

Graduate Guidelines

Department of Electrical and Computer Engineering

University of Florida
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I. Graduate Faculty and Research Areas

Communications

Peyton Z. Peebles, Jr.

Ph.D., University of Pennsylvania, 1967. Radar, communication systems theory.

John M. Shea

Ph.D., Clemson University, 1998. Wireless communications, adaptive modulation and coding, multicast signaling, multimedia transmission over wireless channels, channel-quality estimation, spread spectrum communications.

Tan F. Wong

Ph.D., Purdue University, 1997. Wireless communications, spread spectrum systems, multiuser communications, adaptive signal processing.

Liuqing Yang

Ph.D., University of Minnesota, 2004. Ultra-Wideband (UWB) wireless communications, networking, and signal processing.

Computer Systems and Networks

P. Oscar Boykin

Ph.D., University of California-Los Angeles, 2002. Nanocomputing, quantum computing, quantum communication, quantum cryptography, neural coding, peer-to-peer networking. large scale networks.

Yuguang (Michael) Fang

Ph.D., Boston University, 1997. Wireless networks and mobile communications; personal communication services (PCS).

Renato Figueiredo

Ph.D., Purdue University, 2001. High-performance computer architecture, distributed network computing.

Jose A. B. Fortes

BellSouth Eminent Scholar Chair; Ph.D., University of Southern California, 1983. Network computing, advanced computing architecture, biologically inspired nanocomputing, distributed information processing systems.

Jian-Bo Gao

Ph.D., University of California Los Angeles, 2000. Telecommunications and network, traffic engineering, Quality of Service (QoS), internet dynamics, routing instability, modeling of non-Gaussian noise in wireless communications, nonlinear time series analysis using chaos and fractal theory, bioinformatics, biomedical engineering.

Alan George

Ph.D., Florida State University, 1991. High-performance computer networks, architectures, systems, algorithms, and services for applications in parallel, distributed, and fault-tolerant computing.

Tao Li

Ph.D, University of Texas at Austin, 2004. Computer and digital system architecture, interaction of computer architecture, operating systems, programming language features and managed run-time environments, parallel computing and shared memory microprocessors, boards/systems prototyping and HW/SW integration.

Janise McNair

Ph.D., Georgia Institute of Technology, 2000. Wireless and mobile networking, next generation wireless systems.

Dapeng Wu

Ph.D, Carnegie Mellon University, 2003. Wireless communications, video coding, multimedia communication, computer and communications networks, information and network security, pervasive and mobile computing, information and communication theory, signal processing, detection and estimation theory.

Device and Physical Electronics**Gijs Bosman**

Ph.D., University of Utrecht (Netherlands), 1981. Electronic noise research, quantum devices

Jerry G. Fossum

Ph.D., University of Arizona, 1971. Semiconductor device theory, modeling, simulation; integrated devices and circuits, SOI CMOS ICs, IC technology CAD

Jing Guo

Ph.D., Purdue University, 2004. Computational nanotechnology, nanoelectronics, nano-electo-mechanical systems, biological electronics and systems.

Sheng S. Li

Ph.D., Rice University, 1968. Quantum well infrared photo detectors, IR imaging arrays, CIGS solar cells, SOI materials and devices, defects and radiation effects in semiconductors, photonic and quantum effect devices.

Arnost Neugroschel

Ph.D., Technion (Israel), 1973. Semiconductor device physics, device technology and characterization.

Toshikazu Nishida

Ph.D., University of Illinois, 1988. Semiconductor sensors and devices.

Chih-Tang Sah

Graduate Research Professor and Pittman Eminent Scholar Chair, Ph.D., Stanford, 1956.
Semiconductor electronics, semiconductor device reliability, solid state physics.

Scott Thompson

Ph.D., University of Florida, 1992. Solid state electronics and nanotechnology, new materials and devices to extend Moore's Law, electrical measurements and modeling of strained Si, Ge, GaN semiconductors.

Ant Ural

Ph.D., Stanford University, 2001. Carbon nanotubes, semiconductor nanowires, integration of nanotechnology with silicon microfabrication processes, molecular electronics, nanoscale MEMS, and nanobiotechnology.

Huikai Xie

Ph.D., Carnegie Mellon University 2002. MEMS/NEMS, microelectronics, electro-optics, inertial sensors, microfabrication, analog circuit design.

Digital Signal Processing**John G. Harris**

Ph.D., California Institute of Technology, 1991. Analog and digital signal processing, VLSI, adaptive and neural systems.

Jian Li

Ph.D., Ohio State University, 1991. Signal processing for wireless communications and radar.

Jose C. Principe

Ph.D., University of Florida, 1979. Adaptive non-Gaussian signal processing, nonlinear dynamical systems, information-theoretic learning, applications to pattern recognition and DSP systems, information technology in education.

K. Clint Slatton

Ph.D., University of Texas at Austin, 2001. Remote sensing, multiscale estimation, data fusion, statistical signal processing, lidar and radar applications.

Fred J. Taylor

Ph.D., University of Colorado, 1969. Digital signal processing, digital computer design and architecture.

Electric Energy Systems**Alexander Domijan**

Ph.D., University of Texas-Arlington, 1986. Flexible reliable intelligent electric energy delivery systems, instrumentation, power electronics, power quality, energy efficiency studies, custom power, motor drives.

Khai D. T. Ngo

Ph.D., California Institute of Technology, 1984. Power, power electronics, applied magnetics, power integrated circuits.

Muhammad H. Rashid

Director of the UF/UWF Joint Program in Electrical Engineering. Ph.D., Birmingham U.K., 1976. Power electronics, motor drives, industrial electronics, electrical machines, power engineering.

Electromagnetics**Vladimir A. Rakov**

Ph.D., Tomsk Polytechnic (Russia), 1983. Lightning, atmospheric electricity, lightning protection.

Martin A. Uman

Ph.D., Princeton University, 1961. Lightning, atmospheric electricity, electromagnetics.

Electronic Circuits**Rizwan Bashirullah**

Ph.D., North Carolina State University, 2004. Microelectronics, VLSI design, bio-microsystems, and analog/mixed-mode integrated circuits.

William R. Eisenstadt

Ph.D., Stanford, 1986. Microwave integrated circuits, IC packages, interconnect, VLSI, high-frequency measurements, mixed-mode s-parameters.

Robert M. Fox

Associate Chairman; Ph.D., Auburn, 1986. Analog electronic circuit design.

Mark E. Law

Department Chairman; Ph.D., Stanford, 1988. Design and modeling of IC fabrication process, computer modeling of semiconductor process and device behavior, numerical solution of partial differential equations.

Jenshan Lin

Ph.D., University of California- Los Angeles, 1994. Microwave/millimeter-wave electronics and wireless communication circuits, high speed electronics and broadband communication circuits.

Kenneth K. O

Ph.D., Massachusetts Institute of Technology, 1989. Electronic circuit devices and technology, microwave integrated circuits and technology, silicon device integrated circuits and technology for wireless communication.

Intelligent and Information Systems

A. Antonio Arroyo

Ph.D., University of Florida, 1981. Machine intelligence, artificial intelligence, microprocessors, microcomputers, expert systems, human-machine interaction, computer software and hardware systems, pattern recognition, digital signal/natural language and speech processing.

Herman Lam

Ph.D., University of Florida, 1979. Computer engineering, database management, computer architecture.

Michael C. Nechyba

Ph.D., Carnegie Mellon University, 1998. Human-centered robotics, robot control, machine learning, neural networks, hidden Markov models.

Stanley Y. W. Su

Ph.D., University of Washington, 1968. Database management, parallel architecture, data/knowledge based computers, computer-integrated engineering and manufacturing, semantic modeling, object-oriented systems.

Photonics

Ramu V. Ramaswamy

Ph.D., Northwestern University, 1969. Passive and active guided wave optics, opto-electronics.

Ramakant Srivastava

Ph.D., Indiana University, 1973. Integrated optics, waveguide sensors.

Henry Zmuda

Ph.D., Cornell University, 1984. Optical processing of microwave signals, microwave system and component design, photonics.

Peter S. Zory

Ph.D., Carnegie Mellon University, 1964. Semiconductor laser physics and technology.

Systems and Control

Jacob Hammer

Graduate Coordinator and Director of Graduate Programs; D. Sci, Israel Institute of Technology, 1980. Mathematical system theory, control systems.

Haniph A. Latchman

D. Phil., Oxford, 1986. Mathematical systems theory, control systems, communication theory, data communication networks, multimedia information systems.

II. Introduction

The graduate program of the Department of Electrical and Computer Engineering at the University of Florida offers the Master of Engineering (M.E.), Master of Science (M.S.), Engineer, and Doctor of Philosophy (Ph.D.) degrees. The Graduate Guidelines details the policies and regulations governing these programs and should be used in conjunction with the University of Florida Graduate Catalog. It is the responsibility of the student to be familiar with both publications and to adhere to the stated rules.

Degree Requirements

For the Master's degree, a minimum total of 30 semester hours is required. For the Engineer's degree, at least 30 hours of credit beyond the Master's degree are needed. The Ph.D. degree requires the accumulation of at least 90 hours of credit beyond the bachelor's degree (excluding all credit hours from an Engineer's degree). Doctoral students may transfer up to 30 semester hours credit from a Master's degree program in Electrical and Computer Engineering taken at another qualified institution.

To graduate from any of the above mentioned degree programs, an overall and EEL cumulative GPA of at least 3.0 is required; refer to section IX for more details.

An off-campus student who is a candidate for an Electrical Engineering degree must take at least half the coursework from full-time University of Florida faculty members. Students can presently meet this requirement by attending lectures on campus, at the Eglin Graduate Center, or using video taped lectures.

No graduate credit is allowed for Electrical and Computer Engineering courses below the 5000 level. Graduate students may take additional undergraduate courses, but credits earned in these courses is not counted toward the minimum degree requirements. A summary of the pertinent degree requirements is shown in the following table. For detailed requirements, see the appropriate sections that follow.

Requirements	ME (Thesis)	ME (Non-thesis)	MS (Thesis)	MS (Non-thesis)	Engineer	Ph.D.
Total Hours	30	30	30	30	30 ^a	90 ^b
Course hours of EE type	18*	21*	18*	21*	50%	24**
Minimum 6000 & 7000 level credits ^j	-	-	-	-	50%	50%
Minimum EEL credits	18*	21*	18*	21*	50%	50%
Minimum number of areas	2	3	2	3	1	3
Supervisory committee members (min. number)	3	1	3	1	3 ^c	4 ^c
Qualifying Exam	None	None	None	None	None ^d	e
Final Exam	Oral ^g	None	Oral ^g	Written ^f	Oral ^g	Oral ^h
Time limit for completing degree	7 years	7 years	7 years	7 years	5 years	5 ⁱ

a. Beyond Master's b. May include 30 hours from Master's program c. Includes one member outside the EE Department d. Must have Master's Degree e. Written part within first year of entry f. Exam covers 1 area g. On Thesis and Coursework h. On Dissertation i. 5 years from admission to candidacy j. UF courses unless waived	* Excludes: EEL 5905 EEL 6905 EEL 6910 EEL 6932 EEL 6940 EEL 6971	** Excludes: EEL 5905 EEL 6905 EEL 6910 EEL 6932 EEL 6940 EEL 6971 EEL 7979 EEL 7980

Articulation Requirements

All degree-track students accepted into the graduate program who do not have an equivalent U.S. bachelor's degree in Electrical and Computer Engineering are required to take articulation courses. The articulation requirement is determined on an individual basis by the Graduate Committee. In most cases, the articulation requirement consists of one course selected from each of the four categories listed below, and exemptions are given for equivalent undergraduate courses taken at other institutions. If the student earns less than a B in an articulation course, the student must petition the Graduate Committee to continue in the graduate program.

CATEGORY I - Circuits	Credits
EEL 3111C Circuits 1 with lab	4 hrs
EEL 3112 Circuits 2 plus EEL 3303L Circuits Lab	4 hrs
EEL 3304C Electronic Circuits with lab	4 hrs
CATEGORY II - Signals	
EEL 3135 Signals and Systems	3 hrs
CATEGORY III - Computer	
EEL 3701C Digital Logic and Computer Systems	4 hrs
EEL 4744C Microprocessor Applications	4 hrs
CATEGORY IV - Breadth	
EEL 3211 Basic Electric Energy Systems	3 hrs
EEL 3396 Solid-State Electronic Devices	3 hrs
EEL 3472 Electromagnetic Fields and Applications	3 hrs
EEL 4514 Communication Systems and Components	3 hrs
EEL 4657 Linear Control Systems	3 hrs
EEL 3211 Basic Electric Energy Systems	3 hrs
EEL 3396 Solid-State Electronic Devices	3 hrs
EEL 3472 Electromagnetic Fields and Applications	3 hrs

The articulation requirements are usually satisfied by taking the required courses and laboratories, and earning a grade of B or better in each. The courses and grades will be listed on the student's transcript. These grades will be included in the overall GPA, but not in the graduate course GPA. The credit hours of the articulation courses are not counted toward the credit hours required for the degree. For courses (not laboratories) that have written final exams, the articulation requirements can be satisfied by auditing the courses and scoring a B or better on the final exams, with the exam grades reported in writing by the instructors to the Student Services Office. Part or all of these articulation requirements can also be satisfied by using equivalent courses taken for previous degrees (as determined by the Graduate Coordinator and the Graduate Committee). If possible, the articulation requirements should be satisfied by the end of the first semester, and they must be completed by the end of the second semester.

III. Master's Degree

The Department of Electrical and Computer Engineering offers both thesis and non-thesis options for the Master's degree. A student seeking the Master's degree with a thesis option is required to pass an oral final examination, while the non-thesis Master of Science student is required to pass a written final examination. The non-thesis Master of Engineering has no final exam.

The Master of Engineering (M.E.) degree is awarded only to students with a B.S. in engineering, or to students who have completed appropriate articulation courses. The Master of Science (M.S.) degree is awarded to students with an undergraduate degree in any appropriate area of science or engineering.

All work counted for the Master's degree must be completed during the seven years immediately preceding the date on which the degree is to be awarded.

Admission Procedures

The minimum admission requirements of the Department of Electrical and Computer Engineering for the Master's degree are an undergraduate upper division grade point average of at least 3.0 on a 4.0 scale, a GRE verbal plus quantitative score of at least 1200, a GRE analytical writing score of at least 3.5 and where applicable, a TOEFL score of no less than 550. For the old format of the GRE, a quantitative plus analytical core of at least 1200 is required. Three letters of recommendation (by professors who taught the student) are also required. Meeting these minimum requirements does not guarantee admission. Minimum requirements are subject to change; check with the Student Services Office when applying.

Before applications may be processed, test scores and all college transcripts (undergraduate and graduate) must be forwarded to the Office of the Registrar at the University of Florida as well as to the Student Services Office of the department.

Please visit the Student Services Office to discuss a plan of study before your first registration.

ADMISSION CHECKLIST

- * Obtain all application materials from the Department of Electrical and Computer Engineering or through the ECE homepage, www.ece.ufl.edu.
- * Take the Graduate Record Examination (GRE) and indicate that the results are to be sent to the University of Florida Office of the Registrar. Where applicable, also have TOEFL scores forwarded. Unofficial copies are not acceptable.
- * Complete the application and return it with a \$30 check or money order to the Office of the Registrar. Make checks payable to the University of Florida. Applications will not be processed without payment of the \$30 application fee.
- * Forward all college transcripts (graduate and undergraduate) to the Registrar's Office with copies to Student Services Office.
- * Have three letters of recommendation sent to the Student Services Office, Department of Electrical and Computer Engineering. The recommendation letters should be written by professors of a university where the student has studied.

IV. Master's Degree — Thesis Option

Course Requirements

For the thesis option Master's degree, the student must complete at least 30 semester credit hours, which include a maximum of six semester hours and a minimum of three semester hours of EEL 6971 (Research for Master's Thesis). Thesis students must be registered for three credits of thesis research (EEL 6971) in the term of graduation (fall and spring, and 2 credits summer). The course requirements include a minimum of 18 hours of Electrical and Computer Engineering courses: 5905, 6905, 6910, 6932, 6940, and 6971 are not coursework for the purpose of these requirements. Two breadth areas are required. One breadth area can be a minor in a different department related to the ECE degree.

Up to 18 hours of Special Topics (i.e., EEL 5934, EEL 6935, and EEL 7936) may be applied toward the degree. Up to six hours each of Individual Work (EEL 6905/5905) may be applied toward the degree.

Students holding graduate research assistantships may register for EEL 6910 (Supervised Research) and those holding graduate teaching assistantships may register for EEL 6940 (Supervised Teaching) with the advisor's approval. The number of credits in EEL 6910 and in EEL 6940 is limited to five each, and none of these credits can be counted toward degree requirements.

A course with a final grade of C and above cannot be repeated for credit. In case a student receives a grade lower than a C for a course, s/he may retake the course and an average GPA will be used for compiling GPA graduation requirements.

Appointment of Supervisory Committee

The supervisory committee is the group of faculty members that supervises and approves the student's graduate program. The supervisory committee should be selected as soon as possible but no later than the end of the second semester. After the committee has been determined, the student should get a Supervisory Committee Form from the ECE Student Services Office and have the professors sign the form indicating their willingness to serve on the committee. The Graduate School may deny degrees to any persons who have failed to comply with this regulation at the proper time. The committee's function is to guide the student through her/his thesis research and to administer the final examination. The thesis option Master's degree committee must consist of at least three graduate faculty members (including the chairperson). The chairperson must be a faculty member in Electrical and Computer Engineering. The chairperson is usually the student's academic advisor and should advise the student in the selection of other members.

Submission of Master's Thesis

Students may submit their thesis either on paper or electronically. (Students admitted Fall 2001 and after are required to submit electronically.) If paper submission, Graduate School guidelines can be found in the Graduate School Editorial Office, 106 Grinter Hall. If electronic submission, refer to <http://gradschool.rgp.ufl.edu/etd/>. Refer to the "Deadline Dates" published each semester by the

Graduate School and also available from the Student Services Office.

Final submission of a paper thesis requires two bond copies and one plain copy. Students will submit the original (bond) copy of their thesis to the Editorial Office, along with the Signature Page and Final Exam form signed by the supervisory committee and the Dean of the College of Engineering. One bond copy will be given to the Dean's Office and the plain paper copy to the Student Services Office. The Editorial Office will be responsible for getting the signature of the Graduate School Dean.

Electronic submission requires a signed EDT Submission Approval Form, Final Exam form, and one plain paper copy to the Student Services Office.

Final Examination Procedures

Within six months prior to graduation, the supervisory committee will give the student an oral examination on the thesis, on major and minor subjects, and on matters pertaining to any specific field of study.

Each student is responsible for applying for her/his degree by the published deadline for the semester of graduation. The Degree Application form is available from the Registrar's Office, on-line, or through the Student Services Office. If a student fails to apply by the specified deadline, s/he will not receive the degree that semester.

It is imperative that copies of the student's thesis be given to the supervisory committee at least one week in advance of the final examination. Graduation may be delayed for those who do not adhere to this rule. When submitting your final copies of the thesis (two bond copies, one plain paper copy) be sure to deliver a copy with the signed signature page to the Student Services Office. The Student Services Office will not validate the Final Exam Report until this final copy is received.

Checklist for THESIS Master's Degree

First Semester

- * If appropriate, transfer up to 9 credit hours from graduate courses taken previously to your UF master's program.

Second Semester

- * Appoint supervisory committee. This committee must be appointed by the end of the second semester.

Semester Prior to Graduation

- * Check with Student Services Office to see if all graduation requirements, including appropriate course hour credit, will be satisfied.
- * If you have any D, I or E grades, discuss your option for meeting graduation requirements.

Semester of Graduation

- * Submit degree application to Student Services Office or Registrar's Office prior to deadline.
- * Comply with Graduate School thesis and final examination "Deadline Dates."
- * Be registered for at least the minimum number of thesis hours (3 hours in the fall and spring semesters and 2 hours in the summer).
- * Schedule the Thesis Defense with the supervisory committee. Inform the Student Services Office of plans to take the examination, and reserve a conference room. The Student Services Office will send the announcement of exam and prepare the Final Exam Report.
- * At least one week in advance of the final examination, give the supervisory committee members a copy of the thesis.
- * On the day of examination, report to Student Services Office to pick up necessary forms.
- * Have the Final Examination Report and the original signature page signed by the supervisory committee members. Return the Final Examination Report to the Student Services Office.
- * Submit final thesis, as required, to the department, the College Dean, and Graduate School.

V. Master's Degree — Non-thesis Option

The requirements for the non-thesis master's degree are the same as for the thesis master's degree except for the following:

1. No thesis is required and no EEL 6971 credit is allowed.
2. Master of Science non-thesis students must pass a final written examination. Master of Engineering non-thesis students **do not** have to pass a final written examination.
3. At least 21 hours of Electrical and Computer Engineering course work must be taken. 5905, 6905, 6910, 6932, and 6940 are not counted for this 21 hour requirement.
4. Requires 30 credits, all which must be letter graded courses. S/U grades will not be counted toward degree requirements
5. Complete at least one ECE breadth sequence **in each** of three of the following areas: Communications, Computer Systems & Networks, Device & Physical Electronics, Digital Signal Processing, Electric Energy Systems, Electromagnetics, Electronic Circuits, Intelligent and Information Systems, Photonics, and Systems & Controls. Exception: One breadth area can be satisfied by a minor in another department related to ECE.
6. Only one ECE faculty member needs to be appointed to a non-thesis Master's supervisory committee.

Final Examination Procedures (Master of Science Only. Master of Engineering has no Final Exam)

The non-thesis written examination, also called the Comprehensive Examination, is offered as part of the second course of each breadth sequence. If the course has a final exam, then a 15 minute question about the first course of the sequence will be added to the exam for students that intend to satisfy the MS exam requirements. If the course has only projects, an item related to the first course of the sequence will be added to one of the projects for students that intend to satisfy the MS exam requirements. The combined grade of the exam or project and the extra question will serve as the MS exam grade. Students are required to pass one of these exams or projects for the Master of Science degree (the exam is not required for the Master of Engineering degree). The final results of the examinations are determined by the Graduate Committee. In case of failure, the exam can be re-taken the next time it is offered.

Students must register at the Student Services Office in order to take the MS degree examination. Sign up sheets will be posted six weeks in advance of the next scheduled examination.

Passing the Ph.D. Written Qualifying Examination counts as passing the MS degree examinations as well. Note that only students admitted to the Ph.D. program are allowed to take the Ph.D. Written Qualifying Exam.

Checklist for NON-THESIS Master's Degree

First Semester

- * If appropriate, transfer up to 9 credit hours from graduate courses taken previously to your UF master's program.

Second Semester

- * Appoint supervisory committee (only one EE professor required). This committee must be appointed by the end of the second semester.
- * Take master's exam this semester. By the application deadline, apply for the exam at the Student Services Office and indicate your selected area.

Semester Prior to Graduation

- * Check with the Student Services Office to see if all graduation requirements, including appropriate course hour credits, will be satisfied.
- * If you have any D, I or E grades, discuss your options for meeting graduation requirements.
- * If you have not passed the master's exam, take it this semester. By the application deadline, apply for the exam at the Student Services Office and indicate your selected area.

Semester of Graduation

- * If you have not passed the master's exam, take it this semester. By the application deadline, apply for the exam at the Student Services Office and indicate your selected area.
- * Submit degree application to Student Services Office or Registrar's Office prior to deadline.

VI. Juris Doctor/Master of Science in ECE

The faculties of the College of Law and of the Department of Electrical and Computer Engineering of the College of Engineering have approved a joint degree program culminating in two degrees: a Juris Doctor degree, awarded by the College of Law; and a Master of Science of Electrical and Computer Engineering, awarded by the College of Engineering.

Under the joint degree program, a student can obtain both degrees in approximately two semesters less than it would take to obtain both degrees if pursued consecutively.

Essential criteria related to the joint degree program are as follows:

Candidates for the program must meet the entrance requirements and be accepted by both colleges. Both colleges must be informed by the student at the time of application that s/he intends to pursue the joint degree program.

The joint degree program is not open to students who have already earned one of the two degrees.

Admission to the second program is required no later than the end of the fourth consecutive semester after beginning one degree of the joint degree program. A summer term is counted as half a single semester.

A student must satisfy the curriculum requirements for each degree before either degree is awarded. The graduate division of the College of Engineering will allow 12 credits of appropriate law courses to be credited toward both M.S. and J.D. degrees. These 12 credits must be approved by the Associate Dean for Graduate Studies upon the recommendation of the student's graduate supervisory committee. Students who have participated in the BS/MS program of Electrical and Computer Engineering can count only (15-n) credit hours of Law courses toward their M.S. degree; here n is the number of credit hours double counted as part of the BS/MS program. Reciprocally, Law students may receive toward the satisfaction of the J.D. degree not more than 12 semester credits of courses taken in the graduate curriculum of Electrical and Computer Engineering in the College of Engineering. Two of these courses, not more than a total of 6 semester credits, will be treated as the two graduate courses ordinarily allowed to be taken outside of the College of Law for credit toward Law School graduation. Students must carry the minimum number of credits required by either college.

ECE courses which are to be credited toward the J.D. degree must carry a grade of B or higher and will not be counted in the College of Law grade point average. College of Law courses which are to be credited toward the M.S. degree must carry a grade of C or higher and will not be counted in the grade point average in the College of Engineering.

Students enrolled in the joint degree program must complete the College of Law's advanced writing requirement. An approved master's thesis in Electrical and Computer Engineering will satisfy the advanced writing requirement of the College of Law if so certified by a Law school faculty member. Non-thesis students must still satisfy the College of Law's writing requirement.

A student enrolled in the joint degree program will not receive either degree until s/he has satisfied all of the requirements for both degrees, or until s/he has satisfied the requirements of one of the degrees as if s/he had not been a joint degree candidate.

Students who enroll in the joint degree program but do not complete the program may receive credit toward the College of Law degree under the graduate level course option for a maximum of two courses, not to exceed 6 semester credits, taken from the graduate curriculum of the Electrical and Computer Engineering Department of the College of Engineering. Although the grade is not computed in the student's grade point average, a grade of B or higher must be earned to receive credit hours for the course(s). Students who enroll in the joint degree program but do not complete the program may receive credit toward the Master of Science in ECE, not to exceed 6 semester credits, taken from the graduate curriculum of the College of Law. Although the grade is not computed in the student's GPA, a grade of C or higher must be earned to receive credit hours for the course(s).

Students in the joint program will be eligible for the graduate teaching assistantships and research assistantships in the Electrical and Computer Engineering Department on the same basis as other graduate students, subject to the guidelines and restrictions set by the ECE department.

To facilitate student progress in the joint program, it is proposed that to the fullest extent possible given the availability and consent of appropriate law faculty, the student's graduate supervisory committee be comprised of two ECE graduate faculty members and one Law faculty member.

VII. Joint Master's Degree Program — College of Business Administration and College of Engineering

Approved for the fall 2002 semester, the joint program will permit a graduate student to earn both a Master of Science degree in Electrical and Computer Engineering and a Master's degree from the Department of Management in the Warrington College of Business.

If accepted for graduate study by both departments, a student can earn two Master's degrees and share 12 credits. Six graduate credits from the ECE degree can be shared with the Management degree, and six credits from the Management degree can be shared with the ECE master's degree. Contact each department for the current minimum admission requirements. This program is not open to BS/MS student due to Graduate School rules; however a concurrent degree (share of six credits only) is possible for BS/MS students.

VIII. Engineer's Degree

This degree requires a thesis and a minimum of 30 semester credit hours taken in technical work beyond a Master's degree in Engineering. This includes a maximum of 12 semester credit hours of thesis research (EEL 6972). At least 50 percent of the course credit hours taken for the Engineer's degree must be 6000 level courses and at least 50 percent of the course credit hours must be Electrical and Computer Engineering courses.* 5905, 6905, 6910, 6932, 6940, and 6972 are not counted for purposes of this 50% / 50% requirement.

The Supervisory Committee should be appointed as soon as possible after the student has been admitted to the Graduate School but no later than after the completion of 12 semester hours of course work. The Supervisory Committee consists of at least two members selected from the Department of Electrical and Computer Engineering and at least one from a supporting department. In addition, every effort should be made to have a representative from industry as an external advisor for the student's program.

The Engineer's degree is a terminal degree and is not to be considered as a partial requirement toward the Ph.D. degree. The student's objective after the Master's degree should be either the Ph.D. or the Engineer's degree. All work counted for the Engineer's degree must be completed during the five years immediately preceding the date on which the degree is to be awarded.

IX. Doctor of Philosophy Degree

Higher standards are applied for admission into the Ph.D. program. Some evidence of research capability is expected as measured by strong letters of recommendation as well as grades and GRE scores well above the minimum requirements of the M.S. program.

Minimum Admission Requirements *

To be admitted for study toward a Ph.D. degree in the Department of Electrical and Computer Engineering the following requirements must be satisfied by students who have a master's degree from the ECE Department at the University of Florida:

1. GPA of at least 3.5 in the Master's program.
2. GRE verbal plus quantitative of at least 1200, and a minimal analytical writing score of 3.5. (For the old format of the GRE, a quantitative plus analytical of at least 1200.)
3. TOEFL (for international students) of at least 550.
4. Three letters of recommendation for the Ph.D. program from ECE faculty members. The recommendations must be strong and at least one faculty member must agree to serve as the student's supervisory committee chair.

For applicants who do not have a Master's degree from the University of Florida Department of Electrical and Computer Engineering, the minimum requirements are:

1. Undergraduate work and graduate work (if taken) equivalent to a 3.5 GPA on a 4.0 scale.
2. GRE verbal plus quantitative of at least 1200, and a minimal analytical writing score of 3.5. (For the old format of the GRE, a quantitative plus analytical of at least 1200.)
3. TOEFL (for international students) of at least 550.
4. At least three strong letters of recommendation for the Ph.D. program from respected professors.
5. Upon acceptance into the Ph.D. program, students must form a supervisory committee by the end of their second semester, or by the end of the semester in which they will have accumulated 12 semester credits, whichever comes **later**.

All college transcripts must be forwarded to the Office of the Registrar at the University of Florida, with copies to the Student Services Office. Admission materials may be obtained from the Student Services Office in Electrical and Computer Engineering. Three letters of recommendation should be forwarded to the Student Services Office. Students who have received a Master's degree from UF must submit three new letters supporting their application for admission into the Ph.D. program, but are not required to submit another application to the Registrar's Office.

* Minimum requirements are subject to change; check with the Student Services Office when applying.

Course Requirements and Period of Concentrated Study

For the Ph.D. degree, at least 90 semester hours of credit are required beyond the bachelor's degree. These hours include master's degree work taken at the University of Florida or, if appropriate, up to 30 hours of master's degree work in Electrical and Computer Engineering earned at another approved university. The hours accumulated for the Ph.D. degree have the following restrictions:

1. At least 24 hours of 5000, 6000, or 7000 level Electrical Engineering courses are required; 5905, 6905, 6910, 6932, 6940, 6971, 7979 and 7980 are not considered coursework for the purpose of this 24 hour requirement. EEL courses taken in a master's program at UF are included and, upon approval of a petition to the ECE Graduate Committee, courses taken at other schools may be included.
2. All EEL 7980 (Research for Doctoral Dissertation) hours are counted. The student may not enroll for EEL 7980 until s/he has been admitted to candidacy; if the qualifying exam is taken before midpoint of the term, the Graduate School will change the student's EEL 7979 to EEL 7980. This midpoint of the term is determined by the Graduate School and is published in its "Deadline Dates."
3. Fifty percent of the hours accumulated have to be at the 6000 or 7000 level (including 7980).
4. Fifty percent of all hours accumulated have to be in Electrical and Computer Engineering at the 5000, 6000 or 7000 level (including EEL 7980).
5. Completion of the hours stated in the breadth requirement.

Candidates for the doctoral degree must satisfy the minimum requirements for a period of concentrated study, beyond the first 30 semester hours counted toward the doctoral program. Students must complete 30 hours in residence at the University of Florida campus or at the Graduate Engineering and Research Center (courses at the 1000 or 2000 level will not be counted toward the requirement for concentrated study).

Appointment of Supervisory Committee

The student's supervisory committee is the group of faculty members that supervise and approve qualifications for the Ph.D. degree. The Ph.D. Supervisory Committee should be appointed as soon as possible, but no later than the end of the second semester or the Graduate School may put a hold on the student's record. The Ph.D. Supervisory Committee consists of four or more members, of which at least two are from the Electrical and Computer Engineering Graduate Faculty of UF. The chairman must have GF status in the Department of Electrical and Computer Engineering and one member has to be in a discipline outside of the department.

After the committee has been determined, the student should get a Supervisory Committee Form

from the Student Services Office and have the professors sign the form indicating that they are willing to serve on her/his committee.

Annual Evaluation for Ph.D. Students

The Supervisory Committee Chair, in consultation with the other committee members, will give each Ph.D. student a yearly written evaluation. The student is given an opportunity to discuss the evaluation with her/his Supervisory Committee Chair. Copies of this evaluation and of student comments are placed in the student's academic file.

Ph.D. Course Breadth Requirement

All potential Ph.D. candidates are required to take two one-year EEL course sequences outside of their major area and receive a grade of B or better in each course. The sequences will be selected from two different areas that are not in your main research area. The ten possible areas are: Communications, Computer Systems and Networks, Device & Physical Electronics, Digital Signal Processing, Electric Energy Systems, Electromagnetics, Electronic Circuits, Intelligent and Information Systems, Photonics, and Systems & Controls. The allowed sequences for each area are indicated on the breadth area section at the back of this guide. A total of 12 credits are required. Courses taken at the master's level may be counted if they are in the allowed sequences as shown in the breadth areas.

The student and her/his advisor decide on the appropriate breadth sequences. The student must pass the approved breadth requirement before the oral part of the Ph.D. Qualifying Exam can be taken.

Leave of Absence Policy

A doctoral student who will not be registered at the University of Florida for a period of more than one semester needs to request written permission from her/his faculty advisor for a leave of absence for a designated period of time. A copy of the written permission memo must be taken to the Student Services Office and placed in the student's file.

Official Minor (Optional)

With the pre-approval of the supervisory committee, a student may choose one official minor field (12 graduate credit hours minimum) and substitute it for one Ph.D. breadth area of ECE. Minor work may be completed in any department, other than ECE, that is approved for master's or doctoral degree programs as listed in the *University of Florida Graduate Catalog* and supports a program that is related to the student's Ph.D. research area.

If an official minor is chosen, a representative of the minor department, who may or may not be on the supervisory committee, shall designate at least one 6 hour graduate course sequence in the minor field for written examination. The written part of the qualifying examination in the minor field will be held during the same time period and have the same format as the written part of the ECE Ph.D. Qualifying Examination. It is the student's responsibility to schedule the exam with the professor in the minor department. The student must pass this exam in order for the minor to be valid. Please consult the *University of Florida Graduate Catalog* for additional official minor requirements.

Written Part of the Ph.D. Qualifying Examination

The Ph.D. Written Qualifying Examination is a test reviewing fundamental material that students are expected to have covered before joining the Ph.D. program. The questions are taken from the following eight areas of Electrical and Computer Engineering.

- **Digital Logic**
- **Signals and Systems**
- **Electronic Circuits**
- **Solid State Devices**
- **Electromagnetism and Energy Systems**
- **Microprocessor Applications**
- **Computer Organization and Architecture**
- **Data Structures and Operating Systems**

Each student selects three areas before the examination and receives two questions in each one of the selected areas. Answers must be given to four of the six questions, including at least one question from each one of the three areas. The examination tests problem solving skills, fundamental understanding, reasoning ability, and written communication skills. The test will last for two hours. No materials are allowed during the examination (the department provides scientific calculators for use during the test).

The Written Qualifying Examination is offered only once a year (in the month of January), on the first Saturday after the start of Spring classes. Students must sign up for their selected areas in the Student Services Office by the end of the proceeding month in November. Detailed study guides will be available in the fall semester.

Students must take the Ph.D. Written Qualifying Examination during their first year in the Ph.D. program. Financial support may be contingent on taking the exam. Upon failure, the Written Qualifying Examination can be retaken the next time it is offered. If more than two attempts are required, students may petition the Graduate Committee for permission to retake the exam. A successful petition normally includes a letter of support from the proposed Ph.D. Advisor.

Students with a minor in another department have to arrange for a written qualifying exam in their minor to satisfy the Graduate School requirements. The exam must be administered by the student's minor supervisor.

Oral Part of the Ph.D.

The oral part of the Ph.D. qualifying examination is usually taken within one year after the satisfactory completion of the written portion of the Ph.D. qualifying examination. The oral part of the Ph.D. qualifying exam consists of:

- Student presents her/his written research proposal.
- Student answers to questions asked by her/his supervisory committee and others present.

The Student Services Office must be notified at least two weeks in advance of the oral qualifying examination so the Announcement of Examination can be mailed, and the Admission to Candidacy / Ph.D. Qualifying examination form can be prepared. These forms should be taken to the qualifying examination by the student, signed by the supervisory committee and returned to the Student Services Office for processing.

If the student fails the oral Ph.D. qualifying exam, s/he may retake it only once and it must be retaken within two semesters.

If a student fails the qualifying examination, the Graduate School will be notified. A re-examination may be requested, but it must be recommended by the student's supervisory committee and approved by the Graduate School. At least one semester of additional preparation is considered essential before re-examination.

Between the date of completion of the qualifying examination and the date of the degree, there must be a minimum of two semesters if the candidate is in full-time residence or a calendar year if the candidate is in attendance on less than a full-time basis. The semester in which the qualifying examination is completed is counted provided that the exam is completed before the midpoint of the term. No more than five years may pass between the completion of the qualifying examination and the conferring of the degree.

The Ph.D. student becomes a candidate for the Ph.D. degree when the following requirements are satisfied:

1. The student's academic record is satisfactory.
2. The breadth requirement is completed.
3. The Supervisory Committee certifies that the student has made satisfactory progress to be admitted to candidacy.
4. The student has a dissertation topic approved by her/his Supervisory committee.
5. The student has passed the oral and written parts of the Ph.D. qualifying exam.
6. The Admission to Candidacy form has the required formal approvals.

The Department of Electrical and Computer Engineering requires that the student be admitted to candidacy as soon as the above listed criteria have been met, but not later than **three years** after passing the written part of the qualifying exam.

Ph.D. Final Examination and Submission of Doctoral Dissertation

Within six months of graduation and after the submission of the dissertation and completion of all other prescribed work for the degree, the doctoral candidate will be given a final examination by her/his supervisory committee. The Ph.D. Final Exam consists of an oral defense of the research results that are described in the doctoral dissertation.

Students may submit their dissertation either on paper or electronically. (Students admitted Fall 2001 and after are required to submit electronically.) If paper submission is used, graduate school guidelines can be found in the Graduate School Editorial Office, 106 Grinter Hall. If electronic submission is used, refer to <http://gradschool.rgp.ufl.edu/edt/>. For first dissertation submission instructions refer to the “Deadline Dates” published each semester by the Graduate School, and also available from the Student Services Office.

Final submission of a paper dissertation requires two bond copies and one plain copy. Students will submit the original (bond) copy of their dissertation to the Editorial Office, along with the Signature Page and Final Exam form signed by the supervisory committee and the Dean of the College of Engineering. One bond copy will be given to the Dean’s Office, and the plain paper copy to the Student Services Office. The Editorial Office will be responsible for getting the signature of the Graduate School Dean.

Electronic submission requires a signed ETD Submission Approval Form, Final Exam Form and one plain paper copy to the Student Services Office.

The Student Services Office should be informed of the examination as soon as it is scheduled, in order to process the Final Examination Report and send out notices.

Copies of the student’s dissertation must be given to the supervisory committee members at least two weeks in advanced of the final examination. Graduation may be delayed for those who do not adhere to this rule.

At the time of the defense, all committee members should sign the signature pages in the dissertation and sign the Final Examination Report which is to be returned to the Student Services Office. Students will submit the original copy of their dissertation signed by the supervisory committee and a letter of transmittal. The student’s advisor is responsible for preparing the letter of transmittal.

All work for the Ph.D. degree must be completed within five calendar years after the completion of the Ph.D. qualifying exam.

Checklist for Ph.D. Degree

Second Semester

- * Appoint Supervisory Committee. This committee must be appointed by the end of the second semester.

- * If appropriate, petition to the Graduate Committee to have non-UF Master's coursework (30 hours maximum) transferred onto the doctoral record.

Ph.D. Qualifying Exam

- * Take the written part of the exam within first year of entry into the Ph.D. program.,

- * Complete all breadth requirements before the oral part of the Ph.D. qualifying exam.

- * Arrange with the Supervisory Committee the details of your written research proposal that is to be defended in the oral exam.

- * If possible, take the oral part of the Ph.D. qualifying exam within one year of the written part. You **MUST** take the oral exam within three years after the written part.

- * At least two weeks in advance of the oral exam, notify, in writing the Student Services Office of plans to complete the qualifying exam.

- * Pass oral exam.

Semester Prior to Graduation

- * Check with Student Services Office to see that all graduation requirements, including appropriate course hour credit, will be satisfied.

- * If you have any D, E or I grades, discuss your options for meeting graduation requirements.

Semester of Graduation

- * Complete the Application for Degree form at the Registrar's Office or in the Student Services Office.

- * Must be registered for at least the minimum number of dissertation hours, EEL 7980 (3 hours in the fall and spring semesters and 2 hours in the summer).

- * Comply with Graduate School dissertation and final examination "Deadline Dates."

- * Schedule final exam with Supervisory Committee. Inform Student Services Office, in writing, of your examination plans, the conference room number and the title so that the Announcement of Examination may be sent, and the Final Examination Report may be prepared.

- * At least two weeks in advance of the final, give your Supervisory Committee members a copy of your dissertation.
- * On the day of final examination, report to the Student Services Office to pick up necessary forms.
- * Have the Final Examination Report and the original signature page of your dissertation signed by the supervisory committee members. Return the Final Examination Form to the Student Services Office.
- * Submit the signed, original copy of the dissertation to the Editorial Office of the Graduate School. If paper submission, the Department of Electrical and Computer Engineering, and the College Dean, must have a final signed copy of the dissertation. If dissertation is submitted electronically, only the department needs a paper copy.

X. Administrative Procedures

Graduate Bulletin Boards

At least once a week, check the Department of Electrical and Computer Engineering Graduate Bulletin Boards for announcements, changes in course offerings or room schedules, notice of examinations, and for other matters of interest to ECE graduate students. These bulletin boards are located near the Student Services Office, 230 Larsen Hall.

Graduate Registration

Students can register for course work online at www.isis.ufl.edu. A guide to the registration system is also online.

The Student Services Office is available for help with registration and for registration to departmentally controlled courses.

Graduate students must register for an appropriate course load as indicated in the table below. Audited courses do not count as part of the hourly requirements for full time students or those on assistantships.

Graduate students may **not**, in general, take any courses under the S/U option except for certain graduate courses that have only S/U grading (as specified in the Graduate Catalog). Students who complete all graduate degree requirements during a given semester, but after the deadlines specified by the Graduate School, may receive their degree in the following semester without registering. However, students whose degree requirements are not completed before the first day of classes of the following semester must register for a minimum of three credit hours, which will apply to the degree. **The Graduate School will not accept petitions to this policy.** The 3-hour registration is only applicable if the student is not on an assistantship.

Enrollment Requirements for Students on Appointment

	Minimum Credit Registration	Maximum Credit Registration
Fellows and Trainees	12	18
1/4 Time Assistants	9	15
1/3 Time Assistants	9	15
1/2 Time Assistants	9	15
3/4 Time Assistants	6	9
Full-Time Assistants	3	3

GPA and Probation Policy

In compliance with Graduate School rules, graduate students must maintain a GPA of 3.00 or higher in order to be in good standing. Students cannot graduate if their GPA is below 3.00.

Please note that the term “GPA” includes three different numbers, all of which need to satisfy the requirement of 3.00 or higher.

- * The grade point average of *all* courses (graduate and undergraduate at the 3000 level and above) taken while classified as a graduate student;
- * The grade point average of *all ECE graduate level* courses taken while a graduate student;
- * The grade point average of all graduate level courses that are part of a minor.

An academic hold will be placed on the records of all students whose GPA is below 3.00, thus placing the student on academic probation. These students will be able to register for courses only through the Student Services Office. This will enable our office to provide advice and guidance on an individualized basis.

Students with a GPA below 3.00 must show progress each semester towards improving their GPA, even if it takes more than one semester to reach a GPA of 3.00 or higher.

Students with a GPA below 3.00 and who do not raise their GPA the following semester will be dismissed from the program.

Transfer of Credits

Up to 9 credit hours of graduate level technical courses passed with a grade of B or better may be transferred from another institution. Students may also petition to transfer graduate level courses which were taken while enrolled as an undergraduate, postbaccalaureate, or non-degree seeking student, if proof is provided indicating that courses were not used to satisfy degree requirements for another degree. Normally, no more than 15 credits may be transferred into the student’s graduate program. Credits obtained in non-degree programs, e.g. continuing education, may not be transferred. Credits transferred will be applied toward meeting the degree requirements, but the grades earned will not be computed in the student’s grade point average.

Application for transfer of credits earned **before** admission to a UF graduate program must be filed during the first semester. Permission to transfer an additional 12 hours of graduate courses may be granted under the **Traveling Scholar** program. Participation in the Traveling Scholar program requires advance approval prior to taking the courses. Approved courses are then transferred under the standard procedure as outlined below.

Application for transfer of credits earned **after** admission to a UF graduate program must be filed with the Graduate School as soon as possible but before the last day of classes preceding the term in which the degree is to be conferred. The student must provide a complete description of the graduate course in consideration for transfer and a transcript indicating the grade earned. The approval of the Graduate Coordinator and the Dean of the Graduate School are required for the acceptance of transfer credits.

Financial Aid

Applications for teaching assistantships, research assistantships and fellowships are available from the Department of Electrical and Computer Engineering. Fellowships are highly competitive and generally require completed applications by February each year. Recipients of teaching assistantships are selected by the Associate Chairman of the department, in conjunction with the Graduate Coordinator. Research assistantships are awarded by individual faculty members with funding from governmental or industrial sources and are generally awarded only to those students who have been in residence at least one semester.

Minimum stipends and assigned duties for teaching assistants are determined by the Graduate School and are in accordance with the assistantship appointment. Duties include grading, staff meetings, class preparation, student consultation, required lecture attendance, and research not directly related to the student's thesis or dissertation. Students will also have assigned classroom or laboratory teaching responsibilities. International students who wish to be eligible for graduate assistantships must pass the SPEAK (TSE) test. The passing score is 55. Students who score between 50-55 must take ENS 5502, Academic Spoken English, but are still allowed to hold a graduate assistantship.

Appointment	Minimum Registration Hours	Minimum Biweekly Rate	Total Hours Per Week
1/4 Time	9	\$190.40	10
1/3 Time	9	\$251.34	13.33
1/2 Time	9	\$380.80	20

Tuition Waivers

Tuition waivers are awarded to graduate students who have been awarded an assistantship from 1/4 time - 1/2 time. Fee waivers are contingent on the availability of funds. Due to the limit of available funds, no fee waivers are available without assistantship appointments. The waivers are processed under strict guidelines provided by the Graduate School.

Readmission Procedures

Students who have left the program prior to graduating, and wish to be readmitted require the following:

- * A minimum GPA of 3.00 for readmission into the Master's program and a minimum GPA of 3.5 for readmission to the Ph.D. program.
- * GRE scores that satisfy the admission requirements of the ECE program in effect at the time of readmission.
- * Three letters of recommendation from faculty members in the ECE department.

XI. Graduate Course Descriptions

Websites for courses are at www.ece.ufl.edu/undergraduates/classwebsites.html.

CDA 6156 - Advanced Computer Architecture (3 credits)

Prereq: EEL 5764 or CDA 5155. Evaluation, study, and comparison of computer systems. Development of formal and informal models of computer architecture.

EEL 5182 - State Variable Methods in Linear Systems (3 credits)

Prereq: EEL 4657. Linear algebra and state variable methods for design and analysis of discrete and continuous linear systems.

EEL 5218 - High Voltage DC Transmission Systems (3 credits)

Prereq: Introductory course in electric power. Line-commutated converter analysis, rectifier and inverter controls, system protection, harmonics, supplementary controls, and multiterminal operation.

EEL 5219 - Analysis of Power Transmission Lines (3 credits)

Prereq: EEL 3211, MAS 3114 or equivalents. Calculation of multiphase transmission line parameters for typical power line configurations. Model analysis of wave propagation. Line models and computer applications for transient analysis.

EEL 5225 - Principles of MEMS (Micro-Electro-Mechanical Transducers) (3 credits).

Prereq: EEL 3396 or permission of instructor. Introduction to principles of micro-electro-mechanical devices and systems.

EEL 5317C - Introduction to Power Electronics (4 credits)

Prereq: EEL 3304, 3396. Coreq: EEL 4657. Components and circuits for power applications. Switched-mode power supplies.

EEL 5320 - Bipolar Analog IC Design (3 credits)

Prereq: EEL 3304. Amplifier stages, active loads, output stages, op-amps, feedback, frequency response, compensation.

EEL 5322 - VLSI Circuits and Technology (3 credits)

Prereq: EEL 3396 and EEL 3304. Introduction to VLSI circuit technology and manufacturing fabrication, device models, layout, parasitics, and simple gate circuits.

EEL 5336L - Solid State Technology Laboratory (1 credit)

Solid-state device fabrication. Safety issues..

EEL 5441 - Fundamentals of Photonics (3 credits)

Prereq: EEL 3396 and 3472. Review of electromagnetic fields and waves, energy bands in semiconductors, p-n junctions and optical properties of semiconductors. Fundamentals of optical modulators and switches, laser theory, laser characteristics, photodetectors, optical waveguides, and photonic applications.

EEL 5451L - Photonics Lab (2 credits)

Prereq: EEL 4440 or 4445 or 5441. Experiments in wave optics, acousto-optics, lasers, fiber optics, planar wave guides, and coherent optics.

EEL 5490 - Lightning (3 credits)

Prereq: EEL 3472. Introduction to lightning discharge processes. Electromagnetics relevant to lightning measurements. Applications for determining lightning charge, current, location, and characteristics. Lightning protection.

EEL 5544 - Noise in Linear Systems (3 credits)

Passage of electrical noise and signals through linear systems. Statistical representation of random signals, electrical noise, and spectra.

EEL 5546 - Electronic Countermeasures (3 credits)

Prereq: EEL 4516 or 5544. Analysis of electronic countermeasures for radar systems. Pulsed and spread spectrum detection; barrage, incoherent, and coherent jammers; burn through analysis; auto-correlation receiver structures.

EEL 5547 - Introduction to Radar (3 credits)

Prereq: EEL 4516 or 5544. Basic principles of cw and pulsed radar; angle, range, and doppler tracking; accuracy and resolution; signal design.

EEL 5631 - Digital Control Systems (3 credits)

Prereq: EEL 3701, 4657. A study of the digital computer as a control element, classical sampled data control theory, and application with microcomputers.

EEL 5666C - Intelligent Machines Design (4 credits)

Prereq: EEL 4744C. Design simulation, fabrication, assembly, and testing of intelligent robotic machines.

EEL 5701 - Foundations of Digital Signal Processing (3 credits)

Analysis and design of digital filters for discrete signal processing; spectral analysis; fast Fourier transform.

EEL 5717 - Fundamentals of Computer Hardware (3 credits)

Prereq: EEL 4712C, 4713C, or equivalent. Systematic study of components of a computer system; organization and realization of arithmetic, control and data paths.

EEL 5718 - Computer Communications (3 credits)

Prereq: EEL 4514. Design of data communication networks: modems, terminals, error control, multiplexing, message switching, and data concentration.

EEL 5745C - Microcomputer Hardware and Software (4 credits)

Prereq: EEL 3701 and EEL 3304 or 3003. Functional behavior of microprocessors, memory, peripheral support integrated circuit hardware; microcomputer system and development software; applications.

EEL 5764 - Computer Architecture (3 credits)

Prereq: EEL 4713C, 4744C, or equivalents. Fundamentals in design and quantitative analysis of modern computer architecture and systems, including instruction set architecture, basic and advanced pipelining, superscalar and VLIW instruction-level parallelism, memory hierarchy, storage, and interconnects.

EEL 5840 - Elements of Machine Intelligence (3 credits)

Engineering and hardware concepts pertaining to design of intelligent computer systems.

EEL 5905 - Individual Work (1-4 credits per section number); (max: 6 credits count toward graduation) Prereq: consent of adviser. Selected problems or projects.

EEL 5934 - Special Topics in Electrical and Computer Engineering (1-3 credits per section number; max: 18 credits count toward graduation)

EEL 6171 - Advanced System Theory (4 credits)

Structural analysis of linear dynamical systems. Invariance, F and G invariance, constrained reachability, pole assignment and stability, advanced topics in linear algebra useful in mathematical system theory.

EEL 6200 - Advanced Analysis of Electric Machines (3 credits)

Prereq: EEL 3211, MAS 3114 or equivalents. Principles of electromechanical energy conversion, reference frame theory, analysis and modeling of ac and dc machines, state variable formulation of systems with electromechanical devices.

EEL 6264 - Advanced Electric Energy Systems (3 credits)

Prereq: consent of instructor. Energy systems planning and operation with emphasis on advanced analysis methodologies and computer simulation.

EEL 6265 - Advanced Electric Energy Systems II (3 credits)

Prereq: EEL 6264. Continuation of EEL 6264 with additional emphasis given to the new electric energy technologies.

EEL 6321 - MOS Analog IC Design (3 credits)

Prereq: EEL 5320 or EEL 6311. Design of analog circuits in CMOS IC technologies. MOS switches, MOS op-amps, circuit simulation using SPICE.

EEL 6323 - Advanced VLSI Design (3 credits)

Prereq: EEL 5322. Advanced very large scale integrated circuit design, testability, and performance evaluation. Use of industrial VLSI software. Building an advanced CMOS VLSI circuit.

EEL 6324 - Silicon Fabrication Processes (3 credits)

Prereq: EEL 5322. Advanced modeling of physics of silicon fabrication. Lithography, deposition, etching, oxidation, implantation, and diffusion. Oriented toward silicon device fabrication.

EEL 6325 - Computer Simulation of Integrated Circuits and Devices (3 credits)

Prereq: Graduate standing. Basic methods of numerical simulation of semiconductor devices and

electronic circuits with reference to PISCES and SPICE. PDE discretization; numerical integration, Newton/iterative linearization, linearized system solution.

EEL 6328C - Microwave IC Design (3 credits)

Fundamentals of microwave integrated circuit design. Use of computer software to design simple microwave circuits. Microwave circuit testing.

EEL 6374 - Radio Frequency (RF) Integrated Circuits and Technology (3 credits)

Prereq: EEL 5322, 4306 or equivalent. Requirements for RF integrated circuits. Design and implementation. Interdependence of RF circuit performance with devices, parasitics, packages, and process technology.

EEL 6382 - Semiconductor Physical Electronics I (3 credits)

Crystal structures; imperfections; statistics; lattice dynamics; energy band theory. Equilibrium properties of electrons and holes in semiconductors. Electronic transport phenomena. Boltzmann's equation and transport coefficients in semiconductors.

EEL 6383 - Semiconductor Physical Electronics II (3 credits)

Prereq: EEL 6382. Scattering mechanisms. Recombination-generation and trapping processes; optical properties. Excess carrier phenomena. Photoelectric effects in semiconductors. Metal-semiconductor contacts. Optoelectronic devices. Junction and MOS devices. Superconductors and Josephson Junction devices.

EEL 6388 - Fluctuation Phenomena (3 credits)

Prereq: Graduate standing. Noise theory with applications to Electrical and Computer Engineering. Sources of noise in electronic devices; statistical and spectral representation. Influence of noise upon the performance of circuits and systems. Limitation of detectors and instruments due to noise.

EEL 6390 - VLSI Device Design (3 credits)

Criteria and tradeoffs involved in design of high-performance semiconductor devices in scales (VLSI) Si-based integrated-circuit technologies.

EEL 6397 - Semiconductor Device Theory I (3 credits)

Prereq: EEL 3396. Semiconductor material properties, equilibrium and nonequilibrium processes, quasi-Fermi levels, pn junctions; charge-control modeling; high level injection, heavy doping effects.

EEL 6398 - Semiconductor Device Theory II (3 credits)

Prereq: EEL 6397. Basic mechanisms in bipolar junction transistors, low- and high-current effects; fundamental principles of the MOS system, surface effects on pn junctions, MOS field-effect transistors.

EEL 6443 - Integrated and Fiber Optics (3 credits)

Prereq: EEL 5441. Review of electromagnetic waves. Dielectric interfaces, propagation in graded-index media, slab waveguides, coupled waveguides, waveguide fabrication and characterization.

EEL 6447 - Laser Electronics (3 credits)

Prereq: EEL 3473 and EEL 5441 or equivalent. Study of lasers from basic principles to operational characteristics.

EEL 6486 - Electromagnetic Field Theory and Applications I (3 credits)

Prereq: undergraduate course in fields and waves. Advanced electrostatics, magnetostatics, time-varying electromagnetic fields, wave propagation, waveguides.

EEL 6487 - Electromagnetic Field Theory and Applications II (3 credits)

Prereq: EEL 6486. Electromagnetic radiation, antennas, wave propagation in an isotropic media.

EEL 6502 - Adaptive Signal Processing (3 credits)

Prereq: EEL 5544, EEL 5701. Theory of adaptation with stationary signals; performance measures. LMS, RLS algorithms. Implementation issues and applications.

EEL 6503 - Spread Spectrum (3 credits)

Prereq: EEL 5544 and EEL 6535. Techniques and applications; spreading sequence design; code division multiple access; multi-user detection.

EEL 6507 - Queueing Theory and Data Communications (3 credits)

Prereq: EEL 5544. Introduction to basic queueing models; performance analysis of multiple access protocols; error control strategies.

EEL 6509 - Wireless Communications (3 credits)

Prereq: EEL 5544. Introduction. Satellite and cellular systems, propagation, modulation techniques, multiple access techniques, channel coding, speech and video coding, and wireless computer networks.

EEL 6524 - Statistical Decision Theory (3 credits)

Prereq: EEL 5544. Hypothesis testing of signals in the presence of noise by Bayes, Neyman-Pearson, minimax criteria; estimation of signal parameters.

EEL 6535 - Digital Communication (3 credits)

Prereq: EEL 5544. Optimum receiver principles; analysis of digital and analog communication systems in the presence of noise; modeling of communication channels.

EEL 6537 - Spectral Estimation (3 credits)

Prereq: EEL 5544, EEL 5701. Measurement and analysis of signals and noise. Digital filtering and spectral analysis; fast Fourier transform.

EEL 6548 - Radar I (3 credits)

Basic concepts, wave propagation, antennas, radar equation, cross section, radar signals, detection.

EEL 6550 - Error Correction Coding (3 credits)

Prereq: EEL 5544 or equivalent; Coreq: EEL 5544 or EEL 4516. Introduction to abstract algebra, block coding and decoding, convolutional coding and decoding, trellis coded modulation, run-length-limited codes.

EEL 6562 - Image Processing and Computer Vision (3 credits)

Pictorial data representation; feature encoding; spatial filtering; image enhancement; image segmentation; cluster seeking; two-dimensional z-transforms; scene analysis; picture description language; object recognition; pictorial database; interactive graphics; picture understanding machine.

EEL 6586 - Automatic Speech Processing (3 credits)

Prereq: EEL 5701. Various models of speech production and perception. Operation of speech synthesizers. Discussion of speech recognition. Mathematical models of speech signals.

EEL 6591 - Wireless Networks (3 credits)

Prereq: EEL 5718 and knowledge of probability and statistics. Design and analysis of wireless networks including channel characteristics, physical layer, cellular concepts, multiple access control protocols, FEC and ARQ protocols, resource allocation, and wireless standards.

EEL 6614 - Modern Control Theory I (3 credits)

Prereq: EEL 5182. Optimization of systems using the calculus of variations, dynamic programming, and the maximum principle. Extensive study of the linear plant with a quadratic performance index. Observers and dynamic compensators.

EEL 6617 - Linear Multivariable Control (3 credits)

Prereq: EEL 5182, MAS 4105. Transfer matrix theory of systems, emphasis on feedback, internal stability, model matching and the assignment of invariant factors.

EEL 6619 - Robust Control Systems (3 Credits)

Prereq: EEL 5182. Analysis and design of multivariable control systems in presence of uncertainties.

EEL 6667 - Kinematics and Dynamics of Robot Manipulators (3 credits)

Algebraic formulation of robot manipulator motion. Homogeneous matrices. Methods for computing forward and reverse kinematic solutions of robot manipulators. Robot differential displacements and Jacobians. Newton-Euler and Lagrangian derivations of manipulator dynamics.

EEL 6668 - Intelligent Robot Manipulator Systems (3 credits)

Prereq: EEL 6667. Trajectory planning and computation for robot manipulators. Splines. Force compliance and hybrid control. Machine perception and intelligence: touch, vision, collision avoidance, automatic task planning. Modeling a robotic manufacturing work cell. Robot computer languages.

EEL 6702 - Digital Filtering (3 credits)

Prereq: EEL 5701. Introduction to number transforms, complexity of algorithms, and finite fields. Development of transforms and digital filters using algebraic operators and finite fields plus the technological consideration of DSP systems and system integration.

EEL 6706 - Fault Tolerant Computer Architecture (3 credits)

Prereq: EEL 5764 or CDA 5155. Design and quantitative analysis of fault tolerant architectures and dependable systems including fundamental issues, redundancy techniques, evaluation methods, design methodology, and applications.

EEL 6763 - Parallel Computer Architecture (3 credits)

Prereq: EEL 5764. Advanced architecture emphasizing design and quantitative analysis of parallel architecture and systems, including theory, hardware technologies, parallel and scalable architectures, and software constructs.

EEL 6767 - Database Engineering (3 credits)

Prereq: EEL 4713C. Architecture of database management system, data models and languages, design, integrity, security, concurrency control, distributed database management.

EEL 6769 - Hardware-Software Interactions: Nonnumeric Processing (3 credits)

Prereq: EEL 6767, COP 5725 or consent of instructor. Information representations; content and context search methods; associative memories, retrieval language mapping; parallel processing; hardware and software garbage collections.

EEL 6785 - High-Performance Computer Networks (3 credits)

Prereq: EEL 5718 or CEN 6505. Design and quantitative analysis of high-speed networks and interconnects including protocols, hardware and software interfaces, switching, light-weight communication layers, flow and error control, and quality of service.

EEL 6814 - Neural Networks for Signal Processing (3 credits)

Prereq: EEL 5701. Optimal filters in vector spaces. Linear machines and discriminant functions. Gradient descent learning in the additive neural model. Performance measures of multilayer perceptions and Hopfield networks. Dynamic neural networks and the issues of short term memory. Unsupervised learning networks.

EEL 6825 - Pattern Recognition and Intelligent Systems (3 credits)

Decision functions; optimum decision criteria; training algorithms; unsupervised learning; feature extraction, data reduction; potential functions; syntactic pattern description; recognition grammars; machine intelligence.

EEL 6841 - Machine Intelligence and Synthesis (3 credits)

Prereq: EEL 5701. Theory of machine intelligence applied to general problems of engineering intelligent computer systems and architectures. Applications emphasized.

EEL 6905 - Individual Work (1-4 credits*; max: 6 credits.)**

Prereq: consent of advisor. Selected problems or projects.

EEL 6910 - Supervised Research (1-5 credits*; max: 3 credits.**)**

S/U grading.

EEL 6935 - Special Topics in Electrical and Computer Engineering (1-4 credits*; **)

Topics vary.

EEL 6940 - Supervised Teaching (1-5 credits*; max: 3 credits.**)**

S/U grading.

EEL 6971 - Research for Master's Thesis(1-15 credits*, max: 6 credits**)

S/U grading.

EEL 6972 - Research for Engineer's Thesis (1-15 credits*)

S/U grading.

EEL 7936 - Advanced Topics in Electrical and Computer Engineering (1-4 credits*; **)

EEL 7979 - Advanced Research (1-12 credits*)

Research for doctoral students before admission to candidacy. Designed for students with a master's degree in the field of study or for students who have been accepted for a doctoral program. Not open to students who have been admitted to candidacy. S/U grading.

EEL 7980 - Research for Doctoral Dissertation (1-15 credits*)

S/U grading.

*per section number.

**count for graduation.

***no more than five hours may be taken.

****maximum of 18 credit hours of EEL 5934, EEL 6935, EEL 7936.

XII. Breadth Areas

A Breadth Area consists of two specific courses. Generally, the first course listed in the Breadth Area should be taken prior to taking the follow-up course.

Area	First Semester	Second Semester (choose course corresponding to your first course selection)
Communications	EEL 5544	EEL 6535
Computer Systems & Networks	EEL 5764 →	Choose one: EEL 6763, EEL 6706, EEL 6935- Virtual Computers, or CDA 6156
	EEL 5718 →	Choose one: EEL 6785, EEL 6591, or EEL 6935- Distributed Computing
Device and Physical Electronics	EEL 6382 →	EEL 6383
	EEL 6397 →	EEL 6398
Digital Signal Processing	EEL 5701	Choose one: EEL 6537, EEL 6502, EEL 6702, or EEL 6586
Electric Energy Systems	EEL 6264	EEL 6265
Electromagnetics	EEL 6486	EEL 6487
Electronic Circuits	EEL 5322 →	EEL 6323
	EEL 5320 →	Choose one: EEL 6321 or EEL 6328
Intelligent and Information Systems	EEL 5480 →	EEL 6831
	EEL 6667 →	EEL 6668
	EEL 6767 →	EEL 6769
	EEL 6562 →	EEL 6825
Photonics	EEL 5441	Choose one: EEL 6443 or EEL 6447
Systems and Control	EEL 5182	Choose one: EEL 6614, EEL 6615, EEL 6616, EEL 6617, EEL 6619, EEL 6134, or EEL 6171