Biological Engineering (BIOL_EN)

BIOL_EN 1000: Introduction to Biological Engineering
For first semester engineering students. Develop appreciation for professional engineering. Students will participate with senior design students to conceptualize a case-study problem.

Credit Hour: 1-2

BIOL_EN 2000: Professional Development in Engineering
(same as BME 2000). A review of professional opportunities, registration, ethics, and societies. Graded on A-F basis only.

Credit Hours: 2
Prerequisites: sophomore standing

BIOL_EN 2080: Introduction to Programming for Engineers
(same as BME 2080). This course teaches how to write scientific programs for analysis of data and simulation of physical phenomena using Matlab. Graded on A-F basis only.

Credit Hours: 3
Prerequisites: MATH 1500

BIOL_EN 2180: Engineering Analysis of Bioprocesses
(same as BME 2180). Material and Energy Balances. Integrating principles of physics, chemistry and mathematics to analyze steady state and transient biological/biomedical processes. Graded on A-F basis only.

Credit Hours: 3
Prerequisites: MATH 1700, CHEM 1320, PHYSICS 2750. Restricted to Biological Engineering students only
Recommended: BIOL_EN 2080

BIOL_EN 3070: Biological Fluid Mechanics
(same as BME 3070). Basic principles of fluid mechanics applied to transport processes in biological systems. Graded on A-F basis only.

Credit Hours: 3
Prerequisites: PHYSCS 2750 and MATH 1700

BIOL_EN 3075: Introduction to Materials Engineering
(same as BME 3075). Course covers concepts and techniques in materials engineering from an engineering design perspective, materials requirements for design, and fundamentals; intended for undergraduate engineering students. Graded on A-F basis only.

Credit Hours: 3
Prerequisites: MATH 2300, ENGINR 1200
Corequisites: One of the following BIOL_EN 3180, CH_ENG 3261, MAE 4231, MAE 4300, or instructor consent

BIOL_EN 3170: Biomaterials
(same as BME 3170). Engineering sciences and design will be leverage for the study and design of biomaterials. Understanding the structure-property relationship between biomaterials and tissue will be addressed for implant design.

Credit Hours: 3
Corequisites: BIOL_EN 2180, ENGINR 2200 or instructor's consent

BIOL_EN 3170W: Biomaterials - Writing Intensive
(same as BME 3170W). Engineering sciences and design will be leverage for the study and design of biomaterials. Understanding the structure-property relationship between biomaterials and tissue will be addressed for implant design.

Credit Hours: 3
Prerequisites: BIOL_EN 3075 or BME 3075
Corequisites: BIOL_EN 2180, ENGINR 2200 or instructor's consent

BIOL_EN 3180: Heat and Mass Transfer in Biological Systems
(same as BME 3180). Principles of heat and mass transfer and their applications in biomedical, bioenvironmental, and bioprocessing engineering.

Credit Hours: 3
Prerequisites or Corequisites: ENGINR 2300 or CH_ENG 3261
Prerequisites: BIOL_EN 2180 or CH_ENG 2225

BIOL_EN 4001: Topics in Biological Engineering
Current and new technical developments in biological engineering.

Credit Hour: 3-9
Prerequisites: instructor's consent

BIOL_EN 4070: Bioelectricity
(cross-leveled with BIOL_EN 7070). Application of engineering approaches to understand bioelectricity at the cellular level including the equivalent circuit of cell membranes and the electronic design of patch-clamp amplifiers.

Credit Hours: 3
Prerequisites: PHYSCS 2760 and BIOL_EN 3180

BIOL_EN 4085: Problems in Biological Engineering
Supervised independent study at the undergraduate level.

Credit Hours: 1-5
Prerequisites: instructor's consent

BIOL_EN 4150: Soil and Water Conservation Engineering
(same as CV_ENG 4710; cross-leveled with BIOL_EN 7150, CV_ENG 7710). Urban and rural run-off and erosion analysis. Design and layout of erosion control structures.

Credit Hours: 3
Recommended: BIOL_EN 2180 or CV_ENG 3200

BIOL_EN 4160: Food Process Engineering
(cross-leveled with BIOL_EN 7160). Food engineering is an interdisciplinary field that connects agricultural and biological engineering, chemical engineering, food science, biochemistry, human nutrition, and other fields involving food systems to improve the health of people and planet. The course introduces underlying engineering principles in food processing, and unit operations in food industries. Topics include fluid flow, heat transfer in food processing, preservation process, dehydration, refrigeration, food freezing, psychrometrics, food packaging, emerging technologies, and sustainability.
Biol_EN 4170: Biomaterials Interfaces of Implantable Devices
(same as BME 4170; cross-leveled with Biol_EN 7170). Surface structures and properties to improve biocompatibility will be studied. Engineering sciences and design will be leverage in the design of an improved biocompatible surface.

Credit Hours: 3
Prerequisites: Biol_EN 3170

Biol_EN 4231: Transport Phenomena in Materials Processing
(same as MAE 4231; cross-leveled with Biol_EN 7231, MAE 7231). Applications of fluid flow, heat transfer, and mass transfer in steady-state and unsteady-state materials processing with applications to metals, polymers, and ceramics. Graded on A-F basis only.

Credit Hours: 3
Prerequisites: Biologic_EN 3170

Biol_EN 4250: Irrigation and Drainage Engineering
(cross-leveled with Biol_EN 7250). Soil, water, plant relationships. Water supplies and design of surface, sprinkler and drip irrigation systems. Surface and tile drainage.

Credit Hours: 3
Prerequisites or Co-requisites: CV_ENG 3700 or MAE 3400 or Biol_EN 2180

Biol_EN 4270: Design of Experiments and Statistical Quality Control for Process Engineers
(same as CH_ENG 4270; cross-leveled with Biol_EN 7270, CH_ENG 7270). A practical statistical tool box for experimenters including comparison of process means, effects of variables, design and interpretation of factorial experiments, and statistical quality control.

Credit Hours: 3
Recommended: experience with Excel or instructor's consent

Biol_EN 4310: Feedback Control Systems
(same as ECE 4310, MAE 4750; cross-leveled with Biol_EN 7310, ECE 7310, MAE 7750). System modeling and time and frequency response, closed loop control, stability, continuous system design, introduction to discrete time control, software and hardware experiments on compensator design and PID control. Graded on A-F basis only.

Credit Hours: 3
Prerequisites: Math 4100 and junior/senior standing

Biol_EN 4315: Principles of Biochemical Engineering
(same as CH_ENG 4315; cross-leveled with Biol_EN 7315, CH_ENG 7315). This course serves as an introduction to the application of biological, biochemical, and engineering fundamentals for biochemical processing. Topics include biological basics, enzyme kinetics, metabolic pathways, cell growth kinetics, analysis of intracellular flux, thermodynamics of biological reactions, and bioreactor design and modeling. Analyses proceed through the use of mass balances, energy balances, and empirical or theoretical models.

Credit Hours: 3

Prerequisites: Biol_EN 2180 (for Biological Engineering students) or CH_ENG 2225 (for Chemical Engineering students) or Instructor's consent

Biol_EN 4316: Biomass Refinery Operations
(same as CH_eng 4316; cross-leveled with Biol_EN 7316, CH_ENG 7316). Design and operation of processes for conversion and/or fractionation of biomass and associated upstream and downstream unit operations. Emphasis on separations and product recovery.

Credit Hours: 3
Recommended: Biol.EN 3180 (for Biological Engineering students) or instructor's consent

Biol_EN 4350: Watershed Modeling Using GIS
(same as CV_ENG 4720; cross-leveled with Biol_EN 7350, CV_ENG 7720). Watershed evaluation using AVSWAT for hydrology, sediment yield, water quality; includes USLE, MUSLE, WEPP. Procedures for model calibration/sensitivity data analysis.

Credit Hours: 3
Recommended: Biol_EN 2180 or CH_ENG 2225 (for Chemical Engineering students) or instructor's consent

Biol_EN 4360: Biomanufacturing Technologies
(same as BME 4360). This course is an introduction to biomanufacturing technologies and processes for manufacturing biological products (e.g., vaccine, antibodies, and therapeutic proteins). It mainly covers process development, unit operations, product evaluation, facilities, and regulatory compliance. It is an interdisciplinary course of biochemistry, microbiology, and engineering. The purpose of this course is to help the students acquire the knowledge of modern biomanufacturing and prepare them for rapidly growing fields in biomanufacturing. Graded on A-F basis only.

Credit Hours: 3
Prerequisites: Biol_EN 2180 and Biol_EN 3180 (for biological engineering students) or CH_ENG 2225 and CH_ENG 3234 (for chemical engineering students) -or- Consent of instructor

Biol_EN 4370: Orthopaedic Biomechanics
(same as BME 4370; cross-leveled with Biol_EN 7370). Engineering sciences will be leverage to create a comprehensive study of orthopaedic biomechanics. The tissue mechanics of bone and soft tissue will be studied along with applying structural analysis of the musculoskeletal system. Graded on A-F basis only.

Credit Hours: 3
Prerequisites: Biol_EN 2180 or CV_ENG 3200 or instructor's consent

Biol_EN 4380: Applied Electronic Instrumentation
(same as BME 4380; cross-leveled with Biol_EN 7380). Fundamental concepts and theories, basic electronics, analog and digital circuits, signal conditioning, computer interfacing, measurement principles and techniques used in developing computer-based instrumentation systems. Graded on A-F basis only.

Credit Hours: 4
**Prerequisites:** PHYSCS 2750

**BIOL_EN 4420: Introduction to Biomedical Imaging**
(same as BME 4420, PHYSCS 4420; cross-leveled with BIOL_EN 7420, PHYSCS 7420). This course offers a broad introduction to medical imaging. Topics to be covered include the physics basics and instrumentation of X-ray CT, PET, SPECT, ultrasound, MRI and Optical Imaging, as well as recent developments in biomedical imaging.

**Credit Hours:** 3  
**Prerequisites:** PHYSCS 2760

**BIOL_EN 4470: Biomolecular Engineering and Nanobiotechnology**
(same as BME 4470; cross-leveled with BIOL_EN 7470). Generation of biotechnological products, devices through integration of engineering approaches with contemporary biology, chemistry and nanotechnology starting at the molecular level. Graded on A-F basis only.

**Credit Hours:** 3  
**Prerequisites:** MATH 1700, PHYSCS 2760, CHEM 2100
**Recommended:** Senior/graduate standing or instructor's consent

**BIOL_EN 4470H: Biomolecular Engineering and Nanobiotechnology - Honors**
(cross-leveled with BIOL_EN 7470). Generation of biotechnological products, devices through integration of engineering approaches with contemporary biology, chemistry and nanotechnology starting at the molecular level. Graded on A-F basis only.

**Credit Hours:** 3  
**Prerequisites:** MATH 1700, PHYSCS 2760, CHEM 2100. Honors eligibility required  
**Recommended:** Senior/graduate standing or instructor's consent

**BIOL_EN 4480: Physics and Chemistry of Materials**
(same as PHYSCS 4190, CHEM 4490, NU_ENG 4319, BME 4480; cross-leveled with BIOL_EN 7480, PHYSIC 7190, CHEM 7490, NU_ENG 7319). Physics and Chemistry of Materials is a 3 credit hours course offered every spring semester for students from Physics, Chemistry, Engineering and Medical Departments and consists of lectures, laboratory demonstrations, two mid-term and one final exam. Graded on A-F basis only.

**Credit Hours:** 3  
**Prerequisites:** PHYSCS 2750, CHEM 1320 or equivalent, or instructor's consent

**BIOL_EN 4570: Fluorescent Imaging**
(same as BME 4570; cross-leveled with BIOL_EN 7570). Principles and applications of fluorescent imaging. The course covers: Image formation in microscope; Fundamentals of fluorescence and fluorescent microscopy; molecular and cellular fluorescent imaging.

**Credit Hours:** 3  
**Prerequisites:** BIO_SC 1500 and BIOL_EN 2180 or instructor's consent

**BIOL_EN 4590: Computational Neuroscience**
(same as BIO_SC 4590, ECE 4590, BME 4590; cross-leveled with BIOL_EN 7590, BIO_SC 7590, ECE 7590). An interdisciplinary course with a strong foundation in quantitative science for students in biological-behavioral sciences. Graded on A-F basis only.

**Credit Hours:** 4  
**Prerequisites:** BIO_SC 1010, BIO_SC 1500; MATH 1500

**BIOL_EN 4770: Biomedical Optics**
(same as BME 4770, cross-leveled with BIOL_EN 7770). Essential concepts and methods for applying optical techniques to biomedical diagnosis and therapy will be covered with major application examples being discussed.

**Credit Hours:** 3  
**Prerequisites:** PHYSCS 2760  
**Recommended:** BIOL_EN 3180

**BIOL_EN 4940: Engineering Internship**
(same as BME 4940). Problem course following prior approved work experience. Problem selected by internship company representative, faculty problem adviser and student. Supervised by faculty problem advisor and presented in engineering report form. Graded on S/U basis only.

**Credit Hour:** 1-3  
**Prerequisites:** advisor's consent

**BIOL_EN 4980: Bioengineering Design I**
(same as BME 4980). Capstone design course for Biological Engineering or Biomedical Engineering major. Design of devices or processes for biological or biomedical applications.

**Credit Hours:** 3  
**Prerequisites:** Senior standing or instructor's consent

**BIOL_EN 4980W: Bioengineering Design I - Writing Intensive**
(same as BME 4980W). Capstone design course for Biological Engineering or Biomedical Engineering major. Design of devices or processes for biological or biomedical applications.

**Credit Hours:** 3  
**Prerequisites:** ENGLISH 1000 and senior standing or instructor's consent

**BIOL_EN 4985: Bioengineering Design II**
(same as BME 4985). Second term of capstone, senior design course for the Biomedical Engineering major. Design of biological system devices or processes. Includes prototyping and testing of design. Graded on A-F basis only.

**Credit Hour:** 1-3  
**Prerequisites:** BIOL_EN 4980 or BME 4980

**BIOL_EN 4990: Undergraduate Research in Biological Engineering**
Supervised independent study at the undergraduate level.

**Credit Hour:** 1-5  
**Prerequisites:** instructor's consent

**BIOL_EN 4995: Undergraduate Honors Research in Biological Engineering**
Open only to honor students in Biological Engineering. Independent investigation in biological engineering to be presented as a thesis.

**Credit Hour:** 1-5  
**Prerequisites:** advisor's consent
BIOL_EN 4995H: Undergraduate Honors Research in Biological Engineering
Open only to honor students in Biological Engineering. Independent investigation in biological engineering to be presented as a thesis.
Credit Hour: 1-5
Prerequisites: advisor's consent. Honors eligibility required

BIOL_EN 7001: Topics in Biological Engineering
Study of advanced developments in biological engineering.
Credit Hour: 1-3

BIOL_EN 7070: Bioelectricity
(cross-leveled with BIOL_EN 4070). Application of engineering approaches to understand bioelectricity at the cellular level including the equivalent circuit of cell membranes and the electronic design of patch-clamp amplifiers. Prerequisites: PHYSICS 2760 and BIOL_EN 3180 or instructor's consent
Credit Hours: 3

BIOL_EN 7150: Soil and Water Conservation Engineering
(same as CV_ENG 7710; cross-leveled with BIOL_EN 4150, CV_ENG 4150). Urban and rural run-off and erosion analysis. Design and layout of erosion control structures.
Credit Hours: 3
Prerequisites: BIOL_EN 2180 or CV_ENG 3200, or instructor's consent

BIOL_EN 7160: Food Process Engineering
(cross-leveled with BIOL_EN 4160). Food engineering is an interdisciplinary field that connects agricultural and biological engineering, chemical engineering, food science, biochemistry, human nutrition, and other fields involving food systems to improve the health of people and planet. The course introduces underlying engineering principles in food processing, and unit operations in food industries. Topics include fluid flow, heat transfer in food processing, preservation process, dehydration, refrigeration, food freezing, psychrometrics, food packaging, emerging technologies, and sustainability.
Credit Hours: 3
Prerequisites: BIOL_EN 3180 or instructor's consent

BIOL_EN 7170: Biomaterials Interfaces of Implantable Devices
(cross-leveled with BIOL_EN 4170, BME 4170). Surface structures and properties to improve biocompatibility will be studied. Engineering sciences and design will be leverage in the design of an improved biocompatible surface.
Credit Hours: 3
Prerequisites: BIOL_EN 3170 or instructor's consent

BIOL_EN 7250: Irrigation and Drainage Engineering
(cross-leveled with BIOL_EN 4250). Soil, water, plant relationships. Water supplies and design of surface, sprinkler and drip irrigation systems. Surface and tile drainage.
Credit Hours: 3
Prerequisites: CV_ENG 3700 or MAE 3400 or BIOL_EN 2180

BIOL_EN 7310: Feedback Control Systems
(same as ECE 7310, MAE 7750; cross-leveled with ECE 4310, BIOL_EN 4310, MAE 4750). System modeling and time and frequency response, closed loop control, stability, continuous system design, introduction to discrete time control, software and hardware experiments on compensator design and PID control. Graded A-F only. May be repeated for credit.
Credit Hours: 3
Prerequisites: MATH 4100

BIOL_EN 7315: Introduction to Bioprocess Engineering
(same as CH_ENG 7315; cross-leveled with BIOL_EN 4315, CH_ENG 4315). This course serves as an introduction to the application of biological, biochemical, and engineering fundamentals for biochemical processing. Topics include biological basics, enzyme kinetics, metabolic pathways, cell growth kinetics, analysis of intracellular flux, thermodynamics of biological reactions, and bioreactor design and modeling. Analyses proceed through the use of mass balances, energy balances, and empirical or theoretical models.
Credit Hours: 3
Prerequisites: BIOL_EN 2180 (for Biological Engineering students) or CH_ENG 2225 (for Chemical Engineering students) or Instructor's consent
Recommended: BIOL_EN 3180 (for Biological Engineering students) or CH_ENG 3234 (for Chemical Engineering students) as a prerequisite or a co-requisite

BIOL_EN 7316: Biomass Refinery Operation
(same as CH_ENG 7316; cross-leveled with BIOL_EN 4316, CH_ENG 4316). Design and operation of processes for conversion and/or fractionation of biomass and associated upstream and downstream unit operations. Emphasis on separations and product recovery.
Credit Hours: 3
Prerequisites: BIOL_EN 2180 or CH_ENG 2225 or instructor's consent

BIOL_EN 7350: Watershed Modeling Using GIS
(same as CV_ENG 7720; cross-leveled with BIOL_EN 4350, CV_ENG 4720). Watershed evaluation using AVSWAT for hydrology, sediment yield, water quality; includes USLE, MUSLE, WEPP, Procedures for model calibration/sensitivity data analysis.
Credit Hours: 3
Prerequisites: BIOL_EN 2180 or CV_ENG 3200 or instructor's consent

BIOL_EN 7370: Orthopaedic Biomechanics
(same as V_M_S 7370; cross-leveled with BIOL_EN 4370) . Engineering sciences will be leverage to create a comprehensive study of orthopaedic biomechanics. The tissue mechanics of bone and soft tissue will be studied along with applying structural analysis of the musculoskeletal system. Graded on A-F basis only.
Credit Hours: 3
Prerequisites: ENGINR 1200 and BIOL_EN 3170, instructor's consent required
BIOL_EN 7380: Applied Electronic Instrumentation
(cross-leveled with BIOL_EN 4380; BME 4380). Fundamental concepts and theories, basic electronics, analog and digital circuits, signal conditioning, computer interfacing, measurement principles and techniques used in developing computer-based instrumentation systems. Graded on A-F basis only.

Credit Hours: 4
Prerequisites: PHYSCS 2750

BIOL_EN 7420: Introduction to Biomedical Imaging
(same as PHYSCS 7420; cross-leveled with BIOL_EN 4420, BME 4420, PHYSCS 4420). This course offers a broad introduction to medical imaging. Topics to be covered include the physics basics and instrumentation of X-ray CT, PET, SPECT, ultrasound, MRI and Optical Imaging, as well as recent developments in biomedical imaging, as well as recent developments in biomedical imaging.

Credit Hours: 3
Prerequisites: PHYSCS 2760

BIOL_EN 7470: Biomolecular Engineering and Nanobiotechnology
(cross-leveled with BIOL_EN 4470; BME 4470). Generation of biotechnological products, devices through integration of engineering approaches with contemporary biology, chemistry and nanotechnology starting at the molecular level. Graded on A-F basis only.

Credit Hours: 3
Prerequisites: MATH 1700, PHYSCS 2760, CHEM 2100
Recommended: Senior/graduate standing or instructor's consent

BIOL_EN 7480: Physics and Chemistry of Materials
(same as PHYSCS 7190, NU_ENG 7319, CHEM 7490; cross-leveled with BIOL_EN 4480, PHYSCS 4190, NU_ENG 4319, CHEM 4490, BME 4480). Physics and Chemistry of Materials is a 3 credit hours course offered every spring semester for students from Physics, Chemistry, Engineering and Medical Departments and consists of lectures, laboratory demonstrations, two mid-term and one final exam. Graded on A-F basis only.

Credit Hours: 3
Prerequisites: PHYSCS 2750, CHEM 1320 or equivalent, or instructors consent

BIOL_EN 7570: Fluorescent Imaging
(cross-leveled with BIOL_EN 4570, BME 4570). Principles and applications of fluorescent imaging. The course covers: Image formation in microscope; Fundamentals of fluorescence and fluorescent microscopy; molecular and cellular fluorescent imaging. Graded on A-F basis only.

Credit Hours: 3
Prerequisites: BIO_SC 1500 and BIOL_EN 2180 or instructor's consent

BIOL_EN 7590: Computational Neuroscience
(same as BIO_SC 7590, ECE 7590; cross-leveled with BIOL_EN 4590, BIO_SC 4590, ECE 4590; BME 4590). An interdisciplinary course with a strong foundation in quantitative science for students in biological-behavioral science. Graded on A-F basis only.

Credit Hours: 4
Prerequisites: BIO_SC 1010, BIO_SC 1500; MATH 1500

BIOL_EN 7770: Biomedical Optics
(cross-leveled with BIOL_EN 4770 and BME 4770). Essential concepts and methods for applying optical techniques to biomedical diagnosis and therapy will be covered with major application examples being discussed.

Credit Hours: 3
Prerequisites: PHYSCS 2760 and BIOL_EN 3180; or instructor's consent

BIOL_EN 8000: Scientific Discovery Leading to Life Science Innovations
(same as MPP 8000). The goal of this course is to provide participants with a conceptual and practical understanding of how life science research is conducted in a modern research institution in the US and the pathways involved in translating fundamental discoveries into products and services that affect healthcare. We will cover the transitions from initial discovery concepts to first-in-human studies, clinical trials, healthcare guidelines and policy to product development. We will provide an introduction to essential disciplines and interactions that enable scientific discoveries to move forward into novel device and drug therapies. Participants will come away with a very complete picture of how medical research happens, including: how it is funded; what is required to make discoveries and record and protect intellectual property that is created; how to advance innovations to clinical practice, how to navigate the regulatory and bioethical environment, and how discoveries reach practitioners and benefit patients. The Course is the first in a three course sequence leading to a Graduate Certificate in Life Science Innovation and Entrepreneurship. Graded on A-F basis only.

Credit Hours: 3
Prerequisites: Must be Graduate Standing or receive certificate program director's approval

BIOL_EN 8001: Advanced Topics in Biological Engineering
Study of advanced developments in biological engineering.
Credit Hour: 1-3

BIOL_EN 8085: Problems in Biological Engineering
Supervised individual study at the graduate level.
Credit Hour: 1-99
Prerequisites: departmental consent

BIOL_EN 8087: Seminar in Biological Engineering
Recent investigations in biological engineering and related fields. Discussion of current literature; preparation and presentation of papers.
Credit Hour: 1

BIOL_EN 8100: Design and Development of Biomedical Innovations
(same as ENGINR 8100, MPP 8100). The overarching goal of this course is to help participants understand the design and development (drug or device) process in biomedical innovation. This course will help participants to understand the process of choosing unmet clinical needs, articulate a need statement without integrating solution, design and develop a solution. Participants will learn to assess the commercial potential of clinical needs by performing market analysis and valuing customer needs. A conceptual understanding about development of a prototype for a device and also drug development by
different brainstorming process will be provided. Details of regulatory, reimbursement, patenting process required for product development will be explained with examples. An overview about how to evaluate preliminary designs, define product specifications, comply with manufacturing principles and methods, costs, cGMP requirements will be explained. Quality control and Quality assurance necessities for drug/device will be elucidated with case studies. Participants will gain knowledge about different business models for drug and devices, estimate market penetration and how to make profitable, patient-driven products. Graded on A-F basis only.

**BIOL_EN 8170: Sensors and Biosensors**
The course covers basic principles of chemical and biological sensors, such as immobilization techniques, transducers (optical, electrical, etc.) and performance factors.

**Credit Hours:** 3

**BIOL_EN 8180: Numerical Methods in Engineering Research**
Numerical techniques and case studies in Biological Engineering. Topics include basic numerical methods, mathematical representation of data, matrix algebra, ordinary and partial differential equations.

**Credit Hours:** 3

**Prerequisites:** MATH 4100

**BIOL_EN 8230: Advanced Ceramic Materials**
(same as CH_ENG 8230, MAE 8230). To provide an advanced level understanding between processing, properties, and microstructure of ceramic materials. Topics include crystallography, defect chemistry, transport properties, microstructure, and forming methods. Graded on A-F basis only.

**Credit Hours:** 3

**Prerequisites:** MATH 1500, Computer Engineering and Computer Science course, SOIL 4307 or SOIL 7307 and Soil Conservation course

**BIOL_EN 8250: Water Management Theory**
Advanced studies in erosion control, irrigation, and drainage. Water resources engineering.

**Credit Hours:** 3

**Prerequisites:** MATH 1500, Computer Engineering and Computer Science course

**BIOL_EN 8280: Advanced Biological Transport Processes**
Principles of fluid flow, heat transfer, and mass transfer applied to (a) understanding of how the human body functions (from the cellular up to the system level) and (b) designing biomedical devices. An independent project/case-study of a relevant research topic also required.

**Credit Hours:** 3

**BIOL_EN 8370: Materials Characterization Techniques**
Concepts and techniques in characterizing materials, including bulk and surface analyses. Techniques are presented in terms of use, sample requirements, and the engineering principles. Topics include: contact angle measurement, XPS, SEM, TEM, STM, AFM, XRD, and thermal analyses.

**Credit Hours:** 3

**Prerequisites:** at least one undergraduate course in material science, engineer, or design

**BIOL_EN 8402: Research Methods**
(same as F_S 8402). Review of literature; planning research projects; publication procedures.

**Credit Hours:** 2

**BIOL_EN 8470: Ultrasensitive Biodetection**
Multiplexing single-molecule, single-cell, nanobiotech analytical techniques to improve disease diagnosis, treatment, and understanding of biophenomena (membrane transport, gene expression, enzyme activities, cell communications). Graded A-F only.

**Credit Hours:** 3

**Prerequisites:** Instructor's consent required

**BIOL_EN 8570: Microscopic Imaging**
Advanced topics in microscopic imaging with focus on applications of molecular and cellular imaging using fluorescent microscopy.

**Credit Hours:** 3

**Prerequisites:** BIOL_EN 7570 or instructor's consent

**BIOL_EN 8670: Orthopaedic Failure Modes and Effect Analysis**
Engineering sciences will be leveraged provide a comprehensive study of failure modes and related effects for orthopaedic devices, orthopaedic tissue repair, and surgical interventions. Clinical case studies will be analyzed to introduce real world problems of orthopaedic failures. Graded on A-F basis only.

**Credit Hours:** 3

**Prerequisites:** BIOL_EN 3170 or ENGINR 1200, BIOL_EN 4370 or BIOL_EN 7370 or instructor consent

**Recommended:** For department majors

**BIOL_EN 8870: Molecular and Cell Mechanics**
Application of mechanics and engineering principles to biological systems at the cellular and molecular levels. Graded on A-F basis only.

**Credit Hours:** 3

**Prerequisites:** ENGINR 2200

**BIOL_EN 8990: Masters Thesis Research in Biological Engineering**
Independent investigation to be presented as a thesis. Graded on S/U basis only.

**Credit Hour:** 1-99

**BIOL_EN 9990: Doctoral Dissertation Research in Biological Engineering**
Independent investigation to be presented as a thesis. Graded on S/U basis only.

**Credit Hour:** 1-99