## DEPARTMENT OF ELECTRICAL & COMPUTER ENGINEERING

***Chairperson**: Ali Haidar*
***Professors**: **Soubhi Abou Chahine**, Ziad Osman, Mohamad Tarnini*
***Associate Professors**: Mohamad Ayache, Hamza Issa, Chadi Nohra, Amira Zaylaa*
***Assistant Professors**: Heba Halabi, Manal Fattoum, Rami Khodor, Abdallah Sabbagh, Abdallah Ghali, Bilal Youssef, Alaa Daher, Ziad Doughan, Abdul Rahman El Falou, Hiba Bazzi, Oussama Dankar, Youssef Ajra, Youssof Traboulssi,*
***Lecturer**: Ghina El Wali*

## *Biomedical Engineering Program*

### *Mission*

The educational mission of Biomedical Engineering (BME) Program is to deliver high quality undergraduate education which combines balanced theoretical and practical topics in Biological, Medical and Electrical systems. Graduates of the program will have a mastery of fundamental knowledge in a variety of Biomedical Engineering fields, management, and entrepreneurial skills. Graduates will be qualified to pursue successful careers in their profession or graduate studies in different areas.

### Objectives

The educational objectives of the program are determined to support career advancement of the graduates as they pursue their career goals. The graduates will:

1. Design biomedical systems in tune with community needs and environmental concerns
2. Develop and integrate new technologies as they emerge
3. Engage in a technical/managerial role in diverse teams
4. Pursue entrepreneurial initiatives and launch startup companies

### Learning Outcomes

UPON COMPLETION OF THE PROGRAM GRADUATES SHALL GAIN:

1. an ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics
2. an ability to apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors
3. an ability to communicate effectively with a range of audiences
4. an ability to recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts
5. an ability to function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives
6. an ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions
7. an ability to acquire and apply new knowledge as needed, using appropriate learning strategies

### Degree Requirements

The undergraduate curriculum for the degree of Bachelor of Engineering in Biomedical Engineering consists of 150 credit-hours of course work, where the standard duration of study is 8 semesters 3 summers, or 10 semesters.

### Career Opportunities

Biomedical engineers are responsible for the creation of artificial organs, automated patient monitoring, blood chemistry sensors, advanced therapeutic and surgical devices, application of expert systems and artificial intelligence to clinical decision making, design of optimal clinical laboratories, medical imaging systems, computer modeling of physiological systems, biomaterials design, and biomechanics for injury and wound healing, among many others.

**Program Overview**

The **Student's Study Plan** is given to every BME student upon his/her enrollment. The BME curriculum consists of the following components:

| **I. Common Requirements** | **Credits** |
|---|---|
| General Education Requirements | 16 |
| Basic Sciences and Mathematics | 30 |
| General Engineering Topics | 11 |
| **II. BME Program-Specific Requirements** | **Credits** |
| **A.** Engineering Topics from Outside the Major | 2 |
| **B.** Basic Electrical and Computer Engineering (ECE) Courses | 32 |
| **C.** BME Core | 42 |
| **D.** Technical Electives | 12 |
| **E.** Final Year Projects | 4 |
| **F.** Internship | 1 |

## I. Common Requirements

The list of the Common Requirement courses and their descriptions are presented in the introductory pages of the Faculty of Engineering section in this catalog. In particular, the BME curriculum includes 11 credits offered as general engineering topics. These courses are listed in the table below:

| **Code** | **Name** | **Crs.** |
|---|---|---|
| MCHE 213 | Dynamics | 3 |
| COMP 208 | Programming I | 3 |
| INME 221 | Engineering Economy | 3 |
| ENGR 500 | Research Methodology | 2 |

## II. BME Program-Specific Requirements

### *A.* Engineering Topics from Outside the Major

This part of the biomedical engineering curriculum includes 2 credits offered by other engineering programs. The course is listed in the table below.

| **Course** | **Title** | **Credits** | **Pre-/Co- requisites** |
|---|---|---|---|
| ENGR 002 | Introduction to Engineering | 2 | |

Descriptions of this course is given below:

**ENGR 002 INTODUCTION TO ENGINEERING (2Crs.: 2Lec.):** Introducing the student to the engineering profession in general and the learning objectives that new students should attain, as aligned with the ABET requirements. Covering the basics of the engineering profession and engineering ethics. Introduction to the different engineering majors and to the learning objectives as specified by ABET. Insight into different engineering courses that are not technical in nature (e.g., engineering economy). Engineering design tasks that allow the student to start thinking as engineers: problem definition, specification of constraints, investigation of different solution alternatives, implementation of best solution, writing technical reports. Fundamental tools and numerical software used in engineering. The tools and software covered could be generic or specific to a major.

***B.*** **Basic Electrical and Computer Engineering Courses**

This part of the BME curriculum includes 32 credits courses offered by the Electrical and Computer Engineering (ECE) Department. These courses are listed in the table below.

| Course | Title | Credits | Pre-/Co- requisites |
|---|---|---|---|
| POWE 212 | Electric Circuits I | 3 | |
| POWE 271 | Electromagnetic Fundamentals | 3 | Pre: PHYS 281 |
| COME 214 | Electric Circuits II | 3 | Pre: POWE 212 |
| COME 212L | Electric Circuits Lab | 1 | Pre or Co: COME 214 |
| COME 221 | Electronic Circuits I | 3 | Pre: POWE 212, ENGR 002 |
| COME 222 | Electronic Circuits II | 3 | Pre: COME 221 |
| COME 222L | Electronic Circuits Lab | 1 | Pre or Co: COME 222 |
| COME 381 | Signals and Systems | 3 | |
| COME 384 | Digital Signal Processing | 3 | Pre: COME 381 |
| COMP 225 | Digital Systems I | 3 | |
| COMP 226 | Digital Systems II | 3 | Pre: COMP 225 |
| COMP 335 | Microprocessors for Biomedical Engineering | 3 | Pre: COMP 226 |

**Descriptions of this group of courses are given below:**

**POWE 212 ELECTRIC CIRCUITS I (3Crs.: 3Lec):** Circuit variables: voltage, current, power, and energy. Circuit elements: resistors, inductors, capacitors, voltage sources, and current sources. Circuit reduction techniques: series and parallel resistors and delta-to-wye transformation. Ohm's law. Kirchhoff's laws. DC and AC circuit analysis techniques: node-voltage and mesh-current methods, source transformations, Thévenin and Norton equivalent circuits, and maximum power transfer. Self and mutual inductances. AC steady-state power calculations. Balanced three-phase circuits.

**POWE 271 ELECTROMAGNETIC FUNDAMENTALS (3Crs.: 3Lec):** Three-dimensional orthogonal coordinate systems: Cartesian, Cylindrical and Spherical. Vector Analysis: Gradient, Divergence and Curl of fields, Divergence theorem, Stokes's theorem. Fundamental Postulates of Electrostatics in free space, Coulomb's Law in space, Gauss's Law in space. Material Media: Conductors and Dielectrics, Polarization, Electric Flux Density. Boundary Conditions. Capacitors and Electrostatic Energy. Poisson's Equation, Laplace's Equation, Method of Images, Boundary Value Problems, Steady Electric Currents: conduction and convection currents, equation of continuity, boundary conditions for current density. Resistance and Power calculations. Fundamental Postulates of Magnetostatics in free space, Biot-Savart law in space, Ampere's Law in space. Magnetic materials: Magnetization, Inductance and Magnetostatic Energy. Magnetic circuit analysis. Introduction to Magnetic Forces and Torques. Time varying fields: Faraday's Law for Electromagnetic Induction (stationary circuit in a time- varying magnetic field, Transformers, moving circuit in steady and time-varying magnetic fields), Maxwell's Equations, Electromagnetic boundary conditions. ***Pre-requisite: PHYS 281***

**COME 214 ELECTRIC CIRCUITS II (3Crs.: 3Lec):** Transient analysis, Laplace transform and its application to circuit analysis, two-port networks, frequency selective passive and active circuits. ***Pre-requisite: POWE 212***

**COME 212L ELECTRIC CIRCUITS LAB (1Cr.: 2Lab):** The content of this lab is directly related to the courses POWE 212, COME 214. ***Pre or Co-requisite.: COME 214.***

**COME 221 ELECTRONIC CIRCUITS I (3Crs.: 3Lec):** Introduction to semiconductor physics, junction diodes: construction, I-V characteristics, circuit models, applications, special purpose diodes: Zener diodes. Bipolar junction transistors (BJT) and field effect transistors (FET): types, physical structures, basic configurations, characteristic curves, circuit models, biasing circuits, small-signal amplifiers. ***Pre-requisite.: POWE 212, ENGR 002.***

**COME 222 ELECTRONIC CIRCUITS II (3Crs.: 3Lec):** BJT and FET amplifiers: Types, circuit models, frequency response, differential and multistage amplifiers, large signal analysis and power amplifiers, operational amplifiers: Characteristics, applications, imperfections, feedback amplifiers, sinusoidal oscillators and multi-vibrators. ***Pre-requisite.: COME 221.***

**COME 222L ELECTRONIC CIRCUITS LAB (1Cr.: 2Lab):** The content of this lab is directly related to the courses COME 221, COME 222. ***Pre or Co-requisite: COME 222.***

**COME 381 SIGNALS AND SYSTEMS (3Crs.: 3Lec):** Signals and systems properties and classifications. Continuous Linear Time-Invariant systems. Analytical and graphical convolution and correlation. Fourier series and Fourier Transform. Laplace transform. Frequency spectra, energy and power spectra. Frequency response and transfer function, impulse response and step response. Analog Filter response.

**COME 384 DIGITAL SIGNAL PROCESSING (3Crs.: 2Lec, 2Lab)** Sampling, Quantization and SQNR. Signal Reconstruction and anti-aliasing filter. Discrete time signals. Difference equations and impulse responses. BIBO stability. Digital convolution. Discrete Fourier Transform and Fast Fourier Transform. Z-transform. Digital filter frequency response and transfer function. Z-plane stability. Realization of digital filters. Methods of FIR and IIR filter designs. Digital Butterworth and Chebyshev filter designs***. Pre-requisite: COME 381.***

**COMP 225 DIGITAL SYSTEMS I (3Crs.: 2Lec, 2Lab)** Number systems and coding, Binary systems. Conversion from decimal to other bases. BCD numbers. Boolean algebra. Logic gates. Function minimization, Tabular method, Karnaugh mapping. Arithmetic functions and circuit design (HA, FA, and ALU). Combinational functions and circuit design (decoder, encoder, multiplexer and de-multiplexer). Sequential circuits components (Latches, RS-FF, D-FF, JK-FF, T-FF). Introduction to VHDL. Several laboratory experiments will be based on simple logic gates.

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**COMP 335 MICROPROCESSORS FOR BIOMEDICAL ENGINEERING (3Crs.: 2Lec, 2Lab):** The course focuses on the principle of microprocessors and microcontrollers and their applications in Biomedical Engineering. Introduction to hardware system: CPU, Memory, Input/Output Interfacing, and System Bus. Instruction sets; assembly and machine languages. Fetch Cycle, Execution cycle, Instruction cycle. Detailed study of a particular Microprocessor or Microcontroller architecture: Instruction set; assembly language programming, Programming techniques, Loops, Delays, parallel and serial interfaces, interrupt control systems; Timers. ***Pre- requisite: COMP 226***.

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| **B. Basic Electrical, Computer and Communications** Engineering | | **32** |
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| COMP 208 | Programming I | 3 |
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| POWE 271 | Electromagnetic Fundamentals | 3 | Pre: PHYS 281 |
| COME 214 | Electric Circuits II | 3 | Pre: POWE 212 |
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**POWE 271 ELECTROMAGNETIC FUNDAMENTALS (3 Crs.: 3Lec,0Lab):** Three-dimensional orthogonal coordinate systems: Cartesian, Cylindrical and Spherical. Vector Analysis: Gradient, Divergence and Curl of fields, Divergence theorem, Stokes's theorem. Fundamental Postulates of Electrostatics in free space, Coulomb's Law in

space, Gauss's Law in space. Material Media: Conductors and Dielectrics, Polarization, Electric Flux Density. Boundary Conditions. Capacitors and Electrostatic Energy. Poisson's Equation, Laplace's Equation, Method of Images, Boundary Value Problems, Steady Electric Currents: conduction and convection currents, equation of continuity, boundary conditions for current density. Resistance and Power calculations. Fundamental Postulates of Magnetostatics in free space, Biot-Savart law in space, Ampere's Law in space. Magnetic materials: Magnetization, Inductance and Magnetostatic Energy. Magnetic circuit analysis. Introduction to Magnetic Forces and Torques. Time varying fields: Faraday's Law for Electromagnetic Induction (stationary circuit in a time- varying magnetic field, Transformers, moving circuit in steady and time-varying magnetic fields), Maxwell's Equations, Electromagnetic boundary conditions. ***Pre-requisite: PHYS 281***

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**COMP 335 MICROPROCESSORS FOR BIOMEDICAL ENGINEERING (3Crs.: 2Lec, 2Lab):** The course focuses on the principle of microprocessors and microcontrollers and their applications in Biomedical Engineering. Introduction to hardware system: CPU, Memory, Input/Output Interfacing, and System Bus. Instruction sets; assembly and machine languages. Fetch Cycle, Execution cycle, Instruction cycle. Detailed study of a particular Microprocessor or Microcontroller architecture: Instruction set; assembly language programming, Programming techniques, Loops, Delays, parallel and serial interfaces, interrupt control systems; Timers. ***Pre- requisite: COMP 226***.

### *C.* Biomedical Engineering Program Core

The BME program 42 credits core courses are listed as follows:

| Course | Title | Credits | Pre-/Co-requisites |
|---|---|---|---|
| HESC 201 | Human Anatomy & Physiology | 3 | |
| BIME 320 | Biomedical Ethics amd Human Safety | 1 | Pre: ENGR 001 |
| BIME 312 | Medical Device Maintenance & Repair | 2 | Pre: BIME 441 |
| BIME 350 | Biophysics and Biomechanics | 3 | Pre: PHYS 280 |
| BIME 351 | Artificial Organs and Devices | 3 | Pre: HESC 201 |
| BIME 314L | Hands on Biomedical Prototyping Lab | 1 | Pre: COMP 335 |
| BIME 305 | Control Systems for Medical Applications | 3 | Pre: COME 214, MATH 283 |
| BIME 310 | Biomedical Instrumentation I | 3 | Pre: BIME 441 |
| BIME 336 | Machine Learning for Medical Applications | 3 | |
| BIME 411 | Biomedical Instrumentation II | 3 | Pre: BIME 310 |
| BIME 413 | Biomedical Image Processing | 3 | Pre: COME 384 |
| BIME 441 | Biomedical Sensors | 3 | Pre: COME 222 |
| BIME 411L | Biomedical Instrumentation Lab | 1 | Pre or Co: BIME 411 |
| BIME 421 | Biomedical Imaging I | 3 | Pre: BIME 350 |
| BIME 422 | Biomedical Imaging II | 3 | Pre: BIME 421 |
| BIME 422L | Biomedical Imaging Lab | 1 | Pre or Co: BIME 422 |
| BIME 432 | Biological Materials | 3 | Pre: HESC 201 |

**Description of Core Courses**

**HESC 201 HUMAN ANATOMY AND PHYSIOLOGY (3Cr:2Lec,2Lab):** This course studies the structure (brief anatomy) and function (detailed physiology) of the following body systems: muscular, nervous, endocrine, blood, lymphatic, cardiovascular, respiratory, digestive, urinary, and reproductive.

**BIME 320 BIOMEDICAL ETHICS AND HUMAN SAFETY (1Cr:1Lec):** The course familiarizes students with different kinds of biomedical engineering ethical issues that they might encounter throughout their careers and throughout research. This course aims to introduce the students to the following topics: Introduction to key ethical principles, Understanding and Applying laws and regulations governing biomedical engineering, analysis of ethical issues in biomedical research, including the development of research codes, ethical practices, and the use of human and non-human subjects. Understanding and discussing the ethical implications of emerging technologies, such as artificial intelligence in healthcare, medical imaging devices and innovations. In addition, the Human Safety is covered mainly in the biomedical engineering departments and practices, including questionnaires, common adherence to protocols, etc. and case studies are analyzed on different biomedical engineering topics. ***Pre-requisite: ENGR 001.***

**BIME 312 MEDICAL DEVICE MAINTENANCE AND REPAIR (2Crs.:2Lec):**. This course covers the principles of medical device management, maintenance, and repair. Topics include equipment inspection, calibration, risk management, fault diagnosis, and performance optimization. It also addresses the maintenance of critical devices such as ventilators, autoclaves, imaging systems, defibrillators, pacemakers, and ECG

machines. ***Pre-requisite: BIME 441.***

**BIME 350 BIOPHYSICS AND BIOMECHANICS (3Crs.:3Lec):** This is an introductory course on biophysics and biomechanics fundamentals. This course aims to introduce the following topics: Static biomechanics, properties of biological materials, the principles of physics in fluid flow, specifically in the blood flow, blood rheology, cardiovascular biomechanics, muscle biomechanics. Bioelectric Phenomenon, such as resting and action potentials with their physical tools, and Electric Bio – Signals. An introduction to different types of waves, such as X-rays, Ultrasound and Optical waves, and their interaction and their applications in diagnostic and treatment. ***Pre-requisite: PHYS 280.***

**BIME 351 ARTIFICIAL ORGANS AND DEVICES (3Crs.:3Lec):** The course main goal is to provide technologies that will maintain, preserve, safeguard, improve, or restore the function of diseased organs. This course explores the design, development, and application of artificial organs and medical devices used to replace or support biological functions. The replacement of failing human organs with artificial devices and systems is in order to improve the healthcare services. ***Pre-requisite: HESC 201.***

**BIME 314L HANDS ON BIOMEDICAL PROTOTYPING Lab (1Cr.:3Lab):** This course offers third-year biomedical engineering students a practical, project-based experience in designing, building, and testing biomedical prototypes. The course provides students with hands-on knowledge in the development of medical devices, focusing on the integration of sensors and data acquisition systems. The course emphasizes practical techniques for capturing, processing, and analyzing biomedical signals, enabling students to create innovative solutions for healthcare challenges. ***Pre-requisite: COMP 335.***

**BIME 305 CONTROL SYSTEMS FOR MEDICAL APPLICATRIONS (3Crs.:2Lec, 2Lab):** This course provides an introduction to control systems theory principles for biomedical engineers. It includes mathematical techniques to characterize and design control systems in biomedical engineering contexts. Topics covered are frequency and time-domain modeling, feedback, stability, steady-state error, design, root-locus, and Proportional-Integral-Derivative (PID) Control, with application to biomedical systems. Also, a control system lab offers hands-on experience in applying control theory to biomedical systems. These labs typically involve experiments that design control systems relevant to physiological processes and medical devices. ***Pre-requisite: MATH 283, COME 214.***

**BIME 310 BIOMEDICAL INSTRUMENTATION I (3Crs.:3Lec):** This course covers the fundamentals of biomedical instrumentation, focusing on medical measurement systems. Topics include displacement, capacitive, and piezoelectric transducers, as well as biomedical monitoring devices like plethysmographs, temperature sensors, oxygen saturation monitors, and accelerometers. Students explore cardiovascular measurements, including direct and indirect blood pressure monitoring, harmonic analysis, catheterization, auscultation techniques, and tonometry. Blood flow and volume measurements using indicator dilution, electromagnetic, and ultrasonic flow meters are also covered. The course provides physiological signal acquisition with biopotential electrodes, electromyography (EMG), electrocardiography (ECG), and electroencephalography (EEG). Respiratory system measurements, including pressure and flow parameters, are also discussed. Emphasizing biomedical applications, the course provides a foundation for physiological monitoring and medical device development. ***Pre-requisite: BIME 441.***

**BIME 336 MACHINE LEARNING FOR MEDICAL APPLICATIONS (3Crs.:2Lec, 2Lab):** This course introduces machine learning in the biomedical field, covering advanced signal preprocessing and feature extraction techniques (temporal, frequency, and time-frequency). It explores supervised classification methods, including Bayesian networks, neural networks, Support Vector Machine (SVM), regression models, and classification trees, as well as unsupervised techniques like K-means and fuzzy c-means clustering. An introduction to deep learning is also provided. Real-world applications in computational medicine (oncology, pathology, physiology, and disease anatomy) are discussed, along with interpretability and ethical considerations. A programming lab supports hands-on implementation of machine learning algorithms.

**BIME 411 BIOMEDICAL INSTRUMENTATION II (3Crs.:3Lec):** This course explores advanced biomedical instrumentation techniques used in medical and laboratory applications. It covers spectrophotometry, including single and double-beam systems, Beer-Lambert law, concentration calculations, and system calibration. Flame photometry is introduced for quantitative and qualitative metal concentration measurements. Students also study fluorescence spectroscopy, chromatography techniques (adsorption, ion exchange, membrane filtration, exclusion chromatography, and High-performance liquid chromatography (HPLC), as well as calibration and maintenance of chromatography systems. The course further examines automated chemistry analyzers, hematology analyzers (including Complete Blood Count (CBC) analysis and 3-D cytometric analyzers), sterilization units (autoclaves), electrophoresis, and anesthesia machines. Emphasizing practical biomedical applications, this course provides a strong foundation in diagnostic and analytical instrumentation. ***Pre-requisite.: BIME 310.***

**BIME 413 BIOMEDICAL IMAGE PROCESSING (3Crs.:2Lec, 2Lab):** This course introduces biomedical image processing, covering key techniques and applications in medical imaging. It begins with an overview of imaging systems, distinguishing between ionizing and non-ionizing modalities. Students explore image types, sampling, and quantization. The course covers digital image processing fundamentals, including gray-level histograms, equalization, and transformations. Image enhancement in spatial and frequency domains includes gray-level transformations, intensity windowing, filtering, and Fourier-based methods. Students also learn mathematical morphology operations (dilation, erosion, opening, closing) and their applications in edge detection. Image segmentation techniques, such as thresholding, region-based methods, clustering, and color segmentation, are introduced. A programming lab (MATLAB and LabVIEW) supports hands-on experience in biomedical image analysis. ***Pre-requisite: COME 384.***

**BIME 441 BIOMEDICAL SENSORS (3Crs.:2Lec):** The course addresses how physiological signals are sensed, measured and analyzed in biomedical engineering, in particular the following fields are covered: Signal Conditioning, Pressure measurements, Flow measurements, Motion and force measurements, Temperature and heat flow measurements and Bioelectrical and biomagnetic measurement techniques are provided. Also, the acquisition of biomedical signals and the designs of Elecroencaphalography (EEG), Electrocardiography (ECG), Electromayography (EMG) are covered. Endoscopy and Defibrillators are discussed in details. ***Pre-requisite.: COME 222.***

**BIME 411L BIOMEDICAL INSTRUMENTATION LAB (1Cr: 3 Lab):** The content of this lab is directly related to the courses BIME 310, BIME 411. This laboratory course provides students with practical, hands-on experience in acquiring, processing, and analyzing various physiological signals essential for biomedical engineering applications. By working with real-time data from the human body, students will develop essential skills in biomedical instrumentation, signal interpretation, and the correlation between physiological responses and health conditions. The course integrates theoretical knowledge with experimental techniques and enhances students' programming proficiency in biomedical signal processing using MATLAB and LabVIEW. ***Pre or Co-requisite: BIME 411.***

**BIME 421 BIOMEDICAL IMAGING I (3Crs.:3Lec):** This course introduces imaging methods in medicine and biology. Biomedical imaging systems to be analyzed include conventional X-ray, X-ray image geometry, magnification radiography, X-ray site protection, in addition to Fluoroscopy. Computed Tomography (CT), Bone Densitometry-DEXA, introduction to nuclear medicine (Positron Emission Tomography (PET) and Single Photon Emission Computer Tomography (SPECT)), and Ultrasound (US) imaging are provided. Each of these modalities is introduced from basic physical principles to the process of image formation. Also, basic concepts in medical image processing and topics on Magnetic Resonance Imaging (MRI) are introduced. The course includes actual biomedical imaging devices and a course project to explore real world applications of biomedical imaging devices. ***Pre-requisite: BIME 350***.

**BIME 422 BIOMEDICAL IMAGING II (3Crs.:3Lec):** The course addresses the continuation of Biomedical Imaging I course, it covers nuclear medicine, Positron Emission Tomography (PET) and Single Photon Emission Computer Tomography (SPECT), from theory to application to reconstruction techniques. Image reconstruction techniques include, algebraic image reconstruction and iterative image reconstruction techniques. The course provides Magnetic Resonance Imaging (MRI) from physics of MRI to pulse sequences, designs and equipment, including MRI safety. In particular, the following fields are covered: Anatomical MRI and functional MRI, including fMRI and BOLD MRI imaging. Also advanced topics on Nuclear imaging and MRI imaging and reconstruction, and hybrid medical imaging is introduced . ***Pre-requisite: BIME 421.***

**BIME 422L BIOMEDICAL IMAGING LAB (1Cr, 3Lab):** The course addresses the application of the concepts and lectures of Biomedical Imaging I and II and the Biomedical Photonics and Optical Imaging courses, it includes real imaging of the brain using Electroencaphalography (EEG)s, imaging of the breast using Mamography, abdominal imaging using Ultrasound (US) machines and Imaging using the digital slit lamp. In particular the following fields are covered: X-ray and CT Imaging, EEG installation and Image analysis, MRI imaging, Ultrasound B-mode and doppler imaging and reconstruction, digital slit lamp imaging and reconstruction. Also, the advances in medical imaging devices. ***Pre or Co-requisite: BIME 422.***

**BIME 432 BIOLOGIOCAL MATERIALS (3Crs.:2Lec):** The course addresses the properties of materials used in medicine and in biomedical engineering. It provides the classes of biological materials, biodegradation of materials and toxic kinetic, sterilization processes, cytotoxicity, interactions with blood, genotoxicity, carcinogenicity, and the prevention of prevention of calcification of biological materials. Regulatory aspects of biomaterials, the interaction, types of biomaterials and the surgical biomaterials. A detailed explanation on the biocompatibility of biological materials and the immune system response is provided. ***Pre-requisite.: HESC 201***.

### *D.* Biomedical Engineering Program Technical Electives

The BME curriculum includes 12-credit hour courses as technical electives. 6 of them can be taken from other programs. The courses are chosen from the courses listed in the table below, with their descriptions given thereafter.

| Course | Title | Credits | Pre-/Co-requisites |
|---|---|---|---|
| BIME 511 | Cell and Tissue Engineering | 3 | Pre: BIOL 231 |
| BIME 541 | Telemedicine | 3 | Pre: BIOL 231 |
| BIME 532 | Introduction to Neuroscience for Engineers | 3 | Pre: BIOL 231 |
| BIME 524 | Biomedical Photonics and Optical Imaging | 3 | Pre: BIOL 231 |
| BIOL 451 | Bioinformatics | 3 | Pre: BIOL 334 |
| INME 482 | Engineering Project Management | 3 | Pre: ENGL 300 |
| COMP 424 | Artificial Intelligence and Robotics for Engineers | 3 | Pre: COMP 208 |
| COMP 215 | Python | 3 | Pre: COMP 208 |
| POWE 435 | Electric Machinery I | 3 | Pre: POWE 271 |
| POWE 433 | Power Electronic Circuits I | 3 | Pre: COME 221 |
| COME 411 | Instrumentation | 3 | Pre: COME 221 or COME 223 |
| COME 576 | Optical communications | 3 | Pre: POWE 271 |

**Description of Technical Elective Courses**

**BIME 511 CELL AND TISSUE ENGINEERING (3Crs.:3Lec,0Lab):** Applying engineering principles, combined with molecular cell biology, to develop a fundamental understanding of property-function relationships in cells and tissues. Exploiting this understanding to manipulate cell and tissue properties to alter, restore, maintain, or improve cell and tissue functions; and to design bio-artificial tissue substitutes***. Pre-requisite: BIOL 231.***

**BIME 541 TELEMEDICINE (3Crs.:3Lec,0Lab):** Describes and analyses the role of information and communications technologies in enabling remote patient care, health professional collaboration at a distance, and in supporting patient-self management. This is considered with reference to technological, clinical, sociological and policy perspectives. ***Pre-requisite: BIOL 231.***

**BIME 532 INTRODUCTION TO NEUROSCIENCE FOR ENGINEERS (3Crs.:3Lec,0Lab):** Introduction to the nervous system, with emphasis on the structure and function of the human brain. Functions of nerve cells, sensory systems, control of movement, learning and memory, and diseases of the brain. Review of neuro engineering methods and technologies that enable the study of and therapeutic solutions for diseases or damage of the nervous system. ***Pre-requisite: BIOL 231.***

**BIME 524 BIOMEDICAL PHOTONICS AND OPTICAL IMAGING (3Crs.:3Lec,0Lab):** This course explores the principles and applications of photonics and optical imaging techniques in the biomedical field. It covers the interaction of light with biological tissues, cutting-edge optical imaging modalities and computational methods, and the development of photonic tools for medical diagnostics and therapeutic applications. The course integrates fundamental optical physics, engineering principles, and biomedical applications, providing hands-on experience with imaging technologies. Topics include, but not limited to, fluorescence imaging, confocal microscopy, optical coherence tomography (OCT), spectral imaging, and laser-based medical treatments. ***Pre-requisite: BIOL 231.***

**Description of Technical Elective Courses From Outside the Program:**

**BIOL 451 BIOINFORMATICS (3Crs.:2Lec,2Lab):** This course covers basic principles of bioinformatics. Topics include biological databases, sequence homology searching, sequence alignment, genome browsers, motif finding, protein structure analysis and modeling and gene expression analysis. This course also includes practical application of bioinformatics tools. ***Pre-requisite: BIOL 334.***

**INME 482 ENGINEERING PROJECT MANAGEMENT (3 Crs.: 3 Lec):** The course covers the characteristics, techniques and challenges associated with initiating, planning, executing, controlling and closure of projects. Project management skills are discussed as they apply to projects, with special focus on leadership, teaming, and coordinating individual and group efforts. MS Project is introduced to provide hands-on practical skills with building a project plan, scheduling tasks, assigning resources, managing dependencies, monitoring progress and costs, keeping projects on track, and communicating project data through Gantt charts. ***Pre-requisite: ENGL 300.***

**COMP 424 ARTIFICIAL INTELLIGENCE AND ROBOTICS FOR ENGINEERS (3 Crs.: 3 Lec, 0Lab):** Introduction to artifi cial intelligence and machine learning. Introduction to robotics. Programming in Python: data type, expressions, functions, loops and control. Data plotting and analysis. Smart agent models. Supervised and unsupervised learning. Knowledge representation and reasoning. ***Pre-requisite: COMP 208.***

**COMP 215 PYTHON (3 Crs.: 3 Lec, 0Lab):** Programming in Python for engineers: language, use of external libraries, runtime analysis, applications from data analysis and engineering. Topics include: Control statement and program development, functions, sequences: list and tuples, dictionaries and sets , a deeper look on strings, Array-Oriented Programming with NumPy, and plotting. ***Pre-requisite: COMP208.***

**POWE435 ELECTRIC MACHINERY I (3 Crs: 3 Lec):** History of Electric Machinery. Magnetic circuits. Principles of energy conversion. Single-phase transformers: construction, theory of operation, equivalent circuit, power flow, regulation and testing, autotransformer, tap-change transformer. Three-phase transformers: connections, per-unit equivalent circuit and special connections. DC Machines: construction, theory of operation, armature reaction and commutation, induced voltage, developed torque and equivalent circuits for separately excited, series, parallel and compound DC generators and DC motors, staring methods of DC motors. PMDC motors and brushless DC motors: construction, theory of operation and applications. Introduction to DC motor drives. ***Pre-requisite: POWE271.***

**POWE 433 POWER ELECTRONIC CIRCUITS I (3 Crs.: 3 Lec):** Introduction to power switches: diode, thyristor, triac, diac, GTO, BJT, MOSFET, IGBT, characteristics, modes of operation, selection of switches, firing circuit design and application, analysis and design of suitable circuits and subsystems for practical applications such as dimmer circuit and dc motor control circuit, calculation of switching losses, evaluation of THD and associated power losses. Rectifying circuits: single-phase and three-phase, uncontrolled, half- controlled and fully-controlled rectifiers for different types of passive loads, evaluation and demonstration of steady state voltages and currents, calculation of efficiency, PF and THD of such converters. Circuit analysis software such as PSIM, PROTEUS or MATLAB. ***Pre-req.: COME 221.***

**COME 411 INSTRUMENTATION (3 Crs. : 2 lec, 2 lab):** Different types of transducers and their applications. Instruments used in measuring electrical quantities. Display instruments. Signal generators. Digital to analog and analog to digital conversion. Data acquisition systems components, hardware and software. ***Pre-requisite: COME 221 or COME 223***.

**COME 576 OPTICAL COMMUNICATIONS (3 Crs.: 3Lec, 0Lab):** Review of basic communication systems. Introduction to optical communication systems. Fiber characteristics. Impact of different types of dispersion on bit rates. Optical transmitters and receivers. Lasers. Optical amplifiers. Long haul and multi-channel systems. ***Pre-requisite: POWE 271***.

***Note: Other courses can be added to the technical elective courses pool from outside the program as long as the pre-requisite of the specified course is already taken by the student.***

## *E.* Final Year Project

**BIME 501 FINAL YEAR PROJECT I (1Cr) / BIME 502 FINAL YEAR PROJECT II (3Crs):** After completing 120 credits of course work, the student becomes eligible to sign up for the Final Year Project (FYP) that extends over two semesters; beginning in Fall-semester and ending in the following Spring-semester. The FYP experience requires students to work in teams to complete a specific project, submit a technical report, and give a presentation on a significant, relevant, and comprehensive engineering problem. The FYP is intended to stimulate student creativity and critical thinking, and build skills in formulating, designing, developing, building, communicating, and managing engineering projects. The project aims to provide students with a transitional experience from the academic world to the professional world. ***ENGR 500 *Pre-requisite for BIME501. BIME 501 *Pre-requisite for BIME 502.***
*Refer to the Final Year Project Policy for more details.*
****Starting from Fall 2025-2026.***

## *F.* Internship

**BIME 499 INTERNSHIP (1Cr):** This is a professional training which should not be less than four weeks. The training is followed by a presentation session where the students are supposed to present what they have learned. *Refer to the department policy for further details*.

**Bachelor of Engineering in Biomedical Engineering (150 Credits)**

| **First Semester (17 Credits)** | | **Crs.** | |
|---|---|---|---|
| MATH 281 | Linear Algebra | 3 | Pre: MATH 112 |
| MATH 282 | Calculus | 3 | Pre: MATH 111 |
| MCHE 213 | Dynamics | 3 | |
| PHYS 281 | Electricity and Magnetism | 3 | Pre: PHYS 120 |
| ENGR 002 | Introduction to Engineering | 2 | |
| BLAW 001 | Human Rights | 1 | |
| ARAB 001 | Arabic Language | 2 | |

| **Second Semester (17 Credits)** | | **Crs.** | |
|---|---|---|---|
| COMP 225 | Digital Systems I | 3 | |
| MATH 283 | Differential Equations | 3 | Pre: MATH 281, MATH 282 |
| PHYS 280 | Classical Physics | 3 | |
| COMP 208 | Programming I | 3 | |
| POWE 212 | Electric Circuits I | 3 | |
| ENGL 001 | General English | 2 | |

| **Summer I (9 Credits)** | | **Crs.** | |
|---|---|---|---|
| CHEM 241 | Principles of Chemistry | 3 | Pre: CHEM 110 |
| ENGL 211 | Advanced Writing | 2 | Pre: ENGL 001 |
| BIOL 231 | Biology I | 3 | |
| CHEM 241L | Principles of Chemistry Lab | 1 | Pre or Co: CHEM 241 |

| **Third Semester (16 Credits)** | | **Crs.** | |
|---|---|---|---|
| HESC 201 | Human Anatomy and Physiology | 3 | |
| COME 221 | Electronic Circuits I | 3 | Pre: POWE 212, ENGR 002 |
| COME 214 | Electric Circuits II | 3 | Pre: POWE 212 |
| COME 212L | Electric Circuits LAB | 1 | Pre or Co: COME 214 |
| COMP 226 | Digital Systems II | 3 | Pre: COMP 225 |
| POWE 271 | Electromagnetic Fundamentals | 3 | Pre: PHYS 281 |

| **Fourth Semester (15 Credits)** | | **Crs.** | |
|---|---|---|---|
| MATH 381 | Probability and Statistics | 3 | Pre: MATH 282 |
| MATH 284 | Numerical Analysis | 3 | Pre: MATH 283 |
| COME 222 | Electronic Circuits II | 3 | Pre: COME 221, COME 214 |
| COME 222L | Electronic Circuits Lab | 1 | Pre or Co: COME 222 |
| INME 221 | Engineering Economy | 3 | |
| ENGL 300 | Speech Communications | 2 | Pre: ENGL 211 |

| **Summer II (9 Credits)** | | **Crs.** | |
|---|---|---|---|
| CHEM 405 | Solid State Chemistry | 2 | |
| ENGR 001 | Engineering Ethics | 1 | |
| WRNL 200 | Work Ready Now | 3 | |
| | Elective (General) | 2 | |
| | Elective (General) | 1 | |

| **Fifth Semester (17 Credits)** | | **Crs.** | |
|---|---|---|---|
| COME 381 | Signals and Systems | 3 | |
| ENGR 500 | Research Methodology | 1 | Pre: ENGL 211 |
| BIME 350 | Biophysics and Biomechanics | 3 | Pre: PHYS 280 |
| BIME 441 | Biomedical Sensors | 3 | Pre: COME 222 |
| COMP 335 | Microprocessors for Biomedical Engineering | 3 | Pre: COMP 226 |
| BIME 336 | Machine Learning for Medical Applications | 3 | |

| **Sixth Semester (18 Credits)** | | **Crs.** | |
|---|---|---|---|
| BIME 305 | Control Systems for Medical Applications | 3 | Pre: COME 214, MATH 283 |
| BIME 351 | Artificial Organs and Devices | 3 | Pre: HESC 201 |
| BIME 314L | Hands on Biomedical Prototyping Lab | 1 | Pre: COMP 335 |
| BIME 310 | Biomedical Instrumentation I | 3 | Pre: BIME 441 |
| COME 384 | Digital Signal Processing | 3 | Pre: COME 381 |
| BIME 312 | Medical Device Maintenance and Repair | 2 | Co: BIME 441 |
| | Technical Elective | 3 | |

| **Summer III (1 Credit)** | | **Crs.** |
|---|---|---|
| BIME 499 | Internship (Approved Experience / Independent Study) | 1 |

| **Seventh Semester (15 Credits)** | | **Crs.** | |
|---|---|---|---|
| BIME 413 | Biomedical Image Processing | 3 | Pre: COME 384 |
| BIME 411 | Biomedical Instrumentation II | 3 | Pre: BIME 310 |
| BIME 411L | Biomedical Instrumentation Lab | 1 | Pre or Co: BIME 411 |
| BIME 421 | Biomedical Imaging I | 3 | Pre: BIME 350 |
| BIME 320 | Biomedical Ethics and Human Safety | 1 | Pre: ENGR 001 |
| BIME 501 | Final Year Project I | 1 | Pre: ENGR 500 |
| | Technical Elective | 3 | |

| **Eighth Semester (16 Credits)** | | **Crs.** | |
|---|---|---|---|
| BIME 422 | Biomedical Imaging II | 3 | Pre: BIME 421 |
| BIME 422L | Biomedical Imaging Lab | 1 | Pre or Co: BIME 422 |
| BIME 432 | Biological Materials | 3 | Pre: HESC 201 |
| BIME 502 | Final Year Project II | 3 | Pre: BIME 501 |
| | Technical Elective | 3 | |

| | |
|---|---|
| Technical Elective | 3 |