

# MAJOR IN CHEMICAL AND BIOLOGICAL ENGINEERING

## Requirements Effective Fall 2023

### Freshman

		AUCC	Credits
CBE 160	MATLAB for Chemical and Biological Eng		1
CHEM 111	General Chemistry I (GT-SC2)	3A	4
CHEM 112	General Chemistry Lab I (GT-SC1)	3A	1
CHEM 113	General Chemistry II		3
CHEM 114	General Chemistry Lab II		1
CO 150	College Composition (GT-CO2)	1A	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
PH 141	Physics for Scientists and Engineers I (GT-SC1)	3A	5
Select one group from the following:			3

#### Group A:

CBE 101 Introduction to Chemical and Biological Engr

#### Group B:

CBE 101A Introduction to Chemical and Biological Engr. Lecture

CBE 101B Introduction to Chemical and Biological Engr. Laboratory

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### Total Credits

**33**

### Sophomore

CBE 201	Material and Energy Balances		3
CBE 205	Fundamentals of Biological Engineering		3
CBE 210	Thermodynamic Process Analysis		3
CHEM 341	Modern Organic Chemistry I		3
CHEM 343	Modern Organic Chemistry II		3
CHEM 344	Modern Organic Chemistry Laboratory		2
MATH 261	Calculus for Physical Scientists III		4
MATH 340	Intro to Ordinary Differential Equations		4
PH 142	Physics for Scientists and Engineers II (GT-SC1)	3A	5
Arts and Humanities ( <a href="http://catalog.colostate.edu/general-catalog/all-university-core-curriculum/aucc/#arts-humanities">http://catalog.colostate.edu/general-catalog/all-university-core-curriculum/aucc/#arts-humanities</a> )			3B
Total Credits			33

### Junior

BC 351	Principles of Biochemistry		4
CBE 310	Molecular Concepts and Applications		3
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 393	Professional Development Seminar		1
Bioscience Elective (see list below)			3
Technical Elective (see list below)			3

Advanced Writing ( <a href="http://catalog.colostate.edu/general-catalog/all-university-core-curriculum/aucc/#advanced-writing">http://catalog.colostate.edu/general-catalog/all-university-core-curriculum/aucc/#advanced-writing</a> )	2	3
Diversity, Equity, and Inclusion ( <a href="http://catalog.colostate.edu/general-catalog/all-university-core-curriculum/aucc/#diversity-equity-inclusion">http://catalog.colostate.edu/general-catalog/all-university-core-curriculum/aucc/#diversity-equity-inclusion</a> )	1C	3
<b>Total Credits</b>		<b>32</b>
<b>Senior</b>		
CBE 333	Chemical and Biological Engineering Lab I	2
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
CBE 452	Chemical and Biological Engineering Design II	4A,4B,4C
Engineering Elective (see list below)		3
Technical Elective (see list below)		3
Arts and Humanities ( <a href="http://catalog.colostate.edu/general-catalog/all-university-core-curriculum/aucc/#arts-humanities">http://catalog.colostate.edu/general-catalog/all-university-core-curriculum/aucc/#arts-humanities</a> )	3B	3
Historical Perspectives ( <a href="http://catalog.colostate.edu/general-catalog/all-university-core-curriculum/aucc/#historical-perspectives">http://catalog.colostate.edu/general-catalog/all-university-core-curriculum/aucc/#historical-perspectives</a> )	3D	3
Social and Behavioral Sciences ( <a href="http://catalog.colostate.edu/general-catalog/all-university-core-curriculum/aucc/#social-behavioral-sciences">http://catalog.colostate.edu/general-catalog/all-university-core-curriculum/aucc/#social-behavioral-sciences</a> )	3C	3
<b>Total Credits</b>		<b>32</b>
<b>Program Total Credits:</b>		<b>130</b>

## Bioscience Electives

Select a minimum of 3 credits from the following.

Code	Title	Credits
BC 401	Comprehensive Biochemistry I	3
BC 403	Comprehensive Biochemistry II	3
BC 404	Comprehensive Biochemistry Laboratory	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 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 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
CM 501	Advanced Cell Biology	4
CM 502/NB 502	Techniques in Molecular & Cellular Biology	2
LIFE 201B	Introductory Genetics: Molecular/ Immunological/Developmental (GT-SC2)	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 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	4
MIP 450	Microbial Genetics	3

## Engineering Electives

Select a minimum of 3 credits from the following.

Code	Title	Credits
ATS 555	Air Pollution	3
ATS 560	Air Pollution Measurement	2
BIOM 300	Problem-Based Learning Biomedical Engr Lab	4
BIOM 350A	Study Abroad--Ecuador: Prosthetics	1-2
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 525/MECH 525	Cell and Tissue Engineering	3
BIOM 526/ECE 526	Biological Physics	3
BIOM 531/MECH 531	Materials Engineering	3
BIOM 532/MECH 532	Materials Issues in Mechanical Design	3
BIOM 533/CIVE 533	Biomolecular Tools for Engineers	3
BIOM 537/ECE 537	Biomedical Signal Processing	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 579/MECH 579	Cardiovascular Biomechanics	3
CBE 406	Introduction to Transport Phenomena	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 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 401	Hydraulic Engineering	3
CIVE 413	Environmental River Mechanics	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 442	Air Quality Engineering	3
CIVE 520	Physical Hydrology	3
CIVE 531	Groundwater Hydrology	3
CIVE 538	Aqueous Chemistry	3
CIVE 560	Advanced Mechanics of Materials	3
ECE 204	Introduction to Electrical Engineering	3
ENGR 510	Engineering Optimization: Method/ Application	3
ENGR 531	Engineering Risk Analysis	3
MECH 262	Engineering Mechanics	4
MECH 307	Mechatronics and Measurement Systems	4
MECH 324	Dynamics of Machines	4
MECH 325	Machine Design	3
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 432	Engineering of Nanomaterials	3
MECH 507	Laser Diagnostics for Thermosciences	3
MECH 530	Advanced Composite Materials	3
MECH 543	Biofluid Mechanics	3
MECH 552	Applied Computational Fluid Dynamics	3

## Technical Electives

Select a minimum of 6 credits from the following, or select additional credits from the Bioscience Electives or Engineering Electives lists above.

Code	Title	Credits
<b>Technical Electives - A</b>		
AB 410	Understanding Pesticides	3
BSPM 576/MIP 576	Bioinformatics	3
BZ 348/MATH 348	Theory of Population and Evolutionary Ecology	4
CHEM 261	Fundamentals of Inorganic Chemistry	3
CHEM 311	Introduction to Nanoscale Science	3
CHEM 334	Quantitative Analysis Laboratory	1
CHEM 335	Introduction to Analytical Chemistry	3
CHEM 338	Environmental Chemistry	3
CHEM 431	Instrumental Analysis	4
CHEM 433	Clinical Chemistry	3
CHEM 440	Advanced Organic Chemistry Laboratory	2
CHEM 461	Inorganic Chemistry	3
CHEM 522	Methods of Chemical Biology	2
CHEM 532	Advanced Chemical Analysis II	3
CHEM 537	Electrochemical Methods	3
CHEM 539A	Principles of NMR and MRI: Basic NMR Principles	1

CHEM 539B	Principles of NMR and MRI: NMR Diffusion Measurements-2D NMR and MRI	1	HORT 579	Mass Spectrometry Omics-Methods and Analysis	3
CHEM 539C	Principles of NMR and MRI: Advanced NMR and MRI Techniques	1	MATH 301	Introduction to Combinatorial Theory	3
CHEM 541	Organic Molecular Structure Determination	2	MATH 331	Introduction to Mathematical Modeling	3
CHEM 543	Structure/Mechanisms in Organic Chemistry	2	MATH 332	Partial Differential Equations	3
CHEM 545	Synthetic Organic Chemistry I	3	MATH 360	Mathematics of Information Security	3
CHEM 547	Physical Organic Chemistry	3	MATH 366	Introduction to Abstract Algebra	3
CHEM 555	Chemistry of Sustainability	3	MATH 369	Linear Algebra I	3
CHEM 569	Chemical Crystallography	3	MATH 405	Introduction to Number Theory	3
CHEM 570	Chemical Bonding	3	MATH 419	Introduction to Complex Variables	3
CHEM 575	Fundamentals of Chemical Thermodynamics	1	MATH 450	Introduction to Numerical Analysis I	3
CHEM 576	Statistical Mechanics	2	MATH 451	Introduction to Numerical Analysis II	3
CHEM 577	Surface Chemistry	3	MATH 455	Mathematics in Biology and Medicine	3
CHEM 579	Chemical Kinetics	3	MATH 460	Information and Coding Theory	3
CS 165	CS2-Data Structures	4	MATH 466	Abstract Algebra I	3
CS 220	Discrete Structures and their Applications	4	MATH 467	Abstract Algebra II	3
CS 270	Computer Organization	4	MATH 469	Linear Algebra II	3
ECE 430/MATH 430	Fourier and Wavelet Analysis with Apps	3	MATH 525	Optimal Control	3
ENGR 550/ MATH 550	Numerical Methods in Science and Engineering	3	MATH 530	Mathematics for Scientists and Engineers	3
ERHS 320	Environmental Health-Water Quality	3	MATH 532	Mathematical Modeling of Large Data Sets	3
ERHS 332	Principles of Epidemiology	3	MATH 535	Foundations of Applied Mathematics	3
ERHS 410	Environmental Health-Air and Waste Management	3	MATH 546	Partial Differential Equations II	3
ERHS 446	Environmental Toxicology	3	MATH 560	Linear Algebra	3
ERHS 448	Environmental Contaminants	3	MECH 431	Metals and Alloys	3
ERHS 450	Introduction to Radiation Biology	3	MECH 502	Advanced/Additive Manufacturing Engineering	3
ERHS 502	Fundamentals of Toxicology	3	MECH 509	Design and Analysis in Engineering Research	3
ERHS 503	Toxicology Principles	1	MECH 513	Simulation Modeling and Experimentation	3
ERHS 510/VS 510	Cancer Biology	3	MECH 524	Principles of Dynamics	3
ERHS 530	Radiological Physics and Dosimetry I	3	MECH 527	Hybrid Electric Vehicle Powertrains	3
ERHS 542	Biostatistical Methods for Qualitative Data	3	MECH 529	Advanced Mechanical Systems	3
ERHS 547	Equipment and Instrumentation	3	MIP 425	Virology and Cell Culture Laboratory	2
ESS 353	Global Change Impacts, Adaptation, Mitigation	3	MIP 530	Advanced Molecular Virology	4
F 311	Forest Ecology	3	MIP 543	RNA Biology	3
FTEC 447	Food Chemistry	2	MIP 550	Microbial and Molecular Genetics Laboratory	4
GEOL 150	Physical Geology for Scientists and Engineers	4	MIP 555	Principles and Mechanisms of Disease	3
GEOL 452	Hydrogeology	4	MSE 501	Materials Technology Transfer	1
GEOL 454	Geomorphology	4	MSE 502A	Materials Science & Engineering Methods: Materials Structure and Scattering	1
GES 441	Analysis of Sustainable Energy Solutions	3	MSE 502B	Materials Science & Engineering Methods: Computational Materials Methods	1
GES 542	Biobased Fuels, Energy, and Chemicals	3	MSE 502C	Materials Science & Engineering Methods: Materials Microscopy	1
HES 307	Biomechanical Principles of Human Movement	3	MSE 502D	Materials Science & Engineering Methods: Materials Spectroscopy	1
HES 319	Neuromuscular Aspects of Human Movement	4	MSE 502E	Materials Science & Engineering Methods: Bulk Properties and Performance	1
HES 403	Physiology of Exercise	3	MSE 502F	Materials Science & Engineering Methods: Experimental Methods for Materials Research	1
HES 420	Electrocardiography and Exercise Management	3	MSE 503	Mechanical Behavior of Materials	3
			MSE 504	Thermodynamics of Materials	3

MSE 505	Kinetics of Materials	3	MGT 340	Fundamentals of Entrepreneurship	3
NR 319	Introduction to Geospatial Science	4	MKT 305	Fundamentals of Marketing	3
NR 323/GR 323	Remote Sensing and Image Interpretation	3			
NR 505	Concepts in GIS	4			
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 330	Principles of Genetics	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			
STAT 305	Sampling Techniques	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			
STAR 512	Design and Data Analysis for Researchers II	4			
<b>Technical Electives - B</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	2			
IDEA 310D	Design Thinking Toolbox: Digital Imaging	1			
MGT 305	Fundamentals of Management	3			