Biomedical Engineering

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The mission of the Department of Biomedical Engineering is to integrate academia, clinical medicine, and the biomedical industry

- In the education and training of the next generation of biomedical engineers;
- In research and development activities activities leading to innovations in medical technology;
- In transfer of that medical technology to commercialization and clinical implementation; and
- In the continuing development of biomedical engineering as a profession, its impact on the delivery of health care, and its role in the sustainability and growth of the local and national economies.

The objectives of the graduate Biomedical Engineering Program at FIU are the following:

1. Provide highly trained professional at the Ph.D. level in Biomedical Engineering to serve in academic institutions, government agencies, research laboratories, and manufacturing and service industries.
2. Provide "place-bound" students (many of them are minorities) a great opportunity for advanced graduate studies;
3. Supply additional minority doctoral graduates to the Biomedical Engineering field, where minorities are highly underrepresented;
4. Encourage FIU graduates to extend their careers into research and teaching;
5. Enhance the reputation of FIU through increased research and publications; and
6. Help attract more biotechnology industries to Miami-Dade County and South Florida.

Master of Science in Biomedical Engineering

The Department of Biomedical Engineering at Florida International University offers Research and Professional tracks for the Master's Degree. In addition, the Department offers accelerated combined BS/MS and certificate programs. These programs provide an interdisciplinary education intended to prepare the student for professional practice in Biomedical Engineering.

All work counted for the Master's degree must be completed during the six years immediately following the date of admission to the graduate program.

Admission Requirements

The following is in addition to the University's graduate admission requirements:

1. A student seeking admission into the program must have a bachelor's degree in engineering, the physical/life sciences, computer science, or mathematics from an accredited institution, or in the case of foreign students, from an institution recognized in its own country as preparing students for further study at the graduate level.
2. An applicant must have achieved a "B" average in upper level undergraduate work and a combined score of 1000 on the Graduate Record Examination with the following minimum scores on the individual components: verbal $\geq$ 350, and quantitative $\geq$ 650.
3. Applicants who have not satisfied the above will be evaluated for probationary or waiver admission.
4. In addition to the above criteria, International graduate student applicants whose native language is not English are required to submit a score for the Test of English as a Foreign Language (TOEFL) or for the International English Language Testing System (IELTS). A total score of 80 on the iBT TOEFL or 6.3 overall on the IELTS is required.
5. The GPA, GRE, and TOEFL scores specified above are to be considered minimum requirements for admission. Applicants from science and engineering areas other than biomedical engineering will be expected to complete undergraduate courses selected to prepare them for graduate courses in their area of interest. Full admission into the graduate program requires the completion of these background courses with no grades below "C" and a grade point average of 3.0 or better.

Graduation Requirements

The degree will be conferred when the following conditions have been met:

1. Recommendation of the advisor and faculty of the Department.
2. Certification provided by the Department Chair, College Dean, and University Graduate School that all degree requirements have been met.
3. Meet the undergraduate deficiencies, if any existed in the student's program, as additional courses toward the degree.
4. Complete the required semester hours of graduate level credit (not more than six graduate semester hours with a grade of "B" or higher can be transferred from other accredited institutions).
5. Successful defense of an acceptable graduate thesis if required of the program.
6. Students must maintain an overall GPA of 3.0. No grade below a "C" will be accepted in a graduate program. In the event that a student is placed on probationary status, he or she must obtain a directed program from his or her advisor and approved by the Graduate Program Director prior to continuing further course work toward the degree. The student must satisfy the directed course of action within the prescribed time limit, otherwise he or she will be academically dismissed.
7. Comply with all University policies and regulations.

Five Year Accelerated Combined BS/MS Degree Programs

This five year program seamlessly combines a baccalaureate degree in biomedical, mechanical, or electrical engineering with the Master's in biomedical

engineering. Students who have completed a minimum of 90 hours towards their BS degree and have earned at least a 3.25 GPA on both overall and upper division courses may, upon recommendation from the three BME faculty members, apply to the department to enroll in the combined BS/MS program. Students enrolled in the program may count up to 9 hours as credits for both the undergraduate and graduate degree programs. The BS/MS (3+2) program is designed to be a continuous program. Students in the 3+2 programs will apply for graduation with the BS degree and MS at the same time. Students will receive the BS degree and the MS degree on the same date, after requirements for both are completed. The student's advisor will insure that the appropriate forms are completed, and that the students do not apply for the BS degree graduation until both BS and MS requirements are fulfilled. Upon completion of the BS degree requirements, students can elect to permanentaly leave the combined program at any time and earn only the BS degree. Once the BS is granted, the students will have the same access requirements to regular graduate programs as any other student. However, the combined MS degree would not be available to those who elect to leave the combined program.

Admission into the combined program does not automatically qualify the students for admission into the MS degree program. To enroll in the MS degree program, the students must apply (in their senior year) to the graduate school and meet all graduate admission requirements.

Undergraduate students enrolled in the program are encouraged to seek employment with a department faculty to work as student assistants on sponsored research projects. The student will be eligible for graduate assistantships upon admission into the graduate school.

For each of the courses counted as credits for both the BS and MS degrees, a minimum grade of 'B' is required. Upon completion of the entire 3+2 program, students must have accumulated a minimum of 24 hours of credits at the graduate (5000+) level.

Professional Track

This track is tailored for the engineer currently practicing in the biomedical industry. A student shall complete 27 credit hours of course work and a 3 credit hour capstone project. The courses are organized into three core areas: Life Sciences, Engineering Management, and Biomedical Engineering. The student will choose three courses from the Engineering Management core based on personal training requirements. The biomedical engineering core includes a two course sequence in one of the three primary technical areas for industry: manufacturing, instrumentation, or materials. While the degree is structured as a non-thesis program, students will be required to conduct an industrial project (3 credit hours). The project will include contemporary topics and trends in biomedical engineering technology development and will require a formal report and presentation upon completion.

Early in the program (before the end of the second term) the student and advisor will complete a study plan that specifies the courses that will comprise the program. A maximum of three credits of independent study beyond the MS project may be included in a study plan.

Professional track students are required to take an oral final examination dealing with the objectives of their study plan. The student will briefly summarize the project report (20 minutes) as a part of the exam. The examining committee will include a minimum of three faculty members, at least two of whom have appointments in the Department.

Course Requirements

Life Science Core

PCB 4524	Molecular Biology	3
PCB 6025	Molecular and Cellular Biology I	3

Engineering Management Core

Select three of the following courses with advisor approval:

STA 5676	Reliability Engineering	3
EIN 5226	Total Quality Management for Engineers	3
EIN 5322	Engineering Management	3
ACG 6026	Accounting for Managers	3
MAN 6245	Organizational Behavior	3
MAR 6805	Marketing Management	3

Biomedical Engineering Core

Biomedical Engineering Electives		6
BME 6907	Master's Project	3

An additional six credit hours of core courses must be taken depending on the area of interest:

Design and Manufacturing

EML 4585	Design of Biomedical Systems and Devices*	3
Manufacturing Elective		3

Instrumentation

ELR 4202C	Medical Instrumentation*	4
Instrumentation Elective		2

Materials

EMA 5584	Biomaterials Science	3
Materials Elective		3

*Note that if these courses were taken and credited towards the undergraduate degree they must be replaced by another elective in consultation with an advisor.

Research Track

The research track is a more traditional program geared to prepare the graduate for further graduate study or a career in biomedical research. A student shall complete a minimum of 24 semester credit hours of course work, a minimum of 6 semester credit hours of Master's Thesis, and one semester of the Biomedical Engineering Seminar. Early in the program (before the end of the second term) the student and advisor will complete a study plan that specifies the courses that will comprise the program. A maximum of three credits of independent study other than the MS thesis may be included in a study plan.

All students in the research track are required to complete a thesis research project under the supervision of an advisor and committee. When the thesis research is completed, the student should schedule a defense with an examining committee appointed through the Graduate School consisting of at least three faculty members (at least two of whom have appointments in the Department). The thesis, with an approval cover letter from the advisor, should be given to the examining committee for review not less than four weeks before the scheduled defense. The candidate should prepare to summarize the thesis in the manner of a technical paper using appropriate visual aids in 40 minutes or less. Following the presentation, the candidate will answer questions related to the work from the audience and/or the committee. At the conclusion of

the defense, the committee will agree upon the outcome pass or fail and report the results to the Graduate School. Following the exam the student will implement the committee's suggestions for improving the draft document. Each committee member must sign the approval form in the final document. Copies of the approved thesis must be provided to the advisor, Department, and the University Graduate School.

Course Requirements

Biomedical Engineering Core

All students in the Research Track must take two courses in one specialty area, and one course in each of two other specialty areas. The current specialty areas are: 1) biomechanics, biomaterials, and medical devices; 2) bioinstrumentation and biomedical image/signal processing; 3) drug delivery/tissue engineering; 4) medical physics/nuclear medicine; and 5) bio-nanotechnology and systems biology.

BME 6970	Master's Thesis	6
BME 6936	Biomedical Engineering Seminar	0

Mathematics Core

STA 5206	Design of Experiments	3
or		
STA 6176	Biostatistics	3
BME 6705	Nonlinear Systems Applications in Life Science	3

Life Sceince Core

PCB 6025	Molecular and Cellular Biology I	3
PCB 6027	Molecular and Cellular Biology II	3

Doctor of Philosophy in Biomedical Engineering

The PhD program in Biomedical Engineering prepares graduates for industrial or academic research in one (or more) of five areas of specialization: 1) biomechanics, biomaterials, and medical devices; 2) bioinstrumentation and biomedical image/signal processing; 3) drug delivery/tissue engineering; 4) medical physics/nuclear medicine; and 5) bio-nanotechnology and systems biology. To increase the quality of the educational experience, clinical and industrial practice is integrated into the academic programs through the Biomedical Engineering Partnership Program. Students gain valuable exposure to clinical practice and research, and acquire real experience in the practice of engineering, product development, and commercialization. Semester-long clinical research experiences are provided, and students have the opportunity to participate in clinical/industrial R&D projects.

Admission Requirements

A prospective student must meet all admission requirements stipulated in the University's Graduate Policies and Procedures. In addition, the requirements for admission to the doctoral program in Biomedical Engineering are stated as follows:

1. A student seeking admission to the doctoral program must have a Bachelor's or Master's degree in Biomedical Engineering, or other closely related field from an accredited institution.
2. A GPA of at least 3.0/4.0 in the upper division coursework of applicant's Bachelor's degree and a GPA of at least 3.3/4.0 in the applicant's Master's degree are required.
3. A GRE score of at least 1150 points, with the following minimum scores on the individual components: verbal ≥ 450 and quantitative ≥ 700.
4. Three letters of recommendation.
5. A statement of research interests and goals.
6. International graduate student applicants whose native language is not English are required to submit a score for the Test of English as a Foreign Language (TOEFL) or for the International English Language Testing System (IELTS). A total score of 80 on the iBT TOEFL or 6.3 overall on the IELTS is required.

The Graduate Admission Committee will examine credentials of all applicants. Applicants who have not satisfied the above will be evaluated for probationary or waiver admission.

Degree Requirements

Credit Requirements

The PhD program requires a total of 90 credit hours beyond the BS degree. These credits are comprised of a minimum of 48 hours of coursework and a minimum of 24 hours of dissertation.

Applicants having a Master's Degree in Biomedical Engineering or closely related field from an accredited institution are given a maximum of 30 transferred semester hours. Applicants from science and engineering areas other than biomedical engineering will be expected to complete undergraduate courses selected to prepare them for graduate courses in their area of interest. Full admission into the graduate program requires the completion of these background courses with no grades below "C" and a grade point average of 3.0 or better.

Qualifying Examination, Candidacy Requirements, and Final Defense

Students must demonstrate graduate knowledge acquisition in three incremental stages in order to be awarded a Ph.D. in Biomedical Engineering:

- Qualifying Exam (written)
- Proposal Defense and Candidacy Exam (oral and/or written)
- Final Defense (oral)

The Qualifying Exam will generally take place during the first two semesters of the PhD program (following the Master's). If the student enters the PhD directly from the BS, the exam should take place during the second year of study. In the semester prior to his/her taking the Qualifying Exam, student must declare intention to take the exam and must declare a major area. In the event a student fails the Qualifying Exam, the student can retake it one more time in the subsequent semester.

The formal admission to Ph.D. candidacy occurs when the student successfully passes the Qualifying Exam, prepares a formal dissertation proposal, and successfully defends the content of the proposal before his/her advisory committee. Immediately following the proposal defense, the student's dissertation committee will vote to admit the student to candidacy, to have the student resubmit the proposal within six months, or to dismiss the student from the Ph.D. program. A student can only resubmit his/her proposal once. The dissertation committee should be comprised of at least five members, at least three of which should be biomedical engineering faculty and at least one FIU member outside of biomedical engineering.

All students in the PhD program are required to complete a dissertation under the supervision of an advisor and committee. When the dissertation research is completed, the student should schedule a final defense with the examining committee. The disseration, with an approval cover letter from the advisor, should be given to the examining committee for review not less than four weeks before the scheduled defense. The candidate should prepare to summarize the dissertation in the manner of a technical paper using appropriate visual aids in 40 minutes or less. Following the presentation, the candidate will answer questions related to the work from the audience and/or the committee. At the conclusion of the defense, the committee will agree upon the outcome pass or fail and report the results to the Graduate School. Following the exam the student will implement the committee's suggestions for improving the draft document. Each committee member must sign the approval form in the final document. Copies of the approved dissertation must be provided to the advisor, Department, and the University Graduate School.

Program of Study

The program of study will require completion of courses (beyond the BS degree) in the following categories:

***Biomedical Engineering* – minimum of 24 credit hours**

A minimum of four courses (12 credit hours) in one specialty area, and a minimum of two courses (6 credit hours) in each of two other specialty areas are required. The five current specialty areas within biomedical engineering are:

1. Biomechanics, biomaterials, and medical devices
2. Bioinstrumentation and biomedical image/signal processing
3. Drug delivery/tissue engineering
4. Medical physics/nuclear medicine
5. Bio-nanotechnology and systems biology

***Engineering Mathematics* – minimum of 9 credit hours**

Courses in this area must cover the broad areas of statistics, theoretical modeling, and numerical modeling. Example courses in each of these areas are:

Statistics: STA 5206 Design of Experiments or STA 6176 Biostatistics

Theoretical modeling: BME 6715 Mathematical Modeling of Physiological Systems or BME 6716 Mathematical Modeling of Cellular Systems

Numerical modeling: BME 6705 Nonlinear Systems Applications in Life Science

***Life Science* – minimum of 9 credit hours**

Unless otherwise approved by the student's committee, courses in this category should include the following:

PCB 6025	Molecular and Cellular Biology I
PCB 6027	Molecular and Cellular Biology II
BME 6019	Clinical Research Experience

Two biology techniques workshops, examples include the following:

BCH 6130C	Workshop in DNA Synthesis and Amplification
BCH 6131C	Workshop in Radioisotope Use and Safety
BCH 6132C	Workshop in Electrophoresis
BCH 6133C	Workshop in DNA Sequencing
BCH 6507C	Workshop in Radiometry and Spectrophotomtry
BSC 5416C	Workshop in Cell Culture Methods and Applications
BSC 5928	Workshop: Vertebrate Animal Research
PCB 5025L	Molecular Biology Techniques Laboratory
PCB 5184	Workshop in Microtechniques
ZOO 5732	Advanced Anatomy Demonstration

The remainder of the coursework (minimum of 6 credit hours) is reserved for electives.

Course Descriptions

Definition of Prefixes

BME-Biomedical Engineering; EEL-Electrical Engineering; EGM-Engineering Mechanics; EMA-Engineering Materials; EML-Mechanical Engineer-ing

BME 5005 Applied Biomedical Engineering Principles (3). Biomedical engineering applications to instrumentation, transport phenomena, mechanics, materials and imaging. Prerequisite: Permission of instructor.

BME 5340 Introduction to Cardiovascular Engineering (3). Quantitative cardiovascular physiology, engineering applied to cardiovascular system: mechanics, materials, transport, and design.

BME 5350 Radiological Engineering and Clinical Dosimetry (3). Quantities for describing the interaction of radiation fields with biological systems. Absorption of radiant energy by biological systems. Applications to clinical dosimetry and radiation safety procedures. Prerequisite: Permission of the instructor.

BME 5358L Clinical Rotation in Radiation Oncology (3). Practical calibration of radiation therapy instruments, dose calculation and planning of radiation treatment under supervision of certified medical physicist. Prerequisites: BME 5XXX Engineering Foundation of Radiation Therapy and BME 6405C.

BME 5560 Biomedical Engineering Optics (3). Introduction to physical and geometrical optics of biomedical optical devices. Design of optical microscopes, endoscopes, fiber optic delivery systems, spectrometers, fluorometers, and cytometers. Prerequisites: Calculus, Differential Equations, Chemistry, and Physics.

BME 5702 Engineering Analysis of Biological Systems (3). Quantitative description of physiological systems, from cells to organs. Includes engineering analysis relating design to function. Prerequisites: BSC 1010 or Graduate standing.

BME 5726 Protein Engineering (3). Cloning, expressing and purifying proteins, and E. coli and Yeast expression systems. Design of proteins for specific end uses. Prerequisite: Permission of the instructor.

BME 5941 Biomedical Engineering Internship (1-3). Engineering practice in biomedical applications at an industrial partner's site. Intern will be hired through cooperative agreement to conduct collaborative research with supervision of advisor.

BME 6019 Clinical Research Experience (1). Students are matched with and then "shadow" a clinician during procedures (diagnostic and interventional), and research and development activitites. Prerequisite: Permission of instrcutor.

BME 6035 Drug Tansport Modeling (3). Theoretical and experimental models of drug transport systems, computer simulations of fluid and mass transport in biomedical systems, pharmacokinetics modeling and molecular imaging. Prerequisite: EGM 5585.

BME 6037 Controlled Delivery in Biomedicine (3). Overview of methods of controlled drug delivery and their applications in biomedical engineering. Oral, pulmonary, transdermal, and polymeric delivery/devices. Prerequisites: EMA 5584, EGM 5585.

BME 6330 Cell/Tissue Engineering: Theory and Methodology (3). Overview of tissue engineering theory and practice with emphasis on cell behavior and morphology. Prerequisites: EMA 5584, BME 3700/5702.

BME 6345 Advanced Cardiovascular Engineering (3). Engineering modeling, design, and measurements related to Cardiovascular system, disease and diagnosis. Prerequisite: BME 5340.

BME 6351C Radiation Safety in Biomedicine (3). Theory and engineering basis of radiation safety in diagnostic and therapeutic radiology. Regulatory issues for the safe use of radiations in medicine. Prerequisite: BME 5350.

BME 6353C Advanced Radiation Dosimetry (3). Stat of the art of radiation treatment planning in radiation oncology. Intensity modulated radiation treatment methods and instruments. Prerequisite: BME 5XXX Engineering Foundation of Radiation Therapy.

BME 6359L Clinical Rotation in Diagnostic Radiology (3). Measuring of radiation fields for quality assurance of diagnostic radiology and nuclear medicine instruments under supervision of a certified medical physicist. Prerequisite: BME 6405C.

BME 6405C Engineering Foundation of Medical Imaging Instrument (3). Engineering basis of medical imaging systems, including radiology, X-Ray CT, SPECT, PET, MRI, and laser and ultrasound based imaging, as well as instrument quality assurance procedures. Prerequisite: Permission of the instructor.

BME 6408 Molecular Imaging (3). Production of PET and SPECT isotopes and radiopharmaceuticals, pharmacokinetics and experimental models of nuclear medicine tracer kinetics, imaging of molecular processes and function. Prerequisites: BME 6035, BME 5XXX Medical Imaging Instruments.

BME 6565 Quatitative Microscopy and Visualization (3). Practical and useful projects in optical, confocal, near field, scanning probe and other advanced microscopy and cytometry. Spatial and spectral quantitation of physiologic measures in living tissue. Prerequisite: Permission of instructor. Corequisite: BME 5560.

BME 6705 Nonlinear Systems with Applications to Life Sciences (3). Concepts and applications of nonlinear dynamics to life sciences. Specific nonlinear models arising from biology and medicine will be investigated using computer simulations. Prerequisite: Permission of the instructor.

BME 6715 Mathematical Modeling of Physiological Systems (3). Engineering Modeling, design, and measurements related to Cardiovascular system, disease and diagnosis. Prerequisite: Permission of instructor.

BME 6716 Mathematical Modeling of Cellular Systems (3). Development of mathematical modeling techniques for engineers using cellular systems as an application. Biochemical reactions, membrane potentials, excitable cells, wave propagation, cellular regulation. Prerequisite: Permission of the instructor.

BME 6723 Bioinformatics in Cytomics (3). Biomedical data archiving, analysis and visualization. Medical imaging, microscopy imaging, multiparameter cytometry sensors, protein and gene sequencing data processing are emphasized. Prerequisite: BME 5XXX.

BME 6725 Cytomic and Proteomic Measurement Techniques (3). Principles and methods of cytomic, proteomic and genomic technology. Cellular probes, variance of protein expression. Description of the genome. Cytometry assays, protein structure, microarrays. Prerequisite: BME 5XXX.

BME 6750 Artificial Organs (3). Theoretical and experimental models of artificial organs for drug delivery, extracorporeal devices, oxygenators, models of tissue engineered organs, computer simulations of fluid and mass transport. Prerequisites: EGM 5585, EMA 5584, BME 6035.

BME 6905 Independent Studies (1-3). Individual research studies for qualified biomedical engineering graduate students. Work is to be performed under the supervision of an advisor.

BME 6907 BME Master's Project (3). Individual work culminating in a professional practice-oriented report suitable for the requirements of the Professional Track of the MS program in biomedical engineering. Prerequisite: Permission of instructor.

BME 6910 Supervised Research (1-6). Graduate level biomedical engineering research carried out under the supervision of a faculty member.

BME 6936 Biomedical Engineering Seminar (1). Problems in Biomedical Engineering and results of ongoing research will be presented and discussed by invited experts. Prereqisite: Permission of the instructor.

BME 6970 Master's Thesis (1-6). Master's thesis on Biomedical Engineering is to be submitted and an oral presentation is to be made. Thesis should contain aspects of design to fulfill requirements for combined BS/MS program. Prerequisite: Advisor's permission.

BME 6XXX Optical Spectroscopy (3). Introduction to the scientific principles of optical spectroscopic technologies and their usage in the field of medicine. Prerequisite: Permission of the instructor.

BME 7334C Cell/Tissue Engineering: Methods and Applications (4). Overview of tissue engineering theory and practice with emphasis on cell behavior and morphology. Prerequisite: BME 6330.

EEL 5071 Bioelectrical Models (3). Engineering models for electrical behavior of nerve and muscle cells, electrode-tissue junctions, volume conductions in tissue and the nervous system as an electrical network. Prerequisites: ELR 4202 or permission of the instructor.

EEL 5085 Bioradiation Engineering (3). Spectrum of radiation sources, types of fields, properties of living tissue, mechanisms of field propagation in tissue. Applications in imaging and therapy, hazards and safety. Prerequisites: EEL 4410 or permission of the instructor.

EEL 5820 Digital Image Processing (3). Image Fundamentals, Image Transforms, Image Enhancement, Edge Detection, Image Segmentation, Texture Analysis, Image Restoration, and Image Compression. Prerequisites: EEL 3135 and knowledge of any programming language (FORTRAN, Pascal, C).

EEL 6075 Biosignal Processing I (3). Characterizing biosignals by application of time and frequency domain analytic methods. Comparison of analog and digital processing. Engineering design for VLSI implementations in implantable devices. Prerequisites: ELR 4202 and EEL 6505 or permission of the instructor.

EEL 6076 Biosignal Processing II (3). Engineering design of advanced systems for processing biosignals. Methods for signal compression. Adaptive systems for automatic recognition. Application of artificial intelligence for signal classification. Prerequisites: EEL 6075 or permission of the instructor.

EEL 6816 Electronic Neural Systems (3). This course bridges electronics to the understanding of neurobiologically inspired models. Biological tasks and neural computations are studied in the context of networks and processing elements. Prerequisite: Permission of Instructor.

EEL 6821 Computer Vision (3). Image formation and image properties, Radiance and irradiance, introduction to Brain Topography, Color Vision, visual machinery of the brain, statistical pattern classification and decision functions, the eigensystem and its computational aspects, stereo vision, motion vision, size and orientation independence. Prerequisite: EEL 5820.

EEL 6836 Computer Visualization of Brain Electrical Activity (3). Computer techniques for the visualization of brain electrical activity. Analysis of the origin of this activity as it relates to its measurement and visualization through computerized systems. Prerequisites: EEL 4510 or permission of instructor.

EGM 5585 Biotransport Processes (3). Transport of fluid, heat, and mass in the human body. Application to dialyzers and heart-lung devices. Prerequisites: EML 3126L and EML 4140.

EGM 6586 Fluid Mechanics Applications in Physiological Systems (3). Fluid mechanics principles including finite element and finite difference methods as it is applied to the analysis of various physiological systems will be covered. Process flow, diffusion and transport will be discussed in cardiovascular and pulmonary systems. Application of these primarily in the design of heart-lung machines, dialysis units, and heart valves will be discussed. Prerequisites: EGM 4580 or permission of the instructor.

EGM 6587 Applied Biomedical and Diagnostic Measurements (3). Fundamentals of biomedical measurements and the design of biomeasurement systems and devices. This includes transducers and electrodes, EMG, EEG, ECG and medical imaging techniques, and electrical safety. Prerequisites: EGM 4580 or permission of the instructor.

EGM 6588 Solid Mechanics Applications in Physiological Systems (3). Solid mechanics and numerical methods as applied to analysis of the musculoskeletal system and trauma. Design application in orthotics and prosthesis and heart valves. Prerequisites: EGM 4580 or permission of the instructor.

EGM 6589 Advanced Biofluid Mechanics (3). Applications of fluid mechanics principles to human circulatory systems. Unsteady blood flow and wave propagation in elastic tubes. Influence of fluid dynamics on thrombosis and atherosclerosis. Prerequisite: EGM 6586.

EGM 6593 Advanced Cardiac Mechanics (3). Applications of principles of solid mechanics to the human cardiovascular system. 3-D reconstruction of the left ventricle, contractile properties and stress distribution in the myocardium. Prerequisite: EGM 6588.