BIOE - BIOENGINEERING

BIOE120 Biology for Engineers (3 Credits)
Introduction to the functions and interactions of biological systems from a quantitative perspective. Introduction to the modern experimental techniques and methods of data analysis. Roles for bioengineers in biology, and the role of biology in bioengineering will be elucidated.
Prerequisite: Must have completed or be concurrently enrolled in MATH140.
Restriction: Permission of ENGR-Fischell Department of Bioengineering department.

BIOE121 Biology for Engineers Laboratory (1 Credit)
Bioengineering encompasses numerous sub-disciplines that apply engineering principles to analyze biological systems and that utilize engineering design strategies to solve biological and biomedical problems. This course is aimed at providing students with the opportunity to learn how biology and engineering can synergistically contribute to our understanding of such problems, and to gain hands-on experience in basic techniques relevant to Bioengineering.
Prerequisite: Must have completed or be concurrently enrolled in BIOE120.
Restriction: Permission of ENGR-Fischell Department of Bioengineering department.

BIOE221 Academic and Career Planning (1 Credit)
Provides practical tools to help Bioengineering majors think critically about their goals and career paths. Guides Bioengineering students through accessing useful resources both on- and off-campus.
Prerequisite: BIOE120 and BIOE121.
Restriction: Permission of ENGR-Fischell Department of Bioengineering department.

BIOE232 Bioengineering Thermodynamics (3 Credits)
A quantitative introduction to thermodynamic analysis of bioengineering systems. Bioengineering encompasses a wide range of applications from nanoscale interactions (e.g. reactions between molecules), to cellular interactions (e.g. membrane electrical currents), to overall balances on organisms, all the way to large scale manufacturing. Each of these applications (and many others not mentioned) involve energy interactions which is the domain of thermodynamics. The basic laws of thermodynamics will be introduced and explained through a series of examples related to bioengineering systems.
Prerequisite: PHYS261 and PHYS260.
Restriction: Permission of ENGR-Fischell Department of Bioengineering department.
Credit Only Granted for: BIOE232, ENES232, ENME232, or ENME320.

BIOE241 Biocomputational Methods (3 Credits)
Application of computer technology to biological and natural resource systems considering engineering aspects. Designed to help students in the use of computer technology for problem solving. The course will cover 4-5 software packages important for later use by the student.
Restriction: Permission of ENGR-Fischell Department of Bioengineering department.

BIOE331 Biofluids (3 Credits)
Principles and applications of fluid mechanics with a focus on bioengineering topics. Content includes conservation of mass, momentum, and energy, as well as the application of these fundamental relations to hydrostatics, control volume analysis, internal and external flow, and boundary layers. Applications to biological and bioengineering problems such as tissue engineering, bioprocessing, imaging, and drug delivery.
Prerequisite: MATH246, BIOE120, BIOE121, BIOE241, and BIOE371; and must have completed or be concurrently enrolled in BIOE232.
Restriction: Permission of ENGR-Fischell Department of Bioengineering department.
Credit Only Granted for: BIOE331, ENCE305, ENFP300 or ENME331.

BIOE332 Transport Process Design (3 Credits)
Fluid flow, heat transfer, and mass transfer with applications in medicine, environment, biotechnology, food, agriculture, and other biosystems. Design of solutions to current problems in biological engineering is emphasized.
Prerequisite: BIOE331.
Restriction: Permission of ENGR-Fischell Department of Bioengineering department.

BIOE340 Modeling Physiological Systems and Lab (4 Credits)
Topics covered will include cell and general physiology, membrane physiology, blood cells and clotting, circulation, metabolism, respiration, and the nervous system. A lab component will also be included.
Prerequisite: BSCI330, BIOE120, BIOE121, BIOE241, and MATH246.
Restriction: Permission of ENGR-Fischell Department of Bioengineering department.
Credit Only Granted for: BIOE340 or (BSCI440 and BSCI441).

BIOE371 Linear Systems and Ordinary Differential Equations for Bioengineering Applications (3 Credits)
This class utilizes fundamentals in linear systems, including eigenvalues and eigenvectors, as well as linear differential equations, to study various problems in bioengineering and biological systems, with a particular emphasis on feedback, stability, controllability, and control design.
Prerequisite: BIOE241; and must have completed or be concurrently enrolled in MATH246.
Restriction: Permission on ENGR-Fischell Department of Bioengineering department.

BIOE372 Biostatistics for Experimental Design and Data Analysis (3 Credits)
This course will instruct students in the fundamentals of probability and statistics through examples in biological phenomenon, the design of bioengineering experiments, and clinical data analysis. Fundamentals covered in the course include probability distributions, hypothesis testing, power analysis, regression analysis, and correlation analysis.
Prerequisite: BIOE120, BIOE121, and BIOE241.
Recommended: MATH246.
Restriction: Permission of ENGR-Fischell Department of Bioengineering department.
Credit Only Granted for: BIOE372 or STAT464.

BIOE389 Special Projects in Bioengineering (1-3 Credits)
Exploring a variety of projects in Bioengineering.
Restriction: Permission of instructor; and permission of ENGR-Fischell Department of Bioengineering department.
Repeatable to: 6 credits.

BIOE399 Independent Study in Bioengineering (1-3 Credits)
Independent study.
Prerequisite: Permission of ENGR-Fischell Department of Bioengineering department.
Repeatable to: 12 credits if content differs.

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; and must have completed or be concurrently enrolled in BIOE371.
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 BIOE340.
Restriction: Permission of ENGR-Fischell Department of Bioengineering department.
Credit Only Granted for: BIOE411 or CHBE487.

BIOE413 Stem Cell Engineering (3 Credits)
Provides an introduction to the role of stem cells in tissue growth and development, the engineering of stem cells and their environments for regenerative medicine applications, and disease modeling. Topics covered will include basic stem cell biology and mechanobiology; experimental methods for growing, differentiating, studying, and characterizing stem cells; stem cell integration into engineered microenvironments (e.g., tissue scaffolds and biomaterials, organ-on-chip devices, 3D-printed biomaterials); stem cell engineering in clinical applications and disease models; and ethical, commercialization, and regulatory issues in the field of stem cell engineering.
Prerequisite: BIOE241, BIOE120, BIOE121, MATH246, and BIOE340.
Restriction: Permission of ENGR-Fischell Department of Bioengineering department. Jointly offered with: BIOE613.
Credit Only Granted for: BIOE413, BIOE689J or BIOE613.

BIOE414 Macroscale Biomechanics (3 Credits)
An overview of current problems in movement biomechanics. After taking this course, students will be able to 1) Describe the engineering tools needed to study human movement 2) Recognize a variety of clinical research and practice, and 3) Use the framework provided by the course to pursue their own self-teaching and research on these topics. Topics covered include muscle mechanics, joint mechanics, EMG and EEG signal applications, ultrasonography and elastography, anthropometry, human movement 3-D kinematics, inverse dynamics, forward dynamics, work, power and energy. Biomechanics tools will be used to investigate clinical problems. Students will also do research projects on related topics.
Prerequisite: BIOE120, BIOE121, BIOE241, MATH246, and ENES102.
Restriction: Permission of ENGR-Fischell Department of Bioengineering department.
Credit Only Granted for: BIOE414 or BIOE489Z.
Formerly: BIOE489Z.

BIOE416 Cardiovascular Engineering (3 Credits)
An overview of engineering applications in the cardiovascular system. Covers cardiovascular anatomy, physiology and pathophysiology in the context of cell and tissue mechanics, fluid mechanics, thermodynamics, biotransport, neurovascular coupling, and imaging. Includes design of cardiovascular devices, sensors, biomaterials, and tissue engineered constructs.
Prerequisite: BIOE331 and BIOE340.
Restriction: Permission of ENGR-Fischell Department of Bioengineering department.
Credit Only Granted for: BIOE416 or BIOE489V.
Formerly: BIOE489V.

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.

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.

BIOE433 Optical Microscopy (3 Credits)
Includes a large variety of techniques central in many fields of biological and engineering research as well as clinical medicine. This course will provide a comprehensive overview of the fundamentals of optical microscopy. At a fundamental level, the course will cover the interaction of light with tissue, cells and biomaterials, and the mathematical foundations that describe optical systems.
Prerequisite: BIOE120, BIOE121, BIOE241, BIOE371, and MATH246.
Restriction: Permission of ENGR-Fischell Department of Bioengineering department.
Credit Only Granted for: BIOE489I or BIOE433.
Formerly: BIOE489I.

BIOE437 Computer-Aided Design in Bioengineering (3 Credits)
Introduction to Computer-Aided Design (CAD). 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.

BIOE442 Python: Introduction to Programming and Data Analysis (3 Credits)
Provides an introduction to structured programming, computational methods, and data analysis techniques with the goal of building a foundation allowing students to confidently address problems in research and industry. Fundamentals of programming, algorithms, and simulation are covered from a general computer science perspective, while the applied data analysis and visualization portion makes use of the Python SciPy stack.
Prerequisite: BIOE241, BIOE120, BIOE121, and MATH241; or permission of ENGR-Fischell Department of Bioengineering department.
Restriction: Permission of ENGR-Fischell Department of Bioengineering department.
Credit Only Granted for: BIOE489A or BIOE442.
Formerly: BIOE489A.

BIOE447 Clinical Experiences in Bioengineering (3 Credits)
An immersion experience in the clinical settings in which biomedical engineering strategies, technologies, and practices are applied. An emphasis will be placed on both clinical problems and engineering solutions.
Prerequisite: BIOE221.
Restriction: Permission of ENGR-Fischell Department of Bioengineering department.
Credit Only Granted for: BIOE489O or BIOE447.
Formerly: BIOE489O.

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.

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.

BIOE461 Synthetic Biology and Biological Engineering (3 Credits)
Students are introduce 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.

BIOE462 Therapeutic Development and Delivery (3 Credits)
The ultimate purpose of the pharmaceutical and biotechnology industries is the development and delivery of therapeutics. This course covers fundamentals of engineering and the pharmaceutical sciences related to therapeutics, including basic pharmaceutics/drug delivery, pharmacokinetics, biomolecular kinetics, and regulatory issues. Specific focus is placed on biotherapeutics, including antibodies and protein engineering,RNA and DNA therapeutics (gene therapy and RNAi), extracellular vesicle biotechnology (exosomes), and cell-based therapies, including stem cells. The use of delivery technologies to enable therapeutics (e.g. nanomedicine) will also be discussed.
Prerequisite: BIOE120, BIOE121, BIOE241, MATH246, and BSCI330; and must have completed or be concurrently enrolled in BIOE340.
Restriction: Permission of ENGR-Fischell Department of Bioengineering department.
Credit Only Granted for: BIOE489P or BIOE462.
Formerly: BIOE489P.

BIOE464 Introduction to Computational Molecular Bioengineering (3 Credits)
Designed to introduce students to the principles, methods, and software used for simulation and modeling of macromolecules of biological interest such as proteins, lipids, and polysaccharides. Along with experiment and theory, computational modeling provides new tools for analysis, explanation and prediction. The course is also useful for students who plan to use experimental techniques as their primary approach, but who will employ computational modeling as a tool to obtain integrative understanding of complex systems. Finally, the course should be valuable as an introductory overview for students planning to conduct their thesis research in computational modeling of biological systems. Class topics: Basic statistical thermodynamics, Force fields, Molecular dynamics/ monte carlo methods, Conformational analysis, Fluctuations & transport properties, Free-energy calculations, Multiscale modeling.
Prerequisite: BIOE120, BIOE241, MATH246, BIOE232, and BIOE372; or permission of ENGR-Fischell Department of Bioengineering department.
Restriction: Permission of ENGR-Fischell Department of Bioengineering department.
Credit Only Granted for: BIOE489N or BIOE464.
Formerly: BIOE489N.

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.

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.

BIOE488 Research Methods in Bioengineering (1-3 Credits)
Exploring a variety of research methods in the field of Bioengineering.
Restriction: Permission of ENGR-Fischell Department of Bioengineering department.
Repeatable to: 9 credits if content differs.

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.