Electrical and Computer Engineering

College of Engineering and Computer Science

Chair: Ali Amini
Jacaranda Hall (JD) 4509
(818) 677-2190
www.csun.edu/ece

Staff
Deazell Johnson, Farrah Mirzaee

Faculty
Ali Amini, Nagwa Bekir, Somnath Chattopadhyay, Nagi El Naga, Xiaojun (Ashley) Geng, Xiyi Hang, Ichiro Hashimoto, Sharlene Katz, George Law, Benjamin Mallard, Ronald Mehler, Bruno Osorno, Matthew Radmanesh, Sembiam Rengarajan, Ramin Roosta, Deborah van Alphen

Emeritus Faculty
John Adams, Robert Burger, Raymond Davidson, Willis Downing, Jr., Edward J. Hriber, Nirmal Mishra, Ray Pettit, Jagdish Prabhakar, A.F. Ratcliffe, David Schwartz, Yuh Sun

Programs

Undergraduate:
- **B.S., Electrical Engineering**
- **B.S., Computer Engineering**
- **Minor in Electrical Engineering**

Graduate Degree:
- **M.S., Electrical Engineering**

Mission Statement

Our mission is to prepare students for rewarding careers and higher education. Our graduates will be able to solve complex technical problems and address the needs of modern society, and will pursue lifelong learning.

The Major

"Nowadays the world is lit by lightning," the playwright Tennessee Williams wrote. But electrical and computer engineers prove him wrong every day.

From city lights to satellites, from semiconductors to telephone switching systems to audio equipment, the work depends on electricity and the engineers who design and develop ways to harness its power.

Electrical Engineering majors at Cal State Northridge receive a solid, broad-based education. Among the many topic areas in the basic curriculum are mathematics, physics, chemistry, computer programming, engineering materials, electrical circuits, engineering mechanics, thermodynamics, engineering economy, and numerical analysis. At the senior level, students are required to take an approved concentration in one of the Electrical and Computer Engineering options: biomedical engineering, communications, digital systems design, control systems, electronics, microwave and antenna engineering, or power systems.

The Computer Engineering (CompE) program bridges the curriculum gap between Computer Science and Electrical Engineering. Computer Engineers deal with the hardware and software aspects of computer system design and development. The CompE curriculum contains components of both the Computer Science and Electrical Engineering programs.

Computer Engineering majors receive a broad knowledge in the basic curriculum. Among the many topics are: mathematics, physics, chemistry, biology, electrical circuits, engineering economy, algorithms, programming, and computer organization. Computer Engineering students will take coursework in a number of areas (i.e. computer architecture, digital design) from both the software and hardware points of view, allowing them to get a broader, more complete exposure to the subject. Additionally, these curricula will be unified in the one year senior design project course bringing together the existing Electrical and Computer Engineering and Computer Science programs.

The ECE department has 17 labs associated with its ECE classes. In the labs, students work alongside professors who may be designing medical instrumentation for health care, designing microcontroller based applications, developing pager and satellite communications systems, or working on innovations in electrical power systems.

All students in the EE or CompE programs take part in the department's senior design program, modeled on industry work groups that students will encounter on the job. Like professional engineers, students design and develop a project, from conception through manufacture. In the process, they gain valuable experience in working as a team, dealing with personalities as well as technical areas.

Senior design projects have included national intercollegiate competitions. Students compete in designing a micromouse and training it to run through a 10' square maze. Students also work on interdisciplinary teams to design, build, program, and test an unmanned autonomous helicopter. Other projects include developing a sophisticated stereo system, control system for satellite tracking antenna, television tuner, fabrication of hybrid circuit, etc.

The College of Engineering and Computer Science offers an Honors Cooperative Internship Program that allows juniors and seniors to complete their studies while holding down jobs as engineers.

A student chapter of the national professional society, the Institute for Electrical and Electronics Engineers, meets on campus. Other active organizations include Tau Beta Pi, the student engineering honors society; Eta Kappa Nu, the electrical engineering honor society; the Society for Women Engineers; the National Society for Black Engineers; and the Society for Hispanic Professional Engineers.

The Electrical Engineering program is accredited by the Engineering Accreditation Commission of the Accreditation Board for Engineering and Technology (ABET), 111 Market Place, Suite 1050, Baltimore, MD 21202-4012, telephone: (410) 347-7700.

Educational Objectives

The Electrical and Computer Engineering program at California State University, Northridge prepares our graduates for lifelong careers in the field that will allow them to make productive contributions to society and to find personal satisfaction in their work. To accomplish this, graduates of the Electrical and Computer Engineering programs will meet the following educational objectives:

Electrical Engineering:

I. The ability to apply engineering principles in designing and analyzing electrical circuits and systems;
II. The knowledge and application of state-of-the-art design techniques and software tools;
III. The ability to communicate well, both orally and in writing, and work as a productive member of an interdisciplinary team;
IV. The ability to develop engineering solutions with consideration of their impact on society; and
V. The ability to maintain life long learning.

Computer Engineering:

I. The ability to apply engineering principles in designing and analyzing electrical circuits and computer systems;
II. The knowledge and application of state-of-the-art design techniques and software tools;
III. The ability to communicate well, both orally and in writing, and work as a productive member of an interdisciplinary team;
IV. The ability to develop engineering solutions with consideration of their impact on society; and

V. The ability to maintain lifelong learning.

These objectives are consistent with ABET Criteria 2000 and the mission of our department.

Student Learning Outcomes of the Undergraduate Programs

Graduates of the Bachelor of Science in Electrical Engineering program at California State University, Northridge will have:

a. An ability to apply knowledge of math, science, and engineering to the analysis of electrical engineering problems.
b. An ability to design and conduct scientific and engineering experiments, as well as to analyze and interpret data.
c. An ability to design systems which include hardware and/or software components within realistic constraints such as cost, manufacturability, safety and environmental concerns.
d. An ability to function in multidisciplinary teams.
e. An ability to identify, formulate, and solve electrical engineering problems.
f. An understanding of ethical and professional responsibility.
g. An ability to communicate effectively through written reports and oral presentations.
h. An understanding of the impact of engineering in a social context.
i. A recognition of the need for and an ability to engage in life-long learning.
j. A broad education and knowledge of contemporary issues.
k. An ability to use modern engineering techniques for analysis and design.
l. Knowledge of probability and statistics.
m. An ability to analyze and design complex devices and/or systems containing hardware and/or software components.
n. Knowledge of math including differential equations, linear algebra, complex variables and discrete math.
o. The ability to be competitive in the engineering job market and/or to continue studies at the graduate level.

Graduates of the Bachelor of Science in Computer Engineering program at California State University, Northridge will have:

a. An ability to apply knowledge of math, science, and engineering to the analysis of computer engineering problems.
b. An ability to design and conduct scientific and engineering experiments, as well as to analyze and interpret data.
c. An ability to design systems which include hardware and/or software components within realistic constraints such as cost, manufacturing, safety and environmental concerns.
d. An ability to function in multidisciplinary teams.
e. An ability to identify, formulate, and solve computer engineering problems.
f. An understanding of ethical and professional responsibility.
g. An ability to communicate effectively through written reports and oral presentations.
h. An understanding of the impact of engineering in a social context.
i. A recognition of the need for and an ability to engage in life-long learning.
j. A broad education and knowledge of contemporary issues.
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l. Knowledge of probability and statistics.
m. An ability to analyze and design complex devices and/or systems containing hardware and/or software components.
n. Knowledge of math including differential equations, linear algebra, complex variables and discrete math.
o. The ability to be competitive in the engineering job market and/or to continue studies at the graduate level.

Careers

The department's practical approach to engineering offers hands-on design experience as well as theoretical knowledge. This is an advantage on the job because graduates actually have experience in implementing projects as well as designing them. Students who enjoy using math and science creatively to solve real-world problems will find rewarding careers as electrical and computer engineers.

Careers in Electrical Engineering: Graduates in Electrical Engineering design and build communication systems, information processing systems, entertainment devices, medical diagnosis equipment, robotics control, navigation, and traffic control systems. Graduates can find work in virtually every industry. Among the major employers are electronic manufacturing firms, communication companies, the entertainment industry, public utilities, oil companies, laboratories, transportation companies, and chemical plants. Some graduates pursue professions as patent attorneys, technical writers, consultants, teachers, or technical sales representatives. This program not only prepares students to enter the work force, but also to enter graduate school to pursue an area of specialization.

According to the Bureau of Labor Statistics, from 2000 to 2010 the number of jobs for electrical engineers is predicted to increase by 11.3%. Furthermore, in California, the State Employment Development Department predicts 15.1% growth in jobs for electrical engineers of 15.1% during the same period.

High School Preparation

It must be emphasized that this program is based upon an expectation of adequate high school preparation in science, mathematics, and English. High school courses should include algebra, plane geometry, trigonometry, chemistry, or physics (all desirable) and four years of English. Students who have not had an adequate background of pre-engineering work in high school may be required to take some additional course work in their first year and may not be able to complete an engineering program in eight semesters. Entering beginning engineering students must take or be exempt from the Entry Level Mathematics Test and the Mathematics, Chemistry, and English Placement Tests before registration in basic courses will be permitted.

Pre-registration Testing Requirements

The campus requires most beginning students to take the Entry Level Mathematics Exam (ELM) and the English Placement Test (EPT) prior to enrolling in their courses. Refer to the section of this catalog entitled "Appendices-Admission" for further details on these exams. In addition to these general university requirements, students in any of the engineering programs may also need the following exams:

1. Mathematics Placements Test (MPT) is required prior to enrollment in MATH 150A. Students who have passed or are exempt from the ELM should take this exam prior to enrolling in their classes so they may be placed in the appropriate mathematics course. Students with scores of 3, 4, or 5 on the AP Calculus AB or BC are exempt from the MPT.
2. Chemistry Placement Test (CPT) is required with a score of 40 or higher prior to enrolling in CHEM 101. Students who do not receive this score must receive a grade of "C" or better in CHEM 105 before taking CHEM 101.

Transfer Requirements

All degree programs in engineering accommodate students beginning as freshmen or as transfer students. Transfer students should have completed lower division writing, mathematics, physics, and chemistry courses. Courses that are transferred into the major are reviewed to ensure that they satisfy the same requirements as courses at Northridge.

Courses transferred into the engineering major must have been completed with a grade of "C" or better.

Special Grade Requirements

No grade lower than a "C" will be accepted for transfer classes from another institution to the Electrical and Computer Engineering major requirements. No CSUN grade lower than a "C-" will be accepted as satisfactory for courses required for the major. More stringent prerequisite requirements may apply to some courses.

Academic Advisement

For the first two semesters, freshmen are required to seek advisement by the department undergraduate advisor prior to enrolling in any class. Based on the results of their placement tests, they will be placed in the appropriate courses and supplied with all advisement materials.

The undergraduate advisor also advises new transfer students and places them into the proper classes for their first semester. All continuing undergraduate students in good standing are encouraged to seek advisement each semester.

Requirements for the Bachelor of Science Degree in Electrical Engineering

The B.S. in Electrical Engineering program requires a minimum of 126 units total, including General Education and Title 5 requirements of 27 units, an Electrical Engineering core of 81, and a minimum of 18 units of approved electives.

Electrical Engineering majors must complete a minimum of 39 semester units of upper division engineering courses, in residency, including Senior Design Project I and II.

Additional information about this program and its facilities, faculty and students can be found on the world wide web at: www.csun.edu/ece

1. Lower Division Required Courses (44 Units)

Note: All students must pass the English Placement Test with a score of 151 or above before enrolling in any 200-level engineering courses.

Freshman Year

CHEM	101/L	General Chemistry and Lab (4/1)
ECE	206/L	Computing in Engineering and Science and Lab (2/1)
MATH	150A	Calculus I (5)
MATH	150B	Calculus II (5)
ECE	101/L	Introduction to Electrical Engineering and Lab (1/1)
PHYS	220A/L	Mechanics and Lab (3/1)

Sophomore Year

CE	240	Engineering Statics (3)
ECE	240/L	Electrical Engineering Fundamentals and Lab (3/1)
MATH	250	Calculus III (3)
MATH	280	Applied Differential Equations (3)
MSE	227	Engineering Materials (3)
PHYS	220B/L	Electricity and Magnetism and Lab (3/1)

2. Upper Division Required Courses (37 Units)

Note: All students must complete the Lower Division Writing Requirement before enrolling in any 300-level engineering courses and must attempt the Upper Division Writing Proficiency Exam before enrolling in any 400-level engineering courses.

Junior Year

MSE	304	Engineering Economy (3)
ME	309	Numerical Analysis of Engineering Systems (2)
ECE	320/L	Theory of Digital Systems and Lab (3/1)
ECE	340/L	Electronics I and Lab (3/1)
ECE	350	Linear Systems I (3)
ECE	351	Linear Systems II (3)
ECE	455	Mathematical Models in EE (3)

Select one of the following 3 unit courses:

ME	370	Thermodynamics (3)
ME	375	Heat-Transfer I (3)

Senior Year

The senior core consists of a set of courses considered essential for all students who are seeking a career in Electrical Engineering.

ECE	370	Electromagnetic Fields and Waves I (3)
ECE	450	Probabilistic Systems in Electrical Engineering (3)
ECE	480	Fundamentals of Control Systems (3)
ECE	492	Senior Design Project - Electrical I (2)
ECE	493	Senior Design Project - Electrical II (1)

3. Upper Division Electives (18 Units):

The senior elective packages must contain at least eighteen 400/500-level department courses and labs which are well balanced in both design and analysis. One of the electives must be either ECE 440/L (3/1) or ECE 442/L (3/1). Students will be required to take the corresponding labs for every elective chosen that offers a lab. For each lab taken, the corresponding lecture course is a corequisite. The student's total engineering program should contain at least18 units of engineering design.

Note: Students can take ECE 370L and/or ECE 480L as part of their senior electives.

All senior electives must be completed with a faculty advisor and approved by Department Chair, or a designee. A number of examples of suggested senior elective packages in the Electrical Engineering degree are available in the department office. Other programs are also possible and may be developed with an advisor. The total number of units in the major is 99.

4. General Education (27 Units):

Electrical Engineering majors have to follow a modified general education program depending upon the year and enrollment status as a college student. Returning and transfer students should consult an advisor before planning their general education programs.

Electrical Engineering students are required to take courses in the following GE sections: Analytical Reading and Expository Writing (3 units), Oral Communication (3 units), Social Sciences (3 units), Arts and Humanities (6 units), Comparative Cultures (6 units), U.S. History and Local Government (6 units). All other GE requirements are met through completion of courses in the major. Nine of the GE units must be at the upper division level and two courses must meet the Information Competency requirement.

Total Units Required for the Degree	126

Minor in Electrical Engineering

Out of the 21 units, 17 units must be Upper Division courses. The student may have to complete prerequisite courses such as Math and Physics. Any required non-Electrical Engineering prerequisite courses will not count toward the required 21 units. This program is not available for student with a major in electrical engineering.

1. Lower Division

ECE	240/L	Electrical Engineering Fundamentals and Lab (3/1)

2. Upper Division

ECE	320/L	Theory of Digital Systems and Lab (3/1)
ECE	340/L	Electronics I and Lab (3/1)
ECE	350	Linear Systems I (3)

Select an additional two 400/500 level ECE courses. Students will be required to take the corresponding labs for every elective chosen that offers a lab. All senior electives must be approved by a faculty advisor and the Department Chair, or a designee.

Electrical Engineering Courses Required for the Minor	21

Requirements for the Bachelor of Science in Computer Engineering

The Computer Engineering program requires a minimum of 123 units total, including General Education and Title 5 requirements of 27 units, a Computer Engineering core of 90 units, and a minimum of 6 units of an approved elective.

Computer Engineering majors must complete a minimum of 30 semester units of upper division computer engineering courses in residency, including senior design project I and II.

Additional information about this program and its facilities, faculty and students can be found on the world wide web at: www.csun.edu/ece.

1. Lower Division Required Courses (44 units)

Note: All students must pass the English Placement Test with a score of 151 or higher before enrolling in any 200-level engineering courses.

Freshman Year

MATH	150A	Calculus I (5)
MATH	150B	Calculus II (5)
PHYS	220A/L	Mechanics and Lab (3/1)
COMP	110/L	Introduction to Algorithms and Programming and Lab (3/1)
COMP	122/L	Introduction to Computer Systems and Lab (1/1)
COMP	182/L	Data Structures and Program Design and Lab (3/1)

Sophomore Year

MATH	250	Calculus III (3)
MATH	280	Applied Differential Equations (3)
PHYS	220B/L	Electricity and Magnetism and Lab (3/1)
COMP	222	Computer Organization (3)
COMP	282	Advanced Data Structures (3)
ECE	240/L	Electrical Engineering Fundamentals and Lab (3/1)

2. Math And Science Electives (8 Units)

Select a minimum of 8 units from the following list with corresponding lab if one exists: BIOL 106/L, BIOL 107/L, CHEM 101/L, CHEM 102/L, PHYS 227/L, PHYS 375, MATH 262 and MATH 326.

3. Upper Division Required Courses (38 Units)

Note: All students must complete lower division writing requirements with grade of "C" or better before enrolling in any 300-level course in the major and must attempt the Upper Division Writing Proficiency Exam before enrolling in any 400-level course in the major.

Junior Year

COMP	322/L	Introduction to Operating Systems and System Architecture and Lab (3/1)
ECE	320/L	Theory of Digital Systems and Lab (3/1)
ECE	340/L	Electronics I and Lab (3/1)
ECE	350	Linear Systems I (3)
MSE	304	Engineering Economy (3)

Senior Year: The senior year must include a 'capstone' design experience and additional courses with design content so that the student's total engineering program contains at least one semester of engineering design. This engineering design requirement must be taken in residency. An advisor and the Department Chair must approve all senior year electives.

ECE	422	Design of Digital Computers (3)
ECE	425/L	Microprocessor Systems and Lab (3/1)
ECE	420	Digital Systems Design with Programmable Logic (3)
ECE	442/L	Digital Electronics and Lab (3/1)
ECE	450	Probabilistic Systems in Electrical Engineering Design and Analysis (3)
ECE	492/493	Senior Design Project I and II (2/1)

4. Upper Division Electives (6 Units)

Select a minimum of 6 units from the following:

COMP	380/L	Introduction to Software Engineering (2/1)
ECE	422L	Design of Digital Computers Lab (1)
COMP	429	Computer Network Software (3)
COMP	529	Advanced Network Topics (3)
ECE	443/L	Pulse and Wave shaping Circuit Design and Lab (3/1)
ECE	526/L	Verilog HDL: Modeling, Simulation and Synthesis and Lab (3/1)
ECE	525/L	System on Chip Design and Lab (3/1)
ECE	524/L	FPGA/ASIC Design Methodology and Optimization Using VHDL and LAB (3/1)
ECE	527/L	Application Specific Integrated Circuit Development and Lab (3/1)
ECE	546	Very Large Scale Integrated Circuit Design (3)

Note that some elective courses have prerequisites that are not part of the required program. All courses must include the lab, if one exists. Other courses may be selected with the approval of the ECE Department Chair. The total number of units in the major is 96.

5. General Education (27 Units):

Computer Engineering majors have to follow a modified general education program depending upon the year and enrollment status as a college student. Returning and transfer students should consult an advisor before planning their general education programs.

Computer Engineering students are required to take courses in the following GE sections: Analytical Reading and Expository Writing (3 units), Oral Communication (3 units), Social Sciences (3 units), Arts and Humanities (6 units), Comparative Cultures (6 units), U.S. History and Local Government (6 units). All other GE requirements are met through completion of courses in the major. Nine of the GE units must be at the upper division level and two courses must meet the Information Competency requirement.

Total Units Required for the Degree	123

Requirements for the Master of Science Degree In Electrical Engineering

A. Requirements for Admission to the Program

1. A bachelor's degree in a technical field (i.e. Engineering, Physics, Mathematics from an accredited university or college), with overall GPA of at least 2.75.
2. Have at least a 2.7 undergraduate grade point average in the last 60 semester units or 90 quarter units attempted.
3. International students are required to submit a brief statement of purpose and 3 letters of recommendations.

B. Admission Procedure:

Application forms are available online at www.csumentor.edu and can be completed and submitted online or to the Office of Admissions and Records. The Code number for the ECE major is 562440M. Application deadlines for admission are set by the university Office of Admission and Records.

All applicants, regardless of citizenship, whose preparatory education was principally in a language other than English must take the Test of English as a Foreign Language (TOEFL) and receive a minimum Paper-based score of 550, a minimum Computer-based score of 213 or a minimum Internet-based score of 79. Students must also complete the Test of Written English (TWE). A score below 4.5 on the TWE will require the enrollment in English 090 during the first semester in residence.

Continuing students in either Post-baccalaureate or Graduate status may change their objective and seek admission to a MS in Electrical Engineering by filling out a change of objective form that can be obtained from the Office of Admissions and Records.

It is the student's responsibility to be aware of all university regulations and restrictions such as:

1. No more than 9 units of transfer or extension work;
2. 12-unit rule for classification;
3. Probation and Disqualification;
4. Repeat of courses rules;
5. Advancement to Candidacy;
6. Academic leave;
7. A 7-year time limit for the completion of the degree
8. No more than 9 units of 400-level courses can be counted toward the M.S. degree.

For details on the above, students are advised to meet with the ECE Graduate Coordinator. Prior to the formation of their Graduate Committee, graduate students are advised by the Graduate Coordinator. After the formation of their Graduate Committee, graduate students are advised by their Committee Chair. All courses taken towards the M.S. degree must be approved by the Committee Chair and the Graduate Coordinator.

C. Classified Graduate Status:

The candidate must:

1. Fulfill University requirements for classified status.
2. Complete prerequisite courses with 3.0 GPA or higher.
3. Submit a tentative program of graduate study to the ECE Graduate Coordinator.
4. Complete all 3 sections of the GRE aptitude Exam. The quantitative score must be above the 50th percentile.

D. For the Degree:

1. Completion of 30-33 units under either the Thesis Plan, the Project Plan, or the Comprehensive Exam Plan.
2. Formal approval of granting of the degree by the Electrical Engineering faculty.

Thesis Plan

a. 24 units of course work applicable to the M.S. degree, of which at least 15 units must be Engineering courses at the 500/600-level or above. All course work in the student's graduate program must be completed with a "C" or better while maintaining an overall GPA of 3.0 or higher.

b. 6 units of ECE 698 (Thesis), and successful defense of Thesis before the thesis committee.

Project Plan

a. 27 units of course work applicable to the M.S. degree, of which at least 18 units must be Engineering courses at the 500/600-level or above. All course work in the student's graduate program must be completed with a C or better while maintaining an overall GPA of 3.0 or higher.

b. 3 units of ECE 698 (Graduate Project) culminating in a comprehensive report.

Comprehensive Exam Plan

a. 30 units of coursework applicable to the M.S. degree, of which at least 21 units must be 500/600-level Engineering courses. All course work in the student's graduate program must be completed with a "C" or better while maintaining an overall GPA of 3.0 or higher.

b. 3 units of ECE 697 comprehensive study preparatory to the exam and completion of the comprehensive exam with a grade of "B" or better.

E. Graduate Program:

The 30-33 units of coursework in the graduate program must form a cohesive plan of graduate study that consists of suggested and elective courses from one of the 7 options currently offered in the ECE department. The Thesis Plan may not include ECE 699 (Independent Study) and the Project Plan may include at most 3 units of ECE 699 (Independent study). Inclusion of a course not in the ECE suggested or elective course list must have the written approval of the Graduate Coordinator prior to enrollment in the course.

F. Special Requirements

Students from non-technical fields must fulfill most of the undergraduate prerequisite courses in math and physics, outlined below, with 3.0 GPA or higher before applying for admission to the ECE program. No time limit applies to courses taken to satisfy M.S. prerequisite requirements.

1. Prerequisite Courses

Some or all of these prerequisite courses may be required depending on applicant's prior background. The graduate coordinator will determine the specific prerequisite courses on a case-by-case basis.

MATH	150A	Calculus I (5)
MATH	150B	Calculus II (5)
MATH	250	Calculus III (3)
MATH	280	Applied Differential Equations (3)
PHYS	220A/L	Mechanics and Lab (3/1)
PHYS	220B/L	Electricity and Magnetism and Lab (3/1)
ECE	240/L	Electrical Engineering Fundamentals and Lab (3/1)
ECE	320/L	Theory of Digital Systems and Lab (3/1)
ECE	340/L	Electronics I and Lab (3/1)
ECE	350	Linear Systems I (3)
ECE	351	Linear Systems II (3)
ECE	370	Electromagnetic Fields and Waves I (3)
ECE	455	Mathematical Models in Electrical Engineering (3)

Two ECE 400-level classes approved by Graduate Coordinator related to study objective.

2. Required Courses (30 Units)

The Department of Electrical and Computer Engineering offers the Master of Science degree in Electrical Engineering. Within this degree students may choose an area of concentration in Biomedical Engineering, Communications and Radar Engineering, Control Engineering, Digital and Computer Engineering, Electronics, Solid State Devices and Integrated Circuits Engineering, Microwave and Antenna Engineering, or Power Systems Engineering. For all of these areas of concentration, the student must define a program that conforms to the general MSEE degree requirements as established by the Department. Note that no more than 9 units of ECE 400 level courses are applicable toward MSEE degree. Students may not take a course (counting toward MSEE degree) which is the same or equivalent to a course taken towards one's undergraduate program. In general graduate students are not required to take ECE labs. However some courses require the concurrent enrollment in lab sections. A maximum of 3 lab units (taken concurrent with lecture courses) may count toward MSEE program. Students are advised to meet with an advisor as soon as possible to plan their program. All graduate programs in the Department of Electrical and Computer Engineering must be approved by the faculty advisor and the Graduate Coordinator.

Core Courses: Courses that must be completed for each area of specialization. Only 9 units of these core courses may be included in MSEE formal program.

Suggested Courses for Biomedical Engineering

Core Course:

ECE	425/L	Microprocessor Systems and Lab (3/1)
ECE	440/L	Electronics II and Lab (3/1)
ECE	442/L	Digital Electronics and Lab (3/1)
ECE	455	Mathematical Models in EE (3)
ECE	480/L	Fundamentals of Control Systems and Lab (3/1)

Elective Courses:

ECE	501	Introduction to Biomedical Engineering (3)
ECE	503	Biomedical Instrumentation (3)
ECE	602	Biomedical Engineering I (3)
ECE	603	Biomedical Engineering II (3)
ECE	650	Random Processes (3)

Suggested Courses for Communications and Radar Engineering

Core Courses:

ECE	450	Probabilistic Systems in Electrical Engineering- Design and Analysis (3)
ECE	455	Mathematical Models in EE (3)
ECE	451/L	Real-time Digital Signal Processing and Lab (2/1)
ECE	460/L	Introduction to Communication Systems and Lab (3/1)

Elective Courses:

ECE	561/L	Digital Communications System and Lab (3/1)
ECE	562	Data Communication Networks (3)
ECE	635	Error Detecting and Correcting Systems (3)
ECE	637	Pattern Recognition (3)
ECE	642	RF Electronics Design (3)
ECE	650	Random Processes (3)
ECE	651	Digital Signal Processing I (3)
ECE	652	Digital Processing II (3)
ECE	658	Signal Detection and Estimation Theory (3)
ECE	659	Information Theory and Coding (3)
ECE	660	Modulation Theory (3)
ECE	661	Communications Engineering (3)
ECE	665	Radar Systems (3)
ECE	666/L	Fiber-Optic Communications and Lab (3/1)
ECE	669	Advanced Topics in Communications/Radar (3)

Suggested Courses for Control Engineering

Core Courses:

ECE	450	Probabilistic Systems in Electrical Engineering- Design and Analysis (3)
ECE	455	Mathematical Models in EE (3)
ECE	480/L	Fundamentals of Control Systems and Lab (3/1)

Elective Courses:

ECE	580	Digital Control Systems (3)
ECE	581	Fuzzy Control (3)
ECE	650	Random Processes (3)
ECE	651	Digital Signal Processing I (3)
ECE	652	Digital Signal Processing II (3)
ECE	681	Non-Linear Control Systems (3)
ECE	682	State Variables in Automatic Control (3)
ECE	683	Optimal Control (3)
ECE	684	Stochastic Control (3)

Suggested Courses for Digital and Computer Engineering

Core Courses:

ECE	420	Digital Systems Design w/ Programmable Logic (3)
ECE	422	Design of Digital Computers (3)
ECE	425/L	Microprocessor Systems and Lab (3/1)
ECE	442/L	Digital Electronics and Lab (3/1)

Elective Courses:

ECE	524/L	FPGAASIC Design Methodology/ Optimization/Lab Using VHDL (3/1)
ECE	525/L	System on Chip Design and Lab (3/1)
ECE	526/L	Verilog HDL: Modeling, Simulation and Synthesis and Lab (3/1)
ECE	527/L	Application Specific Integrated Circuit Development and Lab (3/1)
ECE	546	Very Large Scale Integrated Circuit Design (3)
ECE	620	Advanced Switching Theory (3)
ECE	621	Computer Arithmetic Design (3)
ECE	622	Digital Systems Structure (3)
ECE	623	Diagnosis and Reliable Design of Digital Systems (3)
ECE	624	Design Automation of Digital Systems (3)
ECE	625	Microprocessor Applications in Engineering (3)
ECE	629C	Seminar in Digital Systems and Components (3)
ECE	635	Error Detecting and Correcting Systems Design (3)
ECE	639	Robotic Sensing and Computer Vision (3)

Suggested Courses for Electronics, Solid State Devices and Integrated Circuit Engineering

Core Courses:

ECE	440/L	Electronics II and Lab (3/1)
ECE	442/L	Digital Electronics and Lab (3/1)
ECE	443/L	Pulse and Waveshaping Circuit Design and Lab (3/1)
ECE	445	Introduction to Solid State Devices (3)
ECE	455	Mathematical Models in EE (3)
ECE	571	Electromagnetic Fields and Waves II (3)

Elective Courses:

ECE	545	Solid State Devices (3)
ECE	546	Very Large Scale Integrated Circuit Design (3)
ECE	572/L	RF and Microwave Active Circuit Design and Lab (3)
ECE	578	Photonics (3)
ECE	640	Modern Electronic Techniques (3)
ECE	642	RF Electronics Design (3)
ECE	648	Electrical Network Theory (3)
ECE	649	Active Network Synthesis (3)
ECE	650	Random Processes (3)
ECE	673	Microwave Semiconductor Devices (3)

.Suggested Courses for Microwave and Antenna Engineering

Core Courses:

ECE	445	Introduction to Solid State Devices (3)
ECE	455	Mathematical Models in EE (3)
ECE	571	Electromagnetic Fields and Waves II (3)

Elective Courses:

ECE	545	Solid State Devices (3)
ECE	546	Very Large Scale Integrated Circuit Design (3)
ECE	572/L	RF and Microwave Active Circuit Design and Lab (3/1)
ECE	578	Photonics (3)
ECE	642	RF Electronic Design (3)
ECE	648	Electrical Network Theory (3)
ECE	650	Random Processes (3)
ECE	665	Radar Systems (3)
ECE	671	Microwave Engineering (3)
ECE	672	Advanced Microwave Circuit Design (3)
ECE	673	Microwave Semiconductor Devices (3)

ECE	674	Antenna Engineering (3)
ECE	675	Seminar in Antenna Engineering (3)
ECE	676	Numerical Techniques in Applied Electromagnetic (3)

Suggested Courses for Power Systems Engineering

Core Courses:

ECE	410/L	Electric Machines and Lab (3/1)
ECE	411	Electric Power Systems (3)
ECE	412	Power Electronics and Motor Control (3)
ECE	440/L	Electronics II and Lab (3/1)
ECE	455	Mathematics Models in EE (3)
ECE	460/L	Introduction to Communication Systems and Lab (3/1)
ECE	480/L	Fundamentals of Control Systems and Lab (3/1)

Electives Courses:

ECE	610	Fault Analysis in Power Systems (3)
ECE	611	Power Distribution Systems (3)
ECE	612	Selected Topics in Power Systems (3)
ECE	666/L	Fiber-Optic Communications and Lab (3/1)

Total Units Required for the M.S.E.E. Degree 30-33

Undergraduate Courses

ECE 100. The Technological World (3)
An introduction to the concepts, theories, and techniques that contribute to our technological civilization. A course to improve the student's understanding of modern technology, its capabilities, characteristics, and limitations and to develop insights useful in coping with social, economic, political, as well as purely technical problems. An introduction to modeling, digital computers, and control systems. Required writing assignments relating to current trends and treatment of technological problems. May not be used as part of senior programs. (Available for General Education, Lifelong Learning)

ECE 101/L. Introduction to Electrical Engineering and Lab (1/1)
Corequisite: ECE 101L. A Freshman orientation course for the Electrical Engineering Program, the profession, and an orientation to the university. Word processing, spreadsheet, and presentation software along with computer aided design and analysis tools are integrated into the course. One hour lecture-discussion; three hours lab per week.

ECE 196A-Z. Experimental Topics Courses in Electrical Engineering (1-4)

ECE 206/L. Computing for Electrical Engineers and Lab (2/1)
Prerequisite: MATH 150A. Corequisite: ECE 206L. Introduction to computer programming with emphasis on ECE problem solving. Major topics include problem solving, algorithm development, hardware integration, and programming in NQC and C++. Two hours lecture per week; one three-hour lab per week. (Available in General Education, Lifelong Learning if required by major.)

ECE 240. Electrical Engineering Fundamentals (3)
Prerequisite: PHYS 220B/L; MATH 250. Recommended Corequisite: MATH 280; ECE 240L. Introduction to the theory and analysis of electrical circuits; basic circuit elements including the operational amplifier; circuit theorems; dc circuits; forced and natural responses of simple circuits; sinusoidal steady state analysis and the use of a standard computer aided circuit analysis program. Consideration is given to power, energy, impedance, phasors, frequency response and their use in circuit design. Three hours lecture per week.

ECE 240L. Electrical Engineering Fundamentals Lab (1)
Prerequisite: MATH 250; PHYS 220B/L. Corequisite: ECE 240. Introduction to the practical aspects of electrical circuits, analysis and design. Lab includes experiments on resistive circuits, operational amplifiers, network theorems, 1st and 2nd order circuits, dc meters, passive filters, resonant circuits and RC active filters. Several experiments emphasize the design process. Three hours lab per week.

ECE 296A-Z. Experimental Topics Courses in Electrical and Computer Engineering (1-4)

Upper Division

ECE 320/L. Theory of Digital Systems (3/1)
Prerequisite: MATH 150B. Corequisite: ECE 320L. Introduction to digital systems. Topics treated include: number systems, binary codes, Boolean algebra, combinational logic design, logic minimization techniques, sequential circuits design, arithmetic operations, data transfers using register transfer notation, memory devices, digital system organization and digital subsystems design. Three hours lecture; one three-hour lab per week.

ECE 340/L. Electronics I and Lab (3/1)
Prerequisite ECE 240. Corequisite: ECE 340L. Preparatory: ECE 240L. Recommended Corequisite: ECE 350. Linear, piecewise-linear, and nonlinear models for active devices and their interaction with passive network elements. Characteristics and behavior of operational amplifiers, diodes and transistors. Small signal amplifiers and their analysis at low, midband and high frequencies. Three hours lecture; one three-hour lab per week.

ECE 350. Linear Systems I (3)
Prerequisites: ECE 240; Math 280. Systematic development of linear system response models in both the time and frequency domains. Concentrates on continuous system models. Techniques developed include Laplace transform, Fourier analysis, impulse response, convolution, and state variables for continuous linear systems.

ECE 351. Linear Systems II (3)
Prerequisite: ECE 350. Continuation of ECE 350, with concentration on discrete system models. Techniques developed include Z-transforms, Fourier Analysis, impulse response, convolution, and state variables for discrete linear systems.

ECE 370. Electromagnetic Fields and Waves I (3)
Prerequisite: ECE 240; Math 280. Analysis of vector fields. Applications to: electrostatic, magnetostatic and quasi-static systems; dielectric magnetic and conducting materials; and electromagnetic waves and transmission lines. Introduction to the practical aspects of waveguiding systems: stripline, microstrip and coaxial transmission lines and rectangular waveguides. Introduction to the basic microwave measurements and techniques: impedance matching, network analyzers, antenna impedance and pattern measurements and computer controlled instrumentation. Culminating in a design project. One three-hour lab per week.

ECE 370L. Microwave Lab (1)
Prerequisite: ECE 240L. Corequisite: ECE 370. Introduction to the practical aspects of waveguiding systems: stripline, microstrip and coaxial transmission lines, and rectangular waveguides. Introduction to basic microwave measurements and techniques: impedance matching, network analyzers, antenna impedance and pattern measurements and computer controlled instrumentation. Culminating in a design project. One three-hour lab per week.

ECE 396A-Z. Experimental Topics Courses in Electrical and Computer Engineering (1-4)

ECE 400AA-AC. Engineering Design Clinic I (1-3)
Group design experience involving teams of students and faculty working on the solution of engineering design problems submitted by industry and government agencies.

ECE 400BA-B-C. Engineering Design Clinic II (1-2-3)
Prerequisite: ECE 400A. Continuation of ECE 400A.

ECE 410/L. Electrical Machines and Energy Conversion and Lab (3/1)
Prerequisite: ECE 240. Recommended Corequisite: ECE 410L. Phasor analysis of electric circuits. Study of single-phase and 3-phase power systems. Design of magnetic circuits and study of magnetic materials and their losses. Modeling, voltage regulation and efficiency of single-phase and 3-phase transformers. Electromechanical energy conversion, force and voltage induced by magnetic fields. Rotating machinery modeling and analysis. Induction motors, synchronous generators and direct current motors. Design examples and modeling of rotating machinery using software such as: Matlab, Fortran, Excel, Simulink and C. Three hours lecture; one three-hour lab per week.

ECE 411. Electric Power Systems (3)
Prerequisite ECE 350. Recommended Corequisite: ECE 410. Review of basic principles such as complex power, nuclear, hydroelectric and fossil power plan generation. Transmission line parameters, flux linkages, impedance, line capacitance. Design of transmission lines, V-I relationships, wave analysis, models and power handling capabilities. Transformer and generator analysis at the power systems level. Per unit system analysis. Two port analysis and design of power transmission lines. Use of software such as: Matlab, C, Visual Basic and Excel for the simulation, design and homework.

ECE 412. Power Electronics (3)
Prerequisite: ECE 340. Recommended Corequisite: ECE 410. Overview of power semiconductor switches such as diodes, thyristors, mosfets, GTO, and IGTO. Trigonometric Fourier analysis of classic waveforms used in power electronics. Study of line-frequency phase-controlled rectifiers and inverters, switch-mode dc-ac inverters, dc-dc switch-mode converters, resonant converters zero-voltage and zero-current. Analysis of pulse width modulation used in inverters. SPICE design and modeling of most circuits.

ECE 420. Digital Systems Design with Programmable Logic (3)
Prerequisite: ECE 320. Designed to cover and compare a variety of programmable logic devices with design examples to show their applications. Emphasizes the implementation of digital systems with programmable logic devices and it uses VHDL in design description and Maxplus II software in design simulation and verification.

ECE 422. Design of Digital Computers (3)
Prerequisite: ECE 320. Structure and operation of a stored-program general-purpose digital computer. Design of computer hardware modules: arithmetic-logic units, control units, input-output units, memories. Basic organizations of digital computers. Fault diagnosis and fault tolerant design of digital systems.

ECE 422L. Design of Digital Computers Lab (1)
Prerequisite: ECE 320 Corequisite: ECE 422. Laboratory companion course for ECE 422. The structure and operation of a stored-program general-purpose digital computer. Design of computer hardware modules: arithmetic-logic units, control units, input-output units, memories. Basic organizations of digital computers.

ECE 425/L. Microprocessor Systems and Lab (3/1)
Prerequisite: ECE 320/L. Corequisite: ECE 425L. Studies of microprocessor architectures and microcomputer systems. Basic microprocessor software consideration and assembly language programming. Microcomputers system design considerations, applications, and design with a microcontroller.

ECE 435/L. Mechatronics and Lab (2/1)
Prerequisites: ECE 240L. Corequisite: ECE 435L. Recommended Corequisite: ME 335 or ECE 320, 350. Machine and process control applications, data acquisition systems, sensors and transducers, actuating devices hardware controllers, transducer signal processing and conditioning. Two hours lecture; one three-hour lab each week. (Crosslisted with ME 435/L)

ECE 440/L. Electronics II and Lab (3/1)
Prerequisite: ECE 340/L. Corequisite: ECE 440L. Continuation of ECE 340. Power amplifiers, feedback amplifiers, stability, oscillators, RC active filters and switched-capacitor circuits. Three hours lecture; one three-hour lab per week.

ECE 442/L. Digital Electronics and Lab (3/1)
Prerequisites: ECE 320/L; 350; 340. Corequisite: ECE 442L. Models of electronic nonlinear devices and their analysis. The limitations of digital circuits. Design of logic gates and of memory elements and registers. System considerations with reference to various technologies, including NMOS, PMOS, CMOS, RTL, DTL, TTL, IIL and ECL. Study of VLSI. Three hours lecture; one three-hour lab per week.

ECE 443/L. Pulse and Waveshaping Circuit Design and Lab (3/1)
Prerequisites: ECE 320/L; 340/L; 350. Recommended Corequisite: 443L. Waveshaping circuits with application to data acquisition and instrumentation. Design of multivibrator circuits. Design of analog to digital and digital to analog interfaces. Three hours lecture; one three-hour lab per week.

ECE 445. Introduction to Solid State Devices (3)
Prerequisite: ECE 340. Electric and magnetic properties of materials are examined with emphasis on engineering applications. Typical devices which are considered include ohmic and non-ohmic contacts, voltaic cells, PN junction devices, ferroelectric energy converters, ferrite devices and integrated circuits.

ECE 450. Probabilistic Systems in Electrical Engineering-Design and Analysis (3)
Prerequisite: ECE 350. Develops and demonstrates techniques and models useful for solving a wide range of problems associated with the design and analysis of various probabilistic systems in electrical engineering application. These include radar, communication systems, sonar, control systems, information theory, computer systems, circuit design, measurement theory, vulnerability analysis, and propagation.

ECE 451. Real-Time Digital Signal Processing (2)
Prerequisite: ECE 351. Corequisite: ECE 451L. Real-time digital signal processing using DSP processors; architecture, instruction set, sampling, filtering, fast fourier transform, and other applications. Available for Graduate Credit.

ECE 451L. Real-Time Digital Signal Processing Laboratory (1)
Prerequisite: ECE 351. Corequisite: ECE 451. Real-time digital signal processing using DSP processors; architecture, instruction set, sampling, filtering, fast fourier transform, and other applications. Two hours of lecture and four hours of laboratory per week. Available for Graduate Credit.

ECE 455. Mathematical Models in Electrical Engineering (3)
Prerequisite: ECE 350. Advanced topics in Mathematics in the areas of Complex Variables, Linear Algebra, Partial Differential Equations and Series Solutions to Differential Equations are discussed. These mathematical tools are used to model and solve Electrical Engineering related problems in the areas of Circuits, Controls, Electromagnetics, Solid State and Communication Theories.

ECE 460/L. Introduction to Communication Systems and Lab (3/1)
Prerequisite: ECE 350. Corequisite: 460L. Recommended Corequisites: ECE 351; 450. Introduction to information transmission. Analog communication systems. AM. DSB, SSB, VSB, FM, and PM. Digital Communication systems. PCM, DPCM, Delta Modulation, ASK, FSK, PSK, and DPSK. Frequency–division and Time-division multiplexing techniques. Superheterodyne receiver. Three hours lecture; one three-hour lab per week.

ECE 480/L. Fundamentals of Control Systems and Lab (3/1)
Prerequisite: ECE 350. Corequisite: ECE 480L. Review of the relations between transient responses, systems transfer functions, and methods

of specifying system performance. Analysis and synthesis of feedback control systems by means of root-locus methods. Nyquist diagrams, phase-gain-frequency diagrams. Use of compensating networks to optimize control system performance. Three hours lecture; one three-hour lab per week.

ECE 492. Senior Design Project-Electrical I (2)

Prerequisite: Successfully complete two 400 level ECE courses. Recommended Corequisite: Enrollment in a 400-level electrical and computer engineering senior lab course with at least 2.5 design units. The Design of a complex engineering project is undertaken requiring the integrated application and extension of science, engineering, economic and social concepts. Ethics, written and oral communication skills and methods of technical problem-solving will be addressed. Students participate in both group and individual projects through to completion. Requires completion of an acceptable proposal for a design project under faculty supervision with substantial progress toward the project completion. May not be used for graduate credit.

ECE 493. Senior Design Project-Electrical II (1)

Prerequisite: ECE 492. Continuation of ECE 492. Issues concerning science, engineering, economic and social concepts, as well as ethics, written, oral communication and methods of technical problem solving will be further treated. Completion of the design project are under faculty supervision culminating in a comprehensive report. Students who enter their projects in an appropriate technical paper contest are excused from submission of a comprehensive report. May not be used for graduate credit.

ECE 494. Academic Internship A-C (1-3)

Prerequisites: Sophomore, Junior, Senior or Graduate Standing in the Department of Electrical and Computer Engineering, prior approval of the department chair, and in good standing as a matriculated student. Supervised practical professional experience relevant to the field of study in approved public or private organizations. Industrial supervisor and faculty sponsor performance evaluations and student self assessment are required. A final report written by students describing the work accomplished and knowledge and skills acquired are required. Units earned may not be used to fulfill major program requirements. Any combination of internship courses "A", "B", C", cannot exceed six units total. Available for Graduate Credit.

ECE 496A-Z. Experimental Topics Courses in Electrical and Computer Engineering (1-4)

ECE 498A-X. Supervised Individual Projects (1-3)

Studies in selected areas of Electrical Engineering with course content to be determined.

ECE 499A-C. Independent Study (1-3)

Undergraduate/Graduate Courses

ECE 501. Introduction to Biomedical Engineering (3)

Preparatory: Senior or graduate standing. Characterization and properties of anatomical and physiological elements in engineering applications will be studied. Also includes the design of basic medical instrumentation.

ECE 503. Biomedical Instrumentation (3)

Preparatory: Senior standing. Covers the design of medical instrumentation, specifically bios nesors, therapeutic and prosthetic devices, biopotential amplifiers, and lab instrumentation. Applications to associated human organ systems are be covered. Multidisciplinary analysis, design, and simulation of bioengineering instrumentation are studied and implemented using computer methodology and techniques from engineering, physics, and mathematics. (Crosslisted with ME 503)

ECE 524. FPGA/ASIC Design Methodology and Optimization Using VHDL (3)

Prerequisites: ECE 320/L, ECE 420, Corequisite: ECE 524L. This course covers the top down design methodology for FPGA and ASIC using VHDL. Hardware Description Language, VHDL modeling, simulation and synthesis tools are utilized to elaborate the material covered throughout the course. XILINX (Virtex series) and ACTEL (SX and AX series) FPGA architectures and design methodologies are studied. Several sample designs are targeted and tested for each FPGA technology. ASIC design flow and design optimization techniques are discussed. ASIC design constraint file and test benches will be also studied by their applications to some samples designs. The use of FPGAs in space and military applications and their reliability issues are discussed. Lecture: three hours per week.

ECE 524L. FPGA/ASIC Design Lab (1)

Prerequisites: ECE 320L, ECE 420. Recommended Corequisite: ECE 524. The lab accompanying the course covers modeling of digital systems and electronic circuit design hierarchy and the role of methodology in FPGA/ASIC design. Hardware Description Language, VHDL, simulation, and synthesis tools are utilized to elaborate the material covered throughout the course. The lab introduces the systematic top-down design methodology to design complex digital hardware such as FPGAs and ASICs. FPGA and ASIC design flow as well as design optimization techniques are discussed. For FPGAs, Xilinx Virtex and Actel SX architecture are covered. Individual and group projects are assigned to students. Three hour lab per week.

ECE 525. System On Chip Design (3)

Prerequisites: ECE 420 and ECE 425. Corequisites: ECE 525L. Introduction to system on chip design methodology that includes the study of NIOS and ARM architectures, Avalon switch fabric, memory, real-time operating system (RTOS), peripheral interface and components, and contemporary high-density FPGAs.

ECE 525L. System On Chip Design Laboratory (1)

Prerequisites: ECE 420 and ECE 425. Corequisite: ECE 525. This laboratory course reinforces the system-on-chip design concept developed in the lecture course. It focuses on software development and hardware verification of Nios II systems using Altera software tools and Nios development boards.

ECE 526/L. Verilog HDL for Digital Integrated Circuit Design and Lab (3/1)

Prerequisite: ECE 320/L. Corequisite: ECE 526L. This course covers the use of Verilog Hardware Description Language for the design and development of digital integrated circuits, including mask-programmed ASIC's and FPGA's. Hierarchical top down vs. bottom up design, synthesizable vs. non-synthesizable code, verification, hardware modeling, simulation system tasks, compiler directives and subroutines are all covered and illustrated with design examples. Lab exercises emphasize use of professional compilation and simulation tools for debugging and verification. Three hours lecture; one three-hour lab per week.

ECE 527. Application Specific Integrated Circuit Development (3)

Prerequisite: ECE 526/L. Corequisite: ECE 527L. A course covering concepts, techniques and methodologies used in modern VLSI design automation. The course builds on the foundation of hardware description languages and simulation taught in ECE 526 and proceeds to logic synthesis, static timing analysis, formal verification, test generation/fault simulation, and physical design, including floor planning, placement, routing, and design rule checking.

ECE 527L. Electrical and Computer Engineering (1)

Prerequisites: ECE 526/L. Corequisite: ECE 527. Laboratory companion course for ECE 527. Application of electronic design automation

tools for logic synthesis, static timing analysis, formal verification, test generation/fault simulation, and physical design, including floor planning, placement, routing, and design rule checking.

ECE 545. Solid State Devices (3)

Prerequisite: ECE 445, or instructor consent. In-depth study of semiconductor materials and solid state devices. Energy bands and charge carriers, excess carriers in semiconductors, P-N junctions, bipolar junction transistors (BJTs), field effect transistors (FETs), integrated circuits (IC) will be covered in detail. Practical aspects of dielectric and magnetic devices are also treated.

ECE 546. Very Large Scale Integrated Circuit Design (3)

Prerequisite: ECE 442. Survey of VLSI technology and very large scale integrated systems. Problems which occur when ordinary circuits are replicated to involve millions of devices. CMOS technology, design styles up to the point of submission for fabrication. Computerized methods with high density circuits with optimized speed and power consumption. Students perform simple layouts and simulations suitable for extension to a very large scale.

ECE 561/L. Digital Communications Systems (3/1)

Prerequisites: ECE 450; 460. Recommended Corequisite: ECE 561L. Introduction to digital communications systems. Topics include: baseband transmission, bandpass modulation and demodulation, link budget analysis, an introduction to channel codes, and performance analysis for digital communication systems. Three hours lecture; one three-hour lab per week

ECE 562. Data Communication Networks (3)

Prerequisite: ECE 450. Basic analysis and design considerations in data communication networks, including satellite communications networks, computer networks, packet radio networks, and local area networks. Covers network topology, routing and flow control, performance tradeoffs, and queuing analysis of multiple access techniques. Advantages, recent developments, and applications of fiber optics.

ECE 571. Electromagnetic Fields and Waves II (3)

Prerequisite: ECE 370. Analysis of time-varying electromagnetic fields. Maxwell's equations, waves in ideal and lossy matter. Impedance concept, duality, equivalence principle, energy flow, reciprocity theorem. Transmission lines, wave-guides, resonators, surface waves, antennas.

ECE 572. RF and Microwave Active Circuit Design (3)

Prerequisites: ECE 370, 340, or instructor consent. Basic concepts in network parameters and RF/Microwave impedance transformation techniques leading to analysis and design of RF/microwave transistor amplifiers and oscillator circuits using bipolar junction transistors (BJTs) and field effect transistors (FETs) are treated. Basic concepts in noise as well as considerations in gain, power and stability are also included.

ECE 572L. RF and Microwave Active Circuit Design Lab (1)

Prerequisite: 340/L; 370. Recommended Corequisite: ECE 572. Design, construction and testing of microwave passive and active circuits. Introduction to modern CAE and CAD techniques including optimization.

ECE 578. Photonics (3)

Prerequisite: ECE 370. Ray Optics, Wave Optics, Fourier Optics, Electromagnetic Optics, Quantum Optics, Holography, Lasers, Solar Cells, Photonic Semiconductor Materials and Devices, Photonic Integrated Circuits (PICs), Infrared Devices and Circuits, optical waveguides, as well as practical applications of microwaves in combination with lightwaves are included in this course. Theory, analysis and practical design issues of Photonic devices, circuits and systems are addressed.

ECE 580. Digital Control Systems (3)

Prerequisite: ECE 351; 480. Application of z-transform and state variable methods to the analysis and design of digital and sampled-data control systems; the sampling process, data reconstruction devices, stability analysis, frequency response methods, continuous network compensation, digital controllers, z-plane synthesis, state-variable feedback compensation, variable gain methods in non-linear sampled-data system analysis.

ECE 581. Fuzzy Control (3)

Prerequisite: ECE 480. Consists of two parts. 1st part: Introduces basic concepts of fuzzy logic such as fuzzy set, rules, definitions, graphs, and properties related to fuzzification and defuzzification. 2nd part: Introduces fuzzy logic control and its application to control engineering; discusses the basic fuzzy logic controllers, the relevant analytical issues, and their roles in advanced hierarchical control systems.

Graduate Courses

Note: 300-level courses in Electrical and Computer Engineering do not carry credit for a Master's degree in Electrical Engineering.

ECE 602. Biomedical Engineering I (3)

Prerequisite: Instructor consent. Engineering approach to modeling of the mechanisms of signal conduction in the nervous system, the neuromuscular interface, and selected sensory organs. Individual analogous engineering or physical models of the biological processes are developed, presented, and discussed, accompanied by written reports.

ECE 603. Biomedical Engineering II (3)

Prerequisite: Instructor consent. Consideration of bioengineering applications using engineering techniques. Problems are analyzed by the class and solutions proposed. Both individual and team development of the solutions proceed.

ECE 610. Fault Analysis in Power Systems (3)

Prerequisite: ECE 411 or Instructor consent. Geared toward the study of electrical faults in power systems. The following major topics are emphasized: YBUS and ZBUS matrices development for a power systems network. Symmetrical Components techniques. Positive, Negative, and Zero sequence network analysis. Unsymmetrical faults. Study of power systems stability. Overview of protective relaying.

ECE 611. Power Distribution Systems (3)

Prerequisite: ECE 410. Recommended Corequisite: ECE 411. Design of subtransmission lines and distribution substations. Primary and secondary systems, voltage drop and power loss calculations. System voltage regulation, protection and reliability. Markov process analysis, development of the state-transition model to determine the steady-state probabilities, and the zone-branch technique discussion.

ECE 612. Selected Topics in Power Systems (3)

Prerequisite: Instructor consent. Advanced study of topics of current interest in the field of Electric Power Systems. Topics include: The Power Flow Problem, Economic Dispatch, Power Systems Stability, and Electric Transients. Recent developments and applications are reviewed.

ECE 620. Advanced Switching Theory (3)

Prerequisite: ECE 320. Detailed study of synchronous and asynchronous circuits, their design, characterization, optimization, and decomposition. Issues involving combinational and sequential hazards and how to remove them. A detailed study of race free and critical race free asynchronous design. Non-boolean logic design such as galois logic, and many value logics and algorithmic state machine (ASM) designs. VHDL implementation of combinational and sequential circuits.

ECE 621. Computer Arithmetic Design (3)

Design analysis of high speed adders, subtractors, multipliers and dividers of digital computers, integrated circuits and digital devices. Signed-digit adder/subtractor, multiplicative and division algorithms

and hardware. Iterative cellular array multipliers and dividers. Floating point arithmetic processor, pipelined arithmetic.

ECE 622. Digital Systems Structure (3)
Prerequisite: Instructor consent. Studies of digital systems architectures primarily from the hardware viewpoint. Techniques and design methods employed for general purpose computers. Unconventional and special-purpose computers, such as parallel processors, associative processors, pipeline processors, array processors, list processors, hardware compilers.

ECE 623. Diagnosis and Reliable Design of Digital Systems (3)
Prerequisite: ECE 620. Basic theory and techniques for testing digital circuits and systems and design techniques for fault tolerant and early diagnosable systems. Test generation for combinational and sequential logic circuits, checking experiments. Gate level digital simulation, and its application to fault diagnosis. Design techniques using static and dynamic redundancy for reliable systems. Design for testability (DFT) techniques and easily testable FPGA and ASICS. The use of DFT tools for test generation, fault diagnosis, fault coverage, design for testability, reliability computations, and test synthesis. Students participate in VHDL class projects using the EDA software tools in the EDA and ASIC design lab.

ECE 624. Digital Systems Design Automation and VHDL Modeling (3)
Prerequisite: ECE 623. Automated design techniques, verification of digital systems. Problems related to physical packaging, partitioning, assignment, placement and interconnection of elements of digital circuits, i.e. ASICS, FPGA, and CPLD's. VHDL modeling, simulation and synthesis of design automation algorithms. Top-down design of digital systems. Class projects consist of VHDL modeling of some design automation algorithms.

ECE 625. Microprocessor Applications in Engineering (3)
Prerequisite: ECE 425. Microprocessor system architectures, programmable peripherals and applications at the system level. Microprocessor-based system design and development techniques.

ECE 629A-C. Seminar in Digital Systems and Components (1-3)
Prerequisite: Instructor consent. Advanced studies of topics of current interest in the field of digital systems and components engineering. Consists in part of an intensive study of selected papers from current literature.

ECE 635. Error Detecting and Correcting Systems Design (3)
Preparatory: Instructor consent. Theory and application of error detecting and correcting codes. Encoding, decoding and error correcting techniques. System control with emphasis on hardware implementation.

ECE 637. Pattern Recognition (3)
Prerequisite: ECE 450. Design and analysis of linear and sequential classifiers in engineering systems. Decision theories, sequential learning, feature selections and transformations. Applications in diverse fields such as medical diagnoses, speech recognition, part defect detections and scene matching.

ECE 639. Robotic Sensing and Computer Vision (3)
Prerequisite: Instructor consent. Design and development of robotic systems with sensing elements for closed-loop controls. Sensing by vision, proximity and touch. Development of image processing and pattern recognition techniques for object recognitions and location, size and shape determinations using microprocessor-based systems. Robotic trajectory, collision avoidance, path planning and teaching.

ECE 640. Modern Electronic Techniques (3)
Prerequisite: Instructor consent. Advanced electronic design techniques such as switching regulators and switching amplifiers are covered. Also included is thermal effects, manufacturing defects; finally, advanced audio design is emphasized. Computerized design techniques are used.

ECE 642. RF Electronics Design (3)
Prerequisite: Instructor consent. Design of RF amplifiers and tuners is emphasized, covered are AM/FM RF amplifiers, AM/FM tuners. AM/FM detectors. Radar applications are considered: TV circuits including UHF/VHF tuners, video amplifiers, sync. vertical and horizontal circuits. Automatic control circuits are also covered. Phase lock loop techniques are introduced with emphasis on RF applications including frequency synthesis techniques using digital techniques.

ECE 648. Electrical Network Theory (3)
Prerequisite: Instructor consent. Analysis and synthesis of passive networks, using two port theory, Matrix, signal flow graphing, and computerized techniques in active network design with emphasis on signal processing.

ECE 649. Active Network Synthesis (3)
Prerequisite: Instructor consent. Frequency and time domain approximations, introduction to active circuits, modern design of active filters of computerized techniques in active network design with emphasis on signal processing.

ECE 650. Random Processes (3)
Prerequisite: ECE 450. Random systems, stationary and ergodic processes, spectral representation. Prediction, filtering, and estimation of digital and continuous system. Applications to control and communication.

ECE 651. Digital Signal Processing I (3)
Prerequisite: ECE 351. Difference equations, state equations, and frequency-domain analysis of discrete-time systems. Fast Fourier Transform algorithms. Tellegen's theorem and sensitivity analysis. Network structures for digital filters. Digital filter design.

ECE 652. Digital Signal Processing II (3)
Prerequisite: ECE 651. Preparatory: ECE 351. Approximation of filter specifications. Advanced digital filter design techniques. Implementation issues for digital filters, sensitivity and quantization noise. Decimation and interpolation of discrete-time signals. Fast number theory transforms. Two-dimensional digital signal processing.

ECE 658. Signal Detection and Estimation Theory (3)
Prerequisite: ECE 650. Classical detection theory, classical estimation theory, review of representations for random processes, signal detection, signal estimation, linear estimation and filtering applications of detection and estimation theory to radar, modern radar synthesis by decision-theoretic methods.

ECE 659. Information Theory and Coding (3)
Prerequisite: ECE 450, 561. Modeling of information sources and channels. Discrete channels with and without memory, channel capacity, noiseless and noisy channels. Error correcting and detecting codes, source codes, including algebraic and convolution codes, their construction and efficiency.

ECE 660. Modulation Theory and Coding (3)
Prerequisites: ECE 460; 650. Covers channel capacity, channel coding, linear block codes, cyclic codes, convolution coding and decoding algorithms. Modulation and coding tradeoff, spread spectrum techniques, multiplexing, encryption and decryption are also included.

ECE 661. Communications Engineering (3)
Prerequisite: ECE 650. Covers the design and performance of communication systems for particular channel models, with emphasis on the I-Q transmitter/receiver model. Bandwidth-limited channels, fading multipath channels, propagation effects, and colored noise are considered. Also covers the performance of analog communication systems in additive white Gaussian noise.

ECE 665. Radar Systems (3)
Prerequisite: ECE 650. Covers pulse and CW radars and target cross-section, receiver noise and losses, signal detection and matched

filters, pulse compression, target parameter estimation, clutter and interferences.

ECE 666. Fiber-Optic Communications (3)
Prerequisite: ECE 460. Comprehensive description of the technology of fiber optical communication systems. Balanced discussion between component operation and system design considerations. Performance parameters and fabrication problems, lasers, LED modulation and detector responses. Link budget analysis. Advantages of fiber optics, recent developments and applications.

ECE 666L. Fiber Optic Communication Lab (1)
Prerequisites: ECE 460/L. Corequisite: ECE 666. The lab accompanying ECE 666 course covers fiber optic communication design, measurements and simulations. This includes numerical aperture, fiber attenuation, power distribution in single mode fibers, mode distribution in multimode fibers, fiber coupling efficiency and Connectors / splices losses. Design, construction and simulation of WDM communication system components are also covered. Individual and group projects are assigned to students in the Lab: three hours per week.

ECE 669. Advanced Topics in Communications/ Radar (3)
Prerequisite: ECE 650. Presentation of recent topics in communications and radar, using selected papers from current literature as the basis.

ECE 671. Microwave Engineering (3)
Prerequisite: ECE 471. Application of the concepts of modern network theory to waveguiding systems. Impedance transformation and matching, scattering matrix, propagation in non-isotropic media, passive microwave devices, electro magnetic resonators, measurements in microwave systems.

ECE 672. Advanced Microwave Circuit Design (3)
Prerequisite: ECE 572. Preparatory: Instructor consent. Advanced microwave circuit design and in-depth analysis of microwave transistor amplifiers, microwave oscillators, detectors, mixers, microwave control circuits and microwave integrated circuits (MIC's) are included in this course. Practical design issues of microwave circuits are emphasized. Materials, mask layout and fabrication techniques of microwave integrated circuits (MIC's) are also treated.

ECE 673. Microwave Semiconductor Devices (3)
Prerequisite: ECE 545. Preparatory: Instructor consent. Physical principles and applications of microwave solid-state devices. Devices to be considered: Varactors, p-i-n diodes, mixer and detector diodes, avalanche transmit-time devices (IMPATT, TRAPATT), BARRITT, microwave transistors, FETS, transferred electron (Gunn) devices. Applications: frequency multipliers, microwave switches, oscillators and amplifiers.

ECE 674. Antenna Engineering (3)
Prerequisite: ECE 471. 1st course in the theoretical analysis and design of antennas. Review of fundamental concepts beginning with Maxwell's Equations, discussion of significant antenna parameters, elementary antennas, apertures, arrays, traveling-wave antennas, and antennas based upon geometrical optics.

ECE 675. Seminar in Applied Electromagnetics (3)
Prerequisite: ECE 674. Preparatory: Instructor consent. Advanced study of topics of current interest in the field of applied electromagnetics. Consists, in part, of an intensive study of selected papers from the current literature. Participants are expected to prepare bibliographies and present oral and/or written reports.

ECE 676. Numerical Techniques in Applied Electromagnetics (3)
Prerequisite: ECE 674. Preparatory: Instructor consent. Study of current techniques employed to solve practical electro-magnetic field problems. Emphasis are placed upon antenna and radar cross section problems using moment methods. Students are expected to use the techniques treated to solve problems using a digital computer.

ECE 681. Non-Linear Control Systems (3)
Prerequisite: ECE 480. Analysis of non-linear systems by means of describing functions and phase-plane diagrams. Stability studies by means of the 2nd method of Liapunov, and Popov's Methods.

ECE 682. State Variables in Automatic Control (3)
Prerequisite: ECE 480. Application of state-space methods to the analysis and synthesis of feedback control systems; matrices, vectors and vector spaces, coordinate transformations, solution of the vector matrix differential equation, stability, controllability and observability, optimal control systems.

ECE 683. Optimal Control (3)
Prerequisite: ECE 682. Applications of variational methods, Pontryagin's Maximum Principle, and dynamic programming to problems of optimal control theory; iterative numerical techniques for finding optimal trajectories.

ECE 684. Stochastic Control (3)
Prerequisites: ECE 682; 650. Control of linear, discrete-time and continuous-time stochastic systems; statistical filtering, estimation and control with emphasis on the Kalman filter and its applications; Wiener filtering.

ECE 695A-Z. Experimental Topics Courses in Electrical Engineering (1-4)

ECE 696. Directed Graduate Research (1-3)
(Credit/ No Credit Only)

ECE 697. Directed Comprehensive Studies (3)
(Credit/ No Credit Only)

ECE 698. Thesis or Graduate Project (1-6)

ECE 699A-C. Independent Study (1-3)