BIOMEDICAL ENGINEERING UNDERGRADUATE CURRICULUM

Catalog Year 2023

Last update: August 25, 2023

The bachelor of science in biomedical engineering program is accredited by the Engineering Accreditation Commission of ABET, https://www.abet.org, under the General Criteria and the Biomedical Engineering Program Criteria.

Undergraduate Program Mission Statement

To provide education that prepares students to lead, innovate, and self-educate through their careers in bioengineering and biomedical professions and industries.

Program Objectives

Career Achievements – Using a knowledge base with a core foundation in engineering and biology, our students will be able to apply their skills to a variety of challenges in their chosen field. Our graduates will demonstrate skills such as innovation, creativity, adaptability, and critical thinking to solve problems in biomedical industry, medicine, academia, and consulting.

Professionalism – Our graduates will demonstrate leadership in their chosen fields, and make decisions that are socially and ethically responsible. Graduates will function effectively in multidisciplinary, inclusive team environments and communicate effectively with a variety of audiences.

Life-long Learning – Our graduates will build and expand upon their undergraduate foundations by engaging in learning opportunities throughout their careers.

To obtain the B.S. in Biomedical Engineering, a student must obtain 18 course credits in engineering topics.

I. MATHEMATICS (4 courses)

MATH	220-1, 220-1	Single Variable Calculus
MATH	228-1, 228-2	Multivariable Calculus

II. BASIC SCIENCES (4 courses)

PHYSICS	135-2,3	General Physics plus labs* 136-2 and 136-3
and		
CHEM	131, 132	General Chemistry plus labs* 141 and 142
or		
CHEM	151, 152	General Chemistry plus labs* 161 and 162
or		
CHEM	171, 172	Accelerated Chemistry plus labs* 181 and 182

*Labs may be combined and used as technical electives or unrestricted electives.

III. ENGINEERING ANALYSIS (4 courses)

GEN ENG	205-1	Computational Methods and Linear Algebra
GEN ENG	205-2	Linear Algebra and Mechanics
GEN ENG	205-3	Dynamic System Modeling
GEN ENG	205-4	Differential Equations

IV. ENGINEERING DESIGN AND COMMUNICATION (3 courses)

DSGN	106-1,2	Design Thinking and Communication (0.5 each) plus English 106-1,2
BMD_ENG	390-2	Biomedical Engineering Design^

^Another capstone design course (including BME 391-SA) may be substituted for this course by petition.

V. SOCIAL SCIENCES/HUMANITIES THEME (7 courses)

VI. UNRESTRICTED ELECTIVES (5 courses)

VII. BIOMEDICAL ENGINEERING PROGRAM (21 courses, none of which may be taken P/N*)

Students seeking admission to physical therapy, dental, or medical schools should familiarize themselves with the specific entrance requirements of those schools to which they intend to apply. In addition to the specifically required courses of the BME program, many professional schools also require additional courses in physics, organic and/or physical chemistry, biochemistry, and laboratory biology. These requirements can be satisfied through the BME curriculum and by judicious use of electives.

A. Basic Engineering Courses – 5 courses

Take all of these courses:

- BMD_ENG 220 Introduction to Biostatistics or IEMS 303 Statistics I (follow prereqs)
- BMD_ENG 270 Fluid Mechanics or MECH ENG 241 Fluid Mechanics I
- COMP_SCI 150 Fundamentals of Computer Programming 1.5

Take 2 of the following 3 courses:

- BMD_ENG 250 Thermodynamics or MECH ENG 222 Thermodynamics & Statistical Mechanics I
- BMD_ENG 271 Introduction to Biomechanics
- MAT SCI 201 Principles of the Properties of Materials

B. Core – 10 courses + 1 zero credit seminar

BMD_ENG 101	Introduction to Biomedical Engineering (zero credit seminar)
CHEM 215-1	Organic Chemistry (prereq: Gen Chem sequence + lab)
BIOL_SCI 201[#]	Molecular Biology
BMD_ENG 304	Quantitative Systems Physiology (prereq: Physics 135-2, junior standing recommended)
BMD_ENG 305	Quantitative Systems Physiology (prereq: Math 228-1, junior standing recommended)
BMD_ENG 306	Quantitative Systems Physiology (junior standing recommended)
BMD_ENG 207	BME Lab: Experimental Design (prereq: BMD_ENG 220)
BMD_ENG 308	Biomedical Signals and Circuits (prereq: Physics 135-2, BMD_ENG 207 - can be taken concurrently)
BMD_ENG 309	Biomedical Systems Analysis (prereqs: BMD_ENG 207-0; BMD_ENG 308-0; BMD_ENG 220-0; GEN_ENG 205-4)
BMD_ENG 378	Transport Fundamentals (prereq: BMD_ENG 270)
BMD_ENG 390-1	Biomedical Engineering Design (prereqs: BMD_ENG 207-0, BMD_ENG 220-0, BMD_ENG 270-0, BMD_ENG 308-0, BMD_ENG 309-0, COMP_SCI 150, and three of the following: BMD_ENG 250-0, BMD_ENG 271-0, MAT_SCI 201-0)

[#]If you place out of Bio 201 via placement exam, you may substitute this requirement with Bio 202 by submitting a petition

C. Technical Electives - 2 units

Technical electives (2 units required). These may include: BIOL_SCI 202, BIOL_SCI 301, BMD_ENG 250, BMD_ENG 271, CHEM 215-2, CHEM 215-3, DSGN 240 (0.5 unit), DSGN 321 (0.5 unit), COMP_SCI 211, MAT_SCI 201, and graded, 300-level or higher courses in engineering*, science, or mathematics.
Three, 0.34 unit science labs may also be combined and counted as a technical elective. Six total labs can be used.
BMD_ENG 250-0, BMD_ENG 271-0, or MAT_SCI 201-0 may also be used as a technical elective course as long as it not used as a basic engineering course.
*These courses don't need to carry 100% engineering topics. Any 395 course must be approved; not all are acceptable. BME 399 Independent Study is only graded P/N and may not be used as a technical elective. BME 499 is graded and may be used as a technical elective.

D. Biomedical Engineering Electives - 4 courses

Students are required to take two courses from Category A and two courses from Category B.

Category A			
BME 311	BME 327	BME 344	BME 366
BME 312	BME 333	BME 346	BME 371
BME 317	BME 340	BME 347	BME 377
BME 325	BME 343	BME 353	

Category B			
Bio 202*	BME 347	CS 211	IEMS 385
Bio 301*	BME 348	CS 214	ME 301
BME 311	BME 353	CS 217	ME 314
BME 312	BME 354	CS 339	ME 315
BME 313	BME 365	CS 349	ME 333
BME 317	BME 366	DSGN 360	ME 362
BME 323	BME 371	EE 302	ME 382
BME 325	BME 377	EE 332	ME 390
BME 327	BME 380	EE 335	MSE 318
BME 333	BME 388-SA	EE 360	MSE 360
BME 340	ChBE 361	EE 379	Phy 357*
BME 343	ChBE 376	EE 382	
BME 344	ChBE 379	EE 395**	
BME 346	CIV ENV 327	ESAM 370	

Only one non-engineering course can be counted toward the BME electives.
** There are many ELEC_ENG 395 courses. Get approval from BME UG Program Chair for specific courses.

Optional Tracks
Students who seek depth in one particular area may find the guidelines below helpful in selecting their courses.

Biological Mechanics and Rehabilitation

Category A	**Category B**		
BME 371	BME 343 or 344	BME 377	ME 315
BME 366	BME 365	EE 360	ME 333

Biomaterials and Regenerative Medicine

Category A	**Category B**		
BME 343 or 344	Bio 202*	BME 346 or 347	ChBE 361
BME 346 or 347	Bio 301*	BME 348	ChBE 379
	BME 343 or 344	BME 371	
	BME 317	BME 377	

Biosensors and Bioelectronics

Category A	**Category B**	
BME 317	Bio 301	BME 380
BME 312	BME 313	BME 495*
BME 353	BME 354	ChBE 361

*BME 495 Advanced Cardiovascular Engineering will be offered 2024-25

Data Science

Category A	**Category B**		
BME 311	BME 313	CS 217	CS 396*
BME 312	CS 211	CS 339	EE 335
	CS 214	CS 349	IEMS 304

*Course title is Modeling Relationships with Causal Inference

Imaging and Biophotonics

Category A	**Category B**		
BME 325	BME 323	EE 302	EE 382
BME 327 or 333	BME 327	EE 332	EE 395**
	BME 333	EE 360	MSE 360
	CS 211	EE 379	PHY 357*

Biomedical Engineering Electives

Students are required to take two courses from Category A and two courses from Category B.

Category	Eng credit	Course	Course Name	Prerequisites	Add'l Info
		Biomedical Engineering			
A	1	BMD_ENG 311	Computational Genomics	BIOL_SCI 201, BMD_ENG 220 or equivalent, and coding experience	
A	1	BMD_ENG 312	Biomedical Applications in Machine Learning	See BME courses webpage	
A	1	BMD_ENG 313	Wearable Devices: From Sensing to Biomedical Inference	BMD_ENG 207 and 220	
A	1	BMD_ENG 317	Biochemical Sensors	BIOL_SCI 201; CHEM 215-1; PHYSICS 135-2,3	
B	1	BMD_ENG 323	Visual Engineering Science	PHYSICS 135-2	
A	1	BMD_ENG 325	Introduction to Medical Imaging	PHYSICS 135-3 or equivalent	
A	1	BMD_ENG 327	Magnetic Resonance Imaging	PHYSICS 135-3	
A	1	BMD_ENG 333	Modern Optical Microscopy and Imaging	PHYSICS 135-2, GEN ENG 205-4, BME 220 or IEMS 303	
A	1	BMD_ENG 340	Pharmaceutical Engineering: From Discovery to Therapeutics	See BME courses webpage	
A	1	BMD_ENG 343	Biomaterials and Medical Devices	BIOL_SCI 201 and 202; MAT_SCI 201 or MAT_SCI 301	
A	1	BMD_ENG 344	Biological Performance of Materials	BIOL_SCI 201 and 202; MAT_SCI 201. Concurrent enrollment in BIOL_SCI 202-0 is acceptable	
A	1	BMD_ENG 346	Tissue Engineering	BIOL_SCI 201 and 202	
A	1	BMD_ENG 347	Regenerative Engineering Principles and Technologies	BIOL_SCI 201 or 202	
B	1	BMD_ENG 348	Regenerative Engineering Applications	BIOL_SCI 201 or 202	
A	1	BMD_ENG 353	Bioelectronics	None	
	1	BMD_ENG 354	Bioelectronics Lab	Prerequisite or co-req: BMD_ENG 353 or MAT_SCI 353	
B	1	BMD_ENG 365	Control of Human Limbs and Their Artificial Replacements	Senior standing with engineering or physical science background	
A	1	BMD_ENG 366	Biomechanics of Movement	BMD_ENG 271	
A	1	BMD_ENG 371	Mechanics of Biological Tissues	GEN ENG 205-3,4; BMD_ENG 271	
A	1	BMD_ENG 377	Intermediate Fluid Mechanics	BMD_ENG 270 or consent of instructor	
B	1	BMD_ENG 380	Medical Devices, Disease, and Global Health	None; junior or senior standing and BMD_ENG 309 preferred	
B	.5	BMD_ENG 388-SA	Healthcare Technology in Resource Poor Environments	Global Health Technologies program only	
		Biological Sciences			
B	0	BIOL_SCI 202	Cell Biology	BIOL_SCI 201, must be taken concurrently with BIOL_SCI 232	

B	0	BIOL_SCI 301	Principles of Biochemistry	CHEM 215-1 or 212-1 (concurrent enrollment acceptable), BIOL_SCI 201	
		Chemical Engineering			
B	1	CHEM_ENG 361	Introduction to Polymers	CHEM_ENG 211 or other thermodynamics course; CHEM 215-1	
B	1	CHEM_ENG 376	Principles of Synthetic Biology	CHEM_ENG 275 or BIOL_SCI 201 or BIOL_SCI 202	
B	1	CHEM_ENG 379	Computational Biology: Analysis and Design of Living Systems		
		Civil and Environmental Engineering			
B	1	CIV_ENV 327	Finite Element Methods in Mechanics	None	
		Computer Science			
B	1	COMP_SCI 211	Fundamentals of Computer Programming II	COMP_SCI 111 or 150	
B	1	COMP_SCI 214	Data Structures and Algorithms	COMP_SCI 150	
B	1	COMP_SCI 217	Data Management and Information Processing	COMP_SCI 150	
B	1	COMP_SCI 339	Intro to Database Systems	COMP_SCI 214 & (COMP_SCI 213 or COMP_ENG 205)	
B	1	COMP_SCI 349	Machine Learning	See CS courses webpage	
		Manufacturing and Design Engineering			
B	1	DSGN 360	Design Competition	Permission number required, available if the Winter workshops are completed.	
		Electrical Engineering			
B	0	ELEC_ENG 302	Probabilistic Systems	MATH 228-2 or equiv. (can be taken concurrently)	Note that this course is less than 1 eng unit and 18 total eng units are req'd
B	1	ELEC_ENG 332	Introduction to Computer Vision	COMP_SCI 212 or ELEC_ENG 302	
B	1	ELEC_ENG 335	Deep Learning Foundations from Scratch	See EE courses webpage	
B	1	ELEC_ENG 360	Introduction to Feedback Systems	ELEC_ENG 222 or MECH_ENG 390 or BMD_ENG 309	
B	1	ELEC_ENG 379	Lasers and Coherent Optics	None	
B	1	ELEC_ENG 382	Photonic Information Processing	ELEC_ENG 222 and 224	
B	1	ELEC_ENG 395			There are many ELEC_ENG 395 courses. Get approval from BME UG Program Chair for specific courses.
		Engineering Sciences and Applied Mathematics			
B	0.1	ES_APPM 370-1	Introduction to Computational Neuroscience		Note that this course is less than 1 eng unit and 18 total eng units are req'd
		Industrial Engineering and Management Sciences			
B	1	IEMS 385	Introduction to Health Systems Engineering	IEMS 303 and 313	
		Materials Science and Engineering			

B	1	MAT_SCI 318	Materials Selection	MAT_SCI 201 or equiv.	
B	1	MAT_SCI 360	Electron Microscopy	MAT_SCI 301; PHYSICS 135-2,3 or equiv.	
B	1	MAT_SCI 376	Nanomaterials	MAT_SCI 351 or consent of instructor	
		Mechanical Engineering			
B	1	MECH_ENG 301	Introduction to Robotics Laboratory	Some programming experience or permission of instructor	
B	1	MECH_ENG 315	Theory of Machines – Design of Elements	MECH_ENG 240	
B	1	MECH_ENG 333	Introduction to Mechatronics	MECH_ENG 233 or ELEC_ENG 221 or consent of instructor	
B	1	MECH_ENG 341	Computational Methods for Engineering Design	Senior standing or consent of instructor	
B	1	MECH_ENG 362	Stress Analysis	CIV_ENV 216	
B	1	MECH_ENG 382	Micro/Nano Science and Engineering	MECH_ENG 381 or consent of instructor	
B	1	MECH_ENG 390	Introduction to Dynamic Systems	MECH_ENG 241, CIV_ENG 216, GEN_ENG 205-4	
		Physics and Astronomy			
B	0	PHYSICS 357	Optics Laboratory	Consent of instructor	Only one non-engineering course can be used as a BME Elective