DUAL DEGREE PROGRAM: BIOMEDICAL ENGINEERING COMBINED WITH ELECTRICAL ENGINEERING, LASERS AND OPTICAL ENGINEERING CONCENTRATION

Requirements
Effective Fall 2023

In order to maintain professional standards required of practicing engineers, the Department of Electrical and Computer Engineering requires a cumulative grade point average of at least 2.000 in ECE courses as a graduation requirement. It is the responsibility of any student who fails to maintain a 2.000 average to work with their advisor to correct grade point deficiencies. In addition, it is required that students retake any Electrical Engineering course at the 300-level or below in which they receive a grade below a C (2.000).

Freshman

		AUCC	Credits
BIOM 100	Overview of Biomedical Engineering		1
CHEM 111	General Chemistry I (GT-SC2)	3A	4
CO 150	College Composition (GT-CO2)	1A	3
ECE 102	Digital Circuit Logic		4
ECE 103	DC Circuit Analysis		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
	Total Credits		**32**

Sophomore

BIOM 200	Fundamentals of Biomedical Engineering		2
CHEM 112	General Chemistry Lab I (GT-SC1)	3A	1
Select from one of the following groups:[1]			3-4
Group A			
CS 150B	Culture and Coding: Python (GT-AH3)	3B	
Group B			
CS 152	Python for STEM		
CS 162	CS1--Introduction to Java Programming		
Group C			
CS 163	CS1---No Prior Programming Experience		
ECE 202	Circuit Theory Applications		4
ECE 232	Introduction to Project Practices		1
ECE 303/STAT 303	Introduction to Communications Principles		3
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
PH 314	Introduction to Modern Physics		4
	Total Credits		**31-32**

Junior

BIOM 300	Problem-Based Learning Biomedical Engr Lab		4

BMS 300	Principles of Human Physiology		4
Select from the following to complete group sequence:[1]			3-4
Group A			
CS 164	CS1--Computational Thinking with Java		
Group B			
Arts and Humanities (http://catalog.colostate.edu/general-catalog/all-university-core-curriculum/aucc/#arts-humanities)		3B	
Group C			
Arts and Humanities (http://catalog.colostate.edu/general-catalog/all-university-core-curriculum/aucc/#arts-humanities)		3B	
ECE 311	Linear System Analysis I		3
ECE 331	Electronics Principles I		4
ECE 332	Electronics Principles II		4
ECE 341	Electromagnetic Fields and Devices I		3
ECE 342	Electromagnetic Fields and Devices II		3
	Total Credits		**28-29**

Senior

BIOM 431/ECE 431	Biomedical Signal and Image Processing		3
CHEM 113	General Chemistry II		3
CHEM 245	Fundamentals of Organic Chemistry		4
ECE 404	Experiments in Optical Electronics		2
ECE 441	Optical Electronics		3
ECE 457	Fourier Optics		3
ECON 202	Principles of Microeconomics (GT-SS1)	3C	3
MECH 262	Engineering Mechanics		4
MECH 337	Thermodynamics		4
PH 353	Optics and Waves		4
	Total Credits		**33**

Fifth Year

BIOM 486A	Biomedical Design Practicum: Capstone Design I	4A,4B,4C	4
BIOM 486B	Biomedical Design Practicum: Capstone Design II	4A,4B,4C	4
PH 451	Introductory Quantum Mechanics I		3
Select one course from the following:			3
CO 301B	Writing in the Disciplines: Sciences (GT-CO3)	2	
JTC 300	Strategic Writing and Communication (GT-CO3)	2	
ECE Lasers & Optical Engineering Technical Electives (See list below)			8
BME Broad Elective (see list below)			3
Arts and Humanities (http://catalog.colostate.edu/general-catalog/all-university-core-curriculum/aucc/#arts-humanities)		3B	3
Diversity, Equity, and Inclusion (http://catalog.colostate.edu/general-catalog/all-university-core-curriculum/aucc/#diversity-equity-inclusion)		1C	3
Historical Perspectives (http://catalog.colostate.edu/general-catalog/all-university-core-curriculum/aucc/#historical-perspectives)		3D	3
	Total Credits		**34**
	Program Total Credits:		**158-160**

ECE Lasers & Optical Engineering Technical Electives List – Select 9 credits

Code	Title	Credits
ECE 312	Linear System Analysis II	3
ECE 415	Semiconductor Physics and Junctions	2
ECE 430/MATH 430	Fourier and Wavelet Analysis with Apps	3
A maximum of 3 credits from the following may be used to satisfy this requirement:		var.
ECE 495A	Independent Study	
ECE 495B	Independent Study: Open Option Project	

ECE 495C	Independent Study: Vertically Integrated Projects	
ECE 503	Ultrafast Optics	3
ECE 504	Physical Optics	3
ECE 505	Nanostructures: Fundamentals and Applications	3
ECE 506	Optical Interferometry and Laser Metrology	3
ECE 507	Plasma Physics and Applications	3
ECE 517/BIOM 517	Advanced Optical Imaging	3
ECE 518/BIOM 518	Biophotonics	3
ECE 523/MSE 523	Electronic Properties of Materials	3
ECE 526/BIOM 526	Biological Physics	3
ECE 527B/ BIOM 527B	Biosensing: Signal and Noise in Biosensors	1
ECE 527F/ BIOM 527F	Biosensing: Biophotonic Sensors Using Refractive Index	1
ECE 546	Laser Fundamentals and Devices	3
ECE 572	Semiconductor Transistors	1
ECE 573	Semiconductor Optoelectronics Laboratory	3
ECE 574	Optical Properties in Solids	3
MATH 419	Introduction to Complex Variables	3
PH 315	Modern Physics Laboratory	2
PH 425	Advanced Physics Laboratory	2
PH 452	Introductory Quantum Mechanics II	3
PH 462	Statistical Physics	3

BME Broad Electives - Select 3 credits

Code	Title	Credits
AB 410	Understanding Pesticides	3
ATS 555	Air Pollution	3
ATS 560	Air Pollution Measurement	2
BC 351	Principles of Biochemistry	4
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 465	Molecular Regulation of Cell Function	3
BC 517	Metabolism	2
BC 521/CHEM 521	Principles of Chemical Biology	3
BC 563	Molecular Genetics	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 441	Biomechanics and Biomaterials	3
BIOM 504/CBE 504	Fundamentals of Biochemical Engineering	3
BIOM 517/ECE 517	Advanced Optical Imaging	3
BIOM 518/ECE 518	Biophotonics	3
BIOM 522/CBE 522	Bioseparation Processes	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 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 570/MECH 570	Bioengineering	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
BMS 301	Human Gross Anatomy	5
BMS 302	Laboratory in Principles of Physiology	2
BMS 305	Domestic Animal Gross Anatomy	4
BMS 310	Anatomy for the Health Professions	4
BMS 320	Virtual Laboratory in Physiology	2
BMS 325	Cellular Neurobiology	3
BMS 330	Microscopic Anatomy	4
BMS 345	Functional Neuroanatomy	4
BMS 405	Nerve and Muscle-Toxins, Trauma and Disease	3
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

BZ 420	Evolutionary Medicine	3
BZ 476/BZ 576	Genetics of Model Organisms	3
CBE 330	Process Simulation	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 505	Biochemical Engineering Laboratory	1
CBE 514	Polymer Science and Engineering	3
CBE 521	Mathematical Modeling for Chemical Engineers	3
CBE 524	Bioremediation	1
CBE 540/CIVE 540	Advanced Biological Wastewater Processing	3
CBE 570	Biomolecular Engineering/Synthetic Biology	3
CHEM 246	Fundamentals of Organic Chemistry Laboratory	1
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 343	Modern Organic Chemistry II	3
CHEM 344	Modern Organic Chemistry Laboratory	2
CHEM 346	Organic Chemistry II	4
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
CHEM 539C	Principles of NMR and MRI: Advanced NMR and MRI Techniques	1
CHEM 541	Organic Molecular Structure Determination	2
CHEM 543	Structure/Mechanisms in Organic Chemistry	2
CHEM 545	Synthetic Organic Chemistry I	3
CHEM 547	Physical Organic Chemistry	3
CHEM 555	Chemistry of Sustainability	3
CHEM 560	Foundations of Inorganic Synthesis	1
CHEM 566	Bioinorganic Chemistry	3
CHEM 567	Crystallographic Computation	1
CHEM 569	Chemical Crystallography	3
CHEM 570	Chemical Bonding	3
CHEM 575	Fundamentals of Chemical Thermodynamics	1
CHEM 576	Statistical Mechanics	2
CHEM 577	Surface Chemistry	3
CHEM 578A	Computational Chemistry: Electronic Structure	1
CHEM 579	Chemical Kinetics	3
CIVE 322	Basic Hydrology	3
CIVE 330	Ecological Engineering	3
CIVE 360	Mechanics of Solids	3
CIVE 367	Structural Analysis	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 524/WR 524	Modeling Watershed Hydrology	3
CIVE 531	Groundwater Hydrology	3
CIVE 538	Aqueous Chemistry	3
CIVE 560	Advanced Mechanics of Materials	3
CIVE 562	Fundamentals of Vibrations	3
CM 501	Advanced Cell Biology	4
CM 502/NB 502	Techniques in Molecular & Cellular Biology	2
May choose one of the following if not otherwise taken to meet degree requirements [2]		
CS 152	Python for STEM [2]	
CS 162	CS1--Introduction to Java Programming [2]	
CS 163	CS1---No Prior Programming Experience [2]	
CS 164	CS1--Computational Thinking with Java [2]	
CS 165	CS2--Data Structures	4
CS 220	Discrete Structures and their Applications	4
CS 253	Software Development with C++	4
CS 270	Computer Organization	4
CS 314	Software Engineering	3
CS 320	Algorithms--Theory and Practice	3
CS 356	Systems Security	3
CS 370	Operating Systems	3
CS 4** - Any 400-level CS course except CS 495		
CS 5** - Any 500-level CS course		
DSCI 320	Optimization Methods in Data Science	3
DSCI 369	Linear Algebra for Data Science (credit not allowed for both DSCI 369 and MATH 369)	3-4
or MATH 369	Linear Algebra I	
ECE 312	Linear System Analysis II	3
ECE 4** - Any 400-level ECE course not otherwise required for the degree; also excluding ECE 495		
ECE 5** - Any ECE 500-level course		
ENGR 300	3D Printing Lab for Engineers	1
ENGR 422	Technology Entrepreneurship	3
ENGR 510	Engineering Optimization: Method/ Application	3
ENGR 525	Intellectual Property and Invention Systems	3

ENGR 570	Coupled Electromechanical Systems	3
ERHS 320	Environmental Health--Water Quality	3
ERHS 332	Principles of Epidemiology	3
ERHS 400	Radiation Safety	3
ERHS 410	Environmental Health-Air and Waste Management	3
ERHS 430	Human Disease and the Environment	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 540	Principles of Ergonomics	3
ERHS 542	Biostatistical Methods for Qualitative Data	3
ERHS 547	Equipment and Instrumentation	3
ERHS 560	Health Impact Assessment	2
ESS 353	Global Change Impacts, Adaptation, Mitigation	3
F 311	Forest Ecology	3
FIN 305	Fundamentals of Finance	3
FSHN 470	Integrative Nutrition and Metabolism	3
FTEC 447	Food Chemistry	2
GEOL 150	Physical Geology for Scientists and Engineers	4
GEOL 452	Hydrogeology	4
GEOL 454	Geomorphology	4
GES 441	Analysis of Sustainable Energy Solutions	3
GES 542	Biobased Fuels, Energy, and Chemicals	3
HES 207	Anatomical Kinesiology	4
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
HES 476	Exercise and Chronic Disease	3
HORT 579	Mass Spectrometry Omics-Methods and Analysis	3
IDEA 310B	Design Thinking Toolbox: 3D Modeling	2
IDEA 310D	Design Thinking Toolbox: Digital Imaging	1
IDEA 310H/CS 310H	Design Thinking Toolbox: Mixed Reality Design	3
IDEA 455/MGT 455	Designing for Defense	3
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
MATH 151	Mathematical Algorithms in Matlab I	1
MATH 229	Matrices and Linear Equations	2
MATH 235	Introduction to Mathematical Reasoning	2
MATH 301	Introduction to Combinatorial Theory	3
MATH 317	Advanced Calculus of One Variable	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 405	Introduction to Number Theory	3
MATH 417	Advanced Calculus I	3
MATH 418	Advanced Calculus II	3
MATH 419	Introduction to Complex Variables	3
MATH 430/ECE 430	Fourier and Wavelet Analysis with Apps	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 470	Euclidean and Non-Euclidean Geometry	3
MATH 474	Introduction to Differential Geometry	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 550/ ENGR 550	Numerical Methods in Science and Engineering	3
MATH 560	Linear Algebra	3
MATH 569A	Linear Algebra for Data Science: Matrices and Vectors Spaces	1
MATH 569B	Linear Algebra for Data Science: Geometric Techniques for Data Reduction	1
MATH 569C	Linear Algebra for Data Science: Matrix Factorizations and Transformations	1
MATH 569D	Linear Algebra for Data Science: Theoretical Foundations	1
MECH 200	Introduction to Manufacturing Processes	3
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 4** - Any 400-level MECH Course except MECH 495		
MECH 5** - Any 500-level course		
MGT 305	Fundamentals of Management	3
MGT 340	Fundamentals of Entrepreneurship	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 425	Virology and Cell Culture Laboratory	2
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
MIP 530	Advanced Molecular Virology	4
MIP 543	RNA Biology	3
MIP 550	Microbial and Molecular Genetics Laboratory	4
MIP 555	Principles and Mechanisms of Disease	3
MKT 305	Fundamentals of Marketing	3
MSE 501	Materials Technology Transfer	1
MSE 502A	Materials Science & Engineering Methods: Materials Structure and Scattering	1
MSE 502B	Materials Science & Engineering Methods: Computational Materials Methods	1
MSE 502C	Materials Science & Engineering Methods: Materials Microscopy	1
MSE 502D	Materials Science & Engineering Methods: Materials Spectroscopy	1
MSE 502E	Materials Science & Engineering Methods: Bulk Properties and Performance	1
MSE 502F	Materials Science & 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 315	Modern Physics Laboratory	2
PH 341	Mechanics	4
PH 351	Electricity and Magnetism	4
PH 361	Physical Thermodynamics	3
PH 425	Advanced Physics Laboratory	2
PH 452	Introductory Quantum Mechanics II	3
PH 462	Statistical Physics	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 322	Biomedical Ethics	3
PHIL 410	Gödel's Incompleteness Theorems	3
PSY 253	Human Factors and Engineering Psychology	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
STAR 512	Design and Data Analysis for Researchers II	4
STAT 158	Introduction to R Programming	1
STAT 305	Sampling Techniques	3
STAT 331	Intermediate Applied Statistical Methods	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 534	Human Systems Integration	3
VS 333	Domestic Animal Anatomy	4

[1] Students must take a total of 7 credits from either of these groups: Group A: CS 150B + CS 164 - OR - Group B: AUCC 3B + CS 163 - OR - Group C: AUCC 3B + CS 152 + CS 162. Recommended sequence for most incoming students is Group A: **CS 150B** to **CS 164**.

[2] CS 152, CS 162, CS 163 and CS 164 may be taken as BME Broad Electives ONLY when not taken to fulfill degree requirements. Credit not allowed for both CS 163 and CS 164.