

DEPARTMENT OF BIOMEDICAL ENGINEERING

Contact Information

Department of Biomedical Engineering

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

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Introduction

The joint Department of Biomedical Engineering (BME) is a department of both the University of North Carolina at Chapel Hill (UNC–Chapel Hill) and North Carolina State University (NC State). The department oversees a joint graduate and undergraduate program at these institutions. While a complete curriculum is offered on the UNC–Chapel Hill campus, students can elect to take any number of classes at NC State. The joint program also leverages the industry resources in Research Triangle Park, located roughly half way between the two campuses, providing unique opportunities for students.

Biomedical engineering is a profession that develops and applies engineering knowledge and experience to solve problems in biology and medicine and to enhance health care. Biomedical engineers are professionally trained to combine the rigors of medical and biological studies with the power of engineering analysis and design. People become biomedical engineers to be of service to others, to enjoy the excitement of understanding living systems, and to use state-of-the-art science and technology to solve the complex problems of medical care. The emphasis in biomedical engineering is on finding solutions by researching, testing, and applying medical, biological, chemical, electrical, and materials engineering approaches. Biomedical engineers are unique individuals who make contributions to health care that are both satisfying to themselves and beneficial to others.

Facilities

The Department of Biomedical Engineering houses an undergraduate student design laboratory. It contains equipment for rapid prototyping

(three-dimensional printer and laser cutter), as well as electronics and microcontroller design and development. Students also use facilities in other departments that have laboratory-based courses. The BeAM Makerspace facilities are available to all UNC students, and these facilities house a variety of mechanical and electronic fabrication tools. More information is available at the UNC BeAM Web site.

Graduate School and Career Opportunities

Many students from this program have pursued further education in graduate school in biomedical engineering. Our alumni have attended many of the top-ranked biomedical engineering programs. In addition, some students have pursued graduate degrees in other disciplines in engineering, as well as related fields such as microbiology, sports physiology, public health, and business/engineering management, among others. Students have also been accepted into clinical programs such as medical, dental, physical therapy, and pharmacy schools (in many cases, the student must take several additional courses to meet the requirements for clinical programs).

For those interested in going directly into a career, biomedical engineering is one of the fastest growing career opportunities. Graduates are employed by hospitals, pharmaceutical companies, medical device and testing companies, government agencies, universities, and medical schools.

Major

- Biomedical and Health Sciences Engineering Major, B.S. (<http://catalog.unc.edu/undergraduate/programs-study/biomedical-health-sciences-engineering-major-bs/>)

Graduate Programs

- M.S. in Biomedical Engineering (<http://catalog.unc.edu/graduate/schools-departments/biomedical-engineering/>)
- Ph.D. in Biomedical Engineering (<http://catalog.unc.edu/graduate/schools-departments/biomedical-engineering/>)

Professors

Nancy Allbritton, Paul Dayton, M. Gregory Forest, Edward Grant, Helen Huang, Leaf Huang, Mike Jay, Melina Kibbe, Frances Ligler, Weili Lin, Terry Magnuson, Matthew Mauro, H. Troy Nagle, Roger Narayan, Harold Pillsbury, J. Michael Ramsey, Koji Sode.

Associate Professors

Ted Bateman, Lianne Cartee, Ke Cheng, Bob Dennis, Andrew DiMeo, Oleg Favorov, Caterina Gallippi, Michael Gamcsik, Richard Goldberg, Shawn Gomez, Zhen Gu, Derek Kamper, David Lalush, Jeffrey Macdonald, Scott Magness, Hatice Ozturk, Mark Tommerdahl, Anka Veleva, Glenn Walker, Paul Weinhold, David Zaharoff.

Assistant Professors

Rahima Benhabbour, Ashley Brown, Yevgeny Brudno, Jacqueline Cole, Michael Daniele, Brian Diekman, Matthew Fisher, Jason Franz, Donald Freytes, Naji Husseini, Xiaogang Hu, Stephanie Huang, Kennita Johnson, Gianmarco Pinton, William Polacheck, David Rojas Sr., Michael Sano, Anne Taylor, James Tsuruta.

Lecturers

Kenneth Donnelly, Devin Hubbard.

Professors Emeriti

Frank Abrams, Albert Banas, Carol Lucas.

BMME—Biomedical Engineering Undergraduate-level Courses

BMME 89. First Year Seminar: Special Topics. 3 Credits.

Special topics course. Content will vary each semester.

Repeat rules: May be repeated for credit; may be repeated in the same term for different topics; 6 total credits. 2 total completions.

Grading status: Letter grade.

BMME 101. Frontiers of Biomedical Engineering. 1 Credit.

Restricted to first-year students only. An introduction to the groundbreaking tools and topics of biomedical engineering, including medical imaging, medical robotics, rehabilitative engineering, regenerative medicine, and medical device design.

Grading status: Letter grade.

BMME 150. Introduction to Materials Science. 3 Credits.

Majors only. Focus on the materials science and processing of electronic, metallic, polymeric, ceramic, and composite materials. The electronic, optical, magnetic, and structural properties of materials are related to their applications.

Requisites: Prerequisite, CHEM 102; co-requisites, MATH 383 and PHYS 117 or 119.

Grading status: Letter grade.

BMME 160. Statics. 3 Credits.

Course restricted to admitted majors only. Course covers rigid body mechanics of bodies at equilibrium or at rest (statics), and an introduction to rigid body mechanics of bodies in motion (dynamics). A foundation in engineering concepts and practices required to design and analyze many types of structural members is presented. Provides a foundation for more advanced courses.

Requisites: Prerequisites, MATH 232, and PHYS 116 or 118.

Grading status: Letter grade.

BMME 190. Special Topics in Biomedical Engineering. 1-3 Credits.

A study in the special fields under the direction of the faculty. Offered as needed for presenting material not normally available in regular BMME courses.

Repeat rules: May be repeated for credit; may be repeated in the same term for different topics; 9 total credits. 3 total completions.

Grading status: Letter grade.

BMME 201. Computer Methods in Biomedical Engineering. 3 Credits.

Majors only. This course introduces students to problem-solving techniques using the MATLAB programming language. Fundamental computer science basics are taught as they relate to problems encountered in biomedical engineering and other scientific disciplines. Programming activities will incorporate actual data (e.g., stress/strain data and microscopy images) for relevant, real-world examples.

Grading status: Letter grade.

BMME 205. Introduction to Biomedical Mechanics. 4 Credits.

Majors only. Course covers rigid body mechanics of bodies at equilibrium or at rest (statics), and an introduction to rigid body mechanics of bodies in motion (dynamics). A foundation in engineering concepts and practices required to design and analyze many types of structural members is presented. In lab component, statics and dynamics subjects will be studied with experimental techniques, including strain gauges and accelerometers, and computational methods, including finite-element analysis and motion capture.

Requisites: Co-requisite, BMME 201 or COMP 116.

Grading status: Letter grade.

BMME 209. Introduction to the Materials Science of Biomaterials. 4 Credits.

Majors only. Focus on the materials science and processing of electronic, metallic, polymeric, ceramic, and composite materials. The electronic, optical, magnetic, and structural properties of materials are related to their applications. Lab component focused on integrating biological engineering and materials engineering principles by exploring key topics in materials science. Topics include biomaterial fabrication, evaluation of their physical properties and interpretation of results.

Requisites: Corequisite, PHYS 117 or 119.

Grading status: Letter grade.

BMME 210. BME Design and Manufacturing I. 2 Credits.

Course restricted to admitted majors only. Students will learn: use of design software (SolidWorks and support/analysis programs); basic techniques for directly measuring solid objects; electronic assembly techniques; and how to design simple electronic circuits. Note: BME Toolkit purchase is required for this course.

Requisites: Co-requisite, PHYS 117 or 119.

Grading status: Letter grade.

BMME 215L. Biomedical Mechanics Lab. 1 Credit.

Statics and dynamics subjects will be studied with experimental techniques, including strain gauges and accelerometers, and computational methods, including finite-element analysis and motion capture.

Requisites: Prerequisite, BMME 160; corequisite, BMME 201 or COMP 116.

Grading status: Letter grade.

BMME 219L. Materials Science of Biomaterials Lab. 1 Credit.

Introductory laboratory experience focused on integrating biological engineering and materials engineering principles by exploring key topics in materials science. Topics include biomaterial fabrication, evaluation of their physical properties and interpretation of results.

Requisites: Prerequisite, BMME 150.

Grading status: Letter grade.

BMME 295. Research in Biomedical Engineering for Undergraduates. 1-3 Credits.

Permission of the director of undergraduate studies. At least three hours per credit hour of independent work a week. Research with a faculty mentor. Approved learning contract required. Research proposal and final research paper also required. Previously offered as BMME 395.

Gen Ed: EE- Mentored Research.

Grading status: Letter grade.

BMME 310. BME Design and Manufacturing II. 2 Credits.

Students learn basic tools and procedures of modern design and practice traditional and modern rapid manufacturing technologies/techniques. Laboratory exercises and Web-based instructional content.

Requisites: Prerequisite, BMME 210.

Grading status: Letter grade.

BMME 315. Biotransport. 3 Credits.

This course serves as introduction for engineers pursuing transport phenomena and for future pharmaco-engineers requiring predictive models of mass transfer or pharmacodynamic models. Material is designed to address heat and mass transfer issues in nanotechnology, microfabrication, mems, cell therapies, bioartificial organs, as well as pharmacodynamic modeling of dynamic "omics" datasets. Previously offered as BMME 475

Requisites: Prerequisites, BIOL 101, BMME 205 or BMME 160, and MATH 383.

Grading status: Letter grade.

BMME 325. Biochemistry for Biomedical Engineers. 3 Credits.

An overview of how alterations in bioenergetics, enzyme catalysis, protein and membrane structure, carbohydrate, lipid and nucleic acid metabolism affect human health. Topics include: biological thermodynamics, energy of macromolecular structure and binding, structure/function of proteins, enzymes and nucleic acids, kinetics, enzyme catalysis and biochemical network analysis, generation of chemical and electrical potential in membranes, carbohydrate/lipid/protein metabolism and energy production, DNA synthesis, transcription, and the technologies used to monitor/detect biochemical processes.

Requisites: Prerequisites, CHEM 261 and BMME 150 or BMME 209.

Grading status: Letter grade.

BMME 345. Biomedical Solid Mechanics. 3 Credits.

This course covers topics ranging from multi-body systems to stress superposition to failure criteria to prepare students for the more advanced subjects of biomechanics and rehabilitation engineering. Topics include free-body diagrams, multibody statics and dynamics, linkage kinematics and kinetics, anthropometric kinematics, stress/strain/torsion, beam bending, stress superposition, constitutive relationship, strain gauges, finite-element analysis, failure analysis, and failure mechanisms.

Requisites: Prerequisites, BMME 205 or BMME 215L, BMME 150 or BMME 209, and BMME 201 or COMP 116.

Grading status: Letter grade.

BMME 350. Electronics for Biomedical Engineers. 4 Credits.

Fundamentals of analog and digital circuit analysis and design as applied to biomedical instrumentation and measurement of biological potentials. Class will consist of lectures and problem solving of analog and digital circuits. In lab students will design, develop, and test circuits, and acquire data to a computer using LabView.

Requisites: Prerequisite, PHYS 117 or 119.

Grading status: Letter grade.

BMME 351. Human Physiology and Biological Measurements for Engineers. 4 Credits.

A course on the quantitative aspects of basic human physiology. Class work will provide students with a basic understanding of human anatomy and physiology. A laboratory portion will explore actual physiological measurement techniques and quantitatively evaluate human physiology using statistical analyses.

Requisites: Prerequisite, BMME 350; co-requisite, BIOL 252.

Grading status: Letter grade.

BMME 355. Biocontrols. 3 Credits.

Quantitative analysis of dynamic and feedback control systems, including modeling of physiological systems and physiological control systems, system time and frequency responses, control characteristics, and stability analysis. Design techniques for feedback systems in biomedical applications.

Requisites: Prerequisites, BMME 350 and MATH 383; corequisite, BMME 410.

Grading status: Letter grade.

BMME 396. Independent Study in Biomedical Engineering. 1-3 Credits.

Permission of the director of undergraduate studies. Independent study under a member of the biomedical engineering faculty. Approved learning contract required.

Repeat rules: May be repeated for credit. 12 total credits. 4 total completions.

Grading status: Letter grade.

Advanced Undergraduate and Graduate-level Courses**BMME 405. Biomechanics of Movement. 3 Credits.**

This course provides an overview of musculoskeletal anatomy, and of the mechanical behavior of biological tissues and biological systems. Students learn to apply fundamental principles of mechanics to analyze movement in humans and other animals. Applications in rehabilitation and orthopedics are emphasized.

Requisites: Prerequisites, BMME 160 and MATH 383.

Grading status: Letter grade.

BMME 410. Systems and Signals. 3 Credits.

Analysis of linear systems by transform methods to networks, including Fourier transforms, Laplace transforms, and convolution. Survey of linear systems applications to biomedical problems.

Requisites: Prerequisite, MATH 383; co-requisite, MATH 528.

Grading status: Letter grade.

BMME 420. Introduction to Synthetic Biology. 3 Credits.

This course provides an introduction to the ideas and methodologies in the field of synthetic biology. Lectures focus on fundamental concepts in molecular biology and engineering as applied to biological system design. The laboratory portion of the course provides hands-on application of fundamental techniques in synthetic biology research.

Requisites: Prerequisites, BIOL 101 and CHEM 101; corequisite, BIOL 202 and CHEM 102.

Grading status: Letter grade.

BMME 435. Biological Physics. 3 Credits.

How diffusion, entropy, electrostatics, and hydrophobicity generate order and force in biology. Topics include DNA manipulation, intracellular transport, cell division, molecular motors, single molecule biophysics techniques, nerve impulses, neuroscience.

Requisites: Prerequisites, PHYS 116 and 117, or PHYS 118 and 119.

Grading status: Letter grade

Same as: PHYS 405, BIOL 431.

BMME 441. Thermal Physics. 3 Credits.

Equilibrium statistical mechanics; the laws of thermodynamics, internal energy, enthalpy, entropy, thermodynamic potentials, Maxwell's equations.

Requisites: Prerequisites, MATH 233, and PHYS 117 or 119; permission of the instructor for students lacking the prerequisites.

Grading status: Letter grade

Same as: PHYS 441.

BMME 445. Systems Neuroscience. 3 Credits.

Introduction to methodologies used to characterize a) the aggregate behavior of living neural networks and b) the changes in that behavior that occur as a function of stimulus properties, pharmacological manipulations, and other factors that dynamically modify the functional status of the network.

Requisites: Prerequisite, BMME 351 or BIOL 252.

Grading status: Letter grade.

BMME 447. Neural Basis of Rehabilitation Engineering. 3 Credits.

The course will 1) introduce basic neuroscience topics underlying sensorimotor control, and 2) introduce different types of childhood and adult neuromuscular disorders with both central and peripheral origins. The main focus of the class will be on the different techniques used for diagnosis, assessment, and rehabilitation interventions.

Requisites: Prerequisites, BMME 351, and BMME 160 or BMME 345.

Grading status: Letter grade.

BMME 455. Biofluid Mechanics. 3 Credits.

This course introduces students to basics of fluid mechanics (steady and pulsatile flows, laminar and turbulent flows, and Newtonian and non-Newtonian flows). Students learn the fundamental relationships and governing equations describing these types of flows and the basic physiology of certain systems that are highly associated with fluid flows.

Requisites: Prerequisites, BMME 315, or BMME 160 and MATH 528 and COMP 116.

Grading status: Letter grade.

BMME 461. Introduction to Medical Imaging. 3 Credits.

This class covers the underlying concepts and instrumentation of modern medical imaging modalities. Review of applicable linear systems theory and relevant principles of physics. Modalities covered include X-ray radiography (conventional film-screen imaging and modern electronic imaging), computerized tomography (including the theory of reconstruction), magnetic resonance imaging, SPECT/PET, and ultrasound imaging.

Requisites: Prerequisite, BMME 410.

Grading status: Letter grade.

BMME 465. Biomedical Instrumentation I. 4 Credits.

Topics include basic electronic circuit design, analysis of medical instrumentation circuits, physiologic transducers (pressure, flow, bioelectric, temperature, and displacement). This course includes a laboratory where the student builds biomedical devices. Note, an embedded computer kit purchase is required for this course.

Requisites: Prerequisites, BMME 350, and COMP 116 or BMME 201.

Grading status: Letter grade.

BMME 470. Tissue Engineering. 3 Credits.

Lectures in this course address how to quantitatively evaluate functional engineered tissues. The course provides an overview of the field, with emphasis on detailed evaluation of scientific and commercial progress over time, and design principles that must be met to develop a process or fabricate a functional tissue-engineered part.

Requisites: Prerequisites, BIOL 252 and BMME 351.

Grading status: Letter grade.

BMME 485. Biotechnology. 3 Credits.

This course is designed to prepare a biomedical engineering student with the survey tools to understand key components in modern biotechnologies. Fundamental concepts, theory, design, operation, and analysis of the most common biotechnologies in bioengineering will be presented.

Requisites: Prerequisite, BMME 210.

Grading status: Letter grade.

BMME 490. Special Topics in Biomedical Engineering. 3-9 Credits.

A study in the special fields under the direction of the faculty. Offered as needed for presenting material not normally available in regular BMME courses.

Repeat rules: May be repeated for credit; may be repeated in the same term for different topics; 12 total credits. 4 total completions.

Grading status: Letter grade.

BMME 495. Undergraduate Research in Biomedical Engineering as a Technical Elective. 3 Credits.

Opportunity for hands-on faculty mentored research project in biomedical engineering. Approved plan of work required with significant independent research culminating in a final paper and presentation at an appropriate venue. Departmental approval required. Course may not be repeated.

Grading status: Letter grade.

BMME 505. Skeletal Biomechanics. 3 Credits.

A firm understanding of the principles of mechanics is an important foundation to biomechanics. In this course, students will study the mechanics of materials with applications to the strength of bone, implant analysis, and testing of biological materials. A goal of this course is for students to understand how the interface of biology, mechanics, and therapies affect skeletal pathological conditions.

Requisites: Prerequisites, BMME 160 and MATH 383.

Grading status: Letter grade.

BMME 510. Biomaterials. 3 Credits.

Focus on the mechanical, chemical, and biocompatibility considerations of any material (e.g., metal, ceramic, or polymer) designed to interface with the body. Various applications of biomaterials are presented and analyzed, including femoral implants and vascular grafts, in order to guide students in a semester-long design project.

Requisites: Prerequisites, BIOL 101 and BMME 150; corequisites BIOL 252 and 252L.

Grading status: Letter grade.

BMME 550. Medical Imaging I: Ultrasonic, Optical, and Magnetic Resonance Systems. 3 Credits.

Physical and mathematical foundations of ultrasonic, optical, and magnetic resonance imaging systems in application to medical diagnostics. Each imaging modality is examined, highlighting critical system characteristics: underlying physics of the imaging system, including mechanisms of data generation and acquisition; image creation; and relevant image processing methods, such as noise reduction.

Requisites: Prerequisites, BIOS 550, BMME 530, and PHYS 128.

Grading status: Letter grade.

BMME 551. Medical Device Design I. 3 Credits.

Student multidisciplinary teams work with local medical professionals to define specific medical device concepts for implementation.

Grading status: Letter grade.

BMME 552. Medical Device Design II. 3 Credits.

Device prototypes designed in the first course in series. Good manufacturing practices; process validation; FDA quality system regulations; design verification and validation; regulatory approval planning; and intellectual property protection.

Grading status: Letter grade.

BMME 560. Medical Imaging II: X-Ray, CT, and Nuclear Medicine Systems. 3 Credits.

Overview of medical imaging systems using ionizing radiation. Interaction of radiation with matter. Radiation production and detection. Radiography systems and applications. Tomography. PET and SPECT systems and applications.

Requisites: Prerequisites, BIOS 550, BMME 410, and PHYS 128.

Grading status: Letter grade.

BMME 565. Biomedical Instrumentation I. 4 Credits.

Graduate students or permission of the instructor. Topics include basic electronic circuit design, analysis of medical instrumentation circuits, physiologic transducers (pressure, flow, bioelectric, temperate, and displacement). This course includes a laboratory where the student builds biomedical devices.

Grading status: Letter grade.

BMME 576. Mathematics for Image Computing. 3 Credits.

Mathematics relevant to image processing and analysis using real image computing objectives and provided by computer implementations.

Requisites: Prerequisites, COMP 116 or 401, and MATH 233; a grade of C or better is required in COMP 116 or 401, and MATH 233.

Grading status: Letter grade

Same as: COMP 576.

BMME 580. Microcontroller Applications I. 3 Credits.

Introduction to digital computers for real-time processing and control of signals and systems. Programming input and output devices using C and assembly language is stressed. Case studies are used to present software design strategies for real-time laboratory systems.

Requisites: Prerequisites, BIOL 252, BMME 350, and COMP 116 or BMME 201; co-requisite, BMME 351.

Grading status: Letter grade.

BMME 581. Microcontroller Applications II. 3 Credits.

Advanced topics in microcontroller systems used for biomedical instruments. Problems of interfacing computers with biomedical systems are studied. Students collaborate to develop a new biomedical instrument. Platforms could include the use of digital signal processing (DSP) microcontrollers or field programmable gate arrays (FPGAs), and topics could include applications such as digital signal processing and high speed data acquisition to computers.

Requisites: Prerequisites, BMME 465 and 580.

Grading status: Letter grade.

BMME 681. Human Factors Engineering and Quality Management Systems for Engineers. 3 Credits.

This course teaches human factors engineering, risk assessment, and quality management systems. At the end of the course, students will be able to apply their knowledge to their senior design project and test for a six sigma green belt certification.

Grading status: Letter grade.

BMME 691H. Honors Thesis. 3 Credits.

Research honors course. Prior approval needed from the chair or associate chair of the program for topic selection and faculty research mentor. Minimum GPA requirement, written report, and abstract requirements as set forth by the honors program.

Gen Ed: EE- Mentored Research.

Grading status: Letter grade.

BMME 692H. Honors Thesis. 3 Credits.

Research honors thesis continuation with required GPA, research topic selection with approved faculty mentor. Written abstract and report per honors program guidelines submitted by specific deadlines.

Gen Ed: EE- Mentored Research.

Grading status: Letter grade.

BMME 697. Senior Design Project I. 3 Credits.

Course restricted to admitted majors only. Conceptual prelude and preparation to BMME 698, in which the theoretical and practical knowledge acquired during the undergraduate tenure is applied to develop a solution to a real-world problem.

Requisites: Prerequisites, BMME 310, BMME 351, and one BMME course above 400.

Grading status: Letter grade.

BMME 698. Biomedical Engineering Senior Design II. 3 Credits.

Implementation phase of the senior design experience. Students apply the theoretical and practical knowledge they have acquired in their previous seven semesters to the design and implementation of a solution to a real-world problem.

Requisites: Prerequisite, BMME 697.

Gen Ed: CI, EE- Mentored Research.

Grading status: Letter grade.