UNIVERSITY of DAYTON

The Department of Electrical And Computer Engineering

Graduate Handbook

Programs, Facilities, Faculty

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Summer 2017

From the Departmental Chair

Dear Colleagues and Friends of the Department:

This brochure serves as an academic guide to our students in the graduate programs in Electrical and Computer Engineering. Contained herein are details relating to the requirements, specializations, and milestones for the masters degree and doctoral degree offered by the faculty of the Electrical and Computer Engineering Department. In addition, information about our facilities, laboratories, and faculty are included.

Our program provides students with the tools needed to produce cutting-edge technologies in the electronics and computer systems industries. Our students learn to use state-of-the-art computational and engineering tools and are prepared to work in diverse settings with evolving technologies. Students have access to facilities offering top-of-the-line equipment with industry specific software such as MATLAB, FPGA development tools from Altera, Xilinx and Microsoft Visual Studio Pro, real-time control tools from dSPACE, industrial robots from Yaskawa Motoman, design tools for mixed signal ICs, such as Agilent's EESof, AWR Suite for Analog, RF and Microwave design.

Generally, for new students who do not already have an academic advisor, the Chair of the department serves as the interim advisor until the student selects one who will be the student's mentor. A few teaching assistants are awarded as available by the Chair of the department and research assistantships are awarded by the faculty who have funded research projects. There are several competitively awarded fellowships and scholarships available. Other financial aid is available through our Financial Aid office.

As you can see from the brochure, we have a world class faculty, and research laboratories. Our faculty excel in teaching, research, and service to students and the community. We welcome you to enjoy the ECE graduate experience.

Warmest regards to all.

Sincerely,
Guru Subramanyam

OUR MISSION OF GRADUATE EDUCATION

Graduate education at the University of Dayton:

- Advances learning, knowledge, and skills, and prepares students for immediate and ethically-grounded leadership and service to their professions, intellectual disciplines, and communities.
- Promotes significant, focused, and programmatic research and scholarship.
- Reflects and advances the unique Catholic and Marianist identity of the University.
- Responds to the needs of the region, the larger society, and the Catholic Church
- Contributes to the academic excellence and reputation of the University as a Catholic leader in higher education.
- Strengthens the academic excellence of undergraduate programs.

Programs

The UD School of Engineering, through its Department of Electrical and Computer Engineering (ECE), offers programs of study leading to:

Master of Science (MS),
Doctor of Philosophy (PhD).

The MS degree has an instructional and a research component (where students can pursue a thesis option). Students receiving any type of assistantship (teaching or research) are required to take the thesis option. The PhD is granted in recognition of superior achievement in independent research and course work. The research must demonstrate that the student possesses capacity for original thought, talent for research, and ability to organize and present findings.

Admission Requirements

To be considered for admission to a master's degree program in Electrical and Computer Engineering (ECE), a student should have received an undergraduate degree from an accredited program in electrical and/or computer engineering equivalent to a Bachelor of Science (BS). Students who have degrees in other engineering areas or related sciences are encouraged to apply, but they may be required to take a limited amount of undergraduate course work to complete their preparation for graduate studies in ECE. For students with a BS or equivalent degree, a grade point average of 3.2 or above, based on a 4.0 scale, is required (3.5 or above is required for students with an Engineering Technology degree). Students with lower grade point averages may be considered for acceptance on a conditional basis, in which case particular attention will be given to their last 60 semester hours of undergraduate course work, professional experience, and recommendations. In some cases, a limited number of undergraduate courses are required. Although not mandatory, we encourage submission of GRE scores to assess a candidate's potential.

To be considered for admission to the doctoral program in ECE, a student must have received the equivalent of a Masters degree in ECE, with a minimum grade point average of 3.4/4.0, in addition to having a GPA of 3.2 or above in their undergraduate degree. In each case, particular attention is given to prior academic preparation, research experience (in the form of publications and MS Thesis) and interests (which should be clearly specified, and aligned with one of the main research areas of the ECE department), and recommendations. All international students are required to have a minimum score of 560 in traditional TOEFL, 87 in the internet-based TOEFL, or 6.5 in the IELTS test for admission to the ECE graduate program at the University of Dayton.

Application Deadlines

To be considered for admission to the graduate programs in ECE, applications must be received by

- March 15 for Fall admission
- Sept. 15 for Spring admission

Financial Assistance

A substantial amount of financial aid, in the form of teaching and research assistantships and fellowships, is available to students with appropriate academic background. Through a host of available programs, ECE offers competitive monthly stipends for assistantships, based on half-time employment during the academic year and up to three months of summer employment. For instance, from the department's MUMMA foundation, we offer tuition scholarships and assistantships to exceptional incoming candidates. Graduate students can also receive teaching assistantships from the department for helping professors with undergraduate courses and laboratories. In addition, student-faculty research fellowships are available through the Dayton Area Graduate Studies Institute (DAGSI), a state-funded consortium of Ohio universities. As DAGSI participants, students have the added benefit of tuition free course work, using the libraries, computational and research resources (including the Ohio Super Computer System) from any DAGSI institution. More information is available at http://www.dagsi.org.

Master of Science Programs

Advising

In case of a graduate research assistant (RA), the research supervisor shall serve as the academic advisor. For all other students, the graduate student advisor or the ECE chairperson will serve as the temporary advisor until the student has identified his/her advisor from among the ECE faculty members. The advisor will assist the student in the preparation of a plan of study.

Plan of Study

The individual plan of study will include the specific courses the student is expected to complete and reflect all other requirements of the MS degree. *It must be filed with the Office of Graduate Engineering Programs & Research prior to registration for the 10th semester hour or before registration for the third semester.* The proper form may be obtained from the Office of Graduate Engineering Programs and Research.

https://porches.udayton.edu/web/porches/engineering

The plan of study and any amendment thereof must be approved by the advisor, the ECE chairperson, and the associate dean of graduate engineering programs and research.

Master of Science in Electrical Engineering

The MS in Electrical Engineering (MSEE) program of study must include a minimum of 30 semester hours consisting of the following:

1. The zero credit hour class ECE 500, to be taken within the first year at UD.
2. Nine semester hours of core courses selected from ECE 501, 503, 505, 506, 507, and 509.
3. Nine semester hours in an electrical engineering specialization area, such as Computing Systems, Sensors and Devices, Signals and Systems, Aerospace Electronics, or any other interdisciplinary area approved by the advisor/Chair.
4. Six semester hours in approved basic and engineering science, which may include ECE courses approved by the advisor/Chair.
5. Six semester hours of an approved thesis or six semester hours of electrical engineering graduate courses.

Only up to six semester hours of graduate courses can be included as transfer credits. Only six semester hours of graduate courses can be taken outside ECE as technical electives.

Thesis

While all students are encouraged to do a thesis, students supported by an assistantship (teaching or research) are required to complete a thesis. Each student whose plan of study requires a thesis must register for a total of six semester hours of thesis and prepare it in accordance with the general format guidelines as described in *A Manual for the Preparation of Graduate Theses and Dissertations*, which can be found online at http://gradschool.udayton.edu/initiative/guidelines.pdf.

Students completing a thesis for their MS degree are examined by a thesis committee consisting of three members, at least two of whom, including the committee chair, must be members of the graduate faculty. Two of the committee members must be ECE faculty members with graduate faculty status. Exceptions may be granted by the department chairperson and reviewed by the Graduate Council and the Dean of the Graduate School. The thesis examination requires an oral presentation, given only after the final draft of the written thesis has been adequately reviewed by all members of the thesis committee and the thesis advisor has approved the draft. A student who fails to successfully defend his/her thesis cannot be given another examination in the same semester. No student shall be allowed to take this examination more than twice.

A pass/fail grade will be assigned upon completion of the thesis.

Master of Science in Computer Engineering

The program of study leading to the Master of Science in Computer Engineering (MSCPE) must include a minimum of 30 semester hours of credit consisting of the following:

1. The zero credit hour class ECE 500, to be taken within the first year at UD.
2. At least nine semester hours in computer engineering core courses approved by the advisor/advisory committee. Six semester hours must be ECE coursework, and 3 semester hours must be CPS coursework to be selected from ECE 501, 532, 533, and CPS 510, 536 and 570.
3. At least nine semester hours in a concentration area such as Embedded Systems, Software Engineering, Operating Systems and Computer Architecture, or Communications and Networking, or as approved by the advisor/advisory committee. At least twelve semester hours are required in the concentration area for the non-thesis option.
4. At least six semester hours of selected technical electives. Selected courses must be approved by the advisor. At least nine semester hours of technical electives are required for the non-thesis option.
5. Six semester hours on an approved thesis for the thesis option. Students receiving 50% assistantship/stipend over one academic year or more will be required to pursue the thesis option.

Additionally, the MSCPE degree requires a culminating academic experience through completion of one of three possible options. These options are:

1. Successful completion of a Master's Thesis. Currently, ECE Department policy requires a thesis for students who are supported as Research or Teaching Assistants.
2. Successful completion of a non-thesis research or design project, including submission of a written report of suitable length and a seminar presentation to interested faculty and students. All such projects will be supervised by a faculty member with similar research interests.
3. Successful completion of two approved 3 semester hour courses requiring extensive project-based learning.

Extensive project-based learning courses are given below, by concentration area:

1. Embedded Systems: ECE531 and ECE536.
2. Software Engineering: ECE537, ECE538, CPS512, CPS543 and CPS542/562.
3. Operating Systems & Computer Architecture: ECE536, ECE636, and CPS544.
4. Communications and Networking: ECE505, ECE537, and CPS572.

Doctoral Programs

Doctoral Advisory Committee (DAC)

Before the end of the first enrolled semester, the student, in consultation with the ECE chairperson, selects an ECE faculty member to serve as the chair of the DAC. The chair of the DAC must be a member of the graduate faculty. The advisory committee of at least four members, consisting of the chair and at least two other graduate faculty members, requires concurrence by the ECE chairperson and the Engineering Dean (or designate), and approval by the Dean of the Graduate School. One of the members must be an external member whose primary appointment is outside the candidate's department or outside the University. The external member must be familiar with the standards of doctoral research and should be in a collateral field supportive of the dissertation topic. The duties of the DAC shall include advising the student, assisting the student in preparing the program of study, administering and reporting the candidacy examination, assisting in planning and conducting research, approving the dissertation, and reporting the results of the dissertation defense. A dissertation advisor other than the chair of the DAC may be appointed by the DAC.

Semester-Hour Requirements

The minimum semester-hour requirement for the doctoral degree is 90 semester hours beyond the bachelor's degree, or 60 semester hours beyond the master's degree. This includes the credits for the doctoral dissertation. Of the 60 semester hours beyond the MS, a minimum of 48 semester hours must be taken at the University of Dayton. Doctoral candidates must be registered for a minimum of two semester hours every semester during their candidacy, including the semester in which the final examination is taken.

Plan of Study

The plan of study shall include all courses beyond the master's degree that the student is required to complete. *It must be filed with the Office of Graduate Engineering Programs & Research prior to registration for the 13th semester hour*. The plan shall indicate the time and manner in which these requirements are to be met. It is to be completed and approved by the DAC, the ECE chairperson, and the associate dean of graduate engineering programs and research, before the end of the second semester of the student's enrollment. The proper form may be obtained from the Office of Graduate Engineering Programs and Research.
https://porches.udayton.edu/web/porches/engineering

The plan of study of a student seeking a PhD degree in electrical engineering requires a minimum of 60 semester hours beyond the Master's degree and must include the following:

1. The zero credit hour class ECE 500, to be taken within the first year at UD.
2. Thirty semester hours of graduate course work, comprised of:
   a. Nine semester hours from an approved concentration area such as Computing Systems, Sensors and Devices, Signals and Systems, Aerospace Electronics, or any other interdisciplinary area approved by the advisor/Chair (excludes ECE 695-699).
   b. At least six semester hours of approved graduate mathematics courses. Math classes beyond the BS degree taken at UD may be used to satisfy this requirement (although in this case they need to be replaced with other relevant coursework). Graduate level math classes taken at another institution beyond the BS degree are evaluated and approved by the dissertation adviser on a case by case basis.
   c. At least three semester hours of Graduate Seminar (ECE 696).
   d. The remaining twelve credit hours can be any combination of advanced graded course work, Guided Research Leading to Conference Publication (ECE 695-P1), and Guided Research Leading to Journal Publication (ECE 695-P2)
3. Thirty semester hours of PhD dissertation in electrical engineering.

Preliminary Examination

The Preliminary Examination (PE) is a diagnostic test to assess the baseline background of the student based on questions drawn from four Preliminary Exam Courses (PEC). Before PE is taken, student must have earned at least twelve ECE graduate credit hours beyond the MS degree and completed at least four PECs. The approved PECs are: ECE 501, 503, 505, 506, 507, 509, 521, 531, 533, 536, 547, 572, and 581. PE is a requirement for every student who does not apply for a waiver. The PE consists of questions drawn from four PECs chosen by the student. The ECE graduate program committee (GPC) coordinates with the appropriate faculty to put together the set of questions. The exam is a five hour period and takes place only once per semester, at a time determined by the ECE department. The student has two chances to pass the PE. If the second attempt is also failed, the student is dismissed from the PhD program. The PE requirement may be waived for students with overall GPA greater than or equal to 3.5 in four PECs taken at UD. Students who have taken PEC-equivalent courses at another institution may apply for a waiver of the PE, which may be granted if the student has a UD GPA of 3.5 or higher, and the combined GPA of four PECs (taken at UD or elsewhere) is 3.5 or higher. Students will only be permitted to proceed with the PhD Candidacy Examination if they have passed the PE or a waiver has been granted.

ECE PhD Candidacy Examination

The purpose of the PhD candidacy exam is to determine the student's preparedness for carrying out advanced studies at the doctoral level, and to assess the student's ability to perform independent research. The student must have a DAC in place before the candidacy exam can be attempted. The DAC consists of three ECE faculty members (including the dissertation advisor) in the student's research area and an

external member. The external member may be a faculty member in a related department at UD holding graduate faculty status, or a qualified expert in the student's research area from outside the university holding a PhD. The student must have filed a plan of study, and the DAC must be in place, before the candidacy exam can be attempted. The candidacy exam can only be attempted after the student has earned at least 12 ECE graduate credit hours beyond the MS degree, and the PE has been passed or a waiver been granted.

The candidacy examination consists of two parts:

1. Qualifying Examination (QE): a written and an oral examination on a research question (or set of questions) formulated by the dissertation advisor with input from the DAC members. The objective of the QE is to assess the student's ability to carry out independent, unsupervised research leading to a well-written report. The student is given no more than a month to submit the report, after which the oral examination takes place. The oral presentation is open to the public. After the public dismissal following the presentation, the DAC members pose questions related to the written report, or any other relevant areas. The student cannot take more than 12 dissertation credit hours before passing the QE. The student has two chances to pass the QE. If the second attempt is also failed, the student is dismissed from the PhD program.

2. Dissertation proposal defense (DPD): a written proposal and an oral examination on the research topic the student intends to pursue. The objective of the DPD is to assess the student's qualification for delivering a meaningful and publishable PhD dissertation, and for defending a research idea before a critical audience. The DPD can only be attempted after QE has been passed; after all coursework requirements have been completed; and at least six dissertation credit hours have been completed. The student must take at least 12 dissertation credits after successful completion of the DPD. The student will submit the written proposal to the DAC detailing the area of dissertation research at least one week prior to the oral examination. The proposal must present a clear problem definition, a review of the literature in the area, the justification and the uniqueness of the research, the methodology, preliminary work performed and expected results, the laboratories and/or other facilities needed, and a schedule of work. The proposal must also show preliminary evidence of doctoral level research work commensurate with rigors of a journal submission. The student will make an oral presentation open to the public summarizing the written proposal. After the public dismissal following the presentation, the student will be asked by the DAC questions related to the proposal.

The timeline and milestones for the PhD program are shown on page 16. For more details about the QE and DPD, please visit ECE's website at http://www.udayton.edu/engineering

Dissertation

A dissertation is required of each doctoral candidate who has passed the candidacy examination. The student, in consultation with the advisor and the DAC, selects the dissertation topic. The dissertation topic must be approved by the DAC. The dissertation must be prepared in accordance with the instructions outlined on the Thesis and Dissertation guidelines, which can be found on the library website: http://libguides.udayton.edu/content.php?pid=65891&sid=486730.
Instructions on the electronic submission of the completed dissertation can also be found on this website. The student must obtain approval from the DAC to undertake all or part of the dissertation in absentia. A letter requesting such permission, signed by the chair of the DAC, must be submitted to the associate dean of graduate engineering programs and research. This letter should outline in detail the relationship between the advisor and the candidate and the name and background of the person who will directly advise the candidate during the accomplishment of this independent research. This person will be added to the advisory committee.

Journal Paper Submission Requirement

The PhD dissertation must either add to the fundamental knowledge of the field or provide a new and better interpretation of facts that are already known. It is expected to result in one or more papers suitable for publication in a refereed journal. A proof of publication or manuscript prepared for an appropriate journal and an acknowledgement of receipt by the editor must also be submitted along with the dissertation. Journal paper submissions resulting from ECE695-P2 are considered coursework and do not count towards this requirement.

Dissertation Defense

No earlier than six months after the successful candidacy examination, the candidate shall defend the doctoral dissertation in a public forum to demonstrate to the committee that all the preparation for which the doctoral degree is awarded has been met. The defense is open to all members of the University of Dayton faculty, student body, and interested outside parties. The members of the DAC, with the advisor acting as chair, will conduct this dissertation defense. Students are expected to complete the requirements for the doctoral degree within five years after the candidacy examination has been passed.

Before the announcement of this defense, the DAC must agree that the dissertation is ready for public defense. At least two weeks prior to the date of the defense, the candidate must provide the committee with copies of the nearly final version of the dissertation and submit to the Chair the request to schedule the defense. For the defense to be satisfactory, the advisory committee members must agree that the dissertation defense has been successfully completed. If the candidate's defense is deemed unsatisfactory by at least one member, the case will be referred to the associate dean of graduate engineering programs and research for appropriate action.

Academic Standards

Graduate students are expected to do high-caliber work at all times and demonstrate continuing progress toward the degree. This requires that students maintain a minimum average grade of B in course work. The MS students are allowed to have no more than two grades of C. Students who fail to meet these requirements are either placed on academic probation or dismissed from the program. For PhD students, one grade of F, or more than one grade of C may be grounds for dismissal from the program pending recommendation of the DAC. All students are expected to adhere to the established university policies on *Attendance, Academic Dishonesty, Computing Ethics, Misconduct in Research and Scholarship, and Software Audit.*

Courses of Instruction

ECE 500: INTRO TO GRAD PROG IN ECE: Introduction to ECE graduate program, research methods in ECE, technical writing, literature research, ethics, software and resources. *0 sem. hrs.*

ECE 501: CONTEMPORARY DIGITAL SYSTEMS: Introduction to sequential logic; state machines; high performance digital systems: theory and application of modern design; alternative implementation forms and introduction to HDL; productivity, recurring and non-recurring costs, flexibility, and testability; software drivers; hardware/software integration; finite state machines. Required background: ECE 215 or equivalent. *3 sem. hrs.*

ECE 503: ADVANCED ENGINEERING PROBABILITY: Random variables as applied to system theory, communications, signal processing and controls. Topics include advanced engineering probability, random variables, random vectors, and an introduction to random processes. Required background: ECE 340, or equivalent. *3 sem. hrs.*

ECE 505: DIGITAL SIGNAL PROCESSING I: A study of one-dimensional digital signal processing, including a review of continuous-system and analysis and sampling. Topics include z-transform techniques, digital filter design and analysis, and fast Fourier transform processing techniques. Required background: ECE 334 or equivalent. *3 sem. hrs.*

ECE 506: MICROELECTRONIC DEVICES: Crystalline structure of matter, quantum mechanics and energy band theory; bulk properties of semiconductors; p-n and metal-semiconductor junctions; bipolar junction transistors; field-effect transistors; heterostructures; optical properties of semiconductors; devices and applications. Required background: ECE 304 or equivalent. *3 sem. hrs.*

ECE 507: ELECTROMAGNETIC FIELDS I: Fundamental concepts, wave equations and its solutions, wave propagation, reflection and transmission; potential theory; construction of modal solutions; various Electromagnetic theorems: concept of source, uniqueness, equivalence, induction and reciprocity theorems. Required background: ECE 333 or equivalent. *3 sem. hrs.*

ECE 509: ANALYSIS OF LINEAR SYSTEMS: State variable representation of linear systems and its relationship to the frequency domain representation using transfer functions and the Laplace transform. State transition matrix and solution of the state equation, stability, controllability, observability, state feedback and state observers are studied. *3 sem. hrs.*

ECE 510: MICROWAVE ENGINEERING & SYSTEMS: Microwave transmission, planar transmission lines, microwave components and filters. Microwave semiconductor devices. Microwave tubes, microwave communication, radar systems, and electronic support measures. Prerequisite: ECE 507. *3 sem. hrs.*

ECE 511: ANTENNAS: Fundamental principles of antennas; analysis and synthesis of arrays; resonant antennas; frequency-independent antennas; aperture and reflector antennas; applications to radar and communication systems. Prerequisite: ECE 507 or equivalent. *3 sem. hrs.*

ECE 515: ENGINEERING MAGNETIC MATERIALS: Magnetic fundamentals including spontaneous magnetization; advanced magnetic materials, computer modeling of magnetic circuits using 2D/3D finite element analyses. Applications of magnetic materials in electric machines. Prerequisites: MAT 501 and college physics, or permission of instructor. *3 sem. hrs.*

ECE 518: ELECTROMAGNETIC FIELDS II: Classification and construction of solutions. Plane cylindrical and spherical wave functions. Integral equations, mathematical theory of diffraction. Green's function. Prerequisite: ECE 507. *3 sem. hrs.*

ECE 521: DIGITAL COMMUNICATIONS I: Fundamentals of digital transmission of information over noisy channels; modulation schemes for binary and M-ary digital transmission; optimum receivers; coherent and non-coherent detection; signal design; intersymbol interference; error control coding; the Viberti algorithm; channel capacity and Shannon limits on reliable transmission. Required background: ECE 503 or equivalent. *3 sem. hrs*.

ECE 522: DIGITAL COMMUNICATIONS II: Fundamentals of source coding and compression, Shannon's theorem, Huffman coding; system synchronization; equalization techniques; multiplexing and multiple access systems; spread-spectrum systems and their applications; pseudo-noise, direct sequence systems, frequency hopping, jamming; encryption and decryption systems. Prerequisite: ECE 521. *3 sem. hrs.*

ECE 523: SATELLITE COMMUNICATIONS: Topics related to the theory, design and orbital placement of geostationary and geosynchronous satellites and their communications applications, including transmitters and receivers in the RF, microwave and optical operational windows, the associated modulation and communication strategies, system hardware and international satellite networks. Prerequisite: ECE 507 or permission of instructor. *3 sem. hrs*.

ECE 530: DIGITAL INTEGRATED CIRCUIT DESIGN: Integrated circuit design and layout concepts, design methodology, fabrication process and limitations, MOSFET models for digital design, inverter and logic gates, interconnect and delay, combinational circuits, sequential circuits, datapath subsystems, memory circuits, digital phase lock loops. Required background ECE 304. *3 sem. hrs.*

ECE 531: ANALOG INTEGRATED CIRCUIT DESIGN: Integrated circuit design concepts and layout; system perspective on analog design; MOS device theory and processing technology; current mirrors and biasing circuits; voltage and current references; single-stage, differential and operational amplifiers; CAD

utilization to realize the design process. Required background: ECE 304 or equivalent. *3 sem. hrs.*

ECE 532: EMBEDDED SYSTEMS*:* This course will introduce the student to the concept of embedded systems and the constraints imposed on hard real-time systems. Course will consist of design, development and test of selected hard-deadline hardware and software using Altera's DE2 development boards. The student will design selected hardware interfaces and develop real-time executive and application code in assembly language and C. Each student will design and implement hardware using Verilog HDL. Prerequisite: ECE 501 or equivalent. *3 sem. hrs.*

ECE 533: COMPUTER DESIGN: Design considerations of the computer, register transfer operations; hardware implementation of arithmetic processors and ALU; instruction set format and design and its effect on the internal microengine; hardware and micro-programmed control design; comparative architectures. Required background: ECE 501 or equivalent. *3 sem. hrs.*

ECE 536: MICROPROCESSOR APPLICATIONS: Project studies, applications of microprocessors in practical implementations; logic implementation using software; memory mapped I/O problems and interrupt structure implementation; use of compilers; study of alternate microprocessor families including industrial controllers. Required background: ECE 314 or equivalent. *3 sem. hrs.*

ECE 538: OBJECT ORIENTED PROGRAMMING APPLICATIONS: A semi-formal approach to the engineering applications of object oriented programming (OOP). Application of the concepts of classes, inheritance, polymorphism in engineering problems. Introduction to the use of class libraries. Effective integration of the concepts of application programmer interfaces, language features and class libraries. Required background: C programming experience. *3 sem. hrs.*

ECE 545: AUTOMATIC CONTROL: Study of mathematical models for linear control systems and analysis of performance characteristics and stability. Design topics include pole-placement and the linear quadratic regulator, root locus, and frequency domain techniques; feedback loop sensitivity, basic loopshaping, performance bounds and other introductory aspects of robust control. Required background: ECE 415 or equivalent. *3 sem. hrs.*

ECE 547: NONLINEAR SYSTEMS AND CONTROL: Introduction to nonlinear phenomena in dynamical systems. A study of the major techniques of nonlinear system analysis including phase plane analysis and Lyapunov stability theory. Application of the analytical techniques to control system design including feedback linearization, backstepping and sliding mode control. Prerequisite: ECE 509 or permission of instructor. *3 sem. hrs.*

ECE 563: IMAGE PROCESSING: An introduction to image processing including the human visual system, image formats, two-dimensional transforms, and image reconstruction. Prerequisite: ECE 505. *3 sem. hrs.*

ECE 564: 3D COMPUTER VISION: Develop the skills needed to generate synthetic images of 3D objects and to recover 3D structure from one or more views (projections) of 3D objects. Feature recognition in 2D views (images) of a scene based either on actual photographs or synthetic images (computer graphics generated). Applications in robot pose recognition and mobile robot navigation. Prerequisites: ECE 538 and ECE 563, or permission of instructor. *3 sem. hrs.*

ECE 567: MACHINE LEARNING & PATTERN RECOGNITION: Fundamental concepts and models of machine learning with a practical treatment of design, analysis, implementation and applications of algorithms that learn from examples. Topics include supervised and unsupervised learning, self-organization, pattern association, feed-forward and recurrent architectures, manifold learning, dimensionality reduction, and model selection. Required background: ECE 445 or equivalent. *3 sem. hrs.*

ECE 572: LINEAR SYSTEMS AND FOURIER OPTICS: Mathematical techniques pertaining to linear systems theory; Fresnel and Fraunhaufer diffraction; Fourier transform properties of lenses; frequency analysis of optical systems, spatial filtering, application such as optical information processing and holography. Prerequisite: Acceptance into the ECE graduate program or permission of the department chairperson. *3 sem. hrs.*

ECE 573: ELECTRO-OPTICAL DEVICES AND SYSTEMS: Solid-state theory of optoelectronic devices; photoemitters; photodetectors; solar cells; detection and noise; displays; Electro-optic, magneto-optic, and acousto-optic modulators; integration and application of Electro-optical components in Electro-optical systems of various types. Prerequisite: ECE 507, or permission of the department chairperson. *3 sem. hrs.*

ECE 574: GUIDED WAVE OPTICS: Light Propagation in slab and cylindrical wave guides; signal degradation in optical fibers; optical sources, detectors, and receivers; coupling; transmission link analysis; fiber fabrication and cabling; fiber sensor system. Prerequisite: ECE 507 or permission of the department chairperson. *3 sem. hrs.*

ECE 575: ELECTRO-OPTIC SENSORS: Optical sensors, including amplitude, phase, wavelength, polarization and modal interference based sensors. Photoelasticity effects in stressed optical materials. Quadrature point stabilization, linearity, dynamic range and sensitivity. Modulation and demodulation by both passive and active means. General sensor characteristics. Optical sources and detectors, optical signal-to-noise ratio analysis and general sensor characteristics. Fiber optic sensors and smart skin/structure technology. Prerequisite: ECE 574 or permission of the department chairperson. *3 sem. hrs.*

ECE 577L**:** ELECTRO-OPTIC SYSTEMS LABORATORY: Fiber optic principles and systems: numerical aperture, loss, dispersion, single and multimode fibers, communications and sensing systems; project oriented investigations of Electro/fiber-optic systems and devices in general, sources, detectors, image processing, sensor instrumentation and integration, Electro-optic components, display technology, and nonlinear optical devices and systems. Prerequisite: ECE 574 or permission of the department chairperson. *1 sem. hr.*

ECE 581: NANOELECTRONICS: Introduction to the physics of materials on the nanoscale; quantum confinement theory; electronic and optical properties of semiconductor nanostructure; single electron transistors (SETs); tunneling and ballistic devices; nanostructured LEDs, photodetectors, and lasers; nanophotovoltaics and nanomagnetics; quantum computing and molecular electronics; nanoelectronic fabrication, state-of-the-art and emerging nanoscale devices and applications. Prerequisite: ECE 506 or permission of instructor. *3 sem. hrs.*

ECE 583: ADVANCED PHOTOVOLTAICS: Science and applications of photovoltaics, with special emphasis on inorganic and organic semiconductors, ferroelectrics, chalcopyrites,

metamaterials, quantum structures and photovoltaics architecture. Prerequisite(s): ECE 506 or permission of instructor. *3 sem. hrs.*

ECE 595: SPECIAL PROBLEMS IN ELECTRICAL ENGINEERING: Particular assignments to be arranged and approved by the department chair. *1-6 sem. hrs.*

ECE 599: THESIS: Thesis in Electrical and Computer Engineering. *1-6 sem. hrs.*

ECE 632: CONTEMPORARY MICROELECTRONICS DESIGN: CMOS analog circuit design (oscillators, amplifiers, op-amps), mixed signal design (data converters), introduction to microelectromechanical systems (MEMS) and wireless communications systems design, advanced VLSI digital design projects, seminar topics covering contemporary designs and techniques. Prerequisite: ECE 531. *3 sem. hrs.*

ECE 633: ADVANCED COMPUTER ARCHITECTURE: Examination of modern high performance computing architectures, including out-of-order execution RISC multicore processors and GPGPUs. Design projects integrate the concepts learned in class. Prerequisite: ECE 533. *3 sem. hrs.*

ECE 642**:** OPTIMAL CONTROL AND ESTIMATION: Introduction to optimal control, starting with dynamic programming for stochastic optimal control; continuous time optimal control, including Pontryagin's Maximum Principle and its application to the linear case, leading to linear optimal control. Prerequisites: ECE 509 or permission of instructor. *3 sem. hrs.*

ECE 645: ADAPTIVE CONTROL: On-line approximation based adaptive control techniques for nonlinear systems. An introduction to neural networks and fuzzy systems as part of the control loop is given, leading to a diversity of advanced methods for controlling and stabilizing nonlinear systems subject to uncertainties. Adaptive observers and adaptive output feedback are also introduced. Prerequisites: ECE 547, or permission of instructor. *3 sem. hrs.*

ECE 661: STATISTICAL SIGNAL PROCESSING: This course studies discrete methods of linear estimation theory. Topics include random vectors, linear transformations, linear estimation, optimal filtering, linear prediction, and spectrum estimation. Prerequisite: ECE 503, ECE 505. *3 sem. hrs.*

ECE 662: ADAPTIVE SIGNAL PROCESSING: An overview of the theory, design, and implementation of adaptive signal processors. This includes discussions of various gradient research techniques, filter structures, and applications. An introduction to neural networks is also included. Prerequisite: ECE 661. *3 sem. hrs.*

ECE 663: STATISTICAL PATTERN RECOGNITION: This course provides a comprehensive treatment of the statistical pattern recognition problem. The mathematical models describing these problems and the mathematical tools necessary for solving them are covered in detail. Prerequisite: ECE 661. *3 sem. hrs.*

ECE 674: INTEGRATED OPTICS: Review of Electromagnetic principles; dielectric slab waveguides; cylindrical dielectric waveguides; dispersion, shifting and flattening; mode coupling and loss mechanism; selected nonlinear waveguiding effects; integrated optical devices. Prerequisite: ECE 574. *3 sem. hrs.*

ECE 676: QUANTUM ELECTRONICS: Principles of the quantum theory of electron and photon processes; interaction of electromagnetic radiation and matter; applications to solid state and semiconductor laser systems. Prerequisite: ECE 506, or EOP 506/ECE 573 or equivalent. *3 sem. hrs.*

ECE 682: NANO-FABRICATION LABORATORY: This laboratory course will provide hands-on experience in state-of-the-art device fabrication technology. The course will be conducted primarily in a clean room laboratory with some classroom sessions for discussions. The students will have an opportunity to design, fabricate, and test their own devices. Prerequisite: Permission of instructor. *3 sem. hrs.*

ECE 695: SPECIAL PROBLEMS IN ELECTRICAL AND COMPUTER ENGINEERING: Special topics in electrical engineering not covered in regular courses. Course sections arranged and approved by the chair of the student's doctoral advisory committee and the department chairperson. *1-6 sem. hrs.*

There are two special versions of ECE 695 that doctoral students may take in consultation with their dissertation advisers:

ECE 695-P1: SPECIAL PROBLEMS IN ECE (GUIDED RESEARCH LEADING TO CONFERENCE PUBLICATION): Students enrolled in this class will write a manuscript resulting in a published conference paper. *3 sem. hrs.*

ECE 695-P2: SPECIAL PROBLEMS IN ECE GUIDED RESEARCH LEADING TO JOURNAL PUBLICATION: Students enrolled in this class will write a manuscript resulting in a submitted to a peer-reviewed journal (in addition to the minimum of one required for the PhD degree). *6 sem. hrs.*

ECE 696: GRADUATE SEMINAR: Research oriented independent study course intended for doctoral level graduate students. The student will perform an in-depth research on a selected topic of mutual interest with his/her doctoral adviser, and achieve sufficient expertise to do a technical presentation about the topic in front of his/her peers. The student will prepare a report and present it in one of the graduate seminar sessions during the semester. The student is expected to attend all the seminars presented by other graduate students during the semester and to interact with them to improve the depth and breadth of his/her knowledge. *0-3 sem. hrs.*

ECE 699**:** PhD DISSERTATION: Original research in electrical engineering that makes a definite contribution to technical knowledge. Results must be of sufficient importance to merit publication in a refereed journal. *1-15 sem. hrs.*

Departmental and Computing Facilities

Students have access to facilities offering top-of-the-line equipment with industry specific software including FPGA development tools from Altera, real-time control tools from dSPACE and industrial robots from Yaskawa Motoman, among others. Many software tools are available for design and simulation such as MATLAB, NI Multisim, Silvaco, CoventorWare and MEMS+, FEKO, Keysight EESof and NI AWR Suite for Analog, RF and Microwave design.

Graduate Student Research PC Room – KL 272

The School of Engineering hosts a computer lab in KL 272 that offers 48 student workstations, a network printer and scanner, plus an instructor workstation with projector for presentations. These workstations provide access to both standard student software tools and advanced engineering

software programs. Students must present a valid UD ID card to have a SoE account created through UDit, and this account will be used to login to the workstations in KL 272.

The Innovation Corridor – KL 351

The Department of Electrical and Computer Engineering at the University of Dayton is starting an exciting new initiative to bolster collaborative research and increase undergraduate student participation in research activities. The three key areas that have been selected are physically placed in the newly-developed Innovation Corridor (IC), where collaboration, interchange of ideas and innovative research take place in a fertile environment.

The Corridor is located in the Kettering Labs complex 351, and contains three main laboratories corresponding to rapidly growing areas of research considered key in the development of the department:

1. Advanced Communications Network & Security Laboratory
2. Intelligent Signal and Systems Laboratory
3. Signals and Image Processing Laboratory
4. Embedded Data Processing Laboratory

Broadly speaking, the areas covered by these laboratories are embedded computing, parallel computing, control and automation, robotics, digital and optical imagine processing, and nonlinear adaptive optics. The ECE department strongly believes that there exist connections between all these areas which, if recognized and brought to the forefront, will lead to a wealth of opportunities for collaborative research and will provide a means to attract not only highly qualified graduate students to the University of Dayton, but also motivated undergraduates willing to get involved in research early in their careers.

Advanced Communications Network & Security Laboratory – KL 351A

The Advanced Communications Network & Security (ACNS) Laboratory is equipped with a host of networking devices, computing systems, embedded systems and other platforms from vendors such as Ettus Research (NI), Cisco, Linksys, D-Link, and HP. The ACNS lab provides a highly flexible research network environment suitable for advanced research work in the fields of wireless communications and network security. Wireless device characteristics, such as throughput, power consumption, robustness to multipath propagation, noise, interference, etc., can be evaluated in the ACNS laboratory environment. The lab also supports research in Internet of Things (IoT), with an emphasis on wireless IoT device connection and security.

Signal & Image Processing Laboratory –KL 351B

The Signal and Image Processing Laboratory has received some upgrades in Spring 2017. It is equipped with several high-performance workstations, and a new multimedia wall with a 65 inch 3D video display and powered studio-quality audio monitors. The lab also has a small conference area and researcher desks. We have several camera systems available including a FLIR systems infrared camera, and high quality color and grayscale USB cameras. We also have a Directed Perception pan-and-tilt camera mount. For audio, the lab has a Mackie mixer and professional quality microphones for sound recording. All of the workstations are equipped with the standard engineering software packages such as MATLAB with many toolboxes including the data and image acquisition toolboxes. Using MATLAB we are able to rapidly develop and test audio and video processing algorithms and apply them using the available audio and camera systems. The lab primarily supports research in image and video processing, with an emphasis on medical image processing.

Intelligent Signal and Systems Laboratory- KL 351C & D

Research at Intelligent Signal Systems Laboratory is aimed at understanding the increasingly large role that signal systems play in the real-world. We connect the applied design efforts with the first principle ideas of mathematics, statistics, signal processing, and psychophysical models to enable new capabilities in image processing, computer vision, biomedical imaging, and sensors.

Embedded Data Processing Laboratory – KL 351E

Research is performed in the areas of signal and image processing for real-time systems. Hard execution time thresholds required by real-time signal processing and imaging systems provide research challenges in both algorithm development and algorithm implementation. The Embedded Data Processing Lab is acquiring differing computational resources such as advanced computing servers, embedded data processing cards with Field Programmable Gate Arrays (FPGAs) and other computing platforms to allow for advanced research to be conducted in signal and image processing focused on technology transfer to real-time signal and image processing applications.

Other Specialized Facilities

Nonlinear Control Laboratory

The Nonlinear Control Laboratory in KL 233 houses a variety of experiments dedicated to research in advanced control methods, including nonlinear and adaptive control. Experiments in the laboratory include a single rotational inverted pendulum, a double inverted pendulum, a 3 DOF helicopter, a magnetic levitation experiment, a reaction wheel pendulum, a 9 DOF hyper-redundant robotic arm, a set of five table-top mobile robots and an upper-arm exo-skeleton. These experiments serve as test beds for advanced nonlinear control methods, and provide students with an excellent opportunity to face challenging control problems. The computers in the lab are outfitted with dSPACE real-time control cards, which allow control design and development to be carried out in MATLAB and then compiled into a real-time executable. These control cards are widely used in

industry, and therefore provide students with knowledge of great practical value. The laboratory also has stations dedicated to prototyping and development.

Motoman Robotics Laboratory

The Motoman Robotics Laboratory in KL 232 was established in the Department of Electrical and Computer Engineering at the University of Dayton in August of 2008 with a generous donation from Motoman, Inc. End-of-arm tools for the robots have been donated by SAS Automation. The lab is located in Kettering Labs 232. It houses six state-of-the-art industrial robots, including a revolutionary seven-axis, actuator-driven IA20 robot; a revolutionary 15-axis, actuator-driven and human-like dual-arm DIA10 robot; a four-axis YS450 high-speed SCARA robot; two six-axis MH5S articulated robots and one HP3C six-axis, articulated robot with a compact controller. The lab focuses on visual servoing and other advanced robotics research. It also functions as the centerpiece of the undergraduate Robotics Concentration in the Electrical and Computer Engineering curriculum.

Microfabrication Laboratory

KL 331 houses a Microelectronics Fabrication laboratory, a modular, class 1000 clean room, primarily designed for photolithography processes and thin-film depositions. The lab is equipped with a wet bench, a photoresist spinner, a mask aligner and a microscope. The laboratory is also equipped with a Torr International DC/RF sputtering system, capable of depositing conducting or dielectric thin-films. A Neocera/Pioneer 180 large area pulsed laser deposition (PLD) system is also housed in the clean room. The Nano Engineering Science and Technology (NEST) clean room located in the Science Center currently contains the state of the art microelectronic equipment including lithography, inductively coupled plasma etching system, sputtering and electron-beam evaporation system.

Mumma Radar Laboratory

Funded by the Ohio Research Scholar Program, the Mumma Radar Laboratory is a unique spatially and spectrally diverse RF chamber, with the ability to very precisely and rapidly position transmit and receive antennas using high precision industrial robots. The chamber provides a capability to RF-illuminate articles under test and then collect radio frequency (RF) scattering data using a variety of waveforms (from short pulse to narrowband continuous wave, from stepped FM to OFDM, and beyond). In addition to spectral diversity, a variety of widely spaced transmit and receive antennas permits real-time spatial diversity measurements. While not an anechoic chamber, this new Center of Excellence in Distributed Sensing also supports characterization of antennas and canonical targets in a controlled environment. Mumma Radar Laboratory researchers are also working on using radar to improve sensing for medical imaging, aerospace and manufacturing, including the detection of defects in 3-D printed objects, and in autonomous systems applications in collaboration with UDRI, AFRL and local industries.

Microwave Measurements Laboratory

KL 470 has a Microwave Measurements Lab equipped with HP8720 Vector Network Analyzers (VNA), an on-wafer probe station integrated with a thermo-electric temperature controller, and other microwave accessories. The probe station can be used with DC as well RF/Microwave probes. A Precision LC Tester manufactured by Radiant Technologies is available for characterization at low frequencies up to 1 MHz. The lab also has Sonnet electromagnetic simulation tools, KeySight's EESof Tools, and Applied Wave Research's Microwave Office and Visual System Simulator Design Tools.

Vision Laboratory

UD Vision Lab (KL 461) is established in the Department of Electrical and Computer Engineering as the Wide Area Surveillance (WAS) research initiative under the State of Ohio award for the Ohio Academic Research Cluster for Layered Sensing (OARCLS). The main focus of Vision Lab is to develop advanced algorithms and architectures for real time applications in the areas of signal/image processing, computer vision, pattern recognition, and artificial neural systems. Specific concentration areas in Vision Lab are wide area surveillance for situational awareness, biometrics for human identification, vision guidance and navigation for intelligent robots, brain wave analysis for emotion/intention recognition, and high performance and low power architecture design for real time systems. Vision Lab is equipped with state of the art facilities for long range and wide area surveillance data acquisition, brain wave data acquisition, advanced robotics, and high performance computing.

Integrated Microsystems Laboratory

Integrated Microsystems Laboratory conducts research and development of high value system-on-chip and system-in-package technologies that reach beyond the boundaries of conventional semiconductor technologies by combining technologies that process information with those that interact with people and environment. The research areas of interest include CMOS Sensor Microsystems, RF/Analog Circuits, Neuro/Biomedical-, Prosthetics and Wearables, Bio-/Neuro/RF-MEMS, Biological/Chemical Sensing, and Nano-/Bio- Materials. The lab has gained international recognition for several contributions including (i) development of integrated circuits and sensors that operate under high-temperature and extreme environments, (ii) ultra-clean wafer-level vacuum packaging of microdevices and (iii) miniaturized optical chemical and biological sensors. The lab has been financially supported by various government, industry and non-profit institutions including National Science Foundation and U.S. Air Force.

Faculty and Staff

Vijayan K. Asari, Professor
PhD, Indian Institute of Technology, Madras, 1994
Areas of research interest:
Signal Processing, Image Processing, Computer Vision, Pattern Recognition, Machine Learning, Artificial Neural Networks, High Performance and Low-Power Digital Architectures

Biography: Dr. Vijayan Asari is the Ohio Research Scholars Chair in Wide Area Surveillance and Professor in Electrical and Computer Engineering at University of Dayton. Dr. Asari received his Bachelor's degree in Electronics and Communication Engineering from the University of Kerala, India in 1978, the M.Tech. and PhD degrees in Electrical Engineering from the Indian Institute of Technology, Madras in 1984 and 1994 respectively. He had been working as a Professor in Electrical and Computer Engineering at Old Dominion University, Virginia and joined UD in February 2010. Dr. Asari has so far published more than 260 articles including 55 journal papers in the fields of image processing, computer vision, pattern recognition, artificial neural networks, and high performance and low power digital architectures for image and video processing applications. His current research focus areas are wide area surveillance, biometrics, vision guided robotic navigation, brain wave analysis, and high performance and low power architecture design.

Eric J. Balster
Associate Professor,
Associate Chair,
PhD, The Ohio State University, 2004
Areas of research interest:
Image and Video processing, Software Engineering, Digital Systems

Biography: Eric Balster graduated from the University of Dayton in 1998 with a B.S. and in 2000 with an MS, both in Electrical Engineering. He received his PhD in Electrical Engineering from The Ohio State University in June of 2004. His research area was in the field of image and video processing, specifically in compression and pre-processing algorithm development. From 2002 to 2006, Dr. Balster worked in the Information Directorate, Air Force Research Laboratory (AFRL), continuing his work in image and video processing research. From 2006 to 2008, he worked in the AFRL's Sensor's Directorate, serving as the lead aircraft software development and support engineer for a wide-area persistent surveillance program. Since August 2008, Dr. Balster has worked as an assistant Professor at the University of Dayton where he continues research in image processing and aerial surveillance processing research.

Partha P. Banerjee
Professor
PhD University of Iowa, 1983
Areas of research interest:
Nonlinear optics, photorefractives, information processing, acousto-optics.

Biography: Dr. Partha P. Banerjee received the Bachelor of Engineering in Electronics and Telecommunication Engineering from Indian Institute of Technology, Kharagpur, India in 1979. He received the MS and PhD degrees in Electrical and Computer Engineering from the University of Iowa, I 1980 and 1983 respectively. He served as a faculty member at the University of Alabama in Huntsville from 1991 to 2000, and at Syracuse University from 1984 to 1991. He is the recipient of the NSF Presidential Young Investigator Award in 1987. He is Fellow of the Optical Society of America and of SPIE, and is a senior member of IEEE. To date he has over 80 refereed journal publications and is the coauthor of 3 textbooks.

Monish Chatterjee
Professor
PhD, University of Iowa, 1985
Areas of research interest:
Acousto-optics, optical bistability and chaos, holography, nonlinear system modeling, wave propagation

Biography: Monish R. Chatterjee received the B.Tech (Hons) degree in Electronics and Communications Engineering from I.I.T., Kharagpur, India, in 1979. He received the MS and PhD degrees, both in Electrical and Computer Engineering, from the University of Iowa, Iowa City, Iowa, in 1981 and 1985 respectively. Dr. Chatterjee served as a visiting faculty at the University of Iowa for one year before joining the ECE faculty at Binghamton University, the State University of New York, and conducted teaching and research from 1986 through 2002. In fall 2002, Dr. Chatterjee joined the University of Dayton's ECE department Dr. Chatterjee has published numerous essays, correspondences, and three books of translation from his native Bengali. He received the State University of New York's Chancellor's Award for Excellence in Teaching in 2000. He is a Senior Member of IEEE, and a member of OSA, ASEE and Sigma Xi.

Vamsy Chodavarapu
Professor, State University of New York, Buffalo, 2006
Areas of research interest: CMOS Sensor Microsystems, RF/Analog Circuits, Neuro-/Biomedical- Implants and Wearables, Bio-/Neuro-/RF-MEMS, and Biological/Chemical Sensing

Biography: Vamsy Chodavarapu joined the ECE Dept. in 2015 as an Associate Professor. He obtained his Ph.D. and M.S. degrees in Electrical Engineering from University at Buffalo, The State University of New York in 2006 and 2003, respectively. He obtained his B. Eng. Degree in Instrumentation Engineering from Osmania University, India in 2001. From 2006 to 2015, Chodavarapu was a faculty member in the Dept. of Electrical & Computer Engineering at McGill University, Montreal, Quebec, Canada. Since 2011, he is a full licensed Professional Engineer in the Province of Ontario, Canada. He has co-authored more than 90 refereed journals and conference proceedings. He has 8 approved/pending United Stated patents. He is a Senior Member of both SPIE and IEEE

Malcolm Daniels
Associate Professor
PhD, University of Strathclyde, 1982
Areas of research interest: Automatic Control, Electrical Machines

Biography: Malcolm W. Daniels, Ph.D**.** holds undergraduate (1979) and graduate degrees (1982) in Electrical and Electronic Engineering from the University of Strathclyde in Glasgow, Scotland and has worked at the University of Dayton since 1985. In addition to his faculty responsibilities he has held various administrative positions include Associate Dean for Undergraduate Studies, Associate Dean for Graduate Studies and Research, Interim Dean of Engineering and Chair of the Electrical and Computer Engineering department. His professional areas of research are in electrical machines, control and automation issues on the Smart Grid. Most recently his research has focused on the optimal design of renewable energy systems and the control of micro-grids. In addition to teaching undergraduate and graduate courses in Electrical Engineering he also teaches courses in Appropriate Technology Design.

Dr. Daniels currently serves as Director of the ETHOS Center within the School of Engineering. The Center is the focal point for all community engaged learning and service within the School of Engineering. In this capacity he directs international and domestic technical service immersion programs for undergraduate and graduate engineering students. In 2017, Dr. Daniels was appointed as the Learning Teaching Center (LTC) Fellow for Leadership Development and coordinates new chair training, the Chairs Collaborative and the Associate Deans Collaborative.

Bradley D. Duncan
Professor
PhD, Virginia Tech, 1991
Areas of research interest: Ladar system analysis and design, fiber optic sensing/communications, optical waveguide transmission applications, photorefractive device and system design, scanning and nonlinear optical image processing, non-destructive evaluation and holography.

Biography: Bradley D. Duncan received the Bachelor of Science in Electrical Engineering (BSEE) Degree in 1986 from Virginia Tech. He received the MS and PhD degrees in Electrical Engineering, also from Virginia Tech, in 1988 and 1991 respectively. Dr. Duncan has been with the University of Dayton since August 1991. He holds a joint appointment with the Department of Electrical & Computer Engineering, and the graduate Electro-Optics Program. He is a Senior Member of IEEE.

Russell C. Hardie
Professor
PhD, University of Delaware, 1992
Areas of research interest: Digital Signal and Image Processing, Statistical Signal Processing, Pattern Recognition, Medical Image Processing.

Biography: Russell C. Hardie graduated *Magna Cum Laude* from Loyola College in Baltimore Maryland in 1988 with a B.S. degree in Engineering Science. He obtained an MS and PhD degree in Electrical Engineering from the University of Delaware in 1990 and 1992, respectively. Dr. Hardie served as a Senior Scientist at Earth Satellite Corporation in Maryland prior to his appointment at the University of Dayton in 1993. He is currently a Full Professor in the Department of Electrical and Computer Engineering and holds a joint appointment with the Electro-Optics Program. Along with several collaborators, Dr. Hardie received the Rudolf Kingslake Medal and Prize from SPIE in 1998 for work on multi-frame image resolution enhancement algorithms. Dr. Hardie recently received the University of Dayton's top university-wide teaching award, the 2006 Alumni Award in Teaching. In 1999, he received the School of Engineering Award of Excellence in Teaching at the University of Dayton and was the recipient of the first annual Professor of the Year Award in 2002 from the student chapter of the IEEE at the University of Dayton. His research interests include a wide variety of topics in the area

of digital signal and image processing. His research work has focused on image enhancement and restoration, pattern recognition, and medical image processing. He is currently a senior member of IEEE.

Keigo Hirakawa
Associate Professor
PhD, Cornell University, 2005
Areas of research interest:
Signal and Image Processing, Statistics, Color Image Processing, Digital Camera Processing Pipeline, 3D Image Reconstruction and Display

Biography: Prof. Hirakawa has published in the literature of engineering, computer science, and statistics. He has received a number of recognitions, including a paper award from IEEE and keynote speeches at IS&T CGIV, PCSJ-IMPS, and CSAJ. He has strong track record of collaborating with industry partners. His book, "Digital Camera Processing Pipeline" is scheduled to be published by John Wiley & Sons Inc next year. His research focuses on algorithmic development of image processing, computer vision, biomedical imaging, and sensor designs. He is best known for his expertise in digital camera designs, and his contributions span color science, estimation theory, statistical modeling, and wavelet theory.

John Loomis
Emeritus Professor
PhD, University of Arizona, 1980
Areas of Research Interest:
Image Processing, Computer Graphics, Machine vision, Optical Design and Testing, Interferometry, Ellipsometry.

Biography: Dr. Loomis obtained his B.S. in Physics from Case Institute of Technology in 1966, MS from University of Illinois in 1968, and MS and PhD from the University of Arizona in 1977 and 1980, respectively. He has been a research professor in Electro-optics at the University of Dayton from 1985 to present. He is also a research optical physicist at UDRI from 1979 to present.

Raúl Ordóñez
Professor
PhD, Ohio State University, 1999
Areas of research interest:
Control systems, nonlinear and adaptive control, robotics, multi-vehicle coordination, aircraft control and other control applications

Biography: Raul Ordonez received his M.S. and Ph.D. in electrical engineering from the Ohio State University in 1996 and 1999, respectively. He spent two years as an assistant professor in the department of electrical and computer engineering at Rowan University, and then joined the ECE department at the University of Dayton, where he has been since 2001 and is now a full professor. He has worked with the IEEE Control Systems Society as a member of the Conference Editorial Board of the IEEE Control Systems Society since 1999; Publicity Chair for the 2001 International Symposium on Intelligent Control; member of the Program Committee and Program Chair for the 2001 Conference on Decision and Control; Publications Chair for the 2008 IEEE Multi-conference on Systems and Control. Dr. Ordonez is also serving since 2006 as Associate Editor for the international control journal Automatica. He is a coauthor of the textbook Stable Adaptive Control and Estimation for Nonlinear Systems: Neural and Fuzzy Approximator Techniques, (Wiley, 2002); he is also co-author of the research monograph Extremum Seeking Control and Applications - A Numerical Optimization Based Approach, (Springer, 2011). He worked between 2001 and 2007 in the research team of the Collaborative Center for Control Science (CCCS), funded by AFRL, AFOSR and DAGSI at the Ohio State University. Dr. Ordóñez received a Boeing Welliver faculty fellowship in 2008, and an AFRL Summer Faculty Fellowship in 2014. He spent the summer of 2015 as a visiting professor at the Université de Picardie Jules Verne, with the Laboratoire *M.I.S.* (Modélisation, Information et Systèmes), in Amiens, France.

Robert P. Penno
Professor
PhD, University of Dayton, 1987
Areas of research interest:
Antenna and Electromagnetic Field Theory, Array Signal Processing with applications to Passive Direction Finding, Simulation of Radar Signals

Biography: Robert Penno received the Bachelor of Science in Mechanical Engineering and Master of Science in Electrical Engineering from Rose Hulman Institute of Technology, Terre haute, Indiana in 1971 and 1984 respectively and his PhD at University of Dayton 1987. Prior to joining UD, he worked for the General Electric Co. He is a Senior Member of IEEE, and a member of the Sigma Xi Scientific Research Society. Dr. Penno has twice been selected as "*Engineering Professor of the Year*" by Epsilon Delta Tau, the student engineering fraternity at the University of Dayton. He has twice been a finalist for the Dr. *Samuel Burka Award*, the highest civilian award granted by the USAF for scientific research.

Andrew Sarangan
Professor
PhD, University of Waterloo, Canada, 1997

Areas of research interest: Micro and Nano-fabrication, Infrared Imaging, Optical Thin Films and Nanomaterials, Semiconductor lasers, Photo-Detectors, Computational Electromagnetics

Biography: Biography: Andrew Sarangan has been with the University of Dayton since 2000, where he has been principal investigator of research projects totaling more than $2.5M. He built and currently operates the nanofabrication laboratory. Prior to joining UD, he was at Nortel Networks in Canada, and then at the University of New Mexico and U.S. Air Force Research Laboratory at Kirtland AFB. He has authored over 70 publications and conference proceedings and four U.S. patent disclosures, and received the Sigma-Xi Society's 2008 Noland Award for Excellence in Research. Andrew is a Senior Member of IEEE, and serves as the chair of the Dayton chapter of IEEE's Photonics Society.

Frank Scarpino
Emeritus Professor
PhD, University of Dayton, 1987
Areas of research interest: Digital Systems, Software, Computer Systems, Signal Processing.

Biography: Frank Scarpino received his PhD in Electrical Engineering, University of Dayton, Dayton Ohio, 1987, and his MSEE and BSEE degrees from , University of Cincinnati in 1970 and 1963, respectively. He was Division Manager of Research and Development, Flight Control Division, Wright Patterson AFB, Ohio, 1985 and 1986. Prior to this, he was Division Manager, Systems Division, R&D, Air Force Avionics Laboratory, Wright Patterson AFB from 1982-1985. He was a Senior Engineer and Program Manager at Air Force Avionics laboratory from 1973-1978, and the Department Manager, Microcomputer & Digital Communications Development, NCR Corporation from 1966-1973.

Guru Subramanyam
Professor and Chair
PhD, University of Cincinnati, 1993
Areas of research interest: Electronic & Electro-optic Materials, Devices and Sensors, and Microwave Circuit Design.

Biography: Guru Subramanyam received the Bachelor of Engineering Degree in Electrical and Electronics Engineering from the University of Madras in 1984, with Distinction. He received the MS and PhD degrees in Electrical Engineering from the University of Cincinnati, in 1988 and 1993 respectively. Prior to joining UD, he served as a faculty member at the University of Northern Iowa, Cedar Falls, Iowa from August 93 to May 98. He is currently a Senior Member of IEEE. His research to date has been supported by NASA, NSF, AFRL, AFOSR, and DARPA. He received UD's Alumni Award for Excellence in Scholarship in 2008. Dr. Subramanyam's research in integrated ferroelectrics, integrated microsystems and energy storage have resulted in many patent filings. He had authored/co-authored over 170 publications.

Tarek Taha
Associate Professor
PhD, Georgia Institute of Technology, 2002
Areas of Research Interest: Computer Architecture, Novel Computing Systems for Neuromorphic systems, High Performance Computing

Biography: Dr. Tarek M. Taha received the B.S. degree in pre-engineering from Depauw University, Greencastle, in 1996, and the B.S.E.E., MSE.E., and Ph.D degrees in electrical engineering from the Georgia Institute of Technology, Atlanta, in 1996, 1998, and 2002, respectively. He received the NSF CAREER Award in 2007 and is a member of the IEEE Computer Society.

John Weber
Professor
PhD, University of Missouri, 1971.
Areas of research interest:
Embedded Systems, Computer Architecture, Avionic Systems

Biography: John Weber obtained his B.S. in Electrical engineering from St. Louis University in 1963, and his MS and PhD in Electrical Engineering from the University of Missouri in 1964 and 1971, respectively. He has served in the US Air Force from 1963-1979. He has a wide industrial experience. Most recently, he was vice-president and chief technology officer at Greystone Technology. His responsibilities included the development of new hardware platforms and software experiences for the entertainment industry, the development of simulation software and hardware for the government sector, and the development of commercial GPS based products.

Michael Wicks
Ohio Research Scholar Chair in Sensor Exploitation & Fusion, Radar Systems, Signal Processing
Areas of Research Interest:
Remote Sensing, signal processing, system engineering, distributed sensing and radio frequency technology

Biography: Dr. Michael C. Wicks, Ph.D. E.E. Syracuse University 1995, is the University of Dayton Endowed Chair and Ohio Scholar for Sensor Exploitation and Fusion, a Professor of Electrical and Computer Engineering, and a Distinguished Research Scientist at UDRI. Dr. Wicks has received many honors, including the 2013 IEEE Dennis J. Picard Medal for Radar Technologies and Applications, the 2016 IEEE AESS Pioneer Award recipient. He is an IEEE Fellow. Dr. Wicks is a leading research scientist in remote sensing, signal processing and systems engineering, with a current focus on distributed sensing and radio frequency tomographic radar, counter explosive sensor technology, cognitive radar and radio, space object sensing, deep earth probing radar, multi-dimensional adaptive processing for airborne and space based radar, ultra-wideband radio and radar, passive and active multi-static systems, and concealed weapons/contraband detection and carrier identification. He pioneered the concept of knowledge based signal processing and waveform diversity, and has led national and international research teams on the design, development and fielding of novel algorithms, architectures and systems for remote sensing from space, air and surface platforms. Sponsored research is currently focused on advanced algorithms for the detection and track processing of airborne targets obscured by wind farm clutter, as is research on spatially and spectrally diverse sensing for the automatic detection, identification, and feature exploitation of objects under cover, e.g. below ground, inside structures, or under foliage. Algorithms and architectures for the numerical and symbolic (heuristic) processing of sensor data is a primary focus of this research. Dr. Wicks has published many papers, reports, chapters, books and patents.

Feng Ye
Assistant Professor
PhD, University of Nebraska – Lincoln, 2015
Areas of research interest:
Information and Network Security, Wireless Communications and Networks, IoT and Smart Cities, Big Data and Cloud Computing, Smart Grid Communications

Biography: Dr. Ye received a Ph.D. degree from the University of Nebraska – Lincoln (UNL) in 2015 and a B.S. degree from Shanghai Jiao Tong University, Shanghai, China in 2011. Before joining UD in 2016, he was with the Department of ECE, UNL as an instructor and a researcher. He serves as the Secretary of IEEE ComSoc Green Communications and Computing Technical Committee. He serves as an Associate Editor of China Communications; a Guest Editor of the special issue on Green Internet of Things, Mobile Information Systems, Hindawi. He serves as the Chair of Demo/Poster, IEEE CyberSciTech 2017; the Co-Chair of Cognitive Radio and Networking Symposium, IEEE ICC 2018. He also serves as a TPC member for numerous international conferences, including IEEE Globecom, IEEE VTC, IEEE ICC, etc. He also serves as a reviewer for several International journals, including IEEE Transactions on Big Data, IEEE Transactions on Vehicular Technology, IEEE Transactions on Wireless Communications, etc. He is the recipient of the 2015 Top Reviewer of the IEEE Vehicular Technology Society.

Qiwen Zhan
Associate Professor
Ph. D., University of Minnesota, 2002
Areas of research interest:
Nanophotonics, Biophotonics, Polarization sensing and engineering, Wavefront sensing and engineering

Biography: Prof. Qiwen Zhan received his BS degree in physics (optoelectronics) from the University of Science and Technology of China (USTC) in 1996 and PhD in Electrical Engineering from the University of Minnesota in 2002. After

he joined the University of Dayton in 2002, he established the Nano Electro-Optics Laboratory and developed a microellipsometry system and a new near-field scanning optical microscope (NSOM). Currently, Dr. Zhan is an assistant professor at the Electro-Optics Graduate Program of the University of Dayton and the PI of the Nano Electro-Optics Laboratory in the Center for Materials Diagnostics (CMD).

Staff

Julie Motz
Lab Manager
B.S. Electrical Engineering,
University of Dayton, 1993

James Reed
Research Technician

Nancy Striebich
Senior Administrative Assistant
B.S. University of Dayton, 1983

MASTER MILESTONES

Thesis Route

Prior to the beginning of 1st semester……	See the temporary advisor for course registration
Before the end of 2nd semester……..	File plan of study
Before registering for thesis……	Select thesis advisor
During graduating semester	
By the 4th week…….	File application for graduation
	Appoint a thesis committee
No later than mid-semester……...	Complete thesis writing
	Have advisor approve thesis draft
2 weeks before defense……	Submit thesis to the committee
	Set date and time for defense
	Request department for room
At final exam…….	Successful thesis defense
2 weeks prior to graduation……......	Submit electronic copy of thesis to OhioLink

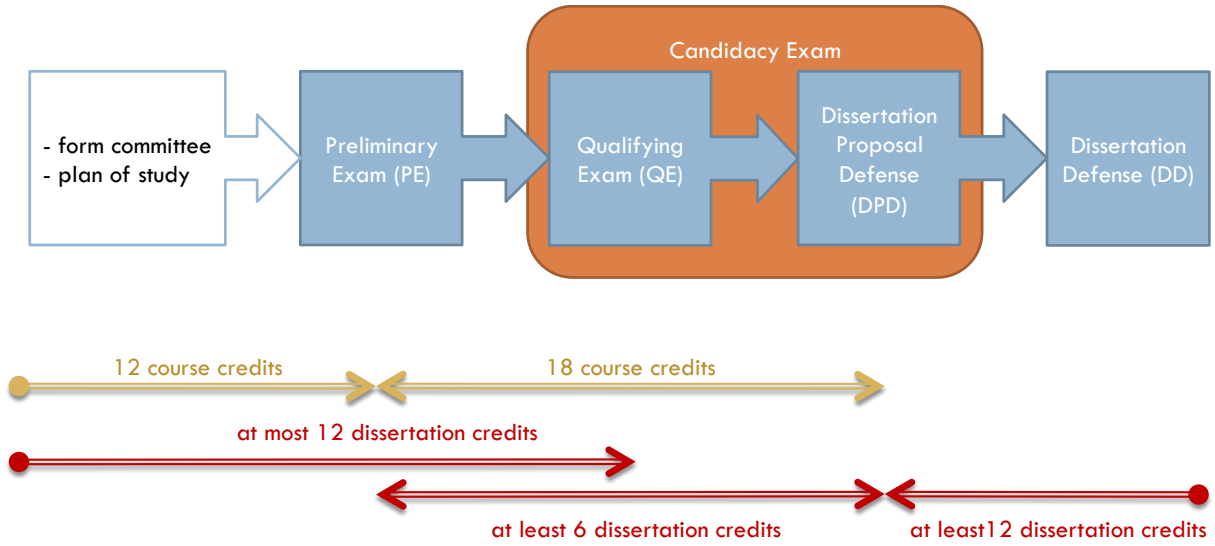
Non-Thesis Route

Prior to beginning of 1st semester……..	See the temporary advisor for course registration
Before the end of 2nd semester…….	File plan of study
During graduating semester	
By the 4th week……	File application for graduation

DOCTORAL MILESTONES

Prior to the beginning of 1st semester……	See the temporary advisor for course registration
By second semester…….	Select doctoral advisory committee (DAC)
Before the end of the 2nd semester……	File plan of study (POS)
Before candidacy exam…….	Complete most of the courses in POS
	File the Candidacy Examination Report form, indicating the grades of four PECs (or substitutes)
During candidacy exam semester……	Pass or waive the Preliminary Exam (PE)
	Pass the Qualifying Exam (QE)
After completing at least 6 dissertation credit hours	Complete and submit your dissertation proposal
	Set date and time for proposal exam
	Contact department for a room
	Pass Dissertation Proposal Defense (DPD)
After candidacy exam……	Complete dissertation research
During the graduating semester	
By the 4th week……	File application for graduation (on-line)
No later than mid-semester……...	Complete dissertation writing
	Have committee approve the draft
2 weeks before defense……	Submit dissertation to the committee
	Schedule date and time for defense
	Request ECE department for room
At final exam…….	Successful dissertation defense
2 weeks before graduation……	Submit electronic copy of dissertation to OhioLink

ECE PhD Candidacy Exam at a Glance



Frequently Asked Questions

1. I received my Masters degree from UD. Must I take more preliminary exam classes (PEC)?
    a. All students are required to complete 12 course credits hours at the PhD level prior to PE.
    b. Students who completed 4 PECs (or equivalent) during Masters at UD may apply for a PE waiver using PECs from their MS degree. The ECE Graduate Program Committee evaluates the waiver application. The GPA in the four PECs used in the waiver application must be 3.5 or greater for the waiver to be granted.

2. I received my Masters degree from another university. Must I take more preliminary exam classes (PEC)?
    a. All students are required to complete 12 course credits hours at the PhD level prior to PE.
    b. Students who completed 4 PECs (or equivalent) during Masters at another university may apply for a PE waiver using PECs from their MS degree. The waiver is granted if the student has a UD GPA of 3.5 or higher, and the combined GPA of four PECs (taken at UD or elsewhere) is 3.5 or higher.

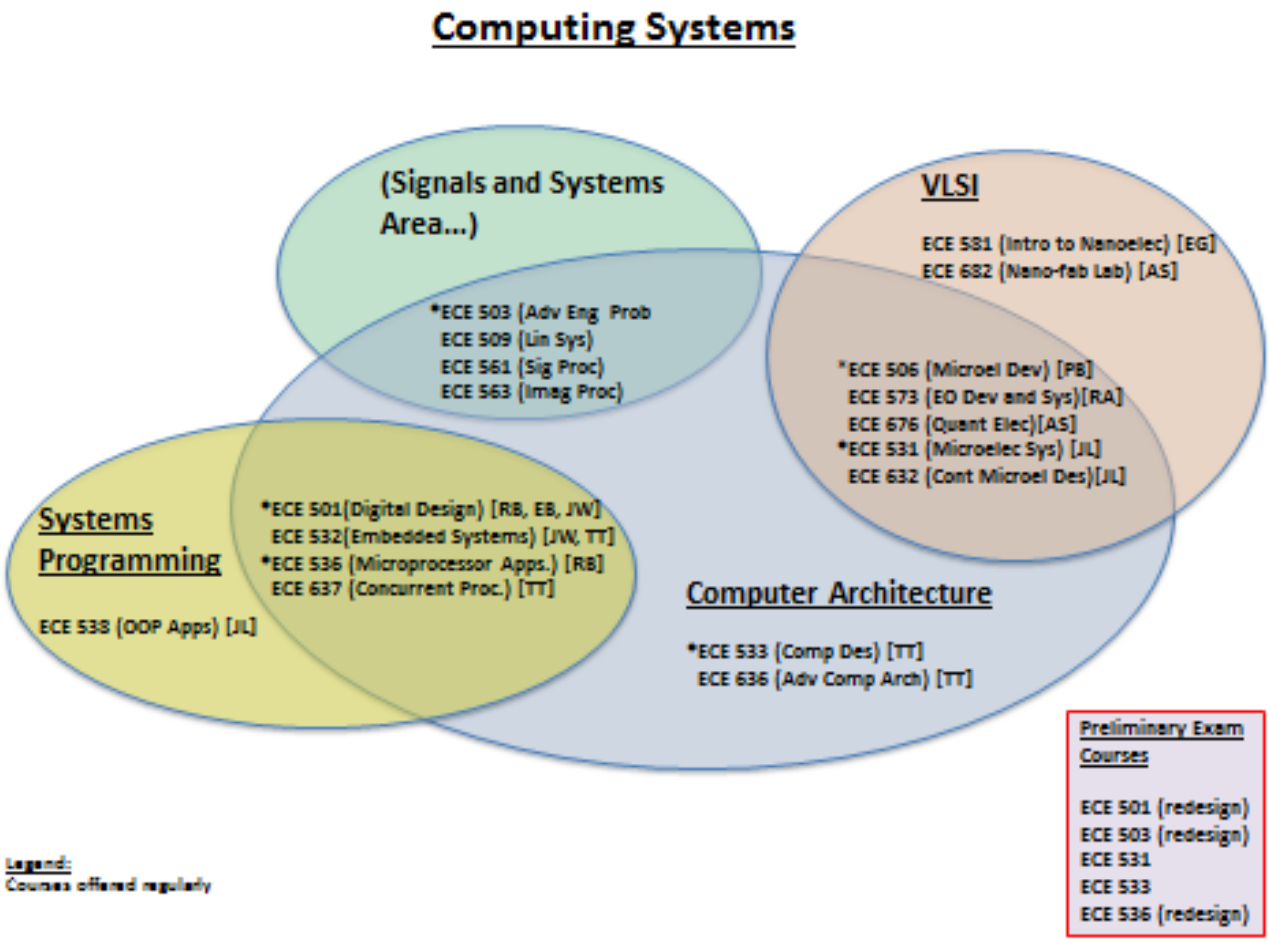
3. I successfully completed DPD. Can I take more classes?
    a. Students must prove that the course is critical for their research work.
    b. Approval by the student's DAC chair is required.

4. What will I need to do if I deviate from dissertation credit timeline?
    a. Students may take no more than 12 dissertation credits before QE.
    b. Students must complete at least 6 dissertation credits before DPD, and at least 12 dissertation credits after DPD.

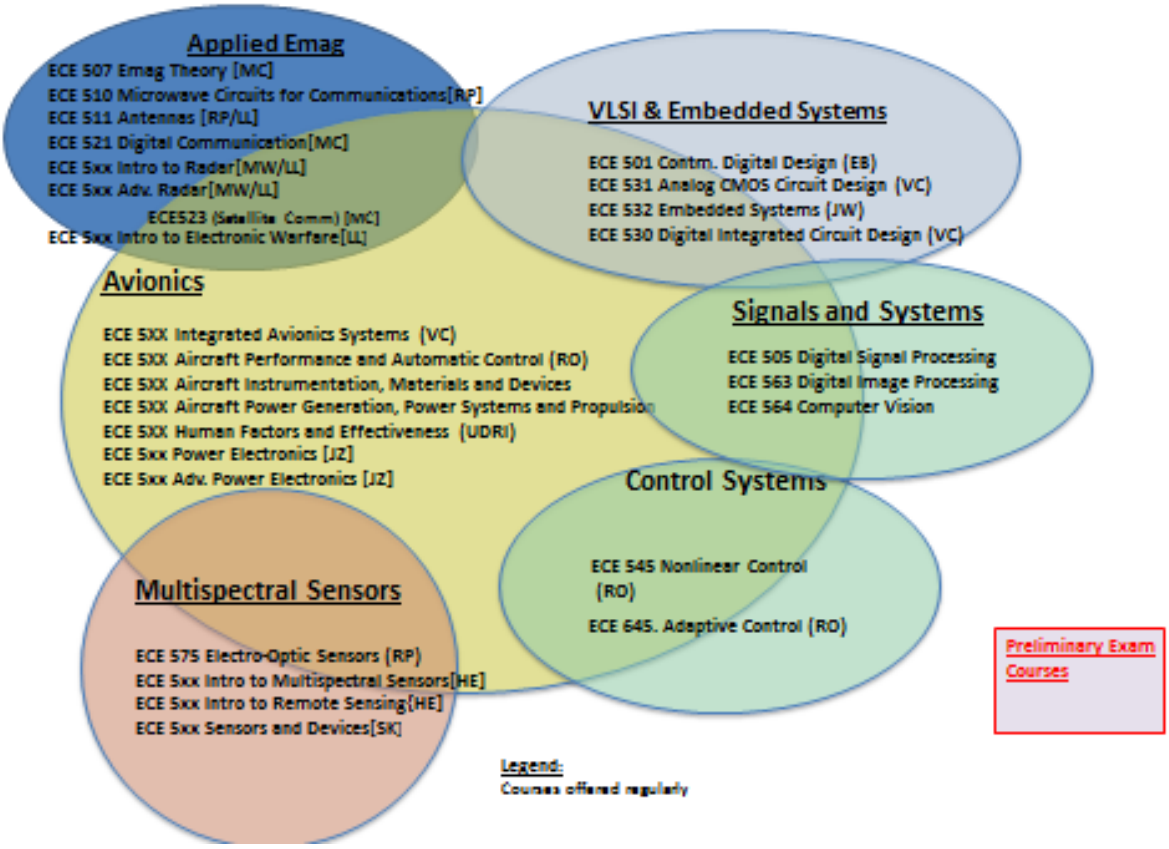
Official PhD policies are detailed in documents below:

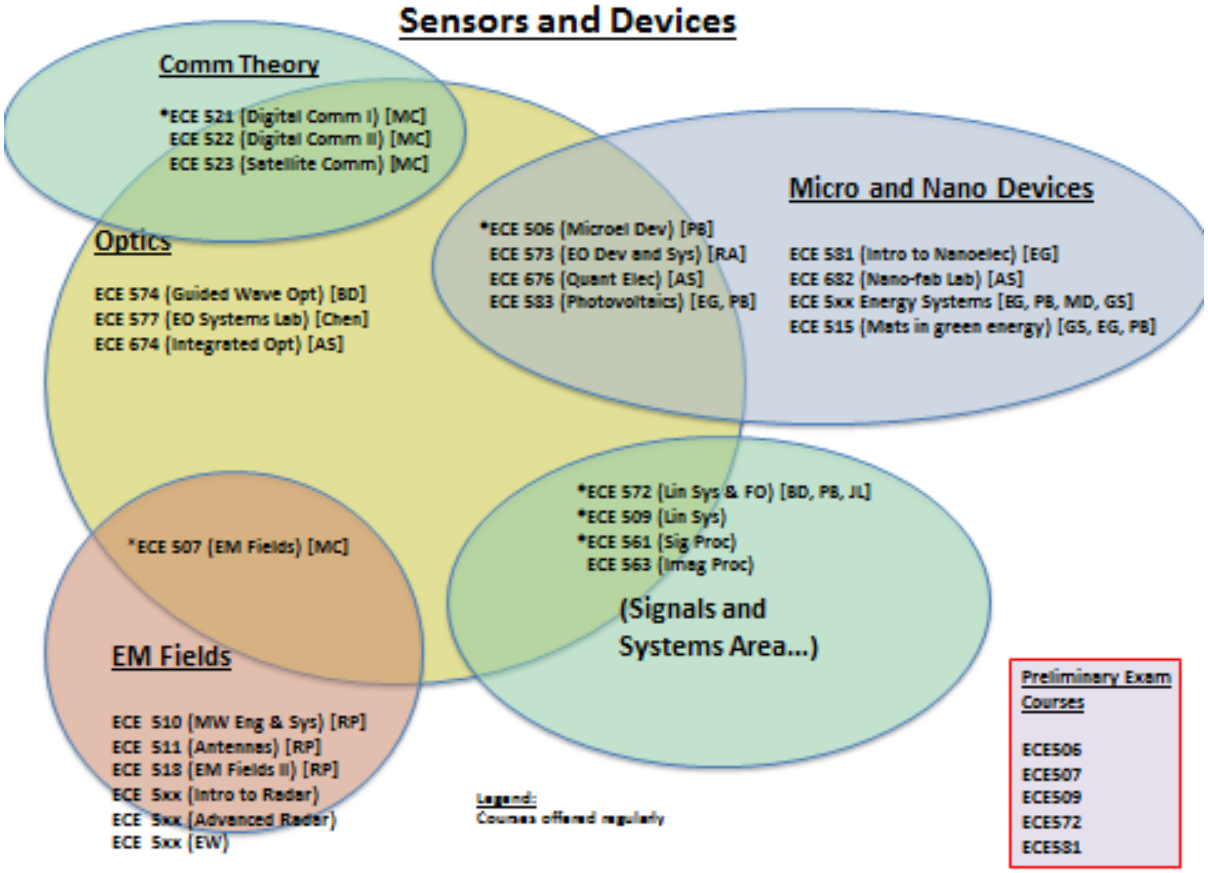
- ☐ **UD Bulletin**: http://bulletin.udayton.edu/content.ud?v=30&p=3474&c=3483
- ☐ **UD Thesis**: http://libguides.udayton.edu/content.php?pid=65891&sid=486730
- ☐ **ECE Bulletin**: http://www.udayton.edu/engineering/electrical_and_computer/grad_electrical/index.php

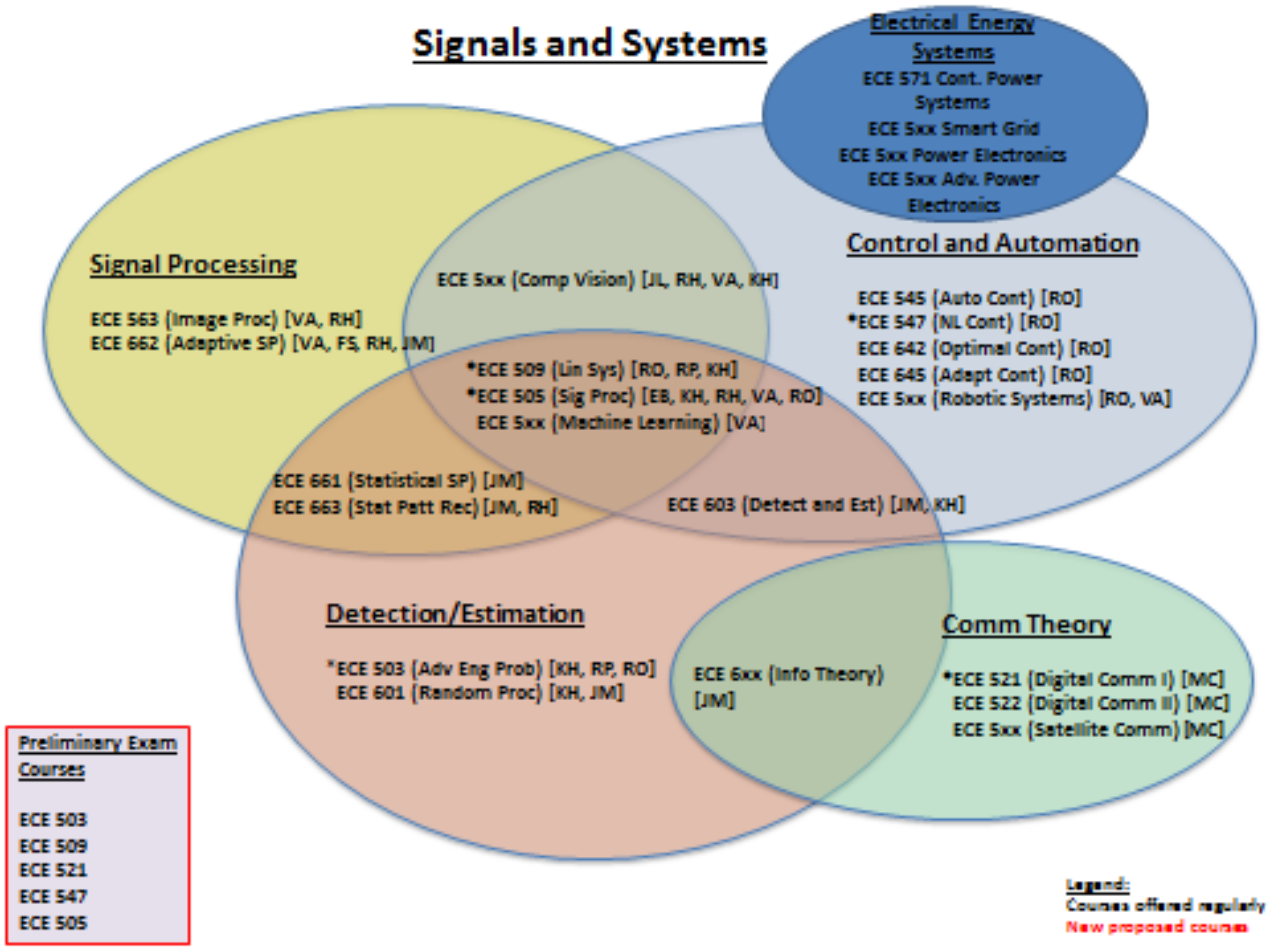
ECE GRADUATE AREAS AT A GLANCE



Aerospace Electronics Systems




Sensors and Devices
Comm Theory
*ECE 521 (Digital Comm I) [MC]
ECE 522 (Digital Comm II) [MC]
ECE 523 (Satellite Comm) [MC]
Optics
ECE 574 (Guided Wave Opt) [BD]
ECE 577 (EO Systems Lab) [Chen]
ECE 674 (Integrated Opt) [AS]
Micro and Nano Devices
*ECE 506 (Microel Dev) [PB]
ECE 573 (EO Dev and Sys) [RA]
ECE 676 (Quant Elec) [AS]
ECE 583 (Photovoltaics) [EG, PB]
ECE 581 (Intro to Nanoelec) [EG]
ECE 682 (Nano-fab Lab) [AS]
ECE 5xx Energy Systems [BG, PB, MD, GS]
ECE 515 (Mats in green energy) [GS, EG, PB]
*ECE 572 (Lin Sys & FO) [BD, PB, JL]
*ECE 509 (Lin Sys)
*ECE 561 (Sig Proc)
ECE 563 (Imag Proc)
(Signals and Systems Area...)
*ECE 507 (EM Fields) [MC]
EM Fields
ECE 510 (MW Eng & Sys) [RP]
ECE 511 (Antennas) [RP]
ECE 513 (EM Fields II) [RP]
ECE 5xx (Intro to Radar)
ECE 5xx (Advanced Radar)
ECE 5xx (EW)
Legend:
Courses offered regularly
Preliminary Exam Courses
ECE506
ECE507
ECE509
ECE572
ECE581



Preliminary Exam Courses

ECE 503
ECE 509
ECE 521
ECE 547
ECE 505

Legend:
Courses offered regularly
New proposed courses

These three charts give a "bird's eye" overview of the entire graduate curriculum in the ECE department. Their purpose is to help you, the student, understand the relationships between different areas of study, and also to help you choose your curriculum and define a well thought-out Plan of Study, in consultation with your MS or PhD advisor. By highlighting the relationship between different parts of the ECE graduate curriculum, these charts will also be helpful when your area of research is interdisciplinary in nature.

It is important to note that only the ECE curriculum is shown here, but you will want to keep in mind how your area of study can benefit from coursework in other departments, such as Mathematics and Computer Science. Use these charts to create a draft of your Plan of Study, then finalize it in consultation with your advisor.

For more information, please visit our webpage: http://engineering.udayton.edu/ece***, or contact: Guru Subramanyam, Chair, Department of Electrical and Computer Engineering, University of Dayton, Dayton OH 45469-0232. ph: (937) 229 3611; fax: (937) 229 4529. e-mail: gsubramanyam1@ udayton.edu***

Forms you may need are available at: http://www.udayton.edu/engineering/about/grad_resources.php

Contact Information for ECE Research Labs

- Center of Excellence in Computer Vision: Dr. Vijayan Asari, ORSP Endowed Chair in Wide Area Surveillance, vasari1@udayton.edu
- Center of Excellence in Distributed Sensing: Dr. Michael Wicks, ORSP Endowed Chair in Sensor Exploitation & Fusion, mwicks1@udayton.edu
- Embedded Data Processing Lab: Dr. Eric Balster, ebalster1@udayton.edu
- Motoman Robotics Lab: Dr. Raul Ordonez, rordonez1@udayton.edu
- Nonlinear Controls Lab: Dr. Raul Ordonez, rordonez1@udayton.edu
- Signal and Image Processing Lab: Dr. Russell Hardie, rhardie1@udayton.edu
- Intelligent Signals and Systems Lab: Dr. Keigo Hirakawa, khirakawa1@udayton.edu
- Center of Excellence for Thin film Research and Surface Engineering (CETRASE): Dr. Guru Subramanyam, gsubramanyam1@udayton.edu
- Electro-optics Graduate Program and Research: Dr. Partha Banerjee, pbanerjee1@udayton.edu
- Nanofabrication Lab: Dr. Andrew Sarangan, asarangan@gmail.com
- Nanophotonics Lab: Dr. Qiwen Zhan, qzhan1@udayton.edu
- Ladar and Optical Communication Institute (LOCI): Dr. Mikhail Vorontsov, ORSP Endowed Chair in Ladar, mvorontsov1@udayton.edu
- Center for High Performance Computing and Neuromorphic Computing: Dr. Tarek Taha, ttaha1@udayton.edu
- Institute for Development and Commercialization of Advanced Sensor Technologies (IDCAST): Mr. Michael O'Connor, Director, Michael.OConnor@udri.udayton.edu