



SCHOOL OF BIOMEDICAL
ENGINEERING
COLORADO STATE UNIVERSITY

B.S. Biomedical Engineering + B.S. Electrical Engineering BME+EE Curriculum and Career Guide Fall 2018

This Guide is designed to help students understand the academic requirements and selected career resources in the Colorado State University undergraduate dual-degree program in Biomedical Engineering and Electrical Engineering (BME+EE). Students graduate with full BS degrees in *both* disciplines and benefit from classroom and experiential learning through lecture, team projects, laboratory, and design courses in a unique multidisciplinary environment. Ours is the first ABET-Accredited BME program in Colorado, and the only accredited BME degree in the country that has an obligatory tie to a partner degree.

During the first and second years, BME+EE students are introduced to biomedical and electrical engineering, in addition to learning the fundamentals of physics and mathematics. The third year of study provides continued depth in BME and EE, including a multidisciplinary, hands-on problem-based BME learning lab. The fourth year rounds out the EE curriculum and adds a 'gateway' BME course that transitions key EE concepts into BME applications. The fifth year culminates in a year-long capstone Senior Design course in which students work in multidisciplinary teams creating solutions to BME industry or research problems.

Students are required to satisfy the scholastic standards of the university, college, and engineering department. (Note that many ECE courses must be passed with a minimum grade of "C".) Full course descriptions and prerequisites can be found at <http://www.catalog.colostate.edu>. All-University Core Curriculum (AUCC – "General Education") [courses can be found here](#). Students will also meet with their advisors each semester to review academic plans and university resources.

We also encourage students to get involved in experiential learning via research and internships. BME faculty are spread among four different colleges, providing students a broad range of research opportunities. BME's academic home is the Scott Bioengineering Building, a cutting-edge interdisciplinary research and academic facility that opened in 2013. The Student Success Center in the Scott Building helps students develop resumes and interviewing skills, and gain access to internships and co-ops. Study Abroad is also encouraged in our program, as biomedical engineering is a global field. Please visit www.engr.colostate.edu/sbme for more information about our program.

We are here to support your CSU experience and warmly welcome you to BME @ CSU!

Sincerely,

Robyn

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Academic Advisor

*(Prospective and entering
first-year students)*

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Biomedical Engineering and Electrical Engineering
Curriculum Checksheet - Effective Summer 2018 and Prior

Name: _____

157-158 Total Credits

COURSE	NAME (PREREQS)	TERM*	CR	COURSE	NAME (PREREQS)	TERM*	CR
1st Year Fall				1st Year Spring			
BIOM 101	Introduction to Biomedical Engineering	F	3	ECE 103	DC Circuit Analysis (MATH 160)	F, S	3
CHEM 111	General Chemistry I (MATH 118 or 141 or 155 or 160 or 161 or 229 or 261)	F, S, SS	4	LIFE 102	Attributes of Living Systems	F, S, SS	4
CHEM 112	General Chem Lab I (CHEM 111 or 117 or conc.)	F, S, SS	1	MATH 161	Calculus for Physical Scientists II (MATH 124; MATH 159 or 160)	F, S, SS	4
MATH 160	Calculus for Physical Scientists I (MATH 124 (B or better); MATH 126 (B or better))	F, S, SS	4	PH 141	Physics for Scientists and Engineers I (MATH 126 or conc.; MATH 155 or 159 or 160 or conc.)	F, S, SS	5
ECE 102	Digital Circuit Logic	F, S	4				
	Total		16			Total	16
2nd Year Fall				2nd Year Spring			
CO 150	College Composition (CO 130 or placement by ACT/SAT or DSP Survey or Challenge Exam)	F, S, SS	3	ECE 202	Circuit Theory Applications (ECE 103, MATH 160)	S,SS	4
CS 163 OR CS 164 OR CS155, CS156, CS157	Java (CS1) No Prior Programming (MATH 124) OR Java (CS1) Prior Programming (MATH 124) OR Unix and C Programming I (CS 155 or conc.; MATH 118) & II (CS 156 or conc.; MATH 118)	F,S	4 or 3	ECE/STAT 303	Introduction to Communication Principles (MATH 261; MATH 340 or 345 or conc.)	S	3
MATH 261	Calculus for Physical Scientists III (MATH 161)	F, S, SS	4	MATH 340 or MATH MECH 262	Introduction to Ordinary Differential Equations (MATH 255 or 261) -- OR -- Differential Equations (MATH 229 Engineering Mechanics (MATH 161; PH 141)	F, S, SS	4
PH 142	Physics for Scientists and Engineers II (PH 141; MATH 161 or 255 or 271 or conc.)	F,S	5			S	4
	Total		15 or 16			Total	15
3rd Year Fall				3rd Year Spring			
ECE 311	Linear Systems Analysis I (ECE 202; MATH 340 or 345; ECE 331 or conc.; ECE 341 or ECE 451 or conc.)	F	3	BIOM 300	Problem-Based Learning BME Lab (BIOM 101 or BIOM 200 or (BIOM 100; CBE 205; MECH 262); MATH 340 or 345)	S	4
ECE 331	Electronics Principles I (ECE 202; MATH 340 or 345; PH 142; ECE 311 or conc.; ECE 341 or ECE 451 or conc.)	F	4	ECE 312*	Linear Systems Analysis II (ECE 311)	S	3
ECE 341	Electromagnetics Fields and Devices I (ECE 202; MATH 340 or 345; PH 142; ECE 311 or conc.; ECE 331 or conc.)	F	3	ECE 332*	Electronics Principles II (ECE 331)	S	4
LIFE 210	Introductory Eukaryotic Cell Biology (LIFE 102; CHEM 111; CHEM 112)	F	3	ECE 342*	Electromagnetic Fields and Devices II (ECE 341)	S	3
AUCC		F, S, SS	3				
	Total		16			Total	14
4th Year Fall				4th Year Spring			
BMS 300	Principles of Human Physiology (BZ 101 or 110 or LIFE 102; CHEM 103 or 107 or 111)	F, S, SS	4	BIOM 431	Biomedical Signal and Image Processing (ECE 303; ECE 311; PH 142)	S	3
CHEM 113	Gen Chem II (CHEM 107 or 111 or 117; MATH 124 or MATH 141, 155, 160, 161, 229, 261 or conc.)	F, S, SS	3	CHEM 245	Fundamentals of Organic Chem. (CHEM 107 or 113)	F, S, SS	4
ECE 251	Introduction to Microprocessors (ECE 102)	F	4	ECE-TE	ECE Technical Elective _____		3
AUCC		F, S, SS	3	MECH 337	Thermodynamics (MATH 261; PH 141)	F, S	4
ECON 202 (AUCC 3C)	Principles of Microeconomics (MATH 117 or 118 or 141 or 155 or 160)	F, S, SS	3	AUCC		F, S, SS	3
	Total		17			Total	17
5th Year Fall				5th Year Spring			
BIOM 486A	Biomedical Design Practicum: Capstone Design I (BIOM 300; (BIOM 421; CBE 320; CBE 442) or (BIOM 431; ECE 311; ECE 332; ECE 342) or (BIOM 441; MECH 301; MECH 307)	F	4	BIOM 486B	Biomedical Design Practicum: Capstone Design II (BIOM 486A; (CBE 451) or (ECE 312) or (MECH 325; MECH 344; MECH 402) or (PH 353).	S	4
BME-TE	BME Technical Elective _____		3	BME-TE	BME Technical Elective _____		3
ECE-TE	ECE Technical Elective _____		6	ECE-TE	ECE Technical Elective _____		5
CO 301B OR JTC 300	Writing in the Disciplines: Sciences OR Professional & Technical Communication (CO 150 or HONR 193)	F, S, SS	3	AUCC		F, S, SS	3
	Total		16			Total	15

* - The combination of 3rd year ECE courses is exceptionally challenging

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

Additional All University Core Courses (AUCCs)
6 cr - 3B Arts and Humanities: _____
3 cr - 3C Social/Behavioral Science: ECON 202
3 cr - 3D Historical Perspective: _____
3 cr - 3E Global/Cultural Awareness: _____

Key:
"conc." = concurrent enrollment *Term: F = Fall, S = Spring, SS = Summer Session
Grey indicates Biomedical Engineering courses
Light green indicates labs
Red indicates exceptionally time-consuming/difficult courses
Must have at least a "C" in BOLDED courses

BME+EE Technical Electives

Technical Electives (TEs) are designed to provide additional breadth and depth in the Biomedical and partner major degrees.

BME-EE students must take 6 credits of BME TEs and 14 credits of ECE TEs chosen from the following lists.

Key:	
F - Fall	* Available Every Other Year (Even)
S - Spring	** Available Every Other Year (Odd)
SS - Summer	
♦ See last page of this document for information on how to obtain course overrides	

- NOTE:**
1. Classes otherwise required for the degree are not allowed for TE credit.
 2. Course availability changes frequently. Please check with individual departments regarding course availability.
 3. Crosslisted courses (e.g. BIOM/MECH 570) are in italics and must be taken as *BIOM* courses to count for BME Technical Elective credit.

● BME+EE students must take 6 credits of BME TEs from the following list:

BME Technical Electives			
COURSE	NAME	TERM	CR
BC 351	Principles of Biochemistry	F, S, SS	4
BC 401	Comprehensive Biochemistry I	F	3
BC 403	Comprehensive Biochemistry II	S	3
BC 404	Comprehensive Biochemistry Laboratory	F,S	2
BC 411	Physical Biochemistry	F	4
BC 463	Molecular Genetics	F	3
BC 465	Molecular Regulation & Cell Function	S	3
BC 565	Molecular Regulation of Cell Function	S	4
BIOM 421	Transport Phenomena in Biomedical Engineering	F	3
BIOM 422	Kinetics of Biomolecular and Cellular Systems	S	3
BIOM 441	Biomechanics and Biomaterials	F	3
BIOM 476 A-B	Biomedical Clinical Practicum (formerly BIOM 486)	F,S,SS	2 or 4
BIOM 495 ¹	BME Independent Study (3 credits max TE allowed of 476 &/or 495)	BIOM F,S,SS	1-6
<i>BIOM/CBE 504</i>	Fundamentals of Biochemical Engineering	S	3
<i>BIOM/ECE 518</i>	Biophotonics	F	3
<i>BIOM/CBE 522</i>	Bioseparation Processes	F	3
<i>BIOM/MECH 525</i>	Cell and Tissue Engineering	S	3
<i>BIOM/ECE 526</i>	Biological Physics	S	3
<i>BIOM/MECH 531</i>	Materials Engineering	S	3
<i>BIOM/CIVE 533</i>	Biomolecular Tools for Engineers	F	3
<i>BIOM/ECE 537</i>	Biomedical Signal Processing	S	3
<i>BIOM/CBE 543</i>	Membranes for Biotechnology and Biomedicine	F	3
<i>BIOM/MECH 570</i>	Bioengineering	F	3
<i>BIOM/MECH 573</i>	Structure and Function of Biomaterials	S	3
<i>BIOM/MECH 574</i>	Bio-Inspired Surfaces	S	3
<i>BIOM/MECH 576</i>	Quantitative Systems Physiology	S	4
<i>BIOM/MECH 578</i>	Musculoskeletal Biosolid Mechanics	F	3
BMS 301	Human Gross Anatomy	F,S,SS	5
BMS 302	Laboratory in Principles in Physiology	F,S	2
BMS 310	Anatomy for the Health Professions (Online)	F, S, SS	4
BMS 325	Cellular Neurobiology	F	3
BMS 345	Functional Neuroanatomy	S	4
BMS 405	Nerve and Muscle-Toxins, Trauma and Disease	S	3
BMS 409	Human and Animal Reproductive Biology	F	3
BMS 420	Cardiopulmonary Physiology	F	3
BMS 430	Endocrinology	F	3
BMS 450	Pharmacology	S	3
BMS 500	Mammalian Physiology I	F	4
BMS 501	Mammalian Physiology II	S	4
BZ 311	Developmental Biology	S,SS	4

BME Technical Electives (Continued)			
COURSE	NAME	TERM	CR
BZ 350	Molecular and General Genetics	F,S,SS	4
BZ 476*/BZ 576	Genetics of Model Organisms	F	3
CBE 330	Process Simulation	F	3
CHEM 334	Quantitative Analysis Laboratory	F, S	1
CHEM 335	Intro to Analytical Chemistry	F,S	3
CHEM 343	Modern Organic Chemistry II	F,S,SS	3
CHEM 344	Modern Organic Chemistry Laboratory	F,S,SS	2
CHEM 346	Organic Chemistry II	F,S	4
CHEM 433**	Clinical Chemistry	S	3
CHEM 539A-C	Principles of NMR and MRI	S	1
CM 501	Advanced Cell Biology	F	4
CM/NB 502	Techniques in Molecular & Cellular Biology	F	2
ECE/MECH 569*	Micro-Electro-Mechanical Devices	S	3
ERHS 450	Introduction to Radiation Biology	S	3
ERHS 502	Fundamentals of Toxicology	F	3
ERHS 510	Cancer Biology	S	3
ERHS 540	Principles of Ergonomics	F	3
FSHN 470	Integrated Nutrition & Metabolism	F,S	3
HES 307	Biomechanical Principles of Human Movement	F,S,SS	4
HES 319	Neuromuscular Aspects of Human Movement	F,S	4
HES 403	Physiology of Exercise	F,S,SS	4
HES 476	Exercise and Chronic Disease	F,S,SS	3
MATH 455**	Mathematics in Biology and Medicine	F	3
MECH 432	Engineering of Nanomaterials	F	3
MECH 543**	Biofluid Mechanics	S	3
MIP 300	General Microbiology	F,S,SS	3
MIP 302	General Microbiology Laboratory	F,S	2
MIP 342	Immunology	F,S	4
MIP 343	Immunology Laboratory	S	2
MIP 351	Medical Bacteriology	S	3
MIP 352	Medical Bacteriology Lab	S	3
MIP 420	Medical and Molecular Virology	F	4
MIP 436*	Industrial Microbiology	F	4
MIP 443	Microbial Physiology	S	4
MIP 450	Microbial Genetics	F	3
MIP/BSPM 576	Bioinformatics	F,S	3
NB 500	Readings in Cellular Neurobiology	F	1
NB 501	Cellular and Molecular Neurophysiology	F	2
NB/BMS 503	Developmental Neurobiology	S	3
NB/BMS 505	Neuronal Circuits, Systems and Behavior	S	3

¹ A maximum total of 3 credits of BIOM 476 and/or BIOM 495 may be applied towards BME technical elective degree requirements.

●BME+EE students must take 14 credits of ECE TEs from the following courses:							
ECE Technical Electives							
Course Number	Course Title	Terms	Credits	Course Number	Course Title	Terms	Credits
CS314	Software Engineering	F, S	3	ECE4XX	Any ECE course at the 400 level	F, S	Varies
CS320	Algorithms--Theory and Practice	F, S	3	ECE495 A-C	Independent Study	F, S, SS	1-6
CS356	Systems Security	F, S	3	ECE5XX	Any ECE course at the 500 level	F,S	Varies
CS370	Operating Systems	F, S	3	MATH417	Advanced Calculus I	F	3
CS410	Introduction to Computer Graphics	F	4	MATH418	Advanced Calculus II	S	3
CS414	Object-Oriented Design	F	4	MATH419	Introduction to Complex Variables	F	3
CS420	Introduction to Analysis of Algorithms	F	4	MATH450	Intro to Numerical Analysis I	F	3
CS430	Database Systems	S	4	MATH451	Intro to Numerical Analysis II	S	3
CS440	Introduction to Artificial Intelligence	F	4	MATH460	Information and Coding Theory	S	3
CS445	Introduction to Machine Learning	S	4	MATH466	Abstract Algebra I	F	3
CS453	Introduction to Compiler Construction	S	4	MATH469	Linear Algebra II	S	3
CS455	Introduction to Distributed Systems	S	4	MATH470	Euclidian and Non-Euclidian Geometry	S	3
CS475	Parallel Programming	F	4	MATH474	Introduction to Differential Geometry	F	3
CS510	Image Computation	S	4	MECH564	Fundamentals of Robot Mechanisms and Controls	S	3
CS520	Analysis of Algorithms	S	4	PH315	Modern Physics Lab	S	2
CS 530	Fault-Tolerant Computing	S	4	PH425	Advanced Physics Laboratory	S	2
CS540	Artificial Intelligence	S	4	PH451	Introductory Quantum Mechanics I	F	3
CS545	Machine Learning	F	4	PH452	Intro to Quantum Mechanics II	S	3
CS553	Algorithmic Language Compilers	F	4	PH462	Statistical Physics	F	3
CS556	Computer Security	F	4	STAT421	Introduction to Stochastic Processes	S	3
CS557	Advanced Networking	S	4				
CS575	Parallel Processing	F	4				

² A maximum total of 3 credits of 495 Independent Study may be applied towards EE technical elective degree requirements.

To Request Overrides - Include your CSU ID and verification that you meet prerequisites; if you do not meet prerequisites, request permission from the prof and indicate why you think you would be successful in the course. If granted permission, forward as indicated below.

- ◆ For 500-level BIOM courses, forward permission to Sara.Mattern@colostate.edu (BME grad adviser) to request override
- ◆ For 500-level CBE courses, you should be able to register if you meet the pre-requisites. If you need an override, forward permission to Claire.Lavelle@colostate.edu.
- ◆ For 500-level ECE courses, you should be able to register if you meet the pre-requisites. If you need an override, forward permission to Courtney.Johnsrud@colostate.edu
- ◆ For CIVE courses, email your BME adviser with the reason you want the override (e.g. meet pre-reqs but are not in the major) and she will forward request to the department on your behalf.
- ◆ For MECH courses, request approval via your BME adviser, who will forward to MECH on your behalf. If you do not meet prerequisites for 500-level courses (cum 3.0+ gpa or coursework), request permission from the prof and forward
- ◆ To request overrides for other courses (e.g. 500-level or prereq override), email the course professor or the department teaching the course.



Biomedical Engineering (BME) degree combined with Electrical Engineering (BME+EE) provides a strong background in applied physics, signal and image processing that combines engineering principles with medical and biological sciences to design and create equipment, devices, computer systems, and software to improve human and animal healthcare. BME+EEs may work in a broad range of medical devices and equipment applications such as biomedical imaging, patient monitoring and therapeutic processes (e.g. robotics that operate surgical equipment, devices that open and cauterize wounds, x-rays, etc.).

Learn more about [biomedical engineers](http://www.bls.gov/ooh/architecture-and-engineering/biomedical-engineers.htm) - <http://www.bls.gov/ooh/architecture-and-engineering/biomedical-engineers.htm> - in the Bureau of Labor Statistics Occupational Outlook Handbook or at the Biomedical Engineering Society: [BMES.org](http://www.BMES.org).

Learn more about [electrical engineers](http://www.bls.gov/ooh/architecture-and-engineering/electrical-and-electronics-engineers.htm) - <http://www.bls.gov/ooh/architecture-and-engineering/electrical-and-electronics-engineers.htm> - in the Bureau of Labor Statistics Occupational Outlook Handbook.

Additional Resources: IEEE (the Institute of Electrical and Electronics Engineers – www.ieee.org); IEEE spectrum - <http://spectrum.ieee.org/biomedical>; EMBS (IEEE Engineering in Medicine & Biology) - <http://www.embs.org> or <http://tbme.embs.org/>.

Our alumni have worked in varied companies such as Applied Medical, DEKA R&D, Inovonics, Otter Box, QuSpin, and 3D systems, to name a few. Some have gone on to graduate school, as well, showing the strong preparation of the BME+EE program.

Finding BME Internships/Jobs

Take advantage of CSU resources

- **Career Fairs** – fall and spring. Many biotech companies don't go to these, but some do. Check with companies for your partner majors, also.
- **Biotech Connect** – held in early March – networking event for biotech companies
- **Handshake** – internship/job posting database (<https://career.colostate.edu/experience/handshake>)
- **Engineering Success Center** – help with resumes, interviewing, job/internship search, co-ops

Attend events, look at job posting and company websites (sign up to have updated jobs sent to you)

- **Biomedical Engineering Society** – www.BMES.org
 - Active student chapter @CSU - <https://www.engr.colostate.edu/organizations/bmes;>
 - Email for further information/membership: csu.bmesociety@gmail.com
 - Job Postings - <http://jobboard.bmes.org/search.cfm>; especially good for academic positions.
- **Colorado Bioscience Association** (THE organization for biotech in CO): www.cobioscience.com
 - **Job postings** – www.cobioscience.com/careers.php; www.aftercollege.com; www.glassdoor.com; www.biospace.com
 - **Local information and opportunities** – find industry updates and a company directory in the back! <http://www.cobioscience.com/sponsorship/marketing-magazine>
- **General Biotech** - www.Biospace.com – wordsearch specific terms (i.e. medical devices, tissue engineering)
- **Pharmaceuticals** – www.ispe.org
- **Medical Device** - <http://www.devicespace.com>
- **Clinical Research** - <http://www.biospace.com/clinicaspacejobs/home>