MECHANICAL ENGINEERING, BACHELOR OF SCIENCE (B.S.) WITH A CONCENTRATION IN NUCLEAR ENGINEERING

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, mechanical engineers design and analyze the energy sources that provide power to machines, fluids that interact with machines and the materials from which machines are constructed. Mechanical engineers also work in cutting-edge fields such as nanotechnology, alternative energy sources and environmentally friendly "green" manufacturing processes. Another important application of mechanical engineering is in medicine, where artificial organs, surgical tools and drug-delivery systems are vital to human well-being.

Mechanical engineers are in continuous demand by virtually all industries and are also employed by state and federal governments and enjoy one of the highest starting salaries of all college majors. Mechanical engineering graduates can, if they wish, continue their studies and obtain advanced degrees in fields such as business, law, medicine and engineering.

The VCU Department of Mechanical and Nuclear Engineering is the largest in the College of Engineering and offers an accredited B.S. degree in mechanical engineering, including the option of obtaining a major concentration nuclear engineering. The curriculum for the freshman year is the same with or without the nuclear concentration.

As part of the B.S. degree in mechanical engineering, all students complete an approved internship or cooperative education experience.

Learning outcomes

Upon completing this program, students will know and know how to do the following:

a. Apply knowledge of mathematics, science and engineering
b. Design and conduct experiments, as well as to analyze and interpret data
c. Design a system, component or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability and sustainability
d. Function on multidisciplinary teams
e. Identify, formulate and solve engineering problems
f. Gain an understanding of professional and ethical responsibility
g. Communicate effectively
h. Complete the broad education necessary to understand the impact of engineering solutions in a global, economic, environmental and societal context
i. Recognize the need for, and an ability to engage in, lifelong learning
j. Gain knowledge of contemporary issues
k. Use the techniques, skills and modern engineering tools necessary for engineering practice

Special requirements

Students must earn a minimum grade of C in all required engineering courses; in all courses used to satisfy nuclear engineering elective requirements; and in the following:

Course	Title	Hours
MATH 200	Calculus with Analytic Geometry I	4
MATH 201	Calculus with Analytic Geometry II	4
MATH 301	Differential Equations	3
MATH 307	Multivariate Calculus	4
PHYS 207	University Physics I	5

Students must maintain a minimum major GPA of 2.0.

Degree requirements for Mechanical Engineering, Bachelor of Science (B.S.) with a concentration in nuclear engineering

General Education requirements

Course	Title	Hours
University Core Education Curriculum		
UNIV 111 Play course video for Focused Inquiry I	Focused Inquiry I	3
UNIV 112 Play course video for Focused Inquiry II	Focused Inquiry II	3
UNIV 200	Inquiry and the Craft of Argument	3
Approved humanities/fine arts		3
Approved natural/physical sciences		3-4
Approved quantitative literacy		3-4
Approved social/behavioral sciences		3-4
Total Hours		21-24

Course	Title	Hours
Additional General Education requirements		
CHEM 101 & CHEZ 101	General Chemistry I and General Chemistry Laboratory I	4
MATH 201	Calculus with Analytic Geometry II	4
MGMT 310	Managing People in Organizations	3
Total Hours		11

Collateral requirements

Course	Title	Hours
MATH 200	Calculus with Analytic Geometry I (satisfies quantitative literacy)	4
MATH 301	Differential Equations	3
MATH 307	Multivariate Calculus	4
PHIL 201	Critical Thinking About Moral Problems (satisfies humanities/fine arts)	3
PHYS 207	University Physics I	5

PHYS 208	University Physics II	5
Total Hours		17

Major requirements

Course	Title	Hours
EGMN 102	Engineering Statics	3
EGMN 103	Mechanical and Nuclear Engineering Practicum I	1
EGMN 190	Introduction to Mechanical and Nuclear Engineering	1
EGMN 201	Dynamics and Kinematics	3
EGMN 202	Mechanics of Deformables	3
EGMN 203	Mechanical and Nuclear Engineering Practicum II	1
EGMN 204	Thermodynamics	3
EGMN 215	Engineering Visualization and Computation	3
EGMN 300	Mechanical Systems Design	3
EGMN 301	Fluid Mechanics	3
EGMN 302	Heat Transfer	3
EGMN 303	Thermal Systems Design	3
EGMN 309	Material Science for Engineers	3
EGMN 311	Solid Mechanics Lab	1.5
EGMN 312	Thermal Sciences Lab	1.5
EGMN 315	Process and Systems Dynamics	3
EGMN 321	Numerical Methods	3
EGMN 351	Nuclear Engineering Fundamentals	3
EGMN 352	Nuclear Reactor Theory	3
EGMN 355	Radiation Safety and Shielding	3
EGMN 402	Senior Design Studio (Laboratory/ Project Time)	2
EGMN 403	Senior Design Studio (Laboratory/ Project Time)	2
EGMN 420	CAE Design	3
EGMN 453	Economics of Nuclear Power Production	3
EGMN 455	Nuclear Power Plants	3
EGMN 456	Reactor Design and Systems	3
EGRE 206	Electric Circuits	4
ENGR 395	Professional Development	1
ENGR 402	Senior Design Studio (Seminar)	1
ENGR 403	Senior Design Studio (Seminar) (Seminar)	1
Approved internship or cooperative education experience		0
ENGR 296	Part-time Internship Experience	
or ENGR 396	Internship Experience	
or ENGR 398	Cooperative Education Experience	
Review of internship or cooperative education experience		0
ENGR 496	Internship Review	0
or ENGR 498	Review of Cooperative Education Experience	
Nuclear engineering electives		6
Total Hours		80

The minimum total of credit hours required for this degree is 130.

Nuclear engineering electives

Mechanical engineering students completing the nuclear engineering concentration will choose two nuclear engineering elective courses from the following list. A special topic, independent study or other course may be used as a nuclear engineering elective with prior written approval of the department chair.

Course	Title	Hours
EGMN 510	Probabilistic Risk Assessment	3
EGMN 530	System Analysis of the Nuclear Fuel Cycle	3
EGMN 545	Energy Conversion Systems	3
EGMN 550	Energy and Sustainability	3
EGMN 560	Monte Carlo Simulations	3
EGMN 574	Nuclear Safeguards, Security and Nonproliferation	3
EGMN 575	Fast Breeder Reactors	3

All courses used to satisfy nuclear engineering elective requirements must be completed with a minimum grade of C.

Courses taken at other institutions

Students enrolled in degree programs at VCU must receive prior approval to take courses at other institutions to ensure credits earned concurrently at another institution are accepted for transfer at VCU. After enrolling in the VCU undergraduate mechanical engineering program, a student must receive prior approval to complete any course at another institution, and the following policies apply.

1. A student will not be approved to take an EGMN-equivalent course at another institution in a semester when the VCU course is offered. The department chair may approve an exception to this policy in extraordinary circumstances.
2. A total of no more than two EGMN-equivalent courses can be taken at another institution after enrolling in the VCU mechanical engineering program. The department chair may approve additional courses in exceptional circumstances.
3. A student may not transfer an EGMN-equivalent course from another institution for an EGMN course in which the student has a VCU honor code violation. The department chair may approve an exception to this policy in extraordinary circumstances.
4. Courses other than EGMN-equivalent courses (EGRE, MATH, PHYS, etc.) may be approved to be taken outside of VCU if the student receives prior approval for each course using the appropriate VCU form.

What follows is a sample plan that meets the prescribed requirements within a four-year course of study at VCU. Please contact your adviser before beginning course work toward a degree.

Freshman year

Fall semester		Hours
CHEM 101 & CHEZ 101	General Chemistry I and General Chemistry Laboratory I	4
EGMN 103	Mechanical and Nuclear Engineering Practicum I	1
EGMN 190	Introduction to Mechanical and Nuclear Engineering	1

MATH 200	Calculus with Analytic Geometry I (satisfies quantitative literacy)	4
UNIV 111 Play course video for Focused Inquiry I	Focused Inquiry I	3
Approved social/behavioral sciences		3
	Term Hours:	16
Spring semester		
EGMN 203	Mechanical and Nuclear Engineering Practicum II	1
EGMN 215	Engineering Visualization and Computation	3
MATH 201	Calculus with Analytic Geometry II	4
PHYS 207	University Physics I	5
UNIV 112 Play course video for Focused Inquiry II	Focused Inquiry II	3
	Term Hours:	16
Sophomore year		
Fall semester		
EGMN 102	Engineering Statics	3
EGMN 351	Nuclear Engineering Fundamentals	3
ENGR 395	Professional Development	1
MATH 301	Differential Equations	3
PHYS 208	University Physics II	5
UNIV 200	Inquiry and the Craft of Argument	3
	Term Hours:	18
Spring semester		
EGMN 201	Dynamics and Kinematics	3
EGMN 202	Mechanics of Deformables	3
EGMN 204	Thermodynamics	3
EGMN 352	Nuclear Reactor Theory	3
MATH 307	Multivariate Calculus	4
	Term Hours:	16
Junior year		
Fall semester		
EGMN 300	Mechanical Systems Design	3
EGMN 301	Fluid Mechanics	3
EGMN 311	Solid Mechanics Lab	1.5
EGMN 321	Numerical Methods	3
EGMN 355	Radiation Safety and Shielding	3
EGMN 420	CAE Design	3
	Term Hours:	16.5
Spring semester		
EGMN 302	Heat Transfer	3
EGMN 303	Thermal Systems Design	3
EGMN 312	Thermal Sciences Lab	1.5
EGMN 455	Nuclear Power Plants	3
EGRE 206	Electric Circuits	4
Nuclear engineering elective		3
	Term Hours:	17.5
Summer semester		
ENGR 396	Internship Experience	0
	Term Hours:	0
Senior year		
Fall semester		
EGMN 309	Material Science for Engineers	3
EGMN 402	Senior Design Studio (Laboratory/Project Time)	2
EGMN 453	Economics of Nuclear Power Production	3
EGMN 456	Reactor Design and Systems	3
ENGR 402	Senior Design Studio (Seminar) (Seminar)	1
ENGR 496	Internship Review	0
PHIL 201	Critical Thinking About Moral Problems (satisfies humanities/fine arts)	3
	Term Hours:	15
Spring semester		
EGMN 315	Process and Systems Dynamics	3
EGMN 403	Senior Design Studio (Laboratory/Project Time)	2
ENGR 403	Senior Design Studio (Seminar) (Seminar)	1
MGMT 310	Managing People in Organizations	3
Approved natural/physical sciences		3
Nuclear engineering elective		3
	Term Hours:	15
	Total Hours:	130

The minimum total of credit hours required for this degree is 130.

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Mechanical and nuclear engineering

EGMN 102. Engineering Statics. 3 Hours.
Semester course; 3 lecture hours. 3 credits. Prerequisite: MATH 200 with a minimum grade of C or permission of instructor. Corequisite: PHYS 207 or permission of instructor. The theory and application of engineering mechanics applied to the design and analysis of rigid structures. Equilibrium of two- and three-dimensional bodies. The study of forces and their effects. Applications to engineering systems.

EGMN 103. Mechanical and Nuclear Engineering Practicum I. 1 Hour.
Semester course; 3 laboratory hours. 1 credit. Students will perform a sequence of laboratory modules designed to provide practical hands-on exposure to important topics, equipment and experimental methods in mechanical and nuclear engineering. Topics covered include communication, optimization, reverse engineering, mechanics, thermodynamics and electric circuits.

EGMN 190. Introduction to Mechanical and Nuclear Engineering. 1 Hour.
Semester course; 1 lecture hour. 1 credit. The course will introduce students to the engineering profession, present basic mechanical and nuclear engineering concepts and include seminars presented by alumni, industry and experts in their fields.

EGMN 201. Dynamics and Kinematics. 3 Hours.
Semester course; 3 lecture hours. 3 credits. Prerequisites: PHYS 207, EGMN 102 and MATH 201, with a minimum grade of C in each, or permission of the instructor. Kinematics and kinetics of particles. Kinematics of rigid bodies; translation and fixed-axis rotation relative to translating axes, general planar motion, fixed-point rotation and general motion. Kinetics of rigid bodies: center of mass, mass moment of inertia, product of inertia, principal-axes, parallelaxes theorems. Planar motion, work-energy method. Design of cams, gears and linkages.

EGMN 202. Mechanics of Deformables. 3 Hours.
Semester course; 3 lecture hours. 3 credits. Prerequisites: EGMN 102 and MATH 201, with a minimum grade of C in both, or permission of the instructor. An introductory course covering the mechanics of deformable solids. Subjects include stress, strain and constitutive relations; bending of beams; torsion; shearing; deflection of beams; column buckling; fatigue; failure theory; analysis and design of bar-type members.

EGMN 203. Mechanical and Nuclear Engineering Practicum II. 1 Hour.
Semester course; 3 laboratory hours. 1 credit. Students will perform a sequence of laboratory modules designed to provide practical hands-on exposure to important topics, equipment and experimental methods in mechanical and nuclear engineering. Topics covered include additive manufacturing, radiation detection and measurement, radiation shielding, data acquisition and computer interfacing, coding for instrumentation control.

EGMN 204. Thermodynamics. 3 Hours.
Semester course; 3 lecture hours. 3 credits. Prerequisites: PHYS 207 and MATH 201 with a minimum grade of C in both, or permission of the instructor. Fundamental concepts of thermodynamics; first and second law of thermodynamics; entropy and equilibrium; equations of state; properties of pure fluids; molecular interpretation of thermodynamic properties; phase equilibria; work and heat; power cycles; chemical reactions.

EGMN 215. Engineering Visualization and Computation. 3 Hours.
Semester course; 2 lecture and 2 laboratory hours. 3 credits. Enrollment restricted to mechanical engineering majors or with permission of the instructor. Programming in Excel and MATLAB will be introduced. The creation and interpretation of graphical communication for engineering students. Two- and three-dimensional part and assembly representations. Dimensioning and tolerancing as a link between design and manufacturing. An introduction to solid modeling and virtual prototyping. The course will impart proficiency in computer and graphical applications of fundamental and practical importance to engineering students.

EGMN 300. Mechanical Systems Design. 3 Hours.
Semester course; 3 lecture hours. 3 credits. Prerequisites: EGMN 201 and EGMN 202, with a minimum grade of C in both, or permission of the instructor. Basic principles of applied mechanics and materials employed for the design of machine elements and mechanical systems; state of stress, deformation and failure criterion is applied to bearings, brakes, clutches, belt drives, gears, chains, springs, gear trains, power screws and transmissions.

EGMN 301. Fluid Mechanics. 3 Hours.
Semester course; 3 lecture hours. 3 credits. Prerequisites: PHYS 207 and EGMN 204, with a minimum grade of C in each, or permission of instructor. Corequisite: MATH 301 or permission of instructor. Basic and applied fluid mechanics; fluid properties; application of Bernoulli and Navier-Stokes equations; macroscopic mass, momentum and energy balances; dimensional analysis; laminar and turbulent flow; boundary layer theory; friction factors in pipes and packed beds; drag coefficients; compressible flow; flow measurements; numerical simulation; applications to the operation and design of turbo machinery.

EGMN 302. Heat Transfer. 3 Hours.
Semester course; 3 lecture hours. 3 credits. Prerequisites: EGMN 204 and EGMN 301, MATH 301 and MATH 307, with a minimum grade of C in each, or permission of instructor. This course includes an overview of the basic modes of heat transfer: conduction, convection and radiation. It provides an in-depth discussion of transient and steady-state heat conduction in one-, two- and three-dimensional space, and both analytical and numerical approaches are discussed. Additional concepts include free and forced convection in external and internal flow configurations.

EGMN 303. Thermal Systems Design. 3 Hours.
Semester course; 3 lecture hours. 3 credits. Prerequisites: MATH 301, EGMN 204 and EGMN 301, with a minimum grade of C in each, or permission of the instructor. Fundamentals of heat transfer, thermodynamics and fluid mechanics applied to the analysis, design, selection and application of energy conversion systems.

EGMN 305. Sensors/Measurements. 3 Hours.
Semester course; 3 lecture hours. 3 credits. Prerequisites: MATH 301 with a minimum grade of C, PHYS 208 and STAT 541; or permission of instructor. Introduction to sensors and their utilization for measurement and control; sensor types: electromechanical, electro-optical, electro-chemical; applications in medicine, chemical manufacturing, mechanical control and optical inspection.

EGMN 309. Material Science for Engineers. 3 Hours.
Semester course; 3 lecture hours. 3 credits. Prerequisite: CHEM 101 or permission of instructor. The study of materials from a microscopic or atomic level. Consideration of mechanical, electrical, thermal, magnetic and optical properties of metals, ceramics, polymers and composites. Thermal processing for modification of properties, dislocation and phase transformation. Material selection for design with consideration of economic, environmental and societal issues.

EGMN 311. Solid Mechanics Lab. 1.5 Hour.
Semester course; 0.5 lecture and 3 laboratory hours. 1.5 credits. Prerequisites: EGMN 201, EGMN 202 and UNIV 200, all with a minimum grade of C, or permission of the instructor. Experiments will be conducted on fundamental principles of solid mechanics, materials and dynamics. Topics covered include testing of materials for tensile, compression, bending and torsional loads, vibrations and material microstructure.

EGMN 312. Thermal Sciences Lab. 1.5 Hour.
Semester course; 0.5 lecture and 3 laboratory hours. 1.5 credits. Prerequisites: EGMN 301 and UNIV 200, each with a minimum grade of C, or permission of the instructor. Experiments will be conducted on fundamental principles of fluid mechanics, thermodynamics and heat transfer. Topics covered include hydrostatics, Bernoulli equation, impact jets, aerodynamic force, heat pump thermodynamics cycles, heat exchangers and convection heat transfer.

EGMN 315. Process and Systems Dynamics. 3 Hours.
Semester course; 3 lecture hours. 3 credits. Prerequisites: MATH 301, EGRE 206, EGMN 201 and PHYS 207, all with a minimum grade of C; or permission of instructor. Undergraduate course covering the analysis of chemical, fluid, mechanical and electrical dynamic systems. Pedagogically, a single approach is taught that applies to any of the systems in any of these disciplines using conservation equations and constitutive relationships to build the systems of differential equations needed for the analysis. The mathematical structures of the types of differential equations typically generated in dynamic physical systems are reviewed and both analytical and numerical solution techniques are taught. Finally, the tools used to develop control components for systems in these areas are covered along with the mathematical tools (e.g., Laplace transforms) needed for their analysis.

EGMN 321. Numerical Methods. 3 Hours.
Semester course; 3 lecture hours. 3 credits. Prerequisites: MATH 301 and EGMN 215, with a minimum grade of C in both, or permission of instructor. A study of numerical algorithms used in error analysis, computing roots of equations, solving linear algebraic equations, curve fitting, numerical differentiation and integration, numerical methods for ordinary differential equations and a brief introduction to numerical methods for partial differential equations. The course content is tailored for mechanical engineering applications.

EGMN 351. Nuclear Engineering Fundamentals. 3 Hours.
Semester course; 3 lecture hours. 3 credits. Restricted to mechanical engineering majors. Prerequisite: MATH 200 with a minimum grade of C or permission of the instructor. An introductory course to familiarize students with the concepts, systems and application of nuclear energy. Topics include radioactivity, fission, fusion, reactor concepts, biological effects of radiation, nuclear propulsion and radioactive waste disposal. Designed to provide students with a broad perspective of nuclear engineering.

EGMN 352. Nuclear Reactor Theory. 3 Hours.
Semester course; 3 lecture hours. 3 credits. Prerequisite: EGMN 351 with a minimum grade of C or permission of instructor. Corequisite: MATH 301 or permission of instructor. This course introduces the fundamental properties of the neutron, the reactions induced by neutrons, nuclear fission, the slowing down of neutrons in infinite and finite media, diffusion theory, the 1-group or 2-group approximation, point kinetics, and fission-product poisoning. Provides students with the nuclear reactor theory foundation necessary for reactor design and reactor engineering problems.

EGMN 355. Radiation Safety and Shielding. 3 Hours.
Semester course; 2 lecture and 3 laboratory hours. 3 credits. Prerequisite: EGMN 352 with a minimum grade of C, or permission of instructor. Fundamentals of radiation safety and shielding with focus on sources of radioactivity, interaction of radiation with matter, biological effects of radiation, dosimetry, attenuation of gamma rays and neutrons and effectiveness of shielding methods.

EGMN 356. Nuclear Instrumentation and Measurements. 3 Hours.
Semester course; 6 laboratory hours. 3 credits. Prerequisite: EGMN 355 with a minimum grade of C or permission of instructor. Provides an in-depth study of radiation detection systems. Students will understand both the practical operation of detection systems as well as the physical processes involved in radiation detection, attenuation and shielding.

EGMN 401. Mechanical Engineering Leadership. 3 Hours.
Semester course; 9 laboratory hours. 3 credits. Enrollment restricted to students with junior or senior standing in mechanical engineering and permission of the instructor. Senior/junior students will serve as lab teaching assistants in EGMN 103, EGMN 203, EGMN 215, EGMN 311 or EGMN 312. Leadership skills will be honed as the senior/junior students guide, lead and supervise other students as they complete hands-on learning modules and/or design, conduct, analyze and report on experiments in one of these lab courses.

EGMN 402. Senior Design Studio (Laboratory/Project Time). 2 Hours.
Semester course; 6 laboratory hours. 2 credits. Prerequisite: five courses from EGMN 300, 301, 302, 303, 315, 321, 355, 416, 420, 421 and 455; and two courses from EGMN 300, 303 and 420. All prerequisite courses must be completed with minimum grades of C. Enrollment restricted to students with senior standing participating in a senior design (capstone) project. A minimum of six laboratory hours per week dedicated to the execution phase of the senior design (capstone) project, which should meet appropriate engineering standards and multiple realistic constraints. Tasks include team meetings, brainstorming, sponsor advising, designing, fabrications, assembling, reviewing, studying, researching, testing and validating projects.

EGMN 403. Senior Design Studio (Laboratory/Project Time). 2 Hours.
Continuous course; 6 laboratory hours. 2 credits. Prerequisite: senior standing and participation in a senior design (capstone) project; EGMN 402. A minimum of six laboratory hours per week dedicated to continuing the execution phase of the senior design (capstone) project, which should meet appropriate engineering standards and multiple realistic constraints. Tasks include team meetings, brainstorming, sponsor advising, designing, fabrications, assembling, reviewing, studying, researching, testing and validating projects.

EGMN 416. Mechatronics. 3 Hours.
Semester course; 2 lecture and 3 laboratory hours. 3 credits. Prerequisite: EGRE 206 with a minimum grade of C, or permission of instructor. Lecture materials and laboratory experiments focus on the fundamentals of design-oriented mechanical, electrical and computer systems integration. Specifically, students learn analog and digital electronic design, data acquisition, transducers, actuator technologies and control, design with microprocessors and embedded electronics, and application of control theory.

EGMN 420. CAE Design. 3 Hours.
Semester course; 3 lecture hours. 3 credits. Prerequisites: EGMN 201 and EGMN 215, with a minimum grade of C in both, or permission of instructor. Review of geometric modeling, engineering visualization tools applicable to engineering design. Develop visual thinking and communication skills with assistance of computer modeling tools. Emphasis placed on creative design, application of physical laws, and hands-on virtual or physical projects. Topics include review of kinematics/dynamics of commonly used planar mechanisms and programming techniques for motion simulation. Interdisciplinary projects will be assigned to assess students' design knowledge.

EGMN 421. CAE Analysis. 3 Hours.
Semester course; 2 lecture and 2 laboratory hours. 3 credits. Prerequisites: EGMN 202 and EGMN 215; and MATH 301 and MATH 307, all with a minimum grade of C, or permission of the instructor. Application of computer-aided techniques to the analysis of engineering problems utilizing linear algebra, computer calculations of matrices and numerical solution of governing differential equilibrium equations common to all fields of engineering. Students will be exposed to formulations of finite element methods of analysis. Emphasis is placed on practical aspects of structural FE modeling. Analysis programs such as ANSYS, MSC/PATRAN, MSC/NASTRAN and/or MATLAB are utilized.

EGMN 422. Design and Additive Manufacturing. 3 Hours.
Semester course; 3 lecture hours. 3 credits. Prerequisites: EGMN 420 or permission of the instructor. Design and additive manufacturing is the use of layer-based processes for producing parts directly from computer-aided design models without part-specific tooling. In this course students will learn about various AM technologies focusing upon their potential to support rapid prototyping and manufacturing processes coupled with the important research challenges associated with AM. This course will expand students' knowledge in design and applied engineering as they model, fabricate, test, discuss and iterate upon mechanical 3D objects they design throughout the semester.

EGMN 425. Introduction to Manufacturing Systems. 3 Hours.
Semester course; 3 lecture hours. 3 credits. Prerequisite: senior standing in the School of Engineering or permission of the instructor. Basic principles of systems analysis and modeling applied to manufacturing processes and operations; numerical control, programmable controllers, flexible manufacturing systems, group technology, process planning and control, modeling and simulation of factory operations.

EGMN 426. Manufacturing Processes. 3 Hours.
Semester course; 3 lecture hours. 3 credits. Prerequisite: senior standing in the School of Engineering or permission of the instructor. Introduction to the operation and design of metal fabrication processes; analysis of metal casting, extrusion, rolling, forging, wire and rod drawing; review of metal removal and joining methods; economic and business considerations.

EGMN 427. Robotics. 3 Hours.
Semester course; 3 lecture hours. 3 credits. Prerequisite: senior standing in the School of Engineering or permission of the instructor. Introduction to the state-of-the-art and technology of robotics and its applications for productivity gain in industry.

EGMN 428. Polymer Processing. 3 Hours.
Semester course; 3 lecture hours. 3 credits. Prerequisites: ENGR 301 and 302, with a minimum grade of C in both, or permission of the instructor. Basic principles of momentum and heat transfer applied to the analysis of polymer processing operations; introduction to polymer rheology; operation and design aspects of extruders, blown film, injection molding, thermoforming and compression molding machinery.

EGMN 435. Design for Manufacturing and Assembly. 3 Hours.
Semester course; 3 lecture hours. 3 credits. Prerequisite: senior standing in the School of Engineering or permission of the instructor. Methodologies used in the synthesis and analysis of product design in order to optimize manufacturing and assembly; relationship of design to the production processes, materials handling, assembly, finishing, quality and costs with emphasis on both formed and assembled products.

EGMN 436. Engineering Materials. 3 Hours.
Semester course; 3 lecture hours. 3 credits. Prerequisite: senior standing in the School of Engineering or permission of the instructor. Materials properties and their modification as related to engineering properties and design; elastic and plastic stress-strain behavior of materials along with diffusion in solids, phase equilibria, and phase transformations; materials selection considerations include design, fabrication, mechanical failure, corrosion, service stability as well as compatibility and function in the human body.

EGMN 437. Principles of Polymer Engineering. 3 Hours.
Semester course; 3 lecture and 1 laboratory hours. 3 credits. Prerequisites: EGMN 202 with a minimum grade of C, or permission of the instructor. Basic principles of mechanics applied to the mechanical design and fabrication of polymers; introduction to polymer structure, rubber elasticity, and viscoelasticity; mechanical properties, plastic part design and plastic materials selection; fabrication processes.

EGMN 450. Nuclear Reactor Control and Dynamics. 3 Hours.
Semester course; 3 lecture hours. 3 credits. Prerequisites: MATH 301, EGMN 201 and EGMN 455, with a minimum grade of C in each, or permission of instructor. An introduction to control theory and its applications for nuclear engineering students. Modeling and development of differential equations for nuclear systems. Analysis of nuclear reactor dynamics in the time and frequency domains. Application of feedback control techniques to reactor operation, stability and performance.

EGMN 451. Nuclear Safety and Security. 3 Hours.
Semester course; 3 lecture hours. 3 credits. Prerequisite: EGMN 455 with a minimum grade of C, or permission of the instructor. A study of technological risks and security issues related to nuclear power. Analysis of nuclear reactor system components and operational features that are relevant to safety; reactor containment; safety analysis of nuclear power plants using deterministic and probabilistic models; methods for human, environmental and ecological risk assessment; NRC regulations and procedures; safeguarding against natural (earthquake, tornadoes) and human (domestic and international) threats; classification and consequences of accidents including historical case studies.

EGMN 453. Economics of Nuclear Power Production. 3 Hours.
Semester course; 3 lecture hours. 3 credits. Prerequisite: EGMN 352 with a minimum grade of C or permission of instructor. Fundamentals of engineering economic analysis are applied to energy supply, demand, prices and production with specific emphasis on nuclear energy, the capital cost of nuclear power plants, the nuclear fuel cycle and associated energy technologies.

EGMN 455. Nuclear Power Plants. 3 Hours.
Semester course; 3 lecture hours. 3 credits. Prerequisites: EGMN 204 and EGMN 352, each with a minimum grade of C, or permission of instructor. Design and analysis of nuclear power plants. Review of thermodynamic cycles and reactor types; analysis of the coupling of the reactor and the power plant; thermal and mechanical design of steam turbines; turbogenerators; auxiliary systems; design synthesis and heat balance calculations; operation of nuclear reactors.

EGMN 456. Reactor Design and Systems. 3 Hours.
Semester course; 3 lecture hours. 3 credits. Prerequisites: EGMN 302, 303 and 455, each with a minimum grade of C, or permission of instructor. Engineering principles of nuclear reactors, emphasizing power reactors. Specific topics include power plant thermodynamics, reactor heat generation and removal (single-phase as well as two-phase coolant flow and heat transfer), and structural mechanics. The course also covers engineering considerations in reactor design.

EGMN 491. Special Topics in Engineering. 1-5 Hours.
Semester course; variable hours. 1-5 credits. May be repeated with different content. Prerequisite: determined by the instructor. Specialized topics in engineering designed to provide a topic not covered by an existing course or program. General engineering or multidisciplinary. See the Schedule of Classes for specific topics to be offered each semester and prerequisites.

EGMN 492. Independent Study in Engineering. 1-5 Hours.
Semester course; variable hours. 1-5 credits. May be repeated with different content. Enrollment requires permission of the instructor. Students must submit a written proposal to be approved by the supervising instructor prior to registration. Investigation of specialized engineering problems that are multidisciplinary or of general interest through literature search, mathematical analysis, computer simulation and/or laboratory experimentation. Written and oral progress reports as well as a final report and presentation are required.

Engineering

ENGR 100. Engineering Student Success. 0 Hours.
Semester course; seminar hours. 0 credits. Enrollment is restricted to new first-year students in the School of Engineering; required for students admitted conditionally. Students will meet for a 90-minute class once per week for five weeks. The course is dedicated to helping students understand the expectations and responsibilities of being a college student. Presentations will center on planning the semester, academic professionalism, study skills and test-taking strategies, financial literacy, health and wellness, time management, and the Honor Code. Seminars will be supplemented throughout the semester with online assignments to reinforce the discussions. Graded as pass/fail.

ENGR 101. Introduction to Engineering. 4 Hours.
Semester course; 3 lecture and 3 laboratory hours. 4 credits. Prerequisites: admission to the School of Engineering or permission of instructor. Introduces basic circuits including resistors, diodes, transistors, digital gates and motors. Simple electromechanical systems are considered including motors, gears and wheels. The laboratory introduces fundamental circuit testing and measurement, and proper laboratory notebook writing; students are required to analyze, build and test a digitally controlled robot.

ENGR 111. Innovation Shop Training I. 0.5 Hours.
Semester course; 1 laboratory hour. 0.5 credits. Enrollment restricted to students in the School of Engineering. The course provides training on innovation shop safety, includes a tour of the shop, measuring and layout tools and techniques, use of general manual and powered hand tools. Students will be instructed on the use of a bench-top drill press, deburring and finishing tools, 3D printing, laser engraving and thermoforming equipment. Students need to achieve a minimum score of 76% in the class to attain Level I (Blue) certification. Only certified students have permission to use tools and equipment covered in this training. Graded as Pass/Fail.

ENGR 121. Engineering Fundamentals. 3 Hours.
Semester course; 3 lecture hours. 3 credits. Prerequisite: permission of instructor. Open only to non-engineering majors in Certificate in Product Innovation program. Introduces engineering fundamentals to students from non-engineering disciplines. Particular focus is the engineering problem-solving process as applied to open-ended problems. Students will be introduced to the different types of engineering, examine engineering issues and apply the engineering problem-solving process.

ENGR 211. Innovation Shop Training II. 1 Hour.
Semester course; 2 laboratory hours. 1 credit. Prerequisite: ENGR 111. Enrollment restricted to students in the School of Engineering. The course provides training on machine/innovation shop safety, blueprint reading, measuring and layout tools and techniques, and use of general and powered hand tools. Students will be instructed on sawing, sanding, drilling and tapping operations, 3D printing and laser engraving/cutting equipment. Hands-on graded assignment is the part of the course.

ENGR 291. Special Topics in Engineering. 1-5 Hours.
Semester course; variable hours. 1-5 credits. Prerequisite: to be determined by the instructor. Specialized topics in engineering designed to provide a topic not covered by an existing course or program. General engineering or multidisciplinary. May be repeated with different content. Graded as pass/fail or normal letter grading at the option of the instructor. See the Schedule of Classes for specific topics to be offered each semester and prerequisites.

ENGR 296. Part-time Internship Experience. 0 Hours.
Semester course; 0 credit. Students may attempt this course a total of six times. Enrollment restricted to School of Engineering majors. The student works part time in an approved internship and must work a minimum of 90 hours, but less than 300 hours during the semester. The student works to meet learning objectives while gaining practical experience relevant to their major. The student completes assignments to document, assess and reflect on their learning experience. The supervisor and student both complete evaluations of the learning experience. Graded pass/fail.

ENGR 303. Junior Seminar. 3 Hours.
Semester course; 3 lecture hours. 3 credits. Prerequisite: permission of instructor. This course provides students an opportunity to explore business and leadership topics. Topics include the fundamentals of product design and new product development, manufacturing and quality systems, finances and financial reports, ethics in the workplace, intellectual property, teamwork, leadership and communications. Students will be assigned selected readings, written compositions and oral presentations. This course prepares the student to participate in the Engineering Laboratory/Manufacturing Internship.

ENGR 311. Innovation Shop Training III. 1 Hour.
Semester course; 2 laboratory hours. 1 credit. Prerequisite: ENGR 211. Enrollment is restricted to students with Level II (Red) certification. The Level III (Green) course provides basic training on set-up and operation of manual milling machines and the lathe. The course covers cutting tool, speed and feed calculation. Students must develop a technological process and machine metal parts per assigned drawings on vertical mill and lathe. They will also use other techniques and equipment that were covered in previous levels. Students need to achieve a minimum score of 76 % in the class to attain Level III (Green) certification. Only certified students have permission to use tools and equipment covered in this training.

ENGR 395. Professional Development. 1 Hour.
Semester course; 1 lecture and 1 workshop hour. 1 credit. Enrollment is restricted to majors in the School of Engineering. Professional development course to help prepare students to find a job and succeed in a professional environment, and specifically to work as an intern or in a cooperative education position. Topics covered include career paths; job searches; resume and cover letter writing; preparing for the interview; personal assessment of interests, values and strengths; networking; professional and ethical behavior on the job; overview of legal issues related to hiring, such as nondisclosure agreements and noncompete clauses; overview of personal finance management at the first job; workplace safety; and expectations and requirements for internships and cooperative education positions.

ENGR 396. Internship Experience. 0 Hours.
Semester course; 0 credit. Students may attempt this course a total of three times. Enrollment restricted to School of Engineering majors. The student works in an approved internship and must work a minimum of 300 hours during the semester. The student works to meet learning objectives while gaining practical experience relevant to their major. The student completes assignments to document, assess and reflect on their learning experience. The supervisor and student both complete evaluations of the learning experience. Graded pass/fail.

ENGR 398. Cooperative Education Experience. 0 Hours.
Semester course; 0 credits. Students may attempt this course a total of four times. Prerequisite: ENGR 395. Restricted to School of Engineering majors in good academic standing. The student works full-time in an approved cooperative education position. The student works to meet specific learning objectives while gaining practical experience relevant to their major. The student completes assignments to document, assess and reflect on their learning experience. The supervisor/mentor and student both complete midterm and final evaluations of the learning experience. Graded pass/fail.

ENGR 399. Cooperative Education Experience II. 3 Hours.
Semester course; 3 credits. Prerequisite: ENGR 398. Restricted to School of Engineering majors in good academic standing. A student that has completed at least one work term in a full-time approved cooperative education position completes an additional full-time work term. The student works to meet specific learning objectives while gaining practical experience relevant to their major. The student completes assignments to document, assess and reflect on their learning experience. The supervisor/mentor and student both complete midterm and final evaluations of the learning experience.

ENGR 402. Senior Design Studio (Seminar). 1 Hour.
Continuous courses; 1 lecture hour. 1-1 credit. Prerequisites: senior standing and participation in a senior design (capstone) project; completion of ENGR 402 to enroll in ENGR 403. This weekly seminar presents and discusses topics relevant to senior-level engineering students in support of the capstone project and upcoming graduation. A single course coordinator manages and administers the course and schedules the various faculty lectures and guest speakers. Topics include, but are not limited to, the following: proposal writing, project planning and management, scheduling resources and budgeting for technical projects, patents and intellectual property, quality systems (six sigma, ISO standards, statistical process control), entrepreneurship, creativity and innovation and professional registration.

ENGR 403. Senior Design Studio (Seminar). 1 Hour.
Continuous courses; 1 lecture hour. 1-1 credit. Prerequisites: senior standing and participation in a senior design (capstone) project; completion of ENGR 402 to enroll in ENGR 403. This weekly seminar presents and discusses topics relevant to senior-level engineering students in support of the capstone project and upcoming graduation. A single course coordinator manages and administers the course and schedules the various faculty lectures and guest speakers. Topics include, but are not limited to, the following: proposal writing, project planning and management, scheduling resources and budgeting for technical projects, patents and intellectual property, quality systems (six sigma, ISO standards, statistical process control), entrepreneurship, creativity and innovation and professional registration.

ENGR 410. Review of Internship. 1 Hour.
Semester course; 1 credit. Prerequisites: chemical, electrical and computer, or mechanical engineering major and experience to satisfy the engineering internship requirements. Students complete oral presentations and written reports summarizing the internship experience.

ENGR 411. Fundamentals of Engineering Exam Preparation. 1 Hour.
Semester course; 1 lecture hour. 1 credit. Prerequisite: senior or graduate standing, or permission of instructor. This course prepares students for taking the fundamentals of Engineering Exam. Passing the FE Exam is the first step to getting a Professional Engineering license. This course is not intended to teach the various subject matters, but to review the subject areas and help students prepare as well as possible for the examination.

ENGR 490. Engineering Seminar. 1-3 Hours.
Semester course; variable hours. 1-3 credits. May be repeated with different content. Prerequisite: permission of the instructor. A series of specialized topics in engineering that are of general interest but not covered by an existing course or program. Lectures will be presented in seminar format by speakers from business, industry, government and academia. Subjects will be multidisciplinary in nature. Graded as pass/fail or normal letter grading at the option of the instructor.

ENGR 491. Special Topics in Engineering. 1-5 Hours.
Semester course; variable hours. 1-5 credits. Prerequisite: determined by the instructor. Specialized topics in engineering designed to provide a topic not covered by an existing course or program. General engineering or multidisciplinary. May be repeated with different content. Graded as pass/fail or normal letter grading at the option of the instructor. See the Schedule of Classes for specific topics to be offered each semester and prerequisites.

ENGR 492. Independent Study in Engineering. 1-5 Hours.
Semester course; variable hours. 1-5 credits. May be repeated with different content. Prerequisite: permission of the instructor. Students must submit a written proposal to be approved by the supervising instructor prior to registration. Investigation of specialized engineering problems that are multidisciplinary or of general interest through literature search, mathematical analysis, computer simulation and/or laboratory experimentation. Written and oral progress reports as well as a final report and presentation are required. Graded as pass/fail or normal letter grading at the option of the instructor.

ENGR 496. Internship Review. 0 Hours.
Semester course; 0 credits. Prerequisite: ENGR 296 or ENGR 396. Restricted to School of Engineering majors. This course is to be taken following the completion of a minimum of 300 hours of approved internship experience relevant to the student's major and documents that a student has fulfilled all internship requirements, including a final evaluation by the employer, a final self-evaluation, a final report describing the experience and a final oral presentation about the experience. Graded pass/fail.

ENGR 497. Vertically Integrated Projects. 1,2 Hour.
Semester course; 3 or 6 laboratory hours. 1 or 2 credits. May be repeated for a maximum total of 8 credits Prerequisites: permission of the project faculty adviser. This course provides undergraduate students the opportunity to participate in multiyear, multidisciplinary projects under the guidance of faculty and graduate students in their areas of expertise. As they address research and development issues, students learn and practice many different professional skills, make substantial technical contributions to the project, and experience many different roles on a large, multidisciplinary design/discovery team. Students must earn a minimum of 4 credits in ENGR 497 with a minimum grade of C in order for these credits to be eligible to count toward a technical or departmental elective. More restrictive requirements may be imposed by individual departments.

ENGR 498. Review of Cooperative Education Experience. 0 Hours.
Semester course; 0 credits. Prerequisite: ENGR 398. Restricted to School of Engineering majors. This course is completed following the final work term of a cooperative education experience and is required to obtain transcript notation to document that a student has fulfilled all the requirements of the school's cooperative education program. The requirements include a final evaluation by the employer, a final self-evaluation, a final report describing the experience and a final oral presentation about the experience.