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,

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Biomedical Engineering and Electrical Engineering **Name:** _____

Curriculum Checksheet - Effective Fall 2018 And After

Program Total Credits = 158

COURSE	NAME (PREREQS (";" DENOTES "AND"))	TERM	C	COURSE	NAME (PREREQS (";" DENOTES "AND"))	TERM	C
1st Year Fall				**1st Year Spring**			
BIOM 100	Overview of Biomedical Engineering	F	1	CHEM 112	General Chemistry Lab I (CHEM 111 or 117 or conc.)	F, S, SS	1
CHEM 111	General Chemistry I (MATH 118 or 141 or 155 or 160 or 161 or 229 or 261; CHEM 105 or an appropriate score in the chemistry preparation module)	F, S, SS	4	**ECE 103**	DC Circuit Analysis (**MATH 160**)	F, S	3
CO 150	College Composition (CO 130 or placement by ACT/SAT or DSP Survey or Challenge Exam)	F, S, SS	3	**MATH 161**	Calculus for Physical Scientists II (MATH 124; MATH 159 or 160)	F, S, SS	4
ECE 102	Digital Circuit Logic	F, S	4	LIFE 102	Attributes of Living Systems	F, S, SS	4
MATH 160	Calculus for Physical Scientists I (MATH 124 and 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
		Total	**16**			**Total**	**17**
2nd Year Fall				**2nd Year Spring**			
BIOM 200	Fundamentals of Biomedical Engineering (BIOM 100 or conc.; LIFE 102; MATH 160)	F	2	**ECE 202**	Circuit Theory Applications (**ECE 103**, **MATH 161**)	S, SS	4
CS 163 OR CS 164	Java (CS1) No Prior Programming (**MATH 124**) OR Java (CS1) Prior Programming (**MATH 124**)	F,S	4	**ECE / STAT 303**	Introduction to Communication Principles (**MATH 261**; MATH 340 or conc.)	S	3
PH 142*	Physics for Scientists and Engineers II (PH 141; MATH 161 or 255 or 271 or conc.)	F,S	5	**MATH 340**	Introduction to Ordinary Differential Equations (MATH 255 or 261)	F, S, SS	4
MATH 261	Calculus for Physical Scientists III (MATH 161)	F, S, SS	4	MECH 262	Engineering Mechanics (MATH 161; PH 141)	S	4
		Total	**15**			**Total**	**15**
3rd Year Fall				**3rd Year Spring**			
ECE 311	Linear Systems Analysis I (**ECE 202**; **MATH 340**; **ECE 331** or conc.; ECE 341 orECE 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)	S	4
ECE 331	Electronics Principles I (**ECE 202**; **MATH 340**; **PH142**; 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**; **PH 142**; ECE 311 or conc.; ECE 331 or conc.)	F	3	**ECE 332**	Electronics Principles II (**ECE 331**)	S	4
BME BE	BME Broad Elective	F, S, SS	3	**ECE 342**	Electromagnetic Fields and Devices II (**ECE 341**)	S	3
AUCC	_____	F, S,	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	General Chemistry 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 Chemistry (CHEM 107 or 113)	F, S, SS	4
ECE 251	Introduction to Microprocessors (**ECE 102**)	F	4	MECH 337	Thermodynamics (MATH 261; PH 141)	F, S	4
ECE-TE	ECE Technical Elective _____	F, S, SS	3	ECE-TE	ECE Technical Elective _____		3
AUCC	_____	F, S, SS	3	ECON 202 (AUCC 3C)	Principles of Microeconomics (MATH 117 or 118 or 141 or 155 or 160)	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) or (PH 353).	S	4
BME-TE	BME Technical Elective _____	F, S, SS	3	BME-TE	BME Technical Elective _____	F, S, SS	3
ECE-TE	ECE Technical Elective _____	F, S, SS	3	ECE-TE	ECE Technical Elective _____	F, S, SS	3
CO 301B OR JTC 300	Writing in the Disciplines: Sciences OR Professional & Technical Communication (CO 150 or HONR 193)	F, S, SS	3	ECE-TE	ECE Technical Elective _____	F, S, SS	2
AUCC	_____	F, S, SS	3	AUCC	_____	F, S, SS	3
		Total	**16**			**Total**	**15**

*** - All course prerequisites for required undergraduate ECE courses must be completed with a C or better**

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

3 Career Development Seminars: 1) Resume Writing; 2) Mock Interview or Behavior Based Interviewing; and 3) Using LinkedIn™

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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 350A	Prosthetics in Ecuador (DARS changes pending)	SS	1 or 2
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	F,S,SS	1-6
BIOM/CBE 504	Fundamentals of Biochemical Engineering	S	3
BIOM/ECE 518	Biophotonics	F	3
BIOM/CBE 522	Bioseparation Processes	F	3
BIOM/MECH 525	Cell and Tissue Engineering	S	3
BIOM/ECE 526	Biological Physics	S	3
BIOM 527 (A-F)	Biosensors	F,S,SS	1
BIOM/MECH 531	Materials Engineering	S	3
BIOM/CIVE 533	Biomolecular Tools for Engineers	F	3
BIOM/ECE 537	Biomedical Signal Processing	S	3
BIOM/CBE 543	Membranes for Biotechnology and Biomedicine	F	3
BIOM/MECH 570	Bioengineering	F	3
BIOM/MECH 573	Structure and Function of Biomaterials	S	3
BIOM/MECH 574	Bio-Inspired Surfaces	S	3
BIOM/MECH 576	Quantitative Systems Physiology	S	4
BIOM/MECH 578	Musculoskeletal Biosolid Mechanics	F	3
BIOM 579/MECH 579	Cardiovascular Biomechanics	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

BME Technical Electives (Continued)

COURSE	NAME	TERM	CR
BZ 310	Cell Biology	F,S,SS	4
BZ 311	Developmental Biology	S,SS	4
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
CBE 505	Biochemical Engineering Laboratory	F	1
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/VS 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 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/BMS 502	Readings in Cellular Neruobiology	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
CS314	Software Engineering	F, S	3
CS320	Algorithms--Theory and Practice	F, S	3
CS356	Systems Security	F, S	3
CS370	Operating Systems	F, S	3
CS410	Introduction to Computer Graphics	F	4
CS414	Object-Oriented Design	F	4
CS420	Introduction to Analysis of Algorithms	F	4
CS430	Database Systems	S	4
CS440	Introduction to Artificial Intelligence	F	4
CS445	Introduction to Machine Learning	S	4
CS453	Introduction to Compiler Construction	S	4
CS455	Introduction to Distributed Systems	S	4
CS475	Parallel Programming	F	4
CS510	Image Computation	S	4
CS520	Analysis of Algorithms	S	4
CS530	Fault-Tolerant Computing	S	4
CS540	Artificial Intelligence	S	4
CS545	Machine Learning	F	4
CS553	Algorithmic Language Compliers	F	4
CS555	Distributed Systems	F	4
CS556	Computer Security	F	4
CS557	Advanced Networking	S	4
CS575	Parallel Processing	F	4
ECE4XX	Any ECE course at the 400 level	F, S	Varies
ECE495 A-C	Independent Study	F,S,SS	1-6
ECE5XX	Any ECE course at the 500 level	F,S	Varies
MATH417	Advanced Calculus I	F	3
MATH418	Advanced Calculus II	S	3
MATH419	Introduction to Complex Variables	F	3
MATH450	Intro to Numerical Analysis I	F	3
MATH451	Intro to Numerical Analysis II	S	3
MATH460	Information and Coding Theory	S	3
MATH466	Abstract Algebra I	F	3
MATH469	Linear Algebra II	S	3
MATH470	Euclidian and Non-Euclidian Geometry	S	3
MECH474	Introduction to Differential Geometry	F	3
MECH564	Fundamentals of Robot Mechanisms and Controls	S	3
PH315	Modern Physics Lab	S	2
PH425	Advanced Physics Laboratory	S	2
PH451	Intro to Quantum Mechanics I	F	3
PH452	Intro to Quantum Mechanics II	S	3
PH462	Statistical Physics	F	3
STAT421	Introduction to Stochastic Processes	S	3

[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 need an override for a non-engineering course, reach out to the prof and request override. For engineering courses, follow procedures as indicated below.

For 500-level BIOM courses, request permission from 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-requisistes. If you need an override, request from prof; forward permission to Claire.Lavelle@colostate.edu.

For 500-level ECE courses, you should be able to register if you meet the pre-requisistes. If you need an override, request from prof; 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. Include your CSU ID#, whether you meet pre-reqs, and any extenuating circumstances/reason(s) for your request. If you do not have a

To request overrides for other courses (e.g. non-engr, 500-level or prereq override), email the course professor or the department teaching the course.

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SCHOOL OF BIOMEDICAL ENGINEERING
COLORADO STATE UNIVERSITY

Careers in Biomedical Engineering + Electrical Engineering (BME+EE)

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 - in the Bureau of Labor Statistics Occupational Outlook Handbook or at the Biomedical Engineering Society: BMES.org.

Learn more about electrical engineers - 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