MAJOR IN CHEMICAL AND BIOLOGICAL ENGINEERING

Chemical and biological engineering is a powerful blend of basic sciences and the skills to quantitatively describe, predict, and control all changes of matter. This provides the foundation to create cutting-edge materials and products, to design new devices to improve health or the environment, and to design processes for the safe production of chemicals and biochemicals, the production of alternative energy sources, and prevention of hazardous waste.

The Chemical and Biological Engineering curriculum is based on the sciences of physics, chemistry, biology, and mathematics. It includes engineering science and design methods, as well as humanities and social sciences. Students can pursue interdisciplinary studies programs or minors. Popular options include minors in chemistry, mathematics, environmental engineering, and biomedical engineering. The curriculum is well-aligned to meet pre-health profession requirements. The Chemical and Biological Engineering program provides an environment that promotes a sense of professionalism, the development of project management skills, and an appreciation for the value of life-long learning. Graduates of our program are well prepared to enter a variety of professions, or to pursue further education. The broad, strong scientific basis of chemical and biological engineering has kept our graduates consistently near or at the top in salary and demand among B.S. graduates.

The Chemical and Biological Engineering major is accredited by the Engineering Accreditation Commission of ABET (https://www.abet.org/).

Concentrations

While our undergraduate program gives students the option to keep their studies broad, they may also specialize in one of the following concentrations:

- Advanced Materials Concentration (http://catalog.colostate.edu/general-catalog/colleges/engineering/biomedical-chemical-engineering/chemical-biological-engineering-major-advanced-materials-concentration/)
- Biomanufacturing Concentration (http://catalog.colostate.edu/general-catalog/colleges/engineering/biomedical-chemical-engineering/chemical-biological-engineering-major-biomanufacturing-concentration/)
- Molecular Medicine Concentration (http://catalog.colostate.edu/general-catalog/colleges/engineering/biomedical-chemical-engineering/chemical-biological-engineering-major-molecular-medicine-concentration/)
- Sustainable Engineering Concentration (http://catalog.colostate.edu/general-catalog/colleges/engineering/biomedical-chemical-engineering/chemical-biological-engineering-major-sustainable-engineering-concentration/)

Program Learning Objectives

The Chemical and Biological Engineering program at CSU will empower graduates with the educational foundation to:

1. Be highly successful, as defined by accomplishments, advanced certifications, and job satisfaction, in chemical and biological engineering practice, post-graduate education, or other careers making use of engineering knowledge.
2. Be identified for both their mastery of fundamental chemical and biological engineering principles and their creative application of those principles to the solution of problems across a diverse range of career disciplines.
3. Be recognized as critical, creative and independent thinkers who use their technical expertise and leadership to address the needs of society and advance their fields of expertise.
4. Be recognized for their effectiveness in teamwork, communication, and service to society through their professional contributions.
5. Hold paramount health and safety of the public and the environment.
6. Demonstrate the highest standards of professional, ethical, and civic responsibility in all endeavors.
7. Demonstrate continued professional growth through a commitment to lifelong learning.

Student Outcomes

Graduates of the undergraduate Chemical and Biological Engineering programs will have the ability to:

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

Potential Occupations

Chemical and Biological Engineering graduates find employment in the biotechnology, biomedical, microelectronics, environmental, consulting, alternative energy, petroleum, chemical, food, pharmaceutical and other private sector industries and with government agencies. Participation in undergraduate research, internships, volunteer activities, or cooperative education opportunities is highly recommended to enhance practical training and development. Graduates who go on for advanced studies can attain more responsible positions with the possibility of rising to top professional levels. In addition to pursuing M.S. and Ph.D. degrees in chemical and biological engineering and related fields, some of our graduates have obtained M.D., D.V.M., law, and M.B.A. degrees.

Requirements Effective Fall 2025

Students may enroll in either the standalone major or (at most) one of the concentrations under the Major in Chemical and Biological Engineering.

Freshman

		AUCC	Credits
CHEM 120[1]	Foundations of Modern Chemistry (GT-SC2)	3A	4
CHEM 121[1]	Foundations of Modern Chemistry Laboratory (GT-SC1)	3A	1
CO 150	College Composition (GT-CO2)	1A	3
ENGR 111	Fundamentals of Engineering		3
ENGR 114	Engineering for Grand Challenges		3
LIFE 102	Attributes of Living Systems (GT-SC1)	3A	4
MATH 160	Calculus for Physical Scientists I (GT-MA1)	1B	4
MATH 161	Calculus for Physical Scientists II (GT-MA1)	1B	4
1C (http://catalog.colostate.edu/general-catalog/all-university-core-curriculum/aucc/#aucc)		1C	3
	Total Credits		**29**

Sophomore

CBE 201	Material and Energy Balances		3
CBE 205	Fundamentals of Biological Engineering		3
CBE 210	Thermodynamic Process Analysis		3
CBE 223	CBE Design and Experimentation I		2
CBE 393	Professional Development Seminar		1
CHEM 241	Foundations of Organic Chemistry		4
CHEM 242	Foundations of Organic Chemistry Laboratory		1
MATH 261	Calculus for Physical Scientists III		4
MATH 340	Intro to Ordinary Differential Equations		4
PH 141	Physics for Scientists and Engineers I (GT-SC1)	3A	5
Arts and Humanities (http://catalog.colostate.edu/general-catalog/all-university-core-curriculum/aucc/#arts-humanities)		3B	3
	Total Credits		**33**

Junior

CBE 320	Chemical and Biological Reactor Design		3
CBE 330	Process Simulation		3
CBE 331	Momentum Transfer and Mechanical Separations		3
CBE 332	Heat and Mass Transfer Fundamentals		3
CBE 334	CBE Design and Experimentation II		1
CBE 335	CBE Design and Experimentation III		1
CBE 340	Statistics for CBE Applications		3
Select one course from the following:			4
BC 351	Principles of Biochemistry		
CHEM 321	Foundations of Chemical Biology		
Bioscience Elective (see list below)			3
Chemistry Electives (see list below)			6
Historical Perspectives (http://catalog.colostate.edu/general-catalog/all-university-core-curriculum/aucc/#historical-perspectives)		3D	3
	Total Credits		**33**

Senior

CBE 430	Process Control and Instrumentation		3
CBE 442	Separation Processes		4
CBE 443	Chemical and Biological Engineering Lab II		2
CBE 451	Chemical and Biological Engineering Design I	4A,4B,4C	3
CBE 452	Chemical and Biological Engineering Design II	4A,4B,4C	3

Technical Elective (see list below)		9
Advanced Writing (http://catalog.colostate.edu/general-catalog/all-university-core-curriculum/aucc/#advanced-writing)	2	3
Arts and Humanities (http://catalog.colostate.edu/general-catalog/all-university-core-curriculum/aucc/#arts-humanities)	3B	3
Social and Behavioral Sciences (http://catalog.colostate.edu/general-catalog/all-university-core-curriculum/aucc/#social-behavioral-sceinces)	3C	3
Total Credits		**33**
Program Total Credits:		**128**

[1] Students who complete General Chemistry (CHEM 111, CHEM 112, and CHEM 113, CHEM 114) do not have to take CHEM 120 and CHEM 121.

Electives

The CBE program requires 18 credit hours of electives. These include 3 credits of Bioscience, 6 credits of Chemistry, and 9 credits of Technical electives that can also include courses from the Bioscience or Chemistry lists. New courses are added all the time, if you find a course you believe is valuable to your education ask your advisor if it is an appropriate elective course.

Bioscience Electives

Select a minimum of 3 credits from the following.

Code	Title	AUCC	Credits
BC 401	Comprehensive Biochemistry I		3
BC 403	Comprehensive Biochemistry II		3
BC 404	Comprehensive Biochemistry Laboratory		2
BC 406A	Investigative Biochemistry: Protein Biochemistry		2
BC 406B	Investigative Biochemistry: Molecular Genetics		2
BC 406C	Investigative Biochemistry: Cellular Biochemistry		2
BC 411	Physical Biochemistry		4
BC 441	3D Molecular Models for Biochemistry		1
BC 463	Molecular Genetics		3
BC 464	Molecular Genetics Recitation		1
BC 465	Molecular Regulation of Cell Function		3
BC 517	Metabolism		2
BC 521/CHEM 521	Principles of Chemical Biology		3
BMS 300	Principles of Human Physiology		4
BMS 301	Human Gross Anatomy		5
BMS 302	Laboratory in Principles of Physiology		2
BMS 305	Domestic Animal Gross Anatomy		4
BMS 325	Cellular Neurobiology		3
BMS 330	Microscopic Anatomy		4
BMS 345	Functional Neuroanatomy		4
BMS 360	Fundamentals of Physiology		4
BMS 409	Human and Animal Reproductive Biology		3
BMS 420	Cardiopulmonary Physiology		3
BMS 430	Endocrinology		3
BMS 450	Pharmacology		3
BMS 460	Essentials of Pathophysiology		3
BMS 500	Mammalian Physiology I		4

BMS 501	Mammalian Physiology II		4
BMS 503/NB 503	Developmental Neurobiology		3
BMS 505/NB 505	Neuronal Circuits, Systems and Behavior		3
BMS 545	Neuroanatomy		5
BMS 575	Human Anatomy Dissection		4
BSPM 302	Applied and General Entomology		2
BSPM 361	Elements of Plant Pathology		3
BZ 240	Synthetic Biology-Principles and Applications		3
BZ 310	Cell Biology		4
BZ 311	Developmental Biology		4
BZ 348/MATH 348	Theory of Population and Evolutionary Ecology		4
BZ 350	Molecular and General Genetics		4
BZ 360	Bioinformatics and Genomics		4
LIFE 201B	Introductory Genetics: Molecular/ Immunological/Developmental (GT-SC2)	3A	3
LIFE 202B	Introductory Genetics Recitation: Molecular		1
LIFE 203	Introductory Genetics Laboratory		2
LIFE 210	Introductory Eukaryotic Cell Biology		3
LIFE 211	Introductory Cell Biology Honors Recitation		1
LIFE 212	Introductory Cell Biology Laboratory		2
LIFE 320	Ecology		3
MIP 300	General Microbiology		3
MIP 302	General Microbiology Laboratory		2
MIP 315	Pathology of Human and Animal Disease		3
MIP 334	Food Microbiology		3
MIP 335	Food Microbiology Laboratory		2
MIP 342	Immunology		4
MIP 343	Immunology Laboratory		2
MIP 351	Medical Bacteriology		3
MIP 352	Medical Bacteriology Laboratory		3
MIP 410	Foundations of Modern Biotechnology		2
MIP 420	Medical and Molecular Virology		4
MIP 432/ESS 432	Microbial Ecology		3
MIP 433/ESS 433	Microbial Ecology Laboratory		1
MIP 443	Microbial Physiology		3
MIP 450	Microbial Genetics		3
MIP 555	Principles and Mechanisms of Disease		3

Chemistry Electives

Select a minimum of 6 credits from the following; 3 credits must be at the 300 level or higher.

Code	Title	Credits
CBE 310	Molecular Concepts and Applications	3
CHEM 231	Foundations of Analytical Chemistry	3
CHEM 232	Foundations of Analytical Chemistry Lab	2
CHEM 261	Fundamentals of Inorganic Chemistry	3
CHEM 263	Foundations of Inorganic Chemistry	4
CHEM 264	Foundations of Inorganic Chemistry Laboratory	1

Upper division courses from subject code BC (400-479) and (500-579)

Upper division courses from subject code CHEM (310-340 and 350-379), (400-479), and (500-579)

Technical Electives

Select a minimum of 9 credits from the following, or select additional credits from the Bioscience Electives or Chemistry Electives lists above.

Code	Title	AUCC	Credits
Technical Electives - A			
AB 410	Understanding Pesticides		3
ATS 350	Introduction to Weather and Climate		2
ATS 351	Introduction to Weather and Climate Lab		1
ATS 440/GES 440	Sea Level Rise and a Sustainable Future		3
ATS 542/GEOL 542	Paleoclimate		3
ATS 543/ESS 543	Global Climate Change		2
ATS 550	Atmospheric Radiation and Remote Sensing		3
ATS 555	Air Pollution		3
ATS 556	Climate Intervention to Cool a Warming Planet		2
ATS 560	Air Pollution Measurement		2
BIOM 300	Problem-Based Learning Biomedical Engr Lab		4
BIOM 304	Global Challenges and Collaborations in BME		3
BIOM 350A	Study Abroad--Ecuador: Prosthetics		1-3
BIOM 350B	Study Abroad--Portugal: Biomedical Engineering and Healthcare		1
BIOM 350C	Study Abroad--Ireland: Biomedical Engineering and Healthcare		1
BIOM 421	Transport Phenomena in Biomedical Engineering		3
BIOM 422	Quantitative Systems and Synthetic Biology		3
BIOM 517/ECE 517	Advanced Optical Imaging		3
BIOM 518/ECE 518	Biophotonics		3
BIOM 525/MECH 525	Cell and Tissue Engineering		3
BIOM 526/ECE 526	Biological Physics		3
BIOM 527A/ECE 527A	Biosensing: Cells as Circuits		1
BIOM 527B/ECE 527B	Biosensing: Signal and Noise in Biosensors		1
BIOM 527C/ECE 527C	Biosensing: Sensor Circuit Fundamentals		1
BIOM 527D/ECE 527D	Biosensing: Electrochemical Sensors		1
BIOM 527E/ECE 527E	Biosensing: Affinity Sensors		1
BIOM 527F/ECE 527F	Biosensing: Biophotonic Sensors Using Refractive Index		1
BIOM 531/MECH 531	Materials Engineering		3
BIOM 533/CIVE 533	Biomolecular Tools for Engineers		3
BIOM 537/ECE 537	Biomedical Signal Processing		3
BIOM 570/MECH 570	Bioengineering		3
BIOM 572/MECH 572	Regenerative Bioengineering with Stem Cells		3

BIOM 573/MECH 573	Structure and Function of Biomaterials	3
BIOM 574/MECH 574	Bio-Inspired Surfaces	3
BIOM 576/MECH 576	Quantitative Systems Physiology	4
BIOM 578/MECH 578	Musculoskeletal Biosolid Mechanics	3
BIOM 579/MECH 579	Cardiovascular Biomechanics	3
CBE 501	Chemical Engineering Thermodynamics	3
CBE 502	Advanced Reactor Design	3
CBE 503	Transport Phenomena Fundamentals	3
CBE 504/BIOM 504	Fundamentals of Biochemical Engineering	3
CBE 505	Biochemical Engineering Laboratory	1
CBE 514	Polymer Science and Engineering	3
CBE 521	Mathematical Modeling for Chemical Engineers	3
CBE 522/BIOM 522	Bioseparation Processes	3
CBE 524	Bioremediation	1
CBE 540/CIVE 540	Advanced Biological Wastewater Processing	3
CBE 543	Membranes for Biotechnology and Biomedicine	3
CBE 560	Engineering of Protein Expression Systems	3
CBE 570	Biomolecular Engineering/Synthetic Biology	3
CIVE 260	Engineering Mechanics-Statics	3
CIVE 261	Engineering Mechanics-Dynamics	3
CIVE 322	Basic Hydrology	3
CIVE 330	Ecological Engineering	3
CIVE 360	Mechanics of Solids	3
CIVE 371	Study Abroad--Peru: Grand Challenges in Engineering in Peru	3
CIVE 401	Hydraulic Engineering	3
CIVE 421	Global Water Challenges	3
CIVE 423	Groundwater Engineering	3
CIVE 438	Fundamentals of Environmental Engr	3
CIVE 439	Applications of Environmental Engr Concepts	3
CIVE 440	Nonpoint Source Pollution	3
CIVE 441	Water Quality Analysis and Treatment	3
CIVE 442	Air Quality Engineering	3
CIVE 515	River Mechanics	3
CIVE 521	Hydrometry	3
CIVE 531	Groundwater Hydrology	3
CIVE 538	Aqueous Chemistry	3
CIVE 560	Advanced Mechanics of Materials	3
CS 165	CS2--Data Structures	4
CS 220	Discrete Structures and the Applications	4
CS 270	Computer Organization	4

ECE 204	Introduction to Electrical Engineering		3
ECE 430/MATH 430	Fourier and Wavelet Analysis with Apps		3
ENGR 300	3D Printing Lab for Engineers		1
ENGR 478	Applied Engineering Data Analytics		3
ENGR 510	Engineering Optimization: Method/ Application		3
ENGR 531	Engineering Risk Analysis		3
ENGR 550/MATH 550	Numerical Methods in Science and Engineering		3
ERHS 320	Environmental Health--Water Quality		3
ERHS 332	Principles of Epidemiology		3
ERHS 410	Environmental Health-Air and Waste Management		3
ERHS 446	Environmental Toxicology		3
ERHS 448	Environmental Contaminants		3
ERHS 450	Introduction to Radiation Biology		3
ERHS 502	Fundamentals of Toxicology		3
ERHS 503	Toxicology Principles		1
ERHS 510/VS 510	Cancer Biology		3
ERHS 530	Radiological Physics and Dosimetry I		3
ERHS 542	Biostatistical Methods for Qualitative Data		3
ERHS 547	Equipment and Instrumentation		3
ESS 311	Ecosystem Ecology		3
ESS 312	Sustainability Science		3
ESS 330	Quantitative Reasoning for Ecosystem Science		3
ESS 353	Global Change Impacts, Adaptation, Mitigation		3
ESS 440	Practicing Sustainability		4
ESS 501	Principles of Ecosystem Sustainability		3
ESS 524	Foundations for Carbon/Greenhouse Gas Mgmt		3
F 311	Forest Ecology		3
FTEC 447	Food Chemistry		3
GEOL 150	Dynamic Earth (GT-SC2)	3A	4
GEOL 452	Hydrogeology		4
GEOL 454	Geomorphology		4
GES 362	Systems Thinking and Sustainability		3
GES 441	Analysis of Sustainable Energy Solutions		3
GES 465/MSE 465	Sustainable Strategies for E-Waste Management		3
GES 528/CIVE 528	Assessing the Food, Energy, Water Nexus		3
GES 542	Biobased Fuels, Energy, and Chemicals		3
HES 307	Biomechanical Principles of Human Movement		3
HES 319	Neuromuscular Aspects of Human Movement		4

HES 403	Physiology of Exercise	3
HES 420	Electrocardiography and Exercise Management	3
HORT 579	Mass Spectrometry Omics-Methods and Analysis	3
MATH 301	Introduction to Combinatorial Theory	3
MATH 331	Introduction to Mathematical Modeling	3
MATH 332	Partial Differential Equations	3
MATH 360	Mathematics of Information Security	3
MATH 366	Introduction to Abstract Algebra	3
MATH 369	Linear Algebra I	3
MATH 405	Introduction to Number Theory	3
MATH 419	Introduction to Complex Variables	3
MATH 450	Introduction to Numerical Analysis I	3
MATH 451	Introduction to Numerical Analysis II	3
MATH 455	Mathematics in Biology and Medicine	3
MATH 460	Information and Coding Theory	3
MATH 466	Abstract Algebra I	3
MATH 467	Abstract Algebra II	3
MATH 469	Linear Algebra II	3
MATH 525	Optimal Control	3
MATH 530	Mathematics for Scientists and Engineers	3
MATH 532	Mathematical Modeling of Large Data Sets	3
MATH 535	Foundations of Applied Mathematics	3
MATH 546	Partial Differential Equations II	3
MATH 560	Linear Algebra	3
MECH 262	Engineering Mechanics	4
MECH 307	Mechatronics II	3
MECH 324	Dynamics of Machines	4
MECH 325	Machine Design with Finite Element Analysis	4
MECH 331	Introduction to Engineering Materials	4
MECH 403	Energy Engineering	3
MECH 407	Laser Applications in Mechanical Engineering	3
MECH 424	Advanced Dynamics	3
MECH 425	Mechanical Engineering Vibrations	4
MECH 431	Metals and Alloys	3
MECH 432	Engineering of Nanomaterials	3
MECH 436/MSE 436	Green Engineering--Materials and Environment	3
MECH 502	Advanced/Additive Manufacturing Engineering	3
MECH 507	Laser Diagnostics for Thermosciences	3
MECH 509	Design and Analysis in Engineering Research	3
MECH 513	Simulation Modeling and Experimentation	3

MECH 516	Life Cycle and Techno-Economic Assessment	3
MECH 524	Principles of Dynamics	3
MECH 527	Hybrid Electric Vehicle Powertrains	3
MECH 529	Advanced Mechanical Systems	3
MECH 530	Advanced Composite Materials	3
MECH 543	Biofluid Mechanics	3
MECH 552	Applied Computational Fluid Dynamics	3
MIP 425	Virology and Cell Culture Laboratory	2
MIP 530	Advanced Molecular Virology	4
MIP 543	RNA Biology	3
MIP 550	Microbial and Molecular Genetics Laboratory	4
MSE 501	Materials Technology Transfer	1
MSE 502A	Materials Science and Engineering Methods: Materials Structure and Scattering	1
MSE 502B	Materials Science and Engineering Methods: Computational Materials Methods	1
MSE 502C	Materials Science and Engineering Methods: Materials Microscopy	1
MSE 502D	Materials Science and Engineering Methods: Materials Spectroscopy	1
MSE 502E	Materials Science and Engineering Methods: Bulk Properties and Performance	1
MSE 502F	Materials Science and Engineering Methods: Experimental Methods for Materials Research	1
MSE 503	Mechanical Behavior of Materials	3
MSE 504	Thermodynamics of Materials	3
MSE 505	Kinetics of Materials	3
NR 319	Introduction to Geospatial Science	4
NR 323/GR 323	Remote Sensing and Image Interpretation	3
NR 505	Concepts in GIS	4
PH 142	Physics for Scientists and Engineers 3A II (GT-SC1)	5
PH 314	Introduction to Modern Physics	4
PH 315	Modern Physics Laboratory	2
PH 341	Mechanics	4
PH 351	Electricity and Magnetism	4
PH 353	Optics and Waves	4
PH 361	Physical Thermodynamics	3
PH 451	Introductory Quantum Mechanics I	3
PH 452	Introductory Quantum Mechanics II	3
PH 517	Chaos, Fractals, and Nonlinear Dynamics	3
PH 521	Introduction to Lasers	3
PH 522	Introductory Laser Laboratory	1
PH 531	Introductory Condensed Matter Physics	3
PH 561	Elementary Particle Physics	3

PH 571	Mathematical Methods for Physics I	3
PH 572	Mathematical Methods for Physics II	3
PHIL 410	Gödel's Incompleteness Theorems	3
SOCR 322	Principles of Microclimatology	3
SOCR 330	Principles of Genetics	3
SOCR 375	Soil Biogeochemistry	3
SOCR 400	Soils and Global Change-Impacts and Solutions	3
SOCR 455	Microbiomes of Soil Systems	3
SOCR 456	Soil Microbiology Laboratory	1
SOCR 467	Soil and Environmental Chemistry	3
SOCR 470	Soil Physics	3
SOCR 471	Soil Physics Laboratory	1
SOCR 567	Environmental Soil Chemistry	4
STAR 512	Design and Data Analysis for Researchers II	4
STAT 305	Sampling Techniques	3
STAT 307	Introduction to Biostatistics	3
STAT 315	Intro to Theory and Practice of Statistics	3
STAT 341	Statistical Data Analysis I	3
STAT 342	Statistical Data Analysis II	3
STAT 400	Statistical Computing	3
STAT 420	Probability and Mathematical Statistics I	3
STAT 421	Introduction to Stochastic Processes	3
STAT 430	Probability and Mathematical Statistics II	3
STAT 460	Applied Multivariate Analysis	3
SYSE 501	Foundations of Systems Engineering	3
SYSE 505	Systems Thinking for the Real World	3
SYSE 512	Systems Sensing and Imaging Analysis	3
SYSE 530	Overview of Systems Engineering Processes	3
SYSE 532/ECE 532	Dynamics of Complex Engineering Systems	3
SYSE 534	Human Systems Integration	3
SYSE 536	Space Mission Analysis and Design	3
SYSE 541	Engineering Data Design and Visualization	3
SYSE 544	Systems-Based AR/VR Environmental Realism	3
SYSE 545	Augmented/Virtual Reality Systems Development	3
SYSE 548	Security Engineering for Systems Engineers	3
SYSE 549	Secure Vehicle and Industrial Networking	3
SYSE 555	Transitions in Energy Systems	3
SYSE 567	Systems Engineering Architecture	3
SYSE 569	Cybersecurity Awareness for Systems Engineers	3

SYSE 571	Analytics in Systems Engineering	3
SYSE 573	Cost Optimization for Systems Engineers	3
Technical Electives - B		
A maximum of 3 credits may be selected from the following courses:		
ENGR 422	Technology Entrepreneurship	3
ENGR 502	Engineering Project and Program Management	3
ENGR 525	Intellectual Property and Invention Systems	3
FIN 305	Fundamentals of Finance	3
IDEA 310B	Design Thinking Toolbox: 3D Modeling	3
IDEA 310D	Design Thinking Toolbox: Digital Imaging	1
MGT 305	Fundamentals of Management	3
MGT 340	Fundamentals of Entrepreneurship	3
MKT 305	Fundamentals of Marketing	3

Major Completion Map

Students may enroll in either the standalone major or (at most) one of the concentrations under the Major in Chemical and Biological Engineering.

Distinctive Requirements for Degree Program:

TO PREPARE FOR FIRST SEMESTER: The curriculum for this major assumes students enter college prepared to take calculus.

Freshman

Semester 1		**Critical**	**Recommended**	**AUCC**	**Credits**
CHEM 120	Foundations of Modern Chemistry (GT-SC2)	X		3A	4
CHEM 121	Foundations of Modern Chemistry Laboratory (GT-SC1)	X		3A	1
CO 150	College Composition (GT-CO2)		X	1A	3
ENGR 111	Fundamentals of Engineering	X			3
MATH 160	Calculus for Physical Scientists I (GT-MA1)	X		1B	4
	Total Credits				**15**
Semester 2		**Critical**	**Recommended**	**AUCC**	**Credits**
ENGR 114	Engineering for Grand Challenges	X			3
LIFE 102	Attributes of Living Systems (GT-SC1)	X		3A	4
MATH 161	Calculus for Physical Scientists II (GT-MA1)	X		1B	4
1C (http://catalog.colostate.edu/general-catalog/all-university-core-curriculum/aucc/#aucc)			X	1C	3
	Total Credits				**14**

Sophomore

Semester 3		**Critical**	**Recommended**	**AUCC**	**Credits**
CBE 201	Material and Energy Balances	X			3
CBE 205	Fundamentals of Biological Engineering	X			3
MATH 261	Calculus for Physical Scientists III	X			4
PH 141	Physics for Scientists and Engineers I (GT-SC1)	X		3A	5
Arts and Humanities (http://catalog.colostate.edu/general-catalog/all-university-core-curriculum/aucc/#arts-humanities)			X	3B	3
	Total Credits				**18**
Semester 4		**Critical**	**Recommended**	**AUCC**	**Credits**
CBE 210	Thermodynamic Process Analysis	X			3
CBE 223	CBE Design and Experimentation I	X			2
CBE 393	Professional Development Seminar		X		1
CHEM 241	Foundations of Organic Chemistry	X			4

CHEM 242	Foundations of Organic Chemistry Laboratory	X			1
MATH 340	Intro to Ordinary Differential Equations	X			4
	Total Credits				**15**
Junior					
Semester 5		**Critical**	**Recommended**	**AUCC**	**Credits**
CBE 320	Chemical and Biological Reactor Design	X			3
CBE 330	Process Simulation	X			3
CBE 331	Momentum Transfer and Mechanical Separations	X			3
CBE 334	CBE Design and Experimentation II	X			1
Select one course from the following:					4
BC 351	Principles of Biochemistry		X		
CHEM 321	Foundations of Chemical Biology				
Chemistry Elective			X		3
	Total Credits				**17**
Semester 6		**Critical**	**Recommended**	**AUCC**	**Credits**
CBE 332	Heat and Mass Transfer Fundamentals	X			3
CBE 335	CBE Design and Experimentation III	X			1
CBE 340	Statistics for CBE Applications	X			3
Bioscience Elective			X		3
Chemistry Elective			X		3
Historical Perspectives (http://catalog.colostate.edu/general-catalog/all-university-core-curriculum/aucc/#historical-perspectives)			X	3D	3
	Total Credits				**16**
Senior					
Semester 7		**Critical**	**Recommended**	**AUCC**	**Credits**
CBE 442	Separation Processes	X			4
CBE 443	Chemical and Biological Engineering Lab II	X			2
CBE 451	Chemical and Biological Engineering Design I	X		4A,4B,4C	3
Technical Elective			X		3
Advanced Writing (http://catalog.colostate.edu/general-catalog/all-university-core-curriculum/aucc/#advanced-writing)			X	2	3
Arts and Humanities (http://catalog.colostate.edu/general-catalog/all-university-core-curriculum/aucc/#arts-humanities)			X	3B	3
	Total Credits				**18**
Semester 8		**Critical**	**Recommended**	**AUCC**	**Credits**
CBE 430	Process Control and Instrumentation	X			3
CBE 452	Chemical and Biological Engineering Design II	X		4A,4B,4C	3
Technical Electives		X			6
Social and Behavioral Sciences (http://catalog.colostate.edu/general-catalog/all-university-core-curriculum/aucc/#social-behavioral-sciences)		X		3C	3
The benchmark courses for the 8th semester are the remaining courses in the entire program of study.		X			
	Total Credits				**15**
	Program Total Credits:				**128**