BIOMEDICAL ENGINEERING (BIEG)

BIEG 1001 Introduction to Biomedical Engineering **3 Credits**
This course utilizes hands-on learning and projects to teach the basic engineering skills important for Biomedical Engineers. Biomedical Engineering is a very interdisciplinary field and students will learn applications of mathematics, statistics, physics, and electronics to solve biomedical problems. Students will work on team projects and will be guided through the engineering design process. In addition, students will practice professional skills such as technical writing and presentation. A variety of career paths within Biomedical Engineering will be covered as well as the roles of Biomedical Engineers in the global society and ethics within the profession.

BIEG 3201 Biomechanics **3 Credits**
Prerequisites: MATH 1141, PHYS 1171.
This course covers solid mechanics of bone with a focus on stress, strain, stiffness, and strength. Joint forces and muscle attachments will be analyzed using free-body diagrams. Introductory musculoskeletal physiology will be covered and Biopac Student Lab software will be used for gait and muscle force analysis. Previously BEN 0201.

BIEG 3301 Biomedical Instrumentation **4 Credits**
Attributes: HSST Health Studies: Science and Technology
Fee: $120 Engineering Lab Fee
Prerequisites: ELEG 2213.
This course presents instrumentation and techniques used in acquisition, processing, and presentation of biomedical signals: transducers, sensors, biosensors, and measurement of physical parameters and electrophysiological signals. Physiology relevant for instrumentation labs will be covered. Previously BEN 0300.

BIEG 3331 Biomedical Signal Processing **3 Credits**
Prerequisites: CPSC 1131 or SWEG 5407; MATH 1142.
This course presents an overview of different methods used in biomedical signal processing. Signals with bioelectric origin are given special attention and their properties and clinical significance are reviewed. In many cases, the methods used for processing and analyzing biomedical signals are derived from a modeling perspective based on statistical signal descriptions. The purpose of the signal processing methods ranges from reduction of noise and artifacts to extraction of clinically significant features. The course gives each participant the opportunity to study the performance of a method on real, biomedical signals. Graduate equivalent: ECEG 5331. Previously BEN 0331.

BIEG 3335 Clinical Engineering **3 Credits**
Biomedical engineering is defined by the application of engineering design in service of human health. To solve problems in healthcare, it is crucial to understand the clinical environment within which biomedical engineers develop solutions. This course will provide students with the opportunity to work with faculty and students in the Egan School Simulation Lab to gain an understanding of modern clinical care and work collaboratively on solutions to existing problems in healthcare. Students will have an opportunity to use existing medical devices and gain an understanding of their fundamental operating principles. Students will gain an understanding of the societal underpinnings contributing to existing disparities in healthcare outcomes and how previous technological development has exacerbated to these disparities. Graduate Equivalent: BIEG 5335.

BIEG 4309 Biosensors **3 Credits**
Prerequisites: CHEM 1171, ELEG 2213.
This course will provide an overview of biosensors, including their use in pharmaceutical research, diagnostic testing, and policing the environment. Topics include the fabrication, characterization, testing, and simulation of biosensors. The phenomenon of transducers, biosensor structure, sensor performance, and simulations utilizing molecular simulation software will also be covered. Graduate Equivalents: BIEG 5309, ECEG 5309

BIEG 4311 Biomaterials **3 Credits**
Prerequisites: BIOL 1107 or BIOL 1108 or BIOL 1171 or BIOL 1172 or BIOL 1173; CHEM 1171.
This course will cover the introductory level of understanding on the different types of biomaterials used in biomedical industry, their design and synthesis. Examples include implants, stents, catheters, smart polymer gels, bone grafts, and tissue scaffolds. Modern biology in biomedical engineering such as but not limited to protein adsorption, immuno-isolation, and regenerative medicine will be covered. Ethical issues in biomedical engineering will also be discussed. Current innovative research on nano-biotechnology that extends to 3D bio-matrix, advanced diagnostics, dental composites, sealants, and adhesives. Graduate equivalents: BIEG 5311, ECEG 5311.

BIEG 4314 Introduction to Molecular Modeling **3 Credits**
Prerequisites: CHEM 1171, PHYS 1171.
This course will cover methodological and practical aspects of the application of system analysis and computational tools to biological and biomedical problems. It will cover computational modeling of biological macromolecules such as proteins, DNA, and synthetic self-assembling materials such as polymers, crystals, colloids, and amphiphiles. The course provides the resources to use Visual Molecular Dynamics (VMD) and Nanoscale Molecular Dynamics (NAMD) to solve computational problems related to protein interactions in case of diseases and protein folding. Graduate equivalent: ECEG 5314.

BIEG 4319 Advanced Experimental Design in Biomedical Engineering **3 Credits**
How do biomedical engineers know which medical problems are worth solving? How do they know that their inventions will work? How do they know that these inventions will be safe across a diverse population? This course uses a “flipped classroom” approach to answer these questions. It will build student skill in experimental design across the diverse disciplines of biomedical engineering with a focus on statistical analysis. Students will spend the first half of the semester reviewing/analyzing classic literature across biomedical engineering and performing classic experiments within our field. Students will spend the second half of the semester designing and performing their own custom-designed experiment that will be presented at Fairfield’s Innovative Research Symposium”

BIEG 4332 Biomedical Imaging **3 Credits**
Attributes: HSST Health Studies: Science and Technology
Prerequisite: BIEG 3331 or CPEG 3331.
The fundamentals and applications of medical imaging techniques will be presented, including x-ray and computed tomography, nuclear imaging, ultrasound, and MRI. Image processing and analysis techniques will be introduced through suitable programming exercises. Graduate equivalent: ECEG 5332. Previously BEN 0332.

BIEG 4333 Biomedical Visualization **3 Credits**
Prerequisite: CPSC 1131.
This course is an introduction to 3-D biomedical visualization. Various technologies are introduced, including ultrasound, MRI, CAT scans, PET scans, etc. Students will learn about spatial data structures, computational geometry and solid modeling with applications in 3-D molecular and anatomical modeling. Graduate equivalent: ECEG 5333. Previously BEN 0333.

BIEG 4350 Medical Device Design **3 Credits**
Attributes: HSST Health Studies: Science and Technology
Prerequisite: Junior standing.
This project-based course focuses on important stages of the medical device product lifecycle including: identifying unmet clinical and global health needs, the FDA approval process, material selection, biocompatibility, ethical considerations, intellectual property, and post-market surveillance of similar products. Students will generate project ideas and design a medical device.

BIEG 4375 Bioelectronics **3 Credits**
Prerequisite: CHEM 1171 and CHEM 1171L, ELEG 2213 and ELEG 2213L.
Bioelectronics have emerged as an exciting research area due to the integration of molecular biology with electronics to create fundamental devices. This course is intended for senior and graduate level engineering students. It will introduce fundamentals of bioelectronics through chemical, biochemical and biophysical concepts from the engineering perspective. It will further apply these concepts to the areas of electron transport through biological macromolecules, microfluidics, electrochemical techniques, DNA and neuron-based electronics, biomaterials and semiconductor-based bioelectronics. Graduate Equivalent: ECEG 5375, BIEG 5375

BIEG 4387 Instrumental Analysis in Biomedical Engineering **3 Credits**
Prerequisite: CHEM 1171 and CHEM 1171L or BIOL 1171 and 1171L or PHYS 1171 and PHYS 1171L.
This course will give an overview on several important analytical tools for characterizing the nanomaterials that are functionally engineered towards biomedical applications. Quantification of mechanical, electrical, electronic and biological properties of the nanomaterials such as carbon nanotubes, metal nanoparticles, quantum dots, nanowires, polymeric nanoparticles and biomedical nanomaterials will be discussed. Fundamental principles of the associated instruments and the evaluation of the physical, chemical and microscopy methods for materials in nano-regime will be highlighted. Modern material science depends on the use of a set of analytical methods that are used normally in specialized laboratories. This course will help the students get familiar with the basics of such specialized methods, their range of applicability and reliability, especially when the materials under test are in sub-100nm dimensions. Graduate Equivalent: BIEG 5387, ECEG 5387.

BIEG 4403 Advanced Biomechanics **3 Credits**
Prerequisite: BIEG 3201.
This course introduces the applications of continuum mechanics to the understanding of various biological tissue properties and biological fluid flow. The structure, function and mechanical properties of bone, muscle, blood vessels and blood flow will be examined. Conservation laws and constitutive equations for solid, fluid, and intermediate biomaterials will be covered. Critical analysis of current research in the field of biomechanics is also emphasized. Graduate Equivalent: BIEG 5403.

BIEG 5260 Robots **3 Credits**
Introductory course in robotics develops understanding of how robotic systems integrate sensors, actuators, and control systems to achieve specific goals. Principles of autonomy, programming, wireless communications, sensor applications, mechatronics, electrical power, electric motors, pneumatics, structure, and locomotion will be understood and applied. Design of robotic subsystems will utilize multiple areas of knowledge. Students will understand degrees of freedom of a robotic arm and their safety parameters through demonstration and use of Fanuc Robot. Service learning is an integral part of the course. All students will participate in mentoring of youth to put into practice the principles learned in class, and gain communication skills through community interaction. Particularly they will participate in mentoring to build small robots to accomplish different feats, for example obstacle avoidance by a mobile robot.

BIEG 5301 Feedback Control System **3 Credits**
This course emphasizes analysis and synthesis of closed loop control systems using both classical and state-space approaches with an emphasis on electro-mechanical systems. The mathematical requirements include the Laplace transform methods of solving differential equations, matrix algebra and basic complex variables. The discussion of classical control system design includes the modeling of dynamic systems, block diagram representation, time and frequency domain methods, transient and steady state response, stability criteria, controller action [Proportional (P), proportional and integral (PI), Proportional, integral and derivative (PID) and pseudo-derivatives feedback], root locus methods, the methods of Nyquist and Bode and dynamics compensation techniques. The discussion of state-space methods includes formulation and solution (analytical and computer-based) of the state equations and pole-placement design. The course integrates the use of computer-aided analysis and design tools (MATLAB) so as to ensure relevance to the design of real world controlled electro-mechanical systems using case studies and applications to electrical and mechanical systems. Includes hands-on lab (hardware-based) exploration of PID control systems. Undergraduate equivalent: ENGR 4301. Previously ME 0400.

BIEG 5309 Biosensors **3 Credits**
This course will provide an overview of biosensors, including their use in pharmaceutical research, diagnostic testing, and policing the environment. Topics include the fabrication, characterization, testing, and simulation of biosensors. The phenomenon of transducers, biosensor structure, sensor performance, and simulations utilizing molecular simulation software will also be covered. Graduate students who intend to pursue a MS in BME can take this course.

BIEG 5311 Biomaterials **3 Credits**
This course will cover the introductory level of understanding on the different types of biomaterials used in biomedical industry, their design and synthesis. Examples include implants, stents, catheters, smart polymer gels, bone grafts, and tissue scaffolds. Modern biology in biomedical engineering such as but not limited to protein adsorption, immuno-isolation, and regenerative medicine will be covered. Ethical issues in biomedical engineering will also be discussed. Current innovative research on nano-biotechnology that extends to 3D bio-matrix, advanced diagnostics, dental composites, sealants, and adhesives.

BIEG 5314 Introduction to Molecular Modeling 3 Credits
This course will cover methodological and practical aspects of the application of system analysis and computational tools to biological and biomedical problems. It will cover computational modeling of biological macromolecules such as proteins, DNA, and synthetic self-assembling materials such as polymers, crystals, colloids, and amphiphiles. The course provides the resources to use Visual Molecular Dynamics (VMD) and Nanoscale Molecular Dynamics (NAMD) to solve computational problems related to protein interactions in case of diseases and protein folding.

BIEG 5319 Advanced Experimental Design in Biomedical Engineering 3 Credits
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BIEG 5333 Biomedical Visualization 3 Credits
An introduction to 3D biomedical visualization. Various technologies are introduced, include ultrasound, MRI, CAT scans, PET scans, etc. Students will learn about spatial data structures, computational geometry and solid modeling with applications in 3D molecular and anatomical modeling. Undergraduate equivalent: BIEG 4333.

BIEG 5335 Clinical Engineering 3 Credits
Biomedical engineering is defined by the application of engineering design in service of human health. To solve problems in healthcare, it is crucial to understand the clinical environment within which biomedical engineers develop solutions. This course will provide students with the opportunity to work with faculty and students in the Egan School Simulation Lab to gain an understanding of modern clinical care and work collaboratively on solutions to existing problems in healthcare. Students will have an opportunity to use existing medical devices and gain an understanding of their fundamental operating principles. Students will gain an understanding of the societal underpinnings contributing to existing disparities in healthcare outcomes and how previous technological development has exacerbated to these disparities.

BIEG 5350 Medical Device Design 3 Credits
This project-based course focuses on important stages of the medical device product lifecycle including: identifying unmet clinical and global health needs, the FDA approval process, material selection, biocompatibility, ethical considerations, intellectual property, and post-market surveillance of similar products. Students will generate project ideas and design a medical device. Students are required to conduct an independent research, write a research report, create a poster and present the research in annual research symposium at the university or elsewhere. Undergraduate Equivalent BIEG 4350.

BIEG 5375 Bioelectronics 3 Credits
Bioelectronics have emerged as an exciting research area due to the integration of molecular biology with electronics to create fundamental devices. This course is intended for senior and graduate level engineering students. It will introduce fundamentals of bioelectronics through chemical, biochemical and biophysical concepts from the engineering perspective. It will further apply these concepts to the areas of electron transport through biological macromolecules, microfluidics, electrochemical techniques, DNA and neuron-based electronics, biomaterials and semiconductor-based bioelectronics.

BIEG 5387 Instrumental Analysis in Biomedical Engineering 3 Credits
This course will give an overview on several important analytical tools for characterizing the nanomaterials that are functionally engineered towards biomedical applications. Quantification of mechanical, electrical, electronic and biological properties of the nanomaterials such as carbon nanotubes, metal nanoparticles, quantum dots, nanowires, polymeric nanoparticles and biomedical nanomaterials will be discussed. Fundamental principles of the associated instruments and the evaluation of the physical, chemical and microscopy methods for materials in nano-regime will be highlighted. Modern material science depends on the use of a set of analytical methods that are used normally in specialized laboratories. This course will help the students get familiar with the basics of such specialized methods, their range of applicability and reliability, especially when the materials under test are in sub-100nm dimensions.

BIEG 5403 Advanced Biomechanics 3 Credits
This course introduces the applications of continuum mechanics to the understanding of various biological tissue properties and biological fluid flow. The structure, function and mechanical properties of bone, muscle, blood vessels and blood flow will be examined. Conservation laws and constitutive equations for solid, fluid, and intermediate biomaterials will be covered. Critical analysis of current research in the field of biomechanics is also emphasized.

BIEG 5407 Computational Genomics 3 Credits
This course will provide an overview of computational genomics. Students will obtain skill in analyzing genomic data and sequencing experiments. The focus will be on achieving proficiency in data management and processing based on popular file formats in genomic biology.

BIEG 5415 Engineering Applications of Numerical Methods 3 Credits
This course provides students with the theoretical basis to proceed in future studies. Topics include root-finding, interpolation, linear algebraic systems, numerical integration, numerical solution of ordinary and partial differential equations, modeling, simulation, initial boundary value problems, and two point boundary value problems. Cross-listed with MEEG 5415, ECEG 5415.

BIEG 5990 Independent Study 1-3 Credits
Graduate students pursue special topics, projects, and/or readings in selected areas. Students must meet with the instructor to discuss the proposed topic of study. Enrollment by departmental approval only.

BIEG 6971 Thesis I 3 Credits
The master's thesis tests students' abilities to formulate a problem, solve it, and communicate the results. The thesis is supervised on an individual basis. A thesis involves the ability to gather information, examine it critically, think creatively, organize effectively, and write convincingly; it is a project that permits students to demonstrate skills that are basic to academic and industry work. The student must also submit a paper for possible inclusion in a refereed journal appropriate to the topic.

BIEG 6972 Thesis II **3 Credits**

The master's thesis tests students' abilities to formulate a problem, solve it, and communicate the results. The thesis is supervised on an individual basis. A thesis involves the ability to gather information, examine it critically, think creatively, organize effectively, and write convincingly; it is a project that permits students to demonstrate skills that are basic to academic and industry work. The student must also submit a paper for possible inclusion in a refereed journal appropriate to the topic.