ELECTRICAL AND COMPUTER ENGINEERING

The D.Eng. major in ECE is an applied research-oriented doctoral degree designed to address the growing needs of industry for engineering professionals with advanced knowledge, technical skills, and the ability to conduct high quality applied research in electrical and computer engineering. It is an interdisciplinary effort to bring together the two broad disciplines of *Electrical Engineering* and *Computer Engineering*.

This program is designed to train students to conduct research and develop innovative technologies in the fields of electrical and computer engineering, robotics, energy systems, data science, and cyber-physical systems. The ECE faculty have expertise in electrical and computer engineering, robotics, energy systems, data science, and cyber-physical systems. Hence, the proposed D. Eng. major in ECE degree program can leverage existing department talent and resources to make the program successful. The program will admit students with a master's degree and industrial experience and offer a curriculum consisting of advanced ECE courses in the following core areas:

- *Electronics and Optoelectronics*
- *Energy and Power Systems*
- *Computer and Embedded Systems*
- *Communications and Computer Networks*
- *Control Systems and Signal Processing*
- *Security and Privacy of Cyber-Physical System*
- *Robotics, and*
- *Intelligent Systems.*

The general premises of the proposal are as follows:

- The new doctoral of engineering major in ECE aims to respond to the society's pressing and growing need for a highly and diversely educated workforce in electrical and computer engineering. This is especially true for the engineering workforce in Southeast Michigan.
- This program is necessary for further growth and development of UM-Dearborn and the ECE Department as an educational and research hub of the metropolitan Detroit community.

Program Details

The D.Eng. major in ECE degree requires a minimum of 39 credits hours consisting of 6 credit hours of curriculum requirement coursework, 3 credit hours of leadership development coursework, 6 credit hours of directed study and pre-candidate research courses, and 24 credit hours of dissertation research.

Program Policies

The D.Eng. major in ECE program falls under the UM-Dearborn Graduate School. Therefore students in this program need to meet the timeline, and processes for pre-candidacy, candidacy, proposal exam, and dissertation defense of the UM-Dearborn Graduate School policies for doctoral students.

The student in this program and his/her faculty advisor need to submit an ***annual progress report*** to the D.Eng. in ECE Doctoral Committee before May 31 of each academic year.

The D.Eng. in ECE Doctoral Committee and the faculty advisor are the main resources for information and guidance for the student throughout the program.

Admission Requirements

The D.Eng. major in ECE is intended for working professionals with research and development experience. Students are expected to maintain their employment status during their doctoral studies. The dissertation research topic is expected to be related to the applicant's area of expertise and job-related R&D responsibilities.

This program is for students who hold a master's degree in the related engineering areas, have industry-relevant research and development or professional working experience, the inspiration of becoming technical leaders, and attaining a higher level of value to their organizations. The minimum admission criteria are listed as follows.

- An MS degree in related engineering fields with a GPA above 3.2
- At least two years of full-time equivalent research and development experience in industry
- Three letters of recommendation from faculty and industry professionals, including at least one letter must be from a supervisor/employer and at least one letter from a faculty member. Working students, the letter must show commitment to the doctoral study and support from the employer.
- A statement of purpose. The statement of purpose should include the research topic and research plan.
- It is strongly recommended that a faculty advisor is identified at the time of application and is required before enrollment.

Preference is given to

- Students with scholarships/support provided by companies or government organizations
- Students with written financial support from their employers such as reduced working hours, e.g., 30 hours/week, for the first three years.

Fall-Term Admissions Only

Students admitted to this program are expected to be working professionals, and all admission offers are only for the Fall term.

Curriculum Requirements

- A student must complete a minimum of 39 credit hours. Out of the 39 credit hours, 6 credit hours of curriculum qualification coursework, 3 credit hours of leadership development coursework, and 30 credit hours of directed study or dissertation research.
- This program does not allow transfer credits towards degree requirements. That is, each candidate needs to complete 39 credit hours of coursework at the UM-Dearborn.
- A student must select two letter-graded courses at the graduate level (minimum 6 credit hours) related to the student's research field as curricular qualification courses. The courses must be selected based upon the faculty advisor's recommendation.

Available Research Areas

The D.Eng. major in ECE requires doctoral students to conduct applied research using emerging technologies in electrical and computer engineering and related areas. To ensure that students are able to select an appropriate and emerging area of study from the existing and

emerging fields of Electrical and Computer Engineering, the D. Eng. major in ECE focus areas are organized in eight areas of research:

1. *Electronics and Optoelectronics*
2. *Energy and Power Systems*
3. *Computer and Embedded Systems*
4. *Communications and Computer Networks*
5. *Control Systems and Signal Processing*
6. *Security and Privacy of Cyber-Physical Systems*
7. *Robotics*
8. *Intelligent Systems*

Course Requirements

Required Courses **39-credit hrs.**

Professional Required Leadership Course **3-credit hrs.**

Take one course from the following courses

Code	Title	Credit Hours
IMSE 515	Fundamentals of Program Mgt	3
OB 560	Management Skills Development	3
EDB 501	Leadership and Administration	3
EMGT 500	Management for Engineers	3

Technical Elective **6-credit hrs.**

Take two courses from one of the eight(8) specializations:

- 1: *Electronics and Optoelectronics*

Code	Title	Credit Hours
ECE 515	Vehicle Electronics II	3
ECE 517	Adv Pwr Electrncs&Motor Drvs	3
ECE 519	Adv Topics in EMC	3
ECE 532	Auto Sensors and Actuators	3
ECE 533	Active Automotive Safety Sys	3
ECE 539	Production of Elec Prods	3
ECE 5462	Elec Aspects of Hybrid Vehicle	3
ECE 566	Mechatronics	3

- 2: *Energy and Power Systems*

Code	Title	Credit Hours
ECE 517	Adv Pwr Electrncs&Motor Drvs	3
ECE 519	Adv Topics in EMC	3
ECE 541	Sustainable Energy Systems	3
ECE 542	Intr to Pwr Mgmt & Reliability	3
ECE 5421	Grid Communication and System	3
ECE 5422	Grid Protection	3
ECE 5423	Advanced Grid Protection	3
ECE 5424	Data Analytics and Machine Learning for Power Systems	3
ECE 5425	Fundamentals of Power Electronics	3
ECE 5426	Electric Machines and Drives	3
ECE 546	Electric Vehicles	3
ECE 5544	Intro. to CPS Security	3
ECE 5545	Sec. & Privacy for Smart Grids	3
ECE 5545	Sec. & Privacy for Smart Grids	3
ECE 5462	Elec Aspects of Hybrid Vehicle	3
ECE 5791	Vehicle Power Management	3
ECE 615	Advanced Power Electronics	3
ECE 616	Advanced Topics in Power Sys	3
ECE 646	Adv Elec Drive Transportation	3

- 3: *Computer and Embedded Systems*

Code	Title	Credit Hours
ECE 514	VLSI Design	3
ECE 528	Cloud Computing	3
ECE 554	Embedded Systems	3
ECE 5541	Embedded Networks	3
ECE 5542	Embedded Sig Proc and Control	3
ECE 5543	Embedded System Security	3
ECE 5544	Intro. to CPS Security	3
ECE 572	Sequential Machines	3
ECE 574	Adv Sftwr Techng in Eng Appl	3
ECE 575	Computer Architecture	3
ECE 5752	Reconfigurable Computing	3
ECE 578	Advanced Operating Systems	3
ECE 614	Ctrl Networks for Embedded Sys	3
ECE 675	Computer Architecture II	3

- 4: *Communications and Computer Networks*

Code	Title	Credit Hours
ECE 528	Cloud Computing	3
ECE 535	Mob Dev & Ubiqys Comp Sys	3
ECE 550	Communication Theory	3
ECE 570	Computer Networks	3
ECE 5701	Intro to Wireless Comm	3
ECE 5702	High-Speed and Adv Networks	3
ECE 612	Wireless Sensor Networks	3
ECE 614	Ctrl Networks for Embedded Sys	3
ECE 670	Adv Comp Netwk&WL Comm	3

- 5: *Control Systems and Signal Processing*

Code	Title	Credit Hours
ECE 512	Analog Filter Design	3
ECE 550	Communication Theory	3
ECE 552	Fuzzy Systems	3
ECE 555	Stochastic Processes	3
ECE 560	Modern Control Theory	3
ECE 565	Digital Control Systems	3
ECE 567	Nonlinear Control Systems	3
ECE 580	Digital Signal Processing	3
ECE 5802	Multirate Sig Proc w/Appl	3
ECE 581	Arch for Digital Signal Proc	3
ECE 582	Intro to Statistical DSP	3
ECE 584	Speech Processes	3
ECE 586	Digital Image Processing	3
ECE 587	Sel Top:Image Proc/Mach Vision	3
ECE 589	Multidimen Digital Signal Proc	3
ECE 661	Sys Ident and Adaptive Control	3
ECE 665	Optimal Control Systems	3
ECE 681	Adv Digital Sig Processing	3

- 6: *Security and Privacy of Cyber-Physical System*

Code	Title	Credit Hours
ECE 527	Multimedia Secur & Forensics	3
ECE 5421	Grid Communication and System	3
ECE 5422	Grid Protection	3
ECE 5423	Advanced Grid Protection	3
ECE 5543	Embedded System Security	3
ECE 5544	Intro. to CPS Security	3
ECE 5545	Sec. & Privacy for Smart Grids	3
CIS 544	Computer and Network Security	3
CIS 545	Data Security and Privacy	3
CIS 546	Security and Privacy in Wireless Networks	3
CIS 548	Security and Privacy in Cloud Computing	3
CIS 549	Software Security	3
CIS 576	Database Security	3
CIS 5761	Advances in Informatn Security	3
CIS 584	Advanced Computer and Network Security	3
ECE 620	Sensor Security and Data Integrity Validation	3
CIS 624	Research Advances in Computer and Network Security	3

- 7: *Robotics*

Code	Title	Credit Hours
ECE 531	Intelligent Vehicle Systems	3
ECE 536	All Weather Automotive Vision	3
ECE 537	Data Mining	3
ECE 539	Production of Elec Prods	3
ECE 543	Kinem, Dynam Control Robots	3
ECE 544	Mobile Robots	3
ECE 545	Intro Robot Syst	3
ECE 555	Stochastic Processes	3
ECE 560	Modern Control Theory	3
ECE 565	Digital Control Systems	3
ECE 566	Mechatronics	3
ECE 567	Nonlinear Control Systems	3
ECE 5770	Autonomous UAS	3
ECE 579	Intelligent Systems	3
ECE 5831	Pat Rec & Neural Netwks	3
ECE 587	Sel Top:Image Proc/Mach Vision	3
ECE 588	Robot Vision	3
ECE 642	Robotic Embed Sys	3
ECE 643	Humanoids	3
ECE 644	Advanced Robotics	3
ECE 645	Coop Robots	3
ECE 661	Sys Ident and Adaptive Control	3
ECE 665	Optimal Control Systems	3

- 8: *Intelligent Systems*

Code	Title	Credit Hours
ECE 531	Intelligent Vehicle Systems	3
ECE 532	Auto Sensors and Actuators	3
ECE 536	All Weather Automotive Vision	3
ECE 537	Data Mining	3
ECE 544	Mobile Robots	3
ECE 552	Fuzzy Systems	3
ECE 5770	Autonomous UAS	3
ECE 579	Intelligent Systems	3
ECE 5831	Pat Rec & Neural Netwks	3
ECE 588	Robot Vision	3
ECE 643	Humanoids	3
ECE 644	Advanced Robotics	3
ECE 679	Adv Intelligent Sys	3

Research

6-credit hrs.

Complete 6 credit hrs. of ECE 691 Adv Directed Studies for Doctoral Independent Study requirement

Dissertation Research

24-credit hrs.

- ECE 980 Pre-Cand Dissertation Research
- ECE 990 Doctoral Dissertation

Curricular Qualification

The program does not have a written qualifying examination, but the program has the following curricular qualification requirements.

- The student must obtain a B+ or better grade for the leadership development course.

- The student must obtain a B+ or better grade in both curriculum qualification courses and maintain combined GPA of 3.5/4.0 or better to meet the curricular qualification requirement.
  - If the combined GPA is below 3.3/4.0, the student is allowed to select another course as a second curriculum qualification course and must get 3.5/4.0 or better to meet the curricular qualification requirement. No additional attempts for combined GPA improvement are permitted.

Early Start Research and Research Maintenance Requirements

- ***Early Start Requirements***

To get an early start in research, each student should have a faculty research advisor at the beginning of the first semester, and work with the advisor to get a dissertation research topic selected. A good plan of research milestones needs to be developed by the end of the second semester in the program. There is an additional requirement that at least 6 credit hours of faculty-guided research be completed within the first year of enrollment in the program. In the first semester, all students need to take the ECE 691 (Doctoral Direct Study) and in the second semester take ECE 980 (Pre-candidate Dissertation Research). The required outcomes of ECE 691 include:

- Well-defined research topic/objective/technical approach
- An in-depth literature review

The required outcomes of ECE 980 include:

- An approved dissertation committee
- Promising preliminary study results
- Well-developed research plan and milestones, and
  - Successfully passed dissertation proposal examination, which also covers the fundamentals of the research related to student's dissertation research area.
    - If a student does not pass the examination, an "I" grade will be given to the student, and the student needs to retake the ECE 980 in the following semester and the dissertation proposal examination. If the student passes the examination the second time, an "S" grade will be given to the ECE 980 course taken in both semesters. If the student fails the examination for the second time, the student must withdraw from the program.
- ***Research Maintenance Requirements:***
  - ECE 990 (Dissertation for candidates) can only be taken after a student achieves candidacy. A minimum of 24 credit hours in ECE 990 is required.
  - During the candidacy, a student enrolls in ECE 990 every semester. The outcomes of ECE 990 include a written dissertation research progress report, a presentation of research results to the dissertation committee. The adviser will give an "S" or "U" grade based on the student's research performance. The metric to measure a student's progress includes, but is not limited to, regular meetings with the adviser, good quality research progress reports, publications, patent applications, and prototype demonstration. The faculty advisor notifies the ECE committee about the student's progress in each semester.

Dissertation Committee

The dissertation committee is formed when a student takes ECE 980. As a rule, the dissertation committee continues overseeing the student's work to the stage of the final dissertation defense.

- The faculty advisor serves as the chair of the Dissertation Committee.
- The dissertation committee will consist of a minimum of three members in addition to the committee chair. The committee members will include two faculty members (at least one member from the ECE Department) and one member from industry.
- The composition of the dissertation committee must be approved by the D. Eng. program committee. The industry member's curriculum vitae must be submitted to the Program Committee for approval.
- Depending on the dissertation topic, a faculty member outside the ECE Department or CECS may be included in the dissertation committee.
- A committee may have a sole chair or two co-chairs. Persons who may serve as co-chair, but not the sole chair, include:
  - Tenure or tenure-track members of the University's instructional faculty;
  - Research faculty;
  - Instructors and lecturers;
  - Similarly qualified University faculty or staff, or person from outside the University; and

Former University faculty members who have moved to a faculty position at another university

Candidacy Requirements

Achieving candidacy for the CECS D. Eng. major in ECE requires:

- Completion of one leadership development course with a B+ or higher grade
- Completion of the two curricular qualification courses with a B + or higher grade for each course and with a combined GPA of 3.5/4.0
- Completion of all the required outcomes of the course ECE 980
- Submission of the candidacy application form
- Approved Doctoral Dissertation Committee

At this point, the student will be allowed to formally pursue the dissertation work by registering for ECE 990 every fall and winter semester until the student completes the dissertation and the oral defense examination.

Graduation Requirements

A student must complete a minimum of 39 credit hours, including 9 credit hours of coursework, 6 credit hours of directed study and pre-candidate research courses, and 24 credit hours of dissertation research. The student must obtain a B+ or better grade for each of the three curricular qualification courses and maintain a cumulative GPA of 3.5/4.0 for good academic standing and graduation.

Dissertation

After passing ECE 980, the student may proceed with the dissertation research and the writing of the dissertation. The dissertation should document the original contributions made by the candidate as a result of independent research. This research work should be of archival quality. In advance of graduation, all members of the student's dissertation committee must approve the dissertation. To obtain this approval a student must submit a written copy of the dissertation to the dissertation committee and defend the research work at a final oral examination open to other faculty, students, and the interested public. Students defending the dissertation must be registered in ECE 990.

Upon completion of the dissertation work, the student initiates the last step toward the degree—the dissertation defense process. The process follows the official guidelines and consists of the following main stages:

- Preparation of a written dissertation formatted in accordance with the guidelines,
- Pre-defense meetings with the members of the program committee,
- Written evaluations of the dissertation by the dissertation committee members
- The oral defense of the dissertation consisting of two parts:
  - Public seminar and open question session held by the student
  - Private deliberations by the Committee,
- The final oral examination report and certificate of approval prepared by the dissertation committee
- Post-defense meeting with the CECS Graduate Education Office

Timeline Requirements

The D.Eng. major in ECE has a time limit of 3 years for completion. Students are expected to complete the degree within 2 years after achieving candidacy, but no more than 3 years from the date of the first enrollment in the program. A student is considered to have completed the D.Eng. major in ECE only if the student has completed the two required courses with satisfactory grades, one leadership development course with a B+ or higher grade, and the required research credit hours, passed the dissertation defense and obtained a satisfactory grade on the written dissertation. A petition for an extension of study time may be submitted by the student with the endorsement of the student's dissertation advisor to the Committee of D.Eng. major in ECE for approval. The time extension will be no more than 2 years.

ECE 500 Math Mthds for Elec & Comp Eng 3 Credit Hours
Topics include: Transform Techniques using Fourier series, Fourier transforms, Laplace transforms and Sampling Theorem. Linear Algebra using eigen expansions, polynomial functions and matrices and determinants. Random Variables using probability density and distribution functions, functions of a random variable, and conditional and joint probabilities.
Restriction(s):
Can enroll if Class is Graduate
Can enroll if Major is Electrical Engineering, Computer Engineering

ECE 5001 Analytic and Comp Math 3 Credit Hours
Full Title: Analytical and Computational Mathematics This course covers selected topics in applied mathematics useful in science and engineering fields, including: solution of linear equations, polynomial interpolation and approximation, solution of nonlinear equations, roots of polynomials, resultants, approximation by orthogonal functions (includes Fourier series), ordinary differential equations, optimization, calculus of variations, probability and stochastic processes, computational geometry, and differential geometry. In addition to providing students with necessary mathematical knowledge for their future course study and research projects, students will be required to program in MATLAB and/or other languages to gain and improve programming ability. Students in RE program must take this course in the first year. This course cannot be taken with ECE 500. Three lecture hours per week. (F)
Restriction(s):
Can enroll if College is Engineering and Computer Science

ECE 502 Electromag Theory & Simul 3 Credit Hours
The course will cover basic devices and applications in Electromagnetic waves. The course will use examples of electromagnetic devices that operate at low frequency, (e.g., coils and motors), and others that operate at high frequency (e.g., Optical fiber, Laser, Imaging Sensor, LEDs, Solar cells and Antenna.) The course will develop fundamental understandings for the behavior of these devices. Three lecture hours per week.
Restriction(s):
Can enroll if Level is Rackham or Graduate
Can enroll if Major is Software Engineering, Industrial & Systems Engin, Mechanical Engineering, Computer Engineering, Electrical Engineering

ECE 505 Intro to Embedded Systems 3 Credit Hours
Introduction to modern digital computer logic. Numbers and coding systems; Boolean algebra with application to logic systems; examples of digital logic circuits; simple machine language programming and Assembly and C/C+ programming language; microprocessors programming (both assembly and C/C+) for input/output, interrupts, and system design. (May not be available to students with EE or CE degrees) Three lecture hours per week.
Restriction(s):
Can enroll if Class is Graduate
Can enroll if Major is Electrical Engineering, Computer Engineering

ECE 507 Intro to Multimedia Sys 3 Credit Hours
This course is designed to provide a broad overview of the engineering, art, and business of developing multimedia systems. In terms of technical and engineering issues, students will learn basic data analysis techniques and computer programming tools. In terms of art and media, students will learn the basics of human perception, communication, and aesthetics. In terms of business, students will learn how to identify customer needs and think like an entrepreneur. By learning and understanding the working vocabulary of each of these three fields, students will be able to contribute creative and effective multimedia-based solutions to interesting real-world problems. Three lecture hours per week.
Restriction(s):
Can enroll if Class is Graduate

ECE 510 Vehicle Electronics I 3 Credit Hours
This course discusses the principles of electrical engineering and applications of electrical and electronic systems in automobiles, including resistive, inductive, and capacitive circuit analysis, semiconductor diodes, junction transistors, FETS, rectifiers, and power supplies, small signal amplifiers, biasing considerations, gain-bandwidth limitations, circuit models. Some automotive EE applications are used for case study. Three lecture hours per week. (Not open to students with EE degree.)
Restriction(s):
Can enroll if Class is Graduate
Cannot enroll if Major is Electrical Engineering, Computer Engineering

ECE 512 Analog Filter Design 3 Credit Hours
This course addresses the analysis and design of continuous time (analog) and switched-capacitor filters. Students will analyze and design filters. Effect of tolerances of circuit elements on the performance of the circuit behavior will be analyzed. Students will use simulation tools to design filters and verify circuit performance. Three lecture hours per week.
Prerequisite(s): ECE 314
Restriction(s):
Can enroll if Class is Graduate
Can enroll if Major is Electrical Engineering, Computer Engineering

ECE 5121 Mod & Des of Electrnic Cir&Sys 3 Credit Hours
Review semiconductor circuit elements in detail to model devices for circuit analysis. Devices include diodes, bipolar junction transistors, MOSFETs and operational amplifiers. Discussion of large signal and small signal (ac) models, frequency effects and non-ideal models. Design circuits such as switching circuits, power suppliers, amplifiers, oscillators, non-linear circuits. Students will gain experience in terms of designing, simulating and implementing electronic circuits and systems. Three lecture hours per week.
Restriction(s):
Can enroll if Level is Doctorate or Rackham or Graduate or
Can enroll if Major is Electrical Engineering, Computer Engineering

ECE 513 Computer-Aided Network Design 3 Credit Hours
Numerical methods required for circuit analysis and design using digital computers are investigated. These techniques include matrix analysis of linear systems; network graphic theory, tolerance analysis, transient analysis, numerical integration, nonlinear circuit analysis, network optimization, and device modeling. Practical examples are given requiring the construction of computer subroutines and use of general analysis programs such as ECAP and CIRAN. Three lecture hours.
Prerequisite(s): ECE 410
Restriction(s):
Can enroll if Class is Graduate

ECE 514 VLSI Design 3 Credit Hours
Topics relevant to the design and analysis of VLSI circuits are investigated. These include an introduction to CMOS circuits, their characterization and performance estimation. Logic design and testing of VLSI circuits. Analysis of layout and the design of subsystems. VHDL and commercial CAD packages for VLSI design.
Prerequisite(s): ECE 413
Restriction(s):
Can enroll if Class is Graduate
Can enroll if Major is Electrical Engineering, Computer Engineering

ECE 515 Vehicle Electronics II 3 Credit Hours
This course discusses advanced topics in electronics with an emphasis on vehicle applications. It will include ignition systems and controls, amplifiers, frequency characteristics of electronic circuits, feedback in electronic systems and stability, power electronics and motor drive controls (DC/DC and DC/AC converters) and EMC issues. Selected examples include applications such as voltage regulators and battery chargers. Three lecture hours per week.
Prerequisite(s): AENG 510

ECE 516 Electronic Materials & IC Proc 3 Credit Hours
Review of representative electronic devices and illustrative applications. Properties of electronic materials. Semiconductors. PN junctions, bi-polar and field-effect transistors. Integrated circuit processing, bonding and packaging. Failure mechanisms and interconnect lifetime prediction. Case studies and applications.
Restriction(s):
Can enroll if Class is Graduate
Can enroll if Major is Electrical Engineering, Computer Engineering

ECE 517 Adv Pwr Electrncs&Motor Drvs 3 Credit Hours
This is an advanced course on power electronics and electric drives. Example topics include DC, induction, synchronous and reluctance drives; industrial and residential application of power electronics; practical aspects of design of power electronics devices including heat sink and magnetic components designs. Three lecture hours per week.
Prerequisite(s): ECE 415
Restriction(s):
Can enroll if Class is Graduate
Can enroll if Level is Rackham or Graduate
Can enroll if College is Engineering and Computer Science
Can enroll if Major is Electrical Engineering, Computer Engineering

ECE 518 Mat Selec for Commercial Prod 3 Credit Hours
Impact of modern materials on commercial product performance; representative illustrations from product areas such as automotive vehicles, commercial aircraft, recreational equipment, and electronic products.
Restriction(s):
Can enroll if Class is Graduate

ECE 519 Adv Topics in EMC 3 Credit Hours
This course covers the EMC requirements and EMC test methods for large systems. Examples involving various types of applications (automotive, communications, computers) will be discussed. Discussion of design practices used in large installation, including component segregation, cable routing, connectors, grounding, shielding, common impedance coupling, ground planes, screening and suppression. Classification of electromagnetic environments will also be discussed. Three lecture hours per week.
Restriction(s):
Can enroll if Class is Graduate or Doctorate
Can enroll if Level is Doctorate or Rackham or Graduate or
Can enroll if Major is Electrical Engineering, Computer Engineering

ECE 524 Interactive Media 3 Credit Hours
This course will provide an introduction to computer and human interface and AI, user-interface design from design principles and cognitive perspectives. The course covers such topics innovative multimedia interfaces, design ethics, psychological principles, cognitive models, interaction principles, requirements analysis, project management, I/O devices, standards and styles guides, and visual design principles. This is a project-based class. Three lecture hours per week.
Restriction(s):
Can enroll if Class is Graduate
Can enroll if Level is Rackham or Graduate

ECE 525 Multimedia Data Stor & Retr 3 Credit Hours
This course will cover the fundamental concepts and techniques used in multimedia data, storage and retrieval including storage and retrieval images, videos, audio and text documents. Selected multimedia applications will be discussed and students will be required to work on a project related to multimedia applications such as advertising and marketing, education and training, entertainment, medicine, surveillance, wearable computing, biometrics, and remote sensing. Three lecture hours per week.
Restriction(s):
Can enroll if Class is Graduate
Can enroll if Major is Software Engineering, Electrical Engineering, Computer & Information Science, Computer Engineering

ECE 5251 MM Design Tools I 3 Credit Hours
This course will introduce students to design tools for multimedia systems. Basic concepts, algorithms, and standards will be covered for systems that process digital images, vector graphics, and text. Models and relevant parameters of display technologies (video and printer) will be discussed. Part of the coursework involves a project concerning the analysis and design of a multimedia-based system. Three lecture hours per week.
Restriction(s):
Can enroll if Class is Graduate
Can enroll if Major is Software Engineering, Electrical Engineering, Computer & Information Science, Computer Engineering

ECE 5252 MM Design Tools II 3 Credit Hours
This course will introduce students to multimedia design tools for dynamic media (video and audio). Basic concepts of digital video will be reviewed, such as resolution and compression standards. Algorithms and methods for video and audio processing and effects will be reviewed. Part of the coursework involves a project concerning the analysis and design of a multimedia-based system. Three lecture hours per week.
Restriction(s):
Can enroll if Class is Graduate
Can enroll if Major is Electrical Engineering, Computer Engineering

ECE 526 Multimedia Comm Sys 3 Credit Hours
Object of this course is to introduce current techniques in multimedia communications. This course will cover in-depth study of existing multimedia compression standards such as, MPEG, MJEG, JPEG2000, etc. The course will introduce the basic issues in multimedia communications and networking and is designed to give the student hands-on experience in various aspects of multimedia communications through the various assignments and projects.
Restriction(s):
Can enroll if Class is Graduate
Can enroll if Major is Software Engineering, Electrical Engineering, Computer & Information Science, Computer Engineering

ECE 527 Multimedia Secur & Forensics 3 Credit Hours
Object of this course is to introduce current techniques information security in general and multimedia security in particular. This course will cover existing information hiding techniques such as digital watermarking, steganography, and fingerprinting. The course will also cover basics of cryptography and coding theory. This course will cover the basic issues in multimedia security and forensics and is designed to give the student hands-on experience in various aspects of information security and forensic analysis through the various assignments and projects. Three lecture hours per week.
Restriction(s):
Can enroll if Class is Graduate
Can enroll if Major is Software Engineering, Electrical Engineering, Computer & Information Science, Computer Engineering

ECE 528 Cloud Computing 3 Credit Hours
Cloud computing represents the emerging Internet-based services/ platforms with elastic and scalable computation powers operating at costs associated with service. Topics of the course include advanced web technologies, distributed computing models and technologies, software as a service (SaaS), virtualization, pallelization, security/privacy and the advance in cloud computing. Course work includes building up a SaaS project. Students cannot take both ECE 428 and ECE 528 for degree credit. Three lecture hours per week.
Restriction(s):
Cannot enroll if Class is
Can enroll if Level is Graduate or Doctorate
Cannot enroll if Major is

ECE 529 Intro to Computer Music 3 Credit Hours
This course will introduce students to methods and technologies of computer music. The basics of digital audio will be covered, including sampling, quantization, and compression standards. Various analysis tools will be covered, including the Fourier transform and windowing techniques. Mathematical models of physical instruments will be introduced. Various sound synthesis strategies will be introduced: wave tables, additive synthesis, subtractive synthesis, frequency modulation, and granular synthesis. Three lecture hours per week.
Restriction(s):
Can enroll if Class is Graduate
Can enroll if Major is Electrical Engineering, Computer Engineering

ECE 530 Energy Storage Systems 3 Credit Hours
This course introduces the basics of energy storage systems for EDV. It will cover battery basics, ultracapacitors, flywheels, and hybrid energy storage concepts. Battery management, battery charging, and battery safety will be covered. Finally, the requirements of EDV and renewable energy application examples will be explained. Lead acid, nickel metal hydride, and lithium ion batteries will be covered. Other energy storage systems such as super conducting magnetic, hydraulic, compressed air, and integrated (hybrid) energy storage systems, will be discussed as well.
Restriction(s):
Can enroll if Class is Graduate or Doctorate
Can enroll if Level is Doctorate or Rackham or Graduate or
Can enroll if College is Engineering and Computer Science
Can enroll if Major is Computer & Information Science, Software Engineering, Electrical Engineering, Industrial & Systems Engin, Mechanical Engineering, Automotive Systems Engineering, Computer Engineering

ECE 531 Intelligent Vehicle Systems 3 Credit Hours
The course covers important technologies relevant to intelligent vehicle systems including systems architecture, in-vehicle electronic sensors, traffic modeling and simulation. Students will design and implement algorithms and simulate driver-highway interactions.
Restriction(s):
Can enroll if Class is Graduate or Doctorate
Can enroll if Level is Doctorate or Rackham or Graduate or
Cannot enroll if Major is

ECE 532 Auto Sensors and Actuators 3 Credit Hours
Study of automotive sensory requirements; types of sensors; available sensors and future needs. Study of functions and types of actuators in automotive systems. Dynamic models of sensors and actuators. Integrated smart sensors and actuators. Term project.
Restriction(s):
Can enroll if Class is Graduate or Doctorate

ECE 533 Active Automotive Safety Sys 3 Credit Hours
The course addresses enabling technologies relevant to active automotive safety systems. The study of intelligent vehicle systems includes system architectures, sensors, and algorithms. Modeling and simulation will also be covered. Students will design and simulate systems encompassing important concepts presented in the course. Three lecture hours per week.
Restriction(s):
Can enroll if Class is Graduate or Doctorate

ECE 535 Mob Dev & Ubiqys Comp Sys 3 Credit Hours
This class will introduce students to the technology used in mobile/smart devices and mobile communication networks. Various hardware and software aspects will be introduces, with particular emphasis on the constraints intrinsic to such system. Students will get an overview of various mobile operating systems and will learn how to develop software for mobile devices. The topics of ubiquitous and pervasive computing will be introduced and discussed. Three lecture hours per week.
Restriction(s):
Can enroll if Class is Graduate or Doctorate
Cannot enroll if Major is

ECE 536 All Weather Automotive Vision 3 Credit Hours
Coverage of the next generation of active automotive safety systems including intelligent cruise control, lane departure warning, virtual camber, and back-up and blind spot warning systems. Topics include active safety system architecture, enabling technologies for such systems, and future directions. Three lecture hours per week.
Restriction(s):
Can enroll if Class is Graduate

ECE 537 Data Mining 3 Credit Hours
Introduction to the fundamental concepts of data mining including data exploration, pre-and post-processing, OLAP, predictive modeling, association analysis, and clustering. This course also focuses on the analysis of algorithms commonly used for of data mining applications, mining structured, semi-structured and unstructured data, stream data, and web data. Team oriented course project to provide hands-on experience may be required. Three lecture hours per week.
Prerequisite(s): ECE 479 or CIS 479
Restriction(s):
Can enroll if Class is Specialist or Graduate or Doctorate

ECE 539 Production of Elec Prods 3 Credit Hours
The course discussed the manufacturing of discrete components, integrated circuits, hybrid circuits and modules, advances packages, printed circuit boards, optical components, and MEMS products. Special topics on product testing, reliability assurance, accelerated reliability testing, product lifetime models, and automotive environments will also be addressed. The course will be organized as a combination of conventional lectures, workshops-style discussion, and design review sessions. Three lectures hours per week.
Restriction(s):
Can enroll if Major is Electrical Engineering, Manufacturing Engineering, Computer Engineering

ECE 541 Intro to Electrical Energy Sys 3 Credit Hours
The course will cover the sources of energy including coal, nuclear, solar, wind; their impact on the climate; and their technological characteristics in terms of availability, cost and reliability. Three lecture hours per week.
Restriction(s):
Can enroll if Class is Graduate
Can enroll if Major is Mechanical Engineering, Industrial & Systems Engin, Computer Engineering, Electrical Engineering

ECE 542 Intr to Pwr Mgmt & Reliability 3 Credit Hours
This course will give students an introduction to power and energy management systems. Students will be exposed to a broad range of topics including optimal power flow, Smart Grid technology, economic dispatch, unit commitment, and the impact of renewable energy on power and management systems. Three lecture hours per week.
Restriction(s):
Can enroll if Class is Graduate
Can enroll if Level is Doctorate or Rackham or Graduate or
Can enroll if College is Engineering and Computer Science

ECE 5421 Grid Communication and System 3 Credit Hours
This course (1) includes communication models for monitoring and controlling the electrical system, specific legacy protocols and modern approaches, such as IEC 61850, and (2) covers introductory topics in cyber-physical systems (CPSs) security for power grids. This class includes assignments to reinforce learning and uses industry leading edge hardware to simulate control and monitoring of real world scenarios. (F, W).
Restriction(s):
Can enroll if Level is Doctorate or Rackham or Graduate or
Can enroll if Major is Computer & Information Science, Computer Engineering, Software Engineering, Industrial & Systems Engin, Mechanical Engineering, Automotive Systems Engineering, Electrical Engineering

ECE 5422 Grid Protection 3 Credit Hours
The goal of this course is to introduce protecting an electrical system from faults and other concerns in distribution system. Includes symmetrical component calculations and use; protection coordination; network, radial and ringed system protection; central station and distributed generator protection; and an overview of emerging topics. The focus of this class is on protection of radial fed system, fault studies and arc-flash calculations. (F, W).
Restriction(s):
Can enroll if Level is Doctorate or Rackham or Graduate or
Can enroll if Major is Computer & Information Science, Computer Engineering, Electrical Engineering, Software Engineering, Information Sys Engineering, Mechanical Engineering, Automotive Systems Engineering, Industrial & Systems Engin

ECE 5423 Advanced Grid Protection 3 Credit Hours
This course builds on ECE 5422 Grid Protection to include more advanced topics including a focus on networked and ringed systems, generation protection, grounding and protecting distribution networks with two-way power flow. (F, W).
Prerequisite(s): ECE 5422
Restriction(s):
Can enroll if Level is Doctorate or Rackham or Graduate or
Can enroll if Major is Computer & Information Science, Computer Engineering, Electrical Engineering, Software Engineering, Information Sys Engineering, Mechanical Engineering, Automotive Systems Engineering, Industrial & Systems Engin

ECE 5424 Data Analytics and Machine Learning for Power Systems 3 Credit Hours
The course is designed to provide introductory coverage of data analytics and machine learning with the major applications in power engineering. Students will be exposed to a broad range of topics including data collection, data processing, and data mining for electrical power systems. This course provides students with hands-on experience through computer-based simulation projects. Advisory prerequisite: Basic understanding of power systems and machine learning. (F).
Restriction(s):
Can enroll if Level is Graduate or or Doctorate
Can enroll if Major is Computer & Information Science, Computer Engineering, Electrical Engineering, Software Engineering, Information Sys Engineering, Mechanical Engineering, Automotive Systems Engineering, Industrial & Systems Engin

ECE 543 Kinem, Dynam Control Robots 3 Credit Hours
Full Title: Kinematics, Dynamics, and Control of Robots This course provides a systematic study of robotics, covering various topics in kinematics, dynamics, control, and planning for robot systems. The purpose of this course is to let students get familiar with the traditional mathematical description of a robotic system and understand fundamental concepts and principles in robotics, to enable students to derive equations of motion for robotic systems, analyze their kinematic and dynamic properties, and design control strategies, and also to have students gain knowledge and experience about commonly-used robotic systems and mechanisms. Starting with rigid body motion, we will learn a systematic way to describe a robot system that consists of multiple links connected through different kinds of joints. Kinematics will include forward and inverse kinematics and their analytical and constraints. Control will include the classic PID control, position and force control, and trajectory tracking. This course will also discuss some specific topics in robotics research, including robot manipulators, mobile and walking robots, and robot hands, in which we will see how the above principles and methods are being used together. Three lecture hours per week. (W)
Prerequisite(s): ECE 347
Restriction(s):
Can enroll if Class is Graduate or Doctorate
Can enroll if Level is Graduate or or Doctorate
Can enroll if College is Engineering and Computer Science

ECE 544 Mobile Robots 3 Credit Hours
This course gives an introduction to all the fundamentals of mobile robots, ranging from theory, such as kinematics, over hardware, such as sensors and motors, to core algorithms for sensory information processing, motion planning and control, and etc. A high level-overview of different types of mobile robots is presented first. Then, theoretical methods for analyzing the kinematic and dynamic properties of a mobile robot are discussed, followed by the discussion on the key subsystems of a mobile robot, including perception, localization, planning and control. For each subsytem, the discussion includes relevant methods for understanding and constructing the model of the environment or planning and controlling the motion of the robot. The course has three lecture hours per week. Students are expected to have knowledge of MATLAB or C/C++ programming and will be required to accomplish a course-related project. Three lecture hours per week. (F)
Restriction(s):
Can enroll if Class is Graduate
Can enroll if Level is Graduate or or Doctorate
Can enroll if College is Engineering and Computer Science

ECE 545 Intro Robot Syst 3 Credit Hours
Full Title: Introduction to Robotic Systems This courses introduces basic components of robotic systems, selection of coordinate frames, homogeneous transformations, solutions to kinematics of manipulators, velocity and force/torque relations, dynamic equations using Euler-Lagrange formulation, obstacle avoidance and motion planning, classical controllers for manipulators and controller design using torque method, and robot simulation tools. Sensing technologies including basic computer vision will be covered. Robot simulation technologies and tools will be introduced. Robotic systems other than manipulators will be introduced at the end of this course. Three lecture hours per week. (F)
Restriction(s):
Can enroll if College is Engineering and Computer Science

ECE 546 Electric Vehicles 3 Credit Hours
To introduce fundamental concepts and specifications of electric and hybrid vehicles; vehicle design fundamentals; motors for electric vehicles; controllers and power electronics; energy sources; engineering impact of electric vehicles and practical design considerations. Three lecture hours per week.
Restriction(s):
Can enroll if Class is Graduate

ECE 5462 Elec Aspects of Hybrid Vehicle 3 Credit Hours
To introduce fundamental concepts and the electrical aspects of HEV, including the design, control, modeling, battery and other energy storage devices, and electric propulsion systems. It covers vehicle dynamics, energy sources, electric propulsion systems, regenerative braking, parallel and series HEV design, practical design considerations, and specifications of hybrid vehicles. Three lecture hours per week.
Restriction(s):
Can enroll if Class is Graduate
Can enroll if Major is Electrical Engineering, Computer Engineering

ECE 550 Communication Theory 3 Credit Hours
The basic limitations and alternatives for communications signaling are studied, using appropriate mathematical tools. The topics include: review of information measure; random process and vector description of signals and noise; optimum receiver principles; signaling alternatives; channel capacity; block and convolutional coding; waveform estimation concepts. Practical system examples are stressed.
Prerequisite(s): ECE 450
Restriction(s):
Can enroll if Major is Electrical Engineering, Computer Engineering

ECE 552 Fuzzy Systems 3 Credit Hours
A study of the concept of fuzzy set theory including operations on fuzzy sets, fuzzy relations, fuzzy measures, fuzzy logic, with an emphasis on engineering application. Topics include fuzzy set theory, applications to image processing, pattern recognition, artificial intelligence, computer hardware design, and control systems.
Prerequisite(s): IMSE 317
Restriction(s):
Can enroll if Class is Graduate or Doctorate

ECE 553 Sftware/Hrdware Rapid Protyp 3 Credit Hours
Rapid prototyping technology is primarily aimed at reducing the lead times and costs associated with new product development. Rapid prototyping requires a good quality 3D CAD system. This course will cover the software and hardware widely used in the rapid prototyping, including Stereolithography (SLA) and virtual reality software and hardware used for rapid prototyping. (YR)
Restriction(s):
Can enroll if Class is Graduate

ECE 554 Embedded Systems 3 Credit Hours
Survey of real time, sampled data systems and embedded applications, e.g. digital controllers, diagnostic systems. Principles and characteristics of embedded micro-processors: processor/device interfaces; time critical I/O handling; data communications in embedded environments. Overview of embedded operating systems, cross-development techniques & tools. Design of real time systems. The software life Cycle. Embedded specification and design techniques. Real Time Kernels. Multi-tasking. Real TIme Memory management.. Performance Analysis. Reliability & Fault Tolerance. Project oriented course. (YR)
Restriction(s):
Can enroll if Class is Graduate
Can enroll if Major is Software Engineering, Electrical Engineering, Computer & Information Science, Computer Engineering

ECE 5541 Embedded Networks 3 Credit Hours
Embedded network systems merge modern communications, networks, sensing, distributed control and mobile computing enabling novel applications in a broad area of control, automation, and distributed real time systems. The course will focus on vehicular communications and networking, autonomous vehicles and intelligent transportation systems, robotics networks, and smart grids. Topics include: an overview of embedded processors and microcontrollers, digital signal processors, field programmable gate arrays (FGPAs), sensors and actuators, embedded operating systems including various Linux and Android platforms, and embedded networks. Students will be exposed to advanced system design methods, modeling, simulation, and system verification and evaluation. A term project may be required. Three lecture hours per week.
Restriction(s):
Can enroll if Level is Doctorate or Specialist or Graduate or

ECE 5542 Embedded Sig Proc and Control 3 Credit Hours
This course bridges the gap between embedded software engineering principles and theoretical signal processing and control concepts. Topics include a survey of embedded software architectures, real-time principles and concerns, sensor and actuator interfacing, PIO feedback control systems, Audio/time-series filtering (F IR and llR filters), embedded image processing, automatic code generation from higher level modeling languages such as MATLAB and Simulink, and working with single-board computers and digital signal processors (DSP). It is a project oriented course, with hands-on assignments, group projects and an individual research component. (F)
Prerequisite(s): ECE 473 or ECE 4951 or ECE 554
Restriction(s):
Can enroll if Class is Graduate or Doctorate
Can enroll if College is Engineering and Computer Science

ECE 5543 Embedded System Security 3 Credit Hours
This course introduces fundamental concepts of information security and threat models. In depth study of the principles, algorithms, techniques, protocols and applications of embedded security, including secure software development, light weight cryptographic algorithms, information security protocols for embedded applications, tamper detection, automotive security, embedded network transactions, and other emerging embedded applications in the areas of IoT and cyber-physical systems will be covered. (W.YR)
Restriction(s):
Can enroll if Level is Doctorate or Rackham or Graduate

ECE 5544 Intro. to CPS Security 3 Credit Hours
This course covers introductory topics in cyber-physical systems (CPSs) security. This course is intended to expose students to fundamentals of security primitives specific to CPSs and to apply them to a broad range of current and future security challenges that such systems are facing. Much of the course addresses Industrial Control Systems and smart grids. However, students will be expected to generalize the concepts for other CPSs. Students will work with various tools and techniques used by hackers to compromise computer systems or otherwise interfere with normal operations. Students will also use tools that are unique to interacting with cyber-physical systems. The purpose of this course is NOT to teach students how to become hackers, but rather to teach them about threat models and attack vectors for cyber-physical systems so that they can develop countermeasures to defend against threats. (F,YR)
Restriction(s):
Can enroll if Level is Doctorate or Rackham or Graduate

ECE 5545 Sec. & Privacy for Smart Grids 3 Credit Hours
Full Course Title: Security and Privacy for Smart Grids The goal of this course is to provide a comprehensive understanding of the challenges, issues, solutions, and state-of-the-art research and best practices pertaining to the cyber-security of the modern power grids, also known as "smart power grids". The course is intended to provide an overview of information security, CPS security, risk assessment and mitigation, network security, attack-resiliency for bulk power systems, attack surface analysis and reduction techniques, cyber-security testbeds, security standards and best practices for critical infrastructure, e.g., smart power grids. This course will build the skills needed to design and test the protocols, policies, and specifications for enabling technologies that will guarantee the security and integrity of the smart power grid while preserving personal privacy. (F)
Restriction(s):
Can enroll if Level is Doctorate or Rackham or Graduate

ECE 555 Stochastic Processes 3 Credit Hours
Review of probability and random variables. Introduction to stochastic processes; stationarity, ergodicity; auto correlation and cross correlation, linear systems with random inputs, spectral analysis, Wiener filtering, Kalman filtering. Applications to smoothing, parameters estimation, prediction, system identification.
Prerequisite(s): IMSE 317
Restriction(s):
Can enroll if Major is Electrical Engineering, Computer Engineering

ECE 560 Modern Control Theory 3 Credit Hours
Introduction to linear spaces and operators; mathematical description of multiple input-output systems; state variables and state transition matrix; controllability and observability and its application to irreducible realization of transfer function matrices; state variable estimation; controller synthesis by state feedback; stability of linear systems; analysis of composite systems.
Restriction(s):
Can enroll if Major is Electrical Engineering, Computer Engineering

ECE 565 Digital Control Systems 3 Credit Hours
Mathematical representation of digital control systems; z-transform and difference equations; classical and state space methods of analysis and design; direct digital control of industrial processes.
Prerequisite(s): ECE 460
Restriction(s):
Can enroll if Class is Graduate or Doctorate

ECE 566 Mechatronics 3 Credit Hours
Mechatronics, as an engineering discipline, is the synergistic combination of mechanical engineering, electrical engineering, control engineering, and computer science, all integrated through the design process. The course is to establish a working familiarity with the key engineering elements in the design and control of electro-mechanical systems in general and automotive systems in particular. The key engineering elements include microprocessor technology, electronics, sensors and actuators, data communication and interface, control algorithms, and mechanisms of machine elements. The course is to introduce a design methodology in an integrated system environment through case studies and design projects. (AY).
Prerequisite(s): ME 442 or ECE 365
Restriction(s):
Can enroll if Class is Graduate or Doctorate

ECE 567 Nonlinear Control Systems 3 Credit Hours
Nonlinearities in control systems; phase plane analysis; isoclines, equilibrium points, limit cycles, optimum systems; heuristic methods; harmonic balance, describing function, frequency response and jump phenomena, oscillations in relay systems; state space; optimum relay controls; stability; Liapunov's method.
Prerequisite(s): ECE 460
Restriction(s):
Can enroll if Class is Graduate or Doctorate

ECE 569 Computer-Based Automation 3 Credit Hours
Using interactive graphics in process system design. Modeling machine and process dynamics. Simulating machine and process operations. Computer control of machines and processes. Machine sensing and diagnostic systems.
Prerequisite(s): ME 588 or ECE 539
Restriction(s):
Can enroll if Class is Graduate
Cannot enroll if Major is Electrical Engineering, Computer Engineering

ECE 570 Computer Networks 3 Credit Hours
A study of data communications and network architecture fundamentals. Topics include signals and data transmission, modulation, encoding, and public carriers and network architectures; data link network layer, and transport layer protocols; case studies of existing and emerging networks; wireless, embedded, and conventional wired systems. Three lectures hours per week.
Prerequisite(s): ECE 471
Restriction(s):
Can enroll if Class is Graduate or Doctorate
Cannot enroll if Major is

ECE 5701 Intro to Wireless Comm 3 Credit Hours
A basic introduction to modern wireless communication principles and architectures. Channel models, signal generation and reception are explored. Examples of current protocols and architectures of wireless data and voice networks are studied. Self guided lab assignments. A project is required. Three lecture hours per week.
Prerequisite(s): ECE 550 or ECE 570
Restriction(s):
Can enroll if Class is Graduate
Can enroll if Major is Electrical Engineering, Computer Engineering

ECE 5702 High-Speed and Adv Networks 3 Credit Hours
The course introduces concepts in protocols and architecture of high-speed and advanced networks with an emphasis on Internet, ATM networks, wireless local area networks, cellular systems and wireless sensor networks. Three lecture hours per week.
Restriction(s):
Can enroll if Class is Graduate
Can enroll if Major is Electrical Engineering, Computer Engineering

ECE 571 Switching Theory 3 Credit Hours
Combinational and sequential logic design, minimization of combinational and sequential circuits, functional decomposition, reliable design and fault diagnosis; incompletely specified sequential machine design, asynchronous sequential circuits and interactive methods.
Prerequisite(s): ECE 273
Restriction(s):
Can enroll if Major is Computer Engineering, Electrical Engineering, Computer & Information Science

ECE 572 Sequential Machines 3 Credit Hours
Theoretical aspects and algebraic structure of sequential machines. Characterization of complete and incomplete machines, decomposition and state assignment problems. Deterministic and nondeterministic finite state machine identification. State-identification and fault-detection experiments.
Prerequisite(s): ECE 571
Restriction(s):
Can enroll if Major is Computer Engineering, Electrical Engineering, Computer & Information Science

ECE 574 Adv Sftwr Techng in Eng Appl 3 Credit Hours
Topics relating to Software Development for engineering applications will be discussed. These may include data structures, algorithm complexity, personal software development process, team software process, Six sigma, DFSS, software techniques, software engineering application, and software design. Three lecture hours per week.
Prerequisite(s): ECE 474
Restriction(s):
Can enroll if Class is Graduate
Can enroll if Major is Software Engineering, Electrical Engineering, Computer & Information Science, Computer Engineering

ECE 575 Computer Architecture 3 Credit Hours
This course addresses the basics of computer architecture including central processing architecture, instruction set design, input/output and RAID, main memory, Cache, and virtual memory. Three lecture hours per week.
Prerequisite(s): ECE 375
Restriction(s):
Can enroll if Class is Graduate or Doctorate
Cannot enroll if Major is

ECE 5752 Reconfigurable Computing 3 Credit Hours
This course addresses advances in reconfigurable computing techniques, design, and research. The course topics include introduction to RC, Hardware Description Language (HDL) such as VHDL and Verilog HDL, System-On-Chip (SOC), and Network-On-Chip (NOC). Three lecture hours per week.
Prerequisite(s): ECE 475
Restriction(s):
Can enroll if Class is Graduate
Can enroll if Major is Software Engineering, Electrical Engineering, Computer & Information Science, Computer Engineering

ECE 576 Information Engineering 3 Credit Hours
This course will cover fundamental concepts of information engineering, including theoretical concepts of how information is measured and transmitted, how information is structured and stored, how information can be compressed and decompressed, and information networks such as social networks, affiliation networks and online networks, mathematical theories of information networks. Information engineering applications will be discussed. Three lecture hours per week.
Restriction(s):
Can enroll if Class is Graduate
Can enroll if Level is Doctorate or Rackham or Graduate or
Can enroll if Major is Software Engineering, Electrical Engineering, Computer & Information Science, Computer Engineering

ECE 577 Engineering in Virtual World 3 Credit Hours
An in-depth study of selected topics in design and development of virtual systems in industrial environments. Topics include cyberspaces, techniques for generating virtual worlds in engineering applications, building blocks of virtual environments including hardware and software. Case studies.
Prerequisite(s): ECE 273 and ECE 371
Restriction(s):
Can enroll if Major is Computer Engineering, Electrical Engineering, Computer & Information Science

ECE 5770 Autonomous UAS 3 Credit Hours
This course will introduce the basic concepts of autonomous unmanned aerial systems. Topics will include basic flight principles of fixed-wing and rotary-wing aircraft, inertial representations in 3D space, the principles of Bayesian state estimation, visual odometry, path planning, and autonomous navigation. This course will also cover aircraft actuation, sensors and perception (GPS, inertial meansurements, ranging, and basic computer vision), sensor fusion technique, and motion control of unmanned aircraft. Students are expected to have knowledge of high-level programming language and will be required to accomplish a course project. Three lecture hours per week. (W)
Prerequisite(s): ECE 347 or IMSE 317
Restriction(s):
Can enroll if College is Engineering and Computer Science

ECE 578 Advanced Operating Systems 3 Credit Hours
Advanced techniques and uses in operating system design. Distributed operating systems. Message-based operating systems. Operating systems for parallel architectures. Layered techniques in operating systems. Formal models of operating systems. Current trends in operating system design.
Prerequisite(s): ECE 478 or CIS 450 or IMSE 450

ECE 579 Intelligent Systems 3 Credit Hours
Representative topics include: Intelligent systems design, training and evaluation, decision trees, Bayesian learning, reinforcement learning. A project will be required.
Prerequisite(s): ECE 479
Restriction(s):
Can enroll if Level is Doctorate or Rackham or Graduate or
Can enroll if Major is Software Engineering, Electrical Engineering, Computer & Information Science, Computer Engineering

ECE 5791 Vehicle Power Management 3 Credit Hours
This course provides graduate students with a clear understanding of the latest vehicle power management technologies with an emphasis on alternative fuel vehicles. The course will cover topics such as electrified powertrain configurations. Vehicle power management basic concepts, vehicle propulsion system modeling, vehicle power management approaches (analytical approach, wavelet transform technology, DP&QP, and intelligent systems methods). ESS (especially batter) management, power electronics in HESS and motor drive, HEV component optimization, HIL and SIL, vehicle power management future trends, and so on. Three hours per week.
Restriction(s):
Can enroll if Class is Graduate or Doctorate

ECE 580 Digital Signal Processing 3 Credit Hours
This course addresses the analysis and design of discrete ¿time signals and systems. Students will become familiar with the mathematical tools needed for digital signal processing such as the Fourier transform, frequency response, the sampling theorem, and z-transform method. Topics covered will include the design of digital filters (IIR and FIR filters), characteristics of analog-to-digital and digital-to-analog converters, the spectral analysis of signals, and discrete filters. Three lecture hours per week.
Restriction(s):
Can enroll if Class is Graduate or Doctorate

ECE 5802 Multirate Sig Proc w/Appl 3 Credit Hours
This course provides an introduction to multirate digital signal processing with application in different fields of engineering, with a focus on the presentation of the theoretical foundation for all aspects of multirate digital signal processing. The course examines modern applications of multirate digital signal processing including the design of multirate filter banks, using the wavelets transforms to efficiently encode signals for compression purposes, spectral analysis and synthesis of signals. Students will apply software tools to analyze, design and simulate multirate digital signal processing systems. Three lecture hours per week.
Prerequisite(s): ECE 580
Restriction(s):
Can enroll if Level is Doctorate or Rackham or Graduate or
Can enroll if Major is Computer Engineering, Electrical Engineering, Software Engineering, Industrial & Systems Engin, Information Sys Engineering, Mechanical Engineering, Automotive Systems Engineering, Engineering Management

ECE 581 Arch for Digital Signal Proc 3 Credit Hours
This course introduces the architectural fundamentals and features of programmable digital signal processors. Numeric representations and arithmetic concepts are discussed, which include fixed-point and floating-point representation of numbers, native data word width, and IEE-754 floating-point representation. Memory architecture and memory structures of digital signal processors are examined. Programming concepts for DSP processors such as addressing, instruction set, execution control, pipelining, parallel processing and peripherals are discussed. Finally, students will work on related applications employing digital signal processors such as speech processing, instrumentation, and image processing. Three lecture hours per week.
Prerequisite(s): ECE 580
Restriction(s):
Can enroll if Class is Graduate
Can enroll if Major is Computer Engineering, Electrical Engineering, Computer & Information Science

ECE 582 Intro to Statistical DSP 3 Credit Hours
Review of discrete-time signals and systems, introduction of discrete-time random signals and variables, linear signal models, nonparametric power spectrum estimation, least-squares filtering and prediction, signal modeling and parametric spectral estimation, selected topics. (W).
Prerequisite(s): ECE 580*
Restriction(s):
Can enroll if Class is Graduate
Can enroll if Major is Electrical Engineering

ECE 583 Artificial Neural Networks 3 Credit Hours
Students will gain an understanding of the language, formalism, and methods of artificial neural networks. The student will learn how to mathematically pose the machine learning problems of function approximation/supervised learning, associative memory and self-organization, and analytically derive some well-known learning rules, including backprop. The course will cover computer simulations of various neural network models and simulations. Three lecture hours per week.
Restriction(s):
Can enroll if Class is Graduate
Can enroll if Level is Doctorate or Rackham or Graduate or
Can enroll if Major is Software Engineering, Electrical Engineering, Computer & Information Science, Computer Engineering

ECE 5831 Pat Rec & Neural Netwks 3 Credit Hours
Students will gain understanding of the language, formalism, and methods of pattern recognition. Various solution approaches will be covered including statistical methods and neural network-based methods. Students will learn how to mathematically pose various pattern recognition problems and analytically derive some well-known statistical results and learning rules. In addition, the student will learn how to perform computer simulations of various statistical and neural network models, and learn how to select appropriate model parameters, such as network architecture, hidden layer size, and learning rate. Case Studies will be presented to illustrate a variety of applications.
Restriction(s):
Can enroll if Level is Doctorate or Rackham or Graduate or

ECE 584 Speech Processes 3 Credit Hours
The course introduces the fundamentals of speech processing using digital signal processing methods and techniques. How speech is produced from the human vocal system and the different types of basic speech sound components is addressed, followed by methods to analyze speech signals in both the time domain and frequency domain. Applications of speech processing are also presented. Possible applications covered include speech synthesis, speech coding and speech recognition. A team-based term project may be required. Three lecture hours per week.
Prerequisite(s): ECE 580
Restriction(s):
Can enroll if Class is Graduate

ECE 585 Pattern Recognition 3 Credit Hours
Introduction to pattern recognition (PR) as a process of data analysis. Representation of features in multidimensional space as random vectors. Similarity and dissimilarity measures in feature space. Bayesian decision theory, discriminant functions and supervised learning. Clustering analysis and unsupervised learning. Estimation and learning. Feature extraction and selection. Introduction to interactive techniques in PR. Applications of PR.
Prerequisite(s): IMSE 317
Restriction(s):
Can enroll if Major is Computer Engineering, Electrical Engineering, Computer & Information Science

ECE 586 Digital Image Processing 3 Credit Hours
Monochrome and color vision in man and machines, image quantization edge detection, image enhancement, image restoration, color analysis and processing, multispectral image processing, texture analysis, image coding and compression, morphology, geometrical image modifications.
Prerequisite(s): ECE 450
Restriction(s):
Can enroll if Major is Computer Engineering, Electrical Engineering, Computer & Information Science

ECE 587 Sel Top:Image Proc/Mach Vision 3 Credit Hours
A special topics course providing an in-depth examination of one or several areas in image processing and/or machine vision. Possible areas include medical imaging, advanced concepts in morphology, stereovision, shape form shading, and active vision.
Prerequisite(s): ECE 586
Restriction(s):
Can enroll if Major is Computer Engineering, Electrical Engineering, Computer & Information Science

ECE 588 Robot Vision 3 Credit Hours
This course introduces important theory and modern technology in robot vision. Representative topics are sensors and image formation, advanced algorithms in object feature filtering, extraction and recognition, texture and colors, motion, 3D vision, and applications. Students cannot receive credit for both ECE 4881 and ECE 588. Three lecture hours per week.
Restriction(s):
Can enroll if Major is Computer Engineering, Electrical Engineering, Computer & Information Science

ECE 589 Multidimen Digital Signal Proc 3 Credit Hours
Topics include multidimensional signal analysis methodologies, signal representation, 2-D FIR filter, 2-D recursive systems and IIR filters, spectral estimation and methods, multidimensional signal restoration applications in 2-D and 3-D image processing, reconstruction, and feature estimation. Three lecture hours per week.
Prerequisite(s): ECE 580

ECE 590 Selected Topics 1 to 3 Credit Hours
Individual or group study, design, or laboratory research in a field of interest to the students. Topics may be chosen from any of the areas of electrical engineering. The student will submit a report on the project and give an oral presentation to a panel of faculty members at the close of the term.
Restriction(s):
Can enroll if Class is Graduate
Can enroll if Major is Electrical Engineering, Computer Engineering

ECE 591 Directed Studies 1 to 3 Credit Hours
Special projects for laboratory or library investigation with the intent of developing initiative and resourcefulness. The student will submit a report of the project and give an oral presentation to a panel of faculty members at the close of the term.
Restriction(s):
Can enroll if Class is Graduate
Can enroll if Major is Electrical Engineering, Computer Engineering

ECE 592 Directed Research 1 to 3 Credit Hours
Special problems centered on developing experimental skills. In consultation with a faculty advisor a student will prepare a proposal describing the work to be performed for approval by the department. An oral presentation and a final report on the research effort are required for completion. (F,W,S)
Restriction(s):
Can enroll if Class is Graduate
Can enroll if Major is Electrical Engineering, Computer Engineering

ECE 610 Analog I C 3 Credit Hours
****NO DESCRIPTION AVAILABLE****

ECE 612 Wireless Sensor Networks 3 Credit Hours
Advanced data communications, sensor motes, systems architecture and design, wireless communications standards and protocols, routing, security, operating systems, language support, and applications. Three lecture hours per week.
Prerequisite(s): ECE 570
Restriction(s):
Can enroll if Class is Graduate
Can enroll if Level is Doctorate or Rackham or Graduate or
Can enroll if Major is Mechanical Engineering, Electrical Engineering, Industrial & Systems Engin, Computer & Information Science, Computer Engineering

ECE 614 Ctrl Networks for Embedded Sys 3 Credit Hours
Networks have emerged in a wide range of embedded applications (e.g. aerospace, maritime, vehicular, industrial) as an enabler of flexible and robust system design. These embedded control networks differ from information technology (IT) networks in that the primary users are not humans, but sensors, actuators, and embedded processors. Thus, the data sets, performance requirements, operational environment, and need for reliability and robustness necessitate a different approach to network design. As the complexity of the systems grows, developers will be presented with significant challenges. It is important that engineers are acquainted with fundamental tools and strategies for designing and building such networks. Three lecture hours per week.
Prerequisite(s): ECE 570
Restriction(s):
Can enroll if Level is Doctorate or Rackham or Graduate or
Can enroll if College is Engineering and Computer Science
Can enroll if Major is Computer & Information Science, Computer Engineering, Software Engineering, Industrial & Systems Engin, Information Sys Engineering, Mechanical Engineering, Automotive Systems Engineering, Electrical Engineering

ECE 615 Advanced Power Electronics 3 Credit Hours
This course covers advanced technologies in power electronics with emphasis on hybrid vehicle and renewable applications. The course will cover topics such as resonant converters, vector control, field oriented control, battery chargers, vehicle to grid management, power factor correction and harmonic control, model predictive control, renewable energy systems (solar, wind and ocean) and their requirement for power converters, electric drive transportation components, silicon carbide power devices. Three hours per week.
Prerequisite(s): ECE 515
Restriction(s):
Can enroll if Class is Graduate
Can enroll if Level is Doctorate or Rackham or Graduate or
Can enroll if Major is Computer & Information Science, Computer Engineering, Software Engineering, Industrial & Systems Engin, Information Sys Engineering, Mechanical Engineering, Automotive Systems Engineering, Electrical Engineering

ECE 616 Advanced Topics in Power Sys 3 Credit Hours
This course will cover the advanced topics of power system planning, operation, and control. The course will help students understand the algorithms and tools required to analyze electric power systems. The major focus of this course is to educate and train graduate students in developing research abilities through literature survey on advanced power system technologies and hands-on projects on modeling and analyzing smart grid applications. (F)
Prerequisite(s): ECE 541 or ECE 542
Restriction(s):
Can enroll if Level is Rackham or Graduate or Doctorate or
Can enroll if College is Engineering and Computer Science

ECE 620 Sensor Security and Data Integrity Validation 3 Credit Hours
This course covers sensor data security and integrity verification and its applications to transportation systems, robotics, IoTs, smart cities, and industrial control systems. It will provide threat modeling and risk assessment methods employed when developing security solutions for active and passive sensors. This course aims to cover attack surfaces, threat modeling and attack vector executions for commonly used sensors and develop countermeasures to defend against them. Much of the course aims to cover existing sensing modalities, e.g., LIDAR, Radar, Ultrasonic, Camera, Microphone, etc. Students will work with various tools and techniques used by attackers to compromise active as well as passive sensors. (F).
Prerequisite(s): ECE 580
Restriction(s):
Can enroll if Level is Doctorate or Rackham or Graduate
Can enroll if College is Engineering and Computer Science

ECE 642 Robotic Embed Sys 3 Credit Hours
Full Course Title: Robotic Embedded Systems This course covers advanced topics in embedded systems in the context of modern robotics. It is a research-oriented course including a research literature survey, a final project implementing a state-of-the-art algorithm or system, and a set of hands-on assignments that cover modern tools and real-time embedded systems development frameworks such as the Robot Operating System. Lecture and assignment topics include embedded software architectures and modular software frameworks for robotics, modern computer hardware, robot perception and embedded image processing, automatic code generation from higher level modeling languages (such as MATLAB and Simulink), deployment considerations, as well as other selected advanced topics. (YR)
Restriction(s):
Can enroll if College is Engineering and Computer Science

ECE 643 Humanoids 3 Credit Hours
This course covers two major aspects of humanoid robots, locomotion and manipulation. The purpose of this course is to provide students with advanced techniques for generation and control of movement of a humanoid robot itself and its motion to change the environment. Articulated body dynamics, contact modeling, and contact dynamics will be presented first. Locomotion will cover balance control, footstep planning, walking gait generation, joint space trajectory planning, and human motion tracking. Manipulation will include grasping, optimal planning, and dynamic manipulation. Simulation techniques and software will be introduced. This course will include programming and simulation work and students will be required to accomplish a related course project. The course has three lecture hours per week. (W)
Prerequisite(s): ECE 5001 or ECE 543
Restriction(s):
Can enroll if College is Engineering and Computer Science

ECE 644 Advanced Robotics 3 Credit Hours
This course covers advanced topics related to current research in algorithms and artificial intelligence for robotics such as planning and control issues for robotic systems, taking into account the math and algorithms underneath state-of-the-art robotic systems. The majority of these techniques are heavily based on probabilistic reasoning and optimization-two areas with wide applicability in intelligent robotic systems. Students are expected to have knowledge of high-level programming language and will be required to accomplish a research-related course project. Three lecture hours per week. (W)
Prerequisite(s): (ECE 500 or ECE 5001) and ECE 544
Restriction(s):
Can enroll if College is Engineering and Computer Science

ECE 645 Coop Robots 3 Credit Hours
This course covers advanced topics related to research in algorithms and methods for robots to cooperate. Topics include cooperation, connectivity, navigation, localization, perception, and control. Students will be expected to read research papers and complete a project with actual robots, e.g., TurtleBots. Three lecture hours per week. (W)
Restriction(s):
Can enroll if Level is Graduate or Rackham or Doctorate
Can enroll if College is Engineering and Computer Science

ECE 646 Adv Elec Drive Transportation 3 Credit Hours
This course gives in depth study in advanced technologies in the electrified vehicle powertrain. The course will cover topics such as hybrid powertrain architectures, dynamics of hybrid transmissions, battery management systems, battery control electronics, PHEV and HEV power management, survivability of military hybrid vehicles, packaging of PHEV electric drive components, optimization of PHEV components, optimization of electric drive efficiency through power management, vehicle to grid technology, emerging technology in electric drive transportation. Three hours per week.
Prerequisite(s): ECE 5462
Restriction(s):
Can enroll if Class is Graduate
Can enroll if Level is Doctorate or Rackham or Graduate or
Can enroll if Major is Computer & Information Science, Computer Engineering, Software Engineering, Industrial & Systems Engin, Information Sys Engineering, Mechanical Engineering, Automotive Systems Engineering, Electrical Engineering

ECE 650 Info Theory in Elec Comm 3 Credit Hours
Source models and source coding, channel and channel models, information measure, mutual information and entropy, coding for discrete sources such as variable-length codes and optimum variable-length encoding procedure, discrete memoryless channels and capacity, techniques for coding and decoding such as parity-check codes, cyclic codes, and Hamming codes, quantization and error analysis, coding techniques such as DPCM, run-length coding, sub-band coding, transform coding.
Prerequisite(s): ECE 555

ECE 661 Sys Ident and Adaptive Control 3 Credit Hours
Minimal state space models, on-line estimation schemes, parameter convergence for SISO and MIMO systems, direct and indirect adaptive prediction, minimum prediction error controllers (one-step ahead and model reference control), minimum prediction error adaptive controllers (direct and indirect approach), adaptive control algorithms for close-loop pole assignment, Kalman filter, extended Kalman filter.
Prerequisite(s): ECE 560

ECE 665 Optimal Control Systems 3 Credit Hours
Parameter optimization; optimization problems for deterministic systems; calculus of variations on optimal control; maximum principle of Pontryagin; dynamic programming; numerical solution of optimal programming and control problems; singular solutions.
Prerequisite(s): ECE 560

ECE 670 Adv Comp Netwk&WL Comm 3 Credit Hours
In depth study of advanced technologies in computer networks and wireless communications. The course will cover topics such as advances in Internet, wireless communications and sensor networks, wireless networked control systems, vehicular networks, smart grid, cloud computing, multimedia networking, and network security. Three lecture hours per week.
Prerequisite(s): (ECE 570 and ECE 5701) or CIS 627
Restriction(s):
Can enroll if Class is Graduate
Can enroll if Level is Doctorate or Rackham or Graduate or
Can enroll if Major is Computer & Information Science, Computer Engineering, Software Engineering, Industrial & Systems Engin, Information Sys Engineering, Mechanical Engineering, Automotive Systems Engineering, Electrical Engineering

ECE 675 Computer Architecture II 3 Credit Hours
Parallel and non-Von Neumann architectures. Supercomputers. SIMD and MIMD structures. Pipelining, vector processing, and array processing techniques. Associate processors. Data flow computers. RISC computers. VLSI computer structures. Advances in computer architecture.
Prerequisite(s): ECE 575

ECE 679 Adv Intelligent Sys 3 Credit Hours
This is a research seminar on advanced topics in intelligent systems. The course will focus on intelligent systems in solving complex problems. Topics include ensemble techniques, multi-objective optimization, and intelligent agents. The course will require student presentations and a substantial term project. Three lecture hours per week.
Prerequisite(s): ECE 579 or CIS 579
Restriction(s):
Can enroll if Class is Graduate
Can enroll if Level is Doctorate or Rackham or Graduate or
Can enroll if Major is Computer & Information Science, Computer Engineering, Software Engineering, Industrial & Systems Engin, Information Sys Engineering, Mechanical Engineering, Automotive Systems Engineering, Electrical Engineering

ECE 681 Adv Digital Sig Processing 3 Credit Hours
Topics include statistical signal processing, multi-rate systems, bank of filter design, multi-resolution formation of wavelet, the discrete wavelet transform, wavelet-based digital signal processing. The course has substantial computer simulation and research project components. Three lecture hours per week.
Prerequisite(s): ECE 580
Restriction(s):
Can enroll if Class is Graduate
Can enroll if Level is Doctorate or Rackham or Graduate or
Can enroll if Major is Computer Engineering, Software Engineering, Industrial & Systems Engin, Mechanical Engineering, Computer & Information Science, Electrical Engineering

ECE 691 Adv Directed Studies 1 to 3 Credit Hours
Advanced Directed Studies for Doctoral Students: Special topic in electrical or computer engineering. A project report and a seminar are required.
Restriction(s):
Can enroll if Level is Doctorate or
Can enroll if College is Engineering and Computer Science

ECE 695 Master's Project 3 Credit Hours
Application of the methodologies, tools and theory of software engineering to produce a specific validated software product. Projects can be faculty-generated, self-generated, and/or work related. All projects must be undertaken with one or more students under the supervision of the instructor. Prior to enrollment, a project proposal must be prepared and approved by the instructor and department chair. Standard software engineering documents must be prepared and approved at each phase of the project, and an oral presentation of the project is required. Course includes lectures and case studies. Permission of instructor required.
Restriction(s):
Can enroll if Class is Graduate
Can enroll if Level is Rackham or Graduate
Can enroll if College is Engineering and Computer Science
Can enroll if Major is Software Engineering

ECE 699 Master's Thesis 3 or 6 Credit Hours
Graduate students electing the thesis option, working under the general supervision of a member of the department faculty, are expected to plan and carry out the work themselves. The student will submit a report on the project and give an oral presentation to a panel of faculty members at the close of the term.
Restriction(s):
Can enroll if Class is Graduate
Can enroll if Major is Electrical Engineering, Computer Engineering

ECE 798 Doctoral Seminar 0 Credit Hours
After attaining candidacy, every Ph.D. student is required to attend and actively participate in research seminars given by CECS Dean's office or individual departments in CECS. A student gets a satisfactory grade if he/she attends at least two research seminars during the course period. (F,W,S)
Restriction(s):
Can enroll if Major is

ECE 980 Pre-Cand Dissertation Research 1 to 9 Credit Hours
Full Title: Pre-Candidate Dissertation Research Dissertation work by a pre-candidate student in Electrical and Computer Engineering program conducted under guidance of the faculty advisor. (F,W,S)
Restriction(s):
Can enroll if Level is or Doctorate
Can enroll if Major is

ECE 990 Doctoral Dissertation 1 to 9 Credit Hours
Full Title: Doctoral Dissertation Research Dissertation work by a Ph.D. candidate in Electrical and Computer Engineering program conducted under guidance of the faculty advisor. (F,W,S)
Restriction(s):
Can enroll if Level is or Doctorate
Can enroll if Major is