

DEPARTMENT OF BIOMEDICAL ENGINEERING

Programs

Undergraduate

Major

- Biomedical Engineering Major (<https://catalog.tulane.edu/science-engineering/biomedical-engineering/biomedical-engineering-major>)

Minors

- Biomedical Engineering Minor (<https://catalog.tulane.edu/science-engineering/biomedical-engineering/biomedical-engineering-minor>)
- Biomedical Engineering Minor for Non-Engineering Majors (<https://catalog.tulane.edu/science-engineering/biomedical-engineering/biomedical-engineering-minor-non-engineering-majors>)

Graduate

- Biomedical Engineering, MS (<https://catalog.tulane.edu/science-engineering/biomedical-engineering/biomedical-engineering-ms>)
- Biomedical Engineering, PhD (<https://catalog.tulane.edu/science-engineering/biomedical-engineering/biomedical-engineering-phd>)

Courses

Biomedical Engineering (BMEN)

BMEN 1940 Transfer Coursework (0 Credit Hours)

BMEN 2020 Comput Concepts & Applic (4 Credit Hours)

This course introduces students to the foundations of algorithm development and programming, basics of matrix algebra and numerical analysis, solving ordinary differential equations.

Corequisite(s): BMEN 2021.

BMEN 2021 Computing Concepts & App. Lab (0 Credit Hours)

Lab for ENGP 2020

BMEN 2310 Product & Experimental Design (3 Credit Hours)

The objective of this course is to introduce students to the design process as they are starting the BMEN Curriculum. Through team projects geared toward translating bench research into product development, students will be challenged to begin thinking critically and applying physical fundamentals to complex systems. Weekly lectures will highlight phases of the design process, including problem identification, conceptual design, and early prototyping. Additionally, in the context of product and experimental design, students will gain experience with computer aided design and be provided an introduction to statistics. Course restricted to BMEN majors, or by permission of the instructors.

Corequisite(s): BMEN 2311.

BMEN 2311 Product & Experimentl Dsgn Lab (0 Credit Hours)

Lab section for BMEN 2310

BMEN 2600 Intro Organic & Biochem (3 Credit Hours)

This course introduces the main principles of Organic Chemistry and Biochemistry, preparing the student for BMEN 3030/3040. Topics include nomenclature of organic compounds and bio-molecules, major reactions of organic chemistry, relationship between chemical structures and biological functions, and the reaction pathways of major metabolic processes. Students will be introduced to the three-dimensional structure of organic compounds and biomolecules using molecular models and software tools.

Prerequisite(s): (CHEM 1080, 1080, 1080 or 1080) and (CHEM 1180, 1180, 1180, 1180, 1085, 1085, 1085 or 1085).

BMEN 2730 Biomedical Electronics (4 Credit Hours)

Rectifiers, filters, regulators and power supplies. Analog amplifiers and active filters of interest for medical devices. Combinational and sequential digital logic design techniques and circuits. Brief overview of modulation, encoding, and interfacing. Electrical safety. Extensive weekly lab projects.

Prerequisite(s): ENGP 2010, 2010, 2010 or 2010.

Corequisite(s): BMEN 2731.

BMEN 2731 Biomedical Electronics Lab (0 Credit Hours)

Lab section for BMEN 2730

Corequisite(s): BMEN 2730.

BMEN 2890 Service Learning (0-1 Credit Hours)

Service learning component to BMEN courses. See Schedule of Classes each semester for offerings. 20 or 40 hours of public service with a CPS approved community partner.

BMEN 2940 Transfer Coursework (0 Credit Hours)**BMEN 3010 Physical Dimen of Aging (3 Credit Hours)**

This course is designed to introduce students to the physiological, behavioral, and socio-economic changes associated with aging. In particular, we will focus on what physiological and structural changes are typical for an aging human body focusing on the brain, cardiovascular and musculoskeletal systems. We will also discuss what it means to become older within a community, what can a person expect during the aging process, and what kind of control a person has over his/her aging body. Course participants travel to local aging centers and continuing care facilities as part of the learning process.

BMEN 3030 Anatomy & Physio for Engr (3 Credit Hours)

This course is a single semester course in human structural anatomy. Course participants will examine both typical and pathological examples for the various subsystems including body tissues; the musculoskeletal; neurological; cardiovascular; respiratory; digestive; and reproductive systems.

Corequisite(s): BMEN 3035.

BMEN 3035 Anat & Phys for Engr Lab (1 Credit Hour)

This single-semester laboratory coordinates hands on learning in human structural anatomy. Course participants will dissect and examine both typical and pathological examples for the various subsystems including body tissues; the musculoskeletal; neurological; cardiovascular; respiratory; digestive; and reproductive systems.

BMEN 3045 Anatomy & Physio Lab II (1 Credit Hour)

Corequisite(s): BMEN 3040.

BMEN 3060 Biomedical Acoustics (3 Credit Hours)

Introduction to sounds in the physiological and medical arena. Topics include: physics of sound propagation, sources and mechanisms of cardiac and respiratory sound production, sound transmission, auscultation and stethoscope evaluation, psychoacoustics a

Prerequisite(s): PHYS 1310 and 1320.

BMEN 3070 Quantitative Physiology (3 Credit Hours)

This course places emphasis upon the chemical basis of life; cells and cellular metabolism; histology and tissues; the endocrine, skeletal and nervous systems; respiratory, digestive, cardiovascular, lymphatic and reproductive systems; nutrition and metabolism; water, electrolyte and acid-base balance, and human growth and development.

Corequisite(s): BMEN 3075.

BMEN 3075 Quat. Physiology Lab (1 Credit Hour)

Subject matter will include blood, nutrition, and metabolism; and the cardiovascular, lymphatic, digestive, respiratory, urinary, and reproductive systems.

Corequisite(s): BMEN 3070.

BMEN 3300 Biomechanics (3 Credit Hours)

This course introduces students to the various interdisciplinary fields in biomechanics. Specific topics include: kinematics during human activity; the analysis of forces and stresses/strains in biological structures under loading; models for biological materials; the relationship between structure and function in orthopedic tissues and continuum mechanics. Fulfills departmental ζ "domain" ζ requirement. An additional non-graded once a week lab section to accompany lectures.

Prerequisite(s): (ENGP 2430, 2430, 2430 or 2430) and (BMEN 2600, 2600, 2600 or 2600).

BMEN 3301 Biomechanics Lab (0 Credit Hours)

Lab section for BMEN 3300

BMEN 3400 Biomaterials & Tissue Engr (3 Credit Hours)

This course will focus on fundamental materials science and biological principles that impact the engineering design of biomaterials and tissue-engineered products. Topics addressed will include structural hierarchies of materials and tissues, physical and chemical properties of surfaces, degradation of materials, and cell-surface, cell-cell, and cell-matrix interactions. The course will conclude with inflammatory, immunological, and pathological events associated with responses to such products. Laboratory exercises will be utilized to illustrate selected concepts, introduce assessment methods, and provide hands-on experiences with cells and materials. Fulfills departmental "domain" requirement. An additional non-graded once a week lab section to accompany lectures.

Corequisite(s): BMEN 3401.

BMEN 3401 Biomaterials & Tissue Engr (0 Credit Hours)

Lab section for BMEN 3400

BMEN 3420 Transport in Cells and Organs (3 Credit Hours)

Fundamental principles of Fluid mechanics and mass transport will be applied to biological systems at the cellular, tissue, and organ levels. The topics of this course will be the cardiovascular, respiratory systems and cell adhesion, drug transport and pharmacokinetics, and transport-related pathophysiological conditions (inflammation, atherosclerosis, thrombosis, sickle cell disease, cancer metastasis). The lab session will provide training in measurement and analysis of cell transport in parallel-plate flow systems. Fulfills departmental "domain" requirement.

BMEN 3421 Transport in Cells&Organs Lab (0 Credit Hours)

Lab section for BMEN 3420

BMEN 3440 Biofluid Mechanics (3 Credit Hours)

This class focuses on fundamental concepts and properties of fluid mechanics with applications to the body. Topics to be covered include basic equations of fluid statics, dynamics and mass transport in differential and integral form using both system and control volume viewpoints. Rheological properties of biological fluids are studied as well as dimensional analysis and similitude. Advanced applications are investigated using the finite element method.

BMEN 3650 Biomechanics and Biotransport (3 Credit Hours)

This course introduces students to biomechanics and biotransport. Specific topics include: the analysis of forces and stresses/strains in biological structures under loading; constitutive models for biological materials; the relationship between structure and function in tissues and organs. These topics will be related to fundamental principles of fluid mechanics and mass transport of biological systems at the cellular, tissue, and organ levels including cell adhesion and migration; intracellular, transmembrane and transvascular transport; drug transport and pharmacokinetics. Fulfills departmental "domain" requirement.

Corequisite(s): BMEN 3651.

BMEN 3651 Biomechanics & Biotrans Lab (0 Credit Hours)

Lab section for BMEN 3650

Corequisite(s): BMEN 3650.

BMEN 3730 Biomedical Signals and Systems (3 Credit Hours)

Fundamentals of biomedical Signals and analysis and introduction to control systems. Topics include Laplace and Fourier transforms, the convolution theorem, time- and space-frequency-domain analysis, signals and noise, the mathematics of imaging, and examples and applications to biomedical signals. The use of MATLAB and Simulink to analyze biomedical systems will be reinforced.

BMEN 3820 Math Analysis Bio Systems (3 Credit Hours)

The objective of this course is to teach basic mathematical modeling constructs and analysis techniques that are used for studying biological processes. Topics to be covered include ordinary differential equations, compartment systems, basics of dynamic systems, stability, statistical inference and model construction. These will be applied to study models of chemical kinetics, physiological control, AIDS transmission, population dynamics, and growth. Students will use Mathematica to develop and analyze models.

Prerequisite(s): MATH 2240, 2240, 2240 or 2240.

BMEN 3890 Service Learning (0-1 Credit Hours)

Students complete a service activity in the community in conjunction with the content of a three-credit corequisite course.

BMEN 3932 Elements of BMEN Design (3 Credit Hours)

This course develops the fundamental aspects of the mechanical performance of devices and components. Topics include a review of stress analysis, failure criteria, fatigue analysis and stress concentrations, as well as the mechanical behavior of fasteners, welded joints, spring selection, bearing design, and introduction to finite element analysis; with applications to biomedical engineering.

Prerequisite(s): ENGP 2430.

BMEN 3940 Transfer Coursework (3 Credit Hours)**BMEN 4030 BMEN Team Dsgn Project I (2 Credit Hours)**

Techniques and experience in the solution of constrained and open-ended design problems. Lecture topics include all aspects of the design process, including goal setting, idea generation, prototyping, fabrication, and product and evaluation. Also included are technical presentation, project planning and management. Included as needed are other topics such as standards, fastening and joining, motors and control, esthetics and finish. Each team will design and construct a device or system to assist an individual with a disability. These designs are presented in a public show during the second semester.

BMEN 4031 BMEN Team Design Project I Lab (0 Credit Hours)

Lab section for 4030

BMEN 4040 BMEN Team Dsgn Proj II (3 Credit Hours)

Techniques and experience in the solution of constrained and open-ended design problems. Lecture topics include all aspects of the design process, including goal setting, idea generation, prototyping, fabrication, and product and evaluation. Also included are technical presentation, project planning and management. Included as needed are other topics such as standards, fastening and joining, motors and control, esthetics and finish. Each team will design and construct a device or system to assist an individual with a disability. These designs are presented in a public show during the second semester.

BMEN 4090 Spec Prob In Biomed Engr (1-4 Credit Hours)

Independent study and investigation of special problems in biomedical engineering. Details can be arranged with individual biomedical engineering faculty members.

BMEN 4100 Spec Prob In Biomed Engr (1-4 Credit Hours)

Independent study and investigation of special problems in biomedical engineering. Details can be arranged with individual biomedical engineering faculty members.

BMEN 4310 Continuum Models in BMEN (3 Credit Hours)**BMEN 4560 BME Professional Internship I (1-3 Credit Hours)**

Internship relevant to professional practice in biomedical engineering, 1-3 letter-graded credits (no S/U option), may count as credits towards graduation. May only be taken once.

BMEN 4570 BME Professional Internship II (1-3 Credit Hours)

Internship relevant to professional practice in biomedical engineering, 1-3 credits graded S/U, may NOT count as credits towards graduation. May only be taken once.

Prerequisite(s): BMEN 4560.

BMEN 4660 Special Topics (1-3 Credit Hours)

Special Topics.

BMEN 4890 Service Learning (0-1 Credit Hours)

The required BMEN 4030/4040 design sequence is centered on the design and construction of a device or system to assist an individual with a disability or a group servicing such individuals. As an option, students may choose to supplement their interaction with their clients with a service learning component that follows Tulane's guidelines for service learning courses and specifically requires: Completing at least 40 hours in a community setting during the semester; keeping a journal of weekly activities that will allow the student to describe and evaluate his/her experiences with the activity; and creating a product that can be evaluated as part of the course grade (e.g., a review paper on an issue relevant to the service activity, or some product of value to the site).

BMEN 4900 Art of Professional Eng (1 Credit Hour)

Research and Professional Practice (RPP) is a 2-semester sequence beginning in Spring of the Junior year. It satisfies the University's "Writing Intensive" requirement. A lecture series in the Spring semester, called "Art of Professional Engineering" includes economic analysis, ethics, professional communication including writing and oral presentation, research techniques including literature searching, citation, and the structure of a scientific paper. Students must also register for either 4901 or 4902 in the Spring semester, and continue the sequence with 4911 or 4912/4930 in the following Fall semester.

BMEN 4901 Grand Challenges I (2 Credit Hours)

The 2-semester sequence presents a group of upper division undergraduates with a very difficult problem in biomedical engineering that will require creative invention, innovation, laboratory hard skills, and unique design methodologies to address. Though the problem is tractable, is not expected that the GC problem will be completely solved. Rather, the intent is that the GC group of students will push forward a developed "good solution" to the point where the need to protect intellectual property arises, and where market value and potential venture investments is apparent.

Prerequisite(s): BMEN 4900.

BMEN 4902 SR Research Prof Experience I (2 Credit Hours)

This two-course sequence is designed to facilitate an individual biomedical research or design experience in a laboratory. Students will be introduced to the tools, techniques, and rules necessary to function independently and professionally as a researcher or engineer. Topics include thesis writing, technical communication, and time management. The main component of the course is a two semester long research or design project under the direction of a faculty member, scientist or other professional. The course sequence culminates in a formal Senior Thesis and Research Conference presentation. Students participating in the 5th year BSE-MS program should not register for BMEN 4912 in the Fall of the Senior year, registering instead for BMEN 4930.

Prerequisite(s): BMEN 4900.

BMEN 4911 Grand Challenges II (2 Credit Hours)

The 2-semester sequence presents a group of upper division undergraduates with a very difficult problem in biomedical engineering that will require creative invention, innovation, laboratory hard skills, and unique design methodologies to address. Though the problem is tractable, is not expected that the GC problem will be completely solved. Rather, the intent is that the GC group of students will push forward a developed "good solution" to the point where the need to protect intellectual property arises, and where market value and potential venture investments is apparent.

Prerequisite(s): BMEN 4901 or 4910.

BMEN 4912 SR Research Prof Experience II (2 Credit Hours)

This two-course sequence is designed to facilitate an individual biomedical research or design experience in a laboratory. Students will be introduced to the tools, techniques, and rules necessary to function independently and professionally as a researcher or engineer. Topics include thesis writing, technical communication, and time management. The main component of the course is a two semester long research or design project under the direction of a faculty member, scientist or other professional. The course sequence culminates in a formal Senior Thesis and Research Conference presentation. Students participating in the 5th year BSE-MS program should not register for BMEN 4912 in the Fall of the Senior year, registering instead for BMEN 4930.

Prerequisite(s): BMEN 4902.

BMEN 4930 Bs-Ms Thesis (2 Credit Hours)

In order to meet undergraduate degree requirements, this course will allow fifth year students to more effectively concentrate on their research projects in lieu of completing the course requirements of BMEN 4912. The grade for BMEN 4930 will be listed as In Progress (IP) until such time as the master's thesis is completed, whereupon the student's advisor and thesis committee will assign a grade necessary to fulfill bachelor's degree requirements.

BMEN 4940 Transfer Coursework (3 Credit Hours)**BMEN 5380 Study Abroad (1-20 Credit Hours)**

Courses taught abroad by non-Tulane faculty. Does not count toward Tulane GPA.

BMEN 5390 Study Abroad (1-20 Credit Hours)

Courses taught abroad by non-Tulane faculty. Does not count toward Tulane GPA.

BMEN 6010 Physical Dimen of Aging (3 Credit Hours)

This course is designed to introduce students to the physiological, behavioral, and socio-economic changes associated with aging. In particular, we will focus on the effects of exercise on the aging human system. We will also discuss what it means to become older within a community, what can a person expect during the aging process, and what kind of control a person has over his/her aging body.

Prerequisite(s): CELL 1010, 1010, 1010, 1010, EBIO 1010, 1010, 1010 or 1010.

BMEN 6020 Biosystems (3 Credit Hours)

This course gives students the skills to interpret or predict the behavior of physiologic systems in order to study normal and pathologic phenomena. The body uses many feedback control mechanisms to maintain homeostasis, the keeping of a constant interior environment (eg. pH, temperature, blood pressure, balance, bone stress, muscle length). Transfer functions characterize organ physiology. These functions are the building blocks of an organ system model. By studying these models, complex behavior can often be easily interpreted. Further, these models often suggest ways to make noninvasive physiologic measurements. Applications include: vicious cycles, such as hyperventilation syndrome, and how to break them; hierarchical, parallel, and other redundant systems; causes of instabilities such as Cheyne-Stokes breathing; open and closed loop control of anesthesia and artificial organs. Reference will be made to several common mechanisms such as the thermostat. Lecture demonstrations include pulmonary and cardiovascular measurement. A term paper on a topic of the student's choice is required.

BMEN 6030 Anatomy & Physio for Engr (3 Credit Hours)

This is a single-semester course in human structural anatomy. Course participants will examine both typical and pathological examples for the various subsystems including, body tissues; the musculoskeletal, neurological, cardiovascular, respiratory, digestive and reproductive systems.

Corequisite(s): BMEN 6035.

BMEN 6035 Anat & Phys for Engr Lab (1 Credit Hour)

This single-semester laboratory coordinates hands-on learning in human structural anatomy. Course participants will dissect and examine both typical and pathological examples for the various subsystems including, body tissues; the musculoskeletal, neurological, cardiovascular, respiratory, digestive and reproductive systems.

BMEN 6040 Anatomy & Physiology II (3 Credit Hours)

Corequisite(s): BMEN 6045.

BMEN 6045 Anatomy & Physio Lab II (1 Credit Hour)

Corequisite(s): BMEN 6040.

BMEN 6060 Biomedical Acoustics (3 Credit Hours)

Introduction to sounds in the physiological and medical arena. Topics include: physics of sound propagation, sources and mechanisms of cardiac and respiratory sound production, sound transmission, auscultation and stethoscope evaluation, psychoacoustics and auditory perception, speech production and structure of the speech signal, medical ultrasound applications and safety.

Prerequisite(s): PHYS 1310 and 1320.

BMEN 6070 Quant Physio Lec (3 Credit Hours)

Tulane University Health Sciences Center Staff. This course places emphasis upon the chemical basis of life; cells and cellular metabolism; histology and tissues; the endocrine, skeletal and nervous systems; respiratory, digestive, cardiovascular, lymphatic and reproductive systems; nutrition and metabolism; water, electrolyte and acid-base balance, and human growth and development.

Corequisite(s): BMEN 6075.

BMEN 6075 Quant. Physiology Lab (1 Credit Hour)

Subject matter will include blood, nutrition, and metabolism; and the cardiovascular, lymphatic, digestive, respiratory, urinary, and reproductive systems.

Corequisite(s): BMEN 6070.

BMEN 6080 Tech Invent & Commercialization (3 Credit Hours)

This course models innovation and entrepreneurial theory and practices from across a range of commercial size-scales, from small startup companies to intrapreneurial units within large, established companies. The twin poles of theory and practice are balanced through classroom lectures and experiential training. Weekly lectures furnish students with effective and portable theoretical frameworks for identifying, selecting and executing opportunities for technological innovations in healthcare, energy, water and the environment. In the experiential training, students will apply their classroom learning to targeted innovation and entrepreneurship opportunities within these sectors. Completion of this course will supply students with intellectual groundwork and practical experience in advancing inventive technological ideas towards commercialization and ultimately public benefit.

BMEN 6170 Biomedical Optics (3 Credit Hours)

The field of biophotonics is a rapidly-expanding re-search area in which the interactions of photons with matter are leveraged to increase our understanding of biology and to improve the outcomes in human medicine. The objectives of this course are to familiarize students with the fundamental interactions between light and biological samples, and how these are implemented in an array of technologies that are finding successful application in biomedical research and clinical application. Topics will include fundamentals of photon transport in turbid media; optical spectroscopy variants (reflectance, fluorescence, Raman; steady-state and time-resolved); diffuse optical imaging; biological microscopy; coherence techniques; hybrid technologies (e.g. photo-acoustic imaging); and optical molecular imaging. Special attention will be paid to quantitative methods for spectroscopy and imaging in solid tissues. The class will be composed of lectures, and interactive discussions on recent papers representing the state of the art in the field.

BMEN 6220 Neural Microengineering (3 Credit Hours)

In recent years, a number of technologies have been developed and utilized for probing the nervous system. This course will focus on microscale tools, technologies, and techniques employed for the control, manipulation, and study of the nervous system in vitro. Course material will be presented primarily by students who prepare presentations from extensive background literature review. A number of projects will be assigned as design challenges in which multiple interdisciplinary groups will research and present proposed solutions to the same challenge. Background in neuroscience not required. Generally offered every other Spring.

BMEN 6260 Molec Princ Funct Biomatr (3 Credit Hours)

Functional biomaterials are non-viable materials that have been designed or modified in order to elicit specific biological responses when interacting with human fluids, cells, tissues, or organs. This course will focus on chemical principles utilized in endowing polymeric materials with biological functionality for medical applications. Following a brief review of polymer properties with a focus on hydrogels, topics addressed will include attachment of proteins to materials, induction of cell-binding and differentiation, responsive polymers, and spatial and temporal control of material properties for biological signaling. Unifying concepts will be introduced by directed reading and discussion of landmark papers in the biomaterials literature. Supplemental laboratory exercises will be utilized to illustrate selected concepts and introduce experimental procedures.

Prerequisite(s): BMEN 3400 or 3400.

BMEN 6310 Continuum Models In BMEN (3 Credit Hours)

The course begins with a presentation of the kinematics of continuous media and elementary tensor manipulations. We will then cover the conservation principles of mass, linear momentum, angular momentum, and energy. Additional topics will include the formulation of constitutive laws, continuum models in electrodynamics, and simple descriptions of piezoelectric materials. These concepts will be applied to fundamental problems in bio-solid mechanics, bio-fluid mechanics, and bio-electromagnetism.

BMEN 6330 Advanced Biofluid Mech (3 Credit Hours)

This course will cover general intermediate/advanced fluid mechanics, and will provide a foundation from which to base one's studies of biofluid mechanics. Issues pertinent to the study of biofluid mechanics will be emphasized. Topics to be studied include kinematic principles, the Navier-Stokes equations, boundary conditions for viscous flows, basic solutions to steady and unsteady Navier-Stokes equations, turbulence, analysis of the vorticity equation, and interfacial phenomena. Whenever possible, problems of a biological nature will be used as examples.

BMEN 6340 Soft Tissue Mechanics (3 Credit Hours)

This course provides an introduction to the various approaches used in modeling soft tissues, with particular attention paid to those of the musculoskeletal system (e.g. ligament, tendon, cartilage). Particular emphasis will be placed on the theoretical and experimental consequences of the large deformation behavior of these tissues. An important objective of this class is to enable the student to develop a sense for the physical and mathematical relationships between the many types of models (and the associated experiments) currently being utilized in soft tissue mechanics.

BMEN 6350 Adv Soft Tissue Mech (3 Credit Hours)

This course covers special topics in soft tissue biomechanics, such as numerical implementation of porous medium models for soft tissues and the nonequilibrium thermodynamics principles with chemical potential and Donnan osmotic swelling behaviors of hydrated soft tissues. The course will also include various contemporary research topics in soft tissue biomechanics.

BMEN 6360 Intro to Finite Element Method (3 Credit Hours)

Matrix structural analysis techniques as applied to frames, problems in plane strain, plane stress, and axisymmetric and 3-D structures. Development of the isoparametric family of finite elements. Use of user written and packaged software.

BMEN 6400 Biomaterials & Tissue Engr (3 Credit Hours)

This course will focus on fundamental materials science and biological principles that impact the engineering design of biomaterials and tissue-engineered products. Topics addressed will include structural hierarchies of materials and tissues, physical and chemical properties of surfaces, degradation of materials, and cell-surface, cell-cell, and cell-matrix interactions. The course will conclude with inflammatory, immunological, and pathological events associated with responses to such products. Laboratory exercises will be utilized to illustrate selected concepts, introduce assessment methods, and provide hands-on experiences with cells and materials. An additional non-graded once a week lab section to accompany lectures.

Corequisite(s): BMEN 6401.

BMEN 6401 Biomaterials & Tissue Engr Lab (0 Credit Hours)

Lab section for BMEN 6400

BMEN 6420 Transport in Cells and Organs (3 Credit Hours)

Open only to graduate students. Fundamental principles of fluid mechanics and mass transport will be applied to biological systems at the cellular, tissue, and organ levels. The topics of this course will be the cardiovascular and respiratory systems; and cell adhesion and migration, intracellular, transmembrane and transvascular transport: drug transport and pharmacokinetics, and transport-related pathophysiological conditions (inflammation, atherosclerosis, thrombosis, sickle cell disease, cancer metastasis). The lab sessions will provide training in measurement and analysis of cell transport in parallel-plate flow systems.

Corequisite(s): BMEN 6425.

BMEN 6421 Transport in Cells&Organs Lab (0 Credit Hours)

Lab section for BMEN 6420

BMEN 6430 Vascular Bioengineering (3 Credit Hours)

The objectives of this graduate-level course are to familiarize students with contemporary research areas that cover the field of vascular biology, and to provide an understanding of bioengineering principles related to physiological function and therapeutic modalities. Example topics include smooth muscle cell and endothelial cell lineage, leukocyte-endothelial cell interactions, angiogenesis, drug targeting via the microcirculation, neural vascular control, atherosclerosis, and hypertension. These topics will be presented in the context of four over-arching sections: 1) Vascular Cell Biology; 2) Principles of Vascular Function and Design; 3) Vascular Pathophysiology, and 4) Therapeutic Design. For each section of the course students will be required to read, critically analyze, and present relevant articles. As indicated by the section titles, the course will culminate by highlighting how our basic understanding of physiological function/dysfunction can be translated to therapeutic design.

BMEN 6460 Cell Mechanotransduction (3 Credit Hours)

This course reviews cellular mechanotransduction in a variety of tissues that adapt to physiological loading. A partial list of mechanosensing cells in these tissues include hair cells in inner ears, chondrocytes in cartilage, osteocytes in bone, endothelial cells in blood vessels, etc. In particular, this course emphasizes the role of mathematical modeling in solving biological problems. Hands-on mathematical modeling will be assigned as homework and projects.

BMEN 6600 Comput Model Biomed Sys (4 Credit Hours)

The objective of this graduate course is to provide students with the skills and knowledge necessary for computational modeling of biological and physiological systems. The first half of the course will cover introduction to UNIX, elements of programming (Matlab and FORTRAN), and numerical methods commonly used in biomedical research. The second half will immerse the students in specific biomedical applications including hemodynamics, respiratory flow, cellular mechanobiology, and neural dynamics. Most lectures will be accompanied by computer labs.

BMEN 6601 Comp Model Biomed Sys Lab (0 Credit Hours)

Lab section for BMEN 6600

Corequisite(s): BMEN 6600.

BMEN 6610 Intro Comp Biomechanics (3 Credit Hours)

This course covers fundamentals of computational methods with the emphasis in biomechanics applications. The computational methods include finite element methods and finite difference methods at the introductory level. The course will use MATLAB to implement these methods. The underlying theories of these numerical methods will be taught, and example problems will be discussed during the lecture. Example problems will include those from implant design, bone biomechanics, soft tissue biomechanics, etc. in static and dynamic conditions. The course will also discuss some special issues such as the stability/convergence criteria and the error estimation. The student will work on a term project to exercise these issues on a biomechanics problem of his/her choice.

BMEN 6630 Cell Mechanics (3 Credit Hours)

Fundamental principles of continuum mechanics will be applied to problems of biomechanics at the cellular level. Topics covered include structure of mammalian cells, cell membrane mechanics, mechanics of the cytoskeleton, models of cell viscoelasticity, cell adhesion, active cell processes, flow-induced deformation of blood cells, and experimental techniques (micropipette aspiration, biointerface probe, atomic force microscopy, magnetic twisting cytometry, optical tweezers, and flow chamber assays).

BMEN 6650 Biomechanics and Biotransport (3 Credit Hours)

This course provides a review of the mechanics of finitely deformable structures and thermomechanics with applications to the study of biological tissues. The focus of the course will be on the development of mathematical models describing fluid-solid interactions in biological tissues, nutrient transport, damage repair, and discontinuities. In particular, we will cover mixture theory, poroelasticity, microstructural models of cortical and cancellous bone, tendon, ligament, and other tissues, transient and steady-state nutrient transport, and continuum damage theories.

Corequisite(s): BMEN 6651.

BMEN 6651 Biomechanics and Biotrans Lab (0 Credit Hours)

Lab section for BMEN 6650

Corequisite(s): BMEN 6650.

BMEN 6660 Special Topics (1-3 Credit Hours)

Special Topics.

BMEN 6670 Pulmonary Mechanics (3 Credit Hours)

This is a survey course in which mechanical models of the pulmonary system are discussed. Topics to be addressed include mucous transport, airflow/diffusion in the pulmonary airways, ventilation/perfusion relationships, flow through collapsible airways and interfacial phenomena.

BMEN 6680 Orthopaedic Bioengineer (3 Credit Hours)

Concentration on various engineering aspects of the human knee and the treatment of its common orthopaedic pathologies. Topics include histophysiology of wound healing, synovial joint anatomy and tissue biomechanics, knee biomechanics, osteochondral and ligamentous graft reconstruction, prosthetic ligaments, and knee arthroplasty with emphasis on the design issues involved and the integration of clinical practice.

BMEN 6710 Departmental Seminar (1 Credit Hour)

Each week, a one-hour seminar on research within or outside the department is presented. During the Spring semester, all seniors are required to give a presentation on their project or internship. Attendance of all seniors and graduate students is required in the Fall semester.

BMEN 6720 Departmental Seminar (0 Credit Hours)

Each week, a one-hour seminar on research within or outside the department is presented. During the Spring semester, all seniors are required to give a presentation on their project or internship.

BMEN 6730 Biomedical Signals and Systems (3 Credit Hours)

Fundamentals of biomedical Signals and analysis and introduction to control systems. Topics include Laplace and Fourier transforms, the convolution theorem, time- and space-frequency-domain analysis, signals and noise, the mathematics of imaging, and exam

BMEN 6760 Biomedical Microdevices (3 Credit Hours)

This graduate level course will focus on design and fabrication of biomedical microdevices for basic biomedical research and clinical diagnostics. Students will learn from examples in recent medical literature how to approach the design of biomedical devices. The course will emphasize two basic engineering concepts: simplicity and biomimetics. It often pays (figuratively and literally) to spend the time to engineer the simplest device with needed functionality, because simple devices are often more robust, inexpensive and user-friendly, and therefore are easier to commercialize. The biomimetic approach to engineering of devices could save a lot of effort simply because nature has already spent the time to try out nearly every possible design, and has often (but not always) arrived at the optimal solution. As an exercise in this course, students will be asked to propose a solution to a medical problem of their choice (from contemporary literature) and explain why they chose the specific design. A goal of this course will be to stimulate students to think creatively and to integrate their knowledge across a wide spectrum of subjects in BMEN curriculum for solving real problems related to human health. This course will specifically emphasize the development of point-of-care diagnostic devices for remote, rural areas, developing world and other resource-limited settings.

BMEN 6790 Design Studio (3 Credit Hours)

This course is intended to provide students with a realistic design experience from virtual design, to rapid prototype fabrication, to testing, through redesign. It will focus on the practical application of leading commercial design software, including the creative extension of this software to innovate research applications. The course will be project intensive with commensurate report submissions and future design recommendations. Projects will include analyses of existing clinical problems, as well as research development of cell scaffolds and cell mechanotransduction.

Corequisite(s): BMEN 6791.

BMEN 6791 Design Studio Lab (0 Credit Hours)

Lab for BMEN 6790

Corequisite(s): BMEN 6790.

BMEN 6820 Math Analysis Bio Systems (3 Credit Hours)

The objective of this course is to teach basic mathematical modeling constructs and analysis techniques that are used for studying biological processes. Topics to be covered include ordinary differential equations, compartment systems, basics of dynamic systems, stability, statistical inference and model construction. These will be applied to study models of chemical kinetics, physiological control, AIDS transmission, population dynamics, and growth. Students will use Mathematica to develop and analyze models.

BMEN 6830 Intro Biomed Imaging & Process (3 Credit Hours)

The objective of this course is to teach graduate students the concepts, algorithms and programming of image analysis techniques and apply them to address real world biomedical imaging challenges. The physics of medical imaging modalities including x-ray, MRI, CT, PET and microscopic imaging will be introduced. The basic underlying mathematical signal processing techniques such as Fourier analysis and linear system theory will be studied to model and process biomedical images. Finally, students will learn how to use MATLAB as a tool and apply the image processing techniques to solve some medical imaging problems such as image enhancement, segmentation and pattern classification.

BMEN 6840 Medical Imaging Physics (3 Credit Hours)

This course will introduce imaging methods in medicine, including radiography, computed tomography (CT), magnetic resonance imaging (MRI), nuclear medicine (PET and SPECT), and ultrasound imaging. The basic physical principles of each imaging modality will be introduced, including the imaging energy source, properties and interaction with tissue. Basic concepts of image reconstruction will be discussed. This course will include laboratory visits to the School of Medicine Department of Radiology to explore real world uses of medical imaging systems. A course project will be assigned for students to assess new and emerging medical imaging systems.

BMEN 6860 Sem In Biofluid Mechanic (0 Credit Hours)**BMEN 6900 Medical Imaging (3 Credit Hours)****BMEN 6932 Elements of BMEN Design (3 Credit Hours)**

This course develops the fundamental aspects of the mechanical performance of devices and components. Topics include a review of stress analysis, failure criteria, fatigue analysis and stress concentrations, as well as the mechanical behavior of fasteners, welded joints, spring selection, bearing design, and introduction to finite element analysis; with applications to biomedical engineering.

BMEN 6940 Transfer Coursework (3 Credit Hours)**BMEN 7030 Anatomy &Physio For Engr (3 Credit Hours)****BMEN 7130 Anat & Phys For Engr Lab (1 Credit Hour)****BMEN 7210 Direct Reads In BME Engr (1-6 Credit Hours)**

Taught on a tutorial basis, this course allows a student to make an in-depth study in an area of expertise of members of the department. Some recent and current topics include non-Newtonian fluid mechanics; the mechanics of the inner ear; the mechanics of bone; the mechanics of soft tissue; ceramics engineering; physical metallurgy; laser applications in medicine; and modeling of neural networks.

BMEN 7220 Direct Reads In BME (1-6 Credit Hours)

Taught on a tutorial basis, this course allows a student to make an in-depth study in an area of expertise of members of the department. Some recent and current topics include non-Newtonian fluid mechanics; the mechanics of the inner ear; the mechanics of bone; the mechanics of soft tissue; ceramics engineering; physical metallurgy; laser applications in medicine; and modeling of neural networks.

BMEN 7320 Research In BME (1-6 Credit Hours)

Individual research supervised by faculty.

BMEN 7410 Research Methods (3 Credit Hours)

Methods and resources for experimental studies in engineering science are introduced. Topics include the nature of scientific inquiry, literature search and writing techniques, experimental design and control, data analysis and presentation, and statistical methods. An original proposal is required.

BMEN 7660 Special Topics (0-4 Credit Hours)

Special Topics.

BMEN 7940 Transfer Credit-Grad (1-12 Credit Hours)**BMEN 7990 Research in BME (1-9 Credit Hours)**

Individual research supervised by faculty.

BMEN 9980 Master's Research (3 Credit Hours)

Research toward completion of a masters degree.

BMEN 9990 Dissertation Research (3 Credit Hours)

Research toward completion of a doctoral degree.