

# ELECTRICAL AND COMPUTER ENGINEERING

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<http://engineering.wayne.edu/ece/>

In the field of electrical and computer engineering, basic physical and mathematical principles are utilized to develop new devices, technologies, and techniques of constantly broadening and rapidly changing applications. Examples include:

- Microcomputers, parallel processing systems, and embedded systems, and their utilization in a growing range of system applications
- Signal processing techniques in telemetry and communication networks
- Image processing techniques in industrial material diagnostics and medical imaging
- Information processing techniques for data analytics and machine learning
- Photonics and fiber optic devices for applications in optical data processing, sensing, and communication
- Sophisticated control techniques, transducers, and robotics for advanced automation and electric systems
- Energy conversion devices and power systems, including smart grid, electric vehicles, and alternative energy systems
- Micro and nano-fabricated smart sensors for biomedical and environmental applications
- Systems on chip for the internet of things, cyber physical systems, wearable and implantable medical devices
- Microelectronics and integrated smart systems for a wide variety of applications, including self-driving vehicles, wireless communications, consumer electronics, instrumentation, multimedia, future smart homes and smart cities

Part-time study in courses offered in the evening allows professionals working in local industry to pursue graduate degrees concurrently with their employment.

ARRATHOON, RAYMOND: Ph.D., Stanford University; M.S., California Institute of Technology; B.S., Cornell University; Professor Emeritus

AVRUTSKY, IVAN: Ph.D., M.S., B.S., Moscow Physical-Technical Institute, Russian Academy of Sciences; Associate Professor

BASU, AMAR: Ph.D., M.S.E, B.S., University of Michigan; Associate Professor

CHEN, PAI-YEN: Ph.D., University of Texas at Austin; M.S., B.S., National Chiao Tung University; Assistant Professor

CHENG, MARK MING-CHENG: Ph.D., B.S., National Tsing-Hua University; Associate Professor

ELNAGGAR, MOHAMMED I.: Ph.D., University of Manitoba; M.S. and B.S., Cairo University; Professor and Chair

ERLANDSON, ROBERT F.: Ph.D., Case Western Reserve University; B.S.E.E., Wayne State University; Professor Emeritus

HAN, XIAOYAN: Ph.D., Wayne State University; M.S., B.S., Nankai University; Professor

HASSOUN, MOHAMAD H.: Ph.D., M.S., B.S., Wayne State University; Professor

LIN, FENG: Ph.D., M.A.Sc., University of Toronto; B.Eng, Shanghai Jiao-Tong University; Professor

LIU, JOHN: Ph.D., University of Southern California; M.S., New Mexico State University; M.S., Peking Depart; B.S., Peking University; Associate Professor

MAHMUD, SYED M.: Ph.D., University of Washington; B.S.E.E., Bangladesh University of Engineering and Technology; Associate Professor

MEISEL, JEROME: Ph.D., B.S.E.E., Case Institute of Technology; M.S.E.E., Massachusetts Institute of Technology; Professor Emeritus

NAZRI, GHOLAM-ABBAS: Ph.D., Case Western Reserve University; Lecturer

NOKLEBY, MATTHEW: Ph.D., Rice University; M.S.E.E, B.S.E.E., Brigham Young University; Assistant Professor

PANDYA, ABHILASH: Ph.D., Wayne State University; M.S., B.S., University of Michigan; Associate Professor

SARHAN, NABIL J.: Ph.D., M.S., Pennsylvania State University; B.Sc. E.E., Jordan University of Science and Technology; Associate Professor

SHAW, MELVIN P.: Ph.D., M.S., Case Institute of Technology; B.S., Brooklyn College; Professor Emeritus

SINGH, HARPREET: Ph.D., M.E., University of Roorkee; B.Sc., Punjab University; Professor

SIY, PEPE: Ph.D., University of Akron; M.S.E.E., University of California; B.S.E.E., Mapua Institute of Technology; Professor Emeritus

WANG, CAISHENG: Ph.D., Montana State University; M.S., B.S., Chongqing University; Associate Professor

WANG, LE YI: Ph.D., McGill University; M.E., Shanghai Institute of Mechanical Engineering; Professor

WU, CHUNG-TSE: Ph.D., M.S., University of California, Los Angeles; B.S. National Taiwan University; Assistant Professor

XU, CHENG-ZHONG: Ph.D., University of Hong Kong; M.S., B.Sc., Nanjing University; Professor

XU, YONG: M.S., Ph.D., California Institute of Technology; B.Sc., Tsinghua University; Professor

YING, HAO: Ph.D., University of Alabama at Birmingham; M.S., B.S., Donghua University; Professor

ZHAO, YANG: Ph.D., Pennsylvania State University; M.S.E.E., Ohio State University; B.S., Zhejiang University; Professor

- Computer Engineering (M.S.) (<http://bulletins.wayne.edu/graduate/college-engineering/electrical-computer-engineering/computer-engineering-ms>)
- Electrical Engineering (M.S.) (<http://bulletins.wayne.edu/graduate/college-engineering/electrical-computer-engineering/electrical-engineering-ms>)
- Computer Engineering (Ph.D.) (<http://bulletins.wayne.edu/graduate/college-engineering/electrical-computer-engineering/computer-engineering-phd>)

- Electrical Engineering (Ph.D.) (<http://bulletins.wayne.edu/graduate/college-engineering/electrical-computer-engineering/electrical-engineering-phd>)

#### **ECE 5020 Matrix Computation I Cr. 4**

Background matrix algebra; linear system sensitivity; basic transformations; Gaussian elimination; symmetric systems; positive definite systems; Householder method for least squares problems; unsymmetric eigenvalue problems; the QR algorithm. Offered Yearly.

**Prerequisites:** 3 of CSC 2200 with a minimum grade of C, CSC 2201 with a minimum grade of C, MAT 2250 with a minimum grade of C- and 1 of ECE 3040 with a minimum grade of C-, BE 2550 with a minimum grade of C-

**Equivalent:** CSC 6620

#### **ECE 5100 Quantitative Physiology Cr. 4**

Basic principles of human physiology presented from the engineering perspective. Bodily functions, their regulation and control discussed in quantitative terms and illustrated by mathematical models where feasible. Offered Fall, Winter.

**Equivalent:** BME 5010, CHE 5100, ME 5100

#### **ECE 5280 Introduction to Cyber-Physical Systems Cr. 3**

Topics include: modeling, design, analysis, and implementation of cyber-physical systems; dynamic behavior modeling, state machine composition, and concurrent computation; sensors and actuators; embedded systems and networks; feedback control systems; temporal logic and model checking. Offered Fall, Winter.

**Prerequisites:** CSC 3100 with a minimum grade of C- and CSC 3110 with a minimum grade of C-

**Restriction(s):** Enrollment limited to students in the College of Engineering.

**Equivalent:** CSC 5280

#### **ECE 5330 Modeling and Control of Power Electronics and Electric Vehicle Powertrains Cr. 4**

Basic methodologies for modeling, control system design of renewable power sources and power electronics systems. Offered Fall.

**Restriction(s):** Enrollment is limited to Graduate or Undergraduate level students; enrollment limited to students in the College of Engineering.

**Equivalent:** AET 5330, EVE 5430

#### **ECE 5340 Advanced Energy Storage Systems for Electrification of Vehicles Cr. 4**

The objective of this course is to learn fundamentals of energy storage systems for electric-based transportation and to provide basic knowledge in the multidisciplinary field of energy storage devices and their applications for land, space and marine vehicles. The focus of the course will be on advanced batteries, supercapacitors, and fuel cells for transportation applications; battery sizing and integration to various land-marine-space vehicles; and the fundamentals of battery management systems including various methodologies in electrical control and thermal management modes. Offered Intermittently.

#### **ECE 5350 Alternative Energy Sources and Conversions Cr. 4**

Covers the fundamentals of alternative energy sources and conversion of these sources to electrical energy. The focus will be on solar and wind energy sources, covering design and operation of photovoltaic cells, solar thermal technologies, and design and operation of wind towers and wind farms. Other topics include: principle operations of geothermal energy, nuclear power plants, hydro-power, tidal and ocean waves and various methods of capturing and transforming these energy resources to electricity. Offered Intermittently.

#### **ECE 5410 Power Electronics and Control Cr. 4**

Control of electric energy using power electronic semiconductor devices; mathematical analysis of circuits containing these devices; design, modeling and control of power converters; applications of power electronic converters. Offered Spring/Summer.

**Prerequisites:** ECE 4330 with a minimum grade of C-

**Restriction(s):** Enrollment limited to students in the College of Engineering.

**Equivalent:** EVE 5410

#### **ECE 5425 Introduction to Robotic Systems Cr. 4**

Introduction to robot kinematics and control. Computational algorithms for robot movement, sensor fusion, and intelligent behavior, which are needed to build a system that performs actions and interacts with its environment. Offered Fall.

**Prerequisites:** BE 2550 with a minimum grade of C- or BE 1500 with a minimum grade of C- or BME 5020 with a minimum grade of C- or ECE 3040 with a minimum grade of C-

**Equivalent:** BME 5425

#### **ECE 5430 Electric Energy Systems Engineering Cr. 4**

Transmission capacity, load characteristics, power frequency control.

Energy system component analysis and modeling. Steady-state analysis, load-flow problem and algorithms, optimal dispatch. Transient stability by simulation and direct methods. Offered Intermittently.

**Prerequisites:** ECE 4330 with a minimum grade of C-

#### **ECE 5440 Computer-Controlled Systems Cr. 4**

Introduction to z-transform and sampling theory. Digital controller design using both transfer function techniques and state space methods.

Implementation aspects of computer-controlled systems. Offered Yearly.

**Prerequisites:** ECE 4470 with a minimum grade of C- or CHE 4600 with a minimum grade of C- or ME 5540 with a minimum grade of C-

#### **ECE 5460 Stochastic Processes in Engineering Cr. 4**

Elements of probability theory. Random variables. Random sequences. Convergence concepts, limit theorems and sampling. Gaussian processes and Brownian motion. Martingales and Markov Processes. Frequency-domain analysis. White noise representations. Sampling Theorem. Wiener Filtering. Recursive Filtering. Linear and nonlinear differential systems. Likelihood ratios and applications. Offered Every Other Year.

**Prerequisites:** 1 of ECE 4330, ME 5000 and IE 3220 with a minimum grade of C-

#### **ECE 5470 Control Systems II Cr. 4**

State space representation of systems; stability and Liapunov methods, controllability and observability, pole placement design using state feedback, observer design, optimal control, linear quadratic regulators, Kalman filter. Offered Yearly.

**Prerequisites:** ECE 4470 with a minimum grade of C-

#### **ECE 5550 Solid State Electronics Cr. 4**

Physical basis for the opto-electric properties of solids with particular emphasis on semiconductors. Basic principles associated with solid-state devices. Extrinsic and intrinsic semiconductors. Behavior of P-N junctions, bi-polar and field-effect transistors. PC-based simulation of device characteristics using the PC1D simulator. Offered Every Term.

**Prerequisites:** ECE 4570 with a minimum grade of C- and ECE 4800 with a minimum grade of C-

#### **ECE 5575 Introduction to Micro and Nano Electro Mechanical Systems (MEMS/NEMS) Cr. 4**

General and specialized micro/nanofabrication techniques; basic sensing and actuating mechanisms (piezoresistive, piezoelectric, capacitive, electrostatic, thermal pneumatic, etc.); and design and operation of various MEMS/NEMS devices for automotive and biomedical applications; fabrication and characterization of basic MEMS structures. Offered Winter.

**ECE 5610 Introduction to Parallel and Distributed Systems Cr. 4**

Fundamentals of parallels and distributed systems. Programming experience in both computing environments. Offered Yearly.

**ECE 5620 Embedded System Design Cr. 4**

Microcontroller architecture and its subsystems. Wired and wireless protocols for vehicular networking applications. Design and implementation of real-time embedded systems. Offered Every Term.

**Prerequisites:** ECE 4600 with a minimum grade of C-

**ECE 5650 Computer Networks and Programming Cr. 4**

Fundamentals of computer networks. TCP/IP and Internet protocols. Mobile and wireless networking. Network programming. Offered Every Term.

**Prerequisites:** ECE 4050 with a minimum grade of C-

**ECE 5680 Computer-Aided Logical Design and FPGAs Cr. 4**

Topics include: review of digital design; advanced applications of Boolean algebra techniques; Computer-Aided Logical Design for large Boolean functions and simplification; threshold function; linear sequential machines; design using Verilog and FPGAs; introduction to cadence. Offered Winter.

**Prerequisites:** ECE 4680 with a minimum grade of C-

**ECE 5690 Introduction to Digital Image Processing Cr. 4**

Provide college engineering seniors and first-year graduate students with introductory preparation in mathematical analysis, vectors, matrices, probability, statistics, sequences and series, and computer programming. Includes concepts of digital image processing from an operational perspective with good exposure to theory, accessibility of DIP to engineering, and a detailed review of current techniques. Offered Fall.

**Prerequisites:** BE 2100 with a minimum grade of C-, ECE 4050 with a minimum grade of C-, and ECE 4330 with a minimum grade of C-

**ECE 5700 Digital Communications Cr. 4**

Digital modulators and demodulators, M-ary PSK, M-ary FSK, optimal receiver for AWGN channel. correlator receiver, matched filter receiver, analysis of probability of bit errors for digital communication systems, Shannon limit, simulation of digital communication system. Offered Intermittently.

**Prerequisites:** ECE 4700 with a minimum grade of C-

**ECE 5770 Digital Signal Processing Cr. 4**

Analysis of discrete signals and systems. Applications to digital filtering, active filters, digital communication and encoding. Offered Yearly.

**Prerequisites:** ECE 4700 with a minimum grade of C-

**ECE 5870 Optical Communication Networks Cr. 4**

Laser and detectors; modulation and demodulation; optical transmitters and receivers; optical filters; optical amplifiers; architecture and network control; multi-access networks; FDDI networks, SONET/SDH, ATM, system performance. Offered Yearly.

**Prerequisites:** ECE 4700 with a minimum grade of C- and ECE 4850 with a minimum grade of C-

**ECE 5990 Directed Study Cr. 1-4**

Supervised study and instruction in the field selected by the student. Offered Every Term.

**Restriction(s):** Enrollment is limited to Graduate level students; enrollment is limited to students in the Department of Electrical & Computer Engineer.

**Repeatable for 4 Credits**

**ECE 5995 Special Topics in Electrical and Computer Engineering I Cr. 1-4**

Special subject matter in electrical and computer engineering. Topics to be announced in Schedule of Classes . Offered Every Term.

**Repeatable for 8 Credits**

**ECE 6180 Biomedical Instrumentation Cr. 4**

Engineering principles of physiological measurements, signal conditioning equipment, amplifiers, recorders and transducers. Recent advances in instrumentation. Offered Winter.

**Prerequisites:** BME 5020 with a minimum grade of C and ECE 3300 with a minimum grade of C or BME 5010 with a minimum grade of C or BMS 6550 with a minimum grade of C

**Equivalent:** BME 6480, ME 6180

**ECE 6570 Smart Sensor Technology I: Design Cr. 4**

Introduction to various types of sensors and the design of basic analog VLSI circuit building blocks. Offered Winter.

**Equivalent:** BME 6470, PHY 6570

**ECE 6660 Introduction to VLSI Systems Cr. 4**

Survey of very large scale integrated circuit components and design procedures. MOS fabrication, MOS gates, circuit architecture, device design, manufacturing and interface techniques. Offered Yearly.

**Prerequisite:** ECE 4680 with a minimum grade of C-

**Course Material Fees:** \$30

**ECE 6991 Industrial Internship Cr. 1-4**

Internship experience that satisfies the curricular practical training requirements. Offered for graduate credit only. Offered Every Term.

**Restriction(s):** Enrollment is limited to Graduate level students.

**Repeatable for 4 Credits**

**ECE 7030 Mathematical Methods in Engineering I Cr. 4**

Introduction to functional analysis. Banach and Hilbert spaces. Fixed-point and projection theorem techniques. Approximation, estimation, and optimization theory. Applications to numerical and error analysis, non-linear equations, and modeling system identification. Offered Yearly.

**Restriction(s):** Enrollment is limited to Graduate level students.

**ECE 7100 Mathematical Modeling in Impact Biomechanics Cr. 4**

Review of models created for impact simulations. Regional impact simulation models. Human and dummy models subject to various restraint systems. Offered Winter.

**Prerequisite:** BME 5010 with a minimum grade of B-

**Restriction(s):** Enrollment is limited to Graduate level students.

**Equivalent:** BME 7100, IE 7100, ME 7100

**ECE 7400 Medical Robotics and Systems Cr. 4**

Technology that interfaces computer engineering and electronics with surgery; introduction of key concepts in the field, including medical robotics, image-guided surgery, segmentation/3D modeling, medical simulation, and medical sensors. Offered Winter.

**Prerequisite:** ECE 5020 with a minimum grade of C

**Restriction(s):** Enrollment is limited to Graduate level students; enrollment limited to students in the College of Engineering.

**Equivalent:** BME 7400

**ECE 7420 Nonlinear Control Systems Cr. 4**

Provide examples of nonlinear dynamical control systems, perform system analysis using phase-portrait, and examine stability using Lyapunov's direct method and invariant set theorems (local and global stability). Introduce describing function method, feedback linearization technique, internal dynamics, and zero-dynamics. Design nonlinear robust controllers. Offered Fall.

**Prerequisite:** ME 6550 with a minimum grade of C or ECE 5470 with a minimum grade of C

**Restriction(s):** Enrollment is limited to Graduate level students; enrollment limited to students in the College of Engineering.

**Equivalent:** ME 7590

**ECE 7430 Control of Discrete Event Systems Cr. 4**

Automation model of discrete event systems; formal languages and regular expressions; supervisory control; controllability and observability; decentralized control and co-observability; timed discrete event systems; performance analysis; applications to manufacturing systems and power systems. Offered Every Other Year.

**Prerequisite:** ECE 5440 with a minimum grade of C or ECE 5470 with a minimum grade of C or ME 5550 with a minimum grade of C

**Restriction(s):** Enrollment is limited to Graduate level students.

**ECE 7440 Dynamic Systems and Optimal Control Cr. 4**

Formulation of optimal control problems. Pontryagin's maximum principle and necessary conditions for optimality, with applications. Dynamic programming; Hamilton-Jacobi equation; optimal feedback control. Offered Intermittently.

**Prerequisite:** ECE 5440 with a minimum grade of C or ECE 5470 with a minimum grade of C or ME 5550 with a minimum grade of C

**Restriction(s):** Enrollment is limited to Graduate level students.

**ECE 7530 Advanced Digital VLSI Design Cr. 4**

Topics include: review of VLSI Design processes; CADENCE tools used to simulate and generate the schematic and layout of the synthesized hardware description language codes; and chip fabrication. Offered Winter.

**Prerequisite:** ECE 5680 with a minimum grade of C and ECE 6660 with a minimum grade of C

**Restriction(s):** Enrollment is limited to Graduate level students.

**ECE 7570 Smart Sensor Technology II: Characterization and Fabrication Cr. 4**

Integration of ongoing research in integrated technology of smart sensors. Design of smart sensor devices using computer simulation. Fabrication of smart sensor. Offered Spring/Summer.

**Prerequisite:** ECE 6570 with a minimum grade of B- or BME 6470 with a minimum grade of B- or PHY 6570 with a minimum grade of B-

**Restriction(s):** Enrollment is limited to Graduate level students.

**Course Material Fees:** \$50

**Equivalent:** BME 7470, PHY 7580

**ECE 7590 Biomedical Microsystems Cr. 4**

Biomedical microsystems, with a focus on microfluidics and lab-on-a-chip technologies for medical diagnostics and biological research. Broad coverage of microscale physics; microfabrication methods; separation, purification, and other on-chip processes; biosensing. Offered Fall.

**Prerequisite:** ECE 5575 with a minimum grade of C or ECE 6570 with a minimum grade of C or BME 6470 with a minimum grade of C

**Restriction(s):** Enrollment is limited to Graduate level students.

**Equivalent:** BME 7490, CHE 7490

**ECE 7610 Advanced Parallel and Distributed Systems Cr. 4**

Advanced topics in parallel and distributed computing, multicore and parallel architecture, communication, synchronization, parallel algorithms and programming, load balancing and scheduling, security. Offered Winter.

**Prerequisite:** ECE 5610 or ECE 5650

**Restriction(s):** Enrollment is limited to Graduate level students.

**ECE 7650 Scalable and Secure Internet Services and Architecture Cr. 4**

Advanced principles of distributed and cloud computing systems, the Internet, Internet server and data center, content delivery networks, performance scalability, energy-aware resource management, security and privacy, cost-effective engineering design. Offered Winter.

**Prerequisite:** ECE 5610 with a minimum grade of C and ECE 5650 with a minimum grade of C

**Restriction(s):** Enrollment is limited to Graduate level students.

**ECE 7660 Parallel Computer Architecture Cr. 4**

Review of parallel computer architectures, including symmetric multiprocessors and scalable machines. Parallel software basics for various architectures. Fundamental issues including cache coherence, interconnection network, and synchronization; influence of these on performance of applications. Offered Yearly.

**Prerequisite:** ECE 5610 with a minimum grade of C and ECE 5620 with a minimum grade of C

**Restriction(s):** Enrollment is limited to Graduate level students.

**ECE 7680 Advanced Digital Image Processing and Applications Cr. 4**

Advanced aspects, algorithms, methods in digital image processing and their corresponding applications in different fields. Students develop comprehensive skills and knowledge in digital image processing. Offered Yearly.

**Prerequisite:** ECE 5690 with a minimum grade of C

**Restriction(s):** Enrollment is limited to Graduate level students.

**ECE 7690 Fuzzy Systems Cr. 4**

From basic fuzzy set theory to advanced topics such as neuro-fuzzy systems. Offered Yearly.

**Restriction(s):** Enrollment is limited to Graduate level students.

**ECE 7700 Statistical Communication Theory Cr. 4**

Decision theory, binary decisions with single and multiple observations, signals in additive Gaussian noise, sequential decision theory, estimation theory, Kalman filtering. Offered Yearly.

**Prerequisite:** ECE 5700 with a minimum grade of C

**Restriction(s):** Enrollment is limited to Graduate level students.

**ECE 7730 Telematics Cr. 4**

Introduction to automotive telematics, mobile communication channels, error correction, automatic crash response, vehicle diagnostics, vehicle tracking, vehicle safety, navigation, and current topics in telematics. Offered Winter.

**Prerequisites:** ECE 5700 with a minimum grade of C

**Restriction(s):** Enrollment is limited to Graduate level students.

**ECE 7740 Medical Imaging Systems Cr. 3**

Exposes students to the world of medical and biomedical imaging with emphasis on principles, approaches and applications of each modern imaging modality. Basic knowledge of MATLAB programming language is required. Offered Fall.

**Restriction(s):** Enrollment is limited to Graduate level students.

**Equivalent:** BME 7730

**ECE 7850 Fiber and Integrated Optics Cr. 4**

Discussion of geometric optics and ray propagation in optical fibers. Extension to physical optics and Maxwell's equations. Analysis of mode coupling and graded index fibers. Integrated optical waveguides: dielectric slabs and integrated optic networks. Coupling phenomenon, light sources, and detectors. Photon statistics and their relation to bit error rates. Power budgets, fan-in, and fan-out as applied to data link design. Offered Yearly.

**Prerequisite:** ECE 5870 with a minimum grade of C

**Restriction(s):** Enrollment is limited to Graduate level students.

**ECE 7860 Operation and Control of Modern Power Systems Cr. 4**

Topics include power system optimal dispatch; power system stability analysis and control; smart grid technologies and applications, covering modeling and control of renewable energy systems; distributed generation; microgrid architecture and control; demand response; energy storage for power grids; grid interface and integration of renewable sources; and electricity market fundamentals. Offered Fall.

**Prerequisite:** ECE 5430 with a minimum grade of C

**Restriction(s):** Enrollment is limited to Graduate level students.

**ECE 7990 Directed Study Cr. 1-8**

Supervised study and instruction in an advanced topic. Offered Every Term.

**Restriction(s):** Enrollment is limited to Graduate level students.

**Repeatable for 12 Credits**

**ECE 7995 Special Topics in Electrical and Computer Engineering II Cr. 1-4**

A consideration of special subject matter in electrical and computer engineering. Topics to be announced in Schedule of Classes . Offered Every Term.

**Restriction(s):** Enrollment is limited to Graduate level students.

**Repeatable for 12 Credits**

**ECE 7996 Research Cr. 1-8**

Design, investigation and experimental work on some phase of electrical and computer engineering. Written report required. Offered Every Term.

**Restriction(s):** Enrollment is limited to Graduate level students.

**Repeatable for 8 Credits**

**ECE 8999 Master's Thesis Research and Direction Cr. 1-8**

Offered Every Term.

**Restriction(s):** Enrollment is limited to Graduate level students; enrollment limited to students with a class of Candidate Masters.

**Repeatable for 8 Credits**

**ECE 9990 Pre-Doctoral Candidacy Research Cr. 1-8**

Research in preparation for doctoral dissertation. Offered Every Term.

**Restriction(s):** Enrollment is limited to Graduate level students.

**Repeatable for 12 Credits**

**ECE 9991 Doctoral Candidate Status I: Dissertation Research and Direction Cr. 7.5**

Offered Every Term.

**Restriction(s):** Enrollment is limited to Graduate level students.

**ECE 9992 Doctoral Candidate Status II: Dissertation Research and Direction Cr. 7.5**

Offered Every Term.

**Prerequisite:** ECE 9991 with a minimum grade of S

**Restriction(s):** Enrollment is limited to Graduate level students.

**ECE 9993 Doctoral Candidate Status III: Dissertation Research and Direction Cr. 7.5**

Offered Every Term.

**Prerequisite:** ECE 9992 with a minimum grade of S

**Restriction(s):** Enrollment is limited to Graduate level students.

**ECE 9994 Doctoral Candidate Status IV: Dissertation Research and Direction Cr. 7.5**

Offered Every Term.

**Prerequisite:** ECE 9993 with a minimum grade of S

**Restriction(s):** Enrollment is limited to Graduate level students.

**ECE 9995 Candidate Maintenance Status: Doctoral Dissertation Research and Direction Cr. 0**

Offered Every Term.

**Restriction(s):** Enrollment is limited to Graduate level students.

**Repeatable for 0 Credits**

**ECE 9997 Doctoral Seminar Cr. 1-4**

Offered Every Term.

**Restriction(s):** Enrollment is limited to Graduate level students.

**Repeatable for 4 Credits**