Bioengineering

Learn more about the Bachelor of Science in Bioengineering (https://www.temple.edu/academics/degree-programs/bioengineering-major-en-bioe-bsbe).

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https://engineering.temple.edu/academics/departments/bioengineering-department

Goals, Objectives & Design Integration

The Bioengineering program will be able to integrate engineering science, rigorous mathematical tools and a quantitative approach to the life sciences and apply this spectrum of knowledge in an interdisciplinary fashion to provide solutions to basic and applied biological and medical problems.

This goal will be accomplished by offering to the students an integrated set of courses aimed at providing a thorough introduction to the complex and interdisciplinary field of Bioengineering:

- Teach engineering science, analysis, and design in the context of quantitative approaches to solving life science and medicine-related problems.
- Integrate interdisciplinary aspects of biology, physiology, and engineering within courses and design projects.
- Emphasize the interdisciplinary nature of Bioengineering, in terms of problem solving, design, within the framework of interdisciplinary teams focusing on the dialogue between "biology-inspired engineering" and "biology as a specific arm of applied engineering principles."
- Immerse students in key life science and medical principles, while focusing on understanding cell/molecular-level events through quantitative analysis and modeling.
- Provide an exceptional learning environment with significant instruction by Bioengineering faculty and researchers in collaboration with experts from other fields, especially the Health Science Campus.

In this curriculum, incoming freshmen will first and foremost be trained as solid Temple engineers, focusing on applying engineering science, design, and analysis to real life problems specifically in the areas of biology and medicine. This firm engineering foundation will be further enhanced with newly developed Bioengineering courses in specific pathways, such as:

- **Biomaterials**: A focus on the design, development, and uses of biomaterials in biology and medicine. It also explores the host-biomaterial interface and interactions.
- **Bioimaging**: A focus on design, development, and uses of imaging modalities and techniques in biology.
- **Bioinstrumentation**: A focus on the design, development, and use of instruments used to record, process, and/or control biological functions.
- **Biomechanics**: A focus on the interaction between forces and motions in tissues, organisms, and biomedical materials.
- **Tissue Engineering**: A focus on building functional tissues using cells and scaffolds and repairing diseased tissues and organs at the cellular and molecular level.
- **Neuroengineering**: A focus on using engineering to understand and interact with neural tissues.
- **Pre-Health**: A broad-based Bioengineering curriculum which fulfills current pre-health course requirements.

Hands-on engineering experience will be gained through intense laboratory coursework and by solving real-life biomedical problems.

Summary of Requirements

University Requirements

All new students are required to complete the university's General Education (GenEd (http://bulletin.temple.edu/undergraduate/general-education)) curriculum.

All Temple students must take a minimum of two writing-intensive courses for a total of at least six credits. The writing-intensive course credits are counted as part of the major; they are not General Education (GenEd) or elective credits. The writing-intensive courses must be completed at Temple University and students may not transfer in credits to satisfy this requirement. The specific writing-intensive courses required for this major are:

Code	Title	Credit Hours
ENGR 2196	Technical Communication	3
or ENGR 2996	Honors Technical Communication by Design	
ENGR 4296	Senior Design Project II	3
or ENGR 4996	Honors Senior Design Project II	

Department and Major Requirements

Code	Title	Credit Hours
Required Math & Basic Science Courses		
MATH 1041	Calculus I	4
or MATH 1941	Honors Calculus I	
MATH 1042	Calculus II	4
or MATH 1942	Honors Calculus II	
MATH 2043	Calculus III	4
or MATH 2943	Honors Calculus III	
MATH 3041	Differential Equations I	3
or MATH 3941	Honors Differential Equations I	
Select one of the following:		4
BIOL 1111	Introduction to Organismal Biology	
BIOL 1012	General Biology II	
BIOL 2112	Introduction to Cellular and Molecular Biology	
BIOL 1911	Honors Introduction to Organismal Biology	
BIOL 2912	Honors Introduction to Cellular and Molecular Biology	
Select one of the following:		3
CHEM 1031	General Chemistry I	
CHEM 1035	Chemistry for Engineers	
CHEM 1951	Honors General Chemical Science I	
CHEM 1033	General Chemistry Laboratory I	1
or CHEM 1953	Honors Chemical Science Laboratory I	
Select one of the following:		4
PHYS 1061	Elementary Classical Physics I	
PHYS 1961	Honors Elementary Classical Physics I	
PHYS 2021	General Physics I	
PHYS 2921	Honors General Physics I	
Select one of the following:		4
PHYS 1062	Elementary Classical Physics II	
PHYS 1962	Honors Elementary Classical Physics II	
PHYS 2022	General Physics II	
PHYS 2922	Honors General Physics II	
Required General Education Courses		
Select one of the following:		4
ENG 0802	Analytical Reading and Writing	
ENG 0812	Analytical Reading and Writing: ESL	
ENG 0902	Honors Literature/Reading/Writing	
IH 0851	Intellectual Heritage I: The Good Life	3
or IH 0951	Honors Intellectual Heritage I: The Good Life	
IH 0852	Intellectual Heritage II: The Common Good	3
or IH 0952	Honors Intellectual Heritage II: The Common Good	
GenEd 08xx or 09xx (Human Behavior)		3
GenEd 08xx or 09xx (Race and Diversity)		3

GenEd 08xx or 09xx (Global/World Society)		3
GenEd 08xx or 09xx (U.S. Society)		3
GenEd 08xx or 09xx (Arts)		3
Required Bioengineering & Engineering Courses (Common for all Pathways)		
BIOE 2001	Frontiers in Bioengineering	2
BIOE 2101	Engineering Principles of Physiological Systems	3
BIOE 3001	Research Design and Methods in Bioengineering	2
BIOE 3101	BioE Lab #1 - Bioelectrical Engineering	3
BIOE 3102	BioE Lab #2 - Biomaterials	3
BIOE 3201	Biomedical Instrumentation	2
BIOE 4101	BioE Lab #3 - Biomechanics	3
ENGR 1101	Introduction to Engineering & Engineering Technology	3
or ENGR 1901	Honors Introduction to Engineering	
ENGR 1102	Introduction to Engineering Problem Solving	3
ENGR 2196	Technical Communication (WI)	3
or ENGR 2996	Honors Technical Communication by Design	
ENGR 3033	Entrepreneurial Engineering	3
or BIOE 4311	The Entrepreneurial Bioengineer	
ENGR 3571	Classical and Statistical Thermodynamics	3
ENGR 4169	Engineering Seminar	1
ENGR 4296	Senior Design Project II (WI)	3
or ENGR 4996	Honors Senior Design Project II	
ENGR 4174	Senior Design Project I for Bioengineering	2
Required Bioengineering Electives (Vary by Pathway)		
BIOE Elective #1		3
BIOE Elective #2		3
BIOE Elective #3		3
Required Technical Electives (Vary by Pathway)		
Technical Elective #1		3
Technical Elective #2		4
Technical Elective #3		4
Technical Elective #4		4
Bioengineering Capstone (Vary by Pathway)		3
Free Electives		
Free Elective #1		3
Free Elective #2		3
Total Credit Hours		128

Pathway Course Plans

Biomaterials Study Plan

Code	Title	Credit Hours
Bioengineering Electives (minimum 9 credits)		
BIOE 2312	Mechanics for Bioengineering I	4
BIOE 3302	Drug Delivery	3
BIOE 3511	Interactions of Biomaterials with Living Tissues	3
Technical Electives (minimum 15 credits)		
CHEM 1032	General Chemistry II	3
CHEM 1034	General Chemistry Laboratory II	1
CHEM 2201	Organic Chemistry I	3
CHEM 2203	Organic Chemistry Laboratory I	1
CHEM 2202	Organic Chemistry II	3

CHEM 2204	Organic Chemistry Laboratory II	1
Approved Technical Elective		3
Bioengineering Capstone		
BIOE 4411	Capstone Elective: Biomaterials	3
Total Credit Hours		28

Bioimaging Study Plan

Code	Title	Credit Hours
Bioengineering Electives (minimum 9 credits)		
BIOE 4333	Applied Biospectroscopy	3
Bioengineering Elective #2		3
Bioengineering Elective #3		3
Technical Electives (minimum 15 credits)		
ECE 2332	Principles of Electric Circuits	4
ECE 2333	Principles of Electric Circuits Lab	1
ECE 3512	Signals: Continuous and Discrete	4
ENGR 2011	Engineering Analysis & Applications	3
Approved Technical Elective		3
Bioengineering Capstone		
BIOE 4451	Capstone Elective: Biomedical Imaging	3
Total Credit Hours		27

Bioinstrumentation Study Plan

Code	Title	Credit Hours
Bioengineering Electives (minimum 9 credits)		
BIOE 3301	Biomedical Signals and Systems	3
Bioengineering Elective #2		3
Bioengineering Elective #3		3
Technical Electives (minimum 15 credits)		
ECE 2332	Principles of Electric Circuits	4
ECE 2333	Principles of Electric Circuits Lab	1
ECE 3412	Classical Control Systems	3
ECE 3413	Classical Control Laboratory	1
ECE 3512	Signals: Continuous and Discrete	4
ENGR 2011	Engineering Analysis & Applications	3
Bioengineering Capstone		
BIOE 4333	Applied Biospectroscopy	3
Total Credit Hours		28

Biomechanics Study Plan

Code	Title	Credit Hours
Bioengineering Electives (minimum 9 credits)		
BIOE 2312	Mechanics for Bioengineering I	4
BIOE 3312	Mechanics for Bioengineering II	4
Approved Bioengineering Elective		3
Technical Electives (minimum 15 credits)		
ECE 2112	Electrical Devices & Systems I	3
ECE 2113	Electrical Devices & Systems I Lab	1
ENGR 1117	Engineering Graphics	2

ENGR 3117	Computer-Aided Design (CAD)	3
ENGR 3553	Mechanics of Fluids	3
MEE 2011	Linear Systems	3
or ENGR 2011	Engineering Analysis & Applications	
or MATH 2101	Linear Algebra	
Bioengineering Capstone		
BIOE 4441	Capstone Elective: Biomechanics	3
Total Credit Hours		29

Tissue Engineering Study Plan

Code	Title	Credit Hours
Bioengineering Electives (minimum 9 credits)		
BIOE 3511	Interactions of Biomaterials with Living Tissues	3
BIOE 4501	Regenerative Engineering	3
Bioengineering Elective #3		3
Technical Electives (minimum 15 credits)		
BIOL 2112	Introduction to Cellular and Molecular Biology	4
CHEM 1032	General Chemistry II	3
CHEM 1034	General Chemistry Laboratory II	1
CHEM 2201	Organic Chemistry I	3
CHEM 2203	Organic Chemistry Laboratory I	1
CHEM 2202	Organic Chemistry II	3
CHEM 2204	Organic Chemistry Laboratory II	1
CHEM 4401	Biochemistry I	3
Bioengineering Capstone		
BIOE 4461	Capstone Elective: Principles of Tissue Engineering	3
Total Credit Hours		31

Neuroengineering Study Plan

Code	Title	Credit Hours
Bioengineering Electives (minimum 9 credits)		
BIOE 3725	Cell Biology for Engineers	3
BIOE 3301	Biomedical Signals and Systems	3
Bioengineering Elective #3		3
Technical Electives (minimum 15 credits)		
BIOL 1111	Introduction to Organismal Biology	4
BIOL 3352	Systems Neuroscience	3
CHEM 1032	General Chemistry II	3
CHEM 1034	General Chemistry Laboratory II	1
CHEM 2201	Organic Chemistry I	3
CHEM 2203	Organic Chemistry Laboratory I	1
Bioengineering Capstone		
BIOE 4431	Capstone Elective: Neuroengineering	3
Total Credit Hours		27

Pre-Health Study Plan

Code	Title	Credit Hours
Bioengineering Electives (minimum 9 credits)		
BIOE 3331	Principles of Macromolecular Science	3

BIOE 3511	Interactions of Biomaterials with Living Tissues	3
Bioengineering Elective #3		3
Technical Electives (minimum 15 credits)		
BIOL 2112	Introduction to Cellular and Molecular Biology	4
CHEM 1032	General Chemistry II	3
CHEM 1034	General Chemistry Laboratory II	1
CHEM 2201	Organic Chemistry I	3
CHEM 2203	Organic Chemistry Laboratory I	1
CHEM 2202	Organic Chemistry II	3
CHEM 2204	Organic Chemistry Laboratory II	1
CHEM 4401	Biochemistry I	3
Bioengineering Capstone		
BIOE 4461	Capstone Elective: Principles of Tissue Engineering	3
Total Credit Hours		31

Suggested Academic Plan

Please note that this is a **suggested** academic plan. Depending on your **pathway**, your academic plan may look different.

Bachelor of Science in Bioengineering

Requirements for New Students starting in the 2018-2019 Academic Year

Year 1		
Fall		**Credit Hours**
MATH 1041 or 1941	Calculus I	4
Select one of the following:		3
CHEM 1031	General Chemistry I	
CHEM 1035	Chemistry for Engineers	
CHEM 1951	Honors General Chemical Science I	
CHEM 1033 or 1953	General Chemistry Laboratory I	1
ENGR 1101 or 1901	Introduction to Engineering Engineering Technology	3
ENG 0802, 0812, or 0902	Analytical Reading and Writing [GW]	4
	Term Credit Hours	15
Spring		
MATH 1042 or 1942	Calculus II	4
Select one of the following:		4
PHYS 1061	Elementary Classical Physics I	
PHYS 1961	Honors Elementary Classical Physics I	
PHYS 2021	General Physics I	
PHYS 2921	Honors General Physics I	
BIOE 2001	Frontiers in Bioengineering	2
ENGR 1102	Introduction to Engineering Problem Solving	3
IH 0851 or 0951	Intellectual Heritage I: The Good Life [GY]	3
	Term Credit Hours	16
Year 2		
Fall		
MATH 2043 or 2943	Calculus III	4
Select one of the following:		4
PHYS 1062	Elementary Classical Physics II	
PHYS 1962	Honors Elementary Classical Physics II	
PHYS 2022	General Physics II	
PHYS 2922	Honors General Physics II	
Technical Elective #1		3
ENGR 2196 or 2996	Technical Communication [WI]	3

IH 0852 or 0952	Intellectual Heritage II: The Common Good [GZ]	3
	Term Credit Hours	17
Spring		
MATH 3041 or 3941	Differential Equations I	3
ENGR 3571	Classical and Statistical Thermodynamics	3
BIOE 2101	Engineering Principles of Physiological Systems	3
Select one of the following:		4
BIOL 1111	Introduction to Organismal Biology	
BIOL 1012	General Biology II	
BIOL 2112	Introduction to Cellular and Molecular Biology	
BIOL 1911	Honors Introduction to Organismal Biology	
BIOL 2912	Honors Introduction to Cellular and Molecular Biology	
Technical Elective #2		4
	Term Credit Hours	17
Year 3		
Fall		
BIOE 3001	Research Design and Methods in Bioengineering	2
BIOE 3101	BioE Lab #1 - Bioelectrical Engineering	3
GenEd Breadth Course		3
BIOE 3201	Biomedical Instrumentation	2
BIOE Elective #1		3
Free Elective #1		3
	Term Credit Hours	16
Spring		
BIOE 3102	BioE Lab #2 - Biomaterials	3
BIOE Elective #2		4-3
GenEd Breadth Course		3
ENGR 4169	Engineering Seminar	1
Select one of the following:		2-3
ENGR 3033	Entrepreneurial Engineering	
BIOE 4311	The Entrepreneurial Bioengineer	
Technical Elective #3		4
	Term Credit Hours	17
Year 4		
Fall		
BIOE 4101	BioE Lab #3 - Biomechanics	3
ENGR 4174	Senior Design Project I for Bioengineering	2
Capstone Elective		3
GenEd Breadth Course		3
GenEd Breadth Course		3
	Term Credit Hours	14
Spring		
ENGR 4296 or 4996	Senior Design Project II [WI]	3
BIOE Elective #3		3
GenEd Breadth Course		3
Free Elective #2		3
Technical Elective #4		4
	Term Credit Hours	16
	Total Credit Hours:	128

Code	Title	Credit Hours
Technical Electives		
BIOL 1111	Introduction to Organismal Biology	4
or BIOL 1911	Honors Introduction to Organismal Biology	
BIOL 2112	Introduction to Cellular and Molecular Biology	4
or BIOL 2912	Honors Introduction to Cellular and Molecular Biology	
BIOL 3096	Cell Structure and Function	4
BIOL 3352	Systems Neuroscience	3
BIOL 3354	Neural Basis of Animal Behavior	3
CIS 1053	Programming in Matlab	4
CIS 1057	Computer Programming in C	4
Select one of the following:		4
CHEM 1032 & CHEM 1034	General Chemistry II and General Chemistry Laboratory II	
CHEM 1952 & CHEM 1954	Honors General Chemical Science II and Honors Chemical Science Laboratory II	
Select one of the following:		4
CHEM 2201 & CHEM 2203	Organic Chemistry I and Organic Chemistry Laboratory I	
CHEM 2921 & CHEM 2923	Organic Chemistry for Honors I and Organic Honors Laboratory I	
Select one of the following:		4
CHEM 2202 & CHEM 2204	Organic Chemistry II and Organic Chemistry Laboratory II	
CHEM 2922 & CHEM 2924	Organic Chemistry for Honors II and Organic Honors Laboratory II	
CHEM 4401	Biochemistry I	3
ECE 2332 & ECE 2333	Principles of Electric Circuits and Principles of Electric Circuits Lab	5
ECE 3412 & ECE 3413	Classical Control Systems and Classical Control Laboratory	4
ECE 3512	Signals: Continuous and Discrete	4
or ECE 3912	Honors Signals: Continuous and Discrete	
ENGR 1117	Engineering Graphics	2
ENGR 2011	Engineering Analysis & Applications	3
or MATH 2101	Linear Algebra	
or MEE 2011	Linear Systems	
ENGR 3117	Computer-Aided Design (CAD)	3
ENGR 3201	Material Science for Engineers	3
ENGR 3553	Mechanics of Fluids	3
or ENGR 3953	Honors Mechanics of Fluids	
Bioengineering Electives		
BIOE 2301	Quantitative Pathophysiology	3
BIOE 2302	Cellular and Molecular Biology for Bioengineers	3
BIOE 2312	Mechanics for Bioengineering I	4
BIOE 3301	Biomedical Signals and Systems	3
BIOE 3302	Drug Delivery	3
BIOE 3303	Biotransport Phenomena	3
BIOE 3312	Mechanics for Bioengineering II	4
BIOE 3331	Principles of Macromolecular Science	3
BIOE 3511	Interactions of Biomaterials with Living Tissues	3
BIOE 3725	Cell Biology for Engineers	3
BIOE 4278	Cardiac Devices	3

BIOE 4301	Bioengineering Seminar	1
BIOE 4500	Special Topics in Bioengineering	3
BIOE 4501	Regenerative Engineering	3
BIOE 4741	Biomaterials for Engineers	3
Capstone Electives		
BIOE 4333	Applied Biospectroscopy	3
BIOE 4411	Capstone Elective: Biomaterials	3
BIOE 4431	Capstone Elective: Neuroengineering	3
BIOE 4421	Capstone Elective: Bionanotechnology	3
BIOE 4441	Capstone Elective: Biomechanics	3
BIOE 4451	Capstone Elective: Biomedical Imaging	3
BIOE 4461	Capstone Elective: Principles of Tissue Engineering	3
BIOE 4555	Capstone Elective - Biophotonics: Seeing is Believing	3

Courses

BIOE 0844. The Bionic Human. 3 Credit Hours.
Can we replace our "worn-out" body parts with space-age materials? Will the day come when an injured athlete buys a tendon for the next big game? Why are your parents spending so much time at the doctor? We are on the verge of building "the bionic human" by repairing many of our body parts indefinitely. Become familiar with bio-engineered technologies for age-, disease-, sports-, and accident-related injuries. Learn why weight bearing exercise strengthens bones, the difference between MRI, CAT scan, and X-Ray, and what the folks at the Food and Drug Administration do. By the time you finish this course, you'll know how a pig heart could save your life, how stem cell research could affect your future, the purpose of animal testing, and why walking through airport security could be a problem if you have had your hip replaced. NOTE: This course fulfills a Science & Technology (GS) requirement for students under GenEd and Science & Technology Second Level (SB) for students under Core. Students cannot receive credit for this course if they have successfully completed BIOE 0944, MEE 0844, or MEE 0944.

Course Attributes: GS

Repeatability: This course may not be repeated for additional credits.

BIOE 0856. Ethical Issues in Biomedical Science, Engineering and Technology. 3 Credit Hours.
At some point in our lives, each of us will be confronted with difficult biomedical and biotechnological questions that present an ethical dilemma. This course is designed to enable you to critically address important issues in ethics that arise from advances in these fields. We will consider potential advantages of using modern technologies to improve human health, in contrast to the risks associated with their application. Some of the questions we will pose include: Is it acceptable to use technology to restore our bodies to a pre-injury state? If so, what about using technology to enhance our bodies to improve our performance? What are the implications of the use of reproductive technology that results in one child having three biological parents? Can a physician text a picture of an X-ray to another colleague? These questions, and many others, will be explored in detail through class and small group discussions, coupled with analysis of current news events and scientific publications. Evidence-based approaches will be used to investigate issues related to a variety of subjects including use/overuse of imaging modalities, organ transplant, regenerative tissue engineering and medicine, human enhancements, genetic engineering, personalized medicine, reproductive control (e.g. IVF, surrogate pregnancy), cloning, stem cell use, medical privacy in the era of the electronic medical record, texting, and Instagram, and animal testing for cosmetics, drugs, or medical devices.

Course Attributes: GS

Repeatability: This course may not be repeated for additional credits.

BIOE 0944. Honors Bionic Human. 3 Credit Hours.
From MRIs to engineered organs, modern healthcare has become synonymous with applications of bioengineering and technology. This course focuses on the new bioengineering paradigm, exploring the ways in which disciplines intersect to produce advances in healthcare. A key goal is to enable students to make more informed decisions about healthcare based on their understanding not only of technological advancements but of the ethical and societal issues arising as a consequence. This discovery-based seminar includes interactive lectures, hands-on and virtual labs, discussion, research and presentations. NOTE: This course fulfills a Science & Technology (GS) requirement for students under GenEd and Science & Technology Second Level (SB) for students under Core. Students cannot receive credit for this course if they have successfully completed BIOE 0844, MEE 0844, or MEE 0944.

Cohort Restrictions: Must be enrolled in one of the following Cohorts: SCHONORS, UHONORS, UHONORSTR.

Course Attributes: GS, HO

Repeatability: This course may not be repeated for additional credits.

BIOE 2001. Frontiers in Bioengineering. 2 Credit Hours.
This survey course will provide a first introduction to the wide scope of biomedical engineering, with emphasis on the application of engineering principles to solving problems in biology and medicine. Specific topics will include biomechanics; bioimaging; bioinstrumentation and biomedical devices; artificial organs; computational biology and bioinformatics; biomaterials and drug delivery; cellular, tissue and regenerative engineering; and nanobiotechnology. At the end of this introductory course the students will be familiar with some of the major molecular, cellular, physiological and engineering principles that allow for problem solving in the vast area of biomedical engineering. Thus the students will be prepared to study in depth some of the specialized topics of bioengineering.

Repeatability: This course may not be repeated for additional credits.

BIOE 2101. Engineering Principles of Physiological Systems. 3 Credit Hours.
This course will introduce biomedical engineering students to quantitative modeling of physiological systems. It will cover fundamental topics in physiology ranging from cell membrane models and chemical messengers to neuronal signaling and control of body movement. In addition, specific physiological systems are discussed in detail, including the cardiovascular, pulmonary, and visual systems. Furthermore, pharmacokinetic models provide quantitative assessment of the dynamics of drug distribution and compartmental interactions. Hands-on laboratories combining actual experiments with computer simulations will reinforce the contents of classroom teaching.

Department Restrictions: Must be enrolled in one of the following Departments: Engineering:Bio Engineering.
Field of Study Restrictions: Must be enrolled in one of the following Fields of study: Bioengineering.

Repeatability: This course may not be repeated for additional credits.

Pre-requisites:
BIOL 2112|Minimum Grade of C-|May be taken concurrently
OR BIOL 1012|Minimum Grade of C-|May be taken concurrently
OR BIOL 2912|Minimum Grade of C-|May be taken concurrently.

BIOE 2301. Quantitative Pathophysiology. 3 Credit Hours.
This course will introduce students to fundamental principles of human pathophysiology. Students will gain a systems level understanding of disease processes necessary for the rational design of novel therapeutic and diagnostic technologies. The course will integrate basic biological science and fundamental engineering principles in the evaluation of clinical disease manifestations. Topics that will be covered include: fundamental concepts of cellular homeostasis; cellular responses (adaptation, injury, cell death) induced by stress, injurious stimuli, and disease, and systemic models of major diseases within the US (cardiac, neoplastic, cerebrovascular, traumatic, neurodegenerative, diabetic, and pulmonary).

Department Restrictions: Must be enrolled in one of the following Departments: Engineering:Bio Engineering.
Field of Study Restrictions: Must be enrolled in one of the following Majors: Bioengineering.

Repeatability: This course may not be repeated for additional credits.

Pre-requisites:
BIOL 2112|Minimum Grade of C-|May not be taken concurrently
OR BIOL 1012|Minimum Grade of C-|May not be taken concurrently
OR BIOL 2912|Minimum Grade of C-|May not be taken concurrently.

BIOE 2302. Cellular and Molecular Biology for Bioengineers. 3 Credit Hours.
This course will enhance the basic knowledge of the students in quantitative cell and molecular biology from the vantage point of a bioengineer, focusing on molecular mechanisms and cellular functions, specifically in cell-cell and cell-matrix communications. Textbook learning will be supplemented with results from recent research and technological innovations in biology. After completing this course, bioengineering students will be able to apply their aptitude in the quantitative, physical and engineering sciences to modern biology. Students will also learn the principles how to establish and test biological models.

Department Restrictions: Must be enrolled in one of the following Departments: Engineering:Bio Engineering.
Field of Study Restrictions: Must be enrolled in one of the following Majors: Bioengineering.

Repeatability: This course may not be repeated for additional credits.

Pre-requisites:
BIOE 2101|Minimum Grade of C-|May not be taken concurrently.

BIOE 2312. Mechanics for Bioengineering I. 4 Credit Hours.
This course will provide students with an understanding of the application of statics and strength of materials to biomechanical problem analyses. Topics will introduce basic concepts of mechanics and kinetic analyses with application to physiologic loading and motion in the body.

Department Restrictions: Must be enrolled in one of the following Departments: Engineering:Bio Engineering.
Field of Study Restrictions: Must be enrolled in one of the following Majors: Bioengineering.

Repeatability: This course may not be repeated for additional credits.

Pre-requisites:
(PHYS 1062|Minimum Grade of C-|May be taken concurrently)
AND (MATH 1042|Minimum Grade of C-|May not be taken concurrently
OR MATH 1942|Minimum Grade of C-|May not be taken concurrently)

BIOE 2401. Bioengineering Design I. 3 Credit Hours.
This course will incorporate the 5-steps of the Design Thinking process in a project-based learning (PBL) environment focusing on bioengineering-specific projects. During these open-ended projects, the students will work in small teams that will a) delve deeply into the development of the problem statements and designing potential solutions during the first part of the semester and b) move on to designing, creating, and testing prototypes and writing up the supporting documentation in the second part of the semester. It will introduce and reinforce key engineering tools, such as Matlab, data acquisition with LabView, and data analysis.

Repeatability: This course may not be repeated for additional credits.

Pre-requisites:
(MATH 1042|Minimum Grade of C-|May not be taken concurrently)
AND (PHYS 1062|Minimum Grade of C-|May not be taken concurrently
OR PHYS 2022|Minimum Grade of C-|May not be taken concurrently)
AND (ENGR 1101|Minimum Grade of C-|May not be taken concurrently)
AND (BIOE 2001|Minimum Grade of C-|May be taken concurrently)

BIOE 3001. Research Design and Methods in Bioengineering. 2 Credit Hours.
In this course the upper division students will learn how to integrate fundamental principles of biology, chemistry, engineering, mathematics (including statistics) and physics to develop practical solutions for a variety of biomedical problems from cells to organisms. Students will use both engineering (methodology) and scientific (hypothesis) approaches to problem-solving thereby learning to distinguish between the two approaches. This course will teach the students the fundamental principles underlying modern measurements and control instrumentation utilized in science and engineering. Taking a quantitative and hands-on approach to measurement theory and practice, this course will present and analyze example instruments currently used in academic and industrial research. In addition, the students will consider and discuss bioethical issues involving biological and living systems. Specific bioethics topics that will be covered include stem cells, patents, conflict of interest, patient rights, animal rights, organ donation, and data manipulations but are not limited to them.

Department Restrictions: Must be enrolled in one of the following Departments: Engineering:Bio Engineering.
Field of Study Restrictions: Must be enrolled in one of the following Majors: Bioengineering.

Repeatability: This course may not be repeated for additional credits.

Pre-requisites:
(MATH 1041|Minimum Grade of C-|May not be taken concurrently
OR MATH 1941|Minimum Grade of C-|May not be taken concurrently
OR MATH 1038|Minimum Grade of C-|May not be taken concurrently)
AND (BIOL 1111|Minimum Grade of C-|May not be taken concurrently
OR BIOL 2112|Minimum Grade of C-|May not be taken concurrently
OR BIOL 1012|Minimum Grade of C-|May not be taken concurrently
OR BIOL 1911|Minimum Grade of C-|May not be taken concurrently
OR BIOL 2912|Minimum Grade of C-|May not be taken concurrently
OR CHEM 1031|Minimum Grade of C-|May not be taken concurrently
OR CHEM 1035|Minimum Grade of C-|May not be taken concurrently
OR CHEM 1951|Minimum Grade of C-|May not be taken concurrently)

BIOE 3101. BioE Lab #1 - Bioelectrical Engineering. 3 Credit Hours.
This laboratory class will introduce students to the empirical study of bioelectric phenomena in physiological systems. This includes the origin of biopotentials, the use of biopotential electrodes in their measurements and subsequent amplification, signal processing and analysis of their physiological relevance. Applications of physical principles and basic electric engineering techniques are emphasized.

Department Restrictions: Must be enrolled in one of the following Departments: Engineering:Bio Engineering.
Field of Study Restrictions: Must be enrolled in one of the following Majors: Bioengineering.

Repeatability: This course may not be repeated for additional credits.

Pre-requisites:
(BIOE 3201|Minimum Grade of C-|May be taken concurrently)
AND (PHYS 1062|Minimum Grade of C-|May not be taken concurrently
OR PHYS 2022|Minimum Grade of C-|May not be taken concurrently)
AND (MATH 1042|Minimum Grade of C-|May not be taken concurrently
OR MATH 1942|Minimum Grade of C-|May not be taken concurrently)
AND (BIOE 2001|Minimum Grade of C-|May be taken concurrently)

BIOE 3102. BioE Lab #2 - Biomaterials. 3 Credit Hours.
This laboratory class will teach students experimental methods used to prepare and characterize biomaterials used in biomedical engineering. Students will learn basic techniques for the fabrication and characterization tools used for polymeric biomaterials, and investigate structure-property relationships as it applies to thermal, mechanical, surface and morphological properties of polymeric biomaterials.

Department Restrictions: Must be enrolled in one of the following Departments: Engineering:Bio Engineering.
Field of Study Restrictions: Must be enrolled in one of the following Majors: Bioengineering.

Repeatability: This course may not be repeated for additional credits.

Pre-requisites:
(BIOE 2101|Minimum Grade of C-|May be taken concurrently)
AND (BIOE 3001|Minimum Grade of C-|May not be taken concurrently)

BIOE 3201. Biomedical Instrumentation. 2 Credit Hours.
This course will introduce the upper division students to the fundamentals of medical instrumentation. Specifically, it will teach the physiological/physicochemical, biomechanical, computational and electronic principles governing the operation of select medical instrumentation. Focusing on classical and modern instrumentation used in specific clinical departments, such as cardiology, pulmonary medicine and critical care, radiology, and anesthesiology, the course will also introduce the students to the operation, safety aspects, and calibration of electronic, optical and acoustical instruments, as well as those involving ionizing radiation.

Department Restrictions: Must be enrolled in one of the following Departments: Engineering:Bio Engineering.
Field of Study Restrictions: Must be enrolled in one of the following Majors: Bioengineering.

Repeatability: This course may not be repeated for additional credits.

Pre-requisites:
(PHYS 1062|Minimum Grade of C-|May not be taken concurrently
OR PHYS 2022|Minimum Grade of C-|May not be taken concurrently)
AND (MATH 1042|Minimum Grade of C-|May not be taken concurrently
OR MATH 1942|Minimum Grade of C-|May not be taken concurrently)

BIOE 3301. Biomedical Signals and Systems. 3 Credit Hours.
This course will expose students to digital signal processing with emphasis on problems in biomedical research and clinical medicine. It covers principles and algorithms for processing signals and systems in both continuous and discrete time domains with examples from biomedical signal processing and control. Theory and practice of Continuous-time linear systems: convolution, steady-state responses, Fourier and Laplace transforms, transfer functions, poles and zeros, stability, sampling, feedback. Discrete-time linear systems: Z transform, filters, Fourier transform, signal processing. This class will make extensive use of Matlab projects.

Department Restrictions: Must be enrolled in one of the following Departments: Engineering:Bio Engineering.
Field of Study Restrictions: Must be enrolled in one of the following Majors: Bioengineering.

Repeatability: This course may not be repeated for additional credits.

Pre-requisites:
MATH 2101|Minimum Grade of C-|May not be taken concurrently
OR ENGR 2011|Minimum Grade of C-|May not be taken concurrently
OR MEE 2011|Minimum Grade of C-|May not be taken concurrently.

BIOE 3302. Drug Delivery. 3 Credit Hours.
This course will cover the engineering principles utilized in the design of drug delivery systems. Topics will include: drug delivery mechanisms (oral, parenteral, passive, targeted, etc.); therapeutic modalities and mechanisms of action; engineering principles of controlled release and quantitative understanding of drug transport (diffusion, convection); effects of electrostatics, macromolecular conformation, and molecular dynamics on interfacial interactions; thermodynamic principles of self-assembly; chemical and physical characteristics of delivery molecules and assemblies (polymer based, lipid based); significance of biodistributions and pharmacokinetic models; toxicity issues and immune responses.

Department Restrictions: Must be enrolled in one of the following Departments: Engineering:Bio Engineering.
Field of Study Restrictions: Must be enrolled in one of the following Majors: Bioengineering.

Repeatability: This course may not be repeated for additional credits.

Pre-requisites:
MATH 3041|Minimum Grade of C-|May be taken concurrently
OR MATH 3941|Minimum Grade of C-|May be taken concurrently.

BIOE 3303. Biotransport Phenomena. 3 Credit Hours.
This course will provide students with a quantitative understanding of momentum transport (viscous flow) and mass transport (convection and diffusion) in living systems. The application of engineering methods to model and quantify aspects of bioengineering systems will be covered. Emphasis will be placed on the analysis of fluid flow phenomena in the cardiovascular and respiratory system as well as other human organ systems.

Department Restrictions: Must be enrolled in one of the following Departments: Engineering:Bio Engineering.
Field of Study Restrictions: Must be enrolled in one of the following Majors: Bioengineering.

Repeatability: This course may not be repeated for additional credits.

Pre-requisites:
(ENGR 3571|Minimum Grade of C-|May not be taken concurrently)
AND (CHEM 1031|Minimum Grade of C-|May not be taken concurrently
OR CHEM 1035|Minimum Grade of C-|May not be taken concurrently
OR CHEM 1951|Minimum Grade of C-|May not be taken concurrently)
AND (MATH 3041|Minimum Grade of C-|May be taken concurrently
OR MATH 3941|Minimum Grade of C-|May be taken concurrently)

BIOE 3312. Mechanics for Bioengineering II. 4 Credit Hours.
This course will provide students with an understanding of the application of mechanics of solids and dynamics to engineering problem analyses. Topics will introduce basic concepts of dynamics and mechanics with application to physiologic loading and motion in the body.

Department Restrictions: Must be enrolled in one of the following Departments: Engineering:Bio Engineering.
Field of Study Restrictions: Must be enrolled in one of the following Majors: Bioengineering.

Repeatability: This course may not be repeated for additional credits.

Pre-requisites:
BIOE 2312|Minimum Grade of C-|May not be taken concurrently.

BIOE 3331. Principles of Macromolecular Science. 3 Credit Hours.
In this course students will gain an understanding of the fundamentals of polymer physical chemistry. We will cover polymer structure and conformation, bulk and solution thermodynamics and phase behavior, polymer networks, and viscoelasticity. We will also apply engineering principles to the analysis of biomacromolecules, such as proteins, polysaccharides and oligonucleotides. Upon the completion of the course, students should be able to understand the influence of monomer structure, temperature, solution conditions, degree of polymerization and 3D conformation on the function of biopolymers.

Department Restrictions: Must be enrolled in one of the following Departments: Engineering:Bio Engineering.
Field of Study Restrictions: Must be enrolled in one of the following Majors: Bioengineering.

Repeatability: This course may not be repeated for additional credits.

Pre-requisites:
CHEM 1032|Minimum Grade of C-|May not be taken concurrently
OR CHEM 1952|Minimum Grade of C-|May not be taken concurrently.

BIOE 3401. Biodesign - Testing and Validation. 3 Credit Hours.
This course aims to reinforce the Design Thinking concepts introduced earlier in the curriculum. Students will apply Design Thinking concepts to team projects. We will introduce topics in project management, machine shop use, computer modeling, ethical conduct of research and translational/entrepreneurial considerations, in addition to building upon the tools acquired and used in the Bioengineering Design I. The first part of the semester will be used for problem statement development and creations of several alternative design solutions. The second part of the semester will then be devoted to prototyping, testing and optimizing the proposed solutions, with oral presentations and written reports of their progress in the project throughout the semester.

Repeatability: This course may not be repeated for additional credits.

Pre-requisites:
(MATH 1042|Minimum Grade of C-|May not be taken concurrently)
AND (PHYS 1062|Minimum Grade of C-|May not be taken concurrently
OR PHYS 2022|Minimum Grade of C-|May not be taken concurrently)
AND (ENGR 1101|Minimum Grade of C-|May not be taken concurrently)

BIOE 3511. Interactions of Biomaterials with Living Tissues. 3 Credit Hours.
This course will cover topics that illustrate how biomaterials interact with living tissues, focusing on cell culture, immunology, cell-biomaterial interfaces, and cell signaling. The students will learn the fundamentals maintaining living cells in culture and how these cells react to the presence of biomaterials using lecture and laboratory format.

Department Restrictions: Must be enrolled in one of the following Departments: Engineering:Bio Engineering.
Field of Study Restrictions: Must be enrolled in one of the following Majors: Bioengineering.

Repeatability: This course may not be repeated for additional credits.

Pre-requisites:
(BIOE 2101|Minimum Grade of C-|May not be taken concurrently)
AND (CHEM 1031|Minimum Grade of C-|May not be taken concurrently
OR CHEM 1035|Minimum Grade of C-|May not be taken concurrently
OR CHEM 1951|Minimum Grade of C-|May not be taken concurrently)

BIOE 3719. Introduction to Bioengineering. 3 Credit Hours.
Course topics include biomaterials and implant materials, research proposal preparation, tyrosine-derived synthetic polymer devices for tissue engineering spine biomechanics, cellular material biomechanics, orthopedic biomechanics, hydroxyapatite/polymer composites, applications of injury biomechanics, biomechanics of the lower extremities, principles of polymers used in dental and biomaterials, interfaces in biomaterials. Students will be required to prepare a proposal for a design-oriented term project (i.e. rationale, concept and design, but no actual construction).

Class Restrictions: Must be enrolled in one of the following Classes: Junior 60 to 89 Credits, Senior 90 to 119 Credits, Senior/Fifth Year 120+ Credits.
College Restrictions: Must be enrolled in one of the following Colleges: Engineering.

Repeatability: This course may not be repeated for additional credits.

BIOE 3725. Cell Biology for Engineers. 3 Credit Hours.
Cell Biology for Engineers is a basic course that introduces biological concepts in modern cellular and molecular biology to engineering students. Topics will include the chemical composition of cells, bioenergetics and metabolism, structure and function of the plasma membrane, transport across membranes, the cytoplasmic membrane system, the extracellular matrix, interactions between cells and their environment, the cytoskeleton and cell motility, sensory systems, and cell signaling. In addition, an introduction to basic anatomy and physiology of vertebrates will include the skeletal system, muscle system, cardiovascular system, and nervous system.

College Restrictions: Must be enrolled in one of the following Colleges: Engineering.

Repeatability: This course may not be repeated for additional credits.

Pre-requisites:
CHEM 1031|Minimum Grade of C-|May not be taken concurrently
OR CHEM 1035|Minimum Grade of C-|May not be taken concurrently
OR CHEM 1951|Minimum Grade of C-|May not be taken concurrently.

BIOE 4101. BioE Lab #3 - Biomechanics. 3 Credit Hours.
In this course students will apply principles of engineering mechanics in the design and utilization of biomechanical instrumentation. Principles of transduction, mechanics, sampling theory, strain, temperature, and flow measurement as applied to biomechanical systems will be covered. A background in data acquisition, electrical safety, operational amplifier and bridge circuits, and measurements is provided. Students will investigate the biomechanics of the musculoskeletal and cardiovascular systems in normal and pathological states.

Department Restrictions: Must be enrolled in one of the following Departments: Engineering:Bio Engineering.
Field of Study Restrictions: Must be enrolled in one of the following Majors: Bioengineering.

Repeatability: This course may not be repeated for additional credits.

Pre-requisites:
BIOE 3101|Minimum Grade of C-|May not be taken concurrently.

BIOE 4182. Independent Study in Bioengineering. 1 to 5 Credit Hour.
Independent study course in bioengineering. Credits are arranged with instructor.

Repeatability: This course may be repeated for additional credit.

BIOE 4278. Cardiac Devices. 3 Credit Hours.
Intended for electrical engineering, biology, and bioengineering students. No course prerequisites. This course will cover cardiac anatomy and physiology, the heart's electrical system in health and disease, cardiac ECG rhythm interpretation, design and function of ECG monitoring devices, pacemakers and external and implanted defibrillators, and arrhythmia detection algorithms. The course will include observation of pacemaker implants, and troubleshooting in a pacemaker follow-up clinic. The course will prepare students to take the Heart Rhythm Society Allied Professional Pacemaker Certification examination. It is intended to put students in a competitive advantage for getting jobs in the expanding pacemaker and other medical electronics device industries.

Repeatability: This course may not be repeated for additional credits.

BIOE 4301. Bioengineering Seminar. 1 Credit Hour.
This seminar is intended for bioengineering students who are interested in acquiring hands-on presentation skills and, in addition, keeping up-to-date with the bioengineering research fields. The aim of the class is to allow upper division students to present a summarized view of a specific bioengineering or biomedical engineering topic. Specific topics that will be suggested to be covered (by the students) are biomaterials, tissue/regenerative engineering, bioimaging, biosensing, bionanotechnology (or nanobiotechnology), neuroengineering, bioinformatics (computational), biomechanics, (but are not limited to them). Guest lecturers from academia and industry will be invited to talk on several occasions.

Department Restrictions: Must be enrolled in one of the following Departments: Engineering:Bio Engineering.
Field of Study Restrictions: Must be enrolled in one of the following Majors: Bioengineering.
Class Restrictions: Must be enrolled in one of the following Classes: Junior 60 to 89 Credits, Senior 90 to 119 Credits, Senior/Fifth Year 120+ Credits.

Repeatability: This course may not be repeated for additional credits.

Pre-requisites:
BIOE 2001|Minimum Grade of C-|May not be taken concurrently.

BIOE 4311. The Entrepreneurial Bioengineer. 3 Credit Hours.
Recognizing the increasingly entrepreneurial landscape of Bioengineering, this course will introduce the students to the fundamentals of entrepreneurship and is designed to provide students with a working knowledge of the modern entrepreneurial and business planning and the regulatory process with the special focus on translational development of bioengineering products from the bench to the bedside.

Department Restrictions: Must be enrolled in one of the following Departments: Engineering:Bio Engineering.
Field of Study Restrictions: Must be enrolled in one of the following Majors: Bioengineering.
Class Restrictions: Must be enrolled in one of the following Classes: Junior 60 to 89 Credits, Senior 90 to 119 Credits, Senior/Fifth Year 120+ Credits.

Repeatability: This course may not be repeated for additional credits.

Pre-requisites:
BIOE 2001|Minimum Grade of C-|May be taken concurrently.

BIOE 4333. Applied Biospectroscopy. 3 Credit Hours.
This course introduces the basics of light propagation in tissue and other turbid media, vibrational spectroscopy, absorption and fluorescence, and emerging spectroscopic applications. Emphasis is on applications for assessment of biomolecules, engineered tissues and clinically-relevant analyses including musculoskeletal disease and cancer diagnosis. Multivariate analyses for complex spectral data sets will also be introduced.

Level Registration Restrictions: Must be enrolled in one of the following Levels: Undergraduate.

Repeatability: This course may not be repeated for additional credits.

Pre-requisites:
(MATH 3041|Minimum Grade of C-|May not be taken concurrently
OR MATH 3941|Minimum Grade of C-|May not be taken concurrently)
AND (PHYS 1061|Minimum Grade of C-|May not be taken concurrently
OR PHYS 1961|Minimum Grade of C-|May not be taken concurrently
OR PHYS 2021|Minimum Grade of C-|May not be taken concurrently
OR PHYS 2921|Minimum Grade of C-|May not be taken concurrently)
AND (CHEM 1031|Minimum Grade of C-|May not be taken concurrently
OR CHEM 1035|Minimum Grade of C-|May not be taken concurrently
OR CHEM 1951|Minimum Grade of C-|May not be taken concurrently)
AND (BIOL 1111|Minimum Grade of C-|May not be taken concurrently
OR BIOL 2112|Minimum Grade of C-|May not be taken concurrently
OR BIOL 1012|Minimum Grade of C-|May not be taken concurrently
OR BIOL 1911|Minimum Grade of C-|May not be taken concurrently
OR BIOL 2912|Minimum Grade of C-|May not be taken concurrently)

BIOE 4411. Capstone Elective: Biomaterials. 3 Credit Hours.
This course will focus on materials and design parameters used to develop human implant devices, bulk and surface characterization methods for biomaterials, biocompatibility, failure mechanisms of current biomaterials, and regulatory requirements for design and testing of human implant devices. Special attention will be given to biomaterials used in tissue regeneration, orthopedics, and controlled drug delivery.

Department Restrictions: Must be enrolled in one of the following Departments: Engineering:Bio Engineering.
Field of Study Restrictions: Must be enrolled in one of the following Majors: Bioengineering.

Repeatability: This course may not be repeated for additional credits.

Pre-requisites:
(BIOE 2101|Minimum Grade of C-|May not be taken concurrently)
AND (CHEM 2201|Minimum Grade of C-|May not be taken concurrently)

BIOE 4421. Capstone Elective: Bionanotechnology. 3 Credit Hours.
This course is intended for upper division students interested in acquiring knowledge involving nanometer-sized objects frequently utilized within the biomedical sciences and engineering areas. The aim of the class is to introduce fundamental concepts critical in the design, preparation, analysis, and usage of bionanotechnology (or nanobiotechnology) and its multiple bottom-up and top-down approaches. Multiple nanomaterials categories, such as nanoparticles, nanotubes, biomacromolecules, synthetic polymers, and self-assembled structures, will be covered in detail along with their applications.

Repeatability: This course may not be repeated for additional credits.

Pre-requisites:
(CHEM 2201|Minimum Grade of C-|May not be taken concurrently)
AND (BIOE 1301|Minimum Grade of C-|May not be taken concurrently)

BIOE 4431. Capstone Elective: Neuroengineering. 3 Credit Hours.
This course will teach students how signals are generated and propagated in neurons and neuronal circuits, and how this knowledge can be utilized to engineer devices to assist people with neurologic disease or injury. The functions of neurons as discrete elements and as parts of neuronal assemblies will be examined; generator and action potentials; conduction in nerve fibers and across synaptic junctions; analysis of sensory and neuromuscular systems; EEG and EKG waveforms. At the completion of the course, students will have gained a fundamental understanding of neural interface/ prosthetics design parameters from basic neural physiology to models of neural mechanisms. We will also review advanced neural interfaces currently being developed and or produced commercially by the field.

Department Restrictions: Must be enrolled in one of the following Departments: Engineering:Bio Engineering.
Field of Study Restrictions: Must be enrolled in one of the following Majors: Bioengineering.

Repeatability: This course may not be repeated for additional credits.

Pre-requisites:
(BIOE 2101|Minimum Grade of C-|May not be taken concurrently)
AND (MATH 3041|Minimum Grade of C-|May be taken concurrently
OR MATH 3941|Minimum Grade of C-|May be taken concurrently)

BIOE 4441. Capstone Elective: Biomechanics. 3 Credit Hours.
This course will provide an integrative and multi-scale understanding of biomechanics that spans from tissues, to organs, to the dynamics of an intact, running body. Foundational topics will include muscle mechanics, skeletal mechanics, gait and whole body dynamics. The course will then move on to cover selected topics at the forefront of applied biomechanics including clinical biomechanics and the design and optimization of prosthetic limbs. Finally, frontiers in neural-interfacing for prostheses and rehabilitation, including optogenetics and other emerging areas affecting biomechanics, including robotics and robotic exoskeletons, will be covered.

Department Restrictions: Must be enrolled in one of the following Departments: Engineering:Bio Engineering.
Field of Study Restrictions: Must be enrolled in one of the following Majors: Bioengineering.
College Restrictions: Must be enrolled in one of the following Colleges: Engineering.

Repeatability: This course may not be repeated for additional credits.

Pre-requisites:
(BIOE 2101|Minimum Grade of C-|May not be taken concurrently
OR BIOE 3725|Minimum Grade of C-|May not be taken concurrently)
AND (BIOE 3312|Minimum Grade of C-|May not be taken concurrently
OR (ENGR 2332|Minimum Grade of C-|May not be taken concurrently
AND ENGR 2333|Minimum Grade of C-|May not be taken concurrently))

BIOE 4451. Capstone Elective: Biomedical Imaging. 3 Credit Hours.
In this course students learn how light, X-rays, radiopharmaceuticals, ultrasound, magnetic fields, and other energy probes are generated and how they interact with tissues and detectors to produce useful image contrast. Practical issues such as beam generation, dose limitations, patient motion, spatial resolution and dynamic range limitations, and cost-effectiveness will be addressed. Emphasis will be placed on diagnostic radiological imaging physics, including the planar X-ray, digital subtraction angiography mammography, computed tomography, nuclear medicine, ultrasound, and magnetic resonance imaging modalities.

Department Restrictions: Must be enrolled in one of the following Departments: Engineering:Bio Engineering.
Field of Study Restrictions: Must be enrolled in one of the following Majors: Bioengineering.

Repeatability: This course may not be repeated for additional credits.

Pre-requisites:
(PHYS 1062|Minimum Grade of C-|May not be taken concurrently)
AND (CHEM 1031|Minimum Grade of C-|May not be taken concurrently
OR CHEM 1035|Minimum Grade of C-|May not be taken concurrently
OR CHEM 1951|Minimum Grade of C-|May not be taken concurrently)
AND (BIOL 1111|Minimum Grade of C-|May not be taken concurrently
OR BIOL 1012|Minimum Grade of C-|May not be taken concurrently
OR BIOL 2112|Minimum Grade of C-|May not be taken concurrently
OR BIOL 1911|Minimum Grade of C-|May not be taken concurrently
OR BIOL 2912|Minimum Grade of C-|May not be taken concurrently)
AND (MATH 3041|Minimum Grade of C-|May not be taken concurrently
OR MATH 3941|Minimum Grade of C-|May not be taken concurrently)

BIOE 4461. Capstone Elective: Principles of Tissue Engineering. 3 Credit Hours.
This course will introduce fundamental concepts of tissue engineering and regenerative medicine, focusing on biomaterials used for scaffolds, mechanisms of cell-biomaterial interactions, biocompatibility and foreign body response, cellular engineering, and tissue biomechanics. Principles of cell/developmental and stem cell biology will be introduced, which will enable the students to apply a multidisciplinary approach to engineering select tissues and organs, such as the musculoskeletal system, cardiovascular tissues, the nervous system, and to design artificial organs. These topics will also be discussed in the context of scale-up, manufacturing, ethical and regulatory concerns. Note: Prior to fall 2017, the course title was "Capstone Elective: Principles of Tissue and Regenerative Engineering."

Department Restrictions: Must be enrolled in one of the following Departments: Engineering:Bio Engineering.
Field of Study Restrictions: Must be enrolled in one of the following Majors: Bioengineering.

Repeatability: This course may not be repeated for additional credits.

Pre-requisites:
(BIOE 2101|Minimum Grade of C-|May not be taken concurrently)
AND (CHEM 2202|Minimum Grade of C-|May not be taken concurrently)

BIOE 4500. Special Topics in Bioengineering. 3 Credit Hours.
An emerging or advanced area of bioengineering research will be covered. Topics vary by semester.

Field of Study Restrictions: Must be enrolled in one of the following Fields of study: Bioengineering.

Repeatability: This course may be repeated for additional credit.

BIOE 4501. Regenerative Engineering. 3 Credit Hours.
This course is a continuation of fundamental concepts introduced in Principles of Tissue and Regenerative Engineering focusing on developmental biology used in tissue engineering and regenerative medicine. Principles of cell development/biology, cell-cell interactions, signal transduction, and stem cell biology will be discussed with applications to regenerative medicine. These topics will also be discussed in the context of scale-up, manufacturing, ethical and regulatory concerns.

Department Restrictions: Must be enrolled in one of the following Departments: Engineering:Bio Engineering.
Field of Study Restrictions: Must be enrolled in one of the following Majors: Bioengineering.
Class Restrictions: Must be enrolled in one of the following Classes: Senior 90 to 119 Credits, Senior/Fifth Year 120+ Credits.

Repeatability: This course may not be repeated for additional credits.

Pre-requisites:
BIOE 4461|Minimum Grade of C-|May not be taken concurrently.

BIOE 4555. Capstone Elective - Biophotonics: Seeing is Believing. 3 Credit Hours.
Only a small portion of the world around us is visible to the human eye. So, is there a way to visualize chaos, force, fractals, viral infection or cancer metastasis? Once we see biology happen, is the result a pretty image or a valuable measurement? Can the light be used to modify biological processes? In this course students will learn how photons are used to visualize and manipulate biomaterials at multiple scales. The first part of the course will provide a review of electromagnetism, light and optics. We will cover typical hardware used for imaging in biology, such as light sources, objectives and detectors used to generate images. Next, chemistry of imaging probes will be covered, including photochemistry and interaction of light and matter. The rest of the course will give a comprehensive overview of methodologies for multiscale imaging in life sciences, ranging from electron to atomic-molecular-cell-multicellular tissue-whole body scales, *in vitro* and *in vivo*. This will include among others Spectroscopy, Microscopy (Electron, Atomic, Fluorescent), Flow Cytometry, Optical Traps, Bioluminescence, X-Ray, MRI. Final classes will include special demonstrations in the imaging labs in the Temple Main Campus.

Field of Study Restrictions: Must be enrolled in one of the following Fields of study: Bioengineering.

Repeatability: This course may not be repeated for additional credits.

Pre-requisites:
(PHYS 1062|Minimum Grade of C-|May not be taken concurrently
OR PHYS 2022|Minimum Grade of C-|May not be taken concurrently)
AND (CHEM 2202|Minimum Grade of C-|May not be taken concurrently)
AND (BIOL 2112|Minimum Grade of C-|May not be taken concurrently
OR BIOE 3102|Minimum Grade of C-|May be taken concurrently)

BIOE 4741. Biomaterials for Engineers. 3 Credit Hours.
This course introduces engineering students to materials as they interact with biological systems, primarily in medicine. Topics will include a review of properties of materials, the classes of materials, tissues that come into contact with materials, the degradation of materials in the biological environment, the application of materials for specific uses, tissue engineering, and biomaterials standards and regulations.

Field of Study Restrictions: May not be enrolled in one of the following Majors: Bioengineering.
Class Restrictions: Must be enrolled in one of the following Classes: Junior 60 to 89 Credits, Senior 90 to 119 Credits, Senior/Fifth Year 120+ Credits.

Repeatability: This course may not be repeated for additional credits.

Pre-requisites:
CHEM 1031|Minimum Grade of C-|May not be taken concurrently
OR CHEM 1035|Minimum Grade of C-|May not be taken concurrently
OR CHEM 1951|Minimum Grade of C-|May not be taken concurrently.