







BIOMEDICAL AND HEALTH SCIENCES ENGINEERING MAJOR, B.S.

In this major, students learn to apply engineering principles to solve problems in medicine and biology. This is a field of great breadth that incorporates medical imaging, informatics, micro and nanosystems, prosthetics, medical devices, tissue engineering and genomics, drug delivery, and applications of signal processing and control.

Admission

Students may declare the biomedical and health sciences engineering major as early as their first year. However, students who wish to complete the biomedical and health sciences engineering major must apply for admission to the program. Admission to the university does not guarantee admission to the program. Admission to the program is granted to rising sophomores, and students will apply in the fall, spring or summer of their first year. Rising juniors may also apply, but admission to rising juniors will only be granted on a limited basis if space is available. Students who are not accepted to the program must select a different major.

In order to apply, students must complete the following courses.

Code	Title	Hours
CHEM 101 & 101L	 General Descriptive Chemistry I and  Quantitative Chemistry Laboratory I ^{1, F}	4
ENGL 105	 English Composition and Rhetoric ²	3
MATH 231	 Calculus of Functions of One Variable I ^{1, H, F}	4
MATH 232	 Calculus of Functions of One Variable II ^{1, H, F}	4
PHYS 118	 Introductory Calculus-based Mechanics and Relativity ^{1, F}	4

H Honors version available. An honors course fulfills the same requirements as the nonhonors version of that course. Enrollment and GPA restrictions may apply.

F FY-Launch class sections may be available. A FY-Launch section fulfills the same requirements as a standard section of that course, but also fulfills the FY-SEMINAR/FY-LAUNCH First-Year Foundations requirement. Students can search for FY-Launch sections in ConnectCarolina using the FY-LAUNCH attribute.

¹ With a grade of C or better. AP, IB, or transfer credit will be accepted according to university policies.

² With a grade of C- or better. Transfer credit will be accepted according to university policies.

More information about this process is available on the department website (<http://bmeundergrad.bme.unc.edu/unc-biomedical-engineering/admission/>).

Program Enhancement Fee

Students will be charged an additional fee of \$750/semester (\$1,500/year). The money is directly applied to the undergraduate program

to enhance the undergraduate laboratory, internship, and outreach experience.

Advising

BME curriculum advisors provide guidance on course and curriculum issues. The advisors are a small group of faculty members and staff who have expertise in the BME curriculum. Students can meet with their designated curriculum advisors at any time. After admission to the program, BME students must get their planned courses approved by a curriculum advisor each semester in order to register for classes. Students can also schedule a meeting with an advisor for additional assistance. The department sends out instructions on this procedure every semester.

First-year students receive advising through the Academic Advising Program. A first-year student can also meet their designated curriculum advisor in BME by scheduling an advising appointment. BME curriculum advisors do not advise students on General Education requirements. Advisors from the Academic Advising Program can provide assistance with these requirements.

Student Learning Outcomes

Upon completion of the biomedical and health sciences engineering program, students should be able to:

General engineering outcomes:

- Demonstrate an ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics
- Demonstrate an ability to apply engineering design to produce solutions that meet specified needs with consideration of public health, safety and welfare, as well as global, cultural, social, environmental, and economic factors
- Demonstrate an ability to communicate effectively with a range of audiences
- Demonstrate an ability to recognize ethical and professional responsibilities in engineering situations and make informed judgements, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts
- Demonstrate an ability to function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives
- Demonstrate an ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgement to draw conclusions
- Demonstrate an ability to acquire and apply new knowledge as needed, using appropriate learning strategies

BME-specific program criteria:

- Apply principles of engineering, biology, human physiology, chemistry, calculus-based physics, mathematics (through differential equations), and statistics
- Solve bio/biomedical engineering problems, including those associated with the interaction between living and non-living systems
- Analyze, model, design, and realize bio/biomedical engineering devices, systems, components, or processes
- Make measurements on and interpret data from living systems

Requirements

In addition to the program requirements listed below, students must

- attain a final cumulative GPA of at least 2.0
- complete a minimum of 45 academic credit hours earned from UNC–Chapel Hill or North Carolina State University (N.C. State) courses
- take at least half of their major course requirements (courses and credit hours) at UNC–Chapel Hill or N.C. State
- earn a minimum cumulative GPA of 2.000 in the major core requirements

For more information, please consult the degree requirements section of the catalog (<http://catalog.unc.edu/undergraduate/degree-requirements/#requirementstext>).

The first two years of study have many courses in common with the B.S. programs in chemistry, physics, computer science, or mathematical sciences. The curriculum, as for all sciences, is vertically structured, with experience and knowledge from each course serving as a foundation for subsequent courses. Students' attention to prerequisites is important. The specific requirements are listed below. Students are also encouraged to engage in research in a laboratory at UNC–Chapel Hill or elsewhere, or have an internship experience in industry.

The degree program requires **124 hours**.

Students who are admitted to the program may take courses at N.C. State. Most classes designated BMME ### are offered as BMME ### on the UNC campus and BME ### on the N.C. State campus. Other N.C. State course numbers are designated in parentheses.

Code	Title	Hours
Core Requirements		
Students should take the following courses, preferably in their second year:		
BMME 201	Computer Methods in Biomedical Engineering (CSC 113)	3
	or COMP 116 Introduction to Scientific Programming	
BMME 205	Biomedical Mechanics	4
BMME 209	Materials Science of Biomaterials	4
BMME 298	Biomedical Engineering Design and Manufacturing I	2
Students should take the following courses, preferably in their third year:		
BMME 207	Biomedical Electronics	4
BMME 301	Human Physiology : Electrical Analysis	4
BMME 302	Human Physiology: Mechanical Analysis	4
BMME 398	Biomedical Engineering Design and Manufacturing II ^H	2
Take three gateway electives to prepare for specialty electives in two areas		
BMME 315	Biotransport	
BMME 325	Biochemistry for Biomedical Engineers	
	or CHEM 43(Introduction to Biological Chemistry	
BMME 335	Biomaterials	
BMME 345	Biomedical Solid Mechanics	
BMME 355	Biocontrols	
BMME 365	Systems and Signals	

BMME 375	Biomedical Microcontroller Applications	
BMME 385	Bioinstrumentation	
Students should take the following courses, preferably in their final year:		
BMME 697	BME Senior Design: Product Development (BME 451)	3
BMME 698	Biomedical Engineering Senior Design: Product Implementation and Strategy (BME 452)	3
Four electives from no more than two specialization areas		12
STEM elective - an upper level (300 or greater) math, science or engineering course (must be engineering if CHEM 430 replaces BMME 325 as a gateway elective)		3
Additional Requirements		
Students should take the following courses, preferably in their first two years:		
BIOL 101 & 101L	Principles of Biology and Introductory Biology Laboratory (BIO 183) ^{H, F}	4
CHEM 101 & 101L	General Descriptive Chemistry I and Quantitative Chemistry Laboratory I (CH 101 + 102) ^F	4
CHEM 102 & 102L	General Descriptive Chemistry II and Quantitative Chemistry Laboratory II (CH 201 + 202) ^{H, F}	4
CHEM 261	Introduction to Organic Chemistry I (CH 221 + CH 222) ^H	3
MATH 231	Calculus of Functions of One Variable I (MA 141) ^{H, F}	4
MATH 232	Calculus of Functions of One Variable II (MA 241) ^{H, F}	4
MATH 233	Calculus of Functions of Several Variables (MA 242) ^{H, F}	4
MATH 383 & 383L	First Course in Differential Equations and First Course in Differential Equations Laboratory ^H	4
PHYS 118	Introductory Calculus-based Mechanics and Relativity (PY 205 + 206) ^F	4
PHYS 119	Introductory Calculus-based Electromagnetism and Quanta (PY 208 + 209) ^F	4
Remaining General Education courses and electives to reach 124 hours		28
Total Hours		124



^H Honors version available. An honors course fulfills the same requirements as the nonhonors version of that course. Enrollment and GPA restrictions may apply.

^F FY-Launch class sections may be available. A FY-Launch section fulfills the same requirements as a standard section of that course, but also fulfills the FY-SEMINAR/FY-LAUNCH First-Year Foundations requirement. Students can search for FY-Launch sections in ConnectCarolina using the FY-LAUNCH attribute.

STEM Elective

This list includes courses at UNC. It does not include BME gateway electives or specialization electives, but any of those courses will meet the engineering elective requirement. It must be an extra course and cannot double count for the gateway/specialty electives requirements.

Additional 300 or greater level math and science courses may be approved by the student's advisor to meet this requirement.


Code	Title	Hours
APPL 430	Optical Instrumentation for Scientists and Engineers	3
APPL 465	Sponge Bob Square Pants and Other Soft Materials	3
APPL 490	Special Topics (Bioelectronic Materials)	1-3
BIOL 202	 Molecular Biology and Genetics ^{H, F}	4
CHEM 430	Introduction to Biological Chemistry (GN 311) ^H	3
STOR 320	 Introduction to Data Science	4
STOR 435	Introduction to Probability	3
STOR 455	Methods of Data Analysis	3

H Honors version available. An honors course fulfills the same requirements as the nonhonors version of that course. Enrollment and GPA restrictions may apply.

F FY-Launch class sections may be available. A FY-Launch section fulfills the same requirements as a standard section of that course, but also fulfills the FY-SEMINAR/FY-LAUNCH First-Year Foundations requirement. Students can search for FY-Launch sections in ConnectCarolina using the FY-LAUNCH attribute.

Students must satisfy all General Education requirements, as outlined elsewhere in this catalog. Some General Education requirements should be met with specific courses as listed above.

Pharmacoengineering


Code	Title	Hours
BMME 485	Biotechnology	3
BMME 495	 Undergraduate Research in Biomedical Engineering as a Technical Elective	3
BMME 511	Genetic Engineering	3
BMME 523	Biomolecular Engineering	3
BMME 524	Biomolecular Sensing Technologies	3
BMME 527	Targeted Photomedicine	3

N. C. State Campus

BME 516	Advanced Drug Delivery	3
BME 570	ImmunoEngineering	3

Biosignals and Imaging


Code	Title	Hours
UNC Campus		
BMME 461	Introduction to Medical Imaging	3
BMME 575	Practical Machine Learning for Biosignal Analysis	3
BMME 576	Mathematics for Image Computing	3
BMME 581	Microcontroller Applications II	3
MATH 528	Mathematical Methods for the Physical Sciences I	3
or MA 501	Adv. Math. for Sci. & Engrs. I (NC State)	

BMME 495	 Undergraduate Research in Biomedical Engineering as a Technical Elective (BME 418: Wearable Biosensors)	3
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N.C. State Campus

BME 412	Biomedical Signal Processing	3
BME 418	Wearable Biosensors	3
BME 425	Bioelectricity	3
BME 463	Biomedical Optics and Lasers	3
BME 565	Microscopy	3
ECE 455	Computer Control of Robots	3
ECE 456	Mechatronics	3
ECE 461	Embedded Systems	3
ECE 505	Neural Interface Engineering	3


Medical Microdevices

Code	Title	Hours
UNC Campus		
BMME 441	Thermal Physics	3
or MSE 301	Intro to Thermo (NC State)	
or MAE 201	Engr. Thermo I (NC State)	
BMME 455	Biofluid Mechanics	3
or CE 382	Hydraulics (NC State)	
or MAE 308	Fluid Mechanics (NC State)	
BMME 486	Biomedical Instrumentation Design and Prototyping II	2
BMME 495	 Undergraduate Research in Biomedical Engineering as a Technical Elective	3

N.C. State Campus


BME 412	Biomedical Signal Processing	3
BME 418	Wearable Biosensors	3
BME 522	Medical Instrumentation	3
E 304	Intro to Nano Science and Technology	3
ECE 436	Digital Control Systems	3
ECE 505	Neural Interface Engineering	3

Regenerative Medicine

Code	Title	Hours
UNC Campus		
BMME 420	Introduction to Synthetic Biology	3
BMME 441	Thermal Physics	3
or MAE 201	Engr. Thermo I (NC State)	
or MSE 301	Intro to Thermo (NC State)	
BMME 435	Biological Physics	3
BMME 455	Biofluid Mechanics	3
or CE 382	Hydraulics (NC State)	
or MAE 308	Fluid Mechanics (NC State)	
BMME 470	Analysis of Tissue Engineering Technologies	3
BMME 495	 Undergraduate Research in Biomedical Engineering as a Technical Elective	3
BMME 511	Genetic Engineering	3
N.C. State Campus		
BME 429	Cellular Engineering	3
BME 448	Functional Tissue Engineering	3









BME 462	Biomaterials Characterization	3
BME 484	Fundamentals of Tissue Engineering	3
BIT 466 & BME 483	Animal Cell Culture; Tissue Engineering Technologies	2+2
TE 463	Polymer Engineering	3



Rehabilitation Engineering

Code	Title	Hours
UNC Campus		
BMME 405	Biomechanics of Movement	3
BMME 445	Systems Neuroscience	3
BMME 447	Neural Basis of Rehabilitation Engineering	3
BMME 495	 Undergraduate Research in Biomedical Engineering as a Technical Elective	3
BMME 505	Skeletal Biomechanics	3
N.C. State Campus		
BME 418	Wearable Biosensors	3
BME 425	Bioelectricity	3
BME 444	Orthopedic Biomechanics	3
BME 467	Mechanics of Tissues and Implants Requirements	3
BME 545	Bone Mechanobiology	3
BME 556	Rehabilitation Robotics	3

Sample Plan of Study




Sample plans can be used as a guide to identify the courses required to complete the major and other requirements needed for degree completion within the expected eight semesters. The actual degree plan may differ depending on the course of study selected (second major, minor, etc.). Students should meet with their academic advisor to create a degree plan that is specific and unique to their interests. The sample plans represented in this catalog are intended for first-year students entering UNC–Chapel Hill in the fall term. Some courses may not be offered every term.

First Year	Hours
First-Year Foundation Courses	
IDST 101  College Thriving	1
ENGL 105  English Composition and Rhetoric ² or ENGL 105I  English Composition and Rhetoric (Interdisciplinary)	3
First-Year Seminar or First-Year Launch (http://catalog.unc.edu/undergraduate/ideas-in-action/first-year-seminars-launches/) ^F	3
Triple-I and Data Literacy (http://catalog.unc.edu/undergraduate/ideas-in-action/triple-i/)	4
Global Language through level 3 (http://catalog.unc.edu/undergraduate/ideas-in-action/global-language/) ^{2,3}	3-4
Major Courses	
MATH 231  Calculus of Functions of One Variable I ^{1, H, F}	4
MATH 232  Calculus of Functions of One Variable II ^{1, H, F}	4
PHYS 118  Introductory Calculus-based Mechanics and Relativity ^{1, F}	4
CHEM 101 & 101L  General Descriptive Chemistry I and  Quantitative Chemistry Laboratory I ^{1, F}	4

BIOL 101 & 101L  Principles of Biology and  Introductory Biology Laboratory ^{H, F}	4
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Hours **34-35**

Sophomore Year

Major Courses	
MATH 233  Calculus of Functions of Several Variables ^{H, F}	4
MATH 383 & 383L First Course in Differential Equations and First Course in Differential Equations Laboratory ^H	4
PHYS 119  Introductory Calculus-based Electromagnetism and Quanta ^F	4
CHEM 102 & 102L  General Descriptive Chemistry II and Quantitative Chemistry Laboratory II ^{H, F}	4
CHEM 261 Introduction to Organic Chemistry I ^H	3
BMME 298 Biomedical Engineering Design and Manufacturing I	2
COMP 116 Introduction to Scientific Programming or BMME 201 Computer Methods in Biomedical Engineering	3
BMME 205 Biomedical Mechanics (Fall only)	4
BMME 209 Materials Science of Biomaterials (Spring only)	4
Additional Courses	
Lifetime Fitness (http://catalog.unc.edu/undergraduate/ideas-in-action/lifetime-fitness/)	1



Hours **33**

Junior Year

Major Courses	
BMME 207 Biomedical Electronics (Fall only)	4
BMME 301 Human Physiology : Electrical Analysis (Spring only)	4
BMME 302 Human Physiology: Mechanical Analysis (Fall only)	4
BMME 398  Biomedical Engineering Design and Manufacturing II ^H	2
BMME -- Gateway elective 1	3
BMME -- Gateway elective 2	3
BMME -- Gateway elective 3	3
STEM Elective	3
Additional Courses	
Remaining IDEAS in Action requirements or electives	4

Hours **30**

Senior Year

Major Courses	
BMME -- Specialty Elective 1	3
BMME -- Specialty Elective 2	3
BMME -- Specialty Elective 3	3
BMME -- Specialty Elective 4	3
BMME 697  BME Senior Design: Product Development (Fall only)	3
BMME 698  Biomedical Engineering Senior Design: Product Implementation and Strategy (Spring only)	3

Additional Courses

Remaining IDEAs in Action requirements or electives to reach 124 credits	9
Hours	27
Total Hours	124-125

- H Honors version available. An honors course fulfills the same requirements as the nonhonors version of that course. Enrollment and GPA restrictions may apply.
- F FY-Launch class sections may be available. A FY-Launch section fulfills the same requirements as a standard section of that course, but also fulfills the FY-SEMINAR/FY-LAUNCH First-Year Foundations requirement. Students can search for FY-Launch sections in ConnectCarolina using the FY-LAUNCH attribute.
- ¹ With a grade of C or better. AP, IB, or transfer credit will be accepted according to university policies.
- ² With a grade of C or better. Transfer credit will be accepted according to university policies.
- ³ Students may wish to consider completing their GLOBL-LANG (<http://catalog.unc.edu/undergraduate/ideas-in-action/global-language/>) requirement over the summer, in the second year, or through transfer credit to allow for taking fewer hours per semester in the first year.

Special Opportunities in Biomedical Engineering

Honors in Biomedical and Health Sciences Engineering

Students who successfully complete a research project and have a sufficiently outstanding academic record are eligible for graduation with honors or highest honors. The requirements for graduation with honors or highest honors include

1. overall grade point average of 3.3 or higher;
2. completion of a two-semester research project, with course credit given in BMME 691H and BMME 692H;
3. presentation of the research to a committee of three faculty members, both as an oral presentation and a written honors thesis; and,
4. approval by that committee.

Additional requirements for BMME 691H and BMME 692H are given to students in those classes. For consideration for highest honors, the research project must be judged to be of publishable quality.

Students wishing to be considered for graduation with honors should apply for approval to enroll in BMME 691H. Additional information can be found in the Academic Credit for Research section of the web page.

Departmental Involvement

Student organizations include the BME Club. This is an official UNC–Chapel Hill club that organizes speakers, outreach to industry and the medical school, and mentoring, among other activities. This is also a joint club with the BME students at North Carolina State University.

Experiential Education

All students in biomedical engineering participate in a capstone design experience in which they develop a device or system that has biomedical applications. This project fulfills the General Education experiential education requirement. There are also opportunities for experiential

education outside of the curriculum. These opportunities include Helping Hands, which develops 3-D printed prosthetic hands, and Engineering World Health, which develops medical equipment for under-resourced populations.

Undergraduate Awards

Awards are given to students in the graduating class each spring.

Undergraduate Research

Students are strongly encouraged to undertake a research project at any time during their education, but particularly during their junior and/or senior years. Through the challenge of a research project, students come face to face with the leading edge of an area, gain expertise with state-of-the-art techniques and instrumentation, and experience a professional scientific career firsthand. Many undergraduate students work in the research laboratories of BME faculty members. In addition, faculty across campus conduct BME-related research, and many undergraduate students take advantage of these research opportunities in the School of Medicine, School of Dentistry, School of Pharmacy, and in the Departments of Biology, Chemistry, Physics and Astronomy, Computer Science, and Exercise and Sport Science.

The BME department helps to coordinate research activities and facilitates connections between students and research laboratories. This is accomplished through communication via e-mail and the department website. Also, the department organizes laboratory open houses, enabling students to visit faculty laboratories and learn about their research opportunities. The UNC–Chapel Hill Office for Undergraduate Research is also an excellent resource for finding research opportunities.

Contact Information

Department of Biomedical Engineering

Visit Program Website (<http://www.bme.unc.edu>)

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