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 undertake 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.
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>
</tr>
</thead>
<tbody>
<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>
</tr>
<tr>
<td>No. of Required BMEN 798 seminars and credits</td>
<td></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>
</tr>
<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>
</tr>
<tr>
<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>
</tr>
<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>
</tr>
<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>
</tr>
<tr>
<td>TOTAL Lecture and research credits</td>
<td>N/A</td>
<td>30 credits</td>
<td>60 credits</td>
</tr>
<tr>
<td>Admission to Candidacy Exam</td>
<td>None</td>
<td>None</td>
<td>Yes</td>
</tr>
<tr>
<td>Comprehensive Exam</td>
<td>None</td>
<td>None</td>
<td>Yes (written and oral)</td>
</tr>
<tr>
<td>Written thesis or dissertation</td>
<td>None</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Final oral defense</td>
<td>None</td>
<td>Yes</td>
<td>Yes</td>
</tr>
</tbody>
</table>
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.
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FACULTY RESEARCH INTEREST

Melissa Moss
Program Director Biomedical Engineering
Associate Professor, Chemical Engineering
Professor Moss’s research focuses on the problem of Alzheimer’s disease. One hallmark of Alzheimer’s disease is the senile plaques that accumulate in the brain where they are associated with neuronal loss and in the cerebrovasculature where they may perpetuate stoke. These plaques are composed primarily of the amyloid B-protein (AB). AB aggregates into fibrils that deposit to yield plaques. The Moss lab studies the biochemistry of this aggregation process, its effects on cellular function, and strategies by which AB aggregates can be prevented to attenuate disease-associated effects.

Mark Uline
Undergraduate Director, Biomedical Engineering
Assistant Professor, Chemical Engineering
The Uline 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. Currently, we are focused on molecular modeling of biological interfaces, in particular, phase transitions and binding in lipid bilayers and surfactant driven nematic-ordering transitions in liquid-crystal thin films.

Tarek Shazly
Graduate Director, Biomedical Engineering Program
Assistant Professor, Mechanical Engineering
Dr. Shazly’s research entails physiological mechanical testing of soft matter, mechanical modeling, multiphysics-based computational modeling, tissue-material adhesion, and scaffold design. Dr. Shazly’s multi-disciplinary research team is focused on understanding how the local biological environment modulates the performance of a broad range of biomedical technologies, including synthetic vascular constructs, tissue-specific surgical sealants, and erodible endovascular implants.

Abdel E. Bayoumi
Professor and Associate Dean, Mechanical Engineering
Director, Condition-Based Maintenance Center
Dr. Bayoumi's research and interests are in the areas of Design and Manufacturing, Information Technology (Modeling, Simulation, and Health Monitoring Systems), Information Technology in Biomedical Research), MEMS/NEMS/Mechatronics (MEMS/NEMS Manufacturing and Qualifications, Mechatronics, Precision Engineering and Metrology), and Materials and Mechanics (Mechanical Diagnosis/Prognosis of Military Equipment, Image Processing in Materials Characterizations, Mechanistic Modeling of MFG Processes).

Gregory Brower
Associate Professor, Cell Biology & Anatomy
Dr. Brower's major research emphasis is focused on understanding the pathogenesis of heart failure. Specifically, the mechanisms and regulatory events influencing cardiac remodeling induced by chronic ventricular volume or pressure overload. Ventricular enlargement, consisting of both hypertrophy and dilatation, together with a thin walled, spherical ventricular shape are known risk factors associated with congestive heart failure. Preventing this adverse myocardial remodeling is a major goal of this laboratory.
Wayne Carver  
Professor and Chair, Cell Biology & Anatomy  
The ventricular wall of the heart is composed of contractile muscle cells and non-muscle cell types including fibroblasts, endothelial cells and others. These cells are inter-connected and supported by an elaborate extracellular matrix. Changes in the density and organization of the extracellular matrix are known to affect cardiovascular performance and have been correlated with heart disease.

Daping Fan  
Assistant Professor, Cell Biology and Anatomy  
Dr. Fan’s research is primarily focused on the role of lipoprotein metabolism and macrophage inflammation in atherogenesis (plaque build-up in arterial wall). Our goal is to promote atherosclerotic plaque regression through modulating plasma lipids and inhibiting macrophage inflammatory responses. Currently, we are expanding our research interests to investigating the impact of dyslipidemia on cancer development and metastasis.

Edie Goldsmith  
Associate Professor, Cell Biology & Anantomy  
Interactions between cells and the surrounding extracellular matrix (ECM) are important in a variety of cellular processes including adhesion, migration, proliferation, differentiation and apoptosis. Elucidating the factors that regulate and mediate these interactions represents a fundamental step in understanding how the dynamic reciprocity between cells and the ECM is mediated.

Michael Gower  
Assistant Professor, Chemical Engineering  
Professor Gower’s research team focuses on understanding the immune response to implanted materials. Special interest is paid to which immune cells infiltrate the implant site, how their gene expression changes while they are there, and where the immune cells go when they leave. The long-term goal is to engineer synthetic microenvironments that control immune cell function so they can be used as cellular therapies for inflammatory disease.

Esmaiel Jabbari  
Associate Professor, Chemical Engineering  
Jabbari’s group research interests are in the areas of tissue engineering, biomaterials, and drug delivery. Tissue regeneration and maintenance is a complex process involving the interactions of cells with growth and differentiation factors, cytokines, and extracellular components. These guiding signals originate from the interactions of cells with bioactive peptide domains attached to the collagenous network or the non-collagenous soluble factors of the extracellular matrix.

Ehsan Jabbarzadeh  
Assistant Professor, Chemical Engineering  
Jabbarzadeh’s laboratory focuses on the design and engineering of tissues through understanding and modeling of the environmental effects on stem cell differentiation and tissue remodeling and development. Investigations in the lab revolve around how cells sense distinctive types of mechanical, biochemical and morphological cues and integrate them to generate an appropriate response.
Joe Janicki  
Professor, Cell Biology & Anatomy  
Dr. Janicki's research is focused on two aspects of cardiac remodeling secondary to abnormal pressure or volume loading conditions. The first deals with the role of the tissue renin-angiotensin system, including tissue angiotensin converting enzyme activity, in the cardiomyocyte hypertrophic response. The second involves the regulation of myocardial collagenase activity and the role that activated collagenase plays in progressive left ventricular dilatation. These two research objectives are related in that hypertrophy is a major risk factor for heart failure.

Susan Lessner  
Associate Professor, Cell Biology & Anatomy  
Dr. Lessner's research interests center on vascular remodeling and angiogenesis (new blood vessel growth) in the contexts of atherosclerosis and tissue engineering. Vascular remodeling can be defined as any lasting change in the diameter, thickness, or structure of a mature blood vessel. In atherosclerosis, vascular remodeling acts as a compensatory mechanism to preserve blood flow in the face of plaque growth, which tends to cause stenosis or narrowing of the artery.

Michael Matthews  
Professor and Associate Dean of Chemical Engineering  
Adjunct Professor of Orthopedic Surgery  
Dr. Matthews' group studies the sterilization tissue engineering scaffolds, and has begun a new initiative in protein processing, using supercritical fluids. Research is based on a novel supercritical carbon dioxide (scCO₂) method developed with support from the National Institutes of Health. Applications include orthopedic implants, tissue scaffolds and surgical instruments. A variety of materials are under investigation, including naturally occurring biopolymers (e.g. chitosan, collagens) and synthetic polymers. Students in this group study biomaterials, and microbiology of infectious organisms, as well as classical engineering thermodynamics and mass transfer.

Shekhar Patel  
Research Associate Professor, Cell Biology and Anatomy  
Dr. Patel's lab studies the molecular regulation of chronic inflammation in cardiovascular tissue. Transport of Nuclear Factor Kappa B across the nuclear membrane is a highly regulated event which results in cell specific transcription in response to inflammatory signaling. Our lab is focused on the role of homeobox genes in the maintenance of cardiovascular function and the events leading to the initiation of chronic inflammation.

Jay D. Potts  
Associate Professor, Cell Biology and Anatomy  
The laboratory of Dr. Potts is focused on the biochemical and biophysical mechanisms that regulate tissue formation as it relates to regenerative medicine. Using a number of tissue engineering approaches, we are creating new models of cartilage, bone and heart valves. By using fundamental principles of development, we hope to be able to create more natural replacement tissues.

John Rose  
Associate Professor, Computer Science & Engineering  
My research interests are in the areas of bioinformatics, normative reasoning and planning, DAI and multiagent systems, and computational chemistry. I have conducted research funded by NSF, NIH, NASA, DOD/ONR, Alexander von Humboldt Foundation, BMFT (German NSF equivalent), as well as the South Carolina Commission on Higher Education. I have been a
NASA Institute for Advanced Concepts (NIAC) Fellow. I am currently the Director of the SC INBRE Bioinformatics Core.

**Michael Sutton**  
**Carolina Distinguished Professor, 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 valve problems, plastic fracture mechanics, finite elements modeling of cracked bodies.

**Jijun Tang**  
**Professor, Computer Science & Engineering**  
Computational biology and bioinformatics, algorithm design, analysis, implementation and performance study.

**Homayoun Valafar**  
**Professor, Department of Computer Science and Engineering**  
Dr. Valafar's principal research interests are the implementation of mathematical, statistical and engineering techniques in the areas of bioinformatics, computational medicine and computational biology. More specific areas of his active research are the problem of protein folding, protein/ligand and protein/protein interaction.

**Guiren Wang**  
**Associate Professor, Mechanical Engineering**  
Dr. Wang's research and interests include micro/nanofluidics sensor, lab-on-a-chip, biomechanics drup delivery, fluid mechanics, turbulence and mixing, optical measurement, flourescence, bioreactor and tissue engineering.