Electrical and Computer Engineering

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Introduction

The Department of Electrical Engineering & Computer Science is one of the academic departments within the College of Engineering at the University of Missouri. It manages two sets of Programs: the Computer Science Program (CSP) and the Electrical & Computer Engineering Program (ECEP). At the undergraduate level, the EECS Department grants three distinct BS degrees including Computer Science (CS), Computer Engineering (CoE) and Electrical Engineering (EE). The CS undergraduate program is accredited by the Computing Accreditation Commission of ABET, while the CoE and EE undergraduate programs are accredited by the Engineering Accreditation Commission of ABET, http://www.abet.org (http://www.abet.org/). At the graduate level, the EECS Department offers MS degrees in CS, CoE and EE, and PhD degrees in CS and Electrical & Computer Engineering (ECE). EECS is undergoing a new wave of innovation broadly referred to as Internet of Things (IoT) or Internet of Everything (IoE) and cyber-physical systems from wearable biocompatible sensors, low power flexible integrated circuits, hybrid multicore computer architectures and hardware level security to new cryptographic protocols, mobile apps, cloud computing, deep learning, robotics, autonomous systems and smart cities. The four year undergraduate degree program prepares students for rewarding careers in hardware and software systems and lays the foundation for graduate study in the next wave of technological innovation.

The department was established in 1885 as the first Electrical Engineering department in the nation, after Thomas Edison helped generate interest in electrical engineering by presenting an electrical dynamo and some incandescent lamps to the University of Missouri in 1882. The EECS department is now home to more than 600 undergraduate students and over 300 graduate students in CS, CoE, EE and ECE, with more than 50 faculty members.

About Electrical and Computer Engineering Program

The Electrical and Computer Engineering Program (ECEP) in the Electrical Engineering and Computer Science (EECS) Department is the most research-active program among all other programs and units in the College of Engineering at the University of Missouri, with over $5 million in externally funded research. The ECE Program offers a comprehensive undergraduate curriculum culminating in a capstone project that provides a solid foundation for undergraduate students to pursue rewarding careers in computer and electrical engineering. Students seeking either one of the two undergraduate degrees offered -- Bachelor of Science in Computer Engineering (BS CoE) (https://engineering.missouri.edu/departments/electrical-engineering-computer-science/bachelor-science-computer-engineering-bs/) and Bachelor of Science in Electrical Engineering (BS EE) (https://engineering.missouri.edu/academics/eecs/eecs-degrees/bachelor-science-electrical-engineering/) -- are able to pursue dual degrees in related fields including information technology and computer science, as well as in the other degree of the ECEP, i.e. BS EE and BS CoE, respectively. Not to mention majors and minors in other colleges. Students have opportunities to gain in-depth hands-on knowledge in specialized areas through undergraduate research experiences working with faculty. The faculty research areas covers both well established and emerging fields including mobile video communication; wireless and digital communications; satellite remote sensing; geospatial image and video processing; computational neuroscience; systems biology; eldercare technology; computational intelligence, machine learning, pattern recognition, deep networks, fuzzy systems; computer vision; robotic vision; robotic assistive technology; human/robot interaction; landmine detection; pulsed power and plasmatechnolwogy; nuclear and renewable energy systems; semiconductor devices; photonics; accelerators and beams; antennas and radar systems; nano and microelectromechanical systems; bioMEMS; heterostructures, microfabrication; feedback and control systems; parallel processing; computer architecture; autonomous systems; real-time embedded architectures; high performance computing; sensor networks; and human-computer interfaces.

The ECEP in EECS also offers a Dual Bachelor of Science in Electrical Engineering & Physics (https://engineering.missouri.edu/academics/eecs/eecs-degrees/dual-bachelor-science-electrical-engineering-physics/).

At the MS and PhD levels, the ECEP offers the following graduate degrees:

- Master of Science in Computer Engineering (https://engineering.missouri.edu/departments/electrical-engineering-computer-science/master-science-computer-engineering/)
- Master of Science in Electrical Engineering (https://engineering.missouri.edu/departments/electrical-engineering-computer-science/master-science-electrical-engineering/)
- Doctoral Degree in Electrical and Computer Engineering (https://engineering.missouri.edu/departments/electrical-engineering-computer-science/phd-electrical-computer-engineering/)

with options for dual masters and Masters in Engineering (ME) -- i.e. coursework only, without thesis. The graduate degree programs prepare graduates of four-year BS degrees in Computer Engineering, Electrical Engineering, Computer Science or closely related areas for further study at the doctoral level or for successful careers as specialized CoE and EE professionals in emerging fields. The PhD program is a professional research degree designed to prepare students for advanced professional careers, including college teaching and research, as well as research and development in industrial, government, and nonprofit organizations. Specialized training, state-of-the-art technology, innovation and entrepreneurship experience is available through close interaction with the faculty in their respective fields of research expertise.

The faculty members in the ECE Program participate in the full spectrum of undergraduate and graduate education. Graduate education, has a strong innovation component with faculty initiated research projects funded by the federal government, state government and industry, and is often multidisciplinary in nature spanning interdepartmental and cross-college research. The aim is to produce professionals who can function well as part of interdisciplinary research teams. Close integration of research with education is a constant goal in the department's graduate programs. It emphasizes in-depth studies that can also be tailored to fit graduate students' individual interests. Additionally, members of the ECEP are among the leading faculty in University's Research Revenue, with major research projects funded by both federal agencies and

industry including the National Science Foundation (NSF), National Institute of Health (NIH), National Geospatial-Intelligence Agency (NGA), Department of Energy (DoE), and Department of Defense (DoD) as well as Microsoft, Honeywell and Monsanto, to cite just a few.

Research facilities are well established around faculty expertise in the broad emphasis areas of Communications and Signal Processing (SP), Intelligent Systems and Robotics (ISR), Physical and Power Electronics (PPE), Applied Physics (AP), Systems Modeling and Control (SMC), Computer Architecture and Systems (CAS), Nano/Micro Technology (NMT). Faculty in the Electrical and Computer Engineering Program work closely with faculty in the Computer Science Program within the EECS Department.

For highly motivated undergraduate students a fast-track five year program of study leading to the BS plus MS degrees in CoE or EE is available.

Teaching assistantships with the EECS Department and research assistantships with faculty are available to fund graduate study especially at the PhD level.

Summary

The ECE Program offers undergrad degrees:

- Bachelor of Science in Computer Engineering (BS CoE) (https://engineering.missouri.edu/departments/electrical-engineering-computer-science/bachelor-science-computer-engineering-bs/)
- Bachelor of Science in Electrical Engineering (BS EE) (https://engineering.missouri.edu/academics/eecs/eecs-degrees/bachelor-science-electrical-engineering/)
- Dual Bachelor of Science in Electrical Engineering & Physics (https://engineering.missouri.edu/departments/electrical-engineering-computer-science/dual-bachelor-science-electrical-engineering-physics/)

with many more options for dual degrees within the EECS department and outside.

Graduates with BS degrees in CE, EE, CS or closely related areas can choose to pursue advanced study towards the following degrees:

- Master of Science in Computer Engineering (MS) (https://engineering.missouri.edu/departments/electrical-engineering-computer-science/master-science-computer-engineering/)
- Master of Science in Electrical Engineering (MS) (https://engineering.missouri.edu/departments/electrical-engineering-computer-science/master-science-electrical-engineering/)
- Doctoral Degree in Electrical and Computer Engineering (PhD) (https://engineering.missouri.edu/departments/electrical-engineering-computer-science/phd-electrical-computer-engineering/)

The MS and PhD are professional research degrees designed to prepare students for advanced professional careers, including teaching and research at university level, as well as research and development in industrial, government, and nonprofit organizations.

The ECE Program offers learning and research opportunities for both undergraduate and graduate students in the areas of:

- mobile video communication;
- wireless and digital communications;
- satellite remote sensing;
- geospatial image and video processing;
- computational neuroscience;
- systems biology;
- eldercare technology;
- computational intelligence, including machine learning, pattern recognition, deep learning, fuzzy systems;
- computer vision;
- robotic vision;
- robotic assistive technology;
- human/robot interaction;
- landmine detection;
- pulsed power and plasma technology;
- nuclear and renewable energy systems;
- semiconductor devices;
- photonics;
- accelerators and beams;
- antennas and radar systems;
- nano and microelectromechanical systems;
- bioMEMS;
- heterostructure and microfabrication;
- feedback and control systems;
- parallel processing;
- computer architecture;
- autonomous systems;
- real-time embedded architectures;
- high performance computing;
- sensor networks; and
- human-computer interfaces.

Research

The ECEP in EECS is the most research-active program among all other programs and units in the College of Engineering at the University of Missouri, with over $5 million in externally funded research with faculty conducting research in the broad emphasis areas of:

- Communications and Signal Processing (CSP)
- Intelligent Systems and Robotics (ISR)
- Physical and Power Electronics (PPE)
- Applied Physics (AP)
- Systems Modeling and Control (SMC)
- Computer Architecture and Systems (CAS)
- Nano/Micro Technology (NMT)

Faculty

Professor J. Cheng**, R. Curry**, C. Davis**, J. Gahl**, S. Gangopadhyay**,S. Goggins**, G. Guidoboni**, Z. He**, D. Ho**, K. Islam**, N. Islam**, S. Kovaleski**, J. Kwon**, S. Nair**, K. Palaniappan**, Y. Shang**, C. R. Shyu**, M. Skubic**, D. Xu**, Y. Zhao**
Associate Professor M. Almasri**, D. Anderson**, P. Calyam**, R. Chadha**, G. DeSouza**, Y. Duan**, T. Engel**, W. Jiang**, M. Jurczyk**, T. Kazic**, J. Legarsky**, D. Lin**, P. Rao, Y. Saab**, J. Uhlmann**, X. Wan, D. Xu**, Y. Zhao**
Assistant Professor I. Akturk**, G. Bana*, K. Anuarul Hoque** T. Joshi*, G. Scott*, P. Valettas*
Assistant Research Professor H. Aliakbarpour*, A. Buck, F. Bunyak**

Associate Teaching Professor D. Musser*
Assistant Teaching Professor F. Wang*
Associate Professor of Practice J. Fischer
Assistant Professor of Practice J. Ries, N. Wergeles*
Professor Emeritus M. Devaney, J. Keller**, R. McLaren**, R. O'Connell**, M. Prelas**, G. K. Springer**, H. Tyrer*, X. Zhuang**
Adjunct Y. Adu-Gyamfi, M. Becchi, D. Heise, G. K. Hubler, F. Esposito, K. Gangopadhyay, W. Harrison**, V. Korampally, D. Korkin**, J. Lin*, A. Mosa, G. Seetharaman*, A. Zare W. Zeng**, Y. S. Zeng

* Graduate Faculty Member - membership is required to teach graduate-level courses, chair master's thesis committees, and serve on doctoral examination and dissertation committees.

** Doctoral Faculty Member - membership is required to chair doctoral examination or dissertation committees. Graduate faculty membership is a prerequisite for Doctoral faculty membership.

Undergraduate

The Department of Electrical Engineering and Computer Science (EECS) offers both the Bachelor of Science with a major in Electrical Engineering and the Bachelor of Science with a major in Computer Engineering. The undergraduate program in both degrees at the University of Missouri provides students with the requisite fundamentals in either disciple and prepares them for beginning practice in both the traditional and emerging fields of these disciplines. The degree programs are flexible 126-credit structures that provide the fundamentals of engineering, in addition to a thorough coverage of the major specialties within their respective fields. In addition, technical electives allow concentration in selected areas.

See Electrical Engineering (http://catalog.missouri.edu/collegeofengineering/electricalengineering/#undergraduatetext) and Computer Engineering (http://catalog.missouri.edu/collegeofengineering/computerengineering/#undergraduatetext) for details on the undergraduate degree programs.

Advising and Scholarship Contact
Tami Beatty
Undergraduate Program Office
W1002 Thomas & Nell Lafferre Hall
(573) 882-2648
beattyt@missouri.edu

Graduate

- PhD in Electrical and Computer Engineering (http://catalog.missouri.edu/collegeofengineering/electricalcomputerengineering/phd-electrical-computer-engineering/)

Graduate Admissions Advisor

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Research Areas

The ECE Program in EECS is the most research-active program among all other programs and units in the College of Engineering at the University of Missouri, with over $5 million in expenditures with faculty conducting research in the broad emphasis areas of:

- Applied Physics
- Communications, Signal Processing
- Computer Architectures, Cyber-Physical Systems
- Nano/Micro Technology
- Neuroscience, Neural Engineering
- Physical and Power Electronics
- System Modeling, Control, Robotics

Application Procedures for PhD Programs

In order to be considered for admission in a particular semester we must receive all required paperwork by these deadlines:

Fall admission: Applications and all paperwork must be received by March 1st. NOTE: If applying for financial assistance in the department, applications and all paperwork must be received by January 15th.
Spring admission: Applications and all paperwork must be received by October 1st.

Application for admission involves submitting a formal application through the online application system. An application must be accompanied by an application fee. In addition, the applicant must have the following original paperwork sent directly from the originating institutions to the Graduate School:

- Official transcripts from ALL institutions attended
- Official GRE score report from Educational Testing Service in New Jersey (and TOEFL or IELTS scores for international applicants)

The following supplemental materials must be uploaded in the online application:

- Your résumé
- A personal goal statement indicating why you feel prepared to pursue the degree program and why you want to pursue this degree
- Three letters of recommendation from professors who know your abilities that must address your ability and readiness to pursue a graduate program in computer science (submitted by your references directly to your online application)
- Copies (unofficial) of all transcripts
- Copies of GRE results (and TOEFL or IELTS, if applicable).

Note: Copies of the required documents (transcripts, GRE scores, etc.) cannot be accepted in lieu of the official reports from the originating institutions. Copies of these records should be submitted for evaluation, but any decision on admission is non-binding until the official records have been received.

Current/Former MU students: All current and former MU students must meet the same requirements as external students *and* file one of the following forms (in lieu of an MU Application Form):

- Current Non-Degree Graduate Students: Change of Division, Degree, Program, Emphasis, or Advisor form,
- Current graduate students in another department: Change of Division, Degree, Program, Emphasis, or Advisor form (same as 1)
- Previous graduate students returning to same program: Re-Activation form.

Degree Completion Requirements

Use the links at the top of the page to direct you to details on the requirements that must be completed in order to earn the respective graduate degrees.

Financial Aid

Teaching and research assistantships are available on a competitive basis for qualified students in the graduate programs. International students who have not completed a MS or UG courses at an American University are not eligible for Teaching assistantships during their first semester of study.

Teaching assistantships and research assistantships are available with tuition waivers in the Department. Once an applicant is accepted into the program, their application materials are shared with faculty for review. Individual faculty are responsible for hiring their own assistants, and will choose from the pool of applicants.

Teaching Assistantships

Teaching assistantships are normally awarded to qualified graduate students with appropriate communication skills who assist faculty members in various phases of instruction. International students may not be appointed to teaching assistantships in their first semester on campus. International students must pass a language screening test at a proper level to be eligible for the TA positions available.

Research Assistantships

Research assistantships are granted to students qualified for working with professors on particular research projects. The research assistants are selected by faculty members who have research funds to support graduate students. Therefore, students should contact the faculty members directly for the RA possibility.

Fellowships

The department faculty actively pursue funding for selected research fellowships. Available fellowship opportunities can be found by contacting the ECE Graduate Office. Additionally, a limited number of “Teaching Fellows” are awarded annually to outstanding PhD students, particularly for those preparing for academic careers. Details can obtained from the ECE Graduate Office.

Seminars

PhD students are required to attend a total of at least ten EECS seminars during the course of their MS program (if completed) and 20 total over the course of the PhD study. PhD students in ECE must also present a 30 minute seminar prior to graduation and defending of the dissertation.

ECE 1000: Introduction to Electrical and Computer Engineering
Introduction to the basic principles of electrical and computer engineering through hands-on activity. Course includes fundaments of programming using Matlab, applied to electrical and computer engineering problems.

Credit Hours: 2

ECE 2001: Experimental Course
For sophomore-level students. Content and number of credit hours to be listed in Schedule of Courses.

Credit Hour: 1-99

ECE 2017: World of Neuroscience
(same as CMP_SC 2017, BIOL_EN 2017, BME 2017, PSYCH 2017, BIO_SC 2017). This in-class course will introduce undergraduates to the growing area of neuroscience from the perspectives of three disciplines: engineering, biology and psychology. Topics in the course will span multiple levels of neuroscience including genomic, genetic, molecular, cellular, systems, behavioral and clinical levels. Due to the interdisciplinary nature of the neuroscience, the classes will cover diverse topics. The topics will range from overviews of the key neurobiology areas, to lab sessions involving how to analyze your own brain signals (EEG), and to visits to brain imaging center and EEG lab. The overall goal is to provide a broad exposure to the fascinating world of interdisciplinary neuroscience. Graded on A-F basis only.

Credit Hour: 1

ECE 2100: Circuit Theory I
DC circuit analysis, inductors and capacitors, first order response, AC circuit analysis, single-phase AC power. Graded on A-F basis only.

Credit Hours: 4
Prerequisites: A grade of C- or better in MATH 1700

ECE 2210: Introduction to Logic Systems
(same as CMP_SC 2270). Introduces basic tools, methods and procedures to design combinational and sequential digital circuits and systems. Topics include number systems, Boolean algebra, logic minimization, circuit design, memory elements, and finite state machine design. Graded on A-F basis only.

Credit Hours: 3
Prerequisites: C or higher in CMP_SC 1050 or INFOTC 1040

ECE 3210: Microprocessor Engineering for Electrical Engineers
Introduction to microprocessor architectures and programming; memory, memory management and cache organizations, bus configurations and timing implications; parallel I/O and serial communication interfaces.

Credit Hours: 4
Prerequisites: A grade of C or better in CMP_SC 1050 and ECE 2210 or CMP_SC 2270

ECE 3220: Software Design in C and C++
Software/Hardware development for embedded systems, including memory, I/O and interrupts; an overview of C and C++, class structures in object oriented programming; software development with UML and testing and debugging strategies. Graded on A-F basis only.

Credit Hours: 3
Prerequisites: ECE 3280 or CMP_SC 3280 or ECE 3210 with a grade of C or better

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ECE 3280: Computer Organization and Assembly Language
(same as CMP_SC 3280). Introduces computer architectures, programming concepts including parameter passing, I/O interrupt handling, DMA, memory systems, cache, and virtual memory. Graded on A-F basis only.

Credit Hours: 3
Prerequisites: C or higher in CMP_SC 2270 or ECE 2210, and C or higher in CMP_SC 2050

ECE 3410: Electronic Circuits and Signals I
Electron Devices, modeling and applications to basic electronic circuits, including RC amplifiers and power supplies.

Credit Hours: 4
Corequisites: ECE 3810

ECE 3510: Electromagnetic Fields
Elements of vector analysis, transmission line theory, electrostatics, magnetostatics, time varying fields and plane waves. Graded on A-F basis only.

Credit Hours: 3
Prerequisites: A grade of C- or better in PHYSCS 2760 and a grade of C or better in ECE 2100
Corequisites: MATH 4100

ECE 3610: Semiconductors and Devices
Crystal structure; quantum aspects of energy, radiation and matter; quantum mechanics and energy bands in solids; electronic and optical properties of semiconductors; p-n junctions and diodes; bipolar and field-effect transistors.

Credit Hours: 3
Prerequisites: A grade of C or better in ECE 3510

ECE 3810: Circuit Theory II
Impulse and step responses, RLC circuits, classical differential equations solutions, complex plane stability, frequency and Bode Analysis, Resonance, Laplace transforms, two-port networks, mutual inductance and transformers. Graded on A-F basis only.

Credit Hours: 4
Prerequisites: A grade of C or better in ECE 2100
Corequisites: MATH 4100

ECE 3830: Signals and Linear Systems
Transform Analysis of Signals and Linear Systems. Laplace transforms, z-transforms, Fourier series and transforms.

Credit Hours: 3
Prerequisites: A grade of C or better in ECE 3810

ECE 3840: Measurement and Instrumentation
Covers 1) theory and applications of measurement and instrumentation systems; 2) signal conditioning circuits; 3) software-controlled automatic test equipment (ATE); and 4) software-controlled data acquisition systems. Graded on an A-F basis only.

Credit Hours: 3
Prerequisites: A grade of C or better ECE 3210 or ECE 3280, ECE 3410, ECE 3830, and a grade of C- or better in STAT 4710

ECE 4001: Topics in Electrical and Computer Engineering
Current and new technical developments in electrical engineering.

Credit Hour: 1-4
Prerequisites: senior standing

ECE 4020: Energy Systems and Resources
(same as NU_ENG 4315, MAE 4371; cross-leveled with ECE 7020, NU_ENG 7315). Analysis of present energy usage in Missouri, USA and the world, evaluation of emerging energy technologies and trends for the future. Economics and environmental impact of the developed technologies.

Credit Hours: 3
Prerequisites: ENGINR 2300

ECE 4030: Introduction to Nuclear Reactor Engineering
(same as NU_ENG 4346; cross-leveled with ECE 7030, NU_ENG 7346). Engineering principles of nuclear power systems, primarily for the production of electrical energy.

Credit Hours: 3
Prerequisites: ENGINR 1200, ENGINR 2300

ECE 4040: Introduction to Nuclear Physics
(cross-leveled with ECE 7040). Introduction of Quantum mechanics for non-physics majors. Course topics include nuclear properties; alpha, beta and gamma radioactive decay; and nuclear reactions. Graded on A-F basis only.

Credit Hours: 3
Prerequisites: senior standing or graduate standing in engineering or equivalent mathematical preparation

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ECE 4070: Numerical Methods for Science and Engineering
(same as CMP_SC 4070; cross-leveled with ECE 7070, CMP_SC 7070). This course introduces the basic numerical methods that are widely used by computer scientists and engineers. Students will learn how to use the MATLAB platform to find the computational solution of various problems arising in many real world applications. By completing this course, students will be able to master algorithms, compare their performances and critically assess which ones are viable options for the particular problem at hand. Graded on A-F basis only.

Credit Hours: 3
Prerequisites: CMP_SC 2050, junior standing, or Instructor's consent
Recommended: Students are expected to have basic knowledge in discrete math and algorithms

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ECE 4085: Problems in Electrical and Computer Engineering
Analytical or experimental problems pertaining to electric circuits, machines, fields or electronics.

Credit Hour: 1-3
Recommended: 12 hours Electrical and Computer Engineering credit or instructor's consent

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ECE 4220: Real Time Embedded Computing
(cross-leveled with ECE 7220). Embedded systems development with real time constraints including RTOS, task management and synchronization, real time scheduling algorithms, deadlocks, performance analysis and optimization, interfacing to external devices, and device drivers. Graded on A-F basis only.

Credit Hours: 3
Prerequisites: A grade of C or better in ECE 3220

ECE 4250: VHDL and Programmable Logic Devices
(cross-leveled with ECE 7250). Design techniques including module definition, functional partitioning, hardware design language descriptions and microprogramming; design examples include arithmetic units, programmable controllers, and microprocessors.

Credit Hours: 4
Prerequisites: ECE 3210 or ECE 3280 or CMP_SC 3280 with a grade of C or better

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ECE 4270: Computer Architecture
(same as CMP_SC 4270; cross-leveled with ECE 7270, CMP_SC 7270). Advanced computer architectures and programming; memory, memory management and cache organizations, parallel processing, graphical processor units for general programming.

Credit Hours: 4
Prerequisites: CMP_SC 2050 and ECE 3280 or CMP_SC 3280 or ECE 3210 with a grade of C or better

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ECE 4280: Network Systems Architecture
(same as CMP_SC 4280; cross-leveled with ECE 7280, CMP_SC 7280). The course covers network systems interconnects and switch fabrics, network considerations: and relevant networking applications at the network, transport and application layer. Graded on A-F basis only.

Credit Hours: 4
Prerequisites: C- or higher in CMP_SC 2050 or ECE 3220 and C- or higher in CMP_SC 3280 or ECE 3210

ECE 4310: Feedback Control Systems
(same as BIOL_EN 4310, MAE 4750; cross-leveled with BIOL_EN 7310, ECE 7310, MAE 7750). System modeling and time and frequency response, closed loop control, stability, continuous system design, introduction to discrete time control, software and hardware experiments on compensator design and PID control. Graded on A-F basis only.

Credit Hours: 3
Prerequisites: MATH 4100

ECE 4320: Architectural Robotics
(cross-leveled with ECE 7320). Architectural robotics has been defined as "intelligent and adaptable built environments (featuring embedded robotic components) that sense, plan, and act". This course will cover the basic concepts required for understanding, developing, and testing embedded robotic systems for the built environment. Students will work together in teams in a studio-style format which emphasizes hands-on projects to develop working prototypes. The goal is to offer students an opportunity for creativity in an interdisciplinary setting. Graded on A-F basis only.

Credit Hours: 4
Prerequisites: junior or senior standing

ECE 4330: Introduction to Mechatronics and Robotic Vision
(cross-leveled with ECE 7330). Covers 1) mechatronic systems; 2) the mathematical tools used to model industrial and mobile robots; and 3) vision sensors, their underlying models and algorithms that allow us to control and interact with robots.

Credit Hours: 4
Prerequisites: ECE 3220 or ECE 4220
Recommended: a C/C++ languages

ECE 4340: Building Intelligent Robots
(same as CMP_SC 4730; cross-leveled with ECE 7340, CMP_SC 7740). Covers the design and development of intelligent machines, emphasizing topics related to sensor-based control of mobile robots. Includes mechanics and motor control, sensor characterization, reactive behaviors and control architectures. Recommended: programming experience in one of the following programming languages: Basic , C, C++, or Java.

Credit Hours: 4
Prerequisites: junior standing

ECE 4350: Programmable Logic Controllers
(cross-leveled with ECE 7350). Hardware and software aspects of PLC's; computer/PLC Communications; developing ladder logic programs; interfacing I/O devices, including sensors, to the PLC; labeling and documentation; utilizing analog capabilities; applications; developing Supervisory Control and Data Acquisitions (SCADA) applications.

Credit Hours: 4
Prerequisites: junior standing

ECE 4410: Power Electronics I
(cross-leveled with ECE 7410). Power electronic device characteristics, important circuit and component concepts, loss mechanisms and thermal analysis, phase controlled rectifiers, dc-dc converters, and dc-ac inverters. Includes laboratory projects.

Credit Hours: 4
Prerequisites: ECE 3410

ECE 4430: Electronic Circuits and Signals II
(cross-leveled with ECE 7430). Advanced study of electronic devices including frequency response of amplifiers, nonlinear effects in transistor amplifiers, oscillators, and feedback amplifiers.

Credit Hours: 3
Prerequisites: ECE 3830 and ECE 3410

ECE 4440: Power Systems Analysis
(cross-leveled with ECE 7440). Selected topics related to modern power system analysis. Single and three-phase balanced power; Transformers and the per unit concept; Properties and analysis of transmission lines; power flow analysis; symmetrical and asymmetrical faults; system stability; power distribution; use of Powerworld software. Graded on A-F basis only.

Credit Hours: 3
Prerequisites: ECE 3810 and MATH 4100 or instructor's consent

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ECE 4460: Energy and Machines
(cross-leveled with ECE 7460). Theory and applications of electric machines. Performance analysis of AC Synchronous, Induction and DC machines with emphasis on modern efficiency improvements. Fundamentals of electronic speed controls.

Credit Hours: 3
Prerequisites: ECE 3510

ECE 4470: Sustainable Electrical Energy Resources
(cross-leveled with ECE 7470). Analysis of renewable electrical energy resources from both the utility and distributed resource perspective. Covers safety, metering and power quality issues associated with coupling distributed resources to the utility grid.

Credit Hours: 3
Prerequisites: ECE 2100 or ENGINR 2100

ECE 4510: Pulsed Power Engineering
(cross-leveled with ECE 7510). Concepts of energy generation and storage systems used in pulse power engineering, high power opening and closing switches, high voltage engineering, grounding and shielding, high voltage safety.

Credit Hours: 3
Prerequisites: ECE 3510

ECE 4540: Neural Models and Machine Learning
(same as CMP_SC 4540, BME 4540, BIOL_EN 4540; cross-leveled with BIOL_EN 7540, CMP_SC 7540, ECE 7540). The projects-based course has three inter-linked components: (I) math models of neurons and neural networks, (II) machine learning in neuroscience, after a brief introduction to python and (III) software automation and cyberinfrastructure to support neuroscience. Extensive projects focusing on software automation and machine learning components, with brief in-class presentations. Graded on A-F basis only.

Credit Hours: 3
Prerequisites: MATH 1500 or consent of instructor
Recommended: Introductory software programming, and introductory cell biology

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ECE 4550: Introduction to Plasmas
(same as NU_ENG 4375; cross-leveled with ECE 7550, NU_ENG 7375). Equations of plasma physics, interaction of waves and plasmas; plasma sheaths and oscillations; measurements and applications.

Credit Hours: 3
Prerequisites: ECE 3510

ECE 4590: Computational Neuroscience
(same as BIOL_EN 4590, BIO_SC 4590, BME 4590; cross-leveled with ECE 7590, BIOL_EN 7590, BIO_SC 7590). Interdisciplinary course in biology and quantitative sciences with laboratory and modeling components. Explores basic computational and neurobiological concepts at the cellular and network level. Introduction to neuronal processing and experimental methods in neurobiology; modeling of neurons and neuron-networks. Graded on A-F basis only.

Credit Hours: 4
Prerequisites: MATH 1500 or equivalent

ECE 4610: CMOS Integrated Circuit Design
(cross-leveled with ECE 7610). Investigates the behavior of microelectronic devices in digital circuits and helps the students develop an understanding of the relationship between the device physics and the device static and dynamic characteristics; short-channel effects in scaled-down transistors; scaling laws; VLSI fabrication technologies; design and layout of digital integrated circuits. Includes laboratory assignments emphasizing computer aids in VLSI design; schematic capture, circuit simulation, and layout of custom integrated circuits.

Credit Hours: 3
Prerequisites: ECE 3610

ECE 4620: Introduction to BioMEMS
(cross-leveled with ECE 7620). Study of BioMEMS devices and applications. Topics cover BioMEMS including overview of microfabrication techniques, common bioMEMS material, microfluidic principles, microfluidic devices, drug delivery, biomedical microdevices for neural implants, patch-clamping and single cell based analysis systems, microelectroporation, DNA microarrays, Plymerase Chain Reaction and biopolymers, chemical and gas sensors and biosensors. Graded on A-F basis only.

Credit Hours: 3

ECE 4630: Introduction to Optical Electronics
(cross-leveled with ECE 7640). Principles, devices and materials used to generate, modulate, and detect optical radiation. Review of important properties of light and semiconductors. Light-emitting diodes and lasers. Electro-optic modulation. Thermal and quantum detection. Emphasis on semiconductor-based devices and application to fiber-optical communications.

Credit Hours: 3
Prerequisites: ECE 3610

ECE 4640: MEMS Laboratory
(cross-leveled with ECE 7640). The main objective of this course is to provide hands-on skills for the interdisciplinary Microelectromechanical Systems (MEMS). It puts emphasis on the practical aspects of design, fabrication, test, and characterization of micro/nano devices and systems. Graded on A-F basis only.

Credit Hours: 4
Prerequisites: PHYSCS 2760, CHEM 1320, or ECE 2100

ECE 4650: Semiconductor Device Theory
(cross-leveled with ECE 7650). Band theory, equilibrium and non-equilibrium semiconductor electronics, junction theory, p-n junction devices, bipolar and field effect transistors including SPICE simulation.

Credit Hours: 3
Prerequisites: ECE 3610

ECE 4655: Digital image Processing
(same as CMP_SC 4650; cross-leveled with ECE 7655, CMP_SC 7650). This course provides fundamentals of digital image processing hardware and software including digital image acquisition, image display, image enhancement, image transforms and segmentation.

Credit Hours: 3
Prerequisites: C- or higher in CMP_SC 2050 and STAT 4710 or instructor's consent

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ECE 4670: Microelectronic Fabrication
(cross-leveled with ECE 7670). Basic silicon integrated circuit fabrication processes, basic techniques of wafer processing, economics of

fabrication and resulting devices properties, interdependence of process flow and device design. Accompanying laboratory.

Credit Hours: 4
Prerequisites: ECE 3610

ECE 4675: Digital Image Compression
(same as CMP_SC 4670; cross-leveled with ECE 7675, CMP_SC 7670). This course provides basic concepts and theorems in information theory, discrete cosine transform, discrete wavelet transform, quantizer design, bit allocation, and rate-distortion analysis and practical coding and communication system design, (such as Huffman coding, arithmetic coding, variable length coding, motion estimation, JPEG.)

Credit Hours: 3
Prerequisites: C- or higher in CMP_SC 2050

ECE 4710: Communications Systems
(cross-leveled with ECE 7710). Concepts of communication systems, signal analysis and power spectrum density, signal transmission and filtering, linear modulation, exponential modulation, sampling, baseband digital communication, modulated digital communication, spread spectrum communication.

Credit Hours: 3
Prerequisites: ECE 3830

ECE 4720: Introduction to Machine Learning and Pattern Recognition
(Same as CMP_SC 4720; cross-leveled with ECE 7720, CMP_SC 7720) This course provides foundation knowledge to the basic methods in machine learning and pattern recognition (MLPR). MLPR addresses the problems of programming computers to optimize certain performance criteria by using example data or expert knowledge and it has wide applications.

Credit Hours: 3
Prerequisites: C- or higher in CMP_SC 2050 and STAT 4710 or instructor consent

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ECE 4730: Introduction to Wireless Communication System
(cross-leveled with ECE 7730). Principles of wireless communication analysis and design. Digital communication basics, cellular radio, wireless PCS communications, multiple access techniques, channel coding and equalization, and standards of digital cellular/PCS systems.

Credit Hours: 3

ECE 4830: Introduction to Digital Signal Processing
(cross-leveled with ECE 7830). Concepts, analytical tools, design techniques used in computer processing of signals; signal representation, sampling, discrete-time systems analysis, recursive and non-recursive filters, design/implementation, discrete Fourier transform.

Credit Hours: 4
Prerequisites: ECE 2210, ECE 3830

ECE 4870: Introduction to Computational Intelligence
(same as CMP_SC 4770; cross-leveled with ECE 7870, CMP_SC 7770). Introduction to the concepts, models, and algorithms for the development of intelligent systems from the standpoint of the computational paradigms of neural networks, fuzzy set theory and fuzzy logic, evolutionary computation and swarm optimization. Graded on A-F basis only.

Credit Hours: 3
Recommended: some exposure to rigorous axiomatic mathematical development of a topic (as can be found in most senior/graduate level math or statistics courses) is needed to appreciate some of the development of the theory. Also, the ability to program (well) in some high level language is essential to perform the computer projects

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ECE 4880: Micro/Nano Systems
(cross-leveled with ECE 7880). Micro/nano systems covers various micro/nanotechnologies, micro sensors and actuators including digital light processors, accelerometers, gyroscopes, micro optical switches and components, micro speakers, RF switches, inertial/mechanical and acoustic M/NEMS and M/Nanofluidic systems. Major mechanisms/principles for micro/Nano devices and systems are also covered. The Micro/Nano Systems focuses on the miniaturization technologies that have important roles in materials, mechanical, and biomedical engineering practice. Graded on A-F basis only.

Credit Hours: 3
Prerequisites: ECE 3610 or instructor's consent

ECE 4930: Intermediate Electromagnetics
(cross-leveled with ECE 7930). Course covers transmission lines, waveguides, microstrip electromagnetic circuits, and radiating systems.

Credit Hours: 4
Prerequisites: ECE 3510

ECE 4940: Antenna Theory, Design and Laboratory
(cross-leveled with ECE 7940). Introduction to antenna theory, design and laboratory. Emphasis on engineering aspects of antenna systems, transmitting and receiving antenna parameters, various antennas.

Credit Hours: 4
Prerequisites: ECE 3510

ECE 4960W: Senior Capstone Design I - Writing Intensive
Lectures on safety, ethics, professionalism, intellectual property, product liability, contemporary issues, and project management. Provides the senior Capstone project proposal experience, incorporating multidisciplinary project design and project management skills. Oral presentations and written reports. Not for graduate credit. Graded A-F only. Recommended: Post-requisite: ECE 4980.

Credit Hours: 3
Prerequisites: Restricted to EECS Department students only, or instructor's consent

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ECE 4970: Senior Capstone Design
Group Design Projects. Design methodology, project management, development of specifications, examination of alternatives, preparation of proposal. Lectures on safety, ethics, professionalism, and economics. Oral and written reports. Not for graduate credit.

Credit Hours: 3
Prerequisites: A grade of C or better in ECE 3110 or ECE 3840 and senior standing. Restricted to Electrical and Computer Engineering students only or instructor's consent

ECE 4970W: Senior Capstone Design - WI
Group Design Projects. Design methodology, project management, development of specifications, examination of alternatives, preparation of proposal. Lectures on safety, ethics, professionalism, and economics. Oral and written reports. Not for graduate credit.

Credit Hours: 3
Prerequisites: A grade of C or better in ECE 3110 or ECE 3840 and senior standing. Restricted to Electrical and Computer Engineering students only or instructor's consent

ECE 4980: Senior Capstone Design II
Provides the senior Capstone design experience where multidisciplinary teams reduce to practice a proposed product. Oral and written reports. Not for graduate credit. Graded A-F only.

Credit Hours: 3
Prerequisites: Grade of C or better in ECE 3840, ECE 4960W, Senior standing, Restricted to EECS Department students only, or instructor's consent

ECE 4990: Undergraduate Research in Electrical Computer Engineering
Supervised independent study or project in electrical or computer engineering, culminating in a written report.

Credit Hour: 1-3
Prerequisites: Undergraduate Program Director's consent

ECE 4995: Undergraduate Honors Research in Electrical Computer Engineering
Independent investigation or project in electrical or computer engineering to be presented as an undergraduate honors thesis. Enrollment is limited to students participation in the Electrical and Computer Engineering Honors Program.

Credit Hour: 1-3

ECE 7001: Advanced Topics in Electrical and Computer Engineering
Current and new technical developments in electrical engineering.

Credit Hour: 1-4

ECE 7010: Digital Computer Applications in Engineering
Use of digital computer for solution of engineering problems involving roots of equations, simultaneous equations, curve fitting, integration, differentiation and differential equations.

Credit Hours: 3
Prerequisites: MATH 2300

ECE 7020: Energy Systems and Resources
(same as NU_ENG 7315, MAE 7371; cross-leveled with ECE 4020, NU_ENG 4315, MAE 4371). Analysis of present energy usage in Missouri, USA and the world, evaluation of emerging energy technologies and trends for the future. Economics and environmental impact of the developed technologies.

Credit Hours: 3
Prerequisites: ENGINR 2300

ECE 7030: Introduction to Nuclear Reactor Engineering
(same as NU_ENG 7346; cross-leveled with ECE 4030, NU_ENG 4346). Engineering principles of nuclear power systems, primarily for the production of electrical energy.

Credit Hours: 3
Prerequisites: graduate ENGINR 1200, ENGINR 2300

ECE 7040: Introduction to Nuclear Physics
(cross-leveled with ECE 4040). Introduction of Quantum mechanics for non-physics majors. Course topics include nuclear properties; alpha, beta and gamma radioactive decay; and nuclear reactions. Graded on A-F basis only.

Credit Hours: 3
Prerequisites: senior standing or graduate standing in engineering or equivalent mathematical preparation

ECE 7070: Numerical Methods for Science and Engineering
(same as CMP_SC 7070; cross-leveled with ECE 4070, CMP_SC 4070). This course introduces the basic numerical methods that are widely used by computer scientists and engineers. Students will learn how to use the MATLAB platform to find the computational solution of various problems arising in many real world applications. By completing this course, students will be able to master algorithms, compare their performances and critically assess which ones are viable options for the particular problem at hand. Graded on A-F basis only.

Credit Hours: 3
Prerequisites: CMP_SC 2050, junior standing, or Instructor's consent
Recommended: Students are expected to have basic knowledge in discrete math and algorithms

ECE 7220: Real Time Embedded Computing
(cross-leveled with ECE 4220). Embedded systems development with real time constraints including RTOS, task management and synchronization, realtime scheduling algorithms, deadlocks, performance analysis and optimization, interfacing to external devices, and device drivers. Graded A-F basis only.

Credit Hours: 3
Prerequisites: A grade of C or better in ECE 3220

ECE 7250: VDHL and Programmable Logic Devices
(cross-leveled with ECE 4250). Design techniques including module definition, functional partitioning, hardware design language descriptions and microprogramming; design examples include arithmetic units, programmable controllers, and microprocessors.

Credit Hours: 4
Prerequisites: ECE 3210 or ECE 3280 or CMP_SC 3280 with a grade of C or better

ECE 7270: Computer Architecture
(same as CMP_SC 7270; cross-leveled with ECE 4270, CMP_SC 4270). Advanced computer architectures and programming; memory, memory management and cache organizations, parallel processing, graphical processor units for general programming.

Credit Hours: 4

Prerequisites: CMP_SC 2050 and ECE 3280 or CMP_SC 3280 or ECE 3210 with a grade of C or better

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ECE 7280: Network Systems Architecture
(same as CMP_SC 7280; cross-leveled with ECE 4280, CMP_SC 4280). The course covers network systems interconnects and switch fabrics, network considerations and relevant networking applications at the network, transport and application layer. Graded on A-F basis only.

Credit Hours: 4
Prerequisites: CMP_SC 2050 or ECE 3200 and CMP_SC 3280 or ECE 3210

ECE 7310: Feedback Control Systems
(same as BIOL_EN 7310, MAE 7750; cross-leveled with ECE 4310, BIOL_EN 4310, MAE 4750). System modeling and time and frequency response, closed loop control, stability, continuous system design, introduction to discrete time control, software and hardware experiments on compensator design and PID control.

Credit Hours: 3
Prerequisites: MATH 4100

ECE 7320: Architectural Robotics
(cross-leveled with ECE 4320). Architectural robotics has been defined as "intelligent and adaptable built environments (featuring embedded robotic components) that sense, plan, and act". This course will cover the basic concepts required for understanding, developing, and testing embedded robotic systems for the built environment. Students will work together in teams in a studio-style format which emphasizes hands-on projects to develop working prototypes. The goal is to offer students an opportunity for creativity in an interdisciplinary setting. Graded on A-F basis only.

Credit Hours: 4
Prerequisites: ECE 4970 or equivalent

ECE 7330: Introduction to Mechatronics and Robotic Vision
(cross-leveled with ECE 4330). Introduces robotics; robot system characteristics; robot motive power systems; geometric structure of robots; sensors and feedback; control applications and algorithms; data acquisition and output actuation function; robots and AI; microprocessor applications. Lecture and Laboratory. Recommendded: a C/C++ Language course.

Credit Hours: 4
Prerequisites: ECE 3220 or ECE 4220

ECE 7335: Nuclear Safeguards Science and Technology
(same as NU_ENG 7335). This course provides an overview of nuclear materials management and safeguards, including physical protection systems, material accounting and control, monitoring, and regulatory issues.

Credit Hours: 3
Prerequisites: NU_ENG 4303 or NU_ENG 7303

ECE 7340: Building Intelligent Robots
(same as CMP_SC 7730; cross-leveled with ECE 4340, CMP_SC 4730). Covers the design and development of intelligent machines, emphasizing topics related to sensor-based control of mobile robots. Includes mechanics and motor control, sensor characterization, reactive behaviors and control architectures.

Credit Hours: 4
Recommended: some programming experience

ECE 7350: Programmable Logic Controllers
(cross-leveled with ECE 4350). Hardware and software aspects of PLC's; computer/PLC Communications; developing ladder logic programs; interfacing I/O devices, including sensors, to the PLC; labeling and documentation; utilizing analog capabilities; applications; developing Supervisory Control and Data Acquisitions (SCADA) applications.

Credit Hours: 4

ECE 7370: Automatic Control System Design
(cross-leveled with ECE 4370). Techniques for feedback system design and analysis; compensation using root locus and frequency-domain methods; state-variable design methods; techniques for nonlinear systems analysis and design; sample-data control systems.

Credit Hours: 3
Prerequisites: ECE 4310

ECE 7410: Power Electronics I
(cross-leveled with ECE 4410). Power electronic device characteristics, important circuit and component concepts, loss mechanisms and thermal analysis, phase controlled rectifiers, dc-dc converters, and dc-ac inverters. Includes laboratory projects.

Credit Hours: 4
Prerequisites: ECE 3410

ECE 7430: Electronic Circuits and Signals II
(cross-leveled with ECE 4430). Advanced study of electronic devices including frequency response of amplifiers, nonlinear effects in transistor amplifiers, oscillators, and feedback amplifiers.

Credit Hours: 3
Prerequisites: ECE 3830 and ECE 3410

ECE 7440: Power Systems Analysis
(cross-leveled with ECE 4440). Selected Topics related to modern power system analysis. Single and three-phase balanced power; Transformers and the per unit concept; Properties and analysis of transmission lines; power flow analysis; symmetrical and asymmetrical faults; system stability; power distribution; use of Powerworld software. Graded on A-F basis only.

Credit Hours: 3
Prerequisites: ECE 3810 and MATH 4100 or instructor's consent

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ECE 7460: Energy and Machines
(cross-leveled with ECE 4460). Theory and applications of electric machines. Performance analysis of AC synchronous induction and DC machines with emphasis on modern efficiency improvements. Fundamentals of electronic speed controls.

Credit Hours: 3
Prerequisites: ECE 3510

ECE 7470: Sustainable Electrical Energy Resources
(cross-leveled with ECE 4470). Analysis of renewable electrical energy resources from both the utility and distributed resource perspective. Covers safety, metering and power quality issues associated with coupling distributed resources to the utility grid.

Credit Hours: 3
Prerequisites: ECE 2100 or ENGINR 2100

ECE 7510: Pulsed Power Engineering
(cross-leveled with ECE 4510). Concepts of energy generation and storage systems used in pulse power engineering, high power opening and closing switches, high voltage engineering, grounding and shielding, high voltage safety.

Credit Hours: 3
Prerequisites: ECE 3510

ECE 7540: Neural Models and Machine Learning
(same as CMP_SC 7540, BIOL_en 7540; cross-leveled with BME 4540, CMP_SC 4540, ECE 4540, BIOL_EN 4540). The projects-based course has three inter-linked components: (I) math models of neurons and neural networks, (II) machine learning in neuroscience, after a brief introduction to python and (III) software automation and cyberinfrastructure to support neuroscience. Extensive projects focusing on software automation and machine learning components, with brief in-class presentations. Graded on A-F basis only.

Credit Hours: 3
Prerequisites: MATH 1500 or consent of instructor
Recommended: Introductory software programming, and introductory cell biology or consent of instructor

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ECE 7550: Introduction to Plasmas
(same as NU_ENG 7375; cross-leveled with ECE 4550, NU_ENG 4375). Equations of plasma physics, interaction of waves and plasmas; plasma sheaths and oscillations; measurements and applications.

Credit Hours: 3
Prerequisites: ECE 4930

ECE 7590: Computational Neuroscience
(same as BIOL_EN 7590, BIO_SC 7590; cross-leveled with BIOL_EN 4590, BIO_SC 4590, ECE 4590, BME 4590). Interdisciplinary course in biology and quantitative sciences with laboratory and modeling components. Explores basic computational and neurobiological concepts at the cellular and network level. Introduction to neuronal processing and experimental methods in neurobiology; modeling of neurons and neuron-networks. Graded on A-F basis only.

Credit Hours: 4
Prerequisites: MATH 1500 or equivalent

ECE 7620: Introduction to BioMEMS
(cross-leveled ECE 4620). BioMEMS materials, fabrication techniques, micro-fluidic principles and devices, drug delivery, biomedical micro-devices for neural implants, patch clamping and single cell based systems, micro-electroporation, DNA microarrays, Plymerase Chain Reaction, chemical/gas/bio-sensors. Graded on A-F basis only.

Credit Hours: 3

ECE 7630: Introduction to Optical Electronics
(cross-leveled with ECE 4630). Principles, devices and materials used to generate, modulate, and detect optical radiation. Review of important properties of light and semiconductors. Light-emitting diodes and lasers. Electro-optic modulation. Thermal and quantum detection. Emphasis on semiconductor-based devices and application to fiber-optical communications.

Credit Hours: 3
Prerequisites: ECE 3610

ECE 7640: MEMS Laboratory
(cross-leveled with ECE 4640). The main objective of this course is to provide hands-on skills for the interdisciplinary Microelectromechanical systems (MEMS). It puts emphasis on the practical aspects of design, fabrication, test, and characterization of micro/nano devices and systems. Graded on A-F basis only.

Credit Hours: 4
Prerequisites: PHYSCS 2760, CHEM 1320 or ECE 2100; instructor's consent

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ECE 7650: Semiconductor Device Theory
(cross-leveled with ECE 7650). Band theory, equilibrium and non-equilibrium semiconductor electronics, junction theory, p-n junction devices, bipolar and field effect transistors including SPICE simulation.

Credit Hours: 3
Prerequisites: ECE 3610

ECE 7655: Digital Image Processing
(same as CMP_SC 7650; cross-leveled with ECE 4655, CMP_SC 4650). The course provides fundamentals of digital image processing hardware and software including digital image acquisition, image display, image enhancement, image transforms and segmentation.

Credit Hours: 3
Prerequisites: STAT 4710 and CMP_SC 2050 or instructor's consent

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ECE 7670: Microelectronic Fabrication
(cross-leveled with ECE 4670). Basic silicon integrated circuit fabrication processes, basic techniques of wafer processing, economics of fabrication and resulting devices properties, interdependence of process flow and device design. Accompanying laboratory.

Credit Hours: 4
Prerequisites: ECE 3610

ECE 7675: Digital Image Compression
(same as CMP_SC 7670; cross-leveled with ECE 4675, CMP_SC 4670). This course provides basic concepts and theorems in information theory, discrete cosine transform, discrete wavelet transform, quantizer design, bit allocation, and rate-distortion analysis and practical coding and communication system design, (such as Huffman coding, arithmetic coding, variable length coding, motion estimation, JPEG.)

Credit Hours: 3
Prerequisites: CMP_SC 2050

ECE 7690: Design and Simulation of VLSI Circuits
(cross-leveled with ECE 4690). Design of CMOS integrated circuits with emphasis on analog applications. Device models are developed for circuit simulation. Lecture and laboratory.

Credit Hours: 4
Prerequisites: ECE 4670

ECE 7710: Communications Systems
(cross-leveled with ECE 4710). Concepts of communication systems, signal analysis and power spectrum density, signal transmission and filtering, linear modulation, exponential modulation, sampling, baseband digital communication, modulated digital communication, spread spectrum communication.

Credit Hours: 3
Prerequisites: ECE 3830

ECE 7720: Introduction to Machine Learning and Pattern Recognition
(same as CMP_SC 7720; cross-leveled with ECE 4720, CMP_SC 4720). This course provides foundation knowledge to the basic methods in machine learning and pattern recognition (MLPR). MLPR addresses the problem of programming computers to optimize certain performance criteria by using example data or expert knowledge and it has wide applications.

Credit Hours: 3
Prerequisites: CMP_SC 2050 and STAT 4710 or instructor's consent

---

ECE 7730: Introduction to Wireless Communication System
(cross-leveled with ECE 4730). Principles of wireless communication analysis and design. Digital communication basics, cellular radio, wireless PCS communications, multiple access techniques, channel coding and equalization, and standards of digital cellular/PCS systems.

Credit Hours: 3

ECE 7810: Multimedia Engineering and Technology
Survey of multimedia applications. Capture, coding, storage, transmission, and software tools for developing productions involving text, graphics, images, animation, sound and video. Term projects. Lecture and laboratory.

Credit Hours: 4
Prerequisites: ECE 3210 and ECE 3830

ECE 7830: Introduction to Digital Signal Processing
(cross-leveled with ECE 4830). Concepts, analytical tools, design techniques used in computer processing of signals; signal representation, sampling, discrete-time systems analysis, recursive and non-recursive filters, design/implementation, discrete Fourier transform.

Credit Hours: 4
Prerequisites: ECE 2210, ECE 3830

ECE 7870: Introduction to Computational Intelligence
(same as CMP_SC 7770; cross-leveled with ECE 4870, CMP_SC 4770). Introduction to the concepts, models, and algorithms for the development of intelligent systems from the standpoint of the computational paradigms of neural networks, fuzzy set theory and fuzzy logic, evolutionary computation and swarm optimization. Graded on A-F basis only.

Credit Hours: 3
Prerequisites: some exposure to rigorous axiomatic mathematical development of a topic (as can be found in most senior/graduate level math or statistics courses) is needed to appreciate some of the development of the theory. Also, the ability to program (well) in some high level language is essential to perform the computer projects

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ECE 7880: Micro/Nano Systems
(cross-leveled with ECE 4880). Micro/Nano systems covers various micro/nanotechnologies, micro sensors and actuators including digital light processors, accelerometers, gyroscopes, micro optical switches and components, micro speakers, RF switches, inertial/mechanical and acoustic M/NEMS and M/Nanofluidic systems. Major mechanisms/principles for micro/Nano devices and systems are also covered. The Micro/Nano Systems focuses on the miniaturization technologies that have important roles in materials, mechanical, and biomedical engineering practice. Graded on A-F basis only.

Credit Hours: 3
Prerequisites: ECE 3610 or instructor's approval

ECE 7930: Intermediate Electromagnetics
(cross-leveled with ECE 4930). Course covers transmission lines, waveguides, microstrip electromagnetic circuits, and radiating systems

Credit Hours: 4
Prerequisites: ECE 3510

ECE 7940: Antenna Theory, Design and Laboratory
(cross-leveled with ECE 4940). Introduction to antenna theory, design and laboratory. Emphasis on engineering aspects of antenna systems, transmitting and receiving antenna parameters, and various wire antennas.

Credit Hours: 4
Prerequisites: ECE 3510

ECE 7950: Microwave Principles
(cross-leveled with ECE 4950). Maxwell's Equations, transmission lines, plane wave propagation and reflection, waveguides, resonant cavities, microwave devices and components, radiation, radio wave propagation. Lecture and laboratory.

Credit Hours: 4
Prerequisites: ECE 3510 and ECE 3410

ECE 8001: Advanced Topics in Electrical and Computer Engineering
Advanced Topics in Electrical and Computer Engineering. Graded on A-F basis only.

Credit Hour: 1-4
Prerequisites: may vary from semester to semester depending on topic

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ECE 8010: Supervised Study in Electrical Engineering
Supervised individual study at the graduate level to be completed within the course of one semester in the form of a brief report. Graded on S/U basis only

Credit Hour: 1-3

ECE 8011: Software and Cyber Automation in Neuroscience
This seminar course will emphasize software and cyber automation tools in neuroscience to address the emerging needs of big data in neuroscience. Students will work in pairs to address such needs of various neuroscience Labs both within MU and with collaborators outside MU. The students pairs will be provided a list of automation projects to work on (one or maximum two) during the semester, under close supervision of the instructors. They will also be provided access to local cyberinfrastructure at MU, national cyberinfrastructure resources such as CyVerse (www.cyverse.org) and Neuroscience Gateway (https://www.nsgportal.org), as well as public clouds such as XSEDE and Amazon Web Services. Graded on A-F basis only.

Credit Hour: 1
Prerequisites: Basic software programming, basic cell biology, or consent of instructor

ECE 8085: Problems in Electrical and Computer Engineering
Supervised investigation of an electrical engineering problem for an MS project. Study culminates in a project report. Graded on a S/U basis only.

Credit Hour: 2-5

ECE 8110: Preparing Advanced Professionals - I
Discussions on a variety of topics: Pedagogy - latest from cognitive science and learning theory, effective teaching, how a university functions, engineering teaching and research; how leading industries perform research and the importance of soft skills, etc. Graded on A-F basis only.

Credit Hour: 1
Prerequisites: restricted to graduate Engineering majors only

ECE 8120: Preparing Advanced Professionals - II
Continues format of ECE 8110 with group discussions and seminars by experts on how to write an effective proposal, including a review of model proposals, model proposal reviews, and a 'hands-on' proposal writing followed by globalization and its effects on professionals. Graded on A-F only.

Credit Hour: 1
Prerequisites: graduate engineering majors only

ECE 8270: Parallel Computer Architecture
The course covers parallel computer architecture (general purpose multi-core and many-core processors, shared and distributed memory systems, clusters). Emphasis will be given to both architectural and programmability aspects. Graded on A-F basis only.

Credit Hours: 3
Prerequisites: ECE 4270 or ECE 7270, ECE 4220 or ECE 7220 or CMP_SC 4250

ECE 8320: Nonlinear Systems
Nonlinear systems including topics such as limit cycles, phase plane analysis, bifurcation, Lyapunov stability, input-output stability, passivity. Topics from control such as feedback linearization, sliding control, and Lyapunov redesign. Graded on A-F basis only.

Credit Hours: 3
Prerequisites: ECE 4310

ECE 8510: Advanced Electromagnetics
Advanced theoretical electromagnetic theory. Investigation of summation problems with general boundary conditions, time varying fields, and time harmonic currents. Basic applications and relationships in classical and relativistic physics.

Credit Hours: 3
Prerequisites: ECE 3510

ECE 8520: Direct Energy Conversion Technologies
Study of direct energy conversion technology and research trends in this area. Topics include energy storage techniques (mechanical, chemical, thermal, inductive, capacitive), thermoelectric generators, photovoltaic generators, thermionic generators, magnetohydrodynamic generators, piezoelectric generators, wind generators, fuel cells. Current research trends in this area will also be examined. Graded on A-F basis only.

Credit Hours: 3
Prerequisites: ECE Majors or instructors consent

ECE 8530: Advanced Photonics
Concentrated study of optical system design, including integrated optics, semiconductor lasers, quantum wells, optical materials, and electro-optical effects used in modern optical systems.

Credit Hours: 3
Prerequisites: ECE 4530

ECE 8540: Advanced Network Theory and Applications
Advanced study of network theorems including compensation, reciprocity, duality, and maximum power. Theory and application of N-port parameters. Linear and non-linear network synthesis techniques. Analysis of ordinary and partial differential equations to develop electrical analogs for mechanical, pneumatic, thermal, hydraulic systems. Study of non-linear circuit analysis and modeling techniques. Current research trends in this area will also be examined. Graded on A-F basis only.

Credit Hours: 3
Prerequisites: ECE Majors or instructors consent

ECE 8570: Neural Dynamics and Communication
(same as CMP_SC 8570). Properties of nerve cells including membrane potential, action potential, ion channel dynamics, GHK equation, dynamical properties of excitable membranes, neuronal communication and plasticity. Entrainment, synchronization and oscillations in neuronal networks, and their functional significance. Graded on A-F basis only.

Credit Hours: 3
Prerequisites: ECE4590/CMP_SC 4590/BIOL_EN 4590/BME 4590 or consent of instructor

ECE 8580: Machine Learning in Neuroscience
(same as CMP_SC 8580). Basics of neuronal and network dynamics including spikes and communication between regions, including via competing hypotheses. Machine learning fundamentals including linear, logistic and artificial neural network mappings. Integration of data-driven and theory-driven models, with emphasis on insights into neuroscience via XAI approaches. Software automation in neuroscience including

python notebooks and cyberinfrastructure tools for interacting with repositories and HPC resources. Graded on A-F basis only.

Credit Hours: 3
Prerequisites: ECE 4590/CMP_SC 4590 or consent of instructor

ECE 8610: Power Semiconductor Devices
A study of the semiconductor devices used in switch-mode power converter circuits. Course surveys the field and discusses selected devices in depth.

Credit Hours: 3
Prerequisites: ECE 3610, ECE 4630 and ECE 4650

ECE 8620: Advanced Microelectromechanical Systems
MEMS development cycle, overview of microfabrication, microsystem modeling, mechanical analysis, thermal analysis, transduction mechanism, case studies; Micromirror, accelerometers, pressure sensors, force sensors, RF MEMS switches, Infrared sensors, and Microsystem packaging.

Credit Hours: 3

ECE 8675: Biomedical Image Processing
(same as CMP_SC 8675). This course introduces students to the fundamentals of biomedical image processing and analysis with an emphasis on cellular and tissue microscopy along with anatomical imaging. The course will cover image and video processing techniques and pipelines for image enhancement, restoration, registration, detection, segmentation, classification, and motion analysis that are tailored for biomedical image informatics. This course will provide a rich exposure to a broad range of imaging datasets from the molecular to the anatomical; and train students to implement algorithms for moderately complex tasks in biomedical image analysis. This course is suitable for graduate students in all fields of engineering and science who are interested in understanding and implementing biomedical and biological image analytics and are seeking pointers to the broad literature in the field. Graded on A-F basis only.

Credit Hours: 3
Prerequisites: ECE 4655/ECE 7655 or CMP_SC 4650/CMP_SC 7650 or instructor's consent

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ECE 8690: Computer Vision
(same as CMP_SC 8690). This course introduces students to the fundamental problems of computer vision, the main concepts and the techniques used to solve such problems. It will enable graduate and advanced undergraduate students to solve complex problems and make sense of the literature in the area. Graded on A-F basis only.

Credit Hours: 3
Prerequisites: ECE 4655 or ECE 7655 or CMP_SC 4650 or CMP_SC 7650 or instructor's consent

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ECE 8695: Cognitive Computer Vision
One of the more recent trends in computer vision research in the pursuit of human-like capability is the coupling of cognition and vision into cognitive computer vision. This course will emphasize the advanced topics in applying machine learning techniques in computer vision.

Credit Hours: 3
Prerequisites: ECE 4850 or ECE 7850 or CMP_SC 4650 or CMP_SC 7650 or consent of instructor

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ECE 8725: Supervised Learning
(same as CMP_SC 8725). This course introduces the theories and applications of advanced supervised machine learning methods. It covers hidden Markov model and expectation maximization (EM) algorithms, probabilistic graphical models, non-linear support vector machine and kernel methods. The course emphasizes both the theoretical underpinnings of the advanced supervised learning methods and their applications in the real world. Graded on A-F basis only.

Credit Hours: 3
Prerequisites: CMP_SC 4720 or CMP_SC 7720 or ECE 4720 or ECE 7720 or instructor's consent

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ECE 8730: Fundamentals of Radar Signal Processing
Study of radar signal processing fundamentals. Topics include radar systems, signal models, sampling and quantization of radar signals, radar waveforms, Doppler processing, detection fundamentals, radar imaging.

Credit Hours: 3

ECE 8735: Unsupervised Learning
(same as CMP_SC 8735). Theoretical and practical aspects of unsupervised learning including topics of expectation maximization (EM), mixture decomposition, clustering algorithms, cluster visualization, and cluster validity. Graded on A-F basis only.

Credit Hours: 3
Prerequisites: CMP_SC 4720 or CMP_SC 7720 or ECE 4720 or ECE 7720 or instructor's consent

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ECE 8770: Advanced Mobile Communication Systems
Channel extimation and equalization, multi-user detection, diversity combining, multi-carrier and OFDM, Standards of 3G Wireless Communication Systems such as EDGE, CDMA 2000 and UMTS.

Credit Hours: 3

ECE 8790: Digital Processing of SAR Data
Study of digital processing of synthetic aperture radar (SAR) data. Topics cover SAR data fundamentals including concepts, signal processing, pulse compression, signal properties, processing algorithms, and image processing.

Credit Hours: 3

ECE 8800: Sensor Array and Statistical Signal Processing
Introduce the basics on sensor array processing, signal detection and parameter estimation, with their applications in communications and signal processing. Graded on A-F basis only.

Credit Hours: 3
Prerequisites: ECE 7830 and ECE 8860 or with instructor consent

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ECE 8810: Advanced Digital Signal Processing
Topics in digital signal analysis and filtering. Including hardware implementation, speech synthesis and recognition, multi-dimensional transforms, random-signal concepts, design methods and computer aids to analysis and design.

Credit Hours: 3
Prerequisites: ECE 4830

ECE 8830: Visual Signal Processing and Communications
Threats visual digital signal processing and network communications covering both theory and application of coding, compression and communications via the web. Covers such standards as JPEG, MPEG-2 and MPEG-4 as well as motion detection. Graded on A-F basis only.

Credit Hours: 3

ECE 8855: Advanced Image Processing
(same as CMP_SC 8650). This course covers advanced topics in image understanding including multispectral multimodal imaging, motion estimation, texture analysis, geometric level set methods.

Credit Hours: 3
Prerequisites: CMP_SC 4650 or CMP_SC 7650 or instructor's consent

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ECE 8860: Probability and Stochastic Processes for Engineers
Introduction to probability, multidimensional complex (phaser) random variables and stochastic processes in electrical engineering.

Credit Hours: 3
Prerequisites: ECE 4830, ECE 4710, or ECE 8620

ECE 8870: Modeling and Management of Uncertainty
(same as CMP_SC 8870). Theoretical and practical issues in the modeling and management of uncertainty. Topics include probabilistic uncertainty, belief theory and fuzzy set theory. Applications to computer vision, pattern recognition and expert systems. Graded on A-F basis only.

Credit Hours: 3
Prerequisites: ECE 4870 or ECE 7870 or instructor's consent

ECE 8875: Advanced Topics in Computational Intelligence
(same as CMP_SC 8780). This course is a continuation of ECE 7870 in the concepts, models, and algorithms for the development of intelligent systems from the standpoint of the computational paradigms of neural networks, fuzzy set theory and fuzzy logic, evolutionary computation, and swarm intelligence. Advanced topics in these areas will be discussed with a focus on applications of these technologies.

Credit Hours: 3
Prerequisites: ECE 4870 or ECE 7870

ECE 8890: Neural Networks
(same as CMP_SC 8770). The course will consider computing systems based on neural networks and learning models along with implementations and applications of such systems.

Credit Hours: 3
Prerequisites: ECE 4870 or ECE 7870 or instructor's consent

ECE 8990: Research-Master Thesis in Electrical and Computer Engineering
Independent investigation in a field of electrical engineering to be presented as thesis or dissertation. Graded on a S/U basis only.

Credit Hour: 1-99

ECE 9001: Advanced Topics in Electrical and Computer Engineering
Advanced Topics in Electrical and Computer Engineering

Credit Hours: 3

ECE 9990: Research-Doctoral Dissertation Electrical & Computer Engineering
Independent investigation in a field of electrical engineering to be presented as thesis or dissertation. Graded on a S/U basis only.

Credit Hour: 1-99
