Biomedical Engineering

Biomedical engineering is currently the fastest growing field of engineering in the U. S. and requires an education that draws from advanced engineering and computing as well as the biological and medical sciences. NJIT offers an extremely flexible Masters program that encourages students to contribute to an individualized plan of study that builds upon the strengths of their B.S. and develop expertise in an area of concentration leading to careers in research and/or product development, or to prepare for further study in medicine, dentistry, law, and management, or for a Ph.D. in biomedical engineering. Major areas in which NJIT offers courses and conducts research are bioinstrumentation, biomaterials and tissue engineering, biomechanics, neural engineering and rehabilitation engineering.

Over the past several years, the M.S. in Biomedical Engineering program at NJIT currently has graduated the largest number of M.S. degrees in BME in the nation. The department offers a comprehensive set of courses specifically in biomedical engineering (usually 14-16 per semester), which are augmented by related engineering and life science courses taught in other departments. NJIT's location, in the middle of the nation's largest concentration of biomedical industries, provides access to expert instructors who offer specialized courses, which add to the richness of the academic environment. These industries also support graduate internships and thesis work, and often provide employment after graduation. The NJIT campus is within walking distance of both the University of Medicine and Dentistry of New Jersey flagship campus and Rutgers University-Newark. Graduate education at the three institutions is enhanced by collaboration agreements that allow cross-registration for courses, use of libraries, and opportunities for independent research. This benefits biomedical engineering by opening the possibilities for M.S. students to take advanced biological and medical science courses in addition to engineering courses.

The NJIT Department of Biomedical Engineering has a very active research program that is accessible to Masters students and provides opportunities for thesis or other independent study, which integrates engineering and the medical sciences. Research is conducted cooperatively between NJIT and the medical and dental schools of RBHS, the Kessler Institute for Rehabilitation, St. Barnabas Medical Center, Veteran's Administration Medical Center in East Orange, the Children's Specialized Hospital, the Public Health Research Institute, the Rutgers Center for Biological and Molecular Neuroscience and other institutions in the New Jersey-New York metropolitan area. In addition, cooperative research opportunities exist with a number of biomedical device and pharmaceutical companies within a short commuting distance from NJIT.

The Doctor of Philosophy in Biomedical Engineering is jointly offered by NJIT and Rutgers Biomedical and Health Sciences (RBHS). It offers advanced graduate education providing students with the skills necessary for careers in basic and applied research, as well as the intellectual foundation to provide leadership in academia and industry. This program emphasizes an integration of engineering and the life sciences to address complex problems. Students are admitted to either institutions and receive the same degree with a joint diploma. Course requirements are the same regardless of admission. The RBHS description of this program can be found at http://njms.rutgers.edu/sgs/current_students/phd/bio_engineering/index.php (http://njms.rutgers.edu/sgs/current_students/phd/bio_engineering/)

The recent National Research Council Ph.D. rankings placed it 26th out of 74 U.S. BME Ph.D. programs.

Aim of the M.S. Program

This program provides the opportunity for individuals with degrees in biomedical engineering to focus on a specialized area to a much greater degree than could be done in their undergraduate studies. Similarly, it also allows those with engineering and science backgrounds in other fields to acquire knowledge and skill that will allow them to join this growing field. Unlike many other graduate programs, the NJIT BME M.S has no core requirements. Each student develops an individualized plan of study with his or her advisor that is based on prior study, past work experience and career goals. The intentional flexibility in the selection of courses reflects the expected maturity of the graduate students as they assume significant responsibility for planning their concentrations. This flexibility also encourages students to exhibit some curiosity about unfamiliar areas of biomedical engineering and allows them to take two courses that may be peripheral to their academic focus.

The opportunity to pursue a thesis has the benefit of allowing students to choose a topic in which they will demonstrate the ability to integrate what they have learned, execute a 2-semester technical project, and communicate their results. Students not electing to pursue a thesis may choose three additional courses (replacing the 6-credit thesis) that increase their depth in engineering and breadth in the life sciences.

Eligibility for the Program

Students who have a B. S. degree in science or engineering are eligible. In general, those with a B.S. in biomedical, mechanical, electrical, computer or chemical engineering will be well prepared to enter the program. Exceptional students with undergraduate degree in the life sciences with sufficient background in mathematics will also be considered for admission.

All applicants must have had courses in scientific computer programming, differential equations, statistics, and physiology. Students who are missing one or more of these can be conditionally admitted with a requirement to take undergraduate bridge courses, which are in addition to the 30-credit graduation requirement. Certain graduate courses or concentrations may require additional background, such as, statics and/or dynamics, thermodynamics, and electronics. Students who do not have these prerequisites may be asked to take additional courses or acquire the necessary material through tutoring and independent study. Prospective students may contact the M.S. Program Director for advice regarding their specific needs.

Students selected for admission should have earned a minimum undergraduate G.P.A. of 3.0, and have GRE Math and Verbal scores higher than 670 and 400, respectively. GRE scores are required for all international applicants, and are optional for graduates of U.S. universities and colleges.

Course Offerings

The courses offered through this program allow students to choose concentrations that genuinely reflect their needs and interests. The sample course concentrations listed below reflect a curriculum that is rich in cutting edge engineering and science, and deep in its content. This critical mass of courses at NJIT, RBHS and Rutgers allows students to acquire a level of expertise that is uncommon among most biomedical engineering programs. The students in this program are nearly evenly split between those continuing their education immediately following their B.S. and those who are returning to study after a number of years of employment. The same is true for the educational backgrounds of the students, with approximately half having studied biomedical engineering and the other half coming from different fields. Most candidates for the Masters degree enroll as full-time students. However, the degree can be completed on a part-time basis for those who wish to study while continuing to work. Most courses are offered in the late afternoon and in the evening.

The BME graduate courses listed in this catalog are each offered at least once per academic year. This listing is frequently updated to avoid the potential of including courses that are no longer offered. Potential applicants are encouraged to view the current academic year's course schedule and course enrollments at http://www.njit.edu/registrar/schedules/.

Course are taught by faculty who have considerable expertise. BME faculty and lecturers from nearby medical institutions offer graduate courses that are related to their ongoing research areas, while lecturers from industry bring experience from a corporate sector.

Approximately 30% of BME M.S. students complete a thesis, which is a mentored two-semester research/development experience. Many students (particularly those with experience in industry) may already have experienced the equivalent of an in-depth, year-long project, and can be better served by taking additional courses. Students considering a thesis are directed to the NJIT Library's website where most recent theses are available online. Those who have questions about the scope and content of biomedical engineering theses should review several that fall within their areas of interest. These can be found at http://archives.njit.edu/vhlib/etd/list-programs.php#Biomedical-Engineering.

The department's Graduate Seminar is a weekly opportunity for students to be exposed to current topics in biomedical engineering and develop an appreciation for the breadth of this exciting field. These lectures are given by visiting scholars and industry experts. The department website offers a current listing of seminar speakers and topics. Please visit http://biomedical.njit.edu/.

In addition to the department seminar, the Graduate Biomedical Engineering Society (GBMES) operates its own lecture series that focuses on BME in industry. Monthly speakers discuss product development and applied research. Many speakers are NJIT BME alumni with whom current students can network.

Co-op Opportunities and Internships

Students have the opportunity to participate in the co-op and internship programs at neighboring medical institutions or at biomedical engineering firms to gain practical experience. NJIT is situated in an area that contains many major biomedical engineering and pharmaceutical companies. The biomedical engineering department has a part-time advisor for co-op and internship experiences.

Prospects for Employment

Considerable opportunity exists in the field of biomedical engineering. This takes the form of basic and applied research and product development. Employment may be found in medical institutes, government agencies, corporations and hospitals, all of which are involved in the design, manufacture and utilization of equipment and procedures intimately involved in health care improvement. Many students go on to obtain professional degrees in medicine, dentistry, law or administration for which an engineering background is becoming ever more important.

Admission Requirements

Prospective students seeking admission to the Program must have an undergraduate degree in engineering, science or mathematics and satisfy the admission and academic requirements of the Graduate School.

1. General Guidelines. Each program of study must satisfy the Graduate School academic requirements (see the latest graduate catalog at www.njit.edu (http://www.njit.edu)).
2. Prerequisite Courses. Minimum Undergraduate Requirements for the Program:
    - B.S. in Biomedical, Chemical, Electrical, Computer, or Mechanical Engineering.
    - Applicants with a B.S. in Computer Science are expected to have had Calculus through differential equations, one full year of Physics, one full year of Chemistry, and a course in Physiology.
    - Applicants with strong life science or medical education, including the equivalent of one full year of Physics as well as Calculus through differential equations, will be considered on a case-by-case basis.
    - Conditional admission may be granted to applicants lacking full preparation with a requirement to take undergraduate bridge courses that will not carry graduate credit.

Admitted students who have not previously taken an upper level physiology course will be required to take BME 669 Engineering Physiology or an equivalent course as one of their graduate courses.

Applicants with a background in life science or other related degrees, such as biology, biochemistry, physical therapists, etc. may be conditionally admitted to the program. Admitted students will be required to register for bridge courses in their first semester prior to taking graduate level BME courses as a condition of admission. In general, the following courses will be required, pending review of transcripts by the graduate advisor:

Calculus 1,2, and 3
Differential Equations
Introduction to Computer Programming
BME 301 Electrical Fundamentals of Biomedical Engineering or equivalent
BME 302 Mechanical Fundamentals of Biomedical Engineering or equivalent

Students must complete BME 301 and BME 302 with a minimum grade of B. Failure to receive a B grade in bridge courses may preclude students from enrolling in regular graduate BME courses. Equivalent courses may be accepted with prior approval from graduate advisor.

Aims of the Ph.D. Program

This joint program builds upon the synergistic relationship between NJIT and RBHS. The physical proximity of the two institutions facilities access to courses, laboratories, libraries, and seminars, as well as blending scientific and clinical opportunities in education and research. In addition, the location of NJIT and RBHS in Newark promotes interaction with New Jersey's pharmaceutical and medical device industries and medical facilities. As the preparation for the Ph.D. involves an extensive research apprenticeship in the form of dissertation, the program is closely linked to the areas of biomedical engineering research at NJIT and RBHS. This research is clustered in the following areas.

- Biomaterials and Biocompatibility
- Tissue Engineering and Regenerative Medicine
- Cellular and Orthopedic Biomechanics
- Biomedical Signal Processing, Imaging and Instrumentation
- Neural and Neuromuscular Engineering

The program requires a minimum of 78 credits beyond the B.S. or 60 credits beyond an M.S. degree in biomedical engineering or closely related field. For the post M.S. student, 24 credits must be in advanced graduate level courses with 12 credits in biomedical engineering and 12 credits in life sciences. The post B.S. student must take an additional 18 credits in approved courses.

The remaining 36 credits are comprised of mentored dissertation research, in which the student demonstrate aptitude for independent research of publishable nature. Individuals completing this degree are well-prepared for employment in academia, industry and government laboratories, or for post-doctoral study.

Eligibility for the Program

Prospective students seeking admission to the joint Ph.D. Program should have an undergraduate degree in engineering, basic science or mathematics, and satisfy the admission and academic requirements of the NJIT Graduate School and the RBHS Graduate School of Biomedical Sciences. In general, applicants are expected to have had Calculus through differential equations equations, one full year of physics, one full year of chemistry, and a course in physiology as part of their prior engineering studies. Non-engineering applicants with strong life science or medical education, with the same physics, chemistry, math and physiology background, but who do not have experience in essential engineering sciences, will be considered on a case-by-case basis. These applicants may be asked to pursue and M.S. in BME prior to admission to the Ph.D. program. Alternatively, conditional admission may be granted to applicants lacking full preparation, the a requirement to take undergraduate bridge courses that will not carry graduate credit. Admitted students who have not previously taken an upper level physiology course will be required to take BME 669 Engineering Physiology or an equivalent course as one of their graduate courses.

Applicants are expect to have a minimum G.P.A of 3.5 in their most recent degree (B.S. or M.S.) and minimum GRE Math and Verbal scores of 750 and 500. The GRE is required for all applicants, and TOEFL is required for all international students.

The program has a joint admission committee, which reviews all application, thus allowing students to apply to either institution. The host institution for a student may be changed depending upon the eventual research advisor and/or the institutional source of the research funding. The only significant institutional difference in the application process is that RBHS only admits students in the spring for the upcoming fall semester. NJIT can admit students who are beginning in either the fall or spring semesters. In general, however, spring admissions are rare.

As the Ph.D. program is significantly based on faculty research, admission depends upon available opportunities and funding in individual laboratories, in addition to prior academic performance. A very limited number of teaching assistantships and university fellowships are available for begging students, with subsequent years of research supported by faculty grants.

Laboratory and funding opportunities vary considerably from year to year. Serious potential applicants are encouraged to contact the Ph.D. program director at either NJIT or RBHS to discuss the current factors influencing admission.

NJIT Faculty

A

Adamovich, Sergei, Professor

Alvarez, Tara L., Distinguished Professor

Arinzeh, Treena L., Affiliate Faculty

B

Buffone, Alexander, Assistant Professor

Biswal, Bharat, Distinguished Professor

C

Chandra, Namas, Professor Emeritus

Chattaraj, Rajarshi, Assistant Professor

D

Di, Xin, Research Professor

F

Foulds, Richard A., Professor Emeritus

G

Grasman, Jonathan, Assistant Professor

K

Khayet, Ghazaleh, University Lecturer

Kallioniemi, Elisa, Assistant Professor

Kumar, Vivek, Associate Professor

L

Li, Ying, Research Professor

Lee, Eun Jung, Associate Professor

Li, Xiaobo, Associate Professor

M

Miri, Amir K., Assistant Professor

P

Pal, Saikat, Associate Professor

Pfister, Bryan J., Chair

R

Reisman, Stanley, Professor Emeritus

S

Son, Jongsang, Assistant Professor

Sahin, Mesut, Professor

Schesser, Joel, Senior University Lecturer

V

Van Buskirk, William C., Professor Emeritus

Z

Zhou, Xianlian (Alex), Associate Professor

- Biomedical Engineering - M.S. (http://catalog.njit.edu/graduate/newark-college-engineering/biomedical/ms/)
- Biomedical Engineering - Ph.D. (http://catalog.njit.edu/graduate/newark-college-engineering/biomedical/phd/)

Programs

- Biomedical Device Development (http://catalog.njit.edu/graduate/newark-college-engineering/biomedical/cert/)

Biomedical Engineering Courses

BME 590. Graduate Co-Op Work Exper I. 1 credit, 1 contact hour.

BME 591. Graduate Co-Op Work Exper II. 1 credit, 1 contact hour.

BME 592. Graduate Co-Op Work Exper III. 1 credit, 1 contact hour.

BME 593. Graduate Co-op Work Experience IV. 0 credits, 0 contact hours.
Restriction: One immediately prior 3-credit registration for graduate co-op work experience with the same employer and approval of departmental co-op advisor and the Division of Career Development Services. Must have accompanying registration in a minimum of 3 credits of course work.

BME 601. Seminar. 1 credit, 1 contact hour.
Required every semester of all master's students in biomedical engineering who receive departmental or research-based support and all doctoral students. To receive a satisfactory grade, students must attend at least five seminars per semester, as approved by the seminar supervisor.

BME 611. Engineering Aspect of Molecular and Cellular Bio I. 1 credit, 1 contact hour.
Molecular and cellular biology is a foundation of the understanding of the biological sciences and is vital to the study of advanced biomedical engineering. This course is to be taken simultaneously with UMDNJ N551 to enrich the crossover between engieering and life sciences. Course topics parallel those covered in N551 and both add engineering relevance, and provide engineering students with a stronger understanding of molecular and cellular biology. For students in joint BME PhD program.

BME 612. Engineering Aspects of Molecular and Cellular Bio II. 1 credit, 1 contact hour.
Molecular and cellular biology is a foundation of the understanding of the biological sciences and is vital to the study of advanced biomedical engineering. This course is to be taken simultaneously with UMDNJ N552 to enrich the crossover between engineering and life sciences. Course topics parallel those covered in N552 and both add engineering relevance, and provide engineering students with a stronger understanding of molecular and cellular biology. For students in joint BME PhD program.

BME 650. Clinical Physiology & Neurophy. 3 credits, 3 contact hours.
Prerequisites: BME 111, BME 303, BME 382 or permission of the instructor. Topics to be covered include gastrointestinal tract, pulmonary respiratory system, renal and liver functions, blood and hemodynamic, cardiovascular and cerebrovascular function, and understanding of neurophysiology in human neurological diseases.

BME 651. Principles of Tissue Engineering. 3 credits, 3 contact hours.
Tissue Engineering is a therapeutic approach to treating damaged or diseased tissues in the biotechnology industry. In essence, new and functional living tissue can be fabricated using living cells combined with a scaffolding material to guide tissue development. Such scaffolds can be synthetic, natural, or a combination of both. This course will cover the advances in the fields of cell biology, molecular biology, and materials science towards developing novel "tissue engineered" materials.

BME 652. Cellular and Molecular Tissue Engineering. 3 credits, 3 contact hours.
This course explores molecular, cellular and tissue level interactions that are an important component of all tissue engineering strategies. Topics include how a cell moves, reacts and maintains viability and function based on its surroundings. We will discuss how to engineer our materials, tissue grafts and implants to integrate with the body. We will also liearn about bodily reactions and the biocompatibility of tissue engineered devices such as immunoreactivity and blood coagulation.

BME 653. Micro/Nanotechnologies for Interfacing Live Cells. 3 credits, 3 contact hours.
In this course, we will study technologies and tools available for interfacing live cells from a sub-cellular, single-cell, and multi-cellular (tissue models) approach. We will introduce key concepts of the biology of cells and tissues and will explore the technologies (micro-/nanotechnologies) and tools (sensors and actuators) available for the investigation of cell and tissue biology. Same as ECE 653.

BME 654. Cardiovascular Mechanic. 3 credits, 3 contact hours.
Fundamental biomechanical mechanisms at work in the cardiovascular system. Topics include the fundamental molecular structure of heart muscle, the biomechanical principles that transform the contraction of heart muscle into stress-strain functions of muscle fibers, pressure-volume flow relations in the vasculature when it is considered as a hemodynamic (blood hydraulic) system, growth and disease of the cardiovascular system, resistance, compliance, inertance, and catheter-tip transducers.

BME 655. Advanced Characterization of Biomaterials. 3 credits, 3 contact hours.
Prerequisites: MTSE 301 or undergraduate equivalent, BIOL 201 or undergraduate equivalent, one semester of undergraduate organic chemistry. With a focus on contemporary biomaterials in the published literature and clinical practice, biomaterial chemical and mechanical testing will complement synthesis theory. Communication and articulation of ideas will be honed in the form of literature debates, write-ups, demonstration/performance of analytical techniques, and concluding with translation of biomaterials that will include entrepreneurship and regulatory aspects.

BME 656. Research Skills in Stem Cell. 3 credits, 3 contact hours.
Stem cells have emerged as new therapeutic potential and offer great opportunities for regenerative medicine, biotechnology and the pharmaceutical industry. This course is intended for graduate students interested in stem cell bioengineering and tissue engineering. The course will cover stem cell biology and biomedical engineering applications for cell-based regeneration therapies. It will discuss techniques for engineering of stem cells and the current literature in this rapidly evolving field.

BME 661. Neural Engineering. 3 credits, 3 contact hours.
Neural Engineering focuses on understanding how the brain functions using engineering principles. The course discusses different instrumentation and signal processing algorithms to study how the brain functions, how to detect different pathologies and new applications for research. Topics include; basic overview of neurology, vector populations, neural networks, vision research, functional MRI, functional electrical stimulation, neural prosthetics, and other advanced research topics studying neurology.

BME 667. Bio-Control Systems. 3 credits, 3 contact hours.
The course provides an introduction to dynamic and control in biological systems, with particular emphasis on engineering aspects of biological oscillators/waves which govern the basic operations of all living organisms and especially higher order life forms. A combination of theoretical and simulation tools will be applied to analyze the qualitative and quantitative properties of selected biological systems. Feedback and control mechanisms in selected biological systems will be introduced. Same as ECE 667.

BME 668. Medical Imaging Systems. 3 credits, 3 contact hours.
This course provides a detailed introduction to medical imaging physics, instrumentation, data acquisition and image processing systems for reconstruction of multi-dimensional anatomical and functional medical images. Three-Dimensional medical imaging modalities including X-ray, Computer Tomography, Magnetic Resonance Imaging, Single Photon Emission Computer Tomography, Positron Emission Tomography, Ultrasound and optical imaging modalities are included. Same as ECE 668.

BME 669. Engineering Physiology. 3 credits, 3 contact hours.
To enable students to apply basic tools in engineering analysis, mathematics, computer science, general physics and chemistry courses so that they can develop models that quantitatively predict the functioning of physiological systems in the human body. To enable students to apply engineering systems analysis to systematic physiology and employ the ideas of feedback control, signal procession, mathematical modeling and numerical simulation. Same as ECE 669.

BME 670. Introduction to Biomechanical Engineering. 3 credits, 3 contact hours.
Prerequisites: undergraduate thermodynamics, statics, and dynamics. Introduction to biomechanical engineering of physiological systems; fluid flow, structural, motion, transport, and material aspects; energy balance of the body, and the overall interaction of the body with the environment. Same as ME 670.

BME 671. Biomechanics of Human Structure and Motion. 3 credits, 0 contact hours.
Prerequisites: undergraduate statics, kinematics, and dynamics. Principles of engineering mechanics and materials science applied to human structural and kinematic systems and to the design of prosthetic devices. Topics include anatomy; human force systems; human motion; bioengineering materials; and design of implants, supports, braces, and replacements limbs.

BME 672. Biomaterials. 3 credits, 3 contact hours.
Prerequisite: MECH 320 (see undergraduate catalog for description) or the equivalent. Materials and processes used to develop devices that are implanted in the human body; clinical aspects of biomechanical engineering; federal government requirements for design and testing of human implant devices; biocompatibility, metal implant devices, material design parameters, plastic and ceramic devices, sterilization techniques, and their effect on biocompatibility.

BME 673. Biorobotics. 3 credits, 3 contact hours.
Basics of control of a robot and telemanipulation are studied. Computer simulations, MATLAB are used to explore biomimetic autonomous robots. This is a studio-based course with hands-on exercises with small robots and actuators. Topics include understanding how biological robots (humans and animals) differ from designed robots, as well as sensors (touch, stereo and position), actuators (muscles, smart materials), and intelligent (neural and computer controlled systems.

BME 674. Principles of Neuromuscular Engineering. 3 credits, 3 contact hours.
Neurophysiology, motor control and robotics are used to study the human motor system. Sensorimotor learning and acquisition of new motor skills are emphasized. Topics include the central nervous system, muscle properties, spinal motor circuitry and dynamics of limb motion. The relation of motor control problems to neurophysiology of the motor system and how motor disorders affect movement control are studied. MATLAB and Simulink are used in simulations and movement date analysis.

BME 675. Computer Methods in Biomedical Engineering. 3 credits, 3 contact hours.
This course uses MATLAB to concentrate on methods that allow students to produce original software that can be used to acquire, process, analyze and present data. Topics include advanced graphics and animation, graphical user interfaces, interfacing to and data acquisition from laboratory instrumentation, filtering and processing of acquired data, and interfacing to user interfaces (e.g. joysticks). Applications in speech, bioelectrical signals, images and virtual reality will be included.

BME 676. Computational Biomechanics. 3 credits, 3 contact hours.
Prerequisites: BME 670 or equivalent. The use of commercially available software to solve complex engineering problems has become standard practice to reduce time and cost and results in a better product. This is an intro course on computational methods and the use of commercial software such as ANSYS, Fluent, and MATLAB to solve problems related to the BME device industry. Suitable for students interested in Computer Aided Design and Engineering (CAD/CAE).

BME 677. CAD for Biomechanics and Biomaterials. 3 credits, 3 contact hours.
Introduction to Computer Aided Design theory and application using software. Topics include datum planes, extrude, cut, sweep, swept cuts, and parallel, rotational, and general blends. Assemblies and generating, dimensioning, editing, and modifying drawing views and creation of balloons, imaging and scanning techniques of anatomical structures such as bone and arteries and 3D printing are also covered.

BME 678. Design of Orthopedic Implants. 3 credits, 3 contact hours.
Prerequisite: BME 677. First of a two part course on design of orthopedic implants using ProEngineer. Additional topics include machanical properties of implant materials, material selection and introduction to FEA. Methods for prototype development with the use of 3D printing will also be discussed. A critical objective of this course is the preparetion of design reports and project presentations.

BME 679. Advanced Design of Orthopedic Implants. 3 credits, 3 contact hours.
Prerequisites: BME 677, BME 678 or equivalent. Advanced modeling techniques for the design of hip, knee, and spine implants. Mechanical properties of materials, including wear and failure modes associated with typical implants. Kinematics and surgical protocols of implants will be discussed. Course will cover assemblies and FEA analysis of implants. Additional topics include large deformations, fatigue, optimization, review and analysis of results.

BME 680. BioMEMS Design and Applications. 3 credits, 3 contact hours.
The advance of bioMEMS (Micro Electrical Mechanical Systems) technology is a key component in making the next generation medical diagnostic tools possible. We will learn how bioMEMS devices are fabricated and combine engineering analysis with knowledge of known biological responses and biomolecule interactions to understand how bioMEMS are designed and function. Topics will include biological, mechanical, electrical, and chemical biosensors, and microfluidics as applied to biotechnology.

BME 681. Cellular Mechanobiology. 3 credits, 3 contact hours.
Prerequisites: Fundamentals in biology. Mechanobiology is an emerging interdisciplinary field that focuses on the role of mechanical cues in governing cellular behavior. This course will address the means by which a cell utilizes its adhesions to neighboring cells and to the surrounding extracellular matrix to sense external forces and furthermore, how these forces are transduced within the cell to alter cellular behavior and regulate tissue architecture. This course will also discuss how the extracellular matrix influences cellular behavior during development, health, and disease. Furthermore, this course will also discuss the various tools and techniques developed that pushed the field of mechanobiology forward.

BME 682. System Mgmt for Medical Device. 3 credits, 3 contact hours.
This course will provide a detailed overview of Project Management techniques and methods applied to medical devices and show the integration of medical device Design Controls from 21 CFR820.30. General knowledge from the field of Project Management will be conveyed from the perspective of engineering or science personnel in the industrial medical field, particularlywith regard to FDA Quality System Regulations (QSR), ISO 13485 guidelines, and Good Clinical Practices (GCP's) for running clinical trials. Students will also take part in practical problem solving simulations based on real-world examples of medical device project anomalies. The combination of specialized project management knowledge for a heavily regulated area and realistic classroom simulation will provide a basis for those interested in commercial medical device development.

BME 684. Medical Device Development. 3 credits, 3 contact hours.
This course will provide a detailed overview of medical device development from a realistic industrial and academic perspective. The processes used in corporations and academic laboratories to conceive and develop devices will be explored from a research, regulatory, clinical, QA/QC, marketing, engineering, and legal perpective under the umbrella of project management techniques. Material will be presented as an aide to students who wish to decide on careers in either industry or academia.

BME 686. Intro. to Instrumentation for Physiomeasurements. 3 credits, 3 contact hours.
Introduction to instrumentation for students without instrumentation background only. This course teaches the hardware and instrumentation needed to measure variables from different physiological systems. Electrodes, sensors and transducers, bioelectric amplifiers safety and digital acquisition will be discussed. Hardware for measurement of the ECG, EEG, EMG, respiratory system, nervous system, clinical laboratory instruments, electrical safety and computers in biomedical instrumentation.

BME 687. Design of Medical Instrumentation. 3 credits, 3 contact hours.
Prerequisite: undergraduate course in electronics. Principles and practice of medical instrumentation. Instrument components and medical instrument systems design. Examples taken from electrocardiography, clinical chemistry, medical imaging. Microprocessor-based systems emphasized.

BME 688. Virtual Biomedical Instrument. 3 credits, 3 contact hours.
Introductory course to the programming language, LabVIEWTM. Topics include loops, arrays, clusters, data acquisition, and file input/output. Students will learn how to apply these basic concepts into the development of algorithms. Examples relevant to the biomedical industry will be given how to debug and solve complex programming problems. By the completion of the course, students will be able to develop programs to automate processes and experimental designs.

BME 698. Selected Topics. 3 credits, 3 contact hours.
Selected topics for Biomedical Engineering.

BME 700B. Master's Project. 3 credits, 3 contact hours.
Restriction: written approval of project advisor. An extensive paper involving design, construction, and analysis, or theoretical investigation. Joint projects with industry or governmental agencies may be acceptable. Work is carried out under the supervision of a member of the department faculty. Master's students registering for the first time in Master's Project must take simultaneously the INTD 799 (Responsible Conduct of Research) course, if they have not already taken it.

BME 701B. Master's Thesis. 3 credits, 3 contact hours.
Restriction: written approval of project advisor. An extensive paper involving design, construction, and analysis, or theoretical investigation. Joint projects with industry or governmental agencies may be acceptable. Work is carried out under the supervision of a member of the department faculty. Master's students registering for the first time in Master's Thesis must take simultaneously the INTD 799 (Responsible Conduct of Research) course, if they have not already taken it.

BME 701C. Master's Thesis. 6 credits, 3 contact hours.
Restriction: written approval of project advisor. An extensive paper involving design, construction, and analysis, or theoretical investigation. Joint projects with industry or governmental agencies may be acceptable. Work is carried out under the supervision of a member of the department faculty.

BME 725. Independent Study I. 3 credits, 3 contact hours.
Restriction: departmental approval. Program of study prescribed and approved by student's faculty coordinator. This special course covers areas of study in which one or more students may be interested but is not of sufficiently broad interest to warrant a regular course offering. Master's degree students cannot count BME 725 as degree credit but can count these credits to qualify for full-time status.

BME 726. Independent Study II. 3 credits, 3 contact hours.
Restriction: departmental approval. Program of study prescribed and approved by student's faculty coordinator. This special course covers areas of study in which one or more students may be interested but is not of sufficiently broad interest to warrant a regular course offering. Master's degree students cannot count BME 725 as degree credit but can count these credits to qualify for full-time status. This course is not available to master's students.

BME 741. Basic Plasma Physics with Spac. 3 credits, 3 contact hours.
Prerequisites: PHYS 611, PHYS 621 or other equivalent, or approval of the instructor. The course will introduce students to basic concepts of plasma physics and its applications to laboratory experiments and space research. The course will cover the following topics: particle motions in magnetic field, adiabatic invariants, magnetic traps, radiation belts, electromagnetic waves in plasma, electrostatic oscillations, waves in magnetized plasma, collisional processes in plasma, kinetic effects on plasma waves, Landau damping, wave instabilities, plasma as fluid, magnetohydrodynamics, magnetic configurations of laboratory and space plasma, MHD instabilities, reconnection, helicity, dynamo theories, the origin of cosmic magnetic fields, stochastic processes, Fermi process, particle acceleration, and cosmic rays.

BME 760. Modeling in Func Brain Imaging. 3 credits, 3 contact hours.
Prerequisites: Although no prerequisites are required, BME 310, ECE 640 or other undergraduate and graduate courses covering knowledge on signals and systems in discrete time domain are suggested to prepare for this course. This course will focus on introducing biomedical computing techniques needed for functional MRI data pre-processing, and individual-level and group-level analyses. Several projects will be assigned for hands-on training in implementing the introduced knowledge.

BME 772. Adv Biomats for Lab and Clinic. 3 credits, 3 contact hours.
Prerequisite: BME 672 or equivalent. Background in Materials Science is encouraged. Advanced course on the design, characterization and clinical/research performance of biomaterials that have or may receive acceptance in medicine or as a biomedical research tool. The course requires the student to integrate background in chemistry, physics, cell and molecular biology, tissue engineering and materials science to review and summarize the scientific rationale for materials that have gained acceptance as medical devices, cell culture or diagnostic tools.

BME 774. Principles of Neurorehabilitation. 3 credits, 3 contact hours.
This is a research-focused course providing in-depth review of current studies in the following fields: Pathophysiology of disability; Advanced therapeutic interventions; Emerging neurorehabilitation technologies that are intended to encourage neural reorganization and relearning; Novel interfaces through chronic implementation in the brain, spinal cord and muscles used in deep brain stimulation, brain-machine interfaces, and functional electrical stimulation and Methods of assessing outcomes.

BME 777. Neuromodulation. 3 credits, 3 contact hours.
Restrictions: Course is designed for PhD Students in BME; All others need Instructor's approval. This course will first cover the fundamentals of electrical neural stimulation by looking at passive and active neuronal membrane models to prepare the students to better understand the mechanisms underlying neuromodulation applications. Then, the topics will expand into more practical aspects of neural stimulation, such as the electrode technologies used and various techniques of electrical neuromodulation in the central and peripheral nervous system. Throughout the course many sensory and motor neural prosthetic applications, e.g. spinal cord and deep brain stimulation devices, will be discussed from textbooks and journal publications. This is a lecture-based course covering a diverse area of materials borrowed mostly from electrophysiology and basic engineering concepts and students should be prepared to read one or two book chapters or journal papers before each class. Knowledge of basic circuits, such as RC circuits and KVL and KCL Analysis, is required. This course is built upon basic engineering concepts (e.g. basic electric circuits, differential equations) and programming skills (Matlab) that are covered at the undergrad level in electrical and biomedical engineering programs.

BME 788. Selected Topics. 3 credits, 3 contact hours.
Selected topics for Biomedical Engineering.

BME 790A. Doctoral Dissertation. 1 credit, 1 contact hour.
Required of all students working toward the Ph.D. in Biomedical Engineering. A minimum of 36 credits is required. The student must register for at least 6 credits of dissertation per semester; registration for additional credits may be permitted beyond the 6, with the approval of the advisor, up to a maximum of 12 credits per semester. If the student is still actively engaged in the research after completion of 36 credits, continued registration of 3 credits per semester is required.

BME 791. Graduate Seminar. 0 credits, 0 contact hours.

BME 792. Pre-Doctoral Research. 3 credits, 3 contact hours.
Restriction: Permission of the department. For students admitted to the program leading to the Ph.D. in Computer Engineering or Electrical Engineering. Research carried on under the supervision of a designated member of the department faculty. If the student's research activity culminates in doctoral research in the same area, up to a maximum of 6 credits may be applied toward the 36 credits required under BME 790 after the student fulfills requirements of doctoral candidacy.