



SCHOOL OF BIOMEDICAL
ENGINEERING
COLORADO STATE UNIVERSITY

B.S. Biomedical Engineering + B.S. Electrical Engineering – Concentration in Lasers & Optics BME+EE-L&O Curriculum 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 with a concentration in Lasers & Optics (BME+EE – L&O). 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-L&O 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, adds in lasers and optics classes as well as 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. Visit www.engr.colostate.edu/sbme for further information!

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

Sincerely,

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Curriculum Checklist - Effective Summer 2018 and Prior

Program Total Credits = 158 or 159

| 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 126 or 127 or 128 or 129 or 130 or 131 or 132 or 133 or 134 or 135 or 136 or 137 or 138 or 139 or 140 or 141 or 142 or 143 or 144 or 145 or 146 or 147 or 148 or 149 or 150 or 151 or 152 or 153 or 154 or 155 or 156 or 157 or 158 or 159 or 160 or 161 or 162 or 163 or 164 or 165 or 166 or 167 or 168 or 169 or 170 or 171 or 172 or 173 or 174 or 175 or 176 or 177 or 178 or 179 or 180 or 181 or 182 or 183 or 184 or 185 or 186 or 187 or 188 or 189 or 190 or 191 or 192 or 193 or 194 or 195 or 196 or 197 or 198 or 199 or 200 or 201 or 202 or 203 or 204 or 205 or 206 or 207 or 208 or 209 or 210 or 211 or 212 or 213 or 214 or 215 or 216 or 217 or 218 or 219 or 220 or 221 or 222 or 223 or 224 or 225 or 226 or 227 or 228 or 229 or 230 or 231 or 232 or 233 or 234 or 235 or 236 or 237 or 238 or 239 or 240 or 241 or 242 or 243 or 244 or 245 or 246 or 247 or 248 or 249 or 250 or 251 or 252 or 253 or 254 or 255 or 256 or 257 or 258 or 259 or 260 or 261 or 262 or 263 or 264 or 265 or 266 or 267 or 268 or 269 or 270 or 271 or 272 or 273 or 274 or 275 or 276 or 277 or 278 or 279 or 280 or 281 or 282 or 283 or 284 or 285 or 286 or 287 or 288 or 289 or 290 or 291 or 292 or 293 or 294 or 295 or 296 or 297 or 298 or 299 or 300 or 301 or 302 or 303 or 304 or 305 or 306 or 307 or 308 or 309 or 310 or 311 or 312 or 313 or 314 or 315 or 316 or 317 or 318 or 319 or 320 or 321 or 322 or 323 or 324 or 325 or 326 or 327 or 328 or 329 or 330 or 331 or 332 or 333 or 334 or 335 or 336 or 337 or 338 or 339 or 340 or 341 or 342 or 343 or 344 or 345 or 346 or 347 or 348 or 349 or 350 or 351 or 352 or 353 or 354 or 355 or 356 or 357 or 358 or 359 or 360 or 361 or 362 or 363 or 364 or 365 or 366 or 367 or 368 or 369 or 370 or 371 or 372 or 373 or 374 or 375 or 376 or 377 or 378 or 379 or 380 or 381 or 382 or 383 or 384 or 385 or 386 or 387 or 388 or 389 or 390 or 391 or 392 or 393 or 394 or 395 or 396 or 397 or 398 or 399 or 400 or 401 or 402 or 403 or 404 or 405 or 406 or 407 or 408 or 409 or 410 or 411 or 412 or 413 or 414 or 415 or 416 or 417 or 418 or 419 or 420 or 421 or 422 or 423 or 424 or 425 or 426 or 427 or 428 or 429 or 430 or 431 or 432 or 433 or 434 or 435 or 436 or 437 or 438 or 439 or 440 or 441 or 442 or 443 or 444 or 445 or 446 or 447 or 448 or 449 or 450 or 451 or 452 or 453 or 454 or 455 or 456 or 457 or 458 or 459 or 460 or 461 or 462 or 463 or 464 or 465 or 466 or 467 or 468 or 469 or 470 or 471 or 472 or 473 or 474 or 475 or 476 or 477 or 478 or 479 or 480 or 481 or 482 or 483 or 484 or 485 or 486 or 487 or 488 or 489 or 490 or 491 or 492 or 493 or 494 or 495 or 496 or 497 or 498 or 499 or 500 | 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 345 | Introduction to Ordinary Differential Equations (MATH 255 or 261) -- OR -- Differential Equations (MATH 229 or MATH 369; MATH 255 or MATH 261) | 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 | PH 314 | Introduction to Modern Physics (PH 142; MATH 261 or conc.) | 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) | F | 4 | BMS 300 | Principles of Human Physiology (BZ 101 or 110 or LIFE 102; CHEM 103 or 107 or 111) | F, S, SS | 4 |
| ECE 341 | Electromagnetics Fields and Devices I (ECE 202; MATH 340 or 345; PH 142; ECE 311 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 15 | | | |
| 4th Year Fall | | | | 4th Year Spring | | | |
| 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 | BIOM 431 | Biomedical Signal and Image Processing (ECE 303; ECE 311; PH 142) | S | 3 |
| ECE 404 | Experimental Optical Electronics (conc. w/ ECE 441) | F | 2 | CHEM 245 | Fundamentals of Organic Chem. (CHEM 107 or 113) | F, S, SS | 4 |
| ECE 441 | Optical Electronics (ECE 342) | F | 3 | ECE 457 | Fourier Optics (ECE 311; ECE 342) | S | 3 |
| MECH 337 | Thermodynamics (MATH 261; PH 141) | F, S | 4 | MECH 262 | Engineering Mechanics (MATH 161; PH 141) | S | 4 |
| PH 353 | Optics and Waves (PH 142; MATH 261) | F | 4 | ECON 202 (AUCC 3C) | Principles of Microeconomics (MATH 117 or 118 or 141 or 155 or 160) | F, S, SS | 3 |
| Total 12 | | | | 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 |
| ECE-TE | ECE Technical Elective _____ | | 3 | ECE-TE | ECE Technical Elective _____ | | 3 |
| ECE-TE | ECE Technical Elective _____ | | 3 | AUCC | | F, S, SS | 3 |
| PH 451 | Introductory Quantum Mechanics I (PH 314; MATH 340 or 345) | F | 3 | AUCC | | 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 | AUCC | | F, S, SS | 3 |
| Total 16 | | | | Total 16 | | | |

* - 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.

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|---|
| 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: _____ |

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|--|
| 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+L&O Technical Electives

Technical Electives (TEs) are designed to provide additional breadth and depth in the Biomedical and partner major degrees. BME-EE-L&O students take 9 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 below 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.

| ● BME-EE-L&O students must take 9 credits of ECE TEs from the following list: | | | |
|---|---|-------|-----|
| ECE Technical Electives | | | |
| COURSE | NAME | TERM | CR |
| ECE 312 | Linear System Analysis II | S | 3 |
| ECE/MATH 430 | Fourier and Wavelet Analysis with Apps | S | 3 |
| ECE471A | Semiconductor Physics | F | 1 |
| ECE471B | Semiconductor Junctions | F | 1 |
| ECE495 (A-C) ² | Independent Study | F, S, | 1-6 |
| ECE 503 | Ultrafast Optics | S | 3 |
| ECE 504 | Physical Optics | F | 3 |
| ECE 505 | Nanostructures: Fundamentals & Applications | F | 3 |
| ECE 506 | Optical Interferometry & Laser Metrology | F | 3 |
| ECE 507 | Plasma Physics and Applications | S | 3 |
| ECE/BIOM 517 | Advanced Optical Imaging | F | 3 |
| ECE/BIOM 518 | Biophotonics | F | 3 |
| ECE/BIOM 526 | Biological Physics | F | 3 |
| ECE 546 | Laser Fundamentals & Devices | S | 3 |
| ECE 572 | Semiconductor Transistors | S | 1 |
| ECE 573 | Semiconductor Optoelectronics Laboratory | S | 3 |
| ECE 574 | Optical Properties in Solids | S | 3 |
| MATH 419 | Introduction to Complex Variables | F | 3 |
| PH 315 | Modern Physics Lab | S | 2 |
| PH 425 | Advanced Physics Lab | S | 2 |
| PH 452 | Intro to Quantum Mechanics II | S | 3 |
| PH 462 | Statistical Physics | F | 3 |

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

◆ 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

◆ 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) combined with an Electrical Engineering (BME+EE) provides a strong background in applied physics, signal and image processing, and instrumentation controls. BME+EE with a concentration in Lasers & Optics (BME+EE-L&O) further refines electrical engineering principles with additional physics, optics and lasers courses, resulting in a specialty that works in areas such as optics, biosensors, or ultra-fast lasers that help image and/or treat biological systems (e.g. radiation therapy, electro-chemical microfluidics) and improve animal and human healthcare.

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: SPIE – the International Society for Optics and Photonics (www.spie.org); 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 a variety of companies and fields, including Applied Medical, QuSpin, 3D Systems, and have also gone on to pursue graduate studies. The BME+EE-L&O degree provides background for many career options!

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** – <https://ispe.org/>
- **Medical Device** - <https://novoengineering.com/product-development-services/medical-device-development/>
- **Clinical Research** - <https://www.biospace.com/jobs/clinical/#browsing>