Biomedical Engineering
Graduate Programs: ME, MS and PhD in Biomedical Engineering

Description of the Program

The graduate degree programs in Biomedical Engineering are a joint effort between the College of Engineering and Computing (CEC), the School of Medicine (SOM), and the College of Arts and Sciences (A & S). Graduate degrees in Biomedical Engineering will focus on the quantitative methods characteristic of engineering that are not a primary focus of traditional medical or biological education. CEC is responsible for the primary administration of the program. The curriculum calls for four core lecture courses, two of which are taught primarily by CEC faculty and two primarily by SOM faculty. Engineering, Medicine, and Arts & Sciences also offer course for elective credit within the curriculum. Faculty from all three colleges and schools collaborate in research.

Purpose and Objectives of the Program

The Biomedical Engineering discipline combines elements of biological and life sciences, engineering sciences, design, manufacturing and operation of biomedical processes and devices. The graduate degree programs (MS, ME and PhD) will:

1. Prepare graduates of the program to meet the growing demands for advanced level research, development, and entrepreneurial positions in the biomedical industry.

2. Respond to the rapidly growing national demand for new biomedical technologies and the supporting industry, and to provide opportunities for economic development and entrepreneurial growth for the State of South Carolina.

3. Meet the goals of the University of South Carolina in its emphasis area of biomedical sciences.

The Master of Engineering (ME) in Biomedical Engineering offers intensive, focused coursework training in the professional practice of biomedical engineering. The program is specifically designed for students who plan to pursue industrial careers, as a graduate degree could enhance their job application, yield a higher starting salary, and enable rapid promotion within many corporate structures. Moreover, the program will provide students who plan to pursue further graduate education a means to distinguish themselves from typical candidates with a BS degree only, and insomuch facilitate admission to leading Biomedical Engineering graduate programs and medical schools nationwide.

The MS degree combines course work and a research-based thesis to serve three student populations. First, traditional biomedical, chemical and mechanical engineers who wish to obtain advance training in biological areas prior to entering industry will be attracted to the MS. Second, science majors who wish to receive quantitative training will use the MS to enhance their qualifications for industry. Third, the MS will also be ideal for students who wish post-
baccalaureate training before entering medical school. Thus, we expect that the MS will ultimately lead to careers in industry or in medical practice.

The PhD program equips students with training in core and elective biomedical engineering topics coupled with research design and execution to advance students into a more focused area of the biomedical engineering field. As such, this program will prepare graduates to enter a research-based career in academia or industry.

**Admission Criteria Specific to the Program**

The admission criteria generally conform to those currently required by the University of South Carolina Graduate School. Admissions are based on the quality of the applicant's prior college work, letters of recommendation, GRE scores, and appropriate coursework in preparation for study in the biomedical field. In general, an applicant must have a baccalaureate degree in biomedical, chemical or mechanical engineering or its equivalent from an accredited college or university. Students with a baccalaureate degree in chemistry, biology, biochemistry, or other related fields and who have completed appropriate coursework during their baccalaureate degree are also eligible. Undergraduate preparation should include two semesters of each of biology, physics, and general chemistry, as well as four semesters of calculus, including differential equations. In additional, undergraduate preparation may include coursework in topics such as material balances, mechanics, dynamics, thermodynamics, transport, kinetics, etc. For otherwise exceptionally qualified students, admission may be granted with the proviso that the student undertakes coursework in areas not fully covered during undergraduate preparation. Typically, however, additional coursework would be required.

For additional information, please contact Dr. Tarek Shazly (BMEN Graduate Program Director) at shazly@cec.sc.edu or Dr. Melissa Moss (BMEN Program Director) at mossme@cec.sc.edu.
Curriculum

The table below lists the required curriculum for the ME, MS and PhD degree programs. All hours listed are beyond the BS degree. Students may be admitted directly to the PhD program.

<table>
<thead>
<tr>
<th>Program Element</th>
<th>ME</th>
<th>MS</th>
<th>PhD</th>
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<tr>
<td>No. of Required BMEN core courses and credits</td>
<td>4 (BMEN 710, 720, 713, 723), 12 credits</td>
<td>4 (BMEN 710, 720, 713, 723), 12 credits</td>
<td>4 (BMEN 710, 720, 713, 723), 12 credits</td>
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<tr>
<td>No. of Required BMEN 798 seminars and credits</td>
<td>BMEN 795, 798, 898 for 1.0 credit ea, 3 credits total</td>
<td>BMEN 795, 798, 898 for 1.0 credit ea, 3 credits total</td>
<td>BMEN 795, 798, 898 for 1.0 credit ea, 3 credits total</td>
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<tr>
<td>No. of Required BMEN elective courses</td>
<td>2 BMEN courses, 6 credits</td>
<td>2 BMEN courses, 6 credits</td>
<td>3 BMEN courses, 9 credits</td>
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<td>No. of other electives required</td>
<td>12 hours of additional approved electives</td>
<td>1 course, BMEN or from approved list, 3 credits</td>
<td>2 courses, BMEN or from approved list, 6 credits</td>
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<tr>
<td>SUBTOTAL Lecture and seminar credits</td>
<td>30 credits</td>
<td>24 credits</td>
<td>30 credits</td>
</tr>
<tr>
<td>Required Thesis or Dissertation Prep (designation determined by the primary appointment of the student's major advisor)</td>
<td>None</td>
<td>BMEN 799, 6 credits</td>
<td>BMEN 899, 12 credits</td>
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<tr>
<td>Required Research (designation determined by the primary appointment of the student's major advisor)</td>
<td>None</td>
<td>Fulfilled by BMEN 799</td>
<td>BMEN 797, 18 credits</td>
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<tr>
<td>TOTAL Lecture and research credits</td>
<td>30 credits</td>
<td>30 credits</td>
<td>60 credits</td>
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<tr>
<td>Admission to Candidacy Exam</td>
<td>None</td>
<td>None</td>
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<tr>
<td>Comprehensive Exam</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes (written and oral)</td>
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<td>Written thesis or dissertation</td>
<td>None</td>
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<td>Final oral defense</td>
<td>None</td>
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Core Course Description

The following are brief catalog course descriptions of the required biomedical engineering core and seminar courses in the graduate curriculum.

- **BMEN 710 — Modeling and Simulation of Biomedical Systems:** Analytical and quantitative techniques applied to engineering problems in biomedical transport, tissue mechanics, cellular and organ physiology, and control of medical devices.

- **BMEN 713 — Human Cell and Molecular Biology for Biomedical Engineers (3):** Advanced examination of the organization and function of the cell with emphasis on the biophysical and quantitative aspects of cellular function. Emphasis will be on the biomedical engineering applications of regulation of cell division, protein transcription and translation within the cell, cellular energetics, and intracellular networks for cell signaling and cell function.

- **BMEN 720 — Transport Phenomena in Biomedical Systems (3):** Conservation of momentum, energy, and mass, physico-chemical properties of biofluids, blood rheology, circulation models and cardiovascular regulation, solute and oxygen transport in tissues, gas transport in lungs and respiratory gas exchange models, kinetics and compartmental modeling, modeling of artificial organs.

- **BMEN 723 — Anatomy and Physiology for Biomedical Engineers (3):** An examination of human biological structure and function from an engineering perspective. Engineering principles will be used to analyze anatomical structures and physiological functions at the tissue, organ, and systems levels.

- **BMEN 795 – Biomedical Engineering Literature (1):** Critical analysis of biomedical engineering literature related to students' research projects. Written report and oral presentations required.

- **BMEN 798 — Graduate Seminar in Biomedical Engineering (1):** Seminar on current biomedical engineering topics and students’ presentations. May be repeated for credit.

- **BMEN 898 – Doctoral Seminar in Biomedical Engineering (1):** Seminar for doctoral students on current biomedical engineering topics and professional preparation.
## BME FACULTY

<table>
<thead>
<tr>
<th>Name</th>
<th>Position</th>
<th>Department/Program</th>
<th>Office Location</th>
<th>Phone</th>
<th>Fax</th>
<th>Email</th>
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</thead>
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<td>Chemical Engineering</td>
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<td></td>
<td>Professor</td>
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<td></td>
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<td></td>
<td>Associate Professor</td>
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<th>Name</th>
<th>Title and Department</th>
<th>Address</th>
<th>Phone</th>
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<tr>
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<td><a href="mailto:ntaherq@cec.sc.edu">ntaherq@cec.sc.edu</a></td>
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<td>Wenbin Tan</td>
<td>Associate Professor, Cell Biology and Anatomy</td>
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<td>803-216-3816</td>
<td><a href="mailto:wenbin.tan@uscmed.sc.edu">wenbin.tan@uscmed.sc.edu</a></td>
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<tr>
<td>Chuanbing Tang</td>
<td>Professor, College of Arts and Sciences Distinguished Professor, Chemistry and Biochemistry</td>
<td>Horizon I Bldg, HZN1 239</td>
<td>803-3628</td>
<td><a href="mailto:tang4@mailbox.sc.edu">tang4@mailbox.sc.edu</a></td>
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<tr>
<td>Homayoun Valafar</td>
<td>Professor, Associate Chair of Research, Associate Infrastructure Director (Visualization), Computer Science and Engineering</td>
<td>550 Assembly, Storey Innovation Center, Room 2251</td>
<td>803-777-2404</td>
<td><a href="mailto:homayoun@cse.sc.edu">homayoun@cse.sc.edu</a></td>
</tr>
<tr>
<td>Guiren Wang</td>
<td>Associate Professor, Mechanical Engineering</td>
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<td>803-777-8013</td>
<td><a href="mailto:guirenwang@sc.edu">guirenwang@sc.edu</a></td>
</tr>
<tr>
<td>James R. Wells</td>
<td>Research Professor, Clinical Assistant Professor of Surgery, Cell Biology and Anatomy</td>
<td>6311 Garners Ferry Rd, Bldg 4 School of Medicine</td>
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<td><a href="mailto:james.wells@uscmed.sc.edu">james.wells@uscmed.sc.edu</a></td>
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**BME Staff**

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FACULTY RESEARCH INTERESTS

Melissa A. Moss
Director, Biomedical Engineering;
Interim Department Chair of Chemical Engineering; Professor
Dr. Moss is the Director of the Biomedical Engineering Program at the University of South Carolina. Her research focuses on understanding the role of amyloid-β protein (Aβ) aggregation in Alzheimer’s disease and inhibiting Aβ aggregation as a therapeutic approach to this widespread and devastating illness.

Mark J. Uline
Associate Director and Undergraduate Director, Biomedical Engineering
Associate Professor, Biomedical & Chemical Engineering
Dr. Uline is the Undergraduate Director of the Biomedical Engineering Program at the University of South Carolina. His research group is working toward the fundamental understanding of how the complex interactions at interfaces couple together to give the rich phenomena observed in various chemical and biological systems.

Tarek Shazly
Graduate Director, Biomedical Engineering
Associate Professor, Biomedical & Mechanical Engineering
Dr. Shazly is the Graduate Director of the Biomedical Engineering Program at the University of South Carolina. His research is in the area of cardiovascular engineering, with specific focus on the mechanical implications of polymeric implants.

Mohamad Azhar
Associate Professor, Cell Biology & Anatomy
Dr. Azhar’s current focus involves using genetically engineered mouse models to investigate the biological function of the transforming growth factor beta (TGFβ) ligands in cardiovascular development and cardiovascular disease, including calcific aortic valve disease, congenital heart disease, and aortic calcification and thoracic aortic aneurysm.

Seongtae Bae
Assistant Professor, Electrical Engineering
Dr. Bae’s research is focused on clinical applications in nanomedicine, bioelectronics, and biosensors/ bioinstrumentation.

Abdel-Moez E. Bayoumi
Professor and Associate Dean, Mechanical Engineering Director, Condition-Based Maintenance Center
Dr. Bayoumi’s current areas of interest can be grouped into three categories: (1) study of Condition-Based Maintenance (CBM) on military aircraft, (2) Micro-Electro Mechanical Systems (MEMS) and Mechatronics, and (3) design and applications of efficient energy resources and systems.

James Otto Blanchette
Instructor, Biomedical Engineering
Dr. Blanchette's research interests fall into the areas of design of cell-instructive materials, delivery of therapeutics and tissue engineering.
Nicholas D. Boltin  
**Instructor, Biomedical Engineering**  
Dr. Boltin’s focus lies in Software Design, Biomedical Informatics, Data Mining, and Machine Learning/Artificial Intelligence.

Wayne Carver  
**Chair, Cell Biology & Anatomy; Professor**  
The research in Dr. Carver’s lab is focused on understanding how fibroblast behavior and gene expression are regulated in the heart. Cell culture and animal models are being used to examine the regulation of fibroblasts in cardiovascular disease.

John F. Eberth  
**Associate Professor, Cell Biology & Anatomy, Biomedical Engineering**  
Dr. Eberth’s work, and that of his lab, Translational Biomechanics Lab (TBL), is based on adapting fundamental engineering principles to understand, manipulate, and control the behavior of healthy and diseased cardiovascular tissue.

Daping Fan  
**Associate Professor, Cell Biology and Anatomy**  
Dr. Fan’s current research interests include: 1) the interaction between lipoprotein metabolism and innate immunity in atherogenesis, 2) the tumor microenvironment of breast cancer, and 3) development of natural compounds as anti-inflammatory and anti-cancer therapies.

Edward P. Gatzke  
**Associate Professor, Biomedical & Chemical Engineering**  
Dr. Gatzke’s research interests are in the area of process modeling, control, and optimization. Application areas of interest include particulate processing, bio-processes, and large scale systems.

Richard L. Goodwin  
**Professor, School of Medicine Greenville**  
Dr. Goodwin’s research lab investigates mechanisms of cardiovascular embryonic development and disease.

R. Michael Gower  
**Assistant Professor, Biomedical & Chemical Engineering**  
Dr. Gower’s research focuses on understanding the immune system in order to develop bio-instructive materials that stimulate specific immune responses.

Silke Henrich  
**Undergraduate Lab Manager; Instructor**  
Dr. Henrich is the undergraduate core lab manager at the Biomedical Engineering Program, and also serves as an instructor.

Esmaiel Jabbari  
**Professor, Biomedical & Chemical Engineering**  
Dr. Jabbari’s research draws upon chemistry, biology, macromolecular science and exploits biomimetic strategies to engineer cellular constructs for regeneration of skeletal tissues.
Ehsan Jabbarzadeh  
Associate Professor, Biomedical & Chemical Engineering  
Dr. Jabbarzadeh's lab is interested in the interdisciplinary areas of biomaterials, stem cells and nano/micro-electromechanical systems with applications in tissue engineering and regenerative medicine. His research activities focus on understanding the principles by which microenvironmental signals regulate cellular responses.

Susan Lessner  
Associate Professor, Cell Biology & Anatomy  
Dr. Lessner's research interests center on processes which lead to the destabilization and rupture of atherosclerotic plaques. In humans, plaque rupture leads directly to clinical events such as heart attack and stroke.

Chang Liu  
Assistant Professor, Biomedical & Chemical Engineering  
Dr. Liu's research group is interested in biosensor development and biomarker discovery using nanomaterials, with a focus on their clinical applications on in vitro diagnostics, point-of-care tests, and liquid biopsy for cancer and infectious diseases.

Michael A. Matthews  
Senior Associate Dean for Research and Graduate Education, Chemical Engineering, Biomedical Engineering; Professor  
Dr. Matthews teaches and conducts research in the broad field of thermodynamics. In Biomedical Engineering, his research and entrepreneurship deal with use of carbon dioxide technology for sterilization, disinfection, modification of tissue scaffolds, and deactivations of allergenic proteins and asthma triggers.

Chandrashekhar Patel  
Associate Professor of Cell Biology & Anatomy  
Director of the Biomedical Studies Certificate Program  
Dr. Patel's research interests include molecular regulation of vascular endothelial and smooth muscle cells.

Jay D. Potts  
Associate Professor, Cell Biology and Anatomy  
Dr. Pott's research team is working toward understanding how the early heart and in particular, the AV canal is formed, laying the foundation for future therapeutic measures for congenital cardiac defects.

John R. Rose  
Professor, Computer Science & Engineering  
Dr. Rose's research interests are in the areas of bioinformatics, normative reasoning and planning, DAI and multiagent systems, and computational chemistry.

Frank G. Spinale  
Professor, Cell Biology & Anatomy  
Dr. Spinale, an internationally renowned cardiovascular scientist, has directed a translational research effort in the thematic area of remodeling with a particular focus upon heart failure. The mechanistic, translational, and clinical studies he has been working on will advance our understanding and potential treatment for major causes of heart failure in patients.
Michael Sutton  
**Distinguished Professor, Biomedical & Mechanical Engineering**
Dr. Sutton's research and interests include coherent and incoherent optics applications, experimental mechanics, digital image processing, Computer Vision, applications of integral methods and experimental mechanics, boundary value problems, plastic fracture mechanics, finite elements modeling of cracked bodies.

Nader Taheri-Qazvini  
**Assistant Professor, Biomedical & Chemical Engineering**
Dr. Taheri-Qazvinis' research includes bio-nano hybrid and biomimetic materials, charge-driven self-assembly, structure-dynamics relations in polymer networks, hydrogels, soft glassy materials and living cells, microfabrication and 3D Bioprinting, and tissue engineering and collective cell migration.

Wenbin Tan  
**Associate Professor, Cell Biology & Anatomy**
Dr. Tan's research laboratory mainly focuses on the molecular pathogenesis of congenital vascular malformations (CVM) including cutaneous capillary malformations, a.k.a. Port Wine Stain (PWS), venous malformation, arteriovenous malformation, Sturge-Web syndrome (SWS) and Klippel-Trenaunay syndrome (KTS), etc.

Chuanbing Tang  
**Professor, Chemistry and Biochemistry**  
**Distinguished Professor, College of Arts and Sciences**
Dr. Tang's research combines synthesis of innovative polymeric materials, including both renewable biobased polymers, nanostructured polymers and metal-containing polymers, which can find applications ranging from novel biodegradable thermoplastics, drug delivery, antimicrobials, nanolithography, etc.

Homayoun Valafar  
**Professor; Associate Chair of Research; Associate Infrastructure Director (Visualization)**
Dr. Valafar's research activities fall into two broad categories: Computational Medicine and Computational Biology.

Guiren Wang  
**Associate Professor, Biomedical & Mechanical Engineering**
Dr. Wang's research and interests include micro/nanofluidics, lab-on-a-chip, far field optical nanoscopy, super-resolution imaging, cancer detection, fluorescence spectroscopy, tissue engineering, fluid dynamics, turbulence and mixing.

James R. Wells  
**Research Professor; Clinical Assistant Professor of Surgery**
Professor Wells’ clinical research focuses on analysis of HPV-Infection in Freshly Resected Tissue Specimens.
List of BMEN Approved Electives
The following is a list of existing courses that may be accepted for graduate elective credit

COEIT Graduate Courses
ECHE 710 Advanced Chemical Engineering Thermodynamics
ECHE 720 Advanced Fluid Flow Analysis
ECHE 721 Advanced Heat Flow Analysis
ECHE 722 Advanced Mass Transfer
ECHE 725 Rheology
ECHE 730 Chemical Reactor Design
ECHE 750 Process Dynamics and Control
ECHE 770 Electrochemical Engineering
ECHE 772 Principles of Polymer Systems
EMCH 717 Advanced Finite Element Methods
EMCH 722 Plasticity
EMCH 741 Viscous and Turbulent Flow
EMCH 751 Advanced Heat Transfer
EMCH 771 Design Properties of Plastics
EMCH 794 Thermodynamics

Arts & Sciences Graduate Courses
CHEM 751 Biosynthesis of Macromolecules
CHEM 752 Regulation and Integration of Metabolism
CHEM 753 Enzymology and Protein Chemistry
CHEM 754 Biomedical Biochemistry I
CHEM 755 Biomedical Biochemistry II
BIOL 714 Advanced Cell Biology
BIOL 736 Advanced Developmental Biology

Computer Science & Engineering
CSCE 555 Algorithms in Bioinformatics.
CSCE 561 Numerical Analysis.
CSCE 563 Systems Simulation.
CSCE 564 Computational Science.
CSCE 580 Artificial Intelligence.
CSCE 758 Probabilistic System Analysis
CSCE 763 Digital Image Processing.
CSCE 768 Pattern Recognition and Classification.
CSCE 769 Computational Structural Biology.
CSCE 784 Neural Information Processing.
CSCE 822 Data Mining and Warehousing.

SOM Graduate Courses
ANAT 700 Principles of Electron Microscopy
ANAT 701 Human Embryology and Gross Anatomy
ANAT 720 Special Topics in Microscopic Anatomy
ANAT 740 Biological Microscopic Imaging
BMSC 720 Signal Transduction
BMSC 730 Cardiovascular Science
CBNS 702 Human Microscopic Anatomy
MBIM 710 Advanced Immunobiology
MBIM 720 Comprehensive Microbiology
MBIM 739 Medical Bacteriology
MBIM 740 Virology
PATH 710 Neoplasia
PATH 741 Pathology I
PATH 742 Pathology II
PATH 760 Topics in Pathobiology
PHPH 705 Biomedical Pharmacology
PHPH 735 Cardiovascular Pharmacology
PHPH 740 Neuroscience
PHPH 745 Neurophysiology
PHPH 750 Fundamental Neuroscience I
PHPH 751 Fundamental Neuroscience II
BMSC 700 Biomedical Science Interdisciplinary Laboratory I
BMSC 701 Biomedical Science Interdisciplinary Laboratory II.
BMSC 702 Medical Cell Biology I.
BMSC 705 Medical Cell Biology II.
BMSC 710 Medical Molecular Biology.
BMSC 720 Signal Transduction.
BMSC 730 Cardiovascular Science.