Opus College of Engineering

From the Dean

Opus College of Engineering website (http://www.marquette.edu/engineering/)

Welcome!

For over a century, the Opus College of Engineering at Marquette University has pursued excellence and leadership in engineering education, research, and service to others. To address today's global challenges and create a better world for the future, engineers must be grounded in engineering and science principles underpinned by a strong foundation in the humanities, ethics, leadership, and a desire for lifelong learning. The Opus College of Engineering strives to provide a student-centered, active learning environment, fostering curiosity, creativity, and a quest for discovery and innovation. We are recognized and renowned for our commitment to *cura personalis,* the Ignatian concept of "care for the whole person," as we seek to educate well-rounded servant leaders.

State-of-the-art engineering facilities allow students to explore and address global challenges in advanced manufacturing, clean water, health and human performance, secure and renewable energy, safe and efficient infrastructure, and many other important areas. Additionally, engineering students participate in a variety of valuable co-curricular opportunities, including co-ops, internships, undergraduate research, service-learning experiences, and more.

Join us as we strive to ignite curiosity and creativity for bold change!

Kristina M. Ropella, Ph.D.
Opus Dean, Opus College of Engineering

College Vision Statement

We are world-class engineers who will lead bold, innovative change to serve the world in the Jesuit tradition.

College Mission Statement

Our diverse community of engineering scholars collaborates in transformative learning environments to lead change for the benefit of humanity. We prepare students for fulfilling careers by providing a strong technical and ethical foundation.

We ignite curiosity, encourage student-centered learning and foster critical thinking by:

- Educating engineering leaders who thrive in innovative, entrepreneurial and dynamic environments.
- Exploring and discovering new knowledge, putting research in action.
- Engaging professional and technical communities worldwide.

These statements reflect the essential nature of the college. The motivation of the college centers about its desire to emphasize to the engineering community the intrinsic value of humankind and of the individuals who comprise it. This motivation flows directly from the fact that the college is an integral part of a Catholic, Jesuit university.

The Opus College of Engineering is a member of the American Society for Engineering Education.

College of Engineering Departments

- Biomedical Engineering (https://bulletin.marquette.edu/engineering/biomedical-engineering/)
- Civil, Construction and Environmental Engineering (https://bulletin.marquette.edu/engineering/civil-construction-environmental-engineering/)
- Electrical and Computer Engineering (https://bulletin.marquette.edu/engineering/electrical-computer-engineering/)
- Mechanical Engineering (https://bulletin.marquette.edu/engineering/mechanical-engineering/)

Undergraduate College Programs

- Biocomputing, BBE (https://bulletin.marquette.edu/engineering/biomedical-engineering/biocomputing-bs/)
- Bioelectronics, BBE (https://bulletin.marquette.edu/engineering/biomedical-engineering/bioelectronics-bs/)
- Biomechanics, BBE (https://bulletin.marquette.edu/engineering/biomedical-engineering/biomechanics-bs/)
- Biomedical Engineering, Minor (https://bulletin.marquette.edu/engineering/biomedical-engineering/biomedical-minor/)
- Civil Engineering, BCE (https://bulletin.marquette.edu/engineering/civil-construction-environmental-engineering/civil-engineering-bs/)
- Civil Engineering, Minor (https://bulletin.marquette.edu/engineering/civil-construction-environmental-engineering/civil-engineering-minor/)
- Computer Engineering, BCO (https://bulletin.marquette.edu/engineering/electrical-computer-engineering/comptuer-engineering-bs/)

- Computer Engineering, Minor (https://bulletin.marquette.edu/engineering/electrical-computer-engineering/computer-engineering-minor/)
- Construction Engineering, BCN (https://bulletin.marquette.edu/engineering/civil-construction-environmental-engineering/construction-engineering-bs/)
- E-Lead Program Innovation Leadership, Concentration (https://bulletin.marquette.edu/engineering/e-lead-program-innovation-leadership-concentration/)
- Electrical Engineering, BEE (https://bulletin.marquette.edu/engineering/electrical-computer-engineering/electrical-engineering-bs/)
- Electrical Engineering, Minor (https://bulletin.marquette.edu/engineering/electrical-computer-engineering/electrical-engineering-minor/)
- Environmental Engineering, BCE (https://bulletin.marquette.edu/engineering/civil-construction-environmental-engineering/environtmental-engineering-bs/)
- Environmental Engineering, Minor (https://bulletin.marquette.edu/engineering/civil-construction-environmental-engineering/environmental-engineering-minor/)
- Mechanical Engineering, BME (https://bulletin.marquette.edu/engineering/mechanical-engineering/mechanical-engineering-bs/)
- Mechanical Engineering, Minor (https://bulletin.marquette.edu/engineering/mechanical-engineering/mechanical-enginerring-minor/)

Graduate Programs

- Biomedical Engineering, ME (https://bulletin.marquette.edu/graduate/biomedical-engineering-me/)
- Biomedical Engineering, MS (https://bulletin.marquette.edu/graduate/biomedical-engineering-ms/)
- Biomedical Engineering, PHD (https://bulletin.marquette.edu/graduate/biomedical-engineering-phd/)
- Civil Engineering, MS (https://bulletin.marquette.edu/graduate/civil-engineering-ms/)
- Civil Engineering, PHD (https://bulletin.marquette.edu/graduate/civil-engineering-phd/)
- Clinical Immersion in Medical Device Design, Certificate (https://bulletin.marquette.edu/graduate/clinical-immersion-medical-device-design-certificate/)
- Electrical and Computer Engineering, MS (https://bulletin.marquette.edu/graduate/electrical-computer-ms/)
- Electrical and Computer Engineering, PHD (https://bulletin.marquette.edu/graduate/electrical-computer-engineering-phd/)
- Healthcare Technologies Management, MS (https://bulletin.marquette.edu/graduate/healthcare-technologies-management-ms/)
- Machine Learning for Engineering Applications, Certificate (https://bulletin.marquette.edu/graduate/machine-learning-engineering-applications-certificate/)
- Mechanical Engineering, ME (https://bulletin.marquette.edu/graduate/mechanical-engineering-me/)
- Mechanical Engineering, MS (https://bulletin.marquette.edu/graduate/mechanical-engineering-ms/)
- Mechanical Engineering, PHD (https://bulletin.marquette.edu/graduate/mechanical-engineering-phd/)
- Renewable Energy Technology and Integration, Certificate (https://bulletin.marquette.edu/graduate/renewable-energy-technology-integration-certificate/)
- Systems Engineering, Certificate (https://bulletin.marquette.edu/graduate/systems-engineering-certificate/)

College of Engineering Policies

Students in the Opus College of Engineering are expected to comply with the academic requirements and policies listed in the university section (https://bulletin.marquette.edu/policies/) of this bulletin, along with all official college regulations. See below Opus College of Engineering policies.

- Absence from Final Exams, Incomplete (I) Grade (https://bulletin.marquette.edu/engineering/policies/absence-finals-incomplete-grade/)
- Academic Dismissal/Probation/Academic Alert (CAA) (https://bulletin.marquette.edu/engineering/policies/dismissal-probation-college-alert/)
- Academic Integrity (https://bulletin.marquette.edu/engineering/policies/academic-integrity/)
- Academic Load (https://bulletin.marquette.edu/engineering/policies/academic-load/)
- Accreditation (https://bulletin.marquette.edu/engineering/policies/accreditation/)
- Admission Requirements (https://bulletin.marquette.edu/engineering/policies/admission-requirements/)
- Articulation Agreements (https://bulletin.marquette.edu/engineering/policies/articulation-agreements/)
- Course and Grade Limitations (https://bulletin.marquette.edu/engineering/policies/course-grade-limitations/)
- Credit/No Credit (CR/NC) Grading Option (https://bulletin.marquette.edu/engineering/policies/credit-no-credit-grading-option/)
- Curriculum Substitution and/or Allowance Petition (https://bulletin.marquette.edu/engineering/policies/curriculum-substitution-allowance-petition/)
- Dean's List (https://bulletin.marquette.edu/engineering/policies/deans-list/)
- Degrees Offered (https://bulletin.marquette.edu/engineering/policies/degrees-offered/)
- Electives (https://bulletin.marquette.edu/engineering/policies/electives/)
- Grade Appeals for Engineering Courses (https://bulletin.marquette.edu/engineering/policies/grade-appeals-engineering-courses/)
- Repeating Courses (https://bulletin.marquette.edu/engineering/policies/repeating-courses/)

- Simultaneous Enrollment in Two Academic Programs (https://bulletin.marquette.edu/engineering/policies/simultaneous-enrollment-two-academic-programs/)
- Transfer Credit from Other Programs (https://bulletin.marquette.edu/engineering/policies/transfer-credit-programs/)
- Undergraduate Independent Study (https://bulletin.marquette.edu/engineering/policies/undergraduate-independent-study/)

College of Engineering Resources

The following resources are available to College of Engineering students.

Student Organizations

Engineering Student Council

Engineering students are eligible for membership in the Engineering Student Council, composed of the elected officers and one member of the governing board of each activity, fraternal, honorary and professional organization within the Opus College of Engineering.

Honor Societies

Engineering students are eligible for membership in the following engineering honor societies: Tau Beta Pi, all-engineering; Chi Epsilon, civil engineering; Eta Kappa Nu, electrical engineering; Pi Tau Sigma, mechanical engineering; Alpha Eta Mu Beta, biomedical engineering; and Upsilon Pi Epsilon, computer engineering. Each year, these societies award membership keys to men and women exhibiting high promise of success.

Professional Fraternities/Sororities

Students in the Opus College of Engineering are eligible to join the following professional sorority and fraternities on campus: Alpha Omega Epsilon, professional engineering sorority; Sigma Phi Delta, the international professional engineering fraternity; and Triangle, national fraternity for engineers, architects and scientists.

Professional Societies

Student chapters have been established by the American Society of Civil Engineers, Builders Coalition of MU: Student Chapter of Associated General Contractors of America, the Institute of Electrical and Electronics Engineers, the American Society of Mechanical Engineers, Association of Computing Machinery, the Society of Automotive Engineers, National Society of Black Engineers, Engineers Without Borders, the Society of Hispanic Professional Engineers, the Society of Women Engineers, the Institute of Transportation Engineers, the Biomedical Engineering Society, the Solar Energy Society, the Society of Manufacturing Engineers, the Robotics Club and Engineering Knights of St. Patrick, engineering service society.

The Cooperative Education Program

Overview

The Cooperative Education Program (co-op) was established at Marquette University in 1919. The program combines in-the-field work experience with the academic program degree requirements for Opus College of Engineering students. Students in this program alternate periods of academic semesters with periods of employment in industry. The industry work experience is technical in nature and provides the opportunity for the student to apply their engineering knowledge and skills. The objective is balanced training; the combination of theory and practical work experience during the early years of professional development. In additional to the formal co-op program, undergraduates may also gain experience through summer internships.

Co-op employment is competitive and available for all engineering majors. All students employed in the co-op program earn an hourly salary. There is a small fee to stay enrolled as a full-time student. Tuition is not charged during full-time work periods, unless the student chooses to enroll in a class. In this case tuition for the class is charged at the per-credit rate in addition to the co-op fee. Students who complete the minimum requirement of three work terms earn enough academic credit to fulfill an engineering technical elective toward the program degree requirements. Most engineering students participate in the co-op and/or internship program prior to graduation.

Student participants have said that the program helps them to clarify their career goals, increase their performance and engagement in the classroom by using their knowledge of industry, form their professional network, and open doors to secure full-time employment once they earn their degree. Students also develop the maturity, poise, communication skills and confidence needed to thrive in a business environment.

Enrollment and participation in the Co-op Program requires that:

1. The student is a full-time, degree-seeking student in the Opus College of Engineering at Marquette University.
2. The student is making satisfactory progress toward their engineering degree and has completed their sophomore-level course work.
3. Students must maintain a minimum GPA of 2.000 or greater to be eligible for and to remain enrolled in the co-op program.
4. The student has taken and passed GEEN 2952 Professional Development for Engineers.
5. The student is able to obtain a co-op job offer from an employer who is approved by the college’s Industry Relations Office.
6. The student reports the employment offer to the Opus College of Engineering’s Industry Relations Office and follows the co-op enrollment procedure, co-op course registration requirements and satisfies the requirements to earn credit for their work term.

7. The employer, the student and the student's academic adviser agree to a work/school plan that satisfies all degree requirements and the completion of at least three work terms.
8. International students must work with Marquette University's Office of International Education to complete the required employment processes prior to their first day of employment as a co-op employee.

Since the cooperative education program is considered an integral part of a student's education, the co-op student is a full-time student at Marquette University; whether they are in school or at work. When the co-op student is at work, they are under the company's direct supervision. The student is subject to the rules of the company which may include background checks and/or drug screening. Wages are paid directly to the student by the employer. The university does not employ the student, but cooperates with industry in arranging such employment.

The Les Aspin Biomedical Internships

Overview

The Department of Biomedical Engineering in conjunction with the Les Aspin Center for Government at Marquette University offers internships in medical regulatory and public policy issues. The Les Aspin Biomedical Engineering Internships began in Spring 1997 with qualified biomedical engineering undergraduates traveling to Washington, D.C. The venue for the engineering internships is Capitol Hill, the Food and Drug Administration or private industry located in the Washington, D.C., area. In addition to participating in the internship experience, the students take Marquette University classes at the Les Aspin Center for Government, located a few blocks from Capitol Hill and reside nearby in Marquette-owned, furnished apartments. This program is unique in providing undergraduate experience in research and regulatory issues.

Education Abroad Programs

Overview

Engineering students may study abroad with a Marquette-affiliated program, a Marquette-exchange program, a Marquette summer or intersession program or a non-Marquette program. Students are urged to contact the Education Abroad office and the Engineering Academic Advising Center as early as possible for details. See also, this bulletin under Education Abroad. The Education Abroad Resource Center is located in the Holthusen Hall, 4th Floor. For additional information, see the Education Abroad website (http://www.marquette.edu/abroad/).

Five-Year Combined B.S./M.S. Program

Overview

Each of the departments in the Opus College of Engineering at Marquette University offers programs, which allow highly qualified students to complete a bachelor of science and master of science degree in five calendar years (six years for students enrolled in the Cooperative Education Program). By increasing course loads slightly in the junior year and/or by taking courses in the summer of the junior and/or senior years, qualified students may be able to complete the B.S. degree on schedule in four years and the M.S. degree at the end of five calendar years.

Students intending to pursue one of these programs should begin planning at the end of the sophomore year. Formal application to the program takes place during the second term of the junior year. See individual departments for details.

Biomedical Engineering

BIEN 1100 Introduction to Biomedical Engineering Methods 1 (2 credits)
Students are introduced to biomedical engineering design and problem-solving processes. Key topics include the measurement of physiological signals, signal acquisition, biomedical instrumentation, and image processing. Students will work in cross-disciplinary teams, enhancing their collaboration, teamwork, and decision-making skills. The course emphasizes practical applications, preparing students to tackle complex issues at the intersection of engineering, medicine, and technology.
Prerequisite: Enrolled in the Opus College of Engineering.
Level of Study: Undergraduate
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=BIEN%201100)

BIEN 1110 Introduction to Biomedical Engineering Methods 2 (2 credits)
Students build upon concepts from BIEN 1100, covering topics in fluid mechanics, rehabilitation engineering, biomaterials and business concepts. Emphasis is placed on a hands-on design challenge, where students gain essential skills in problem identification, prototype development and technical communication. Students enhance their abilities in teamwork, critical thinking and entrepreneurial innovation, preparing them for diverse roles in biomedical engineering.
Prerequisite: BIEN 1100, CEEN 1200, EECE 1200, or GEEN 1200; enrollment in the Opus College of Engineering.
Level of Study: Undergraduate
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=BIEN%201110)

BIEN 1120 Introduction to Computing for Biomedical Engineers (2 credits)
Introductory hands-on experience in computer programming for biomedical engineers. Involves learning linear programming in C and creating flow-charts to solve biomedical applications. Computing topics include syntax, data types, control flow and algorithm development. Biomedical applications include analyzing physiological signals, biological event detection, and biomechanical analysis. Students learn how to use MATLAB to solve biomedical applications. Laptop required.
Prerequisite: BIEN 1100, which may be taken concurrently.
Level of Study: Undergraduate
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=BIEN%201120)

BIEN 2100 Statistics for Biomedical Engineering (3 credits)
Numerical and graphical summary of biomedical data and the use of statistics in problem solving for a variety of case studies in biomedical research, medical device design and clinical trials.
Prerequisite: MATH 1450.
Level of Study: Undergraduate
Marquette Core Curriculum: NSM Expanding Our Horizons
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=BIEN%202100)

BIEN 2200 Engineering Design with SolidWorks (1 credits)
Computer-aided design (CAD) with SolidWorks includes 3D solid part/component and assembly modeling and drafting with various modeling techniques to create virtual and actual 3D computer models, along with the introduction to engineering graphics fundamentals with orthographic project views and geometric dimensioning & tolerancing (GD&T) rules and standards to create professional engineering document drawing. Students develop practical CAD skills for internships and full-time employment.
Prerequisite: Enrolled in Opus College of Engineering.
Level of Study: Undergraduate
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=BIEN%202200)

BIEN 2300 Biomedical Circuits and Electronics (4 credits)
An experience in electrical circuits (AC and DC), electronic devices (Junction, Transistor, Operational, Amplifier) bridges, digital circuits and Boolean implementation, combinational and sequential logic, memories. Analysis and design. 3 hrs. lec., 3 hrs. lab
Prerequisite: PHYS 1004 or PHYS 1014. Enrolled in the Opus College of Engineering.
Level of Study: Undergraduate
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=BIEN%202300)

BIEN 3200 Computer Applications in Biomedical Engineering (3 credits)
Design and implement computer techniques for the acquisition and analysis of biomedical data and the modeling of physiologic phenomena. Emphasis on physiological data acquisition, statistical description of physiological data, time domain and frequency domain methods for physiological signal conditioning and processing and numerical methods for quantitative interpretation of physiological data using C programming language.
Prerequisite: BIEN 1120 or equiv.
Level of Study: Undergraduate
Marquette Core Curriculum: NSM Crossing Boundaries
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=BIEN%203200)

BIEN 3300 Signals and Systems for Biomedical Engineering (3 credits)
Mathematical models of continuous-time signals and systems are studied. The time domain viewpoint is developed for linear time invariant systems using the impulse response and convolution integral. The frequency domain viewpoint is also explored through the Fourier Series and Fourier Transform. Basic filtering concepts including simple design problems are covered. Application of the Laplace transform to block diagrams, linear feedback and stability including Bode plots are discussed. The sampling theorem, the z-transform and the Discrete Fourier Transform are introduced. Examples of electrical, mechanical and biomedical signals and systems are used extensively throughout the course. 3 hrs. lec.
Prerequisite: One of the following: ELEN 2020 with minimum grade of C and MATH 2451; or BIEN 2300 with minimum grade of C and MATH 2451; or ELEN 2020 with minimum grade of C and MATH 2455; or BIEN 2300 with minimum grade of C and MATH 2455. BIEN 1120 or concurrent enrollment.
Level of Study: Undergraduate
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=BIEN%203300)

BIEN 3310 Control Systems for Biomedical Engineering (3 credits)
Provides an introduction to the principles of control systems theory for biomedical engineers. Mathematical techniques to characterize and design control systems will be studied in the context of physiological, bioelectrical, biochemical and biomechanical systems. Topics include frequency and time-domain modeling of physiological control systems, feedback, stability, steady-state error, design, root-locus, state-space techniques, and nonlinear control. Simulation using MATLAB and Simulink will be used to provide hands-on experience in the design of biomedical control systems.
Prerequisite: BIEN 3300.
Level of Study: Undergraduate
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=BIEN%203310)

BIEN 3400 Clinical and Regulatory Issues in Medical Device Design (3 credits)
Students develop clinical literacy in areas including medical terminology, working with medical professionals, professional conduct in the clinical environment, operating room workflow and the technical needs of surgeons, nurses, and other stakeholders. They observe procedures in the clinical environment and learn to identify problems, unmet needs and opportunities for new product development. Students participate in field trips to obtain hands-on experience with various medical devices. Lecture topics include clinical perspectives and current needs and regulatory issues associated with the medical device design. A project proposal for a new medical device or technology is required at the end of the course.
Prerequisite: BIEN major and Jr. stndg; or cons. of instr.
Level of Study: Undergraduate
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=BIEN%203400)

BIEN 4220 Embedded Biomedical Instrumentation (3 credits)
Fundamentals of digital circuit design and analysis and the application to embedded biomedical instrumentation. Topics include microprocessor principles and programming and system design constraints for medical electronics. Laboratory will provide applications of concepts introduced in class.
Prerequisite: BIEN 2300.
Level of Study: Undergraduate
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=BIEN%204220)

BIEN 4280 Biocomputers Design Lab 1 (3 credits)
Hands-on experience in software design and validation, microprocessors, computer architecture, real-time computing, embedded software, graphical user interface and networking. An emphasis on medical devices with embedded software and hardware.
Prerequisite: BIEN 2300, BIEN 3300 and BIEN 4220.
Level of Study: Undergraduate
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=BIEN%204280)

BIEN 4290 Biocomputers Design Lab 2 (3 credits)
Continuation of BIEN 4280 with emphasis on high performance computing in workstation environments.
Prerequisite: BIEN 4280.
Level of Study: Undergraduate
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=BIEN%204290)

BIEN 4320 Biomedical Instrumentation Design (3 credits)
Fundamental knowledge and skills needed to solve instrumentation problems relating to biomedical and physiological measurements in the laboratory and clinic. Key elements include biosignals, signal conditioning, sensors and transducers, data acquisition, instrument design and safety requirements. Includes hands-on experiences in basic instrumentation lab skills, needs identification, design, implementation, testing and troubleshooting, and report writing.
Prerequisite: BIEN 2300 or ELEN 2020; and BIEN 3300, which may be taken concurrently.
Level of Study: Undergraduate
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=BIEN%204320)

BIEN 4380 Bioelectronics Design Lab 1 (3 credits)
Students learn the principles of medical device design, safe operating procedures and the practical issues associated with designing and validating electronic systems to measure physiological parameters. Emphasis is placed on open ended design examples and hands-on experience designing, troubleshooting, and validating electronic systems. Topics include electrical safety; myography; force measurement; minimizing sources of noise, operational amplifier characterization; active filtering; microprocessors. Students gain experience conveying information using different styles of reporting. 2 hrs. lec., 3 hrs. lab.
Prerequisite: EECE 2015, EECE 2035, ELEN 3030.
Level of Study: Undergraduate
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=BIEN%204380)

BIEN 4390 Bioelectronics Design Lab 2 (3 credits)
Students integrate the concepts from Design Lab 1 to design, implement and test an example medical device based in research and clinical applications. Emphasis is placed on open ended design examples and hands-on experience designing, troubleshooting and validating electronic systems. Topics include patient isolation from electrical hazard, biopotential measurement, myoelectric control, EMF and inductive loads, signal multiplexing and demultiplexing, analog to digital conversion, and electrical stimulation. Design projects incorporating microprocessors are also included. Students gain experience conveying information using different styles of reporting. 2 hrs. lec., 3 hrs. lab.
Prerequisite: BIEN 4380 and EECE 3015.
Level of Study: Undergraduate
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=BIEN%204390)

BIEN 4400 Transport Phenomena (3 credits)
Introduction to fluid mechanics and its applications in biomedical engineering. Covers key concepts in fluid mechanics, such as conservation of mass, momentum, and energy in fluids, the Reynolds number, laminar vs. turbulent flows, Poiseuille flow, the Bernoulli equation, and the Navier-Stokes equations. Concepts are applied to physiological phenomena with an emphasis on the cardiovascular and respiratory systems.
Prerequisite: Jr. stndg. and PHYS 1003, or cons. of instr.
Level of Study: Undergraduate
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=BIEN%204400)

BIEN 4410 Applied Finite Element Analysis (3 credits)
Introduction to the finite element method, used for numerical integration of partial differential equations in solid mechanics, fluid mechanics and heat transfer. Summarizes various numerical integration schemes. Assignments include development of finite element code (e.g., Matlab or Python) and/or use of commercial software (e.g., ANSYS, Abaqus). Emphasis is on the application of the finite element method to biomedical applications, such as cardiovascular flows, respiratory flows, or orthopedic biomechanics.
Prerequisite: Sr. stndg., BIEN 1110 and GEEN 2130; or Sr. stndg., GEEN 1210, and GEEN 2130.
Level of Study: Undergraduate
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=BIEN%204410)

BIEN 4420 Biomaterials Science and Engineering (3 credits)
Designed to introduce the uses of materials in the human body for the purposes of healing, correcting deformities and restoring lost function. The science aspect of the course encompasses topics including: characterization of material properties, biocompatibility and past and current uses of materials for novel devices that are both biocompatible and functional for the life of the implanted device. Projects allow students to focus and gain knowledge in an area of biomaterials engineering in which they are interested.
Prerequisite: MEEN 2460 or equiv.
Level of Study: Undergraduate
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=BIEN%204420)

BIEN 4430 Introduction to Tissue Engineering (3 credits)
Introduces the scientific field of tissue engineering, a discipline of biomedical engineering that uses a combination of living cells, biomaterials, and biomechanical and biochemical stimuli to restore or replace damaged or diseased biological tissues. Covers advanced topics in foundational sciences as applicable to the engineering of living tissues. Topics include stem cell biology, biomaterials, immunology, bioreactors and molecular biology. Discusses pathophysiology and engineering strategies for specific tissues, along with examples of current research. Covers the following tissue applications: skin, blood vessels, nervous tissue, heart tissue, heart valves, tendons, ligaments, bone and whole organs.
Prerequisite: Jr. stndg.
Level of Study: Undergraduate
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=BIEN%204430)

BIEN 4480 Biomechanics Design Lab 1 (3 credits)
Intended for those students pursuing the Biomedical Engineering Biomechanics option. The application of principles of engineering mechanics, data acquisition and basic electronics in the design and utilization of biomechanical instrumentation. Principles of transduction, mechanics, sampling theory, strain, temperature, and flow measurement as applied to biomechanical systems. A background in data acquisition, electrical safety, operational amplifier and bridge circuits, and measurements is provided. Experiments investigate biomechanics of the musculoskeletal and cardiovascular systems and include design content. Report writing. 2 hrs. lec., 3 hrs. lab.
Prerequisite: BIEN 2300, GEEN 2120, and GEEN 2130.
Level of Study: Undergraduate
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=BIEN%204480)

BIEN 4490 Biomechanics Design Lab 2 (3 credits)
Provides students with experience in the design and implementation of appropriate experimental procedures to analyze biomechanical problems. Students will become familiar with various types of advanced transducers which will be used in conjunction with data acquisition workstations to obtain thermal, flow, strain, and related physiological data from biomechanical systems. Topics include mechanical properties of active muscle; analysis of human motion; postural stability; thermal regulation; cardiovascular mechanics; stress distribution in skeletal system; and comparison of static and dynamic biomechanical responses to load. 2 hrs. lec., 3 hrs. lab.
Prerequisite: BIEN 4480.
Level of Study: Undergraduate
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=BIEN%204490)

BIEN 4500 Medical Imaging Physics (3 credits)
Students learn how light, X-rays, radiopharmaceuticals, ultrasound, magnetic fields, and other energy probes are generated and how they interact with tissues and detectors to produce useful image contrast. Practical issues such as beam generation, dose limitations, patient motion, spatial resolution and dynamic range limitations, and cost-effectiveness will be addressed. Emphasis is placed upon diagnostic radiological imaging physics, including the planar X-ray, digital subtraction angiography mammography, computed tomography, nuclear medicine, ultrasound, and magnetic resonance imaging modalities.
Prerequisite: PHYS 1004 or PHYS 1014.
Level of Study: Undergraduate
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=BIEN%204500)

BIEN 4510 Image Processing for the Biomedical Sciences (3 credits)
This course serves as an introduction to biomedical image processing. Topics explored included the human visual system, spatial sampling and digitization, image transforms, spatial filtering, Fourier analysis, image enhancement and restoration, nonlinear and adaptive filters, color image processing, geometrical operations and morphological filtering, image coding and compression image segmentation, feature extraction and object classification. Applications in diagnostic medicine, biology and biomedical research are emphasized and presented as illustrative examples.
Prerequisite: MATH 1450 and MATH 1451 or MATH 1455; knowledge of C programming; or cons. of instr.
Level of Study: Undergraduate
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=BIEN%204510)

BIEN 4520 Introduction to Optics for Biomedical Engineers (3 credits)
Introduces the fundamentals of optics, the science and technology of how light is generated, propagated, interacts with matter and detected. Concentrates on geometrical (or ray) optics, which focuses on light reflection, refraction, lenses, mirrors, prisms, fiber optics, GRIN lens and simple imaging systems, as well as wave optics, which focuses on wave equations, superposition, diffraction, interference, polarization, dispersion and electro-optic effects. Also studies more advanced topics, such as fluorescence imaging, optical microscopy, diffuse optical tomography, optical coherence tomography and optical spectroscopy.
Prerequisite: PHYS 1004, BIEN 4320.
Level of Study: Undergraduate
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=BIEN%204520)

BIEN 4600 Neural Engineering (3 credits)
Basic principles of neural engineering and the nervous system, properties of excitable tissues, quantitative models used to examine the mechanisms of natural and artificial stimulation. Basic concepts for the design of neuroprosthetic devices for sensory, motor and therapeutic applications. Design issues including electrode type, biomaterials, tissue response to implanted electrodes, stimulus parameters for electrical stimulation and artificial control and emerging neuromodulation technologies such as optogenetics. Examples of how neural interfaces show increasing promise in the rehabilitation of individuals with various motor or sensory impairments.
Prerequisite: PHYS 1004 or PHYS 1014; programming experience in MATLAB or equiv.
Level of Study: Undergraduate
Marquette Core Curriculum: NSM Cgntn, Lang, Mmry/Intlgnc
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=BIEN%204600)

BIEN 4610 Introduction to Rehabilitation Robotics (3 credits)
Presents the fundamentals of robotics as it is applied to rehabilitation engineering. Specific topics include: the fundamentals of analysis and design of robot manipulators with examples and mini-projects taken from rehabilitation applications pertaining to robotic therapy devices and personal assistants. Additional topics include: overview of rehabilitation robotics field, human-centered design of rehabilitation robots issues and challenges, robot configurations, rigid motions and homogeneous transformations, Denavit-Hartenberg representation, robot kinematics, and inverse kinematics, Euler-Lagrange equations, trajectory generation, sensors, actuators, independent joint control, force control and safety.
Prerequisite: Jr. stndg.
Level of Study: Undergraduate
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=BIEN%204610)

BIEN 4620 Rehabilitation Science and Engineering (3 credits)
Introduces rehabilitation science as the study of tissue and functional change, including:overview of key human sensory modalities and neuromotor systems in the context of functional capabilities and human performance metrics; review of spontaneous recovery mechanisms in response to various types of tissue trauma; review of roles of genetics and gene transcription networks in pathology and functional recovery prognosis; and the concept of rehabilitative assessment and therapeutic interventions as an optimization problem. Also focuses on the use of assistive technology to enhance access to independent living and to optimize the delivery of rehabilitative healthcare services. Includes rehabilitation biomechanics of physical interfaces, use of access and usability engineering in product design and innovative assessment and intervention strategies for neurorehabilitation.
Prerequisite: BIEN 2300 or equiv.
Level of Study: Undergraduate
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=BIEN%204620)

BIEN 4700 Systems Physiology (3 credits)
Analyses of the underlying physiologic and bioengineering aspects of the major cell and organ systems of the human from an engineer's point of view. Classic physiologic approaches used to introduce topics including cell functions, nervous system, nerve, muscle, heart, circulation, respiratory system, kidney, reproduction and biomechanics. Design problems including models of cell-organ-system function and problems in biomechanics illuminate topics covered. Experts on related topics are invited to speak as they are available.
Prerequisite: BIOL 1001 and Jr. stndg.
Level of Study: Undergraduate
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=BIEN%204700)

BIEN 4710 Analysis of Physiological Models (3 credits)
Development of continuous (compartmental), and distributed-in-space-and-time mathematical models of physiological systems and molecular events. Analytical and numerical methods for solving differential equations of the initial and boundary value types. Simulation of model response, and estimation of model parameters using linear and nonlinear regression analysis.
Prerequisite: Jr. stndg. and MATH 2451; or jr. stndg. and MATH 2455.
Level of Study: Undergraduate
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=BIEN%204710)

BIEN 4720 Cardiopulmonary Mechanics (3 credits)
Examination of cardiovascular and respiratory physiology from an engineering perspective. Emphasis is on understanding the mechanical basis of physiologic phenomena via mathematical and computational models.
Prerequisite: BIEN 4700, which may be taken concurrently, or equiv.; and BIEN 4400, which may be taken concurrently, or equiv.; or cons. of instr.
Level of Study: Undergraduate
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=BIEN%204720)

BIEN 4920 Senior Capstone Design 1 (3 credits)
Course content focuses on a structured product design and development process that includes project definition, customer needs identification, product specification, concept generation, and concept selection. Course also focuses on issues related to teamwork, project management, and effective communication. Student team design projects culminate in the development of a technically and economically viable concept and a proposal for future development of this concept (done in the second semester of this two-course sequence). 2 hr. lec., 1 hr. disc.
Prerequisite: Sr. stndg.; co-op students, jr. stndg. Cross-listed with COEN 4920, ELEN 4920 and MEEN 4920.
Level of Study: Undergraduate
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=BIEN%204920)

BIEN 4931 Topics in Biomedical Engineering (1-3 credits)
Course content announced prior to each term. Students may enroll in the course more than once because subject matter changes. Possible topics include biomechanics, experimental methods, neuroanatomy, telemetry, etc.
Prerequisite: Jr. stndg.
Level of Study: Undergraduate
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=BIEN%204931)

BIEN 4995 Independent Study in Biomedical Engineering (1-4 credits)
Undergraduate independent study project of either a theoretical or experimental nature.
Prerequisite: Jr. stndg., 3.000 GPA, cons. of instr., and cons. of dept. ch.; or Sr. stndg., 3.000 GPA, cons. of instr., and cons. of dept. ch. Consent required.
Level of Study: Undergraduate
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=BIEN%204995)

BIEN 4998 Senior Capstone Design 2 (3 credits)
Course focuses on detailed design, prototyping, and testing design concepts. Course includes topics directly relevant to student design projects and careers in the engineering profession. Student team design projects culminate in a final report that documents the performance and details (engineering drawings and/or documentation) of their final design. 2 hrs. lec., 1 hr. disc.
Prerequisite: BIEN 4920. Cross-listed with COEN 4998, ELEN 4998 and MEEN 4998.
Level of Study: Undergraduate
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=BIEN%204998)

BIEN 4999 Senior Thesis within the Department of Biomedical Engineering (3 credits)
Preparation of a thesis by approved students to gain experience in the type of critical research and analysis that an advanced degree requires. The associated extended project is designed to enhance research and communication skills leading to a high quality manuscript that could be submitted for peer-reviewed journal publication.
Prerequisite: MU GPA greater than or equal to 3.5, BIEN 4995, cons. of dept. ch. Consent required.
Level of Study: Undergraduate
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=BIEN%204999)

BIEN 9002 Student Study/Research Placeholder in Biomedical Sciences (0 credits)
Used to enroll a MU or non-MU student who is not enrolled in the term, but is on campus for an educational experience other than academic credit, such as work in a lab or clinic. Used for tracking purposes only. S/U grade assessment.
Prerequisite: Consent required.
Level of Study: Undergraduate
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=BIEN%209002)

Civil, Construction and Environmental Engineering

CEEN 1200 Introduction to Infrastructure (3 credits)
Introduction to civil, construction and environmental engineering with emphasis on civilian infrastructure and the built environment. Introduction to the natural environment and environmental infrastructure, structural infrastructure and construction, transportation infrastructure, civil engineering history and heritage and civil infrastructure systems. Discussion of planning and energy, sustainability, environmental, economic, ethics and security considerations in relation to civilian infrastructure. Introduction to analysis and design as they pertain to infrastructure and the built environment.
Prerequisite: Enrollment in the Opus College of Engineering.
Level of Study: Undergraduate
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=CEEN%201200)

CEEN 1210 Introduction to Computing, Analysis, Design and Communication (3 credits)
Introduction to computational tools, graphical communication tools and economic analysis principles as they relate to civil, construction and environmental engineering. Introduction to sketching as a means with which to convey and communication of ideas and workflow. Algorithm development and graphical display of engineering ideas and information in commercially available programs and programming environments. Implementation of infrastructure engineering analysis and design concepts and procedures from CEEN 1200 using commercially available programs and programming environments.
Prerequisite: BIEN 1100, CEEN 1200, EECE 1200, or GEEN 1200; enrollment in the Opus College of Engineering.
Level of Study: Undergraduate
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=CEEN%201210)

CEEN 2320 Introduction to Civil Infrastructure, Geo-Spatial and Environmental Modeling (3 credits)
Introduction of parametric and geo-spatial modeling and its uses in civil, construction and environmental engineering applications to civilian infrastructure. Activities will focus on Geospatial Information Systems (GIS), civil site modeling, road infrastructure modeling, bridge modeling, watershed modeling/mapping and the use of surveying data in the layout of civil infrastructure. Students learn construction sequencing, infrastructure systems terminology and modeling principles as they relate to civil infrastructure.
Prerequisite: CEEN 1210.
Level of Study: Undergraduate
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=CEEN%202320)

CEEN 3160 Geotechnical Engineering (3 credits)
Fundamental properties and engineering characteristics of soil as a particulate mass aggregate are studied. The formation and the development of soil deposits, the physical and hydraulic properties and the methods of predicting the stress-strain behavior of soils for engineering applications are examined. Laboratory experiments are conducted and reports are required. 2 hrs. lec., 1.25 hrs. lab.
Prerequisite: Jr. stndg. and CIEN, ENEN or CNEN major.
Level of Study: Undergraduate
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=CEEN%203160)

CEEN 3210 Hydraulic Engineering (3 credits)
Fundamentals and applications of hydrostatics and hydrodynamics including pressurized pipe flow and pipeline network design, open channel flow, and sewer design, pump selection and flow measurement. Laboratory assignments and demonstrations. 2 hrs. lec., 1.25 hrs. lab.
Prerequisite: MEEN 3320 which, may be taken concurrently.
Level of Study: Undergraduate
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=CEEN%203210)

CEEN 3320 Civil Engineering Materials (3 credits)
Introduction to the properties and fundamental behavior materials used by civil engineers with emphasis on concrete, asphalt and steel. Lab experiments are used to demonstrate the behavior or materials subjected to various load levels and orientations. Use of spreadsheets and statistical analysis of experimental data are required. 2 hrs. lec; 1.25 hrs. lab.
Prerequisite: Soph. stndg. and CIEN, ENEN or CNEN major.
Level of Study: Undergraduate
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=CEEN%203320)

CEEN 3410 Structural Analysis (3 credits)
Determining the loads that act on structures and load combinations. Basic concepts in structural analysis of determinate beams, trusses, and frames. Deflections of determinate beams by moment area and conjugate beam methods. Development of basic virtual work concept to obtain deformations in determinate trusses, beams, and frames. Introduction to the solution of indeterminate structures by using the method of superposition. Influence lines for determinate beams.
Prerequisite: GEEN 2130.
Level of Study: Undergraduate
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=CEEN%203410)

CEEN 3430 Structural Steel Design (3 credits)
Introduction to building codes, design standards and design specifications as they relate to the physical behavior and design of steel structures. Design of structural steel members subjected to tensile loading; compression loading (columns); and bending (beams). Design of mechanical fasteners, welds and connecting elements. Analysis and design of members subjected to combined loading (beam-columns). Emphasis on AISC Specifications.
Prerequisite: CEEN 3320 and CEEN 3410.
Level of Study: Undergraduate
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=CEEN%203430)

CEEN 3440 Reinforced Concrete Design (3 credits)
Fundamental concepts of reinforced concrete theory and design. Use of current design code for the analysis and design of basic structural members; strength design for flexure, shear and development of reinforcement.
Prerequisite: CEEN 3410 and CEEN 3320.
Level of Study: Undergraduate
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=CEEN%203440)

CEEN 3510 Environmental Engineering (3 credits)
Introduction to environmental engineering with a focus on the water environment. Topics include water quality, water resources, water supply, municipal water and wastewater systems, air quality, and solid and hazardous waste management.
Prerequisite: Jr. stndg. and CIEN, ENEN or CNEN major.
Level of Study: Undergraduate
Interdisciplinary Studies: Environmental Studies, Environmental Ethics
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=CEEN%203510)

CEEN 3610 Transportation Engineering (3 credits)
Airport airside systems based on FAA guidelines. Road user and vehicle characteristics, applications of equations of motion, geometric design of roadways including horizontal and vertical alignment and cross-sectional elements. Also includes traffic calming, signalized intersections, parking lot design and traffic flow models. Emphasis on explaining technical details in writing.
Prerequisite: Jr. stndg. and CIEN, ENEN or CNEN major.
Level of Study: Undergraduate
Marquette Core Curriculum: NSM Basic Needs & Justice
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=CEEN%203610)

CEEN 4145 Advanced Strength and Applied Stress Analysis (3 credits)
Basic concepts of mechanics of deformable bodies. Two- and three-dimensional stress-strain relationships and theories of failure. Unsymmetrical bending analyses. Shear flow and shear center. Torsion of thin-walled sections (tubular and non-tubular). Composite beams. Stress concentration. Energy principles: strain and complementary energy. Castigliano's theorem.
Prerequisite: GEEN 2130.
Level of Study: Undergraduate
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=CEEN%204145)

CEEN 4230 Urban Hydrology and Stormwater Management (3 credits)
Distribution and properties of water on the earth. Concept of the hydrologic cycle and basic principles governing water movement in the environment: precipitation, evapotranspiration, infiltration, runoff generation, streamflow and groundwater flow. Engineering methods of design of flood protection, stormwater management and stormwater pollution abatement systems.
Prerequisite: CEEN 3510 or MEEN 3320.
Level of Study: Undergraduate
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=CEEN%204230)

CEEN 4310 Geographical Information Systems in Engineering and Planning (3 credits)
Fundamentals of GIS, databases, data management, map projections, representations of spatial attributes, GIS analysis and GIS software systems such as ARC Info, ARC View, Grass. GIS use and expanded capabilities are taught. Case studies including environmental, transportation and economic applications are discussed.
Prerequisite: Sr. stndg. and CIEN, ENEN or CEMA major.
Level of Study: Undergraduate
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=CEEN%204310)

CEEN 4340 Urban Planning for Civil Engineers (3 credits)
Concepts and principles underlying urban planning and development. Land use, transportation, utility, community facility planning problems, procedures, and techniques. The master plan and implementation devices such as zoning, subdivision control, official mapping, capital budgeting, and urban renewal.
Prerequisite: Sr. stndg. and CIEN, ENEN or CNEN major.
Level of Study: Undergraduate
Interdisciplinary Studies: Urban Affairs
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=CEEN%204340)

CEEN 4350 Law for Engineers (3 credits)
Basic legal principles and awareness of typical legal questions that arise when engineers and law interact. Topics include: American judicial system, law of contracts, forms of association, construction contracts, professional liabilities of engineers and torts.
Prerequisite: Sr standing and CIEN major or ENEN major; or Jr standing and CNEN major.
Level of Study: Undergraduate
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=CEEN%204350)

CEEN 4411 Matrix Structural Analysis (3 credits)
Introduction to symbolic and numerical linear algebra computations using commercial software. Modeling axial, bending, and torsion deformations in structural members using polynomials. Application of the principle of virtual work to compute deflections for statically determinate and indeterminate problems. Formulation of the matrix stiffness method via the principle of virtual displacements and the matrix flexibility method via the principle of virtual forces. Application of the matrix stiffness method for solving statically indeterminate structural analysis problems. Use of approximate methods of structural analysis (cantilever and portal methods) for critical evaluation of software-generated solutions. Use of commercial software for structural analysis.
Prerequisite: CEEN 3410.
Level of Study: Undergraduate
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=CEEN%204411)

CEEN 4431 Advanced Structural Steel Design (3 credits)
Continuation of CEEN 3430. Design of plate girders, composite beam and slab systems, composite columns and composite beam-columns, simple connections, moment connections, hollow structural shape (HSS) connections, bracing systems and single and multi-story steel framed building systems. Emphasis on AISC Specifications
Prerequisite: CEEN 3430.
Level of Study: Undergraduate
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=CEEN%204431)

CEEN 4441 Advanced Reinforced Concrete Design (3 credits)
Presents advanced concrete design applications to reinforced concrete statically indeterminate systems, two-way slabs, short and slender columns, footings, and walls. Emphasis on ACI code requirements.
Prerequisite: CEEN 3440.
Level of Study: Undergraduate
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=CEEN%204441)

CEEN 4443 Prestressed Concrete Design (3 credits)
Introduction to basic principles and procedures for the design and analysis of prestressed concrete members, including calculations of prestress loss, flexural analysis and design, shear, bond and anchorage requirements, member deflections and cable layouts. Emphasis on ACI and PCI code requirements.
Prerequisite: CEEN 3440 or equiv.
Level of Study: Undergraduate
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=CEEN%204443)

CEEN 4450 Bridge Design (3 credits)
Introduction to bridge engineering and construction including: an abbreviated history of bridge construction; bridge types; bridge nomenclature; lessons from failures; design philosophies; and the construction process. Analysis of single-and multi-span bridge superstructures using classical techniques and commercial software. Design of single-span reinforced concrete slab bridges; reinforced concrete bridge decks; and single-span slab-bridges in prestressed concrete.
Prerequisite: CEEN 3430 and CEEN 3440.
Level of Study: Undergraduate
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=CEEN%204450)

CEEN 4505 Air Quality Engineering (3 credits)
Applies engineering principles to identify, quantify and mitigate sources of air pollution. Takes a systems approach to quantify sources of air pollution, model fate and transport in the environment, identify public health and welfare aspects, develop monitoring and measuring programs, interpret regulatory framework, and design engineering solutions. Atmospheric physics and chemistry are applied in air dispersion modeling to predict air quality impacts. Air pollution control technologies are evaluated to design practical and economic solutions.
Level of Study: Undergraduate
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=CEEN%204505)

CEEN 4515 Environmental Chemistry (3 credits)
Chemical stoichiometry, equilibrium, and kinetics relating to natural and engineered environmental systems. Basic concepts from organic and inorganic chemistry including oxidation-reduction reactions, acid-base chemistry, the carbonate system, alkalinity and acidity. Equilibrium and kinetic theories of chemical partitioning among gas, liquid and solid phases governing chemical fate and transport in the environment. Coordination chemistry describing metal-ligand interactions, precipitation and bioavailability of materials.
Prerequisite: CEEN 3510 and CHEM 1002.
Level of Study: Undergraduate
Marquette Core Curriculum: NSM Basic Needs & Justice
Interdisciplinary Studies: Environmental Studies
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=CEEN%204515)

CEEN 4520 Industrial Wastewater Management (3 credits)
Review of federal legislation and state regulations with regard to industrial wastewater management practices. Consideration of industrial process modifications and wastewater treatment options with respect to their effect on industrial user fees. Pretreatment standards and discharge permit requirements. Case studies of specific industrial applications.
Prerequisite: CEEN 3510.
Level of Study: Undergraduate
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=CEEN%204520)

CEEN 4525 Treatment Plant Design and Operation (3 credits)
Review of water and wastewater characteristics, drinking water, receiving water and effluent standards. Basic design methodology and operational features of common physical, chemical and biological processes for the treatment of waters and wastewaters. Introduction to the processing and disposal of sludges and other treatment plant residuals.
Prerequisite: CEEN 3510.
Level of Study: Undergraduate
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=CEEN%204525)

CEEN 4530 Hazardous and Industrial Waste Management (3 credits)
Overview of hazardous waste management, disposal and soil and ground water remediation. Review of RCRA, CERCLA-SARA, TSCA and Wisconsin's NR 700 and other regulations. Definition of hazardous wastes and characterization of industrial waste stream. Chemical, physical and biological properties of hazardous wastes. Introduction to hazardous waste remediation/treatment methods and technologies. Landfills and the RCRA Land Ban regulations. Site assessments, field investigations and laboratory analytical techniques. Environmental risk assessments, cleanup objectives and waste minimization.
Prerequisite: Sr. stndg.; CIEN or ENEN major.
Level of Study: Undergraduate
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=CEEN%204530)

CEEN 4535 Environmental Engineering Microbiology (3 credits)
Includes microbiological and biochemical properties of microorganisms important in environmental engineering practice. General fundamentals of environmental microbiology and their application to drinking water treatment and distribution, water pollution control and natural systems.
Prerequisite: CEEN 3510.
Level of Study: Undergraduate
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=CEEN%204535)

CEEN 4550 Water Resources Planning and Management (3 credits)
Planning and management of water resources. Institutional frameworks for water resources engineering. Comprehensive integration of the engineering economic, social and legal aspects of water resources planning and management. Case studies of water use and environmental resources are studied.
Level of Study: Undergraduate
Interdisciplinary Studies: Environmental Studies
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=CEEN%204550)

CEEN 4595 GIS Applications in Water Resources (3 credits)
Use of Geographical Information Systems (GIS) concepts and methods to solve water resources problems. GIS fundamentals such as databases, map projections, spatial analysis and raster analysis. Applications for water resources engineering including terrain analysis, watershed characterization and hydrologic analysis and modeling. Approaches to GIS integration with modeling software and online tools.
Level of Study: Undergraduate
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=CEEN%204595)

CEEN 4615 Highway Planning and Design (3 credits)
Emphasis on highway planning, alternate highway alignments and alternate evaluation. Geometric design of highways including horizontal and vertical alignment, cross-section design. Projects on detailed design of reverse curves (plan and profile views); intersection design; cross-section and earthwork quantities. Legal aspects of engineering. Use of American Association of State Highway and Transportation Officials design guidelines.
Prerequisite: CEEN 3610.
Level of Study: Undergraduate
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=CEEN%204615)

CEEN 4640 Traffic Characteristics and Design (3 credits)
Components of the traffic system: vehicle and road user characteristics, geometric design and traffic controls. Intersection types, cross-section design elements and typical dimensions. Basic variables of traffic flow, observed traffic flow values. Freeway operations. Signalized intersections: flow, capacity, level of service. Projects addressing: intersection existing conditions (traffic, geometry, signalization); approach delay; safety performance; capacity; suggestions for improvements. Use of the Highway Capacity Manual and the Highway Capacity Software. Emphasis on technical report-writing and presentation.
Prerequisite: CEEN 3610.
Level of Study: Undergraduate
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=CEEN%204640)

CEEN 4650 Pavement Design (3 credits)
Study of the behavior and properties of highway pavements with emphasis on hot mix asphalt and jointed Portland cement concrete pavement. Pavement thickness designs are developed using current design methods and incorporating subgrade soil properties, traffic forecasts and pavement performance expectations. Use of spreadsheets and computer programs are required.
Prerequisite: CEEN 3160 and CEEN 3610.
Level of Study: Undergraduate
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=CEEN%204650)

CEEN 4660 Pavement Management (3 credits)
Study of the performance of pavement systems based on design, traffic and maintenance activities. Methods for evaluating in-service pavements including distress surveys and nondestructive testing are examined. Maintenance strategies are developed and life-cycle cost analysis of these strategies are studied.
Prerequisite: CEEN 3610.
Level of Study: Undergraduate
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=CEEN%204660)

CEEN 4670 Advanced Transportation Materials (3 credits)
Advanced study of materials used for constructing transportation facilities, with particular emphasis on subgrade soils, bound and unbound aggregates, hot mix asphalt and Portland cement concrete. Laboratory tests are conducted and analytical models used for characterizing transportation materials are examined.
Prerequisite: CEEN 3320 and CEEN 3160.
Level of Study: Undergraduate
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=CEEN%204670)

CEEN 4710 Engineering Fundamentals Review (1 credits)
Review of basic science, mathematics, engineering science and economics. S/U grade assessment.
Prerequisite: Sr. stndg. and CIEN or ENEN major.
Level of Study: Undergraduate
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=CEEN%204710)

CEEN 4715 Sustainable Engineering (3 credits)
Provides a framework for the theory and practice of sustainable engineering. Introduces the importance and role of technological, social and sustainable systems in the modern world, which is increasingly characterized by integrated human/natural/built complex adaptive systems at local, regional and global scales. Develops critical problem solving approaches, including life-cycle assessment, global awareness, consciousness of patterns in technological evolution, and strategies for addressing environmental, economic and social equity issues in engineering design.
Prerequisite: Sr. stndg. in College of Engineering.
Level of Study: Undergraduate
Interdisciplinary Studies: Environmental Studies
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=CEEN%204715)

CEEN 4720 Probability Concepts in Engineering (3 credits)
Applications of probability theory, statistics and decision analysis to engineering problems. Emphasis is placed on probabilistic modeling and analysis of engineering problems, and Bayesian statistics.
Prerequisite: Sr. stndg. and Engineering major.
Level of Study: Undergraduate
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=CEEN%204720)

CEEN 4850 FRP in Civil Engineering Infrastructure (3 credits)
Introduces Fiber Reinforced Polymer (FRP) material properties, FRP reinforced concrete, FRP prestressed concrete, FRP repaired and retrofitted structures and pure FRP structures.
Prerequisite: CEEN 3440.
Level of Study: Undergraduate
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=CEEN%204850)

CEEN 4931 Topics in Civil Engineering (1-3 credits)
Course content announced each term. Potential topics include: probability concepts in engineering, advanced roadway facility design, engineering economy, highway bridge analysis and design, structural engineering of sports facilities.
Prerequisite: Cons. of instr. Consent required.
Level of Study: Undergraduate
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=CEEN%204931)

CEEN 4953 Environmental Seminar (0 credits)
Topics related to environmental engineering, including subjects such as air pollution, urban hydrology and storm water management, wastewater treatment and hazardous waste management. S/U grade assessment.
Level of Study: Undergraduate
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=CEEN%204953)

CEEN 4995 Independent Study in Civil and Environmental Engineering (1-3 credits)
Undergraduate independent study project of either a theoretical or experimental nature.
Prerequisite: Jr. stndg., 3.000 GPA, cons. of instr., and cons. of dept. ch. Consent required.
Level of Study: Undergraduate
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=CEEN%204995)

CEEN 4998 Senior Design Project (4 credits)
Design of selected civil engineering projects including planning, preliminary analysis and final design. Different projects are selected each year. Students are assigned to project teams with specific tasks under the direction of a faculty course coordinator. Professional engineers from local firms propose projects and act as consultants to each design team. Emphasis is placed on student initiative, responsibility and resourcefulness in an open-ended project. A final written design report and oral presentation are required for each design team. Emphasis on technical communications, professional ethics and engineering practices. 1 hr. lec., 3 hrs. disc.
Prerequisite: CEEN 3510 and a Civil Engineering Design Elective for CIEN and ENEN majors. CNEN 3810, CNEN 4830, and CNEN 4845 for CNEN majors.
Level of Study: Undergraduate
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=CEEN%204998)

CNEN 3810 Introduction to Construction Management (3 credits)
Construction contracts, contract bonds, construction funding, cash flow analysis, labor productivity and cost. Analytical techniques for project planning and scheduling. Construction safety.
Prerequisite: Soph. stndg for CNEN, CIEN, and ENEN majors. Sr. stndg. for all other majors.
Level of Study: Undergraduate
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=CNEN%203810)

CNEN 3860 Construction Materials and Methods (3 credits)
Introduction to materials and methods of building construction and construction drawings; foundation, structural framing, floor, room and wall systems; blueprint reading and quantity takeoff techniques; and an introduction to building information modeling.
Prerequisite: CNEN 3810.
Level of Study: Undergraduate
Marquette Core Curriculum: Engage Social Systms & Values 2
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=CNEN%203860)

CNEN 4815 Mechanical and Electrical Systems for Buildings (3 credits)
Provides basic knowledge of electrical, plumbing and HVAC systems used in residential, commercial and industrial buildings. Studies the advantages and disadvantages of various systems, and how their design and installation integrates into the management of the building process. Particular attention is given to soliciting and managing mechanical and electrical subcontractors.
Prerequisite: CNEN 3810.
Level of Study: Undergraduate
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=CNEN%204815)

CNEN 4830 Construction Planning, Scheduling, and Control (3 credits)
A study of principles and techniques used to plan, schedule and control costs on building construction projects. Network and linear scheduling models, resource allocation and time-cost analysis. Develops an appreciation of the resources required in a project and their limitations and introduces the techniques for analyzing and improving their use. Develops an understanding of the correlation between project planning and control and cost estimating and scheduling.
Prerequisite: CNEN 3860.
Level of Study: Undergraduate
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=CNEN%204830)

CNEN 4840 Construction Cost Analysis and Estimating (3 credits)
Study of various cost estimating methods and their applications. Topics include: labor, material, equipment and indirect costs; quantity takeoff; analysis of historical cost data; forecasting and computerized estimating methods.
Prerequisite: CNEN 4845 or cons. of instr.
Level of Study: Undergraduate
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=CNEN%204840)

CNEN 4845 Construction Equipment and Methods (3 credits)
Construction equipment and productivity analysis. Design of equipment fleet operations. Design of temporary structures used during construction such as earth retaining structures and concrete formwork systems. Construction equipment safety and safety standards related to earthwork and concrete forming operations.
Prerequisite: CNEN 3810 and Sr. stndg.
Level of Study: Undergraduate
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=CNEN%204845)

CNEN 4931 Topics in Construction Engineering and Management (1-3 credits)
Course content announced each term.
Prerequisite: Cons. of instr. Consent required.
Level of Study: Undergraduate
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=CNEN%204931)

CNEN 4995 Independent Study in Construction Engineering (1-3 credits)
Undergraduate independent study project of either a theoretical or experimental nature.
Prerequisite: Jr. stndg., 3.000 GPA, cons. of instr., and cons. of dept. ch. Consent required.
Level of Study: Undergraduate
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=CNEN%204995)

Electrical and Computer Engineering

COEN 2020 Electric Circuits 2 (3 credits)
Sinusoidal steady-state analysis. Power in AC circuits. Linear and ideal transformers. Laplace transform methods and circuit analysis applications. Passive and active frequency-selective circuits. Fourier methods. Overview of discrete-time analysis.
Prerequisite: EECE 2010.
Level of Study: Undergraduate
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=COEN%202020)

COEN 2610 Software Methodologies (3 credits)
The first course in software engineering covering the software life cycle with an emphasis on Agile and Scrum. Steps in the software life cycle include requirements engineering, software design and testing, and software evolution. This includes a semester long project using the Scrum process.
Prerequisite: EECE 1610 or COSC 1010.
Level of Study: Undergraduate
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=COEN%202610)

COEN 2710 Microprocessors (3 credits)
Overview of computer system design. Cost and performance specification. Design of arithmetic and logic units. Fundamentals of central processor architecture and a comparative study of computer instruction set architectures. Detailed study of microprocessors, including instruction execution timing and other timing considerations. Discussions of memory and I/O devices, including the interfaces to the CPU and I/O transfer techniques. Study of common bus standards.
Prerequisite: EECE 2030, which must be taken concurrently.
Level of Study: Undergraduate
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=COEN%202710)

COEN 4610 Object-Oriented Software Engineering (3 credits)
Presents advanced software engineering concepts in the context of object-oriented analysis and design. Topics include: concept of object-orientation, UML modeling techniques, use of CASE tools, use-case requirement analysis, modeling with classes, object-oriented design, design patterns, software quality, testing and correctness, sofware reuse and aspect-oriented software engineering.
Prerequisite: COEN 2610.
Level of Study: Undergraduate
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=COEN%204610)

COEN 4620 Modern Programming Practices (3 credits)
Explores advanced topics in computer programming. Topics may include: design patterns, advanced graphical components, software component models such as Java Beans, the Java Security model, Java and databases, servlets, Java Server Pages and Enterprise Java Beans.
Prerequisite: COSC 2100.
Level of Study: Undergraduate
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=COEN%204620)

COEN 4630 Software Testing (3 credits)
Examines the relationship of software testing to quality, emphasizing testing techniques and the role of testing in the validation of system requirements. Topics include: module and unit testing, integration, walkthroughs and inspections, verification and validation, preventing and detecting errors, selecting and implementing project metrics, and defining test plans and strategies traced from system requirements.
Prerequisite: COSC 2100 or equivalent experience.
Level of Study: Undergraduate
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=COEN%204630)

COEN 4650 Introduction to Algorithms (3 credits)
Introduction to the algorithms analysis. Topics to be covered include: the concepts of time and space complexity, advanced data structures, general issues in problem solving methodologies, greedy algorithms, dynamic programming, graph algorithms, AI-related algorithms, and an introduction to NP-completeness theory.
Prerequisite: COSC 2100.
Level of Study: Undergraduate
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=COEN%204650)

COEN 4690 Developments in Computer Software (3 credits)
Course content is announced prior to each semester. Students may enroll in the course more than once because subject matter changes. COEN design elective.
Prerequisite: Cons. of instr. Consent required.
Level of Study: Undergraduate
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=COEN%204690)

COEN 4710 Computer Hardware (3 credits)
Overview of computer system design. Cost and performance specification. Design of arithmetic and logic units. Fundamentals of central processor architecture and a comparative study of computer instruction set architectures. Detailed study of microprocessors, including instruction execution timing and other timing considerations. Discussions of memory and I/O devices, including the interfaces to the CPU and I/O transfer techniques. Study of common bus standards.
Prerequisite: EECE 2030.
Level of Study: Undergraduate
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=COEN%204710)

COEN 4720 Embedded Systems Design (3 credits)
This course introduces students to embedded systems, the types of hardware that can support such systems, and the interfacing used in embedded systems. The course is a combined laboratory and lecture course, which directly applies the embedded systems techniques using hardware description and assembly languages to field programmable gate array technology.
Prerequisite: COEN 2710 and EECE 3015.
Level of Study: Undergraduate
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=COEN%204720)

COEN 4730 Computer Architecture (3 credits)
Review of basic computer architecture. Evaluation of architecture performance. Design and evaluation of instruction sets. Pipeline processors and instruction scheduling. Vector processors. Memory hierarchy and design including cache, main and virtual memories. Memory protection schemes. Input/output and its relation to system performance.
Prerequisite: Sr. stndg. and COEN 2710; or cons. of instr.
Level of Study: Undergraduate
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=COEN%204730)

COEN 4790 Developments in Computer Hardware (3 credits)
Course content is announced prior to each semester. Students may enroll in the course more than once because subject matter changes. COEN design elective.
Prerequisite: Cons. of instr. Consent required.
Level of Study: Undergraduate
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=COEN%204790)

COEN 4800 Networks and Security (3 credits)
A variety of relevant topics are discussed, including communication network architecture, networking protocols, error control, media access control, routing, addressing, congestion/flow control, TCP and UDP, cryptography, authentication and VPNs.
Prerequisite: COEN 2610.
Level of Study: Undergraduate
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=COEN%204800)

COEN 4820 Operating Systems and Networking (3 credits)
Introduces the fundamental concepts of operating systems together with the basics of networking and communications including: memory management, scheduling, concurrent processing, device management, file systems, networking, security and system performance. Examples are drawn from legacy and modern operating systems.
Prerequisite: COSC 2100.
Level of Study: Undergraduate
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=COEN%204820)

COEN 4830 Introduction to Computer Graphics (3 credits)
Introduction to computer graphics algorithm design and implementation; includes considerable actual computer graphics experience. Topics include: point-plotting and line-drawing techniques, two-dimensional curve fitting, two-and three-dimensional graphics, clipping, windowing, hidden line removal, modeling, lighting and shading, 3D viewing, texturing, shadowing, introduction to ray tracing, input-output devices, and other topics as future trends dictate.
Prerequisite: Proficiency in at least one high level computing language.
Level of Study: Undergraduate
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=COEN%204830)

COEN 4840 Computer Security (3 credits)
Introduction to the important issues in computer security, including cryptography, program security, operating system security, database security, and network security. Also discusses the legal, ethical and privacy issues that arise in computer security. Programming projects enable the student to practice implementing many of the security measures discussed in class.
Prerequisite: COSC 2100 or equiv.
Level of Study: Undergraduate
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=COEN%204840)

COEN 4850 Introduction to Intelligent Systems (3 credits)
Provides a broad exposure to intelligent systems, including related fields such as artificial and computational intelligence. Topics include: intelligent agents, search, game playing, propositional logic and first-order predicate calculus, uncertainty, learning, communication and perception and philosophical foundations of intelligent systems.
Prerequisite: COSC 2100, MATH 1450 and MATH 2100.
Level of Study: Undergraduate
Marquette Core Curriculum: NSM Cgntn, Lang, Mmry/Intlgnc
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=COEN%204850)

COEN 4860 Introduction to Neural Networks and Fuzzy Systems (3 credits)
Concepts of artificial neural network architectures and training algorithms, supervised and unsupervised learning, linear and non-linear neural networks, feedback neural networks, applications in scientific and engineering areas, fundamentals of fuzzy sets and fuzzy logic, fuzzy rules and inference systems, fuzzy pattern classification and clustering analysis and fuzzy control systems.
Prerequisite: COSC 2100 and MATH 1451.
Level of Study: Undergraduate
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=COEN%204860)

COEN 4870 Evolutionary Computation (3 credits)
Covers a set of search methods based on the Darwinian principle of survival of the fittest. The methods include genetic algorithms, evolutionary strategies and evolutionary and genetic programming, which have been successfully applied to many different problem domains including optimization, learning, control, and scheduling. Provides students with the background and knowledge to implement various evolutionary computation algorithms, discusses trade-offs between different evolutionary algorithms and other search methods, and discusses issues related to the application and performance evaluation of evolutionary algorithms.
Prerequisite: COSC 2100, MATH 1450 and MATH 2100.
Level of Study: Undergraduate
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=COEN%204870)

COEN 4890 Developments in Intelligent Systems (1-3 credits)
Course content is announced prior to each term. Students may enroll in the course more than once because subject matter changes. Depending upon the subject matter and the instructor, the class may be taught in traditional lecture format or as a seminar which focuses on readings from the current literature.
Prerequisite: Cons. of instr. or Sr. stndg.
Level of Study: Undergraduate
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=COEN%204890)

COEN 4920 Principles of Design (3 credits)
Course content focuses on a structured product design and development process that includes project definition, customer needs identification, product specification, concept generation and concept selection. Also focuses on issues related to teamwork, project management and effective communication. Student team design projects culminate in the development of a technically and economically viable concept and a proposal for future development of this concept (done in the second semester of this two-course sequence). 2 hr. lec., 1 hr. disc.
Prerequisite: Sr. stndg.; Co-op students, Jr. stndg. Cross-listed with BIEN 4920, ELEN 4920 and MEEN 4920.
Level of Study: Undergraduate
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=COEN%204920)

COEN 4995 Independent Study in Computer Engineering (1-4 credits)
Undergraduate independent study project of either a theoretical or experimental nature.
Prerequisite: Jr. stndg. or Sr. stndg., 3.000 GPA, cons. of instr., and cons. of dept. ch. Consent required.
Level of Study: Undergraduate
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=COEN%204995)

COEN 4998 Senior Design Project (3 credits)
Focus on detailed design, prototyping and testing design concepts. Includes topics directly relevant to student design projects and careers in the engineering profession. Student team design projects culminate in a final report that documents the performance and details (engineering drawings and/or documentation) of their final design. 2 hrs. lec., 1 hr. disc.
Prerequisite: COEN 4920; Cross-listed with BIEN 4998, ELEN 4998 and MEEN 4998.
Level of Study: Undergraduate
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=COEN%204998)

EECE 1200 Introduction to Computer and Electrical Engineering 1 (2 credits)
Introduction to computer engineering and electrical engineering through in-class tutorials to support hands-on activities in the computer and electrical engineering disciplines focusing on computer engineering topics relevant to both disciplines. Guest presentations by EECE instructors and industry representatives describe the education and skills needed for engineering careers in these disciplines. A formal opportunity for first-year computer engineering (COEN) and electrical engineering (ELEN) students to interact with their peers and other members of the EECE Department.
Prerequisite: Enrolled in the OPUS College of Engineering.
Level of Study: Undergraduate
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=EECE%201200)

EECE 1210 Introduction to Computer and Electrical Engineering 2 (2 credits)
Introduction to electrical engineering and computer engineering through in-class tutorials to support hands-on activities focusing on electrical engineering topics relevant to both disciplines. Guest presentations by EECE instructors and industry representatives describe the education and skills needed for engineering careers in these disciplines. A formal opportunity for first-year computer engineering (COEN) and electrical engineering (ELEN) students to interact with their peers and other members of the EECE department.
Prerequisite: Enrolled in the OPUS College of Engineering.
Level of Study: Undergraduate
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=EECE%201210)

EECE 1610 Introduction to Computer Programming (3 credits)
Students are introduced to computer programming with an emphasis on object-oriented programming (OOP) and OOP design methodologies. The students learn about typical programming constructs including data types, data structures, control structures, data input and output techniques as well as several algorithms used for solving engineering problems. In addition, students learn to use modern programming tools in an integrated development environment by focusing on developing software solutions to significant engineering problems.
Prerequisite: Enrolled in the OPUS College of Engineering.
Level of Study: Undergraduate
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=EECE%201610)

EECE 2001 Fundamentals of Electric Circuits (3 credits)
Circuit modeling; basic solution methods for DC and AC circuits; DC, transient, and AC analysis of first order and second order circuits. May not be taken for credit by ELEN majors.
Level of Study: Undergraduate
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=EECE%202001)

EECE 2010 Electric Circuits 1 (3 credits)
Ohm's law and Kirchhoff's laws. Mesh and loop analysis of resistive circuits with DC sources. Source transformations. Thevenin's and Norton's theorems. Natural and step response of first- and second-order circuits. Circuits with ideal op amps.
Prerequisite: MATH 1451 or MATH 1455, which may be taken concurrently; enrolled in the OPUS College of Engineering.
Level of Study: Undergraduate
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=EECE%202010)

EECE 2015 Circuits Laboratory 1 (1 credits)
Introduction to circuit design, construction, and test. The basics of circuit construction techniques and electronic test measurement skills are covered. Circuit components such as resistors, inductors, capacitors and op-amps are used. Emphasis placed on DC and transient response of circuits. 1 hr. lec., 2 hrs. lab. EECE 2010 or EECE 2001 must be taken concurrently.
Level of Study: Undergraduate
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=EECE%202015)

EECE 2030 Digital Electronics (3 credits)
Introduces students to the basic principles of digital circuit analysis and design. Topics covered include: Boolean Algebra, number systems, basic logic gates, standard combinational circuits, combinational design, timing diagrams, flip-flops, sequential design, standard sequential circuits and programmable logic devices.
Prerequisite: Soph. stndg.
Level of Study: Undergraduate
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=EECE%202030)

EECE 2035 Circuits Laboratory 2 (1 credits)
Circuit design, construction and test skills are expanded to include digital circuits and programmable logic devices as well as passive and active filters. Emphasis placed on DC, AC and transient response of circuits containing passive and active devices. 1 hr. lec., 2 hrs. lab.
Prerequisite: EECE 2010, EECE 2015, ELEN 2020 or COEN 2020, either of which may be taken concurrently and EECE 2030, which may be taken concurrently.
Level of Study: Undergraduate
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=EECE%202035)

EECE 3010 Electronic Devices and Applications (3 credits)
Electronic components are discussed including semiconducting diodes, bipolar junction transistors, field effect transistors, etc. These devices are analyzed from their terminal characteristics and their behavior in representative electronic circuits. Applications for devices include simple power supply analysis and design, class A amplifier analysis including transistor biasing and stability analysis, simple digital logic gates, etc.
Prerequisite: EECE 2010.
Level of Study: Undergraduate
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=EECE%203010)

EECE 3015 Introduction to Microcontrollers Laboratory (2 credits)
Introduction to the use of microcontrollers and embedded systems with a focus on software and hardware typically encountered in sensor and control applications. 1 hr. lec., 3 hrs. lab.
Prerequisite: EECE 2030; and EECE 1610 or BIEN 1120.
Level of Study: Undergraduate
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=EECE%203015)

EECE 4410 Introduction to Device Fabrication (3 credits)
Fundamentals of integrated circuit (IC) and semiconductor device fabrication technology. Also studies specialized microelectromechanical systems (MEMS) processing. Students develop an advanced understanding of all aspects of IC fabrication including: materials (Si, SiO2, GaAs, Al, Au, etc.), processes (deposition, etching, lithography, oxidation/diffusion, etc.), and equipment (reactive ion etching, evaporator, plasma sputtering, chemical vapor deposition, etc.). Includes both theoretical and experimental considerations.
Prerequisite: Sr. stndg.
Level of Study: Undergraduate
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=EECE%204410)

EECE 4510 Digital Signal Processing (3 credits)
Introduction to the theory and practice of discrete-time signals and systems. Concepts covered include Fourier Transforms, Z-transforms, linear time invariant system analysis in the time and frequency domains, sampling theory and Discrete Fourier Transforms. Application of these concepts includes digital filter design techniques and the use of Fast Fourier Transforms for efficient frequency domain analysis. Labs and design projects related to specific signal processing applications are used to illustrate the material, including topics such as audio and image processing.
Prerequisite: ELEN 3020 or BIEN 3300; or cons. of instr.
Level of Study: Undergraduate
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=EECE%204510)

EECE 4520 Digital Image Processing (3 credits)
Theory and practice of image digitization, processing, coding and analysis. Representations of images, image models. Techniques of image enhancement and restoration. Image compaction and coding. Segmentation and image understanding. Students have the opportunity to experiment with several image processing techniques using the MATLAB Image Processing Toolbox.
Prerequisite: ELEN 3020.
Level of Study: Undergraduate
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=EECE%204520)

EECE 4530 Probability and Statistics for Engineers (3 credits)
Introduction to probability: probability space, random variables, distribution/density functions, expectation, correlation; transformation of random variables; elements of statistics: sample means, confidence intervals, survival rate, hypothesis testing, model parameter estimation; computational statistical analysis using Matlab; elements of stochastic processes: autocorrelation functions, power spectral density, wide-sense stationary processes, transmission through linear time-invariant systems; applications to engineering problems in circuits, reliability, failure analysis, data communication, computer networks, signal processing, and internet-traffic models.
Prerequisite: ELEN 3020.
Level of Study: Undergraduate
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=EECE%204530)

EECE 4740 Advanced VHDL and FPGA Design (3 credits)
Present the background, abstractions, and techniques for advanced digital circuits design and optimization. Emphasis is placed on specification and synthesis using VHDL and on prototyping using FPGAs of complex systems. Such systems represent examples from various application domains, including processors, image and video processing, filtering and other DSPs, and power electronics.
Prerequisite: EECE 2030, EECE 3015.
Level of Study: Undergraduate
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=EECE%204740)

Engineering Ethics & Values

ENEV 1952 Ethics and Values Colloquium 1 (1 credits)
The colloquium consists of a series of lectures, films, and discussions involving social problems with significant technical components, societal values and engineering ethics. S/U grade assessment.
Level of Study: Undergraduate
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=ENEV%201952)

ENEV 2952 Ethics and Values Colloquium 2 (1 credits)
Consists of a series of lectures, films and discussions involving social problems with significant technical components, societal values and engineering ethics. S/U grade assessment.
Prerequisite: ENEV 1952.
Level of Study: Undergraduate
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=ENEV%202952)

ENEV 3952 Ethics and Values Colloquium 3 (1 credits)
Consists of a series of lectures, films and discussions involving social problems with significant technical components, societal values and engineering ethics. S/U grade assessment.
Prerequisite: ENEV 2952.
Level of Study: Undergraduate
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=ENEV%203952)

ENEV 4952 Ethics and Values Colloquium 4 (1 credits)
Consists of a series of lectures, films and discussions involving social problems with significant technical components, societal values and engineering ethics. S/U grade assessment.
Prerequisite: ENEV 3952.
Level of Study: Undergraduate
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=ENEV%204952)

ENEV 4995 Independent Study (1-4 credits)
Undergraduate independent study project of either a theoritical or experimental nature.
Prerequisite: Jr. stndg, 3.000 GPA, cons. of instr., and cons. of dept. ch.
Level of Study: Undergraduate
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=ENEV%204995)

General Engineering Courses

GEEN 1120 Introduction to Engineering Graphics (1 credits)
Practicing and understanding the engineering graphics fundamentals and application of computer-aided design (CAD), utilizing solid modeling software to develop typical industrial product 3-D models and drawings.
Prerequisite: Enrolled in Engineering.
Level of Study: Undergraduate
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=GEEN%201120)

GEEN 1130 Introduction to Engineering Computing (1 credits)
Introduces students to an engineering programming environment and the corresponding algorithm and logic development. Students apply engineering computing techniques to solve selected engineering (model) equations and problems.
Prerequisite: Enrolled in the College of Engineering.
Level of Study: Undergraduate
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=GEEN%201130)

GEEN 1200 Engineering Discovery 1 (3 credits)
Introduces students to engineering and engineers, engineering system investigation and modeling, and engineering graphics fundamentals and computer-aided design (CAD). The lecture and laboratory topics, contents and activities include engineering essentials and Fermi's questions/problems, scientific and engineering dimensions and units, introduction to spreadsheet computing, engineering graphics fundamentals and computer-aided design (CAD), utilizing solid modeling software, and engineering system investigation through various department modules. Professionalism, teamwork and technical communication are stressed. Students participate in a team-based computer graphics design project at the end of the term.
Prerequisite: Enrolled in the College of Engineering.
Level of Study: Undergraduate
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=GEEN%201200)

GEEN 1210 Engineering Discovery 2 (3 credits)
Introduces students to engineering problem solving, the engineering design process and engineering computing. The lecture and laboratory topics/contents and activities include engineering problem solving steps/procedures, introduction to the engineering design process, introduction to programming basics and their applications to scientific and engineering problems, and multidisciplinary engineering problem solving through various department modules. Professionalism, teamwork, and technical communication are stressed. Students participate in a team-based engineering design projects during the semester.
Prerequisite: BIEN 1100, CEEN 1200, EECE 1200, or GEEN 1200; enrollment in the Opus College of Engineering.
Level of Study: Undergraduate
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=GEEN%201210)

GEEN 2110 Statics (3 credits)
Fundamentals of forces and force systems. Internal and external forces. Support reactions. Definition of a free-body diagram (FBD). Emphasis on development of FBD-drawing skills. Moment of a force. Force system resultants. Vector methods in two and three dimensions. Equilibrium analysis of particles and rigid bodies. Truss analysis by methods of joints and sections. Analysis of simple frames and machines. Analysis of friction. Centroids of composite areas and volumes. Resultants of distributed loads.
Prerequisite: MATH 1451 or MATH 1455; enrolled in the OPUS College of Engineering.
Level of Study: Undergraduate
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=GEEN%202110)

GEEN 2120 Dynamics (3 credits)
Fundamental relationships between forces applied to a body and the body motion. Kinematics and kinetics of particles and rigid bodies in planar motion. Applications using Newton-Euler, Work-Energy, and Impulse-Momentum methods.
Prerequisite: GEEN 2110.
Level of Study: Undergraduate
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=GEEN%202120)

GEEN 2130 Mechanics of Materials (3 credits)
Concepts of stress, strain and deflection. Factor of safety. Mechanical properties of materials. Stress and deformation calculations for cases of axially loaded rods, torsion of circular shafts, beam bending and combined loading. Horizontal shear connectors in built-up beams. Area moment of inertia. Parallel-axis theorem. Introduction to beam design. Stress concentration. Stress transformation and principal stress calculation by Mohr's circle. Statically indeterminate analysis. Elastic buckling of columns.
Prerequisite: GEEN 2110.
Level of Study: Undergraduate
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=GEEN%202130)

GEEN 2952 Professional Development for Engineers (1 credits)
Objective is to assist engineering students with their career discernment and to promote professional development. Focuses on the skills needed to secure a job and provides resources and tools to conduct a job search. Topics include: professional development; engineering options; cooperative education and internship opportunities; ethics as well as job search, resume writing, interviewing, professional communication and networking techniques. All sophomore-level and transfer students required to attend.
Prerequisite: Enrolled in the College of Engineering.
Level of Study: Undergraduate
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=GEEN%202952)

GEEN 2960 Engineering Social Systems and Values (0 credits)
Reflection providing an awareness of an engineer's professional responsibilities to the community and world at large. Students are required to participate in an approved experiential learning experience, such as service, research, internship or co-operative education activity and demonstrate that they have engaged with and added value to others across differences in social and/or values systems. Students should reflect upon their own values and social contexts, and develop their capacity to engage with social and value systems different from their own in their place of work or service. Students critically reflect upon how the experience broadened their viewpoints and developed intercultural competencies. S/ grade assessment.
Prerequisite: GEEN 2952, enrolled in the Opus College of Engineering, and cons. of dept. Consent required.
Level of Study: Undergraduate
Marquette Core Curriculum: Engage Social Systms & Values 2
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=GEEN%202960)

GEEN 2961 E-Lead 1: Foundations of Leadership and Individual Development (2 credits)
Identifying and developing individual leadership traits, skills, talents, values, beliefs and behaviors through weekly course work and a week-long leadership conference that contribute to effective leadership practice in a multi-disciplinary environment. Investigation of leadership theories and styles that contribute to effective leadership practice in various environments with people from different backgrounds and perspectives. Personality and behavioral assessments, case studies, readings, presentations, role-playing and simulations are emphasized along with a workshop related to adversity and resilience.
Prerequisite: Second year, full-time student, admitted to the E-Lead Program in the Opus College of Engineering.
Level of Study: Undergraduate
Marquette Core Curriculum: Writing Intensive
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=GEEN%202961)

GEEN 3959 E-Lead Experience: Explorations in Innovation Leadership Practice (2 credits)
Develop skills and practices important for life-long learning related to personal leadership growth and development as an innovator. Studies include selecting and reading E-Lead approved leadership and innovation texts and producing video book reports about the texts; discussing other leadership and innovation texts and reports with peers in the class; identifying, arranging and participating in a shadow experience with innovative leaders in industry.
Prerequisite: GEEN 2961, admitted to the E-Lead Program in the Opus College of Engineering. Consent required.
Level of Study: Undergraduate
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=GEEN%203959)

GEEN 3961 E-Lead 2: Leading With Others (2 credits)
Identifying and developing skills, talents, behaviors and attributes which contribute to effective leadership of teams and projects, especially multi-disciplinary teams working on innovative projects. Investigation into emotional intelligence, team dynamics, collaboration, inclusion and diversity, communication, confrontation, feedback, change management, global leadership and servant leadership. Simulations, role-playing, case studies, readings, presentations and team problem-solving are emphasized along with a workshop related to having honest and authentic conversations.
Prerequisite: GEEN 2961, admitted to the E-Lead Program in the Opus College of Engineering.
Level of Study: Undergraduate
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=GEEN%203961)

GEEN 3990 E-Lead Experience: Professional Leadership Experience (1 credits)
Students in the E-Lead Program are required to participate in a professional experience such as an internship, co-op, clinical rotation, undergraduate research project, etc. During these experiences, E-Leaders make observations and reflect on their experience through the three leadership themes of the E-Lead Program - leading oneself, leading with others and leading innovation. Upon completion of the experience, students submit a reflective and integrative paper about the experience in their role, responding to predetermined questions and citing specific examples from the professional leadership experience to describe their observations and assertions.
Prerequisite: GEEN 2961, admitted to the E-Lead Program in the Opus College of Engineering.
Level of Study: Undergraduate
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=GEEN%203990)

GEEN 3991 Co-Op Work Period 1 (0 credits)
Registration for approved cooperative education program work assignments is required of all co-op students. Grading and credits are accomplished in the accompanying following term when registered for courses numbered 3991, 3992, etc. Fee. S/U grade assessment.
Prerequisite: Enrolled in Opus College of Engineering and Co-op student.
Level of Study: Undergraduate
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=GEEN%203991)

GEEN 3992 Co-Op Grading Period 1 (1 credits)
Grading for preceding co-op work assignments is accomplished by review of employer evaluation forms, work exit reports, and other materials as required during each term in school following a work period. No tuition is charged for grading periods. S/U grade assessment.
Prerequisite: Enrolled in Opus College of Engineering, Co-op student and GEEN 3991.
Level of Study: Undergraduate
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=GEEN%203992)

GEEN 3993 Co-Op Work Period 2 (0 credits)
Registration for approved cooperative education program work assignments is required of all co-op students. Grading and credits are accomplished in the accompanying following term when registered for courses numbered 3991, 3992, etc. Fee. S/U grade assessment.
Prerequisite: Enrolled in Opus College of Engineering, Co-op student and GEEN 3992.
Level of Study: Undergraduate
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=GEEN%203993)

GEEN 3994 Co-Op Grading Period 2 (1 credits)
Grading for preceding co-op work assignments is accomplished by review of employer evaluation forms, work exit reports, and other materials as required during each term in school following a work period. No tuition is charged for grading periods. S/U grade assessment.
Prerequisite: Enrolled in Opus College of Engineering, Co-op student and GEEN 3993.
Level of Study: Undergraduate
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=GEEN%203994)

GEEN 4810 Industrial Ecology and Sustainable Design (3 credits)
Introduces students to the emerging sustainability challenges and impacts on industry and engineering design. Analyzes corporate frameworks to identify and prioritize sustainability initiatives that add business value. Learn tools to characterize sustainability aspects of design and apply the tools in multi-disciplinary case studies to generate recommendations. Integrates essential communication skills to present case study results to various stakeholders.
Prerequisite: Jr. stndg. and cons. of instr.; or Sr. stndg. Consent required.
Level of Study: Undergraduate
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=GEEN%204810)

GEEN 4820 Systems Engineering Principles and Practice (3 credits)
Introduces fundamental systems engineering principles and practices for the development of complex systems throughout the system life cycle: from concept development to engineering development, production, operation and support. Specific topics include needs analysis, concept exploration, concept definition, engineering design, integration and evaluation, production and operation and support. In addition, essential systems engineering methods and tools such as trade-off analysis, risk management, and modeling and simulation are covered.
Prerequisite: Jr. stndg. and cons. of instr.; or Sr. stndg.
Level of Study: Undergraduate
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=GEEN%204820)

GEEN 4830 Engineering Risk Analysis (3 credits)
Introduces key techniques and tools used to establish system design decisions – amid uncertainty – from a risk analysis perspective. Evaluates a holistic view of sources, consequences and mitigation of risks. Important emergent properties that result from effective system risk analysis, such as safety and resilience, are discussed.
Level of Study: Undergraduate
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=GEEN%204830)

GEEN 4840 Model-Based Systems Engineering (3 credits)
Develops experience in the application of model-based systems engineering (MBSE) tools and methodologies to define, analyze and design a complex system. Students will incrementally build and analyze a system model that consists of the following perspectives/levels: operational need, system need, logical architecture and physical architecture.
Prerequisite: GEEN 4830.
Level of Study: Undergraduate
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=GEEN%204840)

GEEN 4850 Global Engineering Practice: Leadership and Culture (3 credits)
Develops global competencies in engineering contexts and helps students understand how problems and viable solutions vary across contexts, and how intercultural communication and global leadership are important in an interconnected global workforce. Additionally, students learn about political, technological, social, cultural, educational and environmental differences and their impact on engineering practice. Taught in a seminar format with a lead faculty and guest lecturers. Students can participate in applied learning through individual and team assignments. Students have the opportunity to travel abroad at the end of the semester for two weeks. The on-campus experience provides students with strategies and background materials to ensure that time spent abroad is meaningful and productive.
Prerequisite: Soph. stndg.
Level of Study: Undergraduate
Marquette Core Curriculum: Engage Social Systms & Values 2
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=GEEN%204850)

GEEN 4931 Topics in General Engineering (3 credits)
Course content announced prior to each term.
Level of Study: Undergraduate
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=GEEN%204931)

GEEN 4961 E-Lead 3: Leading Innovation (2 credits)
Identifying and developing skills, talents, behaviors and attributes which contribute to effectively leading innovation in various contexts. Investigation into understanding innovation as a business strategy, sources and types of innovation, the mindset and skill set required to lead innovation, barriers to innovation, building a culture that supports innovation, ethical conduct and practical implementation of innovation. Simulations, case studies, readings, projects, presentations and problem-solving are emphasized along with a day-long boot camp related to innovation practices.
Prerequisite: GEEN 3961, admitted to the E-Lead Program in the Opus College of Engineering.
Level of Study: Undergraduate
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=GEEN%204961)

GEEN 4991 Co-Op Work Period 3 (0 credits)
Registration for approved cooperative education program work assignments is required of all Co-op students. Grading and credits are accomplished in the accompanying following term when registered for courses numbered 3991, 3992, etc. Fee. S/U grade assessment.
Prerequisite: Enrolled in Opus College of Engineering, Co-op student and GEEN 3994.
Level of Study: Undergraduate
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=GEEN%204991)

GEEN 4992 Co-Op Grading Period 3 (1 credits)
Grading for preceding co-op work assignments is accomplished by review of employer evaluation forms, work exit reports, and other materials as required during each term in school following a work period. No tuition is charged for grading periods. S/U grade assessment.
Prerequisite: Enrolled in Opus College of Engineering, Co-op student and GEEN 4991.
Level of Study: Undergraduate
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=GEEN%204992)

GEEN 4993 Co-Op Work Period 4 (0 credits)
Registration for approved cooperative education program work assignments is required of all Co-op students. Grading and credits are accomplished in the accompanying following term when registered for courses numbered 3991, 3992, etc. Fee. S/U grade assessment.
Prerequisite: Enrolled in Opus College of Engineering, Co-op student and GEEN 4992.
Level of Study: Undergraduate
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=GEEN%204993)

GEEN 4994 Co-Op Grading Period 4 (1 credits)
Grading for preceding co-op work assignments is accomplished by review of employer evaluation forms, work exit reports, and other materials as required during each term in school following a work period. No tuition is charged for grading periods. S/U grade assessment.
Prerequisite: Enrolled in Opus College of Engineering, Co-op student and GEEN 4993.
Level of Study: Undergraduate
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=GEEN%204994)

GEEN 4995 Independent Study in General Engineering (1-3 credits)
Undergraduate independent study project of either theoretical or experimental nature.
Prerequisite: Jr. stndg., 3.000 GPA, cons. of instr., and cons. of dept. ch. Consent required.
Level of Study: Undergraduate
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=GEEN%204995)

GEEN 4998 E-Lead Experience: Capstone Project (3 credits)
The culminating innovation leadership experience for students completing the E-Lead Program. Student uses all knowledge and skills gained in the prerequisite E-Lead courses to intentionally develop both personal leadership capacity and impact the people and processes of a final capstone project.
Prerequisite: GEEN 4961, admitted to the E-Lead Program in the Opus College of Engineering.
Level of Study: Undergraduate
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=GEEN%204998)

Mechanical Engineering

MEEN 2460 Materials Science (3 credits)
Fundamental principles of materials science and engineering. Topics include atomic structure of matter, types of bonding, crystallography, role of imperfections, diffusion, phase diagrams, phase transformations, mechanical behaviors, fracture of materials, classification and property of materials. Laboratory experiments to develop understanding of processing-structure-property relationship in materials. 2 hrs. lec.; 2 hrs. lab.
Prerequisite: CHEM 1001, which may be taken concurrently. Enrolled in the Opus College of Engineering.
Level of Study: Undergraduate
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=MEEN%202460)

MEEN 2930 Special Topics in Mechanical Engineering (1-5 credits)
Offered as an experimental course to evaluate and determine if a course should be incorporated into the regular curriculum of a program, or courses in the approval process pipeline, but not yet officially approved. Once the same course has been offered twice as a Special Topic, it cannot be offered again until it moves through the curriculum approval process and is approved with a regular curriculum course number.
Prerequisite: Enrolled in the Opus College of Engineering.
Level of Study: Undergraduate
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=MEEN%202930)

MEEN 3210 Measurements and Controls (3 credits)
Fundamentals of measurement/instrumentation systems and control systems. Measurement topics include: sensors, signal conditioners, data acquisition, and transducers for measurement of strain, force, displacement, temperature, flow, pressure, and other engineering parameters. Control system topics include: mathematical modeling of dynamic systems, and analysis and design of systems using sensors, actuators, and controllers. Time-domain and frequency-domain methods for design of feedback control systems. Computer and laboratory exercises using MATLAB and LabVIEW. 2 hrs. lec., 2 hrs. lab.
Prerequisite: GEEN 2120 and ELEN 3001.
Level of Study: Undergraduate
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=MEEN%203210)

MEEN 3220 Dynamics of Mechanical Systems (3 credits)
Analytical and computational analysis of the kinematics and kinetics of planar multi-body mechanical systems. Vibration analysis of single degree of freedom systems. Engineering applications including dynamic balancing, vibration absorption and vibration isolation.
Prerequisite: MATH 2451 or MATH 2455; and GEEN 2120.
Level of Study: Undergraduate
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=MEEN%203220)

MEEN 3250 Design of Machine Elements 1 (4 credits)
Detailed design of structural elements, shafts, gears, bearings and other machine elements. Laboratory activities which cover the theoretical and experimental analysis of machine elements. 3 hrs. lec., 2 hrs. lab.
Prerequisite: GEEN 2110 and GEEN 2130.
Level of Study: Undergraduate
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=MEEN%203250)

MEEN 3260 Numerical Methods of Mechanical Systems (3 credits)
Numerical algorithms (math analysis, optimization, function approximation) for analysis and preliminary design of engineering systems. Development and use of MATLAB functions. Finite difference and finite element analysis of thermal and elastic systems. 3 hrs. lec.
Prerequisite: MATH 2451 and GEEN 2130.
Level of Study: Undergraduate
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=MEEN%203260)

MEEN 3310 Thermodynamics 1 (3 credits)
Elementary principles of equilibrium thermodynamics. Property relationships for pure substances, ideal gases and incompressible substances. Work and heat transfer, mass conservation and the first and second laws of thermodynamics applied to closed and open systems, operating at steady and unsteady conditions. Thermal efficiencies of thermodynamic cycles and isentropic efficiencies of single-stream devices.
Prerequisite: MATH 1451 or MATH 1455; PHYS 1030, PHYS 1003 or PHYS 1013; and PHYS 1020.
Level of Study: Undergraduate
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=MEEN%203310)

MEEN 3320 Fluid Mechanics (3 credits)
Fundamental conservation laws of mass, momentum and energy as applied to fluid systems. Properties of fluids, hydrostatics, flow of real fluids in closed and open systems, dynamic similarity, dimensional analysis and viscid and inviscid fluid flow.
Prerequisite: MATH 2450 or MATH 1455; and GEEN 2120.
Level of Study: Undergraduate
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=MEEN%203320)

MEEN 3330 Fundamentals of Heat Transfer (3 credits)
Overview of principal mechanisms of heat transfer: conduction, convection, and thermal radiation. Application of conduction and forced convection to heat exchangers. Discussion of theory and applications of conduction, forced and natural convection, boiling and condensation and thermal radiation.
Prerequisite: MATH 2451 or MATH 2455; MEEN 3310; and MEEN 3320 or BIEN 4400.
Level of Study: Undergraduate
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=MEEN%203330)

MEEN 3340 Thermodynamics 2 (3 credits)
The culmination of thermodynamic, fluid and heat transfer concepts to the application of power and refrigeration cycles, psychrometrics systems, and combustion processes. Includes a laboratory section in which experiments are conducted to demonstrate, test and assess devices, processes and cycles. 2 hrs. lec.; 2 hrs. lab.
Prerequisite: MEEN 3310; MEEN 3330, which may be taken concurrently.
Level of Study: Undergraduate
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=MEEN%203340)

MEEN 3426 Engineering Statistics (3 credits)
Introductory course in statistics, which is the field of study concerned with the collection, analysis and interpretation of uncertainty in data. Topics include summary statistics, basic probability, commonly used distributions, confidence intervals, and hypothesis testing. In addition, introductory concepts of engineering economy and cash flow diagrams will be covered in the first few weeks of the course to prepare students for the FE exam.
Prerequisite: MATH 1451 or MATH 1455.
Level of Study: Undergraduate
Marquette Core Curriculum: NSM Expanding Our Horizons
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=MEEN%203426)

MEEN 3443 Manufacturing Engineering (3 credits)
The types of processes available to manufacture various products. The characteristics of these processes and how they interact with design requirements, tolerances, safety and the environment. Integration of basic concepts into complete processes. Determination of the process to manufacture various assigned products. 2 hrs. lec., 2 hrs. lab.
Prerequisite: MEEN 2460.
Level of Study: Undergraduate
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=MEEN%203443)

MEEN 3460 Materials Selection in Mechanical Design (3 credits)
Design methodology and the criteria for the selection of materials from the four classes of materials (metals, plastics, ceramics and composites) are discussed. Criteria include processing requirements, mechanical properties, and environmental resistance. A rationale for selecting materials based on materials selection charts is presented. The process-structure-property relationship for ferrous and non-ferrous alloys, plastics, ceramics and composites is presented from the point of view of understanding selection criteria. Considerations of cost and availability are also taken into consideration. 3 hrs. lec.
Prerequisite: MEEN 2460.
Level of Study: Undergraduate
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=MEEN%203460)

MEEN 4110 Mechanical Engineering Potpourri (3 credits)
Survey of practical engineering tools and processes utilizing in entry-level engineering positions. Comparison of engineering philosophical paradigms underlying the industrial state gate product design process from ideation, product, design, product manufacture and quality control to end of product life.
Prerequisite: Sr. stndg.
Level of Study: Undergraduate
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=MEEN%204110)

MEEN 4220 Intermediate Dynamics (3 credits)
Develop an understanding of the principles of 3D rigid body kinematics (motion) and kinetics (forces and accelerations). Use these principles to analyze the dynamic behavior of mechanical systems. Learn to use analytical mechanics tools including virtual work and Lagrange's method. Develop a systematic approach for solving engineering problems.
Prerequisite: MEEN 2120.
Level of Study: Undergraduate
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=MEEN%204220)

MEEN 4230 Intermediate Mechanics of Materials (3 credits)
Review of beam theory; asymmetric bending, shear center, thin-walled sections; torsion of non-circular sections, open and closed thin-walled sections; energy methods, Castigliano's second theorem, statically indeterminate structures, internal static indeterminacy; curved beams.
Prerequisite: GEEN 2130.
Level of Study: Undergraduate
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=MEEN%204230)

MEEN 4260 Introduction to Continuum Mechanics (3 credits)
Introduction to tensor notation, tensor analysis and coordinate system invariance; analysis of stress, strain and rate of strain for infinitesimal and finite deformation; application of Newtonian mechanics to deformable media; mechanical constitutive equations; field equations for solid and fluid mechanics.
Prerequisite: MATH 2451, Co-req: MATH 3100 or MEEN 3260, or equivalent.
Level of Study: Undergraduate
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=MEEN%204260)

MEEN 4265 Intermediate Finite Element Methods (3 credits)
Introduces the finite element solution method for linear, static problems. Includes calculation of element stiffness matrices, assembly of global stiffness matrices, exposure to various finite element solution methods, and numerical integration. Emphasizes structural mechanics, and also discusses heat transfer and fluid mechanics applications in finite element analysis. Computer assignments include development of finite element code (FORTRAN or C) and also use of commercial finite element software (ANSYS and/or MARC).
Prerequisite: MEEN 3260.
Level of Study: Undergraduate
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=MEEN%204265)

MEEN 4270 Physical Systems Modeling (3 credits)
Principles of modeling of physical systems, including devices and processes. Development of models of physical systems: mechanical, electrical, fluid, thermal and coupled systems. Time-dependent behavior of interconnected devices and processes. Computer-based modeling and simulation of physical systems. Identification using models and measured data. Introduction to control systems analysis and design.
Prerequisite: MATH 2451.
Level of Study: Undergraduate
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=MEEN%204270)

MEEN 4275 Mechatronics (3 credits)
Mechatronics, as an engineering discipline, is the synergistic combination of mechanical engineering, electronics, control engineering, and computer science, all integrated through the design process. This course covers mechatronic system design, modeling and analysis of dynamic systems, control sensors and actuators, analog and digital control electronics, interfacing sensors and actuators to a microcomputer/microcontroller, discrete and continuous controller design, and real-time programming for control.
Prerequisite: MEEN 3210 and MEEN 3220.
Level of Study: Undergraduate
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=MEEN%204275)

MEEN 4310 Combustion: Thermochemistry, Kinetics and Applications (3 credits)
Fundamentals of combustion, including thermodynamics, chemical equilibrium and chemical kinetics. The application of the principles are emphasized for the development of mathematical models in MATLAB that can be used to simulate combustion in fundamental reactors and internal combustion engines. Prior experience with computer programming is recommended.
Prerequisite: MEEN 3340 and MEEN 3260.
Level of Study: Undergraduate
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=MEEN%204310)

MEEN 4320 Internal Combustion Engines (3 credits)
Fundamental aspects of the design and operating characteristics of spark-ignition and diesel engines. Presents an overview of the thermodynamics, combustion, fluid flow and heat transfer that takes place within the engine cylinder. Discusses efficiency and emissions challenges that the engine must meet.
Prerequisite: MEEN 3330 and MEEN 3340.
Level of Study: Undergraduate
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=MEEN%204320)

MEEN 4325 Intermediate Fluid Mechanics (3 credits)
Intermediate Fluid Mechanics continues to develop fluid mechanic concepts, building on a working knowledge of the Reynolds Transport Theorem. Topics include: differential analysis, irrotational flow theory, boundary layer theory and compressible flow theory. Both laminar and turbulent flows are discussed. Some working knowledge of computer programming is necessary.
Prerequisite: MATH 2450 or MATH 2455, and MEEN 3320 or equiv.
Level of Study: Undergraduate
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=MEEN%204325)

MEEN 4350 Transport Phenomena (3 credits)
The subject of transport phenomena includes three closely related topics: fluid dynamics, mass transfer, and heat transfer. Fluid dynamics involves the transport of momentum, mass transfer is concerned with the transport of mass of various chemical species, and heat transfer deals with the transport of energy. In practice, rarely are these phenomena acting alone. Thus in this introductory course, these three topics are studied together so that a more cohesive understanding of these interrelated processes is developed.
Prerequisite: MEEN 3340.
Level of Study: Undergraduate
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=MEEN%204350)

MEEN 4360 Intermediate Thermodynamics (3 credits)
This intermediate course will cover fundamentals of thermodynamics, including classical and statistical approaches with application to equilibrium and non-equilibrium, non-reactive and reactive systems. Topics relevant to micro/nanoscale and biological systems may be covered.
Prerequisite: MEEN 3340.
Level of Study: Undergraduate
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=MEEN%204360)

MEEN 4370 Heat Exchangers Design and Analysis (3 credits)
Addresses the fundamental thermal-hydraulic equations and correlations used to design and analyze various types of heat exchangers. A systematic approach/method to the thermal-hydraulic design and analysis, or rating, of various types of heat exchanger systems through selected virtual and real problems.
Level of Study: Undergraduate
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=MEEN%204370)

MEEN 4380 Renewable Energy - Fundamentals and Applications (3 credits)
Emphasis on thermodynamics, heat transfer and fluid mechanics aspects of renewable energy systems and applications. Topics include solar, wind, hydropower, geothermal, biomass, and wave and tide. Both technical and economic analyses of renewable energy systems.
Level of Study: Undergraduate
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=MEEN%204380)

MEEN 4410 Experimental Design (3 credits)
Application of statistical concepts to design engineering experiments to improve quality, production techniques, and reliability. Use and advantages of various models; factorial, fractional factorial, orthogonal arrays and fractional designs.
Prerequisite: MATH 4720 or MEEN 3426 or cons. of instr.
Level of Study: Undergraduate
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=MEEN%204410)

MEEN 4420 Failure Analysis (3 credits)
Methodology of failure analysis. Studies of brittle fracture, ductile fracture, fatigue, stress corrosion and electro-chemical corrosion as applied to the failure of metals. Involves some laboratory work and analyses of a variety of metallurgical failures.
Prerequisite: MEEN 2460 and GEEN 2130.
Level of Study: Undergraduate
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=MEEN%204420)

MEEN 4430 Powder Metallurgy (3 credits)
The course introduces a modern technology with growing importance. It covers the basics of powder metallurgy with main emphasis on sintered steel. The primary topics covered are powder production, die compacting, sintering theory and practice, full density processing, properties under static and dynamic loading conditions.
Prerequisite: MEEN 2460.
Level of Study: Undergraduate
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=MEEN%204430)

MEEN 4440 Processing and Forming of Materials (3 credits)
Solidification and microstructural development in metal casting with an overview of selected melting processes. Overview of primary and secondary working principles involved in ferrous materials processing. Stress based and finite element analyses are applied to both sheet and bulk forming to develop a fundamental understanding of deformation processing principles and technology associated with processes such as drawing, open and closed die forging and rolling.
Prerequisite: MEEN 2460 and MEEN 3443, which can be taken concurrently.
Level of Study: Undergraduate
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=MEEN%204440)

MEEN 4450 Mechanical Behavior of Materials (3 credits)
Stress and strain relationships for elastic behavior. Theory of plasticity. Plastic deformation of single crystals and polycrystalline aggregates. Dislocation theory, fracture, internal friction, creep and stress rupture and brittle failure.
Prerequisite: MEEN 2460 and GEEN 2130; or cons. of instr.
Level of Study: Undergraduate
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=MEEN%204450)

MEEN 4470 Computer Integrated Production Systems (3 credits)
Overview of computer integrated production systems, which include computer numerical control, industrial robotics, material transport and storage systems, automated production lines, flexible manufacturing systems, quality control systems, CAD/CAM, production planning and control, just-in-time and lean manufacturing.
Prerequisite: MEEN 3443 or con. of instr.
Level of Study: Undergraduate
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=MEEN%204470)

MEEN 4485 Welding Engineering (3 credits)
Arc welding physics, fundamentals of power supplies and welding circuits, fusion and solid-state welding processes, weld testing, analysis of welded joints, demonstrations using various processes.
Prerequisite: GEEN 2130 and MEEN 3443.
Level of Study: Undergraduate
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=MEEN%204485)

MEEN 4570 Biomaterials Science and Engineering (3 credits)
Designed to introduce the uses of materials in the human body for the purposes of healing, correcting deformities and restoring lost function. The science aspect of the course encompasses topics including: characterization of material properties, biocompatibility and past and current uses of materials for novel devices that are both biocompatible and functional for the life of the implanted device. Projects allow students to focus and gain knowledge in an area of biomaterials engineering in which they are interested. Same as BIEN 4420.
Prerequisite: MEEN 2460 or consent of instructor.
Level of Study: Undergraduate
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=MEEN%204570)

MEEN 4590 Engineering Fundamentals Review (1 credits)
Review of basic science, mathematics, engineering science, and economics. S/U grade assessment.
Prerequisite: Sr. stndg.
Level of Study: Undergraduate
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=MEEN%204590)

MEEN 4920 Principles of Design (3 credits)
Course content focuses on a structured product design and development process that includes project definition, customer needs identification, product specification, concept generation and concept selection. Also focuses on issues related to teamwork, project management and effective communication. Student team design projects culminate in the development of a technically and economically viable concept and a proposal for future development of this concept (done in the second semester of this two-course sequence). 2 hrs. lec., 1 hr. disc.
Prerequisite: Sr. stndg; Co-op students, Jr. stndg. Cross-listed with BIEN 4920, COEN 4920, EECE 4920.
Level of Study: Undergraduate
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=MEEN%204920)

MEEN 4931 Topics in Mechanical Engineering (3 credits)
Covers a unique perspective or in-depth topic in: energy conversion, mechanical analysis and design and manufacturing systems.
Level of Study: Undergraduate
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=MEEN%204931)

MEEN 4995 Independent Study in Mechanical Engineering (1-3 credits)
Undergraduate independent study project of either theoretical or experimental nature.
Prerequisite: Jr. stndg., 3.000 GPA, cons. of instr., and cons. of dept. ch. Consent required.
Level of Study: Undergraduate
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=MEEN%204995)

MEEN 4998 Senior Design Project (3 credits)
Course focuses on detailed design, prototyping, and testing design concepts. Course includes topics directly relevant to student design projects and careers in the engineering profession. Student team design projects culminate in a final report that documents the performance and details (engineering drawings and/or documentation) of their final design. 2 hrs. lec., 1 hr. disc.
Prerequisite: MEEN 4920. Cross-listed with BIEN 4998, COEN 4998, and EECE 4998.
Level of Study: Undergraduate
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=MEEN%204998)