BIOMEDICAL ENGINEERING

Department Website (https://sc.edu/study/colleges_schools/engineering_and_computing/study/biomedical_engineering/)

Melissa Moss, *Director*

Biomedical engineers are involved in the design and improvement of products and procedures that promote improved health. Contributions of biomedical engineers range from the design of artificial organs to the discovery of new therapeutic pharmaceuticals to the development of surgical procedures and associated instrumentation. The Departments of Chemical Engineering and Mechanical Engineering collaborate to offer the Bachelor of Science in Biomedical Engineering. The curriculum provides a strong foundation in the basic and applied sciences, as well as in the liberal arts, to provide students with a well-balanced education. Increasing emphasis is placed upon the application of engineering principles to biological systems in the junior and senior years. The curriculum provides the opportunity to engage in technical electives, laboratory course components, and a capstone design experience. Additional elective components and the design experience can be tailored to the specific interests of the student.

Bachelor's/Master's Degrees Accelerated Program

The Bachelor's/Master's Degrees Accelerated Program in Biomedical Engineering allows undergraduate students to complete both the B.S. degree and M.S. degree in as few as five years. The use of dual credit-courses that can be used toward both degrees enables acceleration of the program, reducing the total enrollment of the student by one semester.

Biomedical Engineering undergraduate students may apply for approval of an accelerated education plan in the semester in which they will complete 90 hours of undergraduate course work. In addition, students must have a sufficient foundation in biomedical engineering course work to enable them to take graduate-level courses. University and program regulations stipulate that applicants must have a minimum GPA of 3.40, both overall and in biomedical engineering courses. Students in the accelerated program must maintain a GPA of 3.40 while pursuing the B.S. degree.

Students applying to this program must submit to The Graduate School a completed "Application for Admission to a Combined Bachelor's/Master's Education Plan" (G-BMPA) with endorsements of the undergraduate advisor, research advisor and the program graduate director. The dean of The Graduate School has final authority for approving accelerated education plans. A "Bachelor's/Master's Degree Accelerated Plan Course Work Authorization" form must be submitted for each semester in which one or more of these courses are taken.

Participation in the accelerated program does not require or insure acceptance into The Graduate School. Students wishing to continue towards a master's degree in biomedical engineering at USC must apply formally to the Graduate School by submitting the appropriate application and all required supporting documents. Students in the accelerated program will be eligible for graduate assistantships upon admission to The Graduate School.

Only graduate-level courses (numbered 500 and above, including up to 3 credit hours of project/research work) satisfying both B.S. and Master's degree requirements may be used for dual credit. BMEN core graduate courses (excluding 1-hour seminar courses and thesis preparation, BMEN 799) or courses from list of the approved BMEN graduate electives (refer to the graduate student handbook) may be used for graduate-level coursework. No more than twelve credit hours may be used as dual credit. The graduate courses used for dual credit must be taken during the student's final undergraduate year.

Programs

- Biomedical Engineering, B.S. (https://academicbulletins.sc.edu/undergraduate/engineering-computing/biomedical-engineering/biomedical-engineering-bs/)

Courses

BMEN 101 - Introduction to Biomedical Engineering (1 Credit)
Introduction to topics comprising the field of Biomedical Engineering, including their ethical impacts. Familiarization with resources and basic skills necessary to succeed in this major and field.
Prerequisite or Corequisite: MATH 141.

BMEN 212 - Fundamentals of Biomedical Systems (3 Credits)
Fundamentals of static equilibrium, free body diagrams, force and momentum balances; viscoelastic mechanical behavior and models of viscoelasticity; introduction to linear circuit analysis.
Prerequisites: C or better in CHEM 111 or CHEM 141; C or better in MATH 141.

BMEN 240 - Cellular and Molecular Biology with Engineering Applications (4 Credits)
Introduction to molecular, cellular, and physical biology principles and concepts and application of engineering principles to further the understanding of biological systems. Protein and nucleic acid structure and function; DNA replication, mutations, and repair; transcription, translation, and post-translational processing; cellular organization; molecular transport and trafficking; and cellular models.
Prerequisites: C or better in BIOL 101, C or better in CHEM 112 or CHEM 142, and C or better in MATH 142.

BMEN 263 - Introduction to Biomechanics (3 Credits)
Mathematical and theoretical analysis of the mechanical properties and functions of materials, including those of biological origin and clinical relevance. Stress, strain, mechanical properties of materials, axial loading, torsion, bending, and stress/strain transformations. Application of the categories and methodology of solid mechanics to study biological tissues and events.
Prerequisites: C or better in BMEN 212, C or better in MATH 241, C or better in PHYS 211.

BMEN 271 - Introduction to Biomaterials (3 Credits)
Properties of metals, ceramics, polymers, natural materials and composites; methods to modify surface and bulk properties of biomaterials; mechanisms of degradation in physiological environments; cell- and tissue-biomaterial interactions; host response to implanted biomaterials; blood-biomaterial interactions; rational design of biomaterials for specific biomedical applications.
Prerequisites: D or better in CHEM 333, C or better in BMEN 240, C or better in BMEN 263, C or better in BMEN 290.

BMEN 290 - Thermodynamics of Biomolecular Systems (3 Credits)
First, second, and third law of thermodynamics; free energy and chemical equilibrium in biological processes; phase equilibrium for biomedical systems; energy and metabolism; membrane potentials and depolarization.
Prerequisites: C or better in MATH 241, C or better in BMEN 240, and C or better in PHYS 211.

BMEN 302 - Professional Development and Ethics in Biomedical Engineering (2 Credits)
Analysis and discussion of biomedical industries, standards, regulations, products, and patents. Ethical issues associated with research, introduction of new products, animal subjects, and human subjects.
Prerequisites: BMEN 101.

BMEN 303 - Professional Development and Ethics in Biomedical Engineering (1 Credit)
Analysis and discussion of industries, products, patents, industrial inventiveness, and biomedical research. Ethical issues associated with research, introduction of new products, animal subjects, and human subjects.
Prerequisites: BMEN 101.

BMEN 321 - Biomonitoring and Electrophysiology (3 Credits)
Basic electric circuits and equivalent cell model circuits used in biomonitoring and electrophysiology. Ohm's and Kirchoff's Laws. Applications of electrical components, such as operations amplifiers, filter, and Wheastone bridge, in biomonitoring and electrophysiology. Origins of bioelectricity. Biopotential and electrochemistry including Nernst and Goldman-Hudgkin-Katz equations for describing membrane potential of nerve and muscle cells. Ion transport involved in maintaining cell pH, action potential, muscle contraction, sensory perception.
Prerequisites: D or better in PHYS 212, C or better in BMEN 212, C or better in BMEN 240, C or better in MATH 242.

BMEN 342 - Infectious Disease & Immunology for Biomedical Engineers (3 Credits)
Qualitative and quantitative aspects of infectious diseases; principles of diagnosis and control. Elements of human immunological response and immune disorders; influence on biomedical engineering of explants and implants.
Prerequisites: BIOL 101.

BMEN 345 - Human Anatomy and Physiology for Biomedical Engineers (4 Credits)
Foundations for biomedical engineering with a focus on human anatomy and physiology. Introduction to the inter-relationships between tissue/organ structure and function; demonstration of how an engineering approach can promote understanding of these relationships. Recent biomedical engineering advances and their relations to underlying anatomy and physiology.
Prerequisites: D or better in BMEN 271, C or better in BMEN 240.

Graduation with Leadership Distinction: GLD: Professional and Civic Engagement Internships, GLD: Research

BMEN 346 - Medical Microbiology for Biomedical Engineers (3 Credits)
Qualitative and quantitative aspects of human system based medical microbiology; principles of diagnosis and control of representative human diseases. Elements of human immunological response and immune disorders.
Prerequisites: D or better in BMEN 240.

BMEN 354 - Biotransport (3 Credits)
Basics of convective and diffusive transport applied to biological and biomedical systems. The effect of fluid flow and mass transport upon biochemical interactions. Scaling and design of biotransport systems.
Prerequisites: ECHE 320 or EMCH 360 or ENCP 360, C or better in MATH 242.

BMEN 361 - Biomedical Instrumentation (4 Credits)
Principles of and experimental measurements using bioinstrumentation. Data acquisition, processing, and statistical analysis. Lab and electrical safety. Analytical methods including hematology, human fluids analysis, biosensors, chromatographic techniques, electrophoresis, dialysis, spectrophotometry, fluorometry, and microscopy. Applications of bioinstrumentation in disease diagnosis.
Prerequisites: BMEN 321, STAT 509.

BMEN 363 - Biomedical Instrumentation (3 Credits)
Sensing and measurement of biophysical and biochemical properties and signals in the human body for quantitative molecular, cell, and tissue analysis. Overview on the theory, design and application of common biomedical instrumentation used for diagnosis, treatment, and scientific study of physiological parameters in clinical medicine and biomedical research.
Prerequisites: BMEN 321.

BMEN 381 - Biomedical Engineering Laboratory I (2 Credits)
Introduction to laboratory techniques and tools used for physiological measurements in biomedical engineering, with focus on biological, physical, and biomaterial methods. Data processing and analysis, as well as effective communication of results in written and oral form.
Prerequisites: D or better in BMEN 263, D or better in STAT 509.

Prerequisite or Corequisite: D or better in BMEN 271.

BMEN 382 - Biomedical Engineering Laboratory II (2 Credits)
Introduction to laboratory techniques and tools used for physiological measurements in biomedical engineering, with focus on measurement of biosignals and common analytical methods employed in biomedical research and clinical settings. Data processing and analysis, as well as effective communication of results in written and oral form.
Prerequisites: BMEN 321, BMEN 381.

Prerequisite or Corequisite: BMEN 363.

BMEN 389 - Special Topics in Biomedical Engineering for Undergraduates (1-3 Credits)
Course content varies and will be announced in the schedule of classes by title. May be repeated as topic varies.

BMEN 391 - Kinetics in Biomolecular Systems (3 Credits)
Kinetic theory applied to biomedical systems, including enzymatic reactions, cell growth, and kinetic models of biological systems.
Prerequisites: D or better in CHEM 550 or BIOL 541; C or better in BMEN 290; C or better in MATH 242.

BMEN 392 - Fundamentals of Biochemical Engineering (3 Credits)
Biological systems are used in chemical industries for a wide variety of applications, including the formation of important products (e.g. pharmaceuticals), sensor technology, degradation, and waste water treatment. This class will provide an overview of materials needed to investigate and model biosystems.
Prerequisites: CHEM 333.

BMEN 411 - Modeling and Simulation of Biomedical Systems (3 Credits)
Introduction to modern computational modeling tools used in biomedical engineering. Analysis, visualization and image processing using engineering software as applied to problems of interest in biomedical engineering.
Prerequisites: BMEN 263, BMEN 271, and BMEN 354 with a minimum grade of D.

BMEN 427 - Senior Biomedical Engineering Design I (3 Credits)
Integrated team work/project management, "voice of the patient", design specifications, design functions, design concepts, economic factors, concept selection and product architecture. The initial feasibility study, selection of the final design approach, and preliminary specifications are required by the end of the semester.
Prerequisites: D or better in all of: BMEN 271, BMEN 345, BMEN 354, BMEN 363.

Graduation with Leadership Distinction: GLD: Professional and Civic Engagement Internships, GLD: Research

BMEN 428 - Senior Biomedical Engineering Design II (3 Credits)
Design for manufacturability, ergonomic and aesthetic considerations, prototype construction and testing, fabrication and biological testing of tissue engineered constructs, statistical methods/design of experiments, ethics/product liability and social/environmental impact. The final engineering design (specifications, drawings, bill of materials, including assessment of economics) will be completed by the end of the semester. Both written and oral reports are to be provided.
Prerequisites: BMEN 427.

Graduation with Leadership Distinction: GLD: Professional and Civic Engagement Internships, GLD: Research

BMEN 499 - Independent Research (1-3 Credits)
Summer internship, REU, or co-op experience in biomedical engineering. Students enroll in this course following their research experience and prepare a summary paper and research seminar on their technical accomplishments. A maximum of 3 credits may be applied toward the degree.
Graduation with Leadership Distinction: GLD: Professional and Civic Engagement Internships, GLD: Research

BMEN 532 - Micro/nanofluidics and Lab-on-a-Chip (3 Credits)
Basic fluid mechanics, capillary, drop and micro/nanoparticle, electrokinetics; micropump, mixer, preconcentrator, electrophoresis, microactuator and particle manipulator; sensors for pressure, velocity, concentration, temperature in environmental monitoring/biodefence, clinical diagnostics, drug discovery/delivery.
Prerequisites: D or better in CHEM 112 and CHEM112L or CHEM 142; D or better in PHYS 212.

Cross-listed course: EMCH 562

BMEN 537 - Bio Nano/Micro Electro-Mechanical Systems (3 Credits)
Fundamentals of nano- and microfabrication, metrology and their applications in biomedical engineering and science. The fabrication covers photolithography, nano/microfabrication for nano/microstructures, etching and additive techniques, MEMS integration and packaging, etc. Metrology focuses on characterization of nanostructures with imaging technologies.
Prerequisites: D or better in CHEM 112 and CHEM 112L or CHEM 142; D or better in PHYS 212.

Cross-listed course: EMCH 567

BMEN 546 - Delivery of Bioactive Agents (3 Credits)
Routes of administration; mechanisms of drug absorption and biological barriers; pharmacokinetic modeling of drug distribution; drug excretion and biotransformation; design and evaluation of controlled release systems, targeted release systems, and responsive release systems.
Prerequisites: D or better in all of: BMEN 240, CHEM 333, and MATH 142.

BMEN 547 - Immunoengineering (3 Credits)
Engineering approaches to study and control immune reactions and their applications in therapy and diagnostics for infectious disease, cancer, allergy, autoimmunity, and transplantation.
Prerequisites: C or better in BMEN 240.

BMEN 548 - Cardiovascular System: From Development to Disease (3 Credits)
Survey of cardiovascular development, anatomy, physiology and pathology. Recent advances in our understanding of the basic mechanisms of congenital cardiovascular defects and cardiovascular disease. Engineering principles, detection and treatment of cardiovascular defects.
Prerequisites: D or better in BMEN 240.

BMEN 565 - Advanced Biomechanics (3 Credits)
Mathematical and theoretical analysis of the mechanical properties and functions of soft biological tissues to include arterial vessels.
Prerequisites: D or better in BMEN 263.

BMEN 572 - Tissue Engineering (3 Credits)
Molecular basis of bioregenerative engineering; biomaterial design; biocompatibility assessment; cell isolation and characterization; rapid prototyping, scaffold fabrication, and biofabrication; protein and gene delivery; bioreactor design; transport in biological tissues; applications of tissue engineering in regenerative medicine.

BMEN 589 - Special Topics in Biomedical Engineering (1-3 Credits)
Course content varies and will be announced in the schedule of classes by title. May be repeated as topic varies.