Biomedical Engineering (Ph.D., M.S.B.M.E., M.S.B.M.E. with Certificate in Life Sciences Entrepreneurship)

Degrees Offered: Ph.D., M.S.B.M.E., M.S.B.M.E. with Certificate in Life Sciences Entrepreneurship

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Faculty

Joel L Berry, Research Associate Professor (Biomedical Engineering); Medical Device Design, Cardiovascular Biomechanics, Cardiovascular and Orthopedic Tissue Engineering, Medical Device Entrepreneurship

Allan C. Dobbins, Associate Professor (Electrical Engineering); Human and Machine Vision, Neural Computation, Brain Imaging, Scientific Visualization

Alan Eberhardt, Professor (Theoretical and Applied Mechanics); Solid Mechanics, Injury Biomechanics, Biomedical Implants, Analytical and Numerical Methods in Biomechanics

Vladimir G. Fast, Associate Professor (Physics); Cardiac Electrophysiology, Optical Mapping of Arrhythmias and Defibrillation

Dale S. Feldman, Associate Professor (Bioengineering); Biomaterials, Soft-Tissue Biomechanics, Polymeric Implants

Ho-Wook Jun, Associate Professor (Bioengineering); Biomimetic Nanotechnology, Biomaterials, Tissue Engineering

Andrew E. Pollard, Professor (Biomedical Engineering); Cardiac Electrophysiology, Computer Simulations and Modeling of Electrical Signals of the Heart

Jack M. Rogers, Professor (Bioengineering); Cardiac Electrophysiology, Computer Simulations, Signal Analysis of Cardiac Arrhythmias
Yuhua Song, Associate Professor (Materials Science and Engineering); Computational Biomechanics, Computational Biology, Multiscale Modeling

Rina Tannenbaum, Professor (Chemical Engineering); Soft Condensed Matter, Nanoscale Self-Assembly, Chemistry at Interfaces

Timothy M. Wick, Professor and Chair (Chemical Engineering); Orthopedic and Cardiovascular Tissue Engineering, Regenerative Medicine, Bioreactor and Bioprocess Design, Cryopreservation, Cell Adhesion

Xincheng Yao, Associate Professor (Optics); Optical Imaging of Neural Function, Optical Coherence Tomography

Adjunct Faculty

Andreas Anayiotos, Associate Professor (Engineering); Professor, Department of Mechanical Engineering and Materials Science and Engineering, Cyprus University of Technology; Cardiovascular Fluid Mechanics, Cardiovascular Modeling, Computational Hemodynamics

Martha W. Bidez, Professor (Biomedical Engineering); President and CEO, BioEchos; Injury Biomechanics, Automotive Safety

Ginger Campbell, Professor (Emergency Medicine); Mind-body medicine, the brain and consciousness

Glenn S. Fleisig, Assistant Professor (Biomedical Engineering); Research Director, American Sports Medicine Institute; Sports and Injury Biomechanics

Richard A. Gray, Associate Professor (Biomedical Engineering); Office of Science and Engineering Laboratories, Center for Devices and Radiological Health, U.S. Food and Drug Administration; Optical Mapping of Fibrillation and Defibrillation

Rodolphe Katra, Assistant Professor (Biomedical Engineering); Principal Scientist, Research and Technology, Corventis Medical; Remote Disease Monitoring and Prediction, Cardiac Electrophysiology

Donald B. Twieg, Professor (Biomedical Engineering); Medical Imaging, Magnetic Resonance Imaging (MRI) Techniques, Functional MRI of Brain and Heart
Emeritus Faculty

**Ernest Stokely**, Professor Emeritus (Biomedical Engineering); Associate Dean Emeritus; Magnetic Resonance Imaging, Signal Processing, Image Processing

**William Smith**, Professor Emeritus (Physics); Biomedical Instrumentation, Cardiac arrhythmias, Fibrillation and Defibrillation.

Secondary Faculty

**Jonas S. Almeida**, Professor and Director, Division of Informatics (Department of Pathology); Computational Infrastructure for Integrative Bioinformatics

**Franklin Amthor**, Professor (Psychology); Neurophysiology of vision computer graphics

**Susan L. Bellis**, Professor (Cell, Developmental & Integrative Biology); Integrin Biology/implant surfaces

**James Broome**, Professor (Prosthodontics); Polymers, adhesives, physical and mechanical testing, clinical research

**Brigitta Brott**, Associate Professor, Division of Cardiovascular Disease (Department of Medicine); Angiogenesis, cardiac angioplasty, coronary artery disease, cardiac catheterization, interventional cardiology and stents

**John O. Burgess**, Professor (Prosthodontics); Clinical trials, caries models, dental materials

**Derrick Dean**, Associate Professor (Materials Science and Engineering); Polymers

**Lawrence J. DeLucas**, Professor (Optometry); Protein crystal growth

**Georg Deutsch**, Associate Professor (Radiology); Cognitive neuroscience and brain imaging

**Crawford Downs**, Professor (Ophthalmology)

**Hassan Fathallah-Shaykh**, Associate Professor (Neurology); Systems biology of cancer, the dynamics of molecular networks, biological rhythms, and modeling/analysis of microarray data

**John Fiveash**, Associate Professor (Radiation Oncology); Clinical trials of novel therapeutics in combination with radiation therapy, particularly in the treatment of brain and prostrate tumors; treatment planning research and education IMRT and IGRT
Paul D. R. Gamlin, Professor (Vision Sciences); Eye movements, Pupillary Light Reflex

Timothy J. Gawne, Associate Professor (Vision Sciences); Central Visual Processing

Ken Hoyt, Assistant Professor (Radiology); Contrast-enhanced ultrasound imaging with a focus on the associated bioeffects, contrast agent targeting, and the potential for localized drug delivery

Raymond E. Ideker, Professor, Division of Cardiovascular Disease (Department of Medicine); Study of Cardiac Arrhythmia, Cardioversion and Electrical Ablation for Treatment of Arrhythmia

Tom Jannett, Professor (Electrical and Computer Engineering); Control systems, Biomedical Instrumentation, Modeling and Simulation, Intelligent Sensor Networks

Amjad Javed, Associate Professor (Oral and Maxillofacial Surgery); Bone, cartilage development and remodeling, Adipogenesis, gene knock-out models, transcriptional regulation of skeletal cell differentiation

Kent T. Keyser, Professor (Vision Sciences); Neurotransmitters and receptors

Hyunki Kim, Assistant Professor (Radiology); Breast, pancreatic, and brain cancer imaging

Dennis F. Kucik, Associate Professor (Pathology); Cell adhesion and motility

Adrienne C. Lahti, Professor (Psychiatry); Use of multimodal brain imaging techniques (PET, fMRI, MR Spectroscopy) to study the neuropathology of schizophrenia and bipolar disorder and to evaluate the effects of psychototropic drugs on brain function and biochemistry; Translational work aiming at bridging human brain imaging and postmortem studies

Chris M. Lawson, Professor (Physics); Nonlinear Optics, Fiber Optics, Optical Sensors

Jack Lemons, Professor (Biomaterials); Biocompatibility profiles of surgical implant devices with an emphasis on the role(s) of element and/or force transfers along biomaterial-to-tissue interfaces

Lei Liu, Associate Professor (Optometry); Low vision visual function and rehabilitation

Mary MacDougall, Professor (Oral and Maxillofacial Surgery); Genetic dental diseases, tooth development, mineralized matrix, gene regulation

Michael McCraken, Associate Professor (Prosthodontics); Dental implants, Biomimetic materials, growth factors

Erwin Montgomery, Professor (Neurology); Deep brain stimulation
Joanne E. Murphy-Ullrich, Professor (Pathology); Regulation of cell death and motility by cell adhesion signaling and role of growth factor control in diabetic and fibrotic diseases

L. Burt Nabors, Professor (Neurology); Brain tumor treatment and research program

Alfred Paige, Assistant Professor (Neurology); Treatment of epilepsy, seizure localization and epilepsy surgery

Vladimir Parpura, Associate Professor (Neurobiology); Ion channels and synaptic function systems Neuroscience and vision

Steven Pogwizd, Professor, Division of Cardiovascular Disease (Department of Medicine), Medicine, Physiology and Biophysics

Brent Ponce, Assistant Professor (Surgery)

Charles W. Prince, Professor (Nutrition Sciences); Dental nutrition, Bone Biochemistry, Vitamin D, Calcium and Phosphorus Metabolism

Firoz Rahemtulla, Professor (Oral Biology); Connective Tissue Biochemistry

Michelle Robbin, Professor (Radiology); Hemodialysis patient ultrasound, ultrasound contrast agents and vascular ultrasound

Rosalia Scripa, Professor (Materials Science and Engineering); Ceramics and glass, Extractive Metallurgy, Semiconductor Crystal Growth, Electronic-Magnetic Materials

Jere Segrest, Professor, Division of Gerontology/Geriatrics/Palliative Care (Department of Medicine); Plasma Lipoprotein Structure and Function

Rosa Serra, Professor (Cell, Developmental & Integrative Biology); Mechanism of TGF-ß action in developmental and disease processes

Murat Tanik, Professor (Electrical and Computer Engineering); Software Systems Engineering, Integrated Systems Design, Process Engineering

Allen Tannenbaum, Professor (Electrical and Computer Engineering); Systems and control; image processing, medical imaging, computer vision, signal processing
Gregg Vaughn, Professor (Electrical and Computer Engineering); Digital signal processing, applications of microprocessors, digital communications

Kristina M. Visscher, Assistant Professor (Neurobiology); Human behavior and brain activity using precise behavioral measurements (including psychophysics and tracking of eye movements), functional magnetic resonance imaging (fMRI) and electroencephalography (EEG)

Yogesh Vohra, Professor (Physics); Biotechnology, Nanostructured Materials

Harrison Walker, Assistant Professor (Neurology); Deep brain stimulation for the management of Parkinson's disease and other movement disorders

Yuhua Zhang, Assistant Professor (Ophthalmology); Advanced retinal imaging technology

LuFang Zhou, Assistant Professor, Division of Cardiovascular Disease (Department of Medicine); Pathophysiology and therapeutics of oxidative stress related to diseases of mitochondrial origin as it pertains to cardiovascular disease and diabetes

Yong Zhou, Assistant Professor, Division of Pulmonary/Allergy/Critical Care (Department of Medicine); Myofibroblast differentiation and emphysema

Program Information

M.S.B.M.E. Program

The Master of Science in Biomedical Engineering prepares students for entry into the doctoral program, biomedical industry, or professional school. Primary research areas are biomedical imaging, biomedical implants and devices, cardiac electrophysiology, multiscale computational modeling, tissue engineering and regenerative medicine. Other research opportunities are available through our ongoing collaborations with the UAB Medical and Dental Schools. With the terminal degree, employment is usually found in health-care delivery, medical devices, pharmaceuticals, biomedical imaging, instrumentation, medical sales and marketing, regulatory agencies, or computer application groups. For admission to the program, a student should have earned a bachelor's degree in biomedical engineering, engineering or a closely related field.

Students with undergraduate degrees in the physical sciences, life sciences, or mathematics will also be considered for admission; however, such students may be required to demonstrate competence in engineering areas usually found in an undergraduate engineering curriculum. In some cases, preparatory courses in mathematics, engineering or life sciences may be required, with specific recommendations
made by the Biomedical Engineering (BME) Graduate Program Committee. Admission to the BME Master's program is competitive, and successful applicants will usually present scores of at least 156 on the verbal and at least 159 on the quantitative sections of the GRE General Test (equivalent to 550 and 750 under the previous scoring system). Typical students have an undergraduate GPA of 3.5 or greater and have participated in at least one research project while an undergraduate (e.g., honors research, summer research experience, laboratory research, senior design, internship).

The student's research advisor and the Graduate Program Committee work to devise an individualized curriculum developed to ensure each student obtains the coursework to provide an in-depth knowledge of both quantitative methods and human physiology necessary to succeed in completion of the thesis research. The master's degree requires a minimum of 30 semester hours of graduate work beyond the bachelor's including 24 semester hours of course work and 6 hours of Thesis Research (BME 699). All students are required to take BME 517 Engineering Analysis, BME 670 Quantitative Physiology, three one-hour departmental seminar courses (BME 601), at least one three-hour Biostatistics course. Additional course work is a combination of graduate level life sciences and bioengineering courses selected in consultation with your thesis advisor and approved by the BME Graduate Program Committee.

The majority of students carry out research leading to a thesis (plan I option). To receive a master's degree in BME, the student must publish their research in a peer-review journal article; typically a first-author publication. The student is expected to present their research at a scientific or technical conference; preferably at a relevant national or international scientific meeting. Publication of at least one peer-reviewed manuscript is a requirement for graduation from the M.S.B.M.E. Program. Plan I students must register for at least six semester hours of BME 699 (thesis research) and successfully write, present and defend a thesis based on their research.

Additionally, BME now offers a Master's in Biomedical Engineering with a Certificate in Life Sciences Entrepreneurship. This represents a unique graduate training program featuring collaboration between BME and the UAB School of Business. Biomedical engineering principles are blended with business-model planning in an effort to equip students to not only become scientists and researchers, but also capable business professionals. BME students partner with Business students pursuing an M.B.A. to turn biomedical devices into commercial successes that are marketed worldwide. They will participate in the Invention to Innovation (i2i) activities, in which they will pitch their start-up companies and enter business plan competition with the Alabama Launchpad (http://www.alabamalaunchpad.com/). In addition to the BME course and thesis requirements, students in the M.S.B.M.E. with a Certificate in Life Sciences Entrepreneurship will take 12 credit hours of M.B.A. coursework, including MBA 681: Idea to IPO; MBA
Ph.D. Program

The Ph.D. degree prepares students for careers in industry and academics. Students entering the doctoral program will possess a B.S. or M.S., or be currently enrolled in the D.M.D/Ph.D. or M.D./Ph.D. program at UAB.

Admission to the Ph.D. program is competitive, and successful applicants will usually present scores of at least 156 on the verbal and at least 159 on the quantitative sections of the GRE General Test (equivalent to 550 and 750 under the previous scoring system). Typical students have a graduate GPA of 3.5 or greater and have a significant research experience. Students admitted to the Doctoral program typically receive a competitive stipend that usually includes payment of tuition.

Students can be admitted to the Ph.D. Program with a B.S. degree in a field of biomedical engineering or closely-related discipline. Students with undergraduate degrees in the physical sciences, life sciences, or mathematics can also be considered for admission. Students entering the Ph.D. program with a B.S. are required to complete at least 72 semester hours of graduate work, including 48 semester hours of graduate course work, and a minimum of 24 hours of Dissertation Research (BME 799) earned over at least two semesters in candidacy. All students are required to take BME 770 Quantitative Physiology, BME 517 Engineering Analysis and BST 621 Statistical Methods I, and 6 semesters of BME seminars (BME 701). The remaining course work should be a combination of life sciences, biomedical engineering, or mathematics elective courses that provide sufficient breadth and depth to gain the necessary graduate-level, interdisciplinary knowledge to complete thesis research. Up to three credit hours of bioengineering elective course work can be taken as directed independent study if approved by the Graduate Program Committee. At least three peer-reviewed first-author publications are required for completion of the Ph.D. in the Department of Biomedical Engineering.

Students can be admitted to the Ph.D. Program following completion of a Master’s Degree in BME or closely-related discipline. If the Master’s Degree in BME was obtained at UAB (plan I option), the admission requires an endorsement from their Master’s Thesis Committee. As a student completes a Master’s thesis and prepares for a defense, he/she should indicate the desire to go on for the Ph.D. to the Research Advisor and the BME Graduate Program Director. All students in the M.S. program who wish to pursue the Ph.D. degree need only write a letter to the Chair to be considered by the Admissions Committee. A student is not required to re-apply to the Graduate School. The BME Graduate Program Committee evaluates all BME students who are required to complete the M.S. degree before entering the
Ph.D. program before they proceed into the Ph.D. program. Admission into the Ph.D. Program with a M.S. requires publication of at least one peer-reviewed journal article (typically a first author publication). Students entering the Ph.D. program with a M.S. are required to complete at least 48 semester hours of graduate work beyond the Master's degree including 24 semester hours of course work and 24 hours of Dissertation Research (BME 799) earned over at least two semesters in candidacy. All students are required to take BME 670/770 Quantitative Physiology, BME 517 Engineering Analysis, and BST 621 Statistical Methods I, if not taken as part of their master’s program, and 3 semesters of BME Seminar (BME 701). The remaining course work should be a combination of life sciences, biomedical engineering or mathematics elective courses that provide sufficient breadth and depth to gain the necessary graduate-level, interdisciplinary knowledge to complete your thesis research. At least two peer-reviewed first-author publications beyond the M.S.B.M.E. degree are required for completion of the Ph.D. in the Department of Biomedical Engineering.

NIBIB Supported T-32 Predoctoral Training Grant

National Institute of Biomedical Imaging and Bioengineering (NIBIB) has awarded an interdisciplinary predoctoral training grant to UAB that is entitled “Nanotechnology in Biosensors and Bioengineering”. It is a five-year program that started on September 1, 2007. Benefits to participating graduate students include: graduate stipends of $25,000 per year, full tuition and health insurance, and a travel award of $1,000 per year. The purpose of this grant is to implement a training program at the interfaces of physics, chemistry, materials science and engineering, and biomedical engineering that will reduce the time from discovery of a new tool in nanotechnology to its application in medical devices, tissue engineering, and biosensors for earliest detection of molecular signatures of disease.

For more information regarding this training program, visit http://www.uab.edu/cnmb/graduate-training

Additional Information

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<tr>
<th>Deadline for Entry Term(s):</th>
<th>Fall</th>
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<tr>
<td>Deadline for All Application Materials to be in the Graduate School Office:</td>
<td>February 1</td>
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<tr>
<td>Number of Evaluation Forms Required:</td>
<td>Three</td>
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Entrance Tests | GRE (TOEFL is also required for international applicants whose native language is not English)
---|---
Comments | Students are rarely admitted for the Spring term

For detailed information, contact Dr. Vladimir Fast, Associate Professor, BME Graduate Program Director, UAB Department of Biomedical Engineering, 1670 University Blvd., Volker Hall B126, Birmingham AL 35294-0019.
Telephone (205) 975-2119
E-mail uabbmegrad@uab.edu
Web www.uab.edu/bme

**Course Descriptions**

Unless otherwise noted, all courses are for three semester hours of credit. Course numbers preceded with an asterisk indicate courses that can be repeated for credit, with stated stipulations.

**Biomedical Engineering (BME)**

598 **Biomedical Product Development.** Design and development issues of the medical products industry. Consideration of the impact of legal, regulatory and marketing issues, business ethics and economics will be addressed. 3 credit hours.

508 **Biofluids.** Application of fluid mechanics in blood flow in the circulatory system; cardiovascular fluid mechanics, wall shear stress and the development of atherosclerosis, viscoelastic behavior of the arteries, Non-Newtonian character of blood. 3 credit hours.

512 **Biomechanical Measurements.** Observation, measurement and analysis of basic biomechanical variables such as stress, strain, pressure and flow. Emphasis on basic experimental examples and using the computer for data acquisitions, processing, analysis and preparation of laboratory reports. 3 credit hours.
517 **Engineering Analysis.** Solutions to engineering problems involving ordinary and partial differential equations; Laplace transforms, power series, Bessel functions, Legendre polynomials, Fourier series, Fourier integral and transform, Sturm-Liouville and separation of variables. 3 credit hours.

520 **Implant-Tissue Interactions.** An overview of implant biocompatibility including tissue histopathology, histology of implant response and the regulatory process for medical devices. 3 credit hours.

523 **Living Systems Analysis.** Basic concepts and techniques of measurement processing and analysis of data from living systems, statistics, analysis of variance, regression analysis. Labs include blood flow data acquisition and analysis, implant biocorrosion testing, evaluation and analysis of cell proliferation and apoptosis. 3 credit hours.

535. **Tissue Engineering.** Principles underlying strategies for regenerative medicine such as stem-cell based therapy, scaffold design, proteins or genes delivery, roles of extracellular matrix, cell-materials interactions, angiogenesis, tissue transplantation, mechanical stimulus and nanotechnology. Prereq: BME 210. 3 hours

542 **Principles of Medical Imaging.** Medical imaging modalities such as x-ray, CT, Nuclear imaging. Principles and physics of interaction of ionizing radiation with matter, bremsstrahlung, attenuation coefficients, compton scatter, nuclear disintegration of radionuclides and generation of medical radionuclides. 3 credit hours.

543 **Medical Image Processing.** A lab-based introduction to processing, analysis and display techniques for medical imaging. 3 credit hours.

546 **Principles of MRI.** Technical fundamentals of NMR imaging and applications. Governing physics, MR imaging techniques and clinical role of MR imaging. 3 credit hours.

550 **Computational Neuroscience.** Computational principles used by the nervous system. Topics include biophysics of axon and synapse, sensory coding with emphasis on vision and audition, planning and decision-making and synthesis of motor responses. Emphasis on a systems approach throughout. Simulations. 3 credit hours.

561 **Bioelectric Phenomena.** Quantitative methods in the electrophysiology of neural, cardiac and skeletal muscle systems. 3 credit hours.

562 **Cardiac Electrophysiology.** Semi-quantitative methods in cardiac electrophysiology. Analysis of the electrocardiogram, cellular dynamics, propagation in the heart including spiral waves, and the effect of electric fields on the heart. 3 credit hours.
571 **Continuum Mechanics of Solids.** Matrix and tensor mathematics, fundamentals of stress, momentum principles, Cauchy and Piola-Kirchoff stress tensors, static equilibrium, invariance, measures of strain, Lagrangian and Eulerian formulations, Green and Almansi strain, deformation gradient tensor, infinitesimal strain, constitutive equations, finite strain elasticity, strain energy methods, 2-D Elasticity, Airy Method, viscoelasticity, mechanical behavior of polymers. 3 credit hours.

580 **Biomolecular Modeling:** Principles and applications for biomolecular modeling: protein structure, molecular dynamics, force field, docking, electrostatics, biomolecular diffusion. Throughout the course, the students are offered hands-on exercises in molecular modeling tools and software. Co-req: BME 517 or the permission of Instructor. 3 credit hours.

601, 701. **Seminars in Biomedical Engineering.** Current topics in biomedical engineering technology and applications. Pass/Fail. 1 hour each.

616, 716. **Instrumental Methods of Analyses.** Techniques used to evaluate biomaterials: FTIR, AES/XPS, AFM/STM, electrochemical corrosion evaluations, and mechanical testing. 3 credit hours.

619 **Advanced Biofluids.** Bioelectric signals, transduction devices and processes; analog and digital signal processing; system response characteristics. 3 credit hours.

623, 723. **Biocompatibility. Wound Healing.** Study of principles of healing and methods to enhance, and clinical applications. 3 credit hours.

633, 733. **Biomechanics: Tissue Mechanics I.** Fundamentals of hard and soft tissue mechanics. Biomechanical problems, with emphasis on bone, ligament, tendon and cartilage. 3 credit hours.

637, 737. **Biomechanics: Tissue Mechanics II.** Advanced topics in tissue mechanics, including structure-function analysis and modeling of trabecular bone, biphasic theory for articular cartilage. 3 credit hours.

646/746 **Biomedical Optics: Principle & Imaging.** Fundamentals of light-matter interactions and principles of biomedical optics imaging techniques, such as light spectroscopy, light microscopy, confocal microscopy, multi-photon microscopy, optical coherence tomography, photoacoustic tomography, etc. 3 credit hours.

647, 747. **Medical Imaging: Advanced MRI and fMRI.** Advanced MRI techniques, functional MRI methods including spectroscopy, perfusion and diffusion imaging. 3 credit hours.
664, 764. **Neural Computation.** The principal theoretical underpinnings of computation in neural networks, understanding the relationship between the different approaches: dynamical systems, statistical mechanics, logic, Kalman filters, and likelihood/Bayesian estimation. 3 credit hours.

665, 765. **Computational Vision.** Study of biological and artificial vision from a theoretical perspective. Begins with a comparative survey of visual systems and examines vision algorithms and architectures. 3 credit hours.

670, 770. **Quantitative Physiology.** Study of physiological problems using advanced mathematical techniques. Topics covered include: mechanics, fluid dynamics, transport, electrophysiology of cell membranes, and control systems. Prereq: BME 517 OR ME 567. 3 credit hours.

676, 776 **Fracture Mechanics.** Linear elastic mechanics, Griffin energy balance, Airy & Westergaard solutions, elastic-plastic fracture mechanics, materials testing and applications. 3 credit hours.

691, 791 **Special Topics in (Area).** Course syllabus and grading policy required. 1-6 hours.

693, 793 **Internship in BME.** Course syllabus and grading policy required. 1-6 hours.

697 **Journal Club in (Area).** 1 hour each.

698. **Non-thesis Research.** Pass/Fail, 1-12 hours.

699. **Thesis Research.** Prerequisite: Admission to candidacy. Pass/Fail. 1-12 hours.

706. **Introduction to Biomedical Instrumentation.** Instrumentation used in measurement of physiological parameters. Prerequisites: EE 351. 3 credit hours.

707 **Biomedical Instrumentation and Signal Processing I, II.** Bioelectric signals, transduction devices and processes, analog and digital signal processing, system response characteristics. Prerequisite: BME 630. 3 hours each.

798. **Non-dissertation Research.** Pass/Fail. 1-12 hours.

799. **Dissertation Research.** Prerequisite: Admission to candidacy. Pass/Fail. 1-12 hours.