BIOENGINEERING (BENG)

100 Level Courses

BENG 100: *Bioengineering and Society.* 3 credits.
The course is organized around a series of modules each addressing a distinct bioengineering topic. Every module overviews the scientific facts as distinct from the "urban myths," as well as the potentials, challenges, and risks of the relevant technologies, concluding with a glance at possible future scenarios.Offered by Bioengineering. Limited to two attempts.
Schedule Type: Lecture

Grading:
This course is graded on the Undergraduate Regular scale. (https://catalog.gmu.edu/policies/academic/grading/)

BENG 101: *Introduction to Bioengineering.* 3 credits.
This course introduces students to the field of Bioengineering in general and here at Mason and the use of technology and innovation in solving problems in biology and medicine with an emphasis on engineering tools and concepts. With its recitation, it also introduces mathematical modeling and analysis of bioengineering problems through the use of standard software packages for simulation. Topics include: exploration of the field of Bioengineering, Matlab and other software applications for modeling and analyzing biomedical problems, engineering design, career development, and ethics.Offered by Bioengineering. Limited to two attempts.
Registration Restrictions:
Students with the terminated from CEC major attribute may **not** enroll.

Schedule Type: Lecture, Recitation

Grading:
This course is graded on the Undergraduate Regular scale. (https://catalog.gmu.edu/policies/academic/grading/)

200 Level Courses

BENG 214: *Physiology for Engineers.* 3 credits.
This course provides a broad introduction to the subject of human physiology, focusing on learning the subject matter from an engineering viewpoint. This course emphasizes organs and physiological systems (e.g. renal, cardiac) and applies engineering modeling concepts (using Matlab) to those systems.Offered by Bioengineering. Limited to two attempts.
Registration Restrictions:
Required Prerequisites: ((BENG 101[C] or 101[XS]) and (BIOL 213[C] or 213[XS]) and MATH 114[B-]).
[C] Requires minimum grade of C.
[XS] Requires minimum grade of XS.
[B-] Requires minimum grade of B-.

Students with the terminated from CEC major attribute may **not** enroll.

Schedule Type: Lecture, Recitation

Grading:
This course is graded on the Undergraduate Regular scale. (https://catalog.gmu.edu/policies/academic/grading/)

BENG 230: *Continuum Biomechanics and Transport I.* 3 credits.
This course introduces the fundamental concepts and mathematical equations describing biosolids, biofluids and biotransport phenomena; and their application to physiological problems encountered in biomedical engineering. Topics will include elasticity, biofluid flows, transport of mass, momentum, and heat in biological systems. Upon completion of this course students should have a fundamental understanding of the basic conservation laws describing biomechanical systems and should be able to apply these concepts to solve a variety of problems in bioengineering.Offered by Bioengineering. Limited to two attempts.
Registration Restrictions:
Required Prerequisites: ((PHYS 160[C] or 160[XS]) and (PHYS 260[*C] or 260[XS]) and (MATH 203[C] or 203[XS]) and (MATH 213[C] or 213[XS]) and (MATH 214[*C] or 214[XS])).
[*] May be taken concurrently.
[C] Requires minimum grade of C.
[XS] Requires minimum grade of XS.

Students with the terminated from CEC major attribute may **not** enroll.

Schedule Type: Lecture, Recitation

Grading:
This course is graded on the Undergraduate Regular scale. (https://catalog.gmu.edu/policies/academic/grading/)

BENG 240: *Biomaterials.* 3 credits.
This course is to introduce Biomaterials science and emphasize its importance in modern medicine. This course will also provide knowledge to students on specific techniques used to characterize biomaterials and on the biological response to implanted materials. This course will emphasize the multidisciplinary nature of biomaterials science and will focus on specific topics including an overview of existing biomaterials (ceramics, metal, polymers and hydrogels), drug delivery applications, development of nanobiomaterials, and the biocompatibility of these materials. Biological testing (in vitro and in vivo) of these biomaterials will also be covered in this course.Offered by Bioengineering. Limited to two attempts.
Registration Restrictions:
Required Prerequisites: ((CHEM 211[C], 211[XS], 271[C] or 271[XS]) and (MATH 113[C] or 113[XS]) and (BIOL 213[C] or 213[XS])).
[C] Requires minimum grade of C.
[XS] Requires minimum grade of XS.

Students with the terminated from CEC major attribute may **not** enroll.

Schedule Type: Lecture

Grading:
This course is graded on the Undergraduate Regular scale. (https://catalog.gmu.edu/policies/academic/grading/)

BENG 241: *Biomechanics and Biomaterials Laboratory.* 1 credit.
This lab course provides students opportunities to learn and get hands-on practice on the basic experimental skills and techniques required in both biomaterial and biomechanics laboratories. The students will begin to learn how to take measurements and properly report their results, in the following topics: mechanical testing, hydrogel experiments, biomaterial degradation, surface modification, nanomaterials for drug delivery, and biomaterial interaction with human body.Offered by Bioengineering. Limited to two attempts.
Registration Restrictions:
Required Prerequisites: ((BENG 230[*C] or 230[XS]) and (BENG 240[*C] or 240[XS])).

* May be taken concurrently.
C Requires minimum grade of C.
XS Requires minimum grade of XS.

Students with the terminated from CEC major attribute may **not** enroll.

Schedule Type: Laboratory

Grading:
This course is graded on the Undergraduate Regular scale. (https://catalog.gmu.edu/policies/academic/grading/)

300 Level Courses

BENG 314: *Pathophysiology and the Role of New Technologies in Human Diseases.* 3 credits.
This course provides examples from clinical medicine of how patients are diagnosed and treated for diseases of their cardiovascular and neurological systems, as well as for cancer and in acute care (emergency) units. The etiology and pathogenesis of disease processes and the current roles of technologies in diagnosis and treatment will be discussed. Unmet needs in these clinical areas that require research and technology development using engineering approaches will be identified and potential pathways towards clinical solutions will be investigated.Offered by Bioengineering. Limited to two attempts.
Registration Restrictions:
Required Prerequisites: ((BENG 214[C] or 214[XS]) or (BENG 313[C] or 313[XS])).
C Requires minimum grade of C.
XS Requires minimum grade of XS.

Enrollment is limited to students with a major, minor, or concentration in Bioengineering.

Students with the terminated from CEC major attribute may **not** enroll.

Schedule Type: Lecture

Grading:
This course is graded on the Undergraduate Regular scale. (https://catalog.gmu.edu/policies/academic/grading/)

BENG 320: *Bioengineering Signals and Systems.* 3 credits.
Introduces the conversion of analog signals to digital ones and methods for using digitally processed signals in biomedical applications.Offered by Bioengineering. Limited to two attempts.
Registration Restrictions:
Required Prerequisites: ((BENG 101[*C] or 101[*XS]) and (MATH 214[*B-]) and (CS 112[C] or 112[XS])).
* May be taken concurrently.
C Requires minimum grade of C.
XS Requires minimum grade of XS.
B- Requires minimum grade of B-.

Enrollment is limited to students with a major, minor, or concentration in Bioengineering.

Students with the terminated from CEC major attribute may **not** enroll.

Schedule Type: Lecture, Recitation

Grading:
This course is graded on the Undergraduate Regular scale. (https://catalog.gmu.edu/policies/academic/grading/)

BENG 322: *Health Data Challenges.* 3 credits.
Covers methodology and tools used to work with health data structures supporting organizations' needs for reliable data that are captured, stored, processed, integrated, and prepared for further querying, decision making, data mining and knowledge discovery for a variety of clinical and organizational purposes. Data security and privacy, data standards, data interoperability, health information exchange, and big data analytics are discussed. Offered by Bioengineering. Limited to two attempts. Equivalent to IT 322.
Registration Restrictions:
Required Prerequisites: (IT 214[C] or 214[XS]) and (STAT 250[C], 250[XS], 344[C] or 344[XS]).
C Requires minimum grade of C.
XS Requires minimum grade of XS.

Students with the terminated from CEC major attribute may **not** enroll.

Schedule Type: Lecture

Grading:
This course is graded on the Undergraduate Regular scale. (https://catalog.gmu.edu/policies/academic/grading/)

BENG 327: *Cellular, Neurophysiological, and Pharmacological Neuroscience.* 3 credits.
What makes neurons different from other cells? What do they do and how do they work? How do they communicate with each other? In this course, we will answer these questions and many more. We will cover the basics of cellular, neurophysiological, and pharmacological neuroscience, including cellular anatomy and membrane function, electrical properties of neurons, intracellular and intercellular signaling, synaptic plasticity, and circuit connectivity.Offered by Bioengineering. Limited to two attempts.
Registration Restrictions:
Required Prerequisites: (BIOL 213[C] or 213[XS]) and ((CHEM 211[C] or 211[XS]) and (CHEM 213[C] or 213[XS])) or ((CHEM 271[C] or 271[XS]) and (CHEM 272[C] or 272[XS])).
C Requires minimum grade of C.
XS Requires minimum grade of XS.

Students with the terminated from CEC major attribute may **not** enroll.

Schedule Type: Lecture

Grading:
This course is graded on the Undergraduate Regular scale. (https://catalog.gmu.edu/policies/academic/grading/)

BENG 330: *Computational Methods in Bioengineering.* 3 credits.
This course introduces students to the development of computational models for understanding physiological systems, and explores a variety of practical computational methods for biomedical problems. Topics include: introduction to scientific computing, linear and non-linear models, and finite difference methods for biomedical models based on ordinary and partial differential equations.Offered by Bioengineering. Limited to two attempts.
Registration Restrictions:
Required Prerequisites: (CS 112[C] or 112[XS]) and (BENG 320[C] or 320[XS]) and (BENG 230[C] or 230[XS]) and (MATH 214[B-]).
C Requires minimum grade of C.
XS Requires minimum grade of XS.
B- Requires minimum grade of B-.

Enrollment is limited to students with a major, minor, or concentration in Bioengineering.

Students with the terminated from CEC major attribute may **not** enroll.

Schedule Type: Lecture

Grading:
This course is graded on the Undergraduate Regular scale. (https://catalog.gmu.edu/policies/academic/grading/)

BENG 331: *Computational Methods in Bioengineering Laboratory.* 1 credit.
This lab course complements BENG 330 to enhance students' knowledge on developing and applying computational models for biomedical engineering problems. Students will be provided analytical problems to solve and computational problems to program in the laboratory. Topics include: introduction to scientific computing, linear and non-linear models, and finite difference methods for biomedical models based on ordinary and partial differential equations.Offered by Bioengineering. Limited to two attempts.
Registration Restrictions:
Required Prerequisites: (BENG 330[*C] or 330[XS]).
[*] May be taken concurrently.
[C] Requires minimum grade of C.
[XS] Requires minimum grade of XS.

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Students with the terminated from CEC major attribute may **not** enroll.

Schedule Type: Laboratory

Grading:
This course is graded on the Undergraduate Regular scale. (https://catalog.gmu.edu/policies/academic/grading/)

BENG 350: *Neural System Designs.* 3 credits.
This course introduces the essential "design principles" of various parts of the mammalian nervous system. The recurring theme is that Evolution successfully managed to re-arrange the same building blocks (neurons, synaptic transmission, and membrane physiology) in different networks exquisitely tuned to their functions, though often in incompletely understood ways. Topics include: neuronal biophysics, network architecture, cortical systems, neuroinformatics, and neurotechnology applications.Offered by Bioengineering. Limited to two attempts.
Registration Restrictions:
Required Prerequisites: ((BENG 313[C], 313[XS], 214[C] or 214[XS]) and (BIOL 213[C] or 213[XS])).
[C] Requires minimum grade of C.
[XS] Requires minimum grade of XS.

Enrollment is limited to students with a major, minor, or concentration in Bioengineering.

Students with the terminated from CEC major attribute may **not** enroll.

Schedule Type: Lecture

Grading:
This course is graded on the Undergraduate Regular scale. (https://catalog.gmu.edu/policies/academic/grading/)

BENG 360: *Biomedical Imaging.* 3 credits.
This course introduces the physical and engineering foundations of modern medical imaging instruments and image processing methods. These methods enable us to see biological organisms at different levels, starting from the atom level and going all the way to seeing inside the human body. It allows a better understanding of how life and its processes work at different levels, and diagnose disease, monitor treatment and perform minimally-invasive interventions. Different modalities include: microscopy, x-rays, computerized tomography (CT), nuclear imaging, ultrasound, and magnetic resonance imaging (MRI). Topics include: underlying physics, basics of instrumentation, clinical applications, and presentation of case studies.Offered by Bioengineering. Limited to two attempts.
Mason Core: Mason Core, Writing Intensive in Major (https://catalog.gmu.edu/mason-core/)

Registration Restrictions:
Required Prerequisites: ((PHYS 260[C] or 260[XS]) and (BENG 320[C] or 320[XS])).
[C] Requires minimum grade of C.
[XS] Requires minimum grade of XS.

Enrollment is limited to students with a major, minor, or concentration in Bioengineering.

Students with the terminated from CEC major attribute may **not** enroll.

Schedule Type: Lecture

Grading:
This course is graded on the Undergraduate Regular scale. (https://catalog.gmu.edu/policies/academic/grading/)

BENG 370: *Bioinstrumentation and Devices I.* 3 credits.
This course involves the design of instruments that allow engineers to both make measurements and intervene with living systems, including the human body. This course aims at providing the foundation for understanding bioinstrumentation electronics, with a special emphasis on sensors and measurements. Topics include: circuit analysis, electronic circuit design, basic sensors and their applications in Bioengineering, as well as learn how to build and make measurements in electronic systems.Offered by Bioengineering. Limited to two attempts.
Registration Restrictions:
Required Prerequisites: ((BENG 320[C] or 320[XS]) and (BENG 371[*C] or 371[XS]) and (CS 112[C] or 112[XS]) and (PHYS 260[C] or 260[XS])).
[*] May be taken concurrently.
[C] Requires minimum grade of C.
[XS] Requires minimum grade of XS.

Enrollment is limited to students with a major, minor, or concentration in Bioengineering.

Students with the terminated from CEC major attribute may **not** enroll.

Schedule Type: Lecture, Recitation

Grading:
This course is graded on the Undergraduate Regular scale. (https://catalog.gmu.edu/policies/academic/grading/)

BENG 371: *Bioinstrumentation and Devices Laboratory.* 1 credit.
This course introduces the basic concepts and tools for making biomedical measurements, both at the level of electronics and at the device level. At the electronics level, students will learn about basic electronic components, using them to build basic circuits, with emphasis on instrumentation components. At the device level, students will learn to describe instrumentation design and analysis considerations, and discuss practical applications. Students will gain hands-on experience

with circuits, basic bioinstrumentation and signal analysis techniques that are fundamental in Bioengineering.Offered by Bioengineering. Limited to two attempts.
Registration Restrictions:
Required Prerequisites: (BENG 370[*C] or 370[XS]).
[*] May be taken concurrently.
[C] Requires minimum grade of C.
[XS] Requires minimum grade of XS.

Enrollment is limited to students with a major, minor, or concentration in Bioengineering.

Students with the terminated from CEC major attribute may **not** enroll.

Schedule Type: Laboratory

Grading:
This course is graded on the Undergraduate Regular scale. (https://catalog.gmu.edu/policies/academic/grading/)

BENG 375: *Intellectual Property, Regulatory Concepts and Product Development.* 3 credits.
The course provides an understanding of 1) intellectual property focusing on patents and the patent process in the US and globally, 2) regulatory frameworks for product approval such as FDA and international regulations, standards (ANSI, ASTM, ISO, GCP, GLP) and 3) product development including ideation and concept development, quality systems, global business models, financing and transactions. An overarching team project will involve invention, proof of concept, patenting, regulatory pathways and product development to market in a global context.Offered by Bioengineering. Limited to two attempts.
Registration Restrictions:
Students with the terminated from CEC major attribute may **not** enroll.

Schedule Type: Lecture

Grading:
This course is graded on the Undergraduate Regular scale. (https://catalog.gmu.edu/policies/academic/grading/)

BENG 391: *Bioengineering Professional Development.* 1 credit.
This course covers the variety of responsibilities of bioengineers to society and helps prepare them for the workplace and/or graduate or professional school. Topics include exploration of various career paths in biomedical/bioengineering and related fields, ethics and professionalism, job/grad/professional school searching, networking, interviewing, and other career preparation topics. Speakers include faculty, invited guests from industry and government, and alumni.Offered by Bioengineering. Limited to two attempts.
Registration Restrictions:
Required Prerequisites: BENG 101[C] or 101[XS].
[C] Requires minimum grade of C.
[XS] Requires minimum grade of XS.

Students with the terminated from CEC major attribute may **not** enroll.

Schedule Type: Lecture

Grading:
This course is graded on the Undergraduate Regular scale. (https://catalog.gmu.edu/policies/academic/grading/)

BENG 394: *Bioengineering Internship Experience.* 1-3 credits.
Students participate in experiential learning in bioengineering or related field through a research or internship opportunity. Students learn and develop valuable skills related to their major, work on real-world problems, and gain work experience. Students may pursue this internship opportunity with external industry partners or Mason research laboratories and centers. Students must identify a research lab or internship opportunity and seek departmental approval prior to registering for this course.Offered by Bioengineering. May be repeated within the term for a maximum 6 credits.
Registration Restrictions:
Required Prerequisites: (BENG 101[C] and 214[C]).
[C] Requires minimum grade of C.

Enrollment is limited to students with a major, minor, or concentration in Bioengineering.

Schedule Type: Internship

Grading:
This course is graded on the Undergraduate Regular scale. (https://catalog.gmu.edu/policies/academic/grading/)

BENG 395: *RS: Mentored Research in Bioengineering.* 1-3 credits.
Introduces the scientific research process through "hands on" experience: students are matched with faculty mentors who are actively involved in Bioengineering-related research. Requires no less than 60 hours per semester working with mentors. Offered by Bioengineering. May be repeated within the degree for a maximum 6 credits.
Specialized Designation: Research/Scholarship Intensive

Recommended Prerequisite: At least 60 credit hours applicable to the Bioengineering program.

Registration Restrictions:
Students with the terminated from CEC major attribute may **not** enroll.

Schedule Type: Independent Study

Grading:
This course is graded on the Undergraduate Regular scale. (https://catalog.gmu.edu/policies/academic/grading/)

400 Level Courses

BENG 413: *Molecular Engineering Laboratory.* 3 credits.
The course covers laboratory techniques in molecular and cellular engineering, such as Good Laboratory Practices according to industry standards, maintaining a laboratory notebook, equipment logbooks, NIST-traceable standards, use of statistics and a standard curve to calculate the concentration of an unknown, sensitivity of a laboratory assay, biomaterial-DNA interactions, imaging of cells and signal processing, interpreting data and writing a scientific report.Offered by Bioengineering. Limited to two attempts.
Registration Restrictions:
Required Prerequisites: (BIOL 213[C] or 213[XS]).
[C] Requires minimum grade of C.
[XS] Requires minimum grade of XS.

Enrollment is limited to students with a major, minor, or concentration in Bioengineering.

Students with the terminated from CEC major attribute may **not** enroll.

Schedule Type: Laboratory, Lecture

Grading:

This course is graded on the Undergraduate Regular scale. (https://catalog.gmu.edu/policies/academic/grading/)

BENG 415: *Biomanufacturing.* 3 credits.
This course will introduce the students to biopharmaceutical products, such as vaccines, monoclonal antibodies, recombinant proteins, biosimilars, and others, and the processes required to manufacture these products. The elements of biomanufacturing that will be discussed include the biological expression systems, upstream and downstream processes, formulation, and vial filling. Operational parameters of bioreactors, separation/isolation methods such as chromatography and a variety of analytical measurements will be discussed. In addition, students will learn about the quality systems that need to be in place to ensure product purity, safety, and potency. The course will also cover the current and future challenges in biomanufacturing of novel biopharmaceuticals.Offered by Bioengineering. Limited to two attempts.
Recommended Prerequisite: CHEM 310

Registration Restrictions:
Required Prerequisites: ((BENG 240[C], 240[XS], 341[C] or 341[XS]) or ((BIOL 213[C] or 213[XS]) and (CHEM 271[C], 271[XS], 211[C] or 211[XS]))).
[C] Requires minimum grade of C.
[XS] Requires minimum grade of XS.

Students with the terminated from CEC major attribute may **not** enroll.

Schedule Type: Lecture

Grading:
This course is graded on the Undergraduate Regular scale. (https://catalog.gmu.edu/policies/academic/grading/)

BENG 417: *Bioengineering World Health.* 3 credits.
This course covers the major types of medical equipment, including the principles of operation, the physiology underlying the measurement, the major functional (system) pieces for each instrument, and typical problems/applications of each instrument. Special focus is placed on making reliable and safe repairs in a low resource setting: Troubleshooting, creative problem solving, calibration and testing. GPA requirement: 3.0 and aboveOffered by Bioengineering. Limited to two attempts.
Registration Restrictions:
Students with the terminated from CEC major attribute may **not** enroll.

Schedule Type: Lecture

Grading:
This course is graded on the Undergraduate Regular scale. (https://catalog.gmu.edu/policies/academic/grading/)

BENG 420: *Biomedical Data Analytics.* 3 credits.
This course introduces the fundamental techniques and tools for analyzing biomedical data, important for many biomedical engineering problems. Topics include classification, regression, clustering, dimensionality reduction, data representation, and algorithm performance evaluation. Students will deepen their understanding of the concepts and gain hands-on experience on data analysis by applying algorithms to analyze and interpret various kinds of standard biological and biomedical data encountered in bioengineering fields. This course will be an innovative course leveraging hybrid learning through a combination of lectures, on-line content, and course project.Offered by Bioengineering. Limited to two attempts.
Registration Restrictions:
Required Prerequisites: (CS 112[C] or 112[XS]) and (BENG 330[C] or 330[XS]) and (STAT 350[C], 350[XS], 360[C] or 360[XS]).
[C] Requires minimum grade of C.
[XS] Requires minimum grade of XS.

Enrollment is limited to students with a major, minor, or concentration in Bioengineering.

Students with the terminated from CEC major attribute may **not** enroll.

Schedule Type: Lecture

Grading:
This course is graded on the Undergraduate Regular scale. (https://catalog.gmu.edu/policies/academic/grading/)

BENG 421: *Cell and Tissue Engineering.* 3 credits.
This course is designed to provide exposure to the concepts of cell/tissue functions and behavior and strategies to manipulate their responses, biomaterials to construct scaffolds, modern techniques of artificial organ development and wound healing and most importantly, the utilization of engineering principles for biomedical applications. The course schedule has been packaged to not only provide fundamental information on the above topics, but also to stimulate team working skills, awareness of the current scientific developments through literature review, real-time experiences through lab visits and demos, and career opportunities through industrial visits.Offered by Bioengineering. Limited to two attempts.
Registration Restrictions:
Required Prerequisites: (BENG 240[C] or 240[XS]).
[C] Requires minimum grade of C.
[XS] Requires minimum grade of XS.

Students with the terminated from CEC major attribute may **not** enroll.

Schedule Type: Lecture

Grading:
This course is graded on the Undergraduate Regular scale. (https://catalog.gmu.edu/policies/academic/grading/)

BENG 426: *Neural Engineering.* 3 credits.
This course is an overview of Neural Engineering. The sequence of topics are designed to cover from fundamentals of Neurophysiology through to applications of neural prosthesis such as retinal and cochlear implants. Other important aspects of Neural Engineering to be discussed include brain-machine interfaces, instrumentation for interfacing electronics to the nervous system, and sensors for neural research.Offered by Bioengineering. Limited to two attempts.
Registration Restrictions:
Required Prerequisites: ((BENG 370[C] or 370[XS]) and (BENG 371[C] or 371[XS])).
[C] Requires minimum grade of C.
[XS] Requires minimum grade of XS.

Students with the terminated from CEC major attribute may **not** enroll.

Schedule Type: Lecture

Grading:
This course is graded on the Undergraduate Regular scale. (https://catalog.gmu.edu/policies/academic/grading/)

BENG 430: *Continuum Biomechanics and Biotransport II.* 3 credits.
This course provides advanced and unifying treatment of the fundamental field equations describing the laws of continuum biomechanical systems including solids, fluids and transport phenomena in biological systems. Topics will include: blood and circulation, viscoelasticity, poroelasticity, thermoelasticity, and molecular and convective transport in biological systems.Offered by Bioengineering. Limited to two attempts.
Registration Restrictions:
Required Prerequisites: (BENG 230[C] or 230[XS]) and (BENG 330[C] or 330[XS]).

[C] Requires minimum grade of C.
[XS] Requires minimum grade of XS.

Enrollment is limited to students with a major, minor, or concentration in Bioengineering.

Students with the terminated from CEC major attribute may **not** enroll.

Schedule Type: Lecture

Grading:
This course is graded on the Undergraduate Regular scale. (https://catalog.gmu.edu/policies/academic/grading/)

BENG 434: *Computational Modelling of Neurons and Networks.* 3 credits.
Introduces the objectives, philosophy, and methodology of neuronal modeling. Instructs students in the use of some of the more popular neural modeling software packages. Students learn the syntax of several software packages, how to create neurons from subcellular components, and how to create networks by connecting neuron models.Offered by Bioengineering. Limited to two attempts.
Registration Restrictions:
Required Prerequisites: (BENG 327[C] or 327[XS]).
[C] Requires minimum grade of C.
[XS] Requires minimum grade of XS.

Students with the terminated from CEC major attribute may **not** enroll.

Schedule Type: Lecture

Grading:
This course is graded on the Undergraduate Regular scale. (https://catalog.gmu.edu/policies/academic/grading/)

BENG 435: *Multi-scale Modeling and Simulation in Biomedicine.* 3 credits.
This course covers a variety of advanced computational methods for biomedical problems spanning multiple scales, from cells and molecules to tissues, organs and systems. Topics include: advanced computational techniques, finite difference methods, finite element methods, particle methods, stochastic simulations, agent-based methods, coupled problems and high-performance computing. Applications will be drawn from a variety of biomedical fields such as biosolid and biofluid mechanics, cell mechanics, pharmacokinetics, and physiologic systems.Offered by Bioengineering. Limited to two attempts.
Registration Restrictions:
Required Prerequisites: (BENG 230[C] or 230[XS]) and (BENG 330[C] or 330[XS]).

[C] Requires minimum grade of C.
[XS] Requires minimum grade of XS.

Enrollment is limited to students with a major, minor, or concentration in Bioengineering.

Students with the terminated from CEC major attribute may **not** enroll.

Schedule Type: Lecture

Grading:
This course is graded on the Undergraduate Regular scale. (https://catalog.gmu.edu/policies/academic/grading/)

BENG 437: *Medical Image Processing.* 3 credits.
This course aims at familiarizing the student with the basic concepts of image processing as they are applied to medical imaging problems. The class consists of two parts. The first part provides a brief overview of basic image processing, including image enhancement and restoration techniques. The second part addresses problems that are central to medical image processing practice, including registration, segmentation and feature detection.Offered by Bioengineering. Limited to two attempts.
Recommended Prerequisite: BENG 360

Registration Restrictions:
Required Prerequisites: (BENG 320[C] or 320[XS]).
[C] Requires minimum grade of C.
[XS] Requires minimum grade of XS.

Enrollment is limited to students with a major, minor, or concentration in Bioengineering.

Students with the terminated from CEC major attribute may **not** enroll.

Schedule Type: Lecture

Grading:
This course is graded on the Undergraduate Regular scale. (https://catalog.gmu.edu/policies/academic/grading/)

BENG 438: *Advanced Biomedical Imaging.* 3 credits.
This course will provide an introduction to the physical, mathematical and engineering foundations of modern medical imaging instruments and imaging physics principles that enable us to “see” inside the human body to diagnose disease, monitor treatment and perform minimally-invasive interventions. The emphasis will be on diagnostic ultrasound, x-ray (CT), and MRI imaging methods, although other modalities will also be discussed. The course will also provide an overview of recent developments in the field of medical imaging and discuss some of the challenges and controversies. The students will get hands on experience in applying the methods learnt in class to real-world problems and imaging data. There will be broad scope to individually and collaboratively explore current problems in medical imaging.Offered by Bioengineering. Limited to two attempts.
Registration Restrictions:
Required Prerequisites: (BENG 360[C] or 360[XS]).
[C] Requires minimum grade of C.
[XS] Requires minimum grade of XS.

Enrollment is limited to students with a major, minor, or concentration in Bioengineering.

Students with the terminated from CEC major attribute may **not** enroll.

Schedule Type: Lecture

Grading:
This course is graded on the Undergraduate Regular scale. (https://catalog.gmu.edu/policies/academic/grading/)

BENG 440: *Advanced Biomaterials and Biomimetic Devices for Nanomedicine.* 3 credits.
This course covers the rapidly evolving field of nanomedicine from a bioengineering point of view, with a strong focus on the nanomaterials developed for biomedical applications ranging from nanoparticles for therapeutics (drug and vaccine delivery) and imaging to biomimetic materials for regenerative medicine. This course aims to present the large panel of nanostructured biomaterials available to date, which include polymeric vesicles, liposomes, and metallic nanoparticles as well as some of their specific applications. Students will learn about the specific properties of these nanomaterials and will get an overview of the different synthesis and characterization methods that are used to determine their chemical and physical properties, as well as their biocompatibility. All the concepts described in this course will be illustrated with recent examples of their applications in nanomedicine.Offered by Bioengineering. Limited to two attempts.
Registration Restrictions:
Required Prerequisites: ((CHEM 310[C], 310[XS], 313[C] or 313[XS]) and (BENG 240[C], 240[XS], 341[C] or 341[XS])).
[C] Requires minimum grade of C.
[XS] Requires minimum grade of XS.

Enrollment is limited to students with a major, minor, or concentration in Bioengineering.

Students with the terminated from CEC major attribute may **not** enroll.

Schedule Type: Lecture

Grading:
This course is graded on the Undergraduate Regular scale. (https://catalog.gmu.edu/policies/academic/grading/)

BENG 470: *Bioinstrumentation and Devices II.* 3 credits.
This course delves deeper into two aspects of bioinstrumentation: the theory and use of different sensors commonly encountered in Bioengineering devices, and the development of microcontroller-based circuits that interface with such sensors. Students will gain knowledge of microcontroller circuit design and programming, interfacing with sensors and their applications in Bioengineering. Students will demonstrate their understanding of the subject by designing a microcontroller-based device that performs a biomedically-relevant measurement.Offered by Bioengineering. Limited to two attempts.
Registration Restrictions:
Required Prerequisites: (BENG 370[C] or 370[XS]).
[C] Requires minimum grade of C.
[XS] Requires minimum grade of XS.

Enrollment is limited to students with a major, minor, or concentration in Bioengineering.

Students with the terminated from CEC major attribute may **not** enroll.

Schedule Type: Lecture

Grading:
This course is graded on the Undergraduate Regular scale. (https://catalog.gmu.edu/policies/academic/grading/)

BENG 487: *Neuroinformatics.* 3 credits.
This class is a hands-on introduction to available and developing neuroinformatics infrastructures focuses on data processing, literature mining, and metadata annotation, with a special emphasis on neuronal morphology and hippocampal neuron types. The aim is to provide students with sufficient practical understanding of basic concepts and representative tools to participate confidently and actively in neuroscience projects with a substantial component of digital data. Prior computational experience is not required, and attendees will start using their newly acquired knowledge immediately.Offered by Bioengineering. Limited to two attempts.
Registration Restrictions:
Required Prerequisite: BENG 350[C].
[C] Requires minimum grade of C.

Students with the terminated from CEC major attribute may **not** enroll.

Schedule Type: Lecture

Grading:
This course is graded on the Undergraduate Regular scale. (https://catalog.gmu.edu/policies/academic/grading/)

BENG 492: *Senior Advanced Design Project I.* 3 credits.
This course covers the whole engineering design process from the selection of a project to the design and construction of a prototype. Teams of students select a senior design project in bioengineering while considering the feasibility of the proposed project. The work includes identifying an engineering problem, establishing objectives and constraints, considering standards and requirements, developing preliminary design and a testable prototype (considering different design alternatives), as well as team management and organization.Offered by Bioengineering. Limited to two attempts.
Mason Core: Mason Core, Mason Apex (https://catalog.gmu.edu/mason-core/)

Recommended Prerequisite: 90 credit hours applicable to the Bioengineering Program and BENG 375

Recommended Corequisite: COMM 100 or COMM 101

Registration Restrictions:
Required Prerequisites: ((ENGH 302[C], 302[XS], HNRS 110[C] or 110[XS]) and (BENG 320[C] or 320[XS]) and (BENG 370[C] or 370[XS]) and (BENG 330[C] or 330[XS])).
[C] Requires minimum grade of C.
[XS] Requires minimum grade of XS.

Students with the terminated from CEC major attribute may **not** enroll.

Schedule Type: Lecture

Grading:
This course is graded on the Undergraduate Regular scale. (https://catalog.gmu.edu/policies/academic/grading/)

BENG 493: *RS: Senior Advanced Design Project II.* 3 credits.
This course is the implementation of a senior design project for which preliminary work was done in BENG 492. It includes testing and refining the initial prototype, enhancing the design and construction of hardware and software, conducting tests via experiments or studies, evaluating/validating complete system. Requires oral presentations and written reports during project and at completion.Offered by Bioengineering. Limited to two attempts.
Specialized Designation: Research/Scholarship Intensive

Registration Restrictions:
Required Prerequisites: (BENG 492[C] or 492[XS]).
[C] Requires minimum grade of C.

[XS] Requires minimum grade of XS.

Students with the terminated from CEC major attribute may **not** enroll.

Schedule Type: Lecture

Grading:
This course is graded on the Undergraduate Regular scale. (https://catalog.gmu.edu/policies/academic/grading/)

BENG 499: *Special Topics in Bioengineering.* 0-4 credits.
Topics of special interest to undergraduates. Notes: May be repeated if topics substantially differ.Offered by Bioengineering. May be repeated within the term for a maximum 11 credits.
Specialized Designation: Topic Varies

Registration Restrictions:
Students with the terminated from CEC major attribute may **not** enroll.

Schedule Type: Lecture

Grading:
This course is graded on the Undergraduate Regular scale. (https://catalog.gmu.edu/policies/academic/grading/)

500 Level Courses

BENG 500: *Special Topics.* 0-4 credits.
Select contemporary topics in Engineering and Computing.Offered by Bioengineering. May be repeated within the degree for a maximum 6 credits.
Specialized Designation: Topic Varies

Registration Restrictions:
Enrollment limited to students with a class of Advanced to Candidacy, Graduate, Junior Plus, Non-Degree or Senior Plus.

Students in a Non-Degree Undergraduate degree may **not** enroll.

Schedule Type: Lecture

Grading:
This course is graded on the Graduate Special scale. (https://catalog.gmu.edu/policies/academic/grading/)

BENG 501: *Bioengineering Research Methods.* 3 credits.
Examines approaches for scientific research with emphasis on bioengineering. Topics include biophysical origins of bioengineering measures, tools and technology for bioengineering data collection, basic principles of experimental design and statistical analyses, and interpretation of scientific results. Special attention will be given to ethical issues associated with the collection, use, and dissemination of data. Offered by Bioengineering. May not be repeated for credit.
Registration Restrictions:
Enrollment limited to students with a class of Advanced to Candidacy, Graduate, Junior Plus, Non-Degree or Senior Plus.

Enrollment is limited to Graduate, Non-Degree or Undergraduate level students.

Students in a Non-Degree Undergraduate degree may **not** enroll.

Enrollment limited to students in the College of Science, Engineering Computing or Schar School of Policy and Gov colleges.

Schedule Type: Lecture

Grading:
This course is graded on the Graduate Regular scale. (https://catalog.gmu.edu/policies/academic/grading/)

BENG 514: *Pathophysiology and the Role of New Technologies in Human Diseases.* 3 credits.
This course will provide examples from clinical medicine of how patients are diagnosed and treated for diseases of their cardiovascular and neurological systems, as well as for cancer and in acute care (emergency) units. The etiology and pathogenesis of disease processes and the current roles of technologies in diagnosis and treatment will be discussed. Unmet needs in these clinical areas that require research and technology development will be identified and potential pathways towards clinical solutions investigated.Offered by Bioengineering. May not be repeated for credit.
Recommended Prerequisite: A grade of C or better in BENG 214 or equivalent

Registration Restrictions:
Enrollment limited to students with a class of Advanced to Candidacy, Graduate, Junior Plus, Non-Degree or Senior Plus.

Students in a Non-Degree Undergraduate degree may **not** enroll.

Schedule Type: Lecture

Grading:
This course is graded on the Graduate Regular scale. (https://catalog.gmu.edu/policies/academic/grading/)

BENG 520: *Biomedical Data Analytics.* 3 credits.
This course introduces the fundamental techniques and tools for analyzing biomedical data, important for many biomedical engineering problems. Topics include classification, regression, clustering, dimensionality reduction, data representation, and algorithm performance evaluation. Students will deepen their understanding of the concepts and gain hands-on experience on data analysis by applying algorithms to analyze and interpret various kinds of standard biological and biomedical data encountered in bioengineering fields. This course will be an innovative course leveraging hybrid learning through a combination of lectures, on-line content, and course project.Offered by Bioengineering. May not be repeated for credit.
Registration Restrictions:
Required Prerequisites: (BENG 330[C] or 330[XS]).
[C] Requires minimum grade of C.
[XS] Requires minimum grade of XS.

Enrollment limited to students with a class of Advanced to Candidacy, Graduate, Junior Plus, Non-Degree or Senior Plus.

Students in a Non-Degree Undergraduate degree may **not** enroll.

Schedule Type: Lecture

Grading:
This course is graded on the Graduate Regular scale. (https://catalog.gmu.edu/policies/academic/grading/)

BENG 521: *Cell and Tissue Engineering.* 3 credits.
This course is designed to provide exposure to the concepts of cell/tissue functions and behavior and strategies to manipulate their responses, biomaterials to construct scaffolds, modern techniques of artificial organ development and wound healing and most importantly, the utilization of engineering principles for biomedical applications. The course schedule has been packaged to not only provide fundamental information on the

above topics, but also to stimulate team working skills, awareness of the current scientific developments through literature review, real-time experiences through lab visit and demo, and career opportunities through industrial visits.Offered by Bioengineering. May not be repeated for credit.
Registration Restrictions:
Required Prerequisites: (BENG 240[C] or 240[XS]).
[C] Requires minimum grade of C.
[XS] Requires minimum grade of XS.

Enrollment limited to students with a class of Advanced to Candidacy, Graduate, Junior Plus, Non-Degree or Senior Plus.

Students in a Non-Degree Undergraduate degree may **not** enroll.

Schedule Type: Lecture

Grading:
This course is graded on the Graduate Regular scale. (https://catalog.gmu.edu/policies/academic/grading/)

BENG 526: *Neural Engineering.* 3 credits.
Provides an overview of topics in Neural Engineering. Topics covered range from sensory and motor prosthetic devices, stimulation of biological tissue, bioelectrodes and characterization techniques, brain-machine interfaces, and engineered devices to ameliorate neurodisorders. Prior knowledge in electrical or computer engineering disciplines required.Offered by Bioengineering. May not be repeated for credit.
Registration Restrictions:
Enrollment limited to students with a class of Advanced to Candidacy, Graduate, Junior Plus, Non-Degree or Senior Plus.

Students in a Non-Degree Undergraduate degree may **not** enroll.

Schedule Type: Lecture

Grading:
This course is graded on the Graduate Regular scale. (https://catalog.gmu.edu/policies/academic/grading/)

BENG 530: *Continuum Biomechanics and Biotransport II.* 3 credits.
This course provides and advanced and unifying treatment of the fundamental field equations describing the laws of continuum biomechanical systems including solids, fluids and transport phenomena in biological systems. Topics will include: blood and circulation, viscoelasticity, poroelasticity, thermoelasticity, and molecular and convective transport in biological systems.Offered by Bioengineering. May not be repeated for credit.
Registration Restrictions:
Required Prerequisites: (BENG 230[C] or 230[XS]) and (BENG 330[C] or 330[XS]).

[C] Requires minimum grade of C.
[XS] Requires minimum grade of XS.

Enrollment limited to students with a class of Advanced to Candidacy, Graduate, Junior Plus, Non-Degree or Senior Plus.

Students in a Non-Degree Undergraduate degree may **not** enroll.

Schedule Type: Lecture

Grading:
This course is graded on the Graduate Regular scale. (https://catalog.gmu.edu/policies/academic/grading/)

BENG 535: *Multi-Scale Modeling and Simulation in Biomedicine.* 3 credits.
This course covers a variety of advanced computational methods for modeling biomedical systems spanning multiple scales, from cells and molecules to tissues, organs and systems. Topics include: modeling cell biomechanics, modeling biofluids including blood flows, modeling biotransport phenomena including bioheat and molecular diffusion, and modeling tissue biomechanics, and modeling organs and physiological systems. Computational techniques will include: discrete particle dynamics methods, finite differences and finite element methods, stochastic and agent-based modeling, and high-performance computing.Offered by Bioengineering. May not be repeated for credit.
Registration Restrictions:
Required Prerequisites: (BENG 230[C] or 230[XS]) and (BENG 330[C] or 330[XS]).

[C] Requires minimum grade of C.
[XS] Requires minimum grade of XS.

Enrollment limited to students with a class of Advanced to Candidacy, Graduate, Junior Plus, Non-Degree or Senior Plus.

Students in a Non-Degree Undergraduate degree may **not** enroll.

Schedule Type: Lecture

Grading:
This course is graded on the Graduate Regular scale. (https://catalog.gmu.edu/policies/academic/grading/)

BENG 537: *Medical Image Processing.* 3 credits.
This course aims at familiarizing the student with the basic concepts of image processing as they are applied to medical imaging problems. The first part of the course provides a brief overview of basic image processing, including image enhancement and restoration techniques. The second part of the course addresses problems that are central to medical image processing practice, including registration, segmentation and feature detection. This course also includes a project focused on biomedical image applications.Offered by Bioengineering. May not be repeated for credit.
Registration Restrictions:
Required Prerequisites: (BENG 320[C] or 320[XS]).
[C] Requires minimum grade of C.
[XS] Requires minimum grade of XS.

Enrollment limited to students with a class of Advanced to Candidacy, Graduate, Junior Plus, Non-Degree or Senior Plus.

Students in a Non-Degree Undergraduate degree may **not** enroll.

Schedule Type: Lecture

Grading:
This course is graded on the Graduate Regular scale. (https://catalog.gmu.edu/policies/academic/grading/)

BENG 538: *Medical Imaging.* 3 credits.
Provides an introduction to the physical, mathematical and engineering foundations of modem medical imaging systems, medical image processing and analysis methods. In addition, this course introduces engineering students to clinical applications of medical imaging. The emphasis is on diagnostic ultrasound and magnetic resonance imaging methods, although several other modalities are covered. The course also provides an overview of recent developments and future trends in the field of medical imaging, discusses some of the challenges and controversies, and involves hands-on experience applying the methods

learned in class to real-world problems.Offered by Bioengineering. May not be repeated for credit. Equivalent to ECE 538.
Recommended Prerequisite: ECE 321 or equivalent

Registration Restrictions:
Enrollment limited to students with a class of Advanced to Candidacy, Graduate, Junior Plus, Non-Degree or Senior Plus.

Enrollment is limited to Graduate, Non-Degree or Undergraduate level students.

Students in a Non-Degree Undergraduate degree may **not** enroll.

Enrollment limited to students in the College of Science, Engineering Computing or Schar School of Policy and Gov colleges.

Schedule Type: Lecture

Grading:
This course is graded on the Graduate Regular scale. (https://catalog.gmu.edu/policies/academic/grading/)

BENG 540: *Advanced Biomaterials and Biomimetic Devices for Nanomedicine.* 3 credits.
This course covers the rapidly evolving field of nanomedicine from a bioengineering point of view, with a strong focus on the nanomaterials developed for biomedical applications ranging from nanoparticles for therapeutics (drug and vaccine delivery) and imaging to biomimetic materials for regenerative medicine. This course aims to present the large panel of nanostructured biomaterials available to date, which include polymeric vesicles, liposomes, and metallic nanoparticles as well as some of their specific applications. Students will learn about the specific properties of these nanomaterials and will get an overview of the different synthesis and characterization methods that are used to determine their chemical and physical properties, as well as their biocompatibility. All the concepts described in this course will be illustrated with recent examples of their applications in nanomedicine.Offered by Bioengineering. May not be repeated for credit.
Recommended Prerequisite: A grade of C or better in CHEM 310 and (BENG 240 or BENG 341) or proof of transfer equivalents.

Registration Restrictions:
Enrollment limited to students with a class of Advanced to Candidacy, Graduate, Junior Plus, Non-Degree or Senior Plus.

Students in a Non-Degree Undergraduate degree may **not** enroll.

Enrollment limited to students in the College of Science, Engineering Computing or Volgenau School of Engineering colleges.

Schedule Type: Lecture

Grading:
This course is graded on the Graduate Regular scale. (https://catalog.gmu.edu/policies/academic/grading/)

BENG 541: *Biomaterials.* 3 credits.
Covers the principles of biomaterials and biological interactions with materials, including an overview of biomaterials characterization, design and testing. Specific topics include the use of polymers, ceramics and metallics in biomaterials, drug delivery applications, tissue engineering from an orthopedic and vascular perspective, biocompatibility, acute and chronic biological response to implanted material, and in vitro and in vivo testing of biomaterials. Offered by Bioengineering. May not be repeated for credit.
Recommended Prerequisite: BIOL 213 or BENG 213 with a C or better CHEM 211 or CHEM 251 or BENG 201 with a C or better

Registration Restrictions:
Enrollment limited to students with a class of Advanced to Candidacy, Graduate, Junior Plus, Non-Degree or Senior Plus.

Enrollment is limited to Graduate, Non-Degree or Undergraduate level students.

Students in a Non-Degree Undergraduate degree may **not** enroll.

Enrollment limited to students in the College of Science, Engineering Computing or Schar School of Policy and Gov colleges.

Schedule Type: Lecture

Grading:
This course is graded on the Graduate Regular scale. (https://catalog.gmu.edu/policies/academic/grading/)

BENG 550: *Advanced Biomechanics.* 3 credits.
Introduces the fundamental concepts of musculoskeletal biomechanics, and how to apply mechanical principles to quantitatively describe and analyze movement. Topics include properties, functions, and models of the musculoskeletal structures, 3D kinematics, locomotion, and instrumentation systems applied in musculoskeletal biomechanics and movement analysis. Offered by Bioengineering. May not be repeated for credit.
Registration Restrictions:
Enrollment limited to students with a class of Advanced to Candidacy, Graduate, Junior Plus, Non-Degree or Senior Plus.

Enrollment is limited to Graduate, Non-Degree or Undergraduate level students.

Students in a Non-Degree Undergraduate degree may **not** enroll.

Enrollment limited to students in the College of Science, Engineering Computing or Schar School of Policy and Gov colleges.

Schedule Type: Lecture

Grading:
This course is graded on the Graduate Regular scale. (https://catalog.gmu.edu/policies/academic/grading/)

BENG 551: *Translational Bioengineering.* 3 credits.
Demonstrates the process for the creation of both medical device prototypes and medical device companies. Focuses on designing and building a robust medical device prototype and writing a business plan. Also addresses cost of healthcare, reimbursement, regulatory processes, intellectual property, and marketing and sales aspects. Course will feature lectures, videos, and guest speakers who are successful medical device entrepreneurs. Offered by Bioengineering. May not be repeated for credit.
Registration Restrictions:
Enrollment limited to students with a class of Advanced to Candidacy, Graduate, Junior Plus, Non-Degree or Senior Plus.

Enrollment is limited to Graduate, Non-Degree or Undergraduate level students.

Students in a Non-Degree Undergraduate degree may **not** enroll.

Enrollment limited to students in the College of Science, Engineering Computing or Schar School of Policy and Gov colleges.

Schedule Type: Lecture

Grading:
This course is graded on the Graduate Regular scale. (https://catalog.gmu.edu/policies/academic/grading/)

BENG 570: *Bioinstrumentation and Devices II.* 3 credits.
A major part of Bioengineering involves the design of instruments that allows us to both make measurements and intervene in living systems. This course delves deeper into two aspects of bioinstrumentation: the theory and use of different sensors commonly encountered in bioengineering devices, and the development of microcontroller-based circuits that interface with such sensors. Students will gain knowledge of microcontroller circuit design and programming, interfacing with sensors and their applications in Bioengineering. Students will demonstrate their understanding of the subject by designing a microcontroller-based device that performs a biomedically-relevant measurement.Offered by Bioengineering. May not be repeated for credit.
Registration Restrictions:
Required Prerequisites: (BENG 370[C] or 370[XS]).
[C] Requires minimum grade of C.
[XS] Requires minimum grade of XS.

Enrollment limited to students with a class of Advanced to Candidacy, Graduate, Junior Plus, Non-Degree or Senior Plus.

Students in a Non-Degree Undergraduate degree may **not** enroll.

Schedule Type: Lecture

Grading:
This course is graded on the Graduate Regular scale. (https://catalog.gmu.edu/policies/academic/grading/)

BENG 575: *Intellectual Property, Regulatory Concepts and Product Development.* 3 credits.
The course provides an understanding of i) intellectual property focusing on patents and the patent process in the US and globally, ii) regulatory frameworks for product approval such as FDA and international regulations, standards (ANSI, ASTM, ISO, GCP, GLP) and iii) product development including ideation and concept development, quality systems, global business models, financing and transactions. An overarching team project will involve invention, proof of concept, patenting, regulatory pathways and product development to market in a global context.Offered by Bioengineering. May not be repeated for credit.
Registration Restrictions:
Enrollment limited to students with a class of Advanced to Candidacy, Graduate, Junior Plus, Non-Degree or Senior Plus.

Students in a Non-Degree Undergraduate degree may **not** enroll.

Schedule Type: Lecture

Grading:
This course is graded on the Graduate Regular scale. (https://catalog.gmu.edu/policies/academic/grading/)

BENG 590: *Selected Topics in Bioengineering.* 3 credits.
Addresses selected topics from recent developments in various Bioengineering disciplines. Content may vary each semester depending on instructor and students' interests. Offered by Bioengineering. May be repeated within the term for a maximum 6 credits.

Specialized Designation: Topic Varies

Registration Restrictions:
Enrollment limited to students with a class of Advanced to Candidacy, Graduate, Junior Plus, Non-Degree or Senior Plus.

Enrollment is limited to Graduate, Non-Degree or Undergraduate level students.

Students in a Non-Degree Undergraduate degree may **not** enroll.

Enrollment limited to students in the College of Science, Engineering Computing or Schar School of Policy and Gov colleges.

Schedule Type: Lecture

Grading:
This course is graded on the Graduate Regular scale. (https://catalog.gmu.edu/policies/academic/grading/)

600 Level Courses

BENG 600: *Bioengineering Seminar.* 0 credits.
Students are required to attend seminars, including talks by distinguished speakers, faculty candidates, and Mason faculty. Notes: Required attendance and participation in a minimum of 2 seminars per semester.Offered by Bioengineering. May be repeated within the degree.
Recommended Prerequisite: Admission to MS Bioengineering program.

Registration Restrictions:
Enrollment limited to students with a class of Graduate.

Schedule Type: Seminar

Grading:
This course is graded on the Satisfactory/No Credit scale. (https://catalog.gmu.edu/policies/academic/grading/)

BENG 601: *Collaborative Bioengineering Basic Science Research.* 3 credits.
This course provides exposure to research in the bioengineering department, provide a broad experience to interdisciplinary research, provide an overview of Biomedical Engineering to new graduate students, and connect students to faculty and scientists in other departments and institutions.Offered by Bioengineering. May not be repeated for credit.
Registration Restrictions:
Enrollment limited to students with a class of Advanced to Candidacy, Graduate, Junior Plus, Non-Degree or Senior Plus.

Students in a Non-Degree Undergraduate degree may **not** enroll.

Schedule Type: Lecture

Grading:
This course is graded on the Graduate Regular scale. (https://catalog.gmu.edu/policies/academic/grading/)

BENG 602: *Collaborative Bioengineering Clinical Science Research.* 3 credits.
This course provides exposure to biomedical research in the bioengineering department, provide a broad experience to interdisciplinary research, provide an overview of how biomedical engineering research can address clinical unmet needs to new graduate students, and connect students to faculty and clinicians in a hospital setting and different institutions.Offered by Bioengineering. May not be repeated for credit.
Registration Restrictions:

Enrollment limited to students with a class of Advanced to Candidacy, Graduate, Junior Plus, Non-Degree or Senior Plus.

Students in a Non-Degree Undergraduate degree may **not** enroll.

Schedule Type: Lecture

Grading:
This course is graded on the Graduate Regular scale. (https://catalog.gmu.edu/policies/academic/grading/)

BENG 615: *Biomanufacturing.* 3 credits.
This course will introduce the students to biopharmaceutical products, such as vaccines, monoclonal antibodies, recombinant proteins, biosimilars, and others, and the processes required to manufacture these products. The elements of biomanufacturing that will be discussed include the biological expression systems, upstream and downstream processes, formulation, and vial filling. Operational parameters of bioreactors, separation/isolation methods such as chromatography and a variety of analytical measurements will be discussed. In addition, students will learn about the quality systems that need to be in place to ensure product purity, safety, and potency. The course will also cover the current and future challenges in biomanufacturing of novel biopharmaceuticals.Offered by Bioengineering. May not be repeated for credit.
Recommended Prerequisite: A grade of C or better in CHEM 310 and BENG 240 or proof of transfer equivalents.

Registration Restrictions:
Enrollment limited to students with a class of Advanced to Candidacy, Graduate, Junior Plus, Non-Degree or Senior Plus.

Students in a Non-Degree Undergraduate degree may **not** enroll.

Enrollment limited to students in the College of Science or Engineering Computing colleges.

Schedule Type: Lecture

Grading:
This course is graded on the Graduate Regular scale. (https://catalog.gmu.edu/policies/academic/grading/)

BENG 641: *Advanced Nanotechnology in Health.* 3 credits.
Presents interdisciplinary scientific and engineering approaches to solve relevant medical problems. Contents include polymer structure, composition, and material properties, natural and synthetic polymers, and their application to design novel nanocarriers for controlled drug release, scaffolds for tissue engineering, and new vectors for vaccines. The relevance of nanotechnology to advance treatments for cancer, infectious and neurodegenerative diseases are discussed in depth. Offered by Bioengineering. May not be repeated for credit.
Recommended Prerequisite: BENG 541, or permission of instructor.

Registration Restrictions:
Enrollment limited to students with a class of Advanced to Candidacy, Graduate, Junior Plus, Non-Degree or Senior Plus.

Enrollment is limited to Graduate, Non-Degree or Undergraduate level students.

Students in a Non-Degree Undergraduate degree may **not** enroll.

Schedule Type: Lecture

Grading:
This course is graded on the Graduate Regular scale. (https://catalog.gmu.edu/policies/academic/grading/)

BENG 699: *Advanced Topics in Bioengineering.* 3 credits.
Advanced topics of current interest in bioengineering. Topics chosen so they do not duplicate other courses in department. Active participation encouraged in form of writing and presenting papers in research areas. Offered by Bioengineering. May be repeated within the term for a maximum 6 credits.
Specialized Designation: Topic Varies

Recommended Prerequisite: Permission of instructor.

Registration Restrictions:
Enrollment limited to students with a class of Advanced to Candidacy, Graduate, Junior Plus, Non-Degree or Senior Plus.

Enrollment is limited to Graduate, Non-Degree or Undergraduate level students.

Students in a Non-Degree Undergraduate degree may **not** enroll.

Enrollment limited to students in the College of Science, Engineering Computing or Schar School of Policy and Gov colleges.

Schedule Type: Lecture

Grading:
This course is graded on the Graduate Regular scale. (https://catalog.gmu.edu/policies/academic/grading/)

700 Level Courses

BENG 703: *Laboratory Rotations in Biomaterials and Nanomedicine.* 3 credits.
Intensive introduction to a research laboratory in the area of biomaterials and nanomedicine. The student will read background material pertinent to the problem under study, learn and practice research methods of the laboratory, and formulate a short final project, which may be a proposal or an actual project, demonstrating some mastery of the techniques and approaches employed.Offered by Bioengineering. May be repeated within the degree for a maximum 6 credits.
Registration Restrictions:
Enrollment limited to students with a class of Graduate or Non-Degree.

Students in a Non-Degree Undergraduate degree may **not** enroll.

Schedule Type: Independent Study

Grading:
This course is graded on the Graduate Regular scale. (https://catalog.gmu.edu/policies/academic/grading/)

BENG 704: *Laboratory Rotations in Biomedical Imaging and Devices.* 3 credits.
Intensive introduction to a research laboratory in the area of biomedical imaging and devices. The student will read background material pertinent to the problem under study, learn and practice research methods of the laboratory, and formulate a short final project, which may be a proposal or an actual project, demonstrating some mastery of the techniques and approaches employed.Offered by Bioengineering. May be repeated within the degree for a maximum 6 credits.
Registration Restrictions:
Enrollment limited to students with a class of Advanced to Candidacy, Graduate or Non-Degree.

Students in a Non-Degree Undergraduate degree may **not** enroll.

Schedule Type: Independent Study

Grading:
This course is graded on the Graduate Regular scale. (https://catalog.gmu.edu/policies/academic/grading/)

BENG 705: *Laboratory Rotations in Computational Biomedical Engineering.* 3 credits.
Intensive introduction to a research laboratory in the area of computational biomedical engineering. The student will read background material pertinent to the problem under study, learn and practice research methods of the laboratory, and formulate a short final project, which may be a proposal or an actual project, demonstrating some mastery of the techniques and approaches employed.Offered by Bioengineering. May be repeated within the degree for a maximum 6 credits.
Registration Restrictions:
Enrollment limited to students with a class of Advanced to Candidacy, Graduate or Non-Degree.

Students in a Non-Degree Undergraduate degree may **not** enroll.

Schedule Type: Independent Study

Grading:
This course is graded on the Graduate Regular scale. (https://catalog.gmu.edu/policies/academic/grading/)

BENG 706: *Laboratory Rotations in Neurotechnology and Computational Neuroscience.* 3 credits.
Intensive introduction to a research laboratory in the area of neurotechnology and computational neuroscience. The student will read background material pertinent to the problem under study, learn and practice research methods of the laboratory, and formulate a short final project, which may be a proposal or an actual project, demonstrating some mastery of the techniques and approaches employed.Offered by Bioengineering. May be repeated within the degree for a maximum 6 credits.
Registration Restrictions:
Enrollment limited to students with a class of Advanced to Candidacy, Graduate or Non-Degree.

Students in a Non-Degree Undergraduate degree may **not** enroll.

Schedule Type: Independent Study

Grading:
This course is graded on the Graduate Regular scale. (https://catalog.gmu.edu/policies/academic/grading/)

BENG 725: *Computational Motor Control.* 3 credits.
Uses approaches from robotics, control theory, and neuroscience to understand biological motor systems. Contents include modeling muscles, reflexes and neural systems to understand how the central nervous system plans and controls movement of the eyes and limbs. The theoretical control problem is compared to known neuronal properties of the motor system and diseases of the motor system affecting movement control. Offered by Bioengineering. May not be repeated for credit.
Registration Restrictions:
Enrollment is limited to Graduate or Non-Degree level students.

Students in a Non-Degree Undergraduate degree may **not** enroll.

Enrollment limited to students in the College of Science, Engineering Computing or Schar School of Policy and Gov colleges.

Schedule Type: Lecture

Grading:
This course is graded on the Graduate Regular scale. (https://catalog.gmu.edu/policies/academic/grading/)

BENG 738: *Advanced Medical Image Processing.* 3 credits.
Advanced Medical Image Processing covers advanced processing techniques used in modern medical imaging. The course aims at developing an understanding of the mathematical background, principles and application of techniques such as segmentation, registration, morphometry, general linear modeling, principal and independent component analysis. Offered by Bioengineering. May not be repeated for credit.
Recommended Prerequisite: BENG 320 (or equivalent), ECE 537 (or equivalent).

Registration Restrictions:
Enrollment is limited to Graduate or Non-Degree level students.

Students in a Non-Degree Undergraduate degree may **not** enroll.

Enrollment limited to students in the College of Science, Engineering Computing or Schar School of Policy and Gov colleges.

Schedule Type: Lecture

Grading:
This course is graded on the Graduate Regular scale. (https://catalog.gmu.edu/policies/academic/grading/)

BENG 797: *Graduate Practicum.* 1-6 credits.
Students participate in experiential learning in bioengineering or related field through a practicum opportunity to work on real-world problems. Projects may be experimental or computational in nature, and they should build upon their coursework and provide students with valuable skills related to their career. Students may pursue this practicum opportunity with external industry partners or Mason research laboratories and centers. Students must seek advisor approval prior to registering for this course.Offered by Bioengineering. May be repeated within the degree for a maximum 6 credits.
Registration Restrictions:
Enrollment limited to students with a class of Advanced to Candidacy, Graduate or Non-Degree.

Enrollment is limited to students with a major, minor, or concentration in Bioengineering.

Students in a Non-Degree Undergraduate degree may **not** enroll.

Schedule Type: Internship

Grading:
This course is graded on the Satisfactory/No Credit scale. (https://catalog.gmu.edu/policies/academic/grading/)

BENG 798: *Independent Reading and Research in Bioengineering.* 1-6 credits.
Independent study in Bioengineering under the supervision of a faculty member, resulting in an acceptable technical report or presentation. This course may be repeated once for a total of 12 credit hours towards a graduate degree in Bioengineering. Offered by Bioengineering. May be repeated within the degree for a maximum 12 credits.

Registration Restrictions:
Enrollment is limited to Graduate or Non-Degree level students.

Students in a Non-Degree Undergraduate degree may **not** enroll.

Enrollment limited to students in the College of Science, Engineering Computing or Schar School of Policy and Gov colleges.

Schedule Type: Thesis

Grading:
This course is graded on the Satisfactory/No Credit scale. (https://catalog.gmu.edu/policies/academic/grading/)

BENG 799: *Master's Thesis.* 1-6 credits.
Research project chosen and completed under guidance of graduate faculty member that results in a technical report and an oral defense acceptable to thesis committee of faculty members.Offered by Bioengineering. May be repeated within the degree.
Recommended Prerequisite: 9 graduate credits, and permission of instructor.

Registration Restrictions:
Enrollment limited to students with a class of Advanced to Candidacy, Graduate or Non-Degree.

Students in a Non-Degree Undergraduate degree may **not** enroll.

Schedule Type: Thesis

Grading:
This course is graded on the Satisfactory/No Credit scale. (https://catalog.gmu.edu/policies/academic/grading/)

800 Level Courses

BENG 800: *Bioengineering Colloquium.* 0 credits.
Students are required to attend colloquia including talks by distinguished speakers, faculty candidates, and Mason faculty. Notes: Required attendance and participation in a minimum of 5 seminars per semester.Offered by Bioengineering. May be repeated within the degree.
Recommended Prerequisite: Admission to PhD Bioengineering program.

Registration Restrictions:
Enrollment is limited to Graduate level students.

Enrollment limited to students in the College of Science, Engineering Computing or Schar School of Policy and Gov colleges.

Schedule Type: Seminar

Grading:
This course is graded on the Satisfactory/No Credit scale. (https://catalog.gmu.edu/policies/academic/grading/)

BENG 801: *Bioengineering Colloquium II.* 3 credits.
Formal record of attending the required number of departmental seminars over multiple semesters. Students should first register for BENG 800 – Bioengineering Colloquium until they have attended 5 seminars per semester for 3 semesters. Once they have done so, they should sign up for BENG 801 and attend at least 5 seminars (while registered for this course) to receive credit.Offered by Bioengineering. May not be repeated for credit.
Registration Restrictions:
Required Prerequisite: BENG 800.

Enrollment is limited to Graduate level students.

Schedule Type: Seminar

Grading:
This course is graded on the Satisfactory/No Credit scale. (https://catalog.gmu.edu/policies/academic/grading/)

900 Level Courses

BENG 998: *Doctoral Dissertation Proposal.* 1-12 credits.
Work on research proposal that forms basis for doctoral dissertation. May be repeated as needed. Notes: No more than 24 credits of BENG 998 and 999 may be applied to doctoral degree requirements.Offered by Bioengineering. May be repeated within the degree for a maximum 12 credits.
Registration Restrictions:
Enrollment is limited to Graduate level students.

Enrollment limited to students in the College of Science, Engineering Computing or Schar School of Policy and Gov colleges.

Schedule Type: Dissertation

Grading:
This course is graded on the Satisfactory/No Credit scale. (https://catalog.gmu.edu/policies/academic/grading/)

BENG 999: *Doctoral Dissertation.* 1-12 credits.
Formal record of commitment to doctoral dissertation research under direction of faculty member in bioengineering. May be repeated as needed. Notes: Once enrolled in 999, students must maintain continuous registration in 999 each semester until graduation, excluding summers. Students who defend in the summer must be registered for at least 1 credit of 999 in the summerOffered by Bioengineering. May be repeated within the degree for a maximum 12 credits.
Registration Restrictions:
Enrollment limited to students with a class of Advanced to Candidacy.

Enrollment is limited to Graduate level students.

Enrollment limited to students in the College of Science, Engineering Computing or Schar School of Policy and Gov colleges.

Schedule Type: Dissertation

Grading:
This course is graded on the Satisfactory/No Credit scale. (https://catalog.gmu.edu/policies/academic/grading/)