Electrical and Computer Engineering

Chairperson: Majeed Hayat, Ph.D.
Department of Electrical and Computer Engineering website (http://www.marquette.edu/engineering/electrical_computer/)

The Department of Electrical and Computer Engineering offers curricula that lead to a bachelor of science degree in electrical engineering or a bachelor of science degree in computer engineering.

Mission

The Department of Electrical and Computer Engineering embraces the missions of Marquette University and its Opus College of Engineering. The mission of the Department of Electrical and Computer Engineering is to offer its students high-quality, up-to-date, nationally recognized programs in electrical and computer engineering that prepare them for successful careers. This success is marked by a commitment to lifelong learning and a deep concern for the impact of their work on others; by research that advances the frontiers of technical and scientific knowledge; and by service to professional and civic communities.

Engineering is the professional art of applying science and mathematics to the efficient conversion of natural resources and to the manipulation of information for human benefit. The basic concepts in this definition can be expanded, particularly for the electrical or computer engineer, by considering their activities. These usually involve

1. the processing and control of energy,
2. the processing and control of information,
3. the processing and control of materials.

Certainly, any educational experience in electrical engineering or computer engineering should be evaluated for the student in terms of its contribution in one or more of these areas.

However, this is not the only consideration. Equally important is the concept of engineering as a dynamic profession. In terms of the educational process, this means that attention must be directed to preparing the student for types of processing and control, which have not yet been developed or perhaps even discovered. The young engineer must be prepared to cope with devices, technologies and systems which will appear years into the future, from the viewpoint of the scientific principles on which the design of these future devices and systems will be based.

There is another important consideration in the practice of electrical and computer engineering. An engineer is called on for many and varied activities but as diversified as these may be, when carefully examined, they lead to this conclusion: Problem-solving is the engineer's most important activity. From the educator's viewpoint, this naturally should lead to a planned, conscious effort to develop the young engineer's problem-solving ability to the limits of their God-given talents. In this regard, it is important to note that since engineers' problems are sometimes creative, sometimes analytic and sometimes experimental, their educational experience must give practice in each of these areas and in all types of problems. Significant design experience is an essential part of the engineer's education.

Finally, the engineer is an individual, a citizen who needs to develop a sense of moral and ethical values on a plane consistent with their education in other areas. In the educational process, this requires that a good balance be developed between the technical and ethical-social-humanistic content.

The electrical engineering and computer engineering curricula at Marquette University are carefully designed to meet the requirements of each student. This is achieved through having a curriculum that includes core requirements on foundational concepts in electrical or computer engineering while having the flexibility in selecting from many electives in areas of specialization. Opportunities are provided for each student to develop in the direction of personal interests and at a rate corresponding to individual ability. Coherent elective programs are planned with each student consistent with their ability and professional goals. Moreover, beyond these electives, interested students have the opportunity for independent study and for participation in research activity.

Educational Objectives

The Educational Objectives for the Electrical Engineering and Computer Engineering Programs derive from the department's vision for our graduates. Alumni of these programs, particularly those individuals who have completed their undergraduate education within the last two to five years, will be thriving professionals who apply the knowledge, skills and values gained through their study of Computer or Electrical Engineering at Marquette University.

Specifically, our graduates are:

1. Engaged in solving significant problems in engineering or another field in the public or private sector, as students pursuing an advanced or professional degree or as volunteers.
2. Capably contributing as members of engineering or other problem-solving teams and communicating effectively within the team and to the team's clients.
3. Advancing in their professional careers — taking on increasing responsibilities and leadership roles.

4. Continually learning, whether in a formal degree program or by participating in professional conferences and continuing education programs.
5. Acting responsibly and respectfully when making professional and personal decisions — serving as examples to those around them.

Computer Science Minor

Students in Electrical or Computer Engineering may obtain a minor in computer science and should consult with the Engineering Academic Advising Center to discuss the requirements of the minor.

Non-Electrical/Computer Engineering Minors

Students in the electrical engineering curriculum who are interested in obtaining a minor (or major) in any other area should consult with the Engineering Academic Advising Center to discuss the requirements of these minors. Careful planning with an academic adviser can minimize the number of additional hours beyond the normal graduation requirements.

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

This program allows students to receive a bachelor of science degree in either electrical engineering or computer engineering, depending on the student's undergraduate major, and a master of science degree in electrical engineering in five years. Students with qualifying grade point averages enroll in the program during their junior year. Additional information about this program is available in the most recent Marquette University Graduate bulletin.

- 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/)
- 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/)

Graduate Programs

- 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/)
- Machine Learning for Engineering Applications, Certificate (https://bulletin.marquette.edu/graduate/machine-learning-engineering-applications-certificate/)
- Renewable Energy Technology and Integration, Certificate (https://bulletin.marquette.edu/graduate/renewable-energy-technology-integration-certificate/)

Computer Engineering Courses

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)

Electrical & Computer Engineer Courses

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)

Electrical Engineering Courses

ELEN 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. Balanced three-phase circuits. Two-port circuits.
Prerequisite: EECE 2010.
Level of Study: Undergraduate
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=ELEN%202020)

ELEN 2040 Engineering Systems (3 credits)
Focuses on the modeling and solution of physical systems including translational and rotational mechanical systems, mass balance systems (fluids, chemical), thermal systems and electrical systems. Analytic solution techniques stress the universality of the mathematics for all systems. Computer solutions using MatLab and Simulink are used to further investigate the linear system behavior and to introduce non-linear system behavior.
Prerequisite: EECE 2010 and either MATH 2450 or MATH 1455.
Level of Study: Undergraduate
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=ELEN%202040)

ELEN 3001 Electric Circuits (3 credits)
Circuit modeling; basic solution methods for DC and AC circuits; DC transient analysis of first order and second order circuits. More advanced circuit solution methods including node voltage equations and Thevenin's Theorem. Op Amp circuits and an introduction to transfer functions. May not be taken for credit by EECE students.
Prerequisite: MATH 1451 or MATH 1455.
Level of Study: Undergraduate
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=ELEN%203001)

ELEN 3020 Linear Systems Analysis (3 credits)
Mathematical models of continuous-time and discrete-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.
Prerequisite: ELEN 2020 and MATH 2451; or EECE 2001 and MATH 2451; or BIEN 2300 and MATH 2451; or ELEN 3001 and MATH 2451.
Level of Study: Undergraduate
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=ELEN%203020)

ELEN 3025 Electrical Instrumentation Laboratory (2 credits)
Develops familiarity with typical electronic instruments and terminology. Combines theory with experience to analyze and design electrical networks. Learn experimental technique and documentation. 1 hr. lec., 3 hrs. lab.
Prerequisite: EECE 3010, ELEN 2020 and EECE 2015.
Level of Study: Undergraduate
Marquette Core Curriculum: Writing Intensive
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=ELEN%203025)

ELEN 3030 Analog Electronics (3 credits)
Analysis and design of analog electronic circuits. Low and high frequency models for both bipolar and field effect transistors. Design features and operating characteristics of integrated linear circuits with emphasis on operational amplifiers and op-amp circuits.
Prerequisite: EECE 3010 and ELEN 2020.
Level of Study: Undergraduate
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=ELEN%203030)

ELEN 3035 Electronics Projects Laboratory (2 credits)
Gain experience in the design, assembly, testing and trouble-shooting of analog electronic circuits. Experiments encompass a wide range of topics, such as: amplifiers, filters, power supplies, power control, oscillators and communication circuits. Transistors, op-amps, general purpose and specific purpose devices are used. 1 hr. lec., 3 hrs. lab.
Prerequisite: ELEN 3030, ELEN 3025 and MATH 4720.
Level of Study: Undergraduate
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=ELEN%203035)

ELEN 3110 Electromagnetic Fields 1 (3 credits)
Development and use of the point and integral forms of Maxwell's equations for static and quasi-static electric and magnetic fields with emphasis placed on the vector nature of these fields. Includes analytic and computational solutions to field's problems. The wave equation for E.M. fields is derived and discussed.
Prerequisite: ELEN 2020, MATH 1455, and PHYS 1004 or PHYS 1014.
Level of Study: Undergraduate
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=ELEN%203110)

ELEN 3120 Electromagnetic Fields 2 (3 credits)
Development and use of Wave Equations as derived from Maxwell's equations to explain the propagation of electromagnetic waves. Includes treatment of physical optics, antennas, waveguides and transmission lines.
Prerequisite: ELEN 3110.
Level of Study: Undergraduate
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=ELEN%203120)

ELEN 3210 Electric Drives (3 credits)
Application of electromagnetic field and circuit theory to electromechanical energy conversion systems. Solutions for the magnetic fields, electromagnetic and electrostatic induced forces, and equivalent circuits using conservation of energy principles. Operation of electric machinery from solid-state power switch converters.
Prerequisite: ELEN 3110.
Level of Study: Undergraduate
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=ELEN%203210)

ELEN 4090 Developments in Electronics (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. Possible topics include laser electronics, optoelectronics and photonics, RF circuit design, SOC design.
Prerequisite: Cons. of instr. or Sr. stndg.
Level of Study: Undergraduate
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=ELEN%204090)

ELEN 4100 Transmission Lines and Electromagnetic Waves (3 credits)
Development and use of wave equations as derived from Maxwell’s equations to explain the propagation of electromagnetic waves. Includes wave propagation, reflection/diffraction, antennas, and transmission lines including use of the Smith chart. Discusses S parameters and the vector network analyzer. An introduction to the physical principles of radio communication.
Prerequisite: ELEN 3110 or equiv.
Level of Study: Undergraduate
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=ELEN%204100)

ELEN 4110 Microwave Engineering (3 credits)
Studies the fundamentals of microwave engineering. After a review of transmission line theory and the Smith chart, the scattering parameters are developed and used to characterize and design a variety of devices including power dividers/directional couplers, filters, amplifiers, oscillators and mixers. Also introduces and develops receiver architectures and system noise.
Prerequisite: ELEN 3120.
Level of Study: Undergraduate
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=ELEN%204110)

ELEN 4130 Antenna Theory and Design (3 credits)
Design and use of antennas of varying types, including wire, broadbands, horn, and reflector antennas in transmitting and receiving applications. The application and design of antenna arrays, and an introduction to diffraction theory.
Prerequisite: ELEN 3120 or ELEN 4100.
Level of Study: Undergraduate
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=ELEN%204130)

ELEN 4150 Applied Finite Elements in Electromagnetics (3 credits)
Introduction to finite element (FE) analysis as applied to linear and static electromagnetic field problems. Review of basic field formulations using Maxwell's electromagnetic field equations, solution of boundary value problems using the finite difference methods, FE formulations, assembly of elemental and global matrices, pre-processing, post-processing. Application of the FE method using one-dimensional and two-dimensional elements, magnetostatic and electrostatic analysis, and the use of commercially available software packages.
Prerequisite: ELEN 3110 or equiv.
Level of Study: Undergraduate
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=ELEN%204150)

ELEN 4190 Developments in Electromagnetics (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. Possible topics include wireless and microwave components and systems, electromagnetic compatibility, radio wave propagation.
Prerequisite: Cons. of instr. or Sr. stndg.
Level of Study: Undergraduate
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=ELEN%204190)

ELEN 4210 Design and Analysis of Electric Motor-Drive Systems (3 credits)
Principles of design of AC and DC electric machines, in particular design of electric motors in power electronically controlled adjustable speed drives, torque and power to volume analysis under constant volts per hertz torque-speed control. Covers design of AC induction, synchronous, universal and DC conventional as well as brushless DC motors, and low horsepower motors in adjustable speed drives. Covers effects of space and time harmonics on motor design and performance, including harmonic abatement for control of torque pulsation. Use of modern modeling techniques throughout.
Prerequisite: ELEN 2020, ELEN 3110 and ELEN 3210.
Level of Study: Undergraduate
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=ELEN%204210)

ELEN 4220 Power Electronics for Renewable Energy Systems (3 credits)
Fundamental concepts, techniques, and methods for design and analysis of power electronic systems. Modeling of semiconductor switching devices for use in power electronic systems. Practical aspects and power electronic conversion techniques for rectifiers, DC-to-DC converters, DC-to-AC inverters and their applications in power electronic systems.
Prerequisite: EECE 3010 and ELEN 3020.
Level of Study: Undergraduate
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=ELEN%204220)

ELEN 4230 Renewable and Legacy Electric Energy Systems Analysis (3 credits)
Elements of electric power systems; fundamental concepts and techniques for design and analysis; per unit system; load flow; economic dispatch; symmetrical components; balanced and unbalanced fault calculations, systems instrumentation and power system protection.
Prerequisite: ELEN 2020 and ELEN 3020.
Level of Study: Undergraduate
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=ELEN%204230)

ELEN 4240 Protection and Monitoring of Electric Energy Systems (3 credits)
Principles of design of relay and sensor systems for detection of faulty operating conditions in electric generators, transformers, power transmission lines, motors and other loads in power systems. Symmetrical components, balanced and unbalanced faults including single and multiple unbalances. Design and hierarchical coordination of protection systems for interconnected generation, transmission and distribution facilities in power systems, which includes integrated generator-transformer-busbar-transmission line-load protection and analysis of operation under fault conditions.
Prerequisite: ELEN 2020, ELEN 3110 and ELEN 3210.
Level of Study: Undergraduate
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=ELEN%204240)

ELEN 4250 Transients in Electric Energy Systems and Devices (3 credits)
Covers microsecond fast transients in power systems and devices resulting from lightning strokes, switching surges in power systems and devices, as well as impulse surges resulting from pulse width modulation in modern adjustable speed drives, using distributed parameter models and analysis of transmission lines and windings of transformers, generators and motors. Also covers successive reflections, transition points, wavefront flattening techniques and studies surge arrestor design applications for voltage buildup reduction and control. Includes polyphase multi-velocity multi-conductor system transients.
Prerequisite: ELEN 2020 and ELEN 3110.
Level of Study: Undergraduate
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=ELEN%204250)

ELEN 4290 Developments in Energy and Power (1-3 credits)
Course content is announced prior to each term. Students may enroll in the course more than once as subject matter changes. May be taught in traditional lecture format or as a seminar which focuses on readings from current literature. Topics may include: electronics for machine and drive systems, electrical transients, faults and diagnostics and protection in power devices and systems, renewable energy systems, smart grids and advanced topics in the electric energy engineering area.
Prerequisite: Cons. of instr. or Sr. stndg.
Level of Study: Undergraduate
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=ELEN%204290)

ELEN 4310 Control Systems (3 credits)
Review of continuous-time linear systems. Time-domain system analysis. Time-domain design of lead/lag and PID controllers. Root-Locus technique. Frequency-domain system analysis including Nyquist, Bode, and Nichols analysis and relative stability. Frequency-domain design/lag and PID controllers.
Prerequisite: ELEN 3020 or BIEN 3300.
Level of Study: Undergraduate
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=ELEN%204310)

ELEN 4320 Digital Control Systems (3 credits)
Review of sampling processes, discrete time linear systems analysis and Z-transforms. Discrete time and sampled data state-variable analysis. Stability analysis, time domain and frequency-domain analysis and design. Digital control design and implementation issues.
Prerequisite: ELEN 3020 or BIEN 3300.
Level of Study: Undergraduate
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=ELEN%204320)

ELEN 4390 Developments in Control (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. Possible topics include optimal, adaptive and robust control methods, digital control and nonlinear systems.
Prerequisite: Cons. of instr. or Sr. stndg.
Level of Study: Undergraduate
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=ELEN%204390)

ELEN 4430 Physical Principles of Solid State Devices (3 credits)
Presents fundamental physical principles of solid state devices. Includes a brief review of Quantum Mechanics and applications of modern semiconductor devices that use the Quantum Mechanics principles. Explains the operation principle of modern semiconductor devices from Quantum Mechanics, and these principles are used to extend the students' knowledge of devices used in electronic circuits.
Prerequisite: EECE 3010 and ELEN 3110.
Level of Study: Undergraduate
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=ELEN%204430)

ELEN 4440 MEMS and Nanotechnology (3 credits)
Lecture and laboratory work are combined to provide students with a practical, hands-on introduction to micro-electro-mechanical systems (MEMS) and nano-electro-mechanical systems (NEMS).
Prerequisite: EECE 3010, ELEN 3110.
Level of Study: Undergraduate
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=ELEN%204440)

ELEN 4460 Sensor Devices: Theory, Design and Applications (3 credits)
Sensor classification and transduction principles. Fundamental principles and theory of operation of various types of sensors, based on various technologies which include optical, electrical, acoustical, thermal, magnetic, mechanical and chemical. Analysis of sensor signals. Study of sensor characteristics which include hysteresis, non-linearity, saturation, repeatability, sensitivity, selectivity and resolution. Design and practical implementations of various sensors for scientific, industrial and consumer applications.
Prerequisite: Sr. stndg.
Level of Study: Undergraduate
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=ELEN%204460)

ELEN 4490 Developments in Devices (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. Possible topics include optoelectronic devices, nano-scale devices, solid-state devices, integrated electronic devices, power devices, electro-mechanical devices, quantum devices.
Prerequisite: Cons. of instr. or Sr. stndg.
Level of Study: Undergraduate
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=ELEN%204490)

ELEN 4550 Developments in Signal Processing (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. Possible topics include filter design, DSP hardware, Nonlinear signal processing and multi-dimensional signal processing.
Prerequisite: Sr. stndg. or cons. of instr.
Level of Study: Undergraduate
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=ELEN%204550)

ELEN 4560 Introduction to Communication Systems (3 credits)
Survey of digital and analog communication systems including signal representation, modulation techniques, transmit and receive network design considerations.
Prerequisite: BIEN 3300 or ELEN 3020.
Level of Study: Undergraduate
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=ELEN%204560)

ELEN 4565 Optical Fiber Communications (3 credits)
Introduces and develops fundamental principles and theories of optical fiber systems. Review of electromagnetic principles of wave-guides. Step-Index and Graded-Index, single and multimode fibers. Signal analysis in optical fibers: mode interaction, attenuation, dispersion and pulse spreading. Operating characteristics of optical sources and photo-receivers with impact on system performance. Coupling to a fiber and distribution system. Optical fiber communication system design.
Prerequisite: MATH 4720, Sr. stndg. and ELEN 3110.
Level of Study: Undergraduate
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=ELEN%204565)

ELEN 4570 Wireless Communications (3 credits)
Fundamentals, analysis and design of cell systems, including trunking theory and grade of service. Large scale and small scale path loss analysis and modeling. Overview of modulation techniques, including amplitude and frequency modulating, and digital modulation techniques.
Prerequisite: ELEN 3020 or BIEN 3300; and ELEN 3110.
Level of Study: Undergraduate
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=ELEN%204570)

ELEN 4590 Developments in Communications (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. Possible topics include digital modulation and detection, coding theory, information theory.
Prerequisite: Cons. of instr. or Sr. stndg.
Level of Study: Undergraduate
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=ELEN%204590)

ELEN 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 and MEEN 4920.
Level of Study: Undergraduate
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=ELEN%204920)

ELEN 4995 Independent Study in Electrical 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. Consent required.
Level of Study: Undergraduate
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=ELEN%204995)

ELEN 4998 Senior Design Project (3 credits)
Focuses 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: ELEN 4920. Cross-listed with BIEN 4998, COEN 4998 and MEEN 4998.
Level of Study: Undergraduate
Schedule of Classes (https://bulletin.marquette.edu/class-search/?details&code=ELEN%204998)