DEPARTMENT OF MECHANICAL AND NUCLEAR ENGINEERING

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Professor and chair

mechanical-and-nuclear.egr.vcu.edu (http://mechanical-and-nuclear.egr.vcu.edu)

Mechanical engineering is one of the oldest and broadest engineering disciplines. Mechanical engineers design and analyze machines of all types including automobiles, airplanes, rockets, submarines, power generation systems, biomedical instrumentation, robots, manufacturing systems, household appliances and many, many more. In addition to well-known areas such as nuclear energy, nuclear propulsion and nuclear medicine, nuclear engineers are involved in many other applications of nuclear science and technology in fields as diverse as agriculture, industry, homeland security, forensics, environmental protection and even art. The Department of Mechanical and Nuclear Engineering provides quality graduate and undergraduate education through the following degree-granting programs:

- B.S. in Mechanical Engineering (general mechanical engineering curriculum)
- B.S. in Mechanical Engineering (nuclear engineering concentration)
- M.S. in Mechanical and Nuclear Engineering (thesis and non-thesis options, as well as online option)
- Ph.D. in Mechanical and Nuclear Engineering

Current areas of research within the department include but are not limited to energy conversion systems, smart materials, corrosion, medical devices, aerosol science, sensors, radiation detection and measurement, nuclear reactor design, robotics, fluid mechanics, nanotechnology, and biomechanics.

- Mechanical and Nuclear Engineering, Doctor of Philosophy (Ph.D.) (http://bulletin.vcu.edu/graduate/school-engineering/mechanical-nuclear-engineering/mechanical-nuclear-engineering-phd)
- Mechanical and Nuclear Engineering, Master of Science (M.S.) (http://bulletin.vcu.edu/graduate/school-engineering/mechanical-nuclear-engineering/mechanical-nuclear-engineering-ms)

EGMN 501. Advanced Manufacturing Systems. 3 Hours.
Semester course; 3 lecture hours. 3 credits. Prerequisites: EGMN 425 and EGMN 426, graduate standing in the School of Engineering, or permission of instructor. Studies the fundamental systems required for mechanical, chemical and electrical manufacturing, including material procurement, logistics, quality and distribution. The principles are applied to all types of manufacturing processes from project through continuous. Advanced systems for lean, agile and global manufacturing also are covered.

EGMN 502. Product Design and Development. 3 Hours.
Semester course; 3 lecture hours. 3 credits. Prerequisite: senior or graduate standing in the School of Engineering, or permission of instructor. Presents engineering concepts and techniques necessary to successfully develop new products and introduce them to the marketplace. Topics include development processes, converting direct customer input to marketing specifications, creating technical specifications, quantifying customer input, using rapid prototyping to reduce development time, design for manufacturability and product certification issues.

EGMN 505. Characterization of Materials. 3 Hours.
Semester course; 3 lecture hours. 3 credits. Prerequisite: senior or graduate standing in the School of Engineering, or permission of instructor. Focuses on characterization techniques of solids at the molecular, surface and bulk levels, including resonant, vibrational and electronic spectroscopies, X-ray methods and optical and electron microscopies. A connection will be developed between the theoretically-derived and experimentally-observed properties of materials and a rationale also will be developed for choosing an appropriate characterization technique for a given material.

EGMN 506. Industrial Hygiene. 3 Hours.
Semester course; 3 lecture hours. 3 credits. Enrollment restricted to students with senior or graduate standing in the School of Engineering or by permission of instructor. The course will acquaint students with methods used by industrial hygienists to identify, evaluate and control human exposure to toxic contaminants and harmful physical agents in the workplace and in the environment. Students will develop an understanding of the ethical issues confronting industrial hygienists and other health professionals.

EGMN 507. Law and Engineering. 3 Hours.
Semester course; 3 lecture hours. 3 credits. Enrollment restricted to students with senior or graduate standing in the school of Engineering, or by permission of instructor. The course proposes to acquaint the student with legal concepts that affect the engineering community and enable the student to understand how technical and scientific regulations are promulgated and how interest groups attempt to ensure that regulations consider their positions. In addition, the course introduces intellectual property law: patents, copyrights and trademarks.

EGMN 508. Lean Manufacturing. 3 Hours.
Semester course; 3 lecture hours. 3 credits. Enrollment restricted to students with senior or graduate standing in the School of Engineering or by permission of instructor. The objective of the class is to introduce lean thinking -- defined as a systematic, logical method of identifying and eliminating waste using continuous assessment. The classes focus on managing flow, identifying and eliminating waste, problem-solving, and product and process design.

EGMN 509. Advanced Lean Manufacturing. 3 Hours.
Semester course; 3 lecture hours. 3 credits. Enrollment restricted to students with senior or graduate standing in the School of Engineering or by permission of instructor. The course builds on the knowledge gained in lean manufacturing. The class allows the student to use their lean tools in a real manufacturing environment. The course reviews autonomation, load leveling, distribution, logistics, flow and added work, among many other topics. At the end of the course students will be able to take the Lean Bronze Certificate Test, given by the Society of Manufacturing Engineers.

EGMN 510. Probabilistic Risk Assessment. 3 Hours.
Semester course; 3 lecture hours. 3 credits. Prerequisite: senior or graduate standing in the School of Engineering, or permission of instructor. An introduction to probabilistic risk assessment methods as applied to nuclear power plants. Students will receive hands-on experience in PRA methods by designing and building a PRA model for an operational nuclear power plant. Students will use state-of-the-art software to design a nuclear plant model, using event trees, fault trees, industry failure and unavailability data, and current human reliability analysis methods. Using the completed model, students will calculate and use appropriate risk metrics in typical applications.

EGMN 515. Vibrations. 3 Hours.
Semester course; 3 lecture hours. 3 credits. Enrollment restricted to students with graduate standing in the School of Engineering or with permission of instructor. Provides students with vibrations theory and practical applications for machines and structures necessary (a) to perform analysis and evaluation of vibrations problems and (b) to recognize suspicious results from canned computer software. Emphasis placed on the formulation of governing differential equations, solution methods, evaluation of results and interpretation of response characteristics of discrete mass systems and continuous mass systems. Work and energy methods, variational methods, and Lagrange's Equations will be used to formulate problems. Solution methods will use exact and approximate methods, including eigensolution methods. Applications to the vibrations of various mechanical systems will use computational techniques, computer simulation and analysis.

EGMN 518. Advanced HVAC. 3 Hours.
Semester course; 3 lecture hours. 3 credits. Enrollment restricted to students with graduate standing in the School of Engineering or by permission of instructor. The course intends to reinforce the fundamentals of HVAC systems and apply them to research topics. Student will review the basics of HVAC systems; the use of psychrometric charts to deal with various moist-air processes; indoor environment health, thermal comfort and indoor air quality control; heat transmission in building structures; solar irradiation; basic space heating and cooling load calculations; and space air distribution and related equipment.

EGMN 525. Feedback Control. 3 Hours.
Semester course; 3 lecture hours. 3 credits. Prerequisites: experience using MATLAB software; EGMN 315 and EGMN 410, with a minimum grade of C in both; graduate standing in the School of Engineering; or permission of instructor. In-depth study of the fundamentals of feedback control systems theory and design. Topics covered include transfer function modeling, system stability and time response, root locus, Bode and Nyquist diagrams, lead, lag, and PID compensators.

EGMN 530. System Analysis of the Nuclear Fuel Cycle. 3 Hours.
Semester course; 3 lecture hours. 3 credits. Prerequisite: EGMN 355, with a minimum grade of C, graduate standing in the School of Engineering or permission of instructor. Provides an in-depth technical and policy analysis of various options for the nuclear fuel cycle. Topics include uranium supply, enrichment fuel fabrication, in-core physics and fuel management of uranium, thorium and other fuel types, reprocessing, and waste disposal. Also covered are the principles of fuel-cycle economics and the applied reactor physics of both contemporary and proposed thermal and fast reactors. Nonproliferation aspects, disposal of excess weapons plutonium and transmutation of actinides and selected fission products in spent fuel are examined. Several state-of-the-art computer programs are provided for student use in problem sets and term papers.

EGMN 545. Energy Conversion Systems. 3 Hours.
Semester course; 3 lecture hours. 3 credits. Prerequisites: EGMN 204 and EGMN 301, with a minimum grade of C in both, graduate standing in the School of Engineering, or permission of the instructor. Quantitative and qualitative study of traditional and alternative systems used to generate electricity. Topics include combustion, coal-fired boilers, nuclear reactors, steam turbine blading, gas turbine combustors, turbo-generator design, internal combustion engines, solar thermal systems, photovoltaic devices, wind energy, geothermal energy and fuel cells. Additional topics of interest to the students may be discussed.

EGMN 550. Energy and Sustainability. 3 Hours.
Semester course; 3 lecture hours. 3 credits. Enrollment requires senior or graduate standing in the School of Engineering or permission of instructor. This course will explore the various available energy resource options and technologies with a focus toward achieving sustainability on a local, national and global scale. The course will examine the broader aspects of energy use, including resource estimation, environmental effects, interactions among energy, water and land use, social impacts, and economic evaluations. Students will review the main energy sources of today and tomorrow, from fossil fuels and nuclear power to biomass, hydropower and solar energy, including discussions on energy carriers and energy storage, transmission, and distribution.

EGMN 551. Experimental Methods for Engineers. 3 Hours.
Semester course; 3 lecture hours. 3 credits. Prerequisite: senior or graduate standing in the School of Engineering or permission of the instructor. An introduction to design of experiments theory, DoE and methods such as six-sigma and factorial experimental design to engineering projects. Provides students with the necessary background to plan, budget and analyze an experiment or project.

EGMN 555. Smart Materials. 3 Hours.
Semester course; 3 lecture hours. 3 credits. Enrollment restricted to students with graduate standing in the School of Engineering or with permission of instructor. Covers various smart materials, such as shape memory alloys and piezoelectric and magnetostrictive materials, current research in material development and diverse applications in areas such as medicine, automobiles and aerospace. The aim of the course is to bridge the gap between different areas of material development, characterization, modeling and practical applications of smart materials.

EGMN 560. Monte Carlo Simulations. 3 Hours.
Semester course; 3 lecture hours. 3 credits. Enrollment restricted to students with senior or graduate standing in the School of Engineering or by permission of instructor. The course covers key aspects of computer modeling and simulation with the emphasis on statistical resampling and Monte Carlo techniques. Students will complete a number of modeling projects utilizing programming languages commonly used in the nuclear industry. As such the course includes gaining a basic proficiency in the appropriate programming language, including the development of good programming practices.

EGMN 565. Design Optimization. 3 Hours.
Semester course; 3 lecture hours. 3 credits. Prerequisites: EGRM 420 and 421, with a minimum grade of C in each, graduate standing in the School of Engineering, or permission of instructor. Focuses on providing students with a methodology and set of skills to apply in improving engineering components, systems and processes. The design of better products and processes is a fundamental goal of all engineering.

EGMN 566. Advanced Computer-aided Design and Manufacturing. 3 Hours.
Semester course; 3 lecture hours. 3 credits. Prerequisites: EGMN 420, EGMN 421, EGMN 425 and EGMN 426, with a minimum grade of C in each, graduate standing in the School of Engineering or permission of instructor. Provides students with an understanding of how modern computer techniques can enhance the generation, analysis, synthesis, manufacturing and quality of engineering products. The design and manufacture of better products and processes is a fundamental goal of all engineering disciplines.

EGMN 568. Robot Manipulators. 3 Hours.
Semester course; 3 lecture hours. 3 credits. Prerequisite: graduate standing in the School of Engineering or permission of instructor. Provides students with a basic knowledge in the dynamic analysis and control of robot manipulators. Topics include Jacobian analysis, manipulator dynamics, linear and nonlinear control of manipulators, force control of manipulators, robot manipulator applications and an introduction to telemanipulation.

EGMN 570. Effective Technical Writing. 3 Hours.
Semester course; 3 lecture hours. 3 credits. Enrollment restricted to juniors, seniors or graduate students in the School of Engineering or with permission of instructor. The course will involve intensive study of different aspects of technical communications. Critical reading and writing skills will be developed particularly for technical essays, targeted for both educated and specialized audience. Nontechnical writing will be used as an inspiration for technical writing. Other aspects of technical communications will also be covered.

EGMN 571. Introduction to Computational Fluid Dynamics. 3 Hours.
Semester course; 3 lecture hours. 3 credits. Prerequisite: EGMN 301 with a minimum grade of C, graduate standing in the School of Engineering or permission of the instructor. Students will become familiar with basic aspects of CFD, including characteristics of the governing equations, finite-difference and finite-volume solution methods, implicit versus explicit solution algorithms, grid generation, and numerical analysis. Emphasis placed on mechanical, chemical and bioengineering systems. The final course project will emphasize issues of current research such as biofluid mechanics, medical devices and MEMS.

EGMN 573. Engineering Acoustics. 3 Hours.
Semester course; 3 lecture hours. 3 credits. Prerequisite: graduate standing in the School of Engineering or permission of the instructor. Designed to equip students to perform design work, testing and research in structural acoustics and vibrations. Applications from the fields of automotive, aerospace, marine, architectural, medical equipment and consumer appliance industries will be investigated.

EGMN 574. Nuclear Safeguards, Security and Nonproliferation. 3 Hours.
Semester course; 3 lecture hours. 3 credits. Enrollment restricted to students with senior or graduate standing in the School of Engineering or by permission of instructor. This course will explore the political and technological issues involved with nuclear safeguards, security and nonproliferation. Topics studied will include the history of nuclear weapons development, description and effects of weapons of mass destruction, nuclear material safeguards, protection of nuclear materials, proliferation resistance and pathways in the nuclear fuel cycle, international and domestic safeguards, nuclear terrorism, and safeguards measurement techniques for material accountancy programs and physical protection mechanisms.

EGMN 575. Fast Breeder Reactors. 3 Hours.
Semester course; 3 lecture hours. 3 credits. Enrollment restricted to students with senior or graduate standing in the School of Engineering or by permission of instructor. This course will examine the physical, technical and economic features of fast breeder reactors. In particular, the course will study the need for fast reactors and their design objectives, typical core design principles, and important plant systems. The course will also discuss the major nuclear safety topics and their design approaches.

EGMN 580. Flow Control. 3 Hours.
Semester course; 3 lecture hours. 3 credits. Prerequisite: EGMN 301 with a minimum grade of C, graduate standing in the School of Engineering or permission of instructor. Passive, active and reactive flow management strategies to achieve transition delay/advance, separation control, mixing augmentation, drag reduction, lift enhancement and noise suppression. Unified framework for flow control. Futuristic reactive control methods using MEMS devices, soft computing and dynamical systems theory.

EGMN 591. Special Topics in Engineering. 1-4 Hours.
Semester course; 1-4 variable hours. 1-4 credits. Prerequisite: senior or graduate standing in the School of Engineering, or permission of the instructor. Lectures, tutorial studies, library assignments in selected areas of advanced study or specialized laboratory procedures not available in other courses or as part of research training.

EGMN 602. Convective Heat Transfer. 3 Hours.
Semester course; 3 lecture hours. 3 credits. Prerequisites: graduate standing in the School of Engineering, or permission of instructor. In-depth quantitative study of convective heat transfer. Topics include laminar boundary layer flow, laminar duct flow, external natural convection, internal natural convection, transition to turbulence, turbulent boundary layer flow, turbulent duct flow, free turbulent flows, convection with change of phase, convection in porous media.

EGMN 603. Mechanical and Nuclear Engineering Dynamic Systems. 3 Hours.
Semester course; 3 lecture hours. 3 credits. Enrollment restricted to students with graduate standing in mechanical and nuclear engineering. This course presents the technical foundation for application and use of dynamic systems and presents methods to formulate the governing differential equations of such systems and to obtain realistic analytical and numerical solutions. The organization of the course presents theory and methods and specific applications for typical dynamic systems.

EGMN 604. Mechanical and Nuclear Engineering Materials. 3 Hours.
Semester course; 3 lecture hours. 3 credits. The course consists of advanced topics in both fundamental and applied materials science including solid state fundamentals, crystal structure, diffraction in crystals, postulates of quantum mechanics, Bloch functions and energy bands, Fermi distributions, classification and processing of materials, alloys and phase diagrams, defects, dislocation dynamics, solid state diffusion, thermal and mechanical properties, corrosion, high temperature deformation mechanisms, basics of fracture mechanics, fundamentals of ionization radiation, irradiation effects on material properties, and materials selection for extreme environment applications.

EGMN 605. Mechanical and Nuclear Engineering Analysis. 3 Hours.
Semester course; 3 lecture hours. 3 credits. Enrollment restricted to students with graduate standing in mechanical and nuclear engineering. The course covers advanced topics in applied mathematics most important for solving practical problems in mechanical and nuclear engineering. Topics include Fourier analysis, partial differential equations, boundary value problems, series solutions, complex analysis, conformal mapping, complex analysis and potential theory, applications in fluid mechanics, vibrations, and mechanical and nuclear engineering problems.

EGMN 606. Mechanical and Nuclear Engineering Continuum Mechanics. 3 Hours.
Semester course; 3 lecture hours. 3 credits. Enrollment restricted to students with graduate standing in mechanical and nuclear engineering. The topics include scalars, vectors and tensors; indicial notation; transformation law; principal values and directions; tensor fields; integral theorems of Gauss and Stokes; stress; Mohr's circle; strain; kinematics of deformation and motion; rate of deformation; general principles (continuity, momentum, energy); constitutive equations; linear elasticity; Hooke's law; three-dimensional elasticity; classical fluids; Navier-Stokes equations; Bernoulli equation; flow (viscous, steady, irrotational).

EGMN 607. Heat and Mass Transfer Theory and Applications. 3 Hours.
Semester course; 3 lecture hours. 3 credits. Enrollment restricted to students with graduate standing in mechanical and nuclear engineering. A solid theoretical and applied understanding of heat and mass transfer is critical for training competent mechanical and nuclear engineers. This course will provide students with a theoretical understanding of the heat transport processes of conduction, convention and radiation as well as an understanding of parallels with mass transfer. Solution techniques will be both analytical and numerical, consistent with problems faced by modern engineers. Applications in the field of mechanical engineering include the design of cooling systems for automobiles, conventional power plants, heat engines and computers. Applications in the field of nuclear engineering include maintaining nuclear core temperatures and nuclear plant heat dissipation. Mass transfer applications include any process involving multiple species (e.g., two gases) as well as medically oriented transport problems (e.g., blood oxygenation), which are frequently encountered when developing materials or medical devices. Specific topics to be covered include 1D conduction, 2D and 3D conduction, transient conduction, external forced convection, internal forced convection, convection with phase change, thermal radiation, and principles of mass transfer (diffusion and advection).

EGMN 608. Solid Mechanics and Materials Behavior. 3 Hours.
Semester course; 3 lecture hours. 3 credits. Prerequisite: graduate standing in the School of Engineering or permission of the instructor. Studies of stresses and strains in two- and three-dimensional elastic problems. Failure theories and yield criteria. Analysis and design of load-carrying members, energy methods and stress concentrations. Elastic and plastic behavior, fatigue and fracture, and composites will be discussed.

EGMN 609. Advanced Characterization of Materials. 3 Hours.
Semester course; 3 lecture hours. 3 credits. Enrollment restricted to students with graduate standing in the School of Engineering or with permission of instructor. Study of the physical properties of a wide range of materials by advanced microscopy techniques including electron and scanning probe-based microscopy. Advanced study of deformation and failure in materials including characterization by hardness, fracture toughness and tensile testing, as well as X-ray diffraction.

EGMN 610. Topics in Nuclear Engineering. 3 Hours.
Semester course; 3 lecture hours. 3 credits. Enrollment restricted to students with graduate standing in the School of Engineering or with permission of instructor. A survey covering the scope of nuclear engineering. Concepts of atomic and nuclear structure, mass and energy, nuclear stability, radioactive decay, radioactivity calculations, nuclear reactions, interaction of radiation (neutrons and photons) with matter, fission chain reaction, neutron diffusion, nuclear reaction theory, reactor kinetics, health physics, reactor power plants (PWR and BWR), waste disposal. Required first course for graduate students in nuclear engineering track who enter with degrees in other disciplines; suitable as a technical elective for other graduate engineering tracks.

EGMN 612. Advanced Computational Methods. 3 Hours.
Semester course; 3 lecture hours. 3 credits. Enrollment restricted to students with graduate standing in the School of Engineering or with permission of instructor. Exposes students to the fundamentals of modern numerical techniques for a wide range of linear and nonlinear elliptic, parabolic and hyperparabolic partial differential equations. Topics include equation characteristics; finite difference, finite volume and finite element discretization methods; and direct and iterative solution techniques. Applications to engineering systems are presented, including fluid dynamics, heat transfer and nonlinear solid mechanics.

EGMN 620. Reactor Theory. 3 Hours.
Semester course; 3 lecture hours. 3 credits. Enrollment restricted to students with graduate standing in the School of Engineering or with permission of instructor. The neutronics behavior of fission reactors, primarily from a theoretical, one-speed perspective. Criticality, fission product poisoning, reactivity control, reactor stability and introductory concepts in fuel management, followed by slowing-down and one-speed diffusion theory.

EGMN 625. Advanced Modeling and Simulations. 3 Hours.
Semester course; 3 lecture hours. 3 credits. Enrollment restricted to students with graduate standing in the School of Engineering or by permission of instructor. Use of finite element method to solve applied engineering problems at an advanced level. Special focus will be largely on solid mechanics and, to a lesser degree, on thermal problems. Topics to be covered include, but are not limited to, material and geometric nonlinearities, contact problems, dynamic problems and application of constraint equations. Commercially available finite element method software ANSYS will be utilized. Students will learn how to use ANSYS at an advanced level through utilizing commands and basic programming features.

EGMN 627. Advanced Manufacturing Simulations. 3 Hours.
Semester course; 3 lecture hours. 3 credits. Enrollment restricted to students with graduate standing in the School of Engineering or with permission of instructor. Advanced mechanics of the manufacturing processes, their modeling and simulation. Fundamentals of process modeling and use of computational tools. Details and governing theory behind the construction of numerical analysis tools such as FEA will not be provided. However, the intelligent use of this kind of FEA tool in the solution of industrial problems will be taught in addition to analytical methods in rapid assessment of manufacturing processes and systems.

EGMN 630. Technology, Security and Preparedness. 3 Hours.
Semester course; 3 lecture hours. 3 credits. An overview of the role of technology in detecting and defeating terrorism. The course begins with a detailed review of weapons of mass destruction including chemical, biological and radiological devices. This is followed by a review of the various technologies currently being developed and deployed to detect the presence of terrorist weapons and associated activities. These technologies include chemical sensors, biosensors and radiation detectors, portal monitors, satellite and infrared imaging systems, as well acoustic sensors and magnetometers.

EGMN 640. Nuclear Safety. 3 Hours.
Semester course; 3 lecture hours. 3 credits. Enrollment restricted to students with graduate standing in the School of Engineering or with permission of instructor. Physical and biological aspects of the use of ionizing radiation in industrial and academic institutions; physics principles underlying shielding instrumentation, waste disposal; biological effects of low levels of ionizing radiation.

EGMN 650. Nuclear Radiation and Shielding. 3 Hours.
Semester course; 3 lecture hours. 3 credits. Enrollment restricted to students with graduate standing in the School of Engineering or with permission of instructor. Basic and advanced concepts in radiation sources, gamma ray and neutron shielding, geometry factors in shielding, computational techniques (such as Monte Carlo and discrete ordinates), special topics (such as shield heating, duct steaming and albedo theory) and practical aspects.

EGMN 655. Nuclear Power Plants. 3 Hours.
Semester course; 3 lecture hours. 3 credits. Enrollment restricted to students with graduate standing in the School of Engineering or with permission of instructor. Descriptions of mechanical features (containment, core design, steam generation, Rankine and Brayton cycles) of PWR and BWR power plants. Reactor core heat generation. Thermal analysis of fuel pins, fuel elements, flow channels and reactor core. Single- and two-phase heat transfer. Single- and two-phase fluid mechanics. Steady-state and unsteady-state thermodynamic analysis.

EGMN 661. Computational Fluid Dynamics. 3 Hours.
Semester course; 3 lecture hours. 3 credits. Prerequisite: graduate standing in the School of Engineering, or permission of instructor. Teaches students how to perform two- and three-dimensional fluid flow and heat transfer analyses. Students will be able to understand and use most of the commercial flow analyses applied in industry today.

EGMN 662. Advanced Turbomachinery Systems. 3 Hours.
Semester course; 3 lecture hours. 3 credits. Enrollment restricted to students with graduate standing in the School of Engineering or with permission of instructor. Teaches students the principles used in analyzing/designing compressors and turbines. Students will be expected to design a gas turbine to meet specific mission requirements. Upon completion of the course, students will be able to understand the design systems and techniques used in the aeropropulsion and gas turbine industries.

EGMN 663. Viscous Flows. 3 Hours.
Semester course; 3 lecture hours. 3 credits. Enrollment restricted to students with graduate standing in the School of Engineering or with permission of instructor. Designed to introduce graduate students to the fundamentals and the theoretical underpinnings of viscous fluid flows. An extensive project will be included as part of this class.

EGMN 664. Advanced Fluid Mechanics. 3 Hours.
Semester course; 3 lecture hours. 3 credits. Prerequisite: graduate standing in the School of Engineering or permission of instructor. Covers the principles necessary to analyze viscous flow. Students learn how to formulate solutions to general viscous flow problems.

EGMN 665. Advanced Biofluid Mechanics. 3 Hours.
Semester course; 3 lecture hours. 3 credits. Enrollment restricted to students with graduate standing in the School of Engineering or with permission of instructor. Emphasizes the application of fluid mechanics to understand the properties of biological materials pertaining to the human body. This objective will be achieved through the application of fundamental laws (mass, momentum and energy) that govern fluid mechanics. Emphasis will be on respiratory flow dynamics, biofluid measurement techniques, steady and unsteady blood flow, flow through biodevices, turbulence, and mass transport with physiologic boundary conditions.

EGMN 680. Advanced Flow Control. 3 Hours.
Semester course; 3 lecture hours. 3 credits. Enrollment restricted to students with graduate standing in the School of Engineering or with permission of instructor. In-depth passive, active and reactive flow-management strategies to achieve transition delay/advance, separation control, mixing augmentation, drag reduction, lift enhancement and noise suppression. Unified framework and theoretical underpinnings of flow control. Futuristic reactive control methods using MEMS devices, soft computing and dynamical systems theory. An extensive project will be included as part of this class. Not open to undergraduate students. Mechanical engineering students may use EGRM 580 or EGRM 680 (but not both) to meet the requirements for the M.S. and/or Ph.D. degrees. Students cannot receive credit for both EGRM 580 and EGRM 680.

EGMN 690. Mechanical and Nuclear Engineering Seminar. 1 Hour.
Semester course; 1 lecture hour. 1 credit. Enrollment restricted to students with graduate standing. Mechanical engineering graduate students will attend a weekly one-hour research seminar. The topic and speaker will change each week in order to cover a broad range of subjects at the forefront of mechanical engineering research. The objective is to expose students to research topics and scholars in the field of mechanical engineering. Graded as satisfactory/unsatisfactory.

EGMN 691. Special Topics in Engineering. 1-4 Hours.
Semester course; 1-4 lecture hours. 1-4 credits. An advanced study of selected topic(s) in engineering. See the Schedule of Classes for specific topics to be offered each semester.

EGMN 692. Independent Study. 1-3 Hours.
Semester course; 1-3 lecture and 1-3 laboratory hours. 1-3 credits. Prerequisites: graduate standing and consent of instructor. The student must identify a faculty member willing to supervise the course and submit a proposal for approval to the appropriate track's graduate committee. Investigation of specialized engineering problems through literature search, mathematical analysis, computer simulation and/or experimentation. Written and oral reports, final report and examination are required.

EGMN 697. Directed Research in Mechanical and Nuclear Engineering. 1-15 Hours.
Semester course; variable hours. 1-15 credits. Prerequisite: graduate standing or permission of instructor. Research directed toward completion of the requirements for the M.S. or Ph.D. in Mechanical Engineering, under the direction of a mechanical engineering faculty member and advisory committee. Graded S/U/F.

EGRM 690. Mechanical Engineering Seminar. 1 Hour.
Semester course; 1 lecture hour. 1 credit. Prerequisite: graduate standing. Mechanical engineering graduate students will attend a weekly one-hour research seminar. The topic and speaker will change each week in order to cover a broad range of subjects at the forefront of mechanical engineering research. The objective is to expose students to research topics and scholars in the field of mechanical engineering.