**BIOE - BIOENGINEERING**

**BIOE404 Biomechanics (3 Credits)**
Introduction to the fundamentals of biomechanics including force analysis, mechanics of deformable bodies, stress and strain, multiaxial deformations, stress analysis, and viscoelasticity. Biomechanics of soft and hard tissues.
**Prerequisite:** MATH246, BIOE120, ENES102, BIOE121, and BIOE241.
**Restriction:** Permission of ENGR-Fischell Department of Bioengineering department.

**BIOE411 Tissue Engineering (3 Credits)**
A review of the fundamental principles involved in the design of engineered tissues and organs. Both biological and engineering fundamentals will be considered.
**Prerequisite:** Must have completed at least one biology course; and (BIOE120, BIOE121, BIOE241, MATH246, and MATH241). Or permission of ENGR-Fischell Department of Bioengineering department.
**Recommended:** BSCI330 and BIOE240.
**Restriction:** Permission of ENGR-Fischell Department of Bioengineering department. Also offered as: CHBE487.
**Credit Only Granted for:** BIOE411 or CHBE487.

**BIOE420 Bioimaging (3 Credits)**
Examines the physical principles behind major biomedical imaging modalities and new ways of using images for bio-related applications.
**Prerequisite:** MATH246, BIOE120, BIOE121, and BIOE241.
**Restriction:** Permission of ENGR-Fischell Department of Bioengineering department.

**BIOE422 Biosystems Engineering (3 Credits)**
Conservation of mass in the context of biological systems at different scales (i.e., cellular, organ, and ecosystem), life cycles such as carbon cycle, nitrogen cycle, photosynthesis, water cycle, Kreb cycle, and aerobic and anaerobic cycles as they relate to biosystem function and health.
**Prerequisite:** BIOE120 and BIOE121; or (BSCI170 and BSCI171); or BSCI105. And (ENME331, BIOE331, ENCE305, or BIOE332).

**BIOE431 Fundamentals of Biosensor Techniques, Instrumentation, and Applications (3 Credits)**
A thorough review of fundamental concepts of biosensing systems, principles of common detection methods, and modern applications of biosensors. Primarily literature driven. Students will obtain a detailed understanding of cutting-edge biosensing techniques, the instrumentation used, and the application space. Students also will develop skills in using current literature as a source of knowledge.
**Prerequisite:** CHEM135, PHYS260, PHYS261, BSCI330, BIOE120, BIOE121, BIOE241, and MATH246; or permission of ENGR-Fischell Department of Bioengineering department.
**Restriction:** Permission of ENGR-Fischell Department of Bioengineering department.

**BIOE432 Fundamentals of Biophotonics Imaging and Microscopy (3 Credits)**
Principles and instrumentation of various biomedical optical techniques, including fluorescent and Raman spectroscopy, confocal and multiphoton microscopy, optical coherence tomography, and diffuse optical tomography. Biomedical applications will also be discussed.
**Prerequisite:** PHYS270 and BIOE420.
**Restriction:** Permission of ENGR-Fischell Department of Bioengineering department.
**Credit Only Granted for:** BIOE432, BIOE632, or BIOE689C.

**BIOE437 Computer-Aided Design in Bioengineering (3 Credits)**
Introduction to Computer-Aided Design (CAD). Basic CAD operations will be demonstrated in class with Creo Parametric (formerly Pro/E). Lecture topics will summarize design methodology, review best-practices in hardware development, and discuss engineering applications. The course will culminate in a student-selected project leveraging CAD.
**Prerequisite:** BIOE120, BIOE121, BIOE241, and MATH246; or permission of ENGR-Fischell Department of Bioengineering department.
**Restriction:** Permission of ENGR-Fischell Department of Bioengineering department.
**Credit Only Granted for:** BIOE437, BIOE689V, ENME414, ENME272, or ENAE488D.
**Formerly:** BIOE689V.

**BIOE453 Biomaterials (3 Credits)**
Examination of the structure and function of natural biomaterials, and cell-extracellular matrix interactions. Study physical properties of synthetic biomaterials for biomedical applications. Understanding molecular level interactions between biomolecules and biomaterials to design novel biomaterials with desirable characteristics. Application of biomaterials as implants, drug delivery systems, biosensors, engineered materials such as artificial skin and bone growth scaffolds will be covered.
**Prerequisite:** CHEM231, MATH246, CHEM232, BIOE120, BIOE121, and BIOE241.
**Restriction:** Permission of ENGR-Fischell Department of Bioengineering department.
**Credit Only Granted for:** BIOE453, CHBE457, or ENMA425.

**BIOE456 Bioinstrumentation (3 Credits)**
Study of biomedical instrumentation and biomedical equipment technology. How biomedical equipment is used to measure information from the human body. Hands-on experience with representative biomedical equipment.
**Prerequisite:** BIOE455.
**Restriction:** Permission of ENGR-Fischell Department of Bioengineering department.
**Credit Only Granted for:** BIOE456 or ENBE456.
**Formerly:** ENBE456.

**BIOE457 Biomedical Electronics & Instrumentation (4 Credits)**
Students learn fundamental concepts of electronics, assembly of electronic components into functional circuits, and integration of functional electronic devices and circuits into a system. In the lab component, students will learn to assemble and evaluate circuits and systems.
**Prerequisite:** BIOE120, BIOE121, BIOE241, PHYS261, MATH246, and PHYS260.
**Restriction:** Permission of ENGR-Fischell Department of Bioengineering department.

**BIOE460 Biotechnology and Bioproduction (3 Credits)**
Basics of recombinant DNA technology and biopharmaceutical manufacturing.
**Restriction:** Junior standing or higher.
**Credit Only Granted for:** BIOE460, BIOE468B, or ENES489Q.
**Formerly:** BIOE468B.
BIOE461 Synthetic Biology and Biological Engineering (3 Credits)
Students are introduced to the scientific foundation and concepts of synthetic biology and biological engineering. Current examples that apply synthetic biology to fundamental and practical challenges will be emphasized. The course will also address the societal issues of synthetic biology, and briefly examine interests to regulate research in this area.
Prerequisite: BIOE120, BIOE121, BIOE241, and MATH246; or permission of ENGR-Fischell Department of Bioengineering department.
Recommended: Completion of BSCI222 and/or BSCI330 recommended.
Restriction: Permission of ENGR-Fischell Department of Bioengineering department.
Credit Only Granted for: BIOE489G or BIOE 461.
Formerly: BIOE489G.

BIOE468 Selected Topics in Bioengineering (3 Credits)
Selected topics in Bioengineering will be covered and taught by a variety of department faculty.
Prerequisite: BIOE120 and BIOE121.
Restriction: Permission of ENGR-Fischell Department of Bioengineering department.
Repeatable to: 9 credits if content differs.

BIOE471 Biological Systems Control (3 Credits)
Principles of control systems designed by biological engineers and analysis of control mechanisms found in biological organisms. Apparent control strategies used by biological systems will be covered.
Prerequisite: BIOE455.
Restriction: Permission of ENGR-Fischell Department of Bioengineering department.
Credit Only Granted for: BIOE471 or ENBE471.
Formerly: ENBE471.

BIOE484 Engineering in Biology (3 Credits)
Engineering with biological systems, with emphasis on utilization, design, and modeling. Broad topics include differences between biological engineering and biological science; basic sciences and how they relate to biology; typical biological responses to environmental stimuli; scaling, and utilization of living things.
Prerequisite: (MATH121 or MATH141; or must have completed MATH221); and (PHYS141 or PHYS161); and must have completed CHEM103 or higher. Or permission of ENGR-Fischell Department of Bioengineering department.
Recommended: BIOE454.
Credit Only Granted for: BIOE484 or ENBE484.
Formerly: ENBE484.

BIOE485 Capstone Design I: Entrepreneurship, Regulatory Issues, and Ethics (3 Credits)
This is the first part of a two-semester senior capstone design course which covers principles involved in engineering design, design approaches, economics of design, ethics in engineering, and patent regulations. It also helps students learn team work and write design project proposals under the mentorship of a faculty advisor.
Prerequisite: 21 credits in BIOE courses.
Restriction: Permission of ENGR-Fischell Department of Bioengineering department; and senior standing; and must be in Engineering: Bioengineering program.
Credit Only Granted for: BIOE485 or ENBE485.
Formerly: ENBE485.

BIOE486 Capstone Design II (3 Credits)
This is the second part of the senior capstone design course. This part is independent instruction where faculty mentoring each project team works with students to order supplies, fabricate their proposed design under BIOE485, test the design, write the report and present it to their fellow seniors and board of faculty mentors. Students are taught to convert the blue print of a design to actual device and test it.
Prerequisite: Must have completed BIOE485 in the immediately preceding semester.
Restriction: Senior standing; and must be in Engineering: Bioengineering program; and permission of ENGR-Fischell Department of Bioengineering department.
Credit Only Granted for: BIOE486 or ENBE486.
Formerly: ENBE486.

BIOE489 Special Topics in Bioengineering (1-3 Credits)
Exploring a variety of topics with Bioengineering.
Restriction: Permission of ENGR-Fischell Department of Bioengineering department.
Repeatable to: 6 credits.

BIOE601 Biomolecular and Cellular Rate Processes (3 Credits)
Presentation of techniques for characterizing and manipulating non-linear biochemical reaction networks. Advanced topics to include mathematical modeling of the dynamics of biological systems; separation techniques for heat sensitive biologically active materials; and rate processes in cellular and biomolecular systems. Methods are applied to current biotechnological systems, some include: recombinant bacteria; plant insect and mammalian cells; and transformed cell lines.
Restriction: Permission of ENGR-Fischell Department of Bioengineering department.
Credit Only Granted for: BIOE601 or ENCH859B.

BIOE602 Cellular and Tissue Biomechanics (3 Credits)
Introduction to the fundamentals of biomechanics including force analysis, mechanics of deformable bodies, stress and strain, multiaxial deformations, stress analysis, and viscoelasticity. Biomechanics of soft and hard tissues.

BIOE604 Cellular and Physiological Transport Phenomena (3 Credits)
A study of transport processes, including momentum, energy and mass transport, relevant to biosystems at various scales from physiological to cellular systems. Transport leads to sets of partial differential equations and the course revolves around approaches to solving these equations to arrive at fundamental understanding of the physics of transport in biosystems.
Restriction: Permission of ENGR-Fischell Department of Bioengineering department.

BIOE605 BIOE Graduate Studies I (1 Credit)
Introduction to the bioengineering graduate program. Students gain exposure to departmental research through lab rotation and to current research in the field through seminar. Students will also gain preparation and guidance on other first-year academic requirements.
Restriction: Must be in ENGR: PhD Only-Bioengineering (Doctoral) program.

BIOE606 BIOE Graduate Studies II (1 Credit)
Second semester continued acclimation to the bioengineering graduate program. Students gain exposure to departmental research through lab rotation and to current research in the field through seminar.
Restriction: Must be in ENGR: PhD Only-Bioengineering (Doctoral) program.
BIOE608 Bioengineering Seminar Series (1 Credit)
A variety of topics related to Bioengineering will be presented in weekly seminars.
**Restriction:** Must be in one of the following programs (ENGR: PhD Only-Bioengineering (Master's); ENGR: PhD Only-Bioengineering (Doctoral)).
**Repeatable to:** 6 credits if content differs.

BIOE611 Advanced Tissue Engineering (3 Credits)
A review of the fundamental principles involved in the design of engineered tissues and organs. Both biological and engineering fundamentals will be considered.
**Prerequisite:** Must have completed at least one biology course; and MATH241. Or permission of ENGR-Fischell Department of Bioengineering department.
**Recommended:** BSCI330 and BIOE340.
**Restriction:** Permission of ENGR-Fischell Department of Bioengineering department.

BIOE612 Physiological Evaluation of Bioengineering Designs (3 Credits)
Bioengineering designs of biomaterials, biomedical devices, imaging and drug delivery agents, tissue engineering, prosthesis (among others), offer the opportunity to improve health care. This course is aimed at providing knowledge to lead bioengineering designs on the basis of biocompatibility and to provide tools to assess their patho-physiological impact in biological systems.
**Restriction:** Permission of ENGR-Fischell Department of Bioengineering department.

BIOE614 Computational Molecular Bioengineering (3 Credits)
Introduction to the principles, methods and software used for simulation and modeling of macromolecules of biological interest. Along with experiment and theory, computational modeling provides new tools for analysis, explanation and prediction.
**Restriction:** Permission of ENGR-Fischell Department of Bioengineering department.
**Credit Only Granted for:** BIOE689D or BIOE614.
**Formerly:** BIOE689D.

BIOE631 Biosensor Techniques, Instrumentation, and Applications (3 Credits)
A thorough review of fundamental concepts of biosensing systems, principles of common detection methods, and modern applications of biosensors. Primarily literature driven. Students will obtain a detailed understanding of cutting-edge biosensing techniques, the instrumentation used, and the application space. Students also will develop skills in using current literature as a source of knowledge.
**Prerequisite:** Permission of ENGR-Fischell Department of Bioengineering department.
**Credit Only Granted for:** BIOE631, BIOE689Z, or CHPH718Z.
**Formerly:** BIOE689Z.

BIOE632 Biophotonic Imaging and Microscopy (3 Credits)
Principles and instrumentation of various biomedical optical techniques, including fluorescene and Raman spectroscopy, confocal and multi-photon microscopy, optical coherence tomography, and diffuse optical tomography. Biomedical applications will also be discussed.
**Recommended:** BIOE420.
**Restriction:** Permission of ENGR-Fischell Department of Bioengineering department.
**Credit Only Granted for:** BIOE432, BIOE632, or BIOE689C.

BIOE640 Polymer Physics (3 Credits)
Graduate course covering theoretical aspects of the behavior of polymeric materials. It covers statistical properties and thermodynamics of single chain and multichain systems.
**Prerequisite:** ENMA471; or permission of instructor. Also offered as: ENMA620.
**Credit Only Granted for:** ENMA620 or BIOE640.

BIOE645 Advanced Engineering Start Up Ventures (3 Credits)
Covers principles and practices important to engineering startup ventures, especially those involving bioengineering and medical device enterprises, and includes the preparation of business plans and tools used to obtain funding.

BIOE650 Quantitative Physiology of the Cell (3 Credits)
Introduction to quantitative aspects of neuronal, skeletal muscle, and cardiac physiological systems, with an emphasis on cellular function and plasticity. Complements BIOE603: Electrophysiology of the Cell.
**Recommended:** MATH246, MATH141, and MATH241.
**Credit Only Granted for:** BIOE689Q or BIOE650.
**Formerly:** BIOE689Q.

BIOE653 Advanced Biomaterials (3 Credits)
Examine the relationship between structure and function of biomaterials. Study physical properties of synthetic and natural biomaterials. Understand molecular level interactions between biomolecules and biomaterials to design novel biomaterials with desirable characteristics. Application of biomaterials as implants, drug delivery systems, biosensors, and scaffold materials for tissue engineering will be covered.
**Restriction:** Permission of ENGR-Fischell Department of Bioengineering department. Also offered as: ENMA625.
**Credit Only Granted for:** ENMA625 or BIOE653.

BIOE689 Special Topics in Bioengineering (1-3 Credits)
Research Oriented Individual Instruction course.
**Repeatable to:** 6 credits if content differs.

BIOE799 Master's Thesis Research (1-6 Credits)

BIOE898 Pre-Candidacy Research (1-8 Credits)

BIOE899 Doctoral Dissertation Research (1-8 Credits)