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. At the graduate level, the EECS Department offers MS and ME 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 (http://missouri.edu/about/history/engineering.php) 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 35 faculty members (http://engineering.missouri.edu/eecs/people), not including instructors, teaching professors, and emeriti.

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) (http://engineering.missouri.edu/ece/degree-programs/bs-coe) and Bachelor of Science in Electrical Engineering (BS EE) (http://engineering.missouri.edu/ece/degree-programs/bs-ee) -- 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 plasmatchnology; 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 (http://engineering.missouri.edu/ece/degree-programs/bs-eep).

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

- Master of Science in Computer Engineering (http://engineering.missouri.edu/ece/degree-programs/program-of-study-msc)
- Master of Science in Electrical Engineering (http://engineering.missouri.edu/ece/degree-programs/program-of-study-msce)
- Doctoral Degree in Electrical and Computer Engineering (http://engineering.missouri.edu/ece/degree-programs/phd)

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, that is often multidisciplinary in nature, spanning interdepartmental and cross-college research. The aim is to produce professionals who can function well as part of interdisciplinay research and development as well as product 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) (http://engineering.missouri.edu/ece/degree-programs/bs-ce)
- Bachelor of Science in Electrical Engineering (BS EE) (http://engineering.missouri.edu/ece/degree-programs/bs-ee)
- Dual Bachelor of Science in Electrical Engineering & Physics (http://engineering.missouri.edu/ece/degree-programs/bs-EEP)

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

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

- Master of Science in Computer Engineering (MS) (http://engineering.missouri.edu/ece/degree-programs/program-of-study-msce)
- Master of Science in Electrical Engineering (MS) (http://engineering.missouri.edu/ece/degree-programs/program-of-study-msee)
- Doctoral Degree in Electrical and Computer Engineering (PhD) (http://engineering.missouri.edu/ece/degree-programs/phd)

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 networks, fuzzy systems;
- computer vision;
- robotic vision;
- robotic assistive technology;
- human/robot interaction;
- landmine detection;
- pulsed power and plasmatechnology;
- 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


Associate Professor M. Almasri**, G. DeSouza**, T. G. Engel**, T. Han**, J. J. Legarsky**

Assistant Professor R. Druce*, L. Rivera*


Associate Professor Emeritus R. W. Leavene Jr.*

Adjunct M. Becchi**, D. Heise, G. K. Hubler*, V. Korampally*, G. Triplett**, A. Zare**
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**

- BS CoE in Computer Engineering (http://catalog.missouri.edu/undergraduate/graduate/collegeofengineering/computerengineering/bscoe-computer-engineering)

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

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 discipline 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.

The EECS department emphasizes close interaction with industry. Industry engineers visit regularly and industry-sponsored student projects are provided to give extra dimension to the program.

Many students in the EECS department combine the electrical engineering major with the computer engineering major in a special 138-credit program. These students receive both the BS EE and BS CoE degrees.

Students interested in interdisciplinary studies may use some electives to study business, premedicine, prelaw, and other areas. Students are able to choose from a variety of courses offered by other departments in the College of Engineering, as well as from other MU colleges, taking advantage of the multidisciplinary nature of the campus.

The current educational objectives of the electrical engineering program are:

- Graduates will meet or exceed the expectations of their employers
- Qualified graduates will pursue advanced study if desired
- Graduates will pursue leadership positions in their profession and/or communities

The current educational objectives of the computer engineering program are:

- Graduates will meet or exceed the expectations of their employers
- Qualified graduates will pursue advanced study if desired
- Graduates will pursue leadership positions in their profession and/or communities

Both the Bachelor of Science in Electrical Engineering (BS EE) and the Bachelor of Science in Computer Engineering (BS CoE) require that students earn a 2.0 GPA or better in all courses that have an MU engineering prefix. All ECE courses require a grade of C or better in ECE prerequisites.

Engineering design in both the electrical engineering and computer engineering programs is provided through an integrated laboratory structure. Beginning with the first laboratory course in the fourth semester of each program, students have a significant design and laboratory experience in each semester of their respective programs.

In addition to the major core requirements, students must complete all University graduation requirements (http://catalog.missouri.edu/academicdegreerequirements/undergraduaterequirements) including University general education (http://catalog.missouri.edu/academicdegreerequirements/generaleducationrequirements), as well as all degree and college or school requirements.

**Electrical and Computer Engineering (ECE) Honors Program**

The ECE Honors Program follows the general rules and philosophy of the College of Engineering Honors Program. Students may enter the program from the beginning of the junior year and must have a GPA of 3.0/4.0 at the start. Eligible students participate in the program by enrolling in ECE 4995 Undergraduate Honors Research in Electrical Computer Engineering for one to three credit hours, which replaces an equivalent number of hours of ECE technical electives.

The heart of the program is a research or advanced design project culminating in an undergraduate honors thesis. The project is conducted under the supervision of the honors advisor, who is an ECE faculty member selected by mutual agreement between the student and the professor. Satisfactory completion of the project requires approval (signatures) of the honors thesis by both the honors advisor and an additional faculty member, who serves as second reader of the thesis. Students who complete the program and graduate with a GPA of at least 3.0 receive the designation “Honors Scholar in Engineering” at graduation and on their diploma.

Another valuable feature of the Honors Program is that participants may reduce the number of credit hours required for degree completion to the University minimum of 120 by substituting up to six hours of credit from graduate courses through dual (undergraduate/graduate) enrollment during the last four semesters of the undergraduate program and after completion of the honors project.

**Double Majors - Electrical Engineering and Computer Engineering**

Many students in the EECS department combine the BS in Electrical Engineering with the BS in Computer Engineering in a special 138-credit program. These students receive both the BS EE and BS CoE degrees.

**Major Program Requirements**

<table>
<thead>
<tr>
<th>Constitutional Elective</th>
<th>Select one of the following:</th>
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<tbody>
<tr>
<td>HIST 1100</td>
<td>Survey of American History to 1865</td>
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<tr>
<td>HIST 1200</td>
<td>Survey of American History Since 1865</td>
</tr>
<tr>
<td>HIST 1400</td>
<td>American History</td>
</tr>
<tr>
<td>HIST 2210</td>
<td>Twentieth Century America</td>
</tr>
<tr>
<td>HIST 2440</td>
<td>History of Missouri</td>
</tr>
<tr>
<td>HIST 4000</td>
<td>Age of Jefferson</td>
</tr>
<tr>
<td>HIST 4220</td>
<td>U.S. Society Between the Wars 1918-1945</td>
</tr>
</tbody>
</table>
HIST 4230  Our Times: United States Since 1945
POL_SC 1100  American Government
POL_SC 2100  State Government

Humans/Fine Arts courses  9
Social Science/Behavioral Science courses  3
Select two of the following:  6
ENGINR 1200  Statics and Elementary Strength of Materials
ENGINR 2300  Engineering Thermodynamics
IMSE 2710  Engineering Economic Analysis

Other major core requirement courses:
MATH 1500  Analytic Geometry and Calculus I  5
MATH 1700  Calculus II  5
MATH 2300  Calculus III  3
MATH 2320  Discrete Mathematical Structures  3
MATH 4100  Differential Equations  3
STAT 4710  Introduction to Mathematical Statistics  3
PHYSICS 2750  University Physics I  5
PHYSICS 2760  University Physics II  5
CHEM 1320  College Chemistry I  4
ENGLISH 1000  Exposition and Argumentation  3
ECONOM 1000  Principles of Microeconomics  3
or ECONOM 1015  Principles of Macroeconomics  3
or ECONOM 1024  Fundamentals of Microeconomics  3
CMP_SC 1050  Algorithm Design and Programming I  3
CMP_SC 2050  Algorithm Design and Programming II  3
ECE 1000  Introduction to Electrical and Computer Engineering  2
ECE 1210  Introduction to Logic Systems  3
ECE 2100  Circuit Theory I  4
ECE 3210  Microprocessor Engineering  4
ECE 3810  Circuit Theory II  4
ECE 3220  Software Design in C and C++  3
ECE 3830  Signals and Linear Systems  3
ECE 3510  Electromagnetic Fields  3
ECE 3410  Electronic Circuits and Signals I  4
ECE 3610  Semiconductors and Devices  3
ECE 3110  Electrical and Computer Engineering Projects  3
ECE 4220  Real Time Embedded Computing  3
ECE 4250  VHDL and Programmable Logic Devices  4
ECE 4270  Computer Organization  4
ECE 4970  Senior Capstone Design  3

Electives:
3000+ ECE or CMP_SC Elective  12
ECE 4000+ Technical Elective  6
ECE 4000-level Senior Lecture/Lab  4
Any Elective  1

Semester Plan
Below is a sample plan of study, semester by semester. A student’s actual plan may vary based on course choices where options are available.

First Year
Fall  CR  CR
CHEM 1320  4  CMP_SC 1050  3
MATH 1500  5  ECE 1210  3

Second Year
Fall  CR  CR
ECE 2100  4  CMP_SC 2050  3
ECE 3210  4  ECE 3810  4
MATH 2300  3  MATH 4100  3
PHYSICS 2750  5  PHYSICS 2760  5

Third Year
Fall  CR  CR
ECE 3410  4  ECE 3610  3
ECE 3220  3  ECE 4250  4
ECE 3810  3  MATH 2320  3
ECE 3830  3  ECE 4000+ Technical Elective  3
STAT 4710  3  Flexible Technical Elective  3

Fourth Year
Fall  CR  CR
ECE 4220  3  ECE 3110  3
ECE 4270  3  ECE 4000+ Technical Elective  3
ENGINR 1200, 2300, or IMSE 2710  3
Flexible Technical Elective  3
Social/Behavioral Science Elective  3

Fifth Year
Fall  CR
ECE 4970 (WI)  3
ECE 4000-level Senior Lecture/Lab  4
Flexible Technical Elective  3
Humanities/Fine Arts Elective  3

Total Credits: 141

Graduate
• MS in Computer Engineering (http://catalog.missouri.edu/undergraduategraduate/collegeofengineering/computerengineering/ms-computer-engineering)

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Columbia, MO 65211
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Director of Graduate Studies: Gui N. DeSouza
325 Naka Hall
Columbia, MO 65211
Phone: (573) 882-5579
Email: DeSouzaG@missouri.edu
http://engineering.missouri.edu/ece/
The Department also offers a PhD in Electrical and Computer Engineering (http://catalog.missouri.edu/undergraduategraduate/collegeofengineering/electricalandcomputerengineering/phd-electrical-computer-engineering), and the College of Engineering offers an interdepartmental ME in Engineering with a focus in Computer or Electrical Engineering (http://catalog.missouri.edu/undergraduategraduate/collegeofengineering/engineering/me-engineering).

**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:

- 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)

**Specific Topics of Study**
- 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.

**Admission Requirements for the MS and ME Programs in EE or CE**

- GPA from BS program
- GRE: Quantitative, Verbal and Analytic scores.
- International students:
  - Computer-based TOEFL, or
  - Paper-based TOEFL, or
  - Internet-based TOEFL, or
  - IELTS exam
- 3 letters of recommendation
- Statement of purpose
- Transcripts

(When registering for the GRE and TOEFL exams, be sure to designate the University of Missouri-Columbia and your program of interest as locations to receive the scores. MU’s Institutional Code for the GRE and TOEFL is: 6875.)

In addition to the Graduate School requirements, the ECE programs have the following additional requirements:

The three letters of recommendation should be from persons familiar with the applicant's engineering or related work. It is required that the recommendation letter use the institutional letterhead or be sent directly from the recommender’s institutional e-mail address (not gmail, hotmail, etc.). Similarly, each provided reference must include the person’s institutional e-mail address. Any letters of recommendation or listed reference that does not comply with the above or otherwise look ‘unofficial’ will be disregarded.

To be accepted outright by the Director of Graduate Studies in ECE (DGS-ECE), the student needs to have a BS degree in either Electrical Engineering or Computer Engineering in addition to meeting the above requirements.

Students who meet the academic requirements but have degrees in other Engineering or Science disciplines can be accepted directly into the MS/ME programs by the Graduate Program Committee in ECE (GPC-ECE). Such students are strongly encouraged to consult with the DGS-ECE or their advisor about appropriate bridge courses. Based on individual circumstances, students may be advised to register as an undeclared graduate student to fill in background course work prior to admission into the department.

Students who don’t meet the above requirements may still be admitted on Probation by the GPC if there are mitigating factors. Students admitted on Probation must receive at least a 3.0 GPA for the first 12 hours of graded graduate coursework completed in their first two semesters. Failure to achieve this GPA will result in expulsion from the ECE MS/ME program.

**Fast Tracking**

In an effort to streamline and accelerate the acquisition of MU graduate degree(s) we establish fast tracking options for our current undergraduate students and our 3+2 students. For MU undergraduate students, the fast track option allows them to become integrated into the research environment of the EECS department early in their career and to earn between 6 and 12 hours of graduate credit as their schedules allow. For these qualified graduate school bound students, we will waive the GRE
requirement and give them preference in TA and RA positions. For the 3+2 students who demonstrate excellence in their first semester of ECE course work at MU, we will waive the GRE and provide up to 12 hours of graduate credit prior to entry into one of the ECE graduate programs. The summary follows.

**MU BS students (all relevant majors)**
- GPA > 3.0 after junior year
- Waive GRE requirement for admission to ECE graduate programs
- Use 6 hours of 126 for graduate credit (after 90 credit hours have been earned)
- Earn 6 additional hours of graduate credit as schedule allows (after 90 credit hours have been earned)
- Participate in Undergraduate Research at least one semester
- Participate in Honors Scholars’ Program

**International or Domestic 3+2 students**
- GPA from Home institution (last 60 hours) > 3.2
- MU GPA in at least 12 hours of ECE courses >= 3.5
- Waive GRE requirement for admission
- Take up to 12 hours as dual enrolled student (second semester of first year)

### Internal Funding

**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.

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

**Credit Hours:** 2

**ECE 1001: Experimental Course**
For freshman-level students. Content and number of credit hours to be listed in Schedule of Courses.

**ECE 1210: Introduction to Logic Systems**
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

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

**Credit Hours:** 1-99

**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 3110: Electrical and Computer Engineering Projects**
Open-ended design projects which encourage innovative solutions to design and measurement problems. Students teams complete several projects from different areas. Both oral and written presentations emphasized. Graded on A-F basis only.

**Credit Hours:** 3

**Prerequisites:** A grade of C or better in ECE 3210 and ECE 3410 and a grade of C- or better in Stat 4710. Restricted to Electrical and Computer Engineering students only or instructor's consent

**ECE 3210: Microprocessor Engineering**
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 ECE 1210 and CMP_SC 1050

**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 3210

**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 3210

**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
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 4001: Topics in Electrical and Computer Engineering
Current and new technical developments in electrical engineering.
Credit Hour: 3-4
Prerequisites: senior standing

ECE 4020: Energy Systems and Resources
(same as NU_ENG 4315; 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

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

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: 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

ECE 4270: Computer Organization
(cross-leveled with ECE 7270). Advanced computer architectures and programming; memory, memory management and cache organizations, parallel processing, graphical processor units for general programming.
Credit Hours: 4
Prerequisites: ECE 3210 and ECE 4220

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: ECE 3220 or ECE 4220

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: ECE 3220 or ECE 4220

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: ECE 3220 or ECE 4220

ECE 4370: Automatic Control System Design
(cross-leveled with ECE 7370). 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 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.

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 4310

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

ECE 4450: Energy and Machines
Credit Hours: 3
Prerequisites: ECE 3510

ECE 4455: Energy and Machines Lab
Electrical safety, magnetic and poly-phase circuits, synchronous and induction machines laboratory.
Credit Hour: 1
Prerequisites or Corequisites: ECE 4460

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 4480: Test and Evaluation of Electrochemical Devices
(cross-leveled with ECE 7480). This combined undergraduate/graduate introductory course will introduce the student to the testing and evaluation of electrochemical cells and batteries. Included with an introduction to battery technology is material emphasizing test safety and operational hazards. Graded on A-F basis only. Recommended: at least 3 college credit hours of chemistry.
Credit Hours: 3
Prerequisites: senior standing in Electrical Engineering or major with equivalent mathematical preparation
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 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 4570: Lasers and Their Applications
(same as NU_ENG 4382; cross-leveled with ECE 7570, NU_ENG 7382). An introductory course in lasers. The course treats the subject from both a conceptual viewpoint and from the application of Maxwell's equations, to develop the optical theory for lasers. The course includes approximately 10 classroom hours of laboratory work with lasers.
Credit Hours: 3
Prerequisites: PHYSICS 2760 and MATH 4110

ECE 4580: Computational Neuroscience
(same as BIO_SC 4580, BIOL_EN 4575; cross-leveled with ECE 7580, BIO_SC 7580, BIOL_EN 7575). 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: Physical Electronics
(cross-leveled with ECE 7610). Introduction to physical principles of semiconductors and semiconductor devices; gas, solid state, and semiconductors lasers; electro-optics; plasma physics and gaseous electronics; materials interaction with electric and magnetic fields.
Credit Hours: 3
Prerequisites: ECE 3510

ECE 4630: Introduction to Optical Electronics
Credit Hours: 3
Prerequisites: ECE 3510

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 3510

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 or STAT 4710 or instructor's consent

ECE 4660: Microelectronic Fabrication
(cross-leveled with ECE 7660). 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 3510

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 3510

ECE 4675: Digital Image Compression
(same as CMP_SC 4675; 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 4690: Design and Simulation of VLSI Circuits
(cross-leveled with ECE 7690). 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 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

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 1210, 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

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 4950: Microwave Principles
(cross-leveled with ECE 7950). 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 4970: Senior Capstone Design

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

ECE 4970W: Senior Capstone Design - WI

Credit Hours: 3
Prerequisites: A grade of C or better in ECE 3110 and senior standing. Restricted to Electrical and Computer Engineering students only or instructor's consent
ECE 4980: Senior Capstone Design II
(same as CMP_SC 4980). Completion of ECE 4970 design project. Design prototyping, testing, evaluation and preparation of documentation. Lectures on ethics, professionalism, safety, economic consideration. Oral and written reports. Not for graduate credit.
Credit Hours: 2
Prerequisites: senior standing and ECE 4970

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: 3

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: 3-4
Prerequisites: MATH 2300

ECE 7020: Energy Systems and Resources
(same as NU_ENG 7315; cross-leveled with ECE 4020, NU_ENG 4315). 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.

ECE 7220: Real Time Embedded Computing
(cross-level 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: 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

ECE 7270: Computer Organization
(cross-leveled with ECE 4270). Advanced computer architectures and programming; memory, memory management and cache organizations, parallel processing, graphical processor units for general programming.
Credit Hours: 4
Prerequisites: ECE 3210

ECE 7270: Computer Organization
(cross-leveled with ECE 4270). Advanced computer architectures and programming; memory, memory management and cache organizations, parallel processing, graphical processor units for general programming.
Credit Hours: 4
Prerequisites: 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: ECE 3200 and CMP_SC 3280 or ECE 3210

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.
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. Recommended: a C/C++ Language course.

Credit Hours: 4
Prerequisites: ECE 4970 or equivalent

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

ECE 7460: Energy and Machines

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 7480: Test and Evaluation of Electrochemical Devices
(cross-leveled with ECE 4480). This combined undergraduate/graduate introductory course will introduce the student to the testing and evaluation of electrochemical cells and batteries. Included with an introduction to battery technology is material emphasizing test safety and operational hazards. Graded on A-F basis only. Recommended: at least 3 college credit hours of chemistry,

Credit Hours: 3
Prerequisites: graduate standing in Electrical Engineering or major with equivalent mathematical preparation

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 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 7570: Lasers and Their Applications
(same as NU_ENG 7382; cross-leveled with ECE 4570, NU_ENG 4382). An introductory course in lasers. The course treats the subject from both a conceptual viewpoint and from the application of Maxwell's equations, to develop the optical theory for lasers. The course includes approximately 10 classroom hours of laboratory work with lasers.
Credit Hours: 3
Prerequisites: PHYSCS 2760 and MATH 4110

ECE 7580: Computational Neuroscience
(same as BIO_SC 7580, BIOL_EN 7575; cross-leveled with ECE 4580, BIO_SC 4580, BIOL_EN 4575). 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 7610: Physical Electronics
(cross-leveled with ECE 4610). Introduction to physical principles of semiconductors and semiconductor devices; gas, solid state, and semiconductors lasers; electro-optics; plasma physics and gaseous electronics; materials interaction with electric and magnetic fields.
Credit Hours: 3
Prerequisites: ECE 3510

ECE 7620: Introduction to BioMEMS
Credit Hours: 3
Prerequisites: ECE 3610

ECE 7630: Introduction to Optical Electronics
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

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). 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 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

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**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 foundational 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

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**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

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**ECE 7810: Multimedia Engineering and Technology**  
(same as CMP_SC 7810). 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

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**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 1210, ECE 3830

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**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

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**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

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**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

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**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

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**ECE 8001: Advanced Topics in Electrical and Computer Engineering**  
Advanced Topics in Electrical and Computer Engineering

**Credit Hours:** 3

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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 Hours:** 1-3

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**ECE 8020: Superconductivity and its Applications**  
(same as NU_ENG 8450). Phenomenology and theory of superconductivity, cryogenic practice, metallurgy of superconducting elements, alloys and compounds. Present and prospective applications.

**Credit Hours:** 3

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**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
<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Prerequisites</th>
<th>Credit Hours</th>
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</thead>
<tbody>
<tr>
<td>ECE 8110</td>
<td>Preparing Advanced Professionals - I</td>
<td>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.</td>
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<td><strong>Prerequisites:</strong> restricted to graduate Engineering majors only</td>
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</tr>
<tr>
<td>ECE 8120</td>
<td>Preparing Advanced Professionals - II</td>
<td>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.</td>
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<td><strong>Prerequisites:</strong> graduate engineering majors only</td>
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<tr>
<td>ECE 8250</td>
<td>Digital Hardware Systems Design</td>
<td>Characteristics and parameters of various hardware subsystems including main memory, auxiliary memory, arithmetic units, card equipment, etc., and principles of organization into efficient system.</td>
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<td><strong>Prerequisites:</strong> ECE 4250</td>
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<tr>
<td>ECE 8260</td>
<td>Computer Networks</td>
<td>Concepts and goals of computer networking, structure of computer networks, OSI model and layers, network control, analysis, design, and management, data communication techniques including fiber optics, WAN, MAN and LAN architectures and protocols, inter-networking, case studies, and hands-on studying the performance by analytic modeling and computer simulation.</td>
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<td><strong>Prerequisites:</strong> CMP_SC 4270</td>
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<tr>
<td>ECE 8270</td>
<td>Parallel Computer Architecture</td>
<td>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.</td>
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<td><strong>Prerequisites:</strong> ECE 4270 or ECE 7270, ECE 4220 or ECE 7220 or CMP_SC 4250 or CMP_SC 7250</td>
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<tr>
<td>ECE 8320</td>
<td>Nonlinear Systems</td>
<td>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.</td>
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<td><strong>Prerequisites:</strong> ECE 4310</td>
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<tr>
<td>ECE 8330</td>
<td>Neural Networks for Learning Control</td>
<td>Neurocomputing techniques and structures for modeling, learning control, control stabilization, and optimization of performance over time.</td>
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<td><strong>Prerequisites:</strong> ECE 4310</td>
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<tr>
<td>ECE 8340</td>
<td>Multivariable Control System Design</td>
<td>This course will cover techniques in multivariable control system design and analysis, including LOG H-2 design, H-oo design, LTR, robust performance, and selected adaptive and learning control techniques for nonlinear control.</td>
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<td><strong>Prerequisites:</strong> at least on 4000, 7000 or 8000- level control course</td>
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<tr>
<td>ECE 8350</td>
<td>Optimal Control Theory</td>
<td>Analysis and design of dynamic systems using optimal control theory: parameter optimization, dynamic optimization, computational methods, differential games.</td>
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<td><strong>Prerequisites:</strong> ECE 8310</td>
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<tr>
<td>ECE 8360</td>
<td>Stochastic Optimal Estimation and Control</td>
<td>Surveys random process theory; stochastic control and optimization; estimation and filtering based on Kalman-Bucy techniques; stochastic stability; adaptive and learning control systems.</td>
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<td><strong>Prerequisites:</strong> ECE 8310</td>
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<tr>
<td>ECE 8370</td>
<td>Digital and Sample-Data Systems</td>
<td>Introduces sampling and quantization, design of digital and sample-data systems, digital filters, adaptive sampling and quantization.</td>
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<td><strong>Prerequisites:</strong> ECE 8310 and STAT 4710</td>
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<td>ECE 8410</td>
<td>Power Electronics II</td>
<td>Circuit concepts and analysis techniques for transistor switching regulators, thyristor choppers, transistor inverters, self-commutated thyristor investors and cycloconverters.</td>
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<td><strong>Prerequisites:</strong> ECE 4410</td>
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<tr>
<td>ECE 8420</td>
<td>Power Electronic Drives</td>
<td>Advanced study of DC and AC motor drives controlled by power electronic methods, including phase controlled rectifier, DC chopper, cycloconverter, variable frequency inverters.</td>
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<td><strong>Prerequisites:</strong> ECE 8410, ECE 8310</td>
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<tr>
<td>ECE 8430</td>
<td>Digital Electronics</td>
<td>Electronic hardware aspects of digital systems. Includes state-of-the-art information on integrated-circuit logic devices and their applications.</td>
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<td><strong>Prerequisites:</strong> ECE 8410, ECE 8310</td>
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<tr>
<td>ECE 8510</td>
<td>Advanced Electromagnetics</td>
<td>Advanced theoretical electromagnetics theory. Investigation of summation problems with general boundary conditions, time varying fields, and time</td>
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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, thermonic 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: Theoretical Neuroscience I
Properties of nerve cells including membrane potential, action potential, ion channel dynamics, GHK equation, dynamical properties of excitable membranes. Equilibria, stability, eigenvalues and phase portraits. Conductance based models, bifurcations, excitability. Graded on A-F basis only.

Credit Hours: 3
Prerequisites: ECE 4310

ECE 8580: Theoretical Neuroscience II
Neural encoding and decoding including firing rate and spike statistics, reverse correlation and visual receptive fields. Cellular and synaptic biophysics. Adaptation and learning including plasticity, classical conditioning, reinforcement learning and representational learning. Graded on A-F basis.

Credit Hours: 3
Prerequisites: ECE 8570

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 8630: Numerical Analysis of Semiconductor Devices
Basic equations of semiconductor device analysis, associated boundary conditions, and physical models; discretization schemes and numerical solution methods; application to one and two dimensional bipolar and field effect device structures in thermal equilibrium and under DC steady State and transient operating conditions.

Credit Hours: 3
Prerequisites: ECE 4630 and ECE 4650

ECE 8640: Advanced Integrated Circuits
Fundamentals of advanced integrated circuit design; diffusion, ion implantation and epitaxy; MOS and bipolar techniques; survey of current LSI design, fabrication and testing.

Credit Hours: 3

ECE 8650: Solid State Theory I
Principles of quantum and wave mechanics as applied to solid state; Boltzman and Fermi statistics; energy band theory of crystals; electrons, holes in semiconductors. Current flow in P-N junctions, semiconductor devices.

Credit Hours: 3

ECE 8660: Solid State Theory II
Fundamentals of crystallography; application of X-ray analysis to the study of crystallinity. Quantum mechanical solution for the wave function of an electron in a solid; concepts of reciprocal space.

Credit Hours: 3
Prerequisites: ECE 8650 or PHYSCS 8150

ECE 8680: Quantum Electronics

Credit Hours: 3
Prerequisites: PHYSCS 3150

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 8720: Microwave and RF Design of Wireless Systems**

Introduces fundamentals of Microwave/RF design and analysis of modern wireless systems. Topics include the following: wireless system components, receiver design, performance issues, noise, distortion, measurement techniques and computer-aided design techniques.

**Credit Hours:** 3

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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 consent of instructor

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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

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**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 8740: Digital Signal Processing in Remote Sensing**

Study of digital signal processing in remote sensing applications. Investigation of digital signal processing methods for visible, near infrared, thermal infrared, and microwave wavelength sensors.

**Credit Hours:** 3

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**ECE 8750: Digital Signal Processing in Telecommunications**

Applications of digital signal processing in telecommunication systems; oversampling and quantizations, Delta-Sigma modulation, linear predictive speech coding, adaptive filtering, echo canceller, adaptive receivers and equalizers for wireless communication, digital cellular, CDMA.

**Credit Hours:** 3

**Prerequisites:** ECE 4830 and ECE 4710

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**ECE 8770: Advanced Mobile Communication Systems**

Channel estimation 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

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**ECE 8780: State Variable Methods in Automatic Control**

(state as CH_ENG 8780, MAE 8780, NU_ENG 8408). State variables for continuous and discrete-time dynamic control systems; controllability and observability; optimal control of linear systems.

**Credit Hours:** 3

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**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

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**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

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**ECE 8820: Pattern Recognition**

(same as CMP_SC 8760). Decision functions, crisp and fuzzy clustering methods, statistical pattern recognition methods, Bayesian classifiers, error probabilities, estimation of density functions, perceptrons, least-mean-square algorithms, feature selection, dimensionality reduction and syntactic pattern recognition.

**Credit Hours:** 3

**Prerequisites:** CMP_SC 4050, STAT 4710

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**ECE 8830: Visual Signal Processing and Communications**

Threats visual digital signal processing and network communications covering both theory and application of coding, compression and
**ECE 8840: Artificial Intelligence**  
Concepts, theories, and models pertaining to neural nets, pattern recognition, learning systems, and programmed problem solving.  
**Credit Hours: 3**

**ECE 8850: Digital Image Processing**  
Image processing methods for segmentation, object representation, scene description and scene interpretation.  
**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

**ECE 8860: Probability and Stochastic Processes for Engineers**  
Introduction to probability, multidimensional complex (phasor) 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 8880: System Modeling**  
System performance requires the assessment of its delay and throughput. Markov theory provides the theoretical basis for such assessment. More general methods describe queues including open and closed queuing networks. Includes performance assessment of computer processors.  
**Credit Hours: 3**  
**Prerequisites:** STAT 4710