) 3
- ANTH 200 Cultures and the Global System (GT-SS3) 3
- E 238 20th Century Fiction (GT-AH2) 3
- E 245 World Drama (GT-AH2) 3
- ECON 211 Gender in the Economy (GT-SS1) 3
- ETST 100 Introduction to Ethnic Studies (GT-SS3) 3
- ETST 205 Ethnicity and the Media (GT-SS3) 3
- ETST 253 Chicana/o History and Culture (GT-HI1) 3
- ETST 256 Border Crossings: People/Poetics/Culture (GT-SS3) 3
- HORT 201 Environmental Issues in Agriculture (GT-SS3) 3
- IE 105 Plants and Civilizations (GT-SS3) 3
- IE 270 World Interdependence-Population and Food (GT-SS3) 3
- IE 390 Model United Nations 3
- LB 170 World Literatures to 1500 (GT-AH2) 3
- LB 171 World Literatures-The Modern Period (GT-AH2) 3
- PHIL 120 World Philosophies (GT-AH3) 3
- POLS 131 Current World Problems (GT-SS1) 3
- POLS 232 International Relations (GT-SS1) 3
- POLS 241 Comparative Government and Politics (GT-SS1) 3
- SA 482 Approved Study Abroad Courses (Contact the Office of International Programs) 12
- SO 205 Contemporary Race-Ethnic Relations (GT-SS3) 3
- SOCR 171 Environmental Issues in Agriculture (GT-SS3) 3

1 Certain Colorado State University courses have been approved by the Colorado Department of Higher Education (CDHE) as general education courses guaranteed to transfer statewide among all public higher education institutions in Colorado. The subcode refers to the specific statewide general education category the course fulfills. For more information visit the CDHE website: highered.colorado.gov/Academics/Transfers/gtPathways/curriculum.html

2 Certain Colorado State University courses have been approved by the Colorado Department of Higher Education (CDHE) as general education courses guaranteed to transfer statewide among all public higher education institutions in Colorado. The subcode refers to the specific statewide general education category the course fulfills. For more information visit the CDHE website: highered.colorado.gov/Academics/Transfers/gtPathways/curriculum.html

3 Certain Colorado State University courses have been approved by the Colorado Department of Higher Education (CDHE) as general education courses guaranteed to transfer statewide among all public higher education institutions in Colorado. The subcode refers to the specific statewide general education category the course fulfills. For more information visit the CDHE website: highered.colorado.gov/Academics/Transfers/gtPathways/curriculum.html

Note Regarding the All-University Core Curriculum

Credits earned in the College Board Advanced Placement Program (AP), the College-Level Examination Program (CLEP), and International Baccalaureate (IB) can be used to satisfy particular All-University Core Curriculum requirements.

ENGLISH COMPOSITION REQUIREMENT

The University English composition requirement must be fulfilled by all undergraduate students prior to completion of 60 credits. Students can complete the requirement in one of five ways:
1. Satisfactory completion of CO 150, College Composition.

2. Fulfillment of the CO 150 requirement by achieving a score of 5 on the Advanced Placement English Composition and Literature Test; or a score of 4 or 5 on the Advanced Placement English Language and Composition Test; or placing in CO 150, section 550 (automatic credit for CO 150) on the Department of English Composition Placement/Challenge Examination (see below).

3. Transfer of equivalent credits from another college. Students who transfer with less than 2.6 semester credits in composition will be required to take the Composition Placement/Challenge Examination before enrolling in CO 150.

4. Satisfactory completion of BOTH HONR 192 AND HONR 193 (honors students only).

5. Submission of International Baccalaureate scores that document a 5, 6, or 7 earned for English and thus have satisfied the All-University Core Curriculum requirement for CO 150.

Credit for CO 150 will not be given for high scores on the College-Level Examination Program (CLEP).

Students (except first semester transfer and readmitted students) who have earned 60 or more Colorado State and transfer semester credits and who have not met this requirement will have a COMPOSITION HOLD placed on their record. Transfer and readmitted students will be allowed the initial term of enrollment before this restriction is imposed.

**COMPOSITION HOLD Removal Procedure**

The procedure to remove a COMPOSITION HOLD is as follows: If a student has completed or has transfer credit for CO 130 (Academic Writing), he or she can contact the Registrar’s Centennial Hall Office (or (970) 491-4860) to register for CO 150. If a student scored 600 or higher on the SAT critical reading or 26 or higher on the ACT English and submitted those scores to Colorado State, he or she can contact the Records Office to register for CO 150. (Students who were enrolled at CSU and taking classes prior to Fall 2008 are eligible to register for CO 150 with an SAT verbal score of 500 or higher or an ACT English score of 20 or higher). Otherwise, the student should take the Composition Placement/Challenge Examination (see below). Once a student’s Composition Placement/Challenge Exam score has been entered into the system, he or she can contact the Registrar’s Centennial Hall Office (or (970) 491-4860) to register for the composition class they placed into. The Registrar’s Office will remove the COMPOSITION HOLD and register the student for either CO 130 or CO 150. If a student drops or withdraws from the course or does not earn a passing grade, the grade of record will become an “F.” This grade of “F” will be included in the calculation of both the semester GPA and the cumulative GPA as a consequence of not completing the 60-credit completion requirement.

**Composition Placement/Challenge Exam and Placement Procedures**

Students who score 600 or higher on the SAT critical reading or 26 or higher on the ACT English are eligible to register for CO 150. (Students who were enrolled at CSU and taking classes prior to Fall Semester 2008 are eligible to register for CO 150 with an SAT verbal score of 500 or higher or an ACT English score of 20 or higher). Students with CO 130 (Academic Writing) credit are eligible to register for CO 150. Students who have not satisfied the University English composition requirement in one of the five ways explained above or who do not have the appropriate SAT/ACT score or CO 130 credit, must take the English Composition Placement/Challenge Exam. For more information refer to [writing.colostate.edu/comp/placement.cfm](http://writing.colostate.edu/comp/placement.cfm). All students taking this exam will be assessed a service charge of $18.00, which will be billed to their student account. The proctored examination is offered at the beginning of each semester and during preregistration each semester (contact the Department of English for time and place, (970) 491-6428). Incoming students may take the Composition Placement/Challenge Exam one time in a non-proctored (online) setting prior to their term of admission using a compatible personal computer. They may retake the test on campus in a proctored setting only ONCE. If a student does choose to retake the test, they will be charged the $18 service charge. Students can check their composition placement by logging onto RAMweb. On the homepage, under Records, select Composition Placement/Challenge Exam Results. On the basis of this examination students are placed as follows:

1. If placement scores indicate a lack of basic writing skills, students can prepare for CO 150 through either a tutorial program in the Writing Center (Eddy 6) or placement into CO 130 – a course designed to provide an intensive writing experience. Students completing the Writing Center Tutorial will then enroll in CO 130. The Writing Center tutorial does not require registration and does not carry University credit. Students will need to stop by the Writing Center the first or second week of the fall or spring semester to schedule their tutorial hour. Students will work with a tutor for one hour a week, for at least one semester, strengthening their writing skills. For tutorial assignment, students should contact the Writing Center (Eddy 6), (970) 491-0222.

2. If placement scores indicate adequate preparation in writing skills, students are placed in CO 150, College Composition.
3. If placement scores indicate superior writing skills, students are placed in CO 150-Section 550, College Composition-By Exam. Students receiving CO 150-Section 550 credit will be automatically enrolled in CO 150-Section 550 and will receive three semester credits of CO 150.

**MATHEMATICS REQUIREMENT**

To satisfy the requirements of category 1B of the All-University Core Curriculum (AUCC), students must earn three credits in mathematics. These credits may be earned by

1. scoring well on the Colorado State University Mathematics Placement Exam (MPE);
2. presenting AP calculus scores from high school of 3, 4, or 5 on either AB or BC exam;
3. taking mathematics courses at Colorado State; or
4. presenting suitable transfer credits from another accredited institution.

The MPE covers pre-college algebra and college algebra, logarithmic and exponential functions, and trigonometry. All entering freshmen are required to take the MPE, unless they can satisfy point 2) or 4) above. All other students must also take the MPE and obtain a satisfactory score before taking any mathematics course, unless they can satisfy either points 2) or 4) above.

A student who displays proficiency on the MPE may place out of one or more of the pre-calculus mini-courses—MATH 117, MATH 118, MATH 124, MATH 125, and MATH 126 without earning credit. Placement out of a mini-course on the MPE will satisfy University prerequisites. A student who demonstrates a higher level of proficiency may earn credit in one or more of those courses. Only earned credits count toward the three-credit University mathematics requirement.

A student (except a first semester transfer or a first semester readmitted student) who has earned 60 or more Colorado State and transfer semester credits and who has not completed the requirements of category 1B of the All-University Core Curriculum must enroll in a course that will fulfill this requirement in order to have a hold lifted from his/her registration. If a student drops or withdraws from the course or does not earn a passing grade, the grade of record will become an “F.” This grade of “F” will be included in the calculation of both the semester GPA and the cumulative GPA as a consequence for not completing the 60-credit completion requirement as defined by this policy. A transfer or readmitted student will be allowed the initial term of full-time enrollment before this restriction is imposed.

**Appeals Process**

A student wishing to appeal this registration restriction must write a detailed rationale as to why he or she was unable to complete the course within the first 60 credits. This appeal must be received by the student’s academic adviser and department head. If both the adviser and department head approve the appeal, it is then sent to the dean’s office of the student’s primary major for approval or disapproval. If the dean supports the appeal, it must be presented through the Records Office, First Floor, Centennial Hall (formerly Administration Annex), to the Vice Provost for Undergraduate Affairs who holds authority for final approval or disapproval.

---

*Colorado State University reserves the right at any time, without notice, to change, modify, or cancel any course, program, procedure, policy, financial requirement, or disciplinary arrangement set forth in this catalog whenever, in its sole discretion, it determines such action to be appropriate. Furthermore, Colorado State will not be responsible for any failure to present or complete any course or program or to perform any other activity, function, or obligation mentioned in this catalog. Since changes may occur at any time, students must check the relevant website (as noted throughout various chapters in this catalog).*
Examples of minors and interdisciplinary studies programs with choices of bioscience and technical electives

For each of the minors and interdisciplinary studies programs (ISPs) listed below, suggested choices are listed for the bioscience, engineering, and technical electives. These are in addition to the required CBE courses (such as CHEM 345, MATH 160, and BC 351). To earn the minor or ISP, all of the courses listed must be taken. However, even if you don’t complete the minor or ISP requirements you will still gain knowledge of that particular subject area.

In all cases, you should contact the department sponsoring the minor or ISP to obtain the most current information and a checksheet.

Biochemistry minor (21 credits total)

**NOTE:** For this minor, you will replace BC 351 (4) with BC 401 (3), 403 (3) and 404 (2)

<table>
<thead>
<tr>
<th>Bioscience elective:</th>
<th>LIFE 201B (3) + LIFE 203 (2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Engineering elective:</td>
<td>any (does not count toward this ISP); CBE 504 is a good choice</td>
</tr>
<tr>
<td>Technical electives:</td>
<td>LIFE 210 (3) + LIFE 212 (2)</td>
</tr>
<tr>
<td></td>
<td>BC 401 (3) + BC 403 (3) + BC 404 (2)</td>
</tr>
<tr>
<td></td>
<td>BC 493 (1)</td>
</tr>
<tr>
<td></td>
<td>Plus BC 411 (4) or BC 463 (3) or BC 465 (3)</td>
</tr>
</tbody>
</table>

Credits beyond CBE requirements: 9/8

Biomedical Engineering ISP (21 credits total)

<table>
<thead>
<tr>
<th>Bioscience elective:</th>
<th>BMS 300 (4)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Engineering elective:</td>
<td>BIOM 470 (3)</td>
</tr>
<tr>
<td>Technical electives:</td>
<td>13 credits from an approved list (BC351 (4) and Chem 341/345 (3/4) are on the list and count towards those 13 credits.</td>
</tr>
</tbody>
</table>

Credits beyond CBE requirements: 1

Biomedical Sciences minor (21 credits total)

<table>
<thead>
<tr>
<th>Bioscience elective:</th>
<th>BMS 300 (4)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Engineering elective:</td>
<td>any (does not count toward this ISP); BIOM 470 is the most relevant</td>
</tr>
<tr>
<td>Technical electives:</td>
<td>BMS 301 (5) or BMS 305 (4) or BMS 330 (4)</td>
</tr>
<tr>
<td></td>
<td>BMS 325 (3) or BMS 345 (4) or BMS 365 (3)</td>
</tr>
<tr>
<td></td>
<td>plus 8-10 credits from an approved list of BMS and BZ courses</td>
</tr>
</tbody>
</table>

Credits beyond CBE requirements: 10

Business minor (24 credits)

<table>
<thead>
<tr>
<th>Bioscience elective:</th>
<th>any</th>
</tr>
</thead>
<tbody>
<tr>
<td>Engineering elective:</td>
<td>any</td>
</tr>
<tr>
<td>Technical electives:</td>
<td>any</td>
</tr>
</tbody>
</table>

**AUCC:** choose ECON 202 for Category 3C

21 credits of specified business courses

Credits beyond CBE requirements: 21
Chemistry minor (24-26 credits total)
Bioscience elective: any
Engineering elective: any (does not count toward this ISP); CBE 514 is the most relevant
Technical electives: 7 credits of chemistry from their list – including at least 1 lab
Credits beyond CBE requirements: 0

Computer Science minor (28 credits total)
Bioscience elective: any
Engineering elective: any
Technical electives: CS 160 (4)
CS 161 (4)
CS 200 (4)
CS 270 (4)
plus 12 credits of CS courses numbered 300 or higher
Credits beyond CBE requirements: 21

Environmental Engineering minor (21 credits total)
Bioscience elective: MIP 300 (3)
Engineering elective: ENVE 438 (4)
Technical electives: CIVE 440
3 credits from the ENVE list (that are also on the CBE list)
Credits beyond CBE requirements: 3 (CIVE 439 (3))

Food Science/Safety ISP (24 credits total)
Bioscience elective: MIP 300 (3)
Engineering elective: any (does not count toward this ISP); CBE 504 is the most relevant
Technical electives: MIP 334 (3)
8 credits from an approved list (with constraints)
Credits beyond CBE requirements: 4

Global and Environmental Sustainability minor (21 credits total)
Bioscience elective: LIFE 320
Engineering elective: any
Technical Elective: EHRS 448 (3) and MATH 348 (3)
Plus 1 additional credit of tech elective from the CBE list
Credits beyond CBE requirements: 9 (AGRI 116 should be chosen for AUCC3E or GR100 for AUCC 3C)

Mathematics minor (23 credits total)
Bioscience elective: any
Engineering elective: any
Technical electives: 7 credits of MATH electives
Credits beyond CBE requirements: none
Microbiology minor (21 credits total)
Bioscience elective: MIP 300 (3)
Engineering elective: any (does not count toward this ISP); CBE 504 is the most relevant
Technical electives: MIP 302 (1) 
MIP 342 (4)
MIP 351 (3) or MIP 420 (4)
MIP 443 (4) or MIP 450 (3)
plus 4-6 credits from an approved list of MIP courses
Credits beyond CBE requirements: 10

Physics minor (22 credits total)
Bioscience elective: any
Engineering elective: any
Technical electives: PH 314 (4)
plus 8 credits from an approved list of AA and PH courses
Credits beyond CBE requirements: 5

Pre-Med (general requirements for medical programs; neither minor nor ISP)
See the CASA Pre-Professional Advising Office for more information: http://www.casa.colostate.edu/Pre-Professional/
General recommendations:
Bioscience elective: LIFE 103 (special permission)
Engineering elective: any (does not count toward this goal); BIOM 470 is the most relevant
Technical electives: STAT 315 (3)
BMS 300 (4) or BMS 360 (4)
BMS 301 (5)
MIP 300 (3) and 302 (2)
AUCC electives: consider CO 300/301 (Category 2B) or E 140 (Category 3B)
Credits beyond CBE requirements: 10

Pre-Vet (general requirements for veterinary programs; neither minor nor ISP)
See the CASA Pre-Professional Advising Office for more information: http://www.casa.colostate.edu/Pre-Professional/
General recommendations:
Bioscience elective: LIFE 103 (special permission)
Engineering elective: any (does not count toward this goal); BIOM 470 is the most relevant
Technical electives: STAT 315 (3)
BMS 300 (4) or BMS 360 (4)
SOCR 330 (3) or MIP 450 (3) or BZ 350 (4) or BC 463 (3)
Credits beyond CBE requirements: 3-4
Chemical and Biological Engineering

Example Focus Areas

The following lists provide suggestions for your choices of bioscience, engineering, and technical electives and are not necessarily complete. Also, you should check the prerequisites required for each course.

Agricultural biotechnology
Do you have an interest in agricultural applications, such as developing new ways to improve crops and their yields?

Bioscience elective:  Principles of Genetics (SOCR 330)

Engineering elective:  Soil and Water Engineering (CIVE 425)

Technical electives:  Entomology (BSPM 302), Fundamentals of Pesticides (BSPM 310), Elements of Plant Pathology (BSPM 361), Plant-Microbe Interactions (BSPM 450), Plant Physiology (BS 440), Plant Ecology (BZ 450), Ecology (LIFE 320), Soil Science (SOCR 240), Soil Microbiology (SOCR 455), Theory and Practice of Animal Biotechnology (BMS 560)

Biochemical engineering and Bioprocessing
Do you have interest in the production of chemicals, pharmaceuticals, and fuels through biotechnology?

Bioscience elective:  General Microbiology (MIP 300)

Engineering elective:  Biochemical Engineering (CBE 504)

Technical electives:  Bioseparation Processes (CBE 522), Fundamentals of Environmental Biotechnology (CBE 540), Industrial Microbiology (MIP 436), Microbial Physiology (MIP 443), Eukaryotic Cell Biology (LIFE 210, 211, 212), Food Microbiology (MIP 334, MIP 335), Topics in Biotechnology (BTEC 450), Statistics for Engineers and Scientists (STAT 315)

Biomedical engineering
Do you have an interest in biomedical engineering, such as developing new artificial organs and medical devices?

Bioscience elective:  Principles of Human Anatomy and Physiology (BMS 300)

Engineering elective:  Biomedical Engineering (BIOM 470)

Technical electives:  Cell and Tissue Engineering (CBE 525), Polymer Science and Engineering (CBE 514), Cell Biology (BZ 310), Biomedical Clinical Practicum (BIOM 468), Biomechanics (BIOM 571), Structure and Function in Biomaterials (BIOM 573), Cardiopulmonary Physiology (BMS 420), Cancer Biology (ERHS 510), Introduction to Engineering Materials (ME 331), Statistics for Engineers and Scientists (STAT 315)
Data analysis and experimental design

Do you have an interest in advanced data analysis techniques and efficient experimental design?

**Bioscience elective:** Ecology (LIFE 320), Genetics (BZ 350, MIP 350), or other

**Engineering elective:** Linear Programming and Network Flows (ENGR 510)

**Technical electives:** Statistics for Engineers and Scientists (STAT 315), Design of Experiments (STAT 350), Multiple Regression Analysis (STAT 340), Sampling Techniques (STAT 305), Probability and Mathematical Statistics (STAT 420, 430), Design and Data Analysis for Researchers (STAT 511, 512)

Environmental science and engineering

Do you have an interest in environmental applications, such as understanding the role of chemicals in the environment and helping to reduce their negative impact?

**Bioscience elective:** Ecology (LIFE 320) or General Microbiology (MIP 300)

**Engineering elective:** Pollution Control Engineering (CIVE 438)

**Technical electives:** Bioremediation (CBE 524), Environmental Biotechnology (CIVE 540), Soil Microbiology (SOCR 455), Wastewater Treatment (CIVE 536), Aqueous Chemistry (CIVE 538), Nonpoint Source Pollution (CIVE 440), Basic Hydrology (ENVE 322), Water and Wastewater Characterization (ENVE 441), Air Pollution (ATS 555, 560), Statistics for Engineers and Scientists (STAT 315), Environmental Toxicology (ERHS 446)

Materials science and engineering

Do you have an interest in the application of physics, chemistry, and engineering towards the fabrication and characterization of new materials?

**Bioscience elective:** General Microbiology (MIP 300)

**Engineering elective:** Polymer Science and Engineering (CBE 514)

**Technical electives:** Polymer Chemistry (CHEM 515), Solid State Chemistry (CHEM 511), Chemistry of Electronic Materials (CHEM 517), Structure and Function in Biomaterials (BIOM 573), Introduction to Engineering Materials (MECH 331), Surface Chemistry (CHEM 577), Materials Engineering (MECH 331), Metals and Alloys (MECH 431)

Mathematical modeling, with applications to physical and biological systems

Do you have an interest in theoretical and computational modeling and advanced mathematics applied to physical and biological systems?

**Bioscience elective:** General Microbiology (MIP 300) or Principles of Human Anatomy and Physiology (BMS 300)

**Engineering elective:** Linear Programming and Network Flows (ENGR 510)

**Technical electives:** Mathematical Modeling for Chemical Engineers (CBE 521), Partial Differential Equations (MATH 332), Introduction to Complex Variables (MATH 419), Discrete Models of Physical Systems (MATH 531), Partial Differential Equations (MATH 545, 546), PMathematical Methods for Physicists I (PH 571, 572), Algorithms and Data Structures (CS 2000), Analysis of Algorithms (CS 420)
Medical applications

Do you have an interest in medicine?

**Bioscience elective:** Principles of Human Anatomy and Physiology (BMS 300)

**Engineering elective:** Biomedical Engineering (BIOM 470)

**Technical electives:** Human Gross Anatomy (BMS 301), Lab in Principles in Physiology (BMS 300), Introductory Genetics (LIFE 201B), Introductory Genetics Lab (LIFE 203), Immunology (MIP 342), Immunology Lab (MIP 343), Medicinal Bacteriology (MIP 351), Medicinal Bacteriology Lab (MIP 352), Biomechanical Principles of Human Movement (HES 307), Neuromuscular Principles of Human Movement (HES 319), Clinical Chemistry (CHEM 433)

Optical and electronic devices

Do you have an interest in the physics of optical and electronic devices and their applications?

**Bioscience elective:** Any

**Engineering elective:** Introduction to Engineering Materials (MECH 331)

**Technical electives:** Electricity and Magnetism PH (351), Optics and Waves (PH 353), Introduction to Lasers (PH 521/522), Instrumental Analysis (CHEM 431), Chemistry of Electronic Materials (CHEM 517), Introduction to Modern Physics (PH 314/315)

Pharmaceuticals: design, development, and production

Do you have an interest in working in the pharmaceutical industry, such as working to understand the effects and safety of newly developed drugs?

**NOTE:** for this focus area, you will replace BC 351 (4) with BC 401 (3), 403 (3) and 404 (2)

**Bioscience elective:** Comprehensive Biochemistry I (BC 401)

**Engineering elective:** Biochemical Engineering (CBE 504)

**Technical electives:** Comprehensive Biochemistry II (BC 403), Comprehensive Biochemistry Lab (BC 404), Pharmacology (BMS 450), Bioseparation Processes (CBE 522), Eukaryotic Cell Biology (LIFE 210), Fundamentals of Physiology (BMS 310), Pharmacology (BMS 450), Instrumental Analysis (CHEM 431), Clinical Chemistry (CHEM 433), Microbial Physiology (MIP 443), Industrial Microbiology (MIP 436), Statistics for Engineers and Scientists (STAT 315)
<table>
<thead>
<tr>
<th>COURSE</th>
<th>NAME (PREREQS)</th>
<th>TERM*</th>
<th>CR</th>
<th>COURSE</th>
<th>NAME (PREREQS)</th>
<th>TERM*</th>
<th>CR</th>
</tr>
</thead>
<tbody>
<tr>
<td>BIOM 101</td>
<td>Intro to Biomedical Engineering</td>
<td>F</td>
<td>3</td>
<td>CBE 102</td>
<td>Chemical and Biological Engineering II</td>
<td>S</td>
<td>3</td>
</tr>
<tr>
<td>CBE 101</td>
<td>Chemical and Biological Engineering I</td>
<td>F</td>
<td>3</td>
<td>MATH 161</td>
<td>Calc for Physical Scientists II (MATH 124; MATH 160)</td>
<td>F,S,SS</td>
<td>4</td>
</tr>
<tr>
<td>MATH160</td>
<td>Calculus for Phys Sci I (MATH 124; MATH 126)</td>
<td>F,S,SS</td>
<td>4</td>
<td>PH 141</td>
<td>Physics for Sci and Engr I (MATH 126; 155 or 160)</td>
<td>F,S,SS</td>
<td>5</td>
</tr>
<tr>
<td>CHEM 111</td>
<td>General Chemistry I (MATH 118 or 124 or 155 or 160 or 161 or 229 or 261)</td>
<td>F,S,SS</td>
<td>4</td>
<td>CHEM 113</td>
<td>General Chemistry II (MATH 107 or 111 or 117; MATH 124 or 141 or 160 or 161 or 229 or 261 (or conc.)</td>
<td>F,S,SS</td>
<td>3</td>
</tr>
<tr>
<td>CHEM 112</td>
<td>General Chemistry Lab I (CHEM 111 (conc.) or 117 (conc.))</td>
<td>F,S,SS</td>
<td>1</td>
<td>CHEM 114</td>
<td>General Chemistry Lab II (CHEM 112 or 113 (or conc.)</td>
<td>F,S,SS</td>
<td>1</td>
</tr>
<tr>
<td>MATH 261</td>
<td>Calc for Physical Scientists III (MATH 161)</td>
<td>F,S,SS</td>
<td>4</td>
<td>CBE 210</td>
<td>Thermodynamic Process Analysis (MATH 201; MATH 261)</td>
<td>S</td>
<td>3</td>
</tr>
<tr>
<td>CO 150</td>
<td>College Composition (CO 130 or 600 SAT vrlb/critcl reading or 26 ACT English score)</td>
<td>F,S,SS</td>
<td>3</td>
<td>CBE 310</td>
<td>Molecular Concepts and Applications (CBE 210; MATH 340)</td>
<td>F</td>
<td>3</td>
</tr>
<tr>
<td>CBE 201</td>
<td>Material and Energy Balances (CBE 102 or MATH 151 (or conc); CHEM 111; LIFE 102 (or conc); PH 141)</td>
<td>F</td>
<td>3</td>
<td>CHEM 341</td>
<td>Modern Organic Chemistry I (CHEM 113)</td>
<td>F,S,SS</td>
<td>3</td>
</tr>
<tr>
<td>CHEM 344</td>
<td>Modern Organic Chem Lab II (CHEM 113; CHEM 114)</td>
<td>F,S,SS</td>
<td>2</td>
<td>LIFE 102</td>
<td>Attributes of Living Systems</td>
<td>F,S,SS</td>
<td>4</td>
</tr>
<tr>
<td>CHEM 310</td>
<td>Process Simulation (CBE 210; MATH 340)</td>
<td>F</td>
<td>3</td>
<td>CHEM 343</td>
<td>Modern Organic Chemistry II (CHEM 245 or CHEM 341 or CHEM 345)</td>
<td>F,S,SS</td>
<td>3</td>
</tr>
<tr>
<td>CBE 330</td>
<td>Momentum Transfer and Mechanical Separations (CBE 210 or MECH 237; MATH 340)</td>
<td>F</td>
<td>3</td>
<td>CHEM 344</td>
<td>Modern Organic Chem Lab (CHEM 113; CHEM 114)</td>
<td>F,S,SS</td>
<td>2</td>
</tr>
<tr>
<td>CBE 201</td>
<td>Introduction to Eukaryotic Cell Biology (CHEM 111; 112 (or conc.); LIFE 102)</td>
<td>F</td>
<td>3</td>
<td>TOTAL</td>
<td>15</td>
<td></td>
<td></td>
</tr>
<tr>
<td>BMS 300</td>
<td>Principles of Human Physiology (BZ 101 or 110 or LIFE 102; CHEM 103 or 107 or 111)</td>
<td>F,S,SS</td>
<td>4</td>
<td>BIOM 330</td>
<td>Transp. Phenom. in BME (BIOM 300; BMS 300; CBE 332 or MECH 344)</td>
<td>S</td>
<td>3</td>
</tr>
<tr>
<td>LIFE 210</td>
<td>Principles of Human Physiology (BZ 101 or 110 or LIFE 102; CHEM 103 or 107 or 111)</td>
<td>F,S,SS</td>
<td>4</td>
<td>CBE 320</td>
<td>Chemical and Biological Reactor Design (CBE 201; CBE 330)</td>
<td>S</td>
<td>3</td>
</tr>
<tr>
<td>CBE 330</td>
<td>Process Simulation (CBE 210; MATH 340)</td>
<td>F</td>
<td>3</td>
<td>CBE 321</td>
<td>Heat &amp; Mass Transfer Fundamentals (CBE 330; CBE 331)</td>
<td>S</td>
<td>3</td>
</tr>
<tr>
<td>CBE 331</td>
<td>Momentum Transfer and Mechanical Separations (CBE 210 or MECH 237; MATH 340)</td>
<td>F</td>
<td>3</td>
<td>CBE 493</td>
<td>Professional Development Seminar</td>
<td>S</td>
<td>1</td>
</tr>
<tr>
<td>CBE 330</td>
<td>Material and Energy Balances (CBE 102 or MATH 151 (or conc); CHEM 111; LIFE 102 (or conc); PH 141)</td>
<td>F</td>
<td>3</td>
<td>BC 351</td>
<td>Principles of Biochem. (BZ 110 or 120 or LIFE 102; CHEM 245 or 341 or 345)</td>
<td>F,S,SS</td>
<td>4</td>
</tr>
<tr>
<td>CBE 442</td>
<td>Separation Processes (CBE 332)</td>
<td>F</td>
<td>4</td>
<td>AUCC</td>
<td>______________</td>
<td>F,S,SS</td>
<td>3</td>
</tr>
<tr>
<td>CBE 443</td>
<td>Separation Processes (CBE 332)</td>
<td>F</td>
<td>4</td>
<td>TOTAL</td>
<td>17</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CBE 333</td>
<td>Chem &amp; Bio Engineering Transfer Laboratory (CBE 332 or conc.)</td>
<td>F</td>
<td>2</td>
<td>BIOM 400</td>
<td>Kinetics of Biomolecular and Cellular Systems (BIOM 330 or CBE 320)</td>
<td>F</td>
<td>3</td>
</tr>
<tr>
<td>BIOM 400</td>
<td>Kinetics of Biomolecular and Cellular Systems (BIOM 330 or CBE 320)</td>
<td>F</td>
<td>3</td>
<td>CBE 442</td>
<td>Chem &amp; Bio Eng Lab II (CBE 442)</td>
<td>S</td>
<td>2</td>
</tr>
<tr>
<td>BIOM 442</td>
<td>Separation Processes (CBE 332)</td>
<td>F</td>
<td>4</td>
<td>CBE 430</td>
<td>Process Control and Instrumentation (CBE 320; CBE 330; CBE 442)</td>
<td>S</td>
<td>3</td>
</tr>
<tr>
<td>CBE-TE</td>
<td>CHEM 330</td>
<td>Heat &amp; Mass Transfer Fundamentals (CBE 330; CBE 331)</td>
<td>S</td>
<td>3</td>
<td>CBE-TE</td>
<td>CHEM 330</td>
<td>Heat &amp; Mass Transfer Fundamentals (CBE 330; CBE 331)</td>
</tr>
<tr>
<td>STAT 315</td>
<td>Stats for Engineers and Scientists (MATH 161 or MATH 255)</td>
<td>S</td>
<td>1</td>
<td>AUCC</td>
<td>______________</td>
<td>F,S,SS</td>
<td>3</td>
</tr>
<tr>
<td>TOTAL</td>
<td>16</td>
<td></td>
<td></td>
<td>TOTAL</td>
<td>15</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* Term: F = Fall, S = Spring, SS = Summer Session

Biomedical Engineering Courses are highlighted

Courses are planned to be first offered:
- BIOM 101 - FA11 Technical Electives: FA14/SP15
- BIOM 400 - FA13
- BIOM 441 – FA13 BIOM 486 –FA14/SP15
- BIOM 300 – SP14 BIOM 330–SP14

Additional All University Core Courses (AUCCs)

- 3B Arts and Humanities 6 cr
- 3C Social/Behavioral Science 3 cr
- 3D Historical Perspective 3 cr
- 3E Global/Cultural Awareness 3 cr

Please note that curricula can change; be sure to check with your advisers regularly to be sure you are on track.

Rev. 3/1/13
“4 + 1” B.S./M.S. and B.S./M.E. in Chemical and Biological Engineering

There are two routes that students in the CBE department can take to obtain a Bachelor’s and Master’s degree. Either of these routes could be a 5-year program. However, for B.S./M.S. students the length of the graduate program will depend upon the emphasis, length, and nature of the research project. Both of these routes require that the student apply to and be admitted to a Master’s degree program. Students should consider whether they want to pursue an M.E. (coursework only) or an M.S. (coursework and research). There are two options for the M.S. – one involving significantly more research than the other. Next, the student should consider whether the “Sequential” or the “Track III” route is the best plan for them. Since no two students have exactly the same situation, this sheet describes these two plans, and is intended to guide the decision making process.

**The Sequential Plan**

The sequential plan requires that the student complete their B.S. degree before being admitted to the Master’s program. However, students can take some graduate credits at CSU before they earn the B.S., subject to the restrictions below.

**Timing of graduate-level coursework.** Undergraduate students at CSU can take up to 9 credits of graduate-level coursework that they intend to use to fulfill degree requirements for a graduate degree. 500-level courses must be “excluded” from the B.S., meaning that they cannot be used to fulfill B.S. degree requirements. Note that “excluded” courses do still compute in the undergraduate GPA, and will not affect the graduate GPA. Courses below the 500-level cannot be excluded, and can therefore not be used toward the graduate degree, if taken prior to completing the B.S. 600-level courses are automatically excluded from counting towards a Bachelor’s degree. To exclude 500-level courses, the student must submit the Request to Exclude Courses from a Bachelor's Degree Form to the Registrar’s office before the end of the term in which the courses are taken. For more information, see this [page at the Registrar’s website](http://registrar.colostate.edu/students/tuitionfees/index.aspx).

**Application timing.** The student should begin preparing their graduate application two semesters before graduation, so that they can be admitted to the M.S. program beginning the semester following graduation. A student planning to graduate in May or August should plan to submit their application by January 15, to be considered for admission to the graduate program the following fall. A student graduating in December should complete their application by September 15 to be considered for admission to the graduate program for the subsequent spring semester.

**Advantages and disadvantages.** The student pays undergraduate tuition and fees, and is considered an undergraduate by the University until they finish their Bachelor’s degree. This might affect their eligibility for financial aid and scholarships. The student can only take up to 9 graduate credits before finishing their Bachelor’s degree, but they will pay tuition and fees as an undergraduate for all credits taken prior to completing their Bachelor’s degree.

**Track III Admissions Plan**

The Track III Admission is a mechanism whereby outstanding students can be formally admitted to and begin a graduate program of study before completion of a Bachelor’s degree. However, the graduate degree will only be awarded concurrently with or after the Bachelor’s degree.

**Requirements for track III admission.** Applicants for track III admission must have completed at least 75 credits of coursework, including 15 credits of upper division coursework (300- and 400-level courses) toward their Bachelor’s degree, and they must have a GPA of at least 3.0. The student must apply to and be admitted to the graduate degree program, and indicate Track III admission on the GS2a form. Students in the B.S. program in Chemical and Biological Engineering would ordinarily meet the credit requirements after the fall semester of their Junior year. Hence, they could be considered for track III admission for the fall of their Senior year.

**Timing of graduate-level coursework.** After being admitted to the graduate program by Track III admission, there is no restriction on the number of graduate courses that a student can take before completing their Bachelor’s degree. To exclude courses from the Bachelor’s degree, that should be used to fulfill requirements for the graduate degree, the student must submit the Request to Exclude Courses from a Bachelor's Degree Form to the Registrar’s office before the end of the term in which the courses are taken.

**Status of Track III Students.** After the student has completed 120 credits of coursework, the University classifies the student as a graduate student.

**Advantages and disadvantages.** Following Track III admission, students can take graduate and undergraduate courses concurrently, with no restriction on the number of graduate credits that can be taken prior to completion of the Bachelor’s degree. After completing 120 credits, the student’s status makes them eligible for graduate awards, scholarships, and fellowships, but they may forfeit eligibility for awards that are restricted for undergraduates. After 120 credits, the student will be charged tuition and fees at graduate rates, which are higher than undergraduate rates.

For most students in the CBE B.S. program who can complete the B.S. degree in four years, and want to complete a Master’s degree, the sequential plan is preferred. These students can still take some graduate coursework (up to 9 credit hours) during their senior year, and pay undergraduate tuition for these credits. Students who, for any number of reasons, require additional flexibility in sequencing senior year courses that would delay completion of the B.S. may benefit from Track III admission. However, they should carefully consider the difference between graduate and undergraduate tuition and fee rates, and their eligibility for scholarships and financial aid. In-state and out-of-state tuition rates can be found at [http://registrar.colostate.edu/students/tuitionfees/index.aspx](http://registrar.colostate.edu/students/tuitionfees/index.aspx), for both graduate and undergraduate programs. In addition to tuition, the College of Engineering charges graduate students a per-credit-hour fee, that is not included in the figures provided on the Registrar’s office website.