# Graduate Student Guide

Department of
Electrical & Computer Engineering

**Fall 2024**

**Note: All Electrical & Computer Engineering graduate students are expected to read this guide before consulting academic advisors.**

# CONTENTS


| | |
|---|---|
| **Introduction** | Page 3 |
| **Graduate Programs** | Pages 4-5 |
| **Certificate Programs** | Pages 6-8 |
| **<u>Electrical Engineering Major</u>** | Pages 9-16 |
| • **Degree Requirements:** | |
| ➢ M.S. in EE non-thesis option | Pages 10 |
| ➢ M.S. in EE thesis option | Pages 11-12 |
| ➢ Ph.D. in EE | Pages 12-13 |
| • **Policies** | Pages 14-16 |
| **<u>Computer Engineering Major</u>** | Pages 17-25 |
| • **Degree Requirements:** | |
| ➢ M.S. in CE non-thesis option | Pages 18-19 |
| ➢ M.S. in CE thesis option | Pages 19-20 |
| ➢ Ph.D. in CE | Pages 21-22 |
| • **Policies** | Pages 23-25 |
| **Area courses for PhD major/minor requirements** | Page 26 |
| **<u>M.S. in Engineering Artificial Intelligence</u>** | Pages 27-30 |
| **Teaching/Graduate Assistant/Tuition Information** | Pages 31-33 |
| **Curricular Practical Training** | Page 34 |
| **Facilities** | Pages 35-39 |
| **Faculty** | Pages 38-40 |
| **Course Listing** | Pages 41-55 |
| **Outside of Dept. Course List for CE Majors** | Page 56 |

# INTRODUCTION

This *Guide* has been written to provide general information to graduate students in the Department of Electrical and Computer Engineering. It is intended to give some assistance and guidance to students regarding routines and other procedures involved in the pursuit of their program. This *Guide* is intended to be an informal one. It supplements, but does not replace, the official University *Graduate Bulletin* as a source of information.

The choice of a program to a large degree is the responsibility of the student. The members of the graduate committee are available for consultation on any point in this *Guide* that may be unclear to the student.

Students may undertake an independent project under the direction of a faculty member, who often becomes the student's best source of advice on professional, academic, and financial support matters. Students should select their research advisor within the first year of the program but only after a careful canvass among the professors in their field of interests.

# GRADUATE PROGRAMS

## M.S. AND PH.D. DEGREES

The Department offers graduate programs leading to the M.S. and Ph.D. Degrees in Electrical or Computer Engineering, and M.S. in Engineering Artificial Intelligence. Graduate Programs are tailored to the needs of each student and provide strong analytical background for studies of advanced engineering problems. Ample opportunities exist for students to initiate independent study and to become involved in active research programs, both experimental and theoretical.

## CHANGE OF MAJOR POLICY

A change of major from Electrical Engineering to Computer Engineering or vice versa will only be permitted once in a student's graduate career (provided the student meets degree requirements and obtains Department approval). Students cannot return to their original major once they have completed the change.

## AREAS OF EMPHASIS

Areas of emphasis in current research and instruction are:

(1) Communications & Signal Processing
(2) Computer Engineering
(3) Power Engineering
(4) Semiconductor Devices and Quantum Electronics
(5) Circuits and VLSI

Specialties that fall under one or more of the above categories include: VLSI, Image Processing, Computer Vision, Integrated Circuit Fabrication, Novel Electronic and Photonic Devices, Microgrids, Power System Optimization and Modeling, Power Electronic Devices and Circuits, Digital Communication, Cyber Security, Biomedical Electronics, Computer-Aided Design, Computer Networks, Parallel Processing, Fault-Tolerant Computing, Microprocessors, Robotics, Network Theory, Optical Signal Processing, and Fiber Optic Sensors. Theoretical and experimental programs reflecting these areas are currently underway and students are encouraged to actively participate in these efforts. Outlined below is an overview of the Department's research areas.

## COMMUNICATIONS AND SIGNAL PROCESSING

Subject areas of current interest include mobile, wireless and personal communications; high speed data and computer communication networks; communications traffic; data compression; coding and modulation techniques; inter-connection networks and high speed packet switching; digital communication; detection and estimation; statistical signal processing; spectrum estimation; image analysis and processing; computer vision.

## COMPUTER ENGINEERING

The goal of computer engineering in the ECE Department is to provide a balanced view of hardware and software issues. The expertise in the program include parallel and/or high-performance computer architecture, embedded microprocessor system design, fault tolerant computing, digital communications and signal processing, parallel and distributed computing, computer networks, computer vision, artificial neural networks and software engineering.

**POWER ENGINEERING**

Power engineering deals with various aspects of the modern and emerging power systems including power electronics hardware, power grids, and renewable energy technologies. The Program covers a combination of fundamental and applied courses in power system analysis, power system dynamics, microgrids, power system optimization, modeling and analysis of photovoltaic power systems, probabilistic methods in power and energy, power system economics, electricity market, artificial intelligence for energy systems, quantum engineering, fundamentals of power electronic devices and circuits, basic converter modeling/control, EMI filtering in power converters, power module packaging and integration, and power-electronics-converter applications in motor drives & renewable energy systems.

**SEMICONDUCTORS DEVICES AND QUANTUM ELECTRONICS**

The program includes topics pertinent to solid-state electronics, electromagnetics and optics ranging from a study of the fundamental electronic processes in solids through a description of the mechanism which yields useful devices to a study of the design simulation, and fabrication of integrated circuits. The program's scientific interests center on physics, characterization and development of optoelectronic devices and systems. Over the past several years, major efforts were focused on the studies of physics of semiconductor lasers and detectors. Additionally, the Department has a strong experimental effort on the development of coherent optical processors, fiber optic sensors and integrated fiber optics.

**CIRCUITS AND VLSI**

The program in the Circuits and VLSI area addresses problems associated to modeling, simulation, design and fabrication of analog, digital, and mixed-signal integrated circuits. Analog and mixed-mode integrated circuit (IC) devices have important applications in many fields including avionics, space technology, and medical technology. The Department offers basic and advanced courses covering the following subjects: integrated circuit technology, device modeling, software tools for circuit design and simulation, analog circuit design, VLSI circuits, testing of analog and digital ICs, design automation for analog, digital and mixed-mode circuits, VLSI systems for communications and signal processing.

**RELATIONS WITH INDUSTRY**

The Department has joint efforts and close contact with many industrial firms. Areas include VLSI, CAD, Controls, Digital Signal Processing, Telecommunications, Power systems, Fiber Optic Sensors and Engineering Education.

# CERTIFICATE PROGRAMS

Matriculated students only. Admission to the certificate programs is limited to students enrolled in either the MS or PhD programs in the Department of Electrical and Computer Engineering. Students may receive the certificate if they have no more than 12 graduate credits in the Department as of the start of Spring 2018.

To apply for the Certificate Program, a student must complete the "Permission to Enroll in a Secondary Certificate Program" form (which requires signatures) from the Graduate School website, and submit it within the first week of the semester when they start the certificate.

*Students are permitted to use up to 6 graduate transfer credits toward the certificate with the approval of the Director. These credits must be from an institution authorized to grant graduate degrees by recognized accredited commission. Credits must not have been used to fulfill the requirements for another degree/certificate; credits must not be more than 5 years old at the time the student is admitted to graduate study at SBU; a course listed as both graduate and/or undergraduate level will not be considered for transfer; credits must carry a letter grade of B or higher.*

## 1. Networking & Wireless Communications Certificate

Networking and wireless communications are key technologies in today's technological world. Networks such as the Internet as well as telephone, cable and wireless networks serve to interconnect people and computers in a ubiquitous and cost-effective way. The area of wireless communications has grown rapidly in recent years and has utilized networking technology to be successful. There is a large industrial base involving networking and wireless communications in terms of equipment and software providers, service providers and end users. Moreover, this technology has made the average consumer's life more productive, flexible and enjoyable.

The Stony Brook Certificate Program in Networking and Wireless Communications is designed to give matriculated students validated graduate level instructions in this area of much recent interest. The program can be completed in a reasonable amount of time as it involves only four (4) courses. These are regular Stony Brook graduate level courses taught by Stony Brook faculty. The SUNY approved certificate program can be tailored to the needs of the individual student. Courses used for the certificate program can also be used toward the MS or PhD degree by matriculated students.

To receive the Stony Brook Certificate in Networking and Wireless Communications, a student must complete FOUR required courses as specified below, with at least a B grade in each course.

**At least ONE course from the following:**

- ESE 505: Wireless Communications
- ESE 506: Wireless Network

**At least ONE course from the following:**

- ESE 532: Theory of Digital Communication
- ESE 546: Networking Algorithms and Analysis
- ESE 548: Computer Networks

**In addition to the above, if needed, courses may be selected from:**

- ESE 503: Stochastic Systems
- ESE 504: Performance Evaluation of Communication and Computer Systems
- ESE 522: Fiber Optic Systems
- ESE 528: Communication Systems
- ESE 531: Statistical Learning and Inference
- ESE 536: Switching and Routing in Parallel and Distributed Systems
- ESE 543: Mobile Cloud Computing

- ESE 544: Network Security Engineering
- ESE 547: Digital Signal Processing
- ESE 550: Network Management and Planning
- ESE 552: Interconnection Networks

## 2. Engineering Machine Learning Systems

The Engineering Machine Learning Systems certificate program educates about the mathematical theory, fundamental algorithms, and optimized engineering of computational learning systems used in real-world, big data applications. Students will also study modern technologies used in devising such data systems, including software tools, architectures, and related hardware structures. Comprehensive, hands-on student projects on designing, implementing, and testing real-world learning systems are part of the certificate program. The certificate program includes a total of four courses: three (3) required courses and one (1) elective course.

To receive the Stony Brook certificate in the Engineering Machine Learning Systems, a student must be currently enrolled in an MS or PhD program in the Electrical and Computer Engineering Department and must complete four courses as specified below, with at least a B grade in each course.

| | |
|---|---|
| **Foundations (1 required):** | ESE 503 Stochastic Systems |
| **Fundamental Methods (2 required):** | ESE 588 Fundamentals of Machine Learning<br>ESE 589 Learning Systems for Engineering Systems |
| **Applications (1 out of four electives):** | ESE 568 Computer and Robot Vision<br>ESE 587 Hardware Architectures for Deep Learning<br>ESE 590: Practical Machine Learning and Artificial Intelligence<br>BMI 511/ESE 569 Translational Bioinformatics |

## 3. Engineering the Internet of Things

The Engineering the Internet-of-Things certificate program provides the fundamental principles, popular technologies and optimized engineering of Internet-of-Things applications and systems. Students gain a broad set of skills and knowledge for IoT development and innovation, including sensors and interfaces, RF communication, microcontroller and embedded systems, wireless radios, network protocols, cloud services and security techniques. Students learn how to design, implement and evaluate IoT systems and applications through hands-on projects on popular embedded system hardware. The certificate program includes a total of four courses: three (3) required courses and one (1) elective course.

To receive the Stony Brook certificate in the Engineering the Internet-of-Things, a student must be enrolled in an MS or PhD program in the Electrical and Computer Engineering Department and must complete four courses as specified below, with at least a B grade in each course.

| | |
|---|---|
| **Foundations (1 required):** | ESE 566 Hardware-Software Co-Design of Embedded Systems |
| **Basic Skills and Knowledge (2 required):** | ESE 506 Wireless Network<br>ESE 525 Modern Sensors in Artificial Intelligence Applications |
| **Cloud and Security (1 out of two electives):** | ESE 543 Mobile Cloud Computing<br>ESE 544 Network Security Engineering |

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After completing the necessary courses, students must request/apply for completion of the certificate program on SOLAR or through the Graduate School website.

**Important Note: Students will not be permitted to extend their time in the MS or PhD degree program based on entering the certificate program. The student MUST complete the secondary certificate within the time limit for the original program.**

All questions should be directed to the Graduate Program Director.

# *ELECTRICAL ENGINEERING*

# ELECTRICAL ENGINEERING DEGREE REQUIREMENTS

## I. M.S. in *Electrical Engineering* NON-THESIS OPTION

**Please Note: Full-time M.S. students typically finish the Master's Degree in three (3) semesters.**

1. At least 30 graduate credits with a cumulative and departmental grade point average of 3.0 or better. Among these 30 credits, up to six credits may be taken from combination of ESE 597, ESE 599, or ESE 698.

Only 3 credits of ESE 698 may be used. Any non-ESE course will need prior approval given by the Graduate Program Director before a student can register.

2. Minimum of eight (8) regular courses. Of these eight, at least seven (7) regular courses must be taken in the Department; three (3) of the seven (7) must be selected from the following CORE Courses:

ESE 502: Linear Systems
ESE 503: Stochastic Systems
ESE 511: Solid-State Electronics or ESE 538: Nanoelectronics.
ESE 516: Integrated Electronic Devices and Circuits I.
ESE 520: Applied Electromagnetics
ESE 528: Communication Systems or ESE 532: Theory of Digital Communication or ESE 505: Wireless Communications
ESE 545: Computer Architecture
ESE 547: Digital Signal Processing
ESE 554: Computational Models for Computer Engineers
ESE 555: Advanced VLSI System Design
ESE 566: Hardware-Software Co-Design of Embedded Systems or ESE 587: Hardware Architecture for Deep Learning.

3. The ESE 597, ESE 599, ESE 697, ESE 698 and ESE 699 are not counted as regular courses in (2). Topics course, ESE 670, can be counted only once as a regular course.

4. At least one (maximum three) credit of ESE 597. In exceptional circumstances, the Graduate Program Director can approve a replacement of ESE 597 credit by ESE 599, ESE 699 or ESE 698.

Credits for ESE 597 can only be applied toward the electrical engineering degree if the following requirements are satisfied:

Prior approval from the Graduate Program Director based on the student submitting a proposal and securing an advisor in the ECE Department as well as a contact person at the company involved. Approval will only be granted if it can be demonstrated that the faculty advisor will be kept in close touch with work on the project. To this end, practicum not in the local geographic area will be discouraged.

To obtain satisfactory credit the faculty advisor must verify that a substantial engineering project was undertaken and completed. This will be based on his/her close contact during the entire period of the project with the student and the contact person and upon reviewing a mandatory written report submitted by the student at the project's completion. The faculty advisor will determine the final grade for the course.

CPT will be approved one (1) time and can be taken during the summer or the academic year. **Extensions of CPT will not be granted.**

*A candidate for the master's degree may petition to transfer a maximum of 12 graduate credits from another institution towards the master's degree requirements. Students transferring from non-matriculated status are also limited to a maximum of 12 credits for the master's degree.*

## II. M.S. in *Electrical Engineering* THESIS OPTION.

**Please Note: Full-time M.S. students typically finish the Master's Degree in four (4) semesters.**

1. Students must inform the Department in writing at the end of their first semester if they would like to choose the M.S. Thesis Option.

2. At least 30 graduate credits with a cumulative and departmental grade point average of 3.0 or better. Among these 30 credits, at least six credits of ESE 599, with a maximum of 12 credits in total being taken from combination of ESE 597, ESE 599, or ESE 698.

   Only 3 credits of ESE 698 may be used. Any non-ESE course will need prior approval given by the Graduate Program Director before a student can register.

3. Minimum of six (6) regular courses. Of these six, at least five (5) regular courses must be taken in the Department; three of the five must be selected from the following CORE Courses:

   ESE 502: Linear Systems
   ESE 503: Stochastic Systems
   ESE 511: Solid-State Electronics or ESE 538: Nanoelectronics.
   ESE 516: Integrated Electronic Devices and Circuits I.
   ESE 520: Applied Electromagnetics
   ESE 528: Communication Systems or ESE 532: Theory of Digital Communication or ESE 505: Wireless Communications
   ESE 545: Computer Architecture
   ESE 547: Digital Signal Processing
   ESE 554: Computational Models for Computer Engineers
   ESE 555: Advanced VLSI System Design
   ESE 566 Hardware-Software Co-Design of Embedded Systems or ESE 587: Hardware Architecture for Deep Learning.

4. The ESE 597, ESE 599, ESE 697, ESE 698 and ESE 699 are not counted as regular courses in (3). Topics course, ESE 670, can be counted only once as a regular course.

5. At least one (maximum three) credit of ESE 597. In exceptional circumstances, the Graduate Program Director can approve a replacement of ESE 597 credits by ESE 599, ESE 699 or ESE 698.

   Credits for ESE 597 can only be applied toward the electrical engineering degree if the following requirements are satisfied:

   Prior approval from the Graduate Program Director based on the student submitting a proposal and securing an advisor in the ECE Department as well as a contact person at the company involved. Approval will only be granted if it can be demonstrated that the faculty advisor will be kept in close touch with work on the project. To this end, practicum not in the local geographic area will be discouraged.

   To obtain satisfactory credit the faculty advisor must verify that a substantial engineering project was undertaken and completed. This will be based on his/her close contact during the entire period of the project with the student and the contact person and upon reviewing a mandatory written report submitted by the student at the project's completion. The faculty advisor will determine the final grade for the course.

CPT will be approved <u>one</u> (1) time and can be taken during the summer or the academic year. **Extensions of CPT will not be granted.**

6. Students must satisfactorily complete a thesis. The thesis must have two readers to read and sign. Both readers are from the department, and one of them is the advisor. The student must give the readers at least three weeks' time to finish reading and giving comments, if any.

*A candidate for the master's degree may petition to transfer a maximum of 12 graduate credits from another institution towards the master's degree requirements. Students transferring from non-matriculated status are also limited to a maximum of 12 credits for the master's degree.*

## III. Ph.D. DEGREE in *Electrical Engineering*

### A. Major and minor area requirements

1. Major area requirement is satisfied by taking minimum of three (3) courses from a selected major area with minimum GPA of 3.5. See preapproved lists of courses for each area.

2. Minor area requirement is satisfied by taking courses from other areas (different from the selected major area) with minimum GPA of 3.0. Students admitted with BS degree are required to take two (2) courses from other areas (one or two areas) while students admitted with MS degree are required to take one (1) course.

### B. Course Requirements

1. A minimum of 14 regular courses (42 regular graduate course credits) beyond the BS degree (including courses taken to satisfy major and minor requirements). The choice must have the prior approval of the designated faculty academic advisor. Any non-ESE course will need prior approval given by the Graduate Program Director before a student can register.

2. The ESE 697 Practicum in Teaching (3 credits) is required to satisfy the teaching requirement. Students must be advance to candidacy in order to take this course.

3. The courses ESE 597, ESE 599, ESE 697, ESE 698, and ESE 699 are not counted as regular courses.

4. Courses presented under the title ESE 670 Topics in Electrical Sciences that have different subject matters, and are offered as formal lecture courses, are considered different regular courses but may not be counted more than twice.

5. Prior MS degree in ECE or related area can reduce the course requirements down to six (6) regular courses.

### C. Advancement to Candidacy

After successfully completing all major/minor course requirements (except ESE 697), the student is eligible to be recommended for Advancement to Candidacy. This status is conferred by the Dean of the Graduate School upon recommendation from the chairperson of the Department. It is strongly recommended that doctoral students Advance to Candidacy within 2.5 years if admitted with a BS degree (after earning 42 regular course credits), or within 1.5 years if admitted with an MS degree (after earning 18 regular course credits).

### D. Preliminary Examination

A student is recommended to pass the Preliminary Examination not more than 1.5 years after Advancement to Candidacy. Both a thesis topic and the thesis background area are emphasized. Students must pass the Preliminary Examination at least ONE year prior to their Defense. See preliminary examination requirements for details.

**E. Dissertation**

The most important requirement for the Ph.D. degree is the completion of a dissertation, which must be an original scholarly investigation. The dissertation must represent a significant contribution to the scientific and engineering literature, and its quality must be compatible with the publication standards of appropriate and reputable scholarly journals.

**F. Approval and Defense of Dissertation**

The dissertation must be orally defended before a dissertation examination committee (normally in three - four years after satisfying the major and the minor requirements). The candidate must obtain approval of the dissertation from this committee. The committee must have a minimum of four (4) members: at least three (3) of whom are faculty members from the Department including the research advisor and committee chair, as well as at least one (1) member from outside of the Department. (Neither the research advisor nor the outside member may serve as the chair.) Within the committee there must be a member with no conflict of interest in relationship to the student (including intellectual, personal, financial, etc.) Based on the committee recommendation, the Dean of Engineering and Applied Sciences will recommend acceptance or rejection of the dissertation to the Dean of the Graduate School. All requirements for the degree will be satisfied upon the successful defense of the dissertation.

**G. Residency Requirement**

The student must complete two (2) consecutive semesters of full-time graduate study. Full-time status implies minimum 9 credits per semester.

# POLICIES: *Electrical Engineering Major*

### 1. MAJOR REQUIREMENT:

The minimum GPA of 3.5 for a minimum of three (3) courses from preapproved lists corresponding to the areas:

1. Communications and Signal Processing
2. Power Engineering
3. Semiconductor Devices and Quantum Electronics
4. Circuits and VLSI

A student without an electrical or computer engineering background may petition the graduate committee in writing to take a non-traditional major written exam in a novel subject of interest to electrical and computer engineering. Petitions must include a letter of support from their intended Ph.D. advisor.

**2. MINOR REQUIREMENT:** adds an extra degree of breadth to the student's Ph.D. education, and makes possible interdisciplinary research.

The minimum GPA of 3.0 for a minimum of one (MS students) or two (BS students) courses selected from the lists corresponding to any of the areas different from the chosen major area:

1. Communications and Signal Processing
2. Power Engineering
3. Semiconductor Devices and Quantum Electronics
4. Circuits and VLSI
5. Computer Engineering

### 3. ADVANCEMENT TO CANDIDACY:

It is strongly recommended that doctoral students Advance to Candidacy within 2.5 years if admitted with a BS degree (after earning 42 regular course credits), or within 1.5 years if admitted with an MS degree (after earning 18 regular course credits).

Students may Advance to Candidacy before completing the Preliminary Examination. ALL required course work (except ESE 697) must be satisfactorily completed prior to Advancing to Candidacy. ALL required course work includes:

- Satisfying major and minor requirements
- At least one (1) year residency (two (2) consecutive semesters of full-time graduate study)
- Six (6) regular courses beyond the MS degree or fourteen (14) regular courses above the BS degree. The ESE 597, ESE 599, ESE 697, ESE 698 and ESE 699 are NOT counted as regular courses
- A GPA of at least 3.0

The student and his/her research advisor will decide when the student is ready to Advance to Candidacy. The Graduate Program Director must approve the request before final approval is decided by the Graduate School.

The student must submit the Request for Advancement to Candidacy to the Department at least ONE full week prior to the start of the semester. If a request is received after the deadline, Advancement to Candidacy will NOT take effect until the NEXT semester or term. The request form is available on ECE website.

To ensure timely completion and high quality of dissertation, in general, Ph.D. students should not change their dissertation advisors after advancement to candidacy. However, if for some special reason, an advanced to candidacy student must change his/her advisor, it is **required that the student spends at least two (2) more years on the new research for the dissertation with the new advisor.** Shorter completion time is allowed if the previous and new advisors of the student have reached a written agreement. The formal switching of advisors and the agreement between the old and new advisors (if any) must be documented at the time of switching by the Graduate Program Coordinator to be effective.

This policy is in effect in order to ensure the high quality of our Ph.D. program, and the above rule will be enforced when the Department submits the Defense form to the Graduate School.

## 4. PRELIMINARY EXAMINATION:

This is an oral examination. Usually, a student prepares a written research proposal and gives a 30-minute presentation. After that the floor is open for questioning.

I. Departmental policy recommends that all doctoral students take the Preliminary Oral Examination **within 1.5 years** after Advancement to Candidacy. ALL required courses (including major/minor courses) must also be satisfactorily completed.

II. The student and his/her research advisor will together propose an examination committee and a date and time for the examination. They must obtain prior agreement to serve from each proposed member. The Graduate Program Director must approve the committee and then recommend to the Dean of the Graduate School that said committee be appointed.

III. The examining Preliminary Committee shall consist of at least four (4) members, including the student's research advisor and committee chair. If the advisor is from outside of the ECE Department, a co-advisor from the Department must be chosen. Of the four, at least three (3) must be full-time faculty members from the ECE Department and at least one (1) must be from outside the Department or University. If member is from outside of the University, their curriculum vitae must be provided.

IV. The student must submit the proposed committee to the Department at least **THREE** (3) full weeks prior to the proposed examination date.

V. At least **five** (5) full days prior to the examination date, the student must deliver to each committee member a readable copy of the following:

   1. Formal research proposal – proposal shall include a brief abstract (not to exceed 200 words), a table of contents, and within a standard format of Introduction, Discussion, etc., an outline of the related state-of-the-art, the specific research goals, methods to be followed, preliminary results (if any), prospects for success, alternatives if success is in doubt, etc. Except where results already obtained are sufficient to justify a near-final draft of one or more papers to be submitted or of whole chapters in the final thesis, the formal proposal should be at least 50 pages.

   2. A brief Vita to include name, education, date of admission to ECE graduate program, and area working on. Part-time students and any students who have interrupted their graduate studies to seek full-time employment must include their record of employment throughout the period. Any awards, significant publications, or other professional recognition should also be included.

**Students must pass the Preliminary Exam at least ONE (1) year prior to their Defense.**

## 5. DISSERTATION DEFENSE:

This is an oral examination. An examination committee will consist of at least four (4) members; three (3) members must be Electrical & Computer Engineering faculty, and at least one (1) member must be from outside of the Department. The student must submit to the committee members a copy of his/her dissertation with enough time before the actual Defense, to permit careful reading. The Defense consists typically of a 45-minute presentation followed by questions.

Note: At least FIVE (5) weeks prior to the Defense date, the student must electronically submit committee member names, title of Defense, date, time and place of Defense, along with an Abstract (350 words or less) to the Department.

Note: The Dissertation Defense Exam should be scheduled at least FOUR (4) weeks prior to the Graduation date.

**Important: A student must be Advanced to Candidacy and pass the Preliminary Exam at least ONE (1) year prior to the Defense.**

# *COMPUTER ENGINEERING*

# COMPUTER ENGINEERING DEGREE REQUIREMENTS

Admission to the M.S. program in Computer Engineering requires the student to have completed a Bachelor's degree in Computer Engineering or Computer Science. Students with a Bachelor's degree in Electrical Engineering could also be admitted if they have taken or will take the following courses or their equivalent:

- ESE 345: Computer Architecture
- ESE 280: Embedded Microprocessor Systems Design I
- ESE 333: Real-Time Operating Systems

## I. M.S. in *Computer Engineering* NON-THESIS OPTION

**Please Note: Full-time M.S. students typically finish the Master's Degree in three (3) semesters.**

1. At least 30 graduate credits with a cumulative and departmental grade point average of 3.0 or better. Among these 30 credits, up to six credits may be from combination of ESE 597, ESE 599, or ESE 698. Only 3 credits of ESE 698 may be used. Any non-ESE course will need prior approval given by the Graduate Program Director before a student can register.

2. *At least one (1) course from each of the following sub-areas:*

**Hardware:**
ESE 507 Advanced Digital System Design & Generation
ESE 536/CSE 626 Switching and Routing in Parallel and Distributed Systems
ESE 545 Computer Architecture
ESE 565 Parallel Processing Architectures
ESE 566 Hardware-Software Co-Design of Embedded Systems
ESE 587: Hardware Architectures for Deep Learning.

**Networking:**
ESE 505 Wireless Communications
ESE 506 Wireless Network
ESE 546 Networking Algorithms and Analysis
ESE 548 Computer Networks

**CAD and VLSI:**
ESE 530 Computer-Aided Design
ESE 549 Advanced VLSI System Testing
ESE 555 Advanced VLSI System Design
ESE 556 VLSI Physical and Logic Design Automation
ESE 575 Advanced VLSI Signal Processing Architecture

*At least two (2) courses from the sub-area:*

**Theory and Software:**
ESE 501: System Specification and Modeling
ESE 533: Convex Optimization and Eng. Applications.
ESE 534: Cyber Physical systems.
ESE 543: Mobile Cloud Computing
ESE 554 Computational Models for Computer Engineers
ESE 558: Digital Image Processing I
ESE 568 Computer Vision
ESE 588 Fundamentals of Machine Learning
ESE 589: Learning Systems for Engineering Applications.

ESE 590: Practical Machine Learning and Artificial Intelligence

**CSE 506 Operating Systems*

**CSE 510 Hybrid Systems*

**CSE 548/AMS 542 Analysis of Algorithms*

** These pre-approved non-ESE courses are treated as regular ones, and no approval from the GPD is needed*

** Ability of ECE students to enroll into CSE and AMS courses cannot be guaranteed.*

3. At least three (3) additional regular lecture-based courses. The ESE 597, ESE 599, ESE 697, ESE 698 and ESE 699 are not counted as regular courses. Topics course, ESE 670, can be counted only once as a regular course.

4. At least one (maximum three) credit of ESE 597. In exceptional circumstances, the Graduate Program Director can approve a replacement of ESE 597 credit by ESE 599, ESE 699 or ESE 698 one.

Credits for ESE 597 can only be applied toward the Computer Engineering degree if the following requirements are satisfied:

Prior approval from the Graduate Program Director based on the student submitting a proposal and securing an advisor in the ECE Department as well as a contact person at the company involved. Approval will only be granted if it can be demonstrated that the faculty advisor will be kept in close touch with work on the project. To this end, practicum not in the local geographic area will be discouraged.

To obtain satisfactory credit the faculty advisor must verify that a substantial engineering project was undertaken and completed. This will be based on his close contact during the entire period of the project with the student and the contact person and upon reviewing a mandatory written report submitted by the student at the project's completion. The faculty advisor will determine the final grade for the course.

CPT will be approved <u>one</u> time and can be taken during the summer or the academic year. **Extensions of CPT will not be granted.**

*A candidate for the Master's degree may petition to transfer a maximum of 12 graduate credits from another institution towards the master's degree requirements. Students transferring from non-matriculated status are also limited to a maximum of 12 credits for the Master's degree.*

## II. M.S. in *Computer Engineering* THESIS OPTION.

**Please Note: Full-time M.S. students typically finish the Master's Degree in four (4) semesters.**

1. Students must inform the Department in writing at the end of their first semester if they would like to choose the M.S. Thesis Option.

2. At least 30 graduate credits with a cumulative and departmental grade point average of 3.0 or better. Among these 30 credits, at least six credits of ESE 599, with a maximum of 12 credits total being taken from combination of ESE 599, ESE 597, or ESE 698. Only three credits of 698 can be used. Any non-ESE course will need prior approval given by the Graduate Program Director before a student can register.

3. *At least one (1) course from each of the following sub-areas:*

**Hardware:**

ESE 507 Advanced Digital System Design & Generation

ESE 536/CSE 626 Switching and Routing in Parallel and Distributed Systems

ESE 545 Computer Architecture

ESE 565 Parallel Processing Architectures

ESE 566 Hardware-Software Co-Design of Embedded Systems
ESE 587: Hardware Architectures for Deep Learning.

**Networking:**
ESE 505 Wireless Communications
ESE 506 Wireless Network
ESE 546 Networking Algorithms and Analysis
ESE 548 Computer Networks

**CAD and VLSI:**
ESE 530 Computer-Aided Design
ESE 549 Advanced VLSI System Testing
ESE 555 Advanced VLSI System Design
ESE 556 VLSI Physical and Logic Design Automation
ESE 575 Advanced VLSI Signal Processing Architecture

*At least two (2) courses from the sub-area:*

**Theory and Software:**
ESE 501: System Specification and Modeling
ESE 533: Convex Optimization and Eng. Applications.
ESE 534: Cyber Physical systems.
ESE 543: Mobile Cloud Computing
ESE 554 Computational Models for Computer Engineers
ESE 558: Digital Image Processing I
ESE 568 Computer Vision
ESE 588 Fundamentals of Machine Learning
ESE 589: Learning Systems for Engineering Applications.
ESE 590: Practical Machine Learning and Artificial Intelligence
**CSE 506 Operating Systems*
**CSE 510 Hybrid Systems*
**CSE 548/AMS 542 Analysis of Algorithms*
** These pre-approved non-ESE courses are treated as regular ones, and no approval from the GPD is needed*

** Ability of ECE students to enroll into CSE and AMS courses cannot be guaranteed.*

4. At least one (1) additional regular lecture-based course. The ESE 597, ESE 599, ESE 697, ESE 698 and ESE 699 are not counted as regular courses. Topics course, ESE 670, can be counted only once as a regular course.

5. At least one (maximum three) credit of ESE 597. In exceptional circumstances, the Graduate Program Director can approve a replacement of ESE 597 credit by ESE 599, ESE 699 or ESE 698 one.

Credits for ESE 597 can only be applied toward the Computer Engineering degree if the following requirements are satisfied:

Prior approval from the Graduate Program Director based on the student submitting a proposal and securing an advisor in the ECE Department as well as a contact person at the company involved. Approval will only be granted if it can be demonstrated that the faculty advisor will be kept in close touch with work on the project. To this end, practicum not in the local geographic area will be discouraged.

To obtain satisfactory credit the faculty advisor must verify that a substantial engineering project was undertaken and completed. This will be based on his close contact during the entire period of the project with the student and the contact person and upon reviewing a mandatory written report submitted by the student at the project's completion. The faculty advisor will determine the final grade for the course.

CPT will be approved <u>one</u> time and can be taken during the summer or the academic year.

**Extensions of CPT will not be granted.**

6. Students must satisfactorily complete a thesis. The thesis must have two readers to read and sign. Both readers are from the department, and one of them is the advisor. The student must give the readers at least three weeks' time to finish reading and giving comments, if any.

*A candidate for the Master's degree may petition to transfer a maximum of 12 graduate credits from another institution towards the master's degree requirements. Students transferring from non-matriculated status are also limited to a maximum of 12 credits for the Master's degree.*

## III. Ph.D. DEGREE in *Computer Engineering*

### A. Major and minor area requirements

1. Major area requirement is satisfied by taking minimum of three (3) courses from a selected major area with minimum GPA of 3.5. See preapproved lists of courses for each area.

2. Minor area requirement is satisfied by taking courses from other areas (different from the selected major area) with minimum GPA of 3.0. Students admitted with BS degree are required to take two (2) courses from other areas (one or two areas) while students admitted with MS degree are required to take one (1) course.

### B. Course Requirements

1. A minimum of 14 regular courses (42 regular graduate course credits) beyond the BS degree (including courses taken to satisfy major and minor requirements). The choice must have the prior approval of the designated faculty academic advisor. Any non-ESE course will need prior approval given by the Graduate Program Director before a student can register.

2. The ESE 697 Practicum in Teaching (3 credits) is required to satisfy the teaching requirement. Students must be advance to candidacy in order to take this course.

3. At least 15 credit hours of ESE 699 for conducting focused research under faculty supervision

4. The courses ESE 597, ESE 598, ESE 599, ESE 698, and ESE 699 are not counted as regular courses.

5. Courses presented under the title ESE 670 Topics in Electrical Sciences that have different subject matters, and are offered as formal lecture courses, are considered different regular courses but may not be counted more than twice.

6. Prior MS degree in ECE or related area can reduce the course requirements down to six (6) regular courses.

### C. Advancement to Candidacy

After successfully completing all major/minor/course requirements (except ESE 697) the student is eligible to be recommended for Advancement to Candidacy. This status is conferred by the Dean of the Graduate School upon recommendation from the chairperson of the Department. It is strongly recommended that doctoral students Advance to Candidacy within 2.5 years if admitted with a BS degree (after earning 42 regular course credits), or within 1.5 years if admitted with an MS degree (after earning 18 regular course credits).

### D. Preliminary Examination

A student is recommended to pass the Preliminary Examination not more than 1.5 years after Advancement to Candidacy. Both a thesis topic and the thesis background area are emphasized. Students must pass the Preliminary Examination at least ONE year prior to their Defense. See preliminary examination requirements for details.

### E. Dissertation

The most important requirement for the Ph.D. degree is the completion of a dissertation, which must be an original scholarly investigation. The dissertation must represent a significant contribution to the scientific and engineering literature, and its quality must be compatible with the publication standards of appropriate and reputable scholarly journals.

### F. Approval and Defense of Dissertation

The dissertation must be orally defended before a dissertation examination committee (normally in three - four years after satisfying the major and the minor requirements). The candidate must obtain approval of the dissertation from this committee. The committee must have a minimum of four (4) members: at least three (3) of whom are faculty members from the Department including the research advisor and committee chair, as well as at least one (1) member from outside of the Department. (Neither the research advisor nor the outside member may serve as the chair.) Within the committee there must be a member with no conflict of interest in relationship to the student (including intellectual, personal, financial, etc.) Based on the committee recommendation, the Dean of Engineering and Applied Sciences will recommend acceptance or rejection of the dissertation to the Dean of the Graduate School. All requirements for the degree will be satisfied upon the successful defense of the dissertation.

### G. Residency Requirement

The student must complete two (2) consecutive semesters of full-time graduate study. Full-time status implies minimum 9 credits per semester.

## POLICIES: *Computer Engineering Major*

### 1. MAJOR REQUIREMENT:

The minimum GPA of 3.5 for a minimum of three (3) courses from preapproved lists corresponding to the areas:

1. Communications and Signal Processing;
2. Computer Engineering;
3. Power Engineering;
4. Circuits and VLSI.

A student without electrical or computer engineering background may petition the graduate committee in writing to take a non-traditional major written exam in a novel subject of interest to electrical and computer engineering. Petitions must include a letter of support from their intended Ph.D. advisor.

**2. MINOR REQUIREMENT:** adds an extra degree of breadth to the student's Ph.D. education, and makes possible interdisciplinary research.

The minimum GPA of 3.0 for a minimum of one (MS students) or two (BS students) courses selected from the lists corresponding to any of the areas <u>different from the chosen major area</u>:

1. Communications and Signal Processing;
2. Semiconductor Devices and Quantum Electronics;
3. Circuits and VLSI;
4. Computer Engineering;
5. Power Engineering.

### 3. ADVANCEMENT TO CANDIDACY:

It is strongly recommended that doctoral students Advance to Candidacy within 2.5 years if admitted with a BS degree (after earning 42 regular course credits), or within 1.5 years if admitted with an MS degree (after earning 18 regular course credits).

Students may Advance to Candidacy before completing the Preliminary Examination. ALL required course work (except ESE 697) must be satisfactorily completed <u>prior</u> to Advancing to Candidacy. ALL required course work includes:

- Satisfying major and minor requirements
- At least one-year residency (two consecutive semesters of full-time graduate study)
- Six (6) regular courses beyond the MS degree or fourteen (14) regular courses above the BS degree. The ESE 597, ESE 599, ESE 697, ESE 698 and ESE 699 are NOT counted as regular courses.
- A GPA of at least 3.0

The student and his/her research advisor will decide when the student is ready to Advance to Candidacy. The Graduate Program Director must approve the request before final approval is decided by the Graduate School.

The student must submit the Request for Advancement to Candidacy to the Department at least <u>ONE</u> (1) full week <u>prior</u> to the start of the semester. If a request is received after the deadline, advancement to candidacy will NOT take effect until the NEXT semester or term. Request form available on ECE website.

To ensure timely completion and high quality of dissertation, in general, Ph.D. students should not change their dissertation advisors after advancement to candidacy. However, if for some special reason, an advanced to candidacy student must change his/her advisor, it is **required that the student spends at least two (2) more years on the new research for the dissertation with the new advisor.** Shorter completion time is allowed if the previous and new advisors of the student have reached a written agreement. The formal switching of advisors and the agreement between the old and new advisors (if any) must be documented at the time of switching by the Graduate Program Coordinator to be effective.

This policy is in effect in order to ensure the high quality of our Ph.D. program, and the above rule will be enforced when the Department submits the Defense form to the Graduate School.

## 4. PRELIMINARY EXAMINATION:

This is an oral examination. Usually, a student prepares a short written research proposal and gives a 30-minute presentation. After that the floor is open for questioning.

I. Departmental policy recommends that all doctoral students take the Preliminary Oral Examination **within 1.5 years** after advancement to candidacy. ALL required courses (including major/minor courses) must also be satisfactorily completed.

II. The student and his/her research advisor will together propose an examination committee and a date and time for the examination. They must obtain prior agreement to serve from each proposed member. The Graduate Program Director must approve the committee and then recommend to the Dean of the Graduate School that said committee be appointed.

III. The examining Preliminary Committee shall consist of at least four members, including the student's research advisor and committee chair. If the advisor is from outside of the ECE department, a co-advisor from the department must be chosen. Of the four (4), at least three (3) must be full-time faculty members from the ECE Department and at least one (1) must be from outside the Department or University. For outside of the University member the curriculum vitae must be provided.

IV. The student must submit the proposed committee to the Department at least **THREE** (3) full weeks prior to the proposed examination date.

V. At least **five** (5) full days prior to the examination date, the student must deliver to each committee member a readable copy of the following:

   3. Formal research proposal – proposal shall include a brief abstract (not to exceed 200 words), a table of contents, and within a standard format of Introduction, Discussion, etc., an outline of the related state-of-the-art, the specific research goals, methods to be followed, preliminary results (if any), prospects for success, alternatives if success is in doubt, etc. Except where results already obtained are enough to justify a near-final draft of one or more papers to be submitted or of whole chapters in the final thesis, the formal proposal should be at least 50 pages.

   4. A brief Vita to include name, education, date of admission to ECE graduate program, and area working on. Part-time students and any students who have interrupted their graduate studies to seek full-time employment must include their record of employment throughout the period. Any awards, significant publications, or other professional recognition should also be included.

**Students must pass the Preliminary Exam at least ONE (1) year prior to their Defense.**

## 5. DISSERTATION DEFENSE:

This is an oral examination. An examination committee will consist of at least four members; three members must be Electrical & Computer Engineering faculty, and at least one member must be from outside the department. The student must submit to the committee members a copy of his/her dissertation with enough time before the actual Defense, to permit careful reading. The Defense consists typically of a 45-minute presentation followed by questions.

Note: At least FIVE weeks prior to the Defense date, the student must electronically submit committee member names, title of Defense, date, time and place of Defense, along with an Abstract (350 words or less) to the Department.

Note: The Dissertation Defense Exam should be scheduled at least FOUR weeks prior to the Graduation date.

**Important: A student must be advanced to Candidacy and pass the Preliminary Exam at least ONE year prior to the Defense.**

# Area Courses for PhD major/minor requirements

## Communications and Signal Processing
ESE 503: Stochastic Systems
ESE 505: Wireless Communications
ESE 528: Communication Systems or ESE 532: Theory of Digital Communications
ESE 531: Statistical Learning and Inference
ESE 546: Networking Algorithms and Analysis
ESE 547: Digital Signal Processing
ESE 558: Digital Image Processing I
ESE 588: Fundamentals of Machine Learning

## Computer Engineering
ESE 501: System Specification and Modeling
ESE 506: Wireless Network or ESE 537: Mobile Sensing Systems & Application
or ESE 543: Mobile Cloud Computing
ESE 507: Advanced Digital System Design & Generation or ESE 555: Advanced VLSI Systems Design
or ESE 556: VLSI Physical and Logic Level Design Automation
ESE 536 (CSE 626): Switching and Routing in Parallel and Distributed Systems
ESE 545: Computer Architecture
ESE 554: Computational Models for Computer Engineers
ESE 566: Hardware-Software Co-Design of Embedded Systems
ESE 568: Computer and Robot Vision
ESE 587: Hardware Architectures for Deep Learning or ESE 534: Cyber Physical systems
or ESE 589: Learning Systems for Engineering Applications.

## Power Engineering
ESE 502: Linear Systems
ESE 509: Modern Energy Technologies
ESE 512: Intro Quantum Systems Engineering or ESE 523 - Quantum Computing and Applications or PHY 568 Quantum Information Science
ESE 531: Statistical Learning and Inference
ESE 533: Convex Optimization and Engineering Applications
ESE 534: Cyber Physical Systems
ESE 548: Computer Networks
ESE 562: AI-driven Smart Grid
ESE 576: Power System Dynamics
ESE 578: Quantum Engineered Power Grids
ESE 586: Micro Grids

## Semiconductor Devices and Quantum Electronics
ESE 511: Solid-States Electronics
ESE 513: Introduction to Photovoltaics
ESE 515: Quantum Electronics I or ESE 538: Nanoelectronics;
ESE 516: Integrated Electronic Devices and Circuits I
ESE 517: Integrated Electronic Devices and Circuits II or ESE 585: Nanoscale Int. Cir. Design
ESE 519: Semiconductor Lasers and Photodetectors
ESE 525: Modern Sensors in Artificial Intelligence Applications

## Circuits and VLSI
ESE 507: Advanced Digital System Design & Generation
ESE 516: Integrated Electronic Devices and Circuits I
ESE 517: Integrated Electronic Devices and Circuits II
ESE 555: Advanced VLSI Systems Design
ESE 556: VLSI Physical and Logic Design Automation
ESE 566: Hardware-Software Co-Design of Emb. Sys. or ESE 549: Advanced VLSI System Testing
or ESE 575: Advanced VLSI Signal Processing Architecture
ESE 585: Nanoscale Integrated Circuit Design

# *ENGINEERING ARTIFICIAL INTELLIGENCE*

# ENGINEERING ARTIFICIAL INTELLIGENCE DEGREE REQUIREMENTS

Admission to the M.S. program in Engineering Artificial Intelligence requires the student to have completed a Bachelor's degree in Computer Engineering, Electrical Engineering, or Computer Science, or a related discipline. Both non-thesis and thesis options are offered.

## M.S. in *Engineering Artificial Intelligence*

**Please Note: Full-time M.S. students typically finish the Master's Degree in three (3) semesters for non-thesis option, and four (4) semesters for thesis option.**

1. Students must inform the Department in writing at the end of their first semester if they would like to choose the M.S. thesis option.

2. At least 30 graduate credits with a cumulative and departmental grade point average of 3.0 or better. Among these 30 credits, up to six credits may be from combination of ESE 597, ESE 599, or ESE 698. Only 3 credits of ESE 698 may be used. Any non-ESE course will need prior approval given by the Graduate Program Director before a student can register.

**Common requirements**: in both options, the student must finish a minimum number of credits in each of these subareas:

Foundations (6 credits):
ESE 503 (Stochastic Systems, 3 credits);
ESE 561 (Theory of Artificial Intelligence, 3 credits);

Methods (6 credits):
ESE 577 (Deep Learning Algorithms and Software, 3 credits);
ESE 588 (Fundamentals of Machine Learning, 3 credits);

Applications (3 credits):
ESE 564 (Artificial Intelligence for Robotics, 3 credits);
ESE 589 (Learning Systems for Eng. Appl., 3 credits);
ESE 590 (Practical Machine Learning & Artificial Intelligence, 3 credits);

Hardware (3 credits):
ESE 507 (Advanced Dig. Sys. Design & Generation, 3 credits);
ESE 525 (Modern Sensors in Artificial Intelligence Applications, 3 credits);
ESE 587 (Hardware Architectures for Deep Learning, 3 credits);

Elective (6 credits for non-Thesis option; 3 credits for Thesis option):
ESE 502 (Linear Systems, 3 credits);
ESE 507 (Advanced Dig. Sys. Design & Generation, 3 credits);
ESE 525 (Modern Sensors in Artificial Intelligence Appl., 3 credits);
ESE 533 (Convex Optimization & Eng. Appl., 3 credits);

ESE 537 (Mobile Sensing Systems & Appl., 3 credits);
ESE 543 (Mobile Cloud Computing, 3 credits);
ESE 558 (Digital Image Processing, 3 credits);
ESE 562 (AI Driven Smart Grids, 3 credits);
ESE 564 (Artificial Intelligence for Robotics, 3 credits);
ESE 568 (Computer and Robot Vision, 3 credits);
ESE 587 (Hardware Architectures for Deep Learning, 3 credits);
ESE 589 (Learning Systems for Eng. Appl., 3 credits);
ESE 590 (Practical Machine Learning & Artificial Intelligence, 3 credits);
ESE 592 (Distributed Computation, Control & Learning over Networks, 3 credits);
ESE 670* (Topics in Electrical Sciences, 3 credits)
AMS 580 (Statistical Learning, 3 credits);
MEC 529 (Introduction to Robotics, 3 credits);
CSE 538 (Natural Language Processing, 3 credits).

*Any ESE or non-ESE course not listed above must be approved by Graduate Program Director (3 credit maximum; and approval must be obtained before enrollment).*

**Thesis option:**

Industry experience (at least one, maximum three credits):

ESE 597 (Practicum in Engineering [Internship], variable credit);

Research experience (at least 6 credits):

ESE 599 (Research for M.S. students, variable and repetitive credit);

Teaching experience (not required but can be used, maximum 3 credits)

ESE 698 (Practicum in teaching, variable credits);

**Non-thesis option:**

Industrial experience (3 credits):

ESE 597 (Practicum in Engineering [Internship], variable credit);

*To meet the 30-credit minimum for the program, non-thesis students may take one of the following:*

Research experience (Maximum 3 credits):

ESE 599 (Research for M.S. students, variable and repetitive credit);

Teaching experience (Maximum 3 credits):

ESE 698 (Practicum in teaching, variable credits);

Additional Elective (3 credits):

Any course listed above in "common requirements" not already used to fulfill another program requirement OR Any ESE or non-ESE course not listed above but approved by Graduate Program Director (3 credit max.; approval must be obtained before enrollment).

3. In exceptional circumstances, the Graduate Program Director can approve a replacement of ESE 597 credit by ESE 599, ESE 699 or ESE 698 one.

Credits for ESE 597 can only be applied toward the degree if the following requirements are satisfied:

Prior approval from the Graduate Program Director based on the student submitting a proposal and securing an advisor in the ECE Department as well as a contact person at the company involved. Approval will only be granted if it can be demonstrated that the faculty advisor will be kept in close touch with work on the project. To this end, practicum not in the local geographic area will be discouraged.

To obtain satisfactory credit the faculty advisor must verify that a substantial engineering project was undertaken and completed. This will be based on his close contact during the entire period of the project with the student and the contact person and upon reviewing a mandatory written report submitted by the student at the project's completion. The faculty advisor will determine the final grade for the course.

CPT will be approved one time and can be taken during the summer or the academic year. **Extensions of CPT will not be granted.**

*A candidate for the Master's degree may petition to transfer a maximum of 12 graduate credits from another institution towards the master's degree requirements. Students transferring from non-matriculated status are also limited to a maximum of 12 credits for the Master's degree.*

# POLICIES REGARDING RA/TA/GA SUPPORT AND TUITION SCHORLARSHIP/TEACHING ASSISTANT DUTIES AND EVALUATION

1. Full-time graduate students are eligible for research assistant (RA) positions. Individual faculty should be contacted on the availability of RA positions.

2. State lines - Teaching Assistantship*s* (TA) and Graduate Assistantships (GA) - are used by the Department to help fulfill its undergraduate academic mission and at the same time to support graduate students, who are making satisfactory progress towards a Ph.D. degree.

3. Tuition scholarship may be awarded to an RA/TA/GA if the Department budget permits. Preference will be given to Ph.D. students. If a student does not pass the Preliminary Oral Examination within **1.5** years after advancing to candidacy, the student may not receive the tuition scholarship.

   <u>Note:</u> **In order to receive a Graduate School Tuition Scholarship as an advanced to candidacy student, the student must have been fully supported as a TA/GA/RA with a Department tuition scholarship for the academic year prior to advancing to candidacy. Otherwise the student will be liable for his/her own tuition costs.**

Graduate tuition scholarships (GTS) may be awarded to cover all or partial tuition charges. Individual tuition scholarships are then awarded, based on criteria established by the Graduate Program, to students who have not yet advanced to candidacy. To be eligible for a tuition scholarship, the graduate student must typically be registered full-time and must be employed as a Graduate/Teaching/Research Assistant. Fulltime graduate students who have advanced to candidacy may receive GTS awards regardless of TA/GA/RA employment if they were continuously supported by their academic program prior to advancement to candidacy.

Once GTS funds are allocated to a graduate program, the distribution of individual tuition scholarship awards to students shall be decided by each graduate program. Decision criteria may vary by program but must be based on academic merit and must adhere to campus wide limitations.

Tuition scholarships do not cover student fees. Student fees are the responsibility of the graduate student. Failure by a student to satisfy the eligibility requirements as of Day 15 of the semester will result in revision of the tuition scholarship award.

4. Because of the limited TA positions, the awarding of a TA will be according to the following guidelines:

State (TA) support is limited to <u>four</u> (4) years, which includes periods when a student is only partially supported during MS or Ph.D.

Except for new incoming supported students, state support will generally be limited to 1/2 TA, with the priority given to eligible students awarded at least 1/2 RA by their faculty advisor.

To be eligible for second-year support, the student must satisfy major requirements and must have a GPA of at least **3.0**. The student must also have a research advisor in the Electrical & Computer Engineering Department. To be eligible in subsequent years, the student must be making satisfactory progress in taking the courses for the Minor Area. Additionally, the student must have a grade of 'S' on all previous research courses and assistantship assignments.

The remaining TA lines will be allocated on a competitive basis, based on the academic merit of the candidate. The guiding principle for the Committee will be the need to ensure continuity and completion of a successful Ph.D. project, as well as to help the new faculty to establish their research program.

5. Academic dishonesty or failure to meet assigned TA or GA responsibilities may result in loss of any support from the program.

Each semester, all Teaching Assistants must be on campus and in contact with the faculty member of the course to which he/she has been assigned by the FIRST day of classes. If a TA does not meet this requirement, they will be subject to having their stipend and tuition scholarship rescinded.

# TEACHING ASSISTANT DUTIES AND EVALUATION

All TAs are expected to behave professionally and take their teaching responsibilities seriously.

All TAs must be on campus and in contact with the faculty member of their TA Assignment by the first day of classes or they are subject to having their stipend and tuition scholarship rescinded.

- A full-time TA is expected to work up to 20 hours a week. However, it is understood that this load is not distributed evenly during the semester. In the first few weeks, the load is usually much less than 20 hours. The load tends to increase towards the semesters end.
- If it becomes apparent that the average load constantly exceeds 20 hours per week, the student should discuss the problem with the supervisor.
- A TA must be familiar with the concepts and course material. TAs must prepare designated material and understand and assist with the everyday operation of the course. TAs are required to attend the course lectures and meetings as requested by course instructor.
- A TA must understand and follow course standards set by the supervisor.
- A TA must be reliable. Perfect attendance is expected in classes, assigned recitation, laboratory and help sessions, office hours, TA meetings, and proctoring. If a TA can't meet a responsibility, they must inform their supervisor as a first step and where appropriate, must find a substitute acceptable to their supervisor.
- A TA must be prepared for all recitations, labs, meetings, etc.
- A TA must treat all students with courtesy regardless of gender, race, ethnic background, etc.
- A TA must not initiate or maintain inappropriate relationships with students. These include romantic, sexual, or financial. The University prohibits such abuses of power.
- A TA must have proficiency in English enough for communication with students.
- A TA must grade consistently and fairly, according to the course standards determined by the course instructor.
- At the end of each semester, a TA must assist the supervisor if necessary to help the supervisor with grading exams, labs, and other assignments.
- A TA must complete grading and other assigned duties promptly based upon the standards and guidelines set by their supervisor.
- A TA must take the designated graduate teaching assistant training classes.

If a TA fails to satisfy any of the above responsibilities, their supervisor will meet with them to rectify any problems. If problems persist, the TA must meet with the Director of Graduate Studies and further actions may be taken.

**TA Evaluation:** TA’s will be evaluated each semester by the supervisor as follows:

- Excellent, well-above expectations
- Very good
- Good, meets expectations
- Below expectations
- Unsatisfactory, well-below expectations

Teaching Assistants who perform below expectations may see their support terminated in the following semester.

# *CURRICULAR PRACTICAL TRAINING*

CPT must be in the student's major area of study and MUST count towards completion of the degree requirements. Students can take CPT during the academic year OR during the summer. Students must plan their CPT credits along with their other course credits accordingly.

**Graduate students in MS programs are required to take at least ONE (maximum 3) credit of ESE 597 (industrial experience or internship) to fulfill the degree requirements. International students will need their CPT request approved to participate in paid internship in industry. The CPT can be taken only ONE time by MS students.**

## ESE Department Requirements for CPT Approval

Students should consult with an International Student Advisor to confirm that they are eligible for CPT. The CPT application and instructions can be found on the International Services website.

If eligible, please submit the following to the Graduate Program Coordinator at least two (2) weeks prior to the start of the internship:

1. Letter of Offer from the internship supervisor to the department, which states the CPT duties. The letter must be on original company letterhead. The letter should explain how CPT is essential to your program of study.
2. For PhD students, the letter from adviser explaining how CPT is essential to the progress of the dissertation work is required.
3. Request for CPT form (can be found on the ECE Department website).

### Registration Requirement

MS students must register for ESE 597 (variable credit). ESE 597 is a non-regular course. Register under your advisor's section number. If you do not have an advisor, you should register under the section number of the Graduate Program Director. PhD students must register for ESE 597 or ESE 700 under the section of their advisor.

### Requirements upon completion of CPT

The internship supervisor must inform the student's advisor or Graduate Program Director via e-mail that the student has satisfactorily fulfilled the CPT requirements.

Student must submit a CPT report (1-2 pages) to their advisor or the Graduate Program Director PRIOR to the beginning of the next semester. A grade of "S" or "U" will then be assigned.

# FACILITIES

The Department operates laboratories for both teaching and research:

**The Advanced Power Electronics Laboratory** supports research and education efforts in the field of power electronics and energy conversion systems for various application ranging from solar power to aircraft propulsion. The lab is working on design of high-density and high-efficiency converters based on wide bandgap semiconductors as well as advanced power module packaging and high-density filtering solutions. Lab research interests include design of the basic converter topologies and controls, converter system modeling/control, electro-magnetic modeling, and power module packaging architecture/process development.

**The Computer-Aided Design Laboratory** offers access to large assortment of software tools used to analyze, model, simulate, and better understand various engineering concepts. The lab comprises 40 Dell PC's, that are networked via switched Ethernet to a Dell file server.

**The Computer Vision Laboratory** has a network of PC's, digital imaging hardware, and custom-built Computer Vision Systems for experimental research in 3D vision and digital image processing.

**The COSINE Laboratory** supports the research efforts of faculty members and graduate and undergraduate students in the areas of signal processing, communications, and networking. Current and recent research projects involve Bayesian signal processing, inference, Monte Carlo signal processing, signal modeling, machine learning, deep networks, signal processing over networks, graph signal processing, sensor signal processing, positioning and navigation, biomedical signal processing, wireless networks, radio-frequency identification, the Internet of Things, computer networking, data transmission, multiple-access systems, scheduling, network performance evaluation, grid computing, information theory, and image processing.

**The Digital Signal Processing Laboratory** is involved in digital signal processing architectures and hardware and software research. The laboratory has extensive list of relevant software and hardware tools.

**The Electric Power and Energy Systems Laboratory** is dedicated to enabling innovations for different layers of grid infrastructures that will transform today's power grids into tomorrow's autonomic networks and flexible services towards self-configuration, self-healing, self-optimization, and self-protection against grid changes, renewable power injections, faults, disastrous events and cyber-attacks. Our lab conducts cutting edge research in Quantum Grid (QGrid), Smart Programmable Microgrids (SPM), networked microgrids with a focus on learning-based control and stability, formal methods and reachability analysis, software-defined smart grid, cyber-physical resilience of power grid, power system stability and control, and real-time electromagnetic transient analysis.

**The Fiber Optic Sensors Laboratory (FOSL) -** Research emphasis is on the development and fabrication of novel fiber optic systems for very diverse applications ranging from aerospace to biomedical. Research work has been supported by NSF, NASA, NIH and various state and industrial partners. Some of the current research projects include development of capillary waveguide based biosensors for detection of pathogens in a marine environment, laser debridement, cavity sensors for flight control surfaces, and photonic power conversion for mobile platforms. The laboratory is equipped with various capabilities for optical and electronic diagnosis. These include a fiber optic fusion splicer, fiber polisher, diamond saw, optical microscope, optical spectral analyzer, single photon-counting systems, a high speed digital autocorrelator and various laser sources. Additionally, the laboratory has the facilities for designing and fabricating printed circuit boards and fabricating optical and electronic sub-systems.

**The Fluorescence Detection Laboratory** is involved in the design and development as well as implementation and testing of various instruments for Life Sciences. Research areas include laser induced fluorescence detection, single photon counting techniques, fast data acquisition and transfer, design and development of analog and digital integrated circuits, signal processing, capillary electrophoresis phenomena, DNA sequencing, and microfluidics.

**The Graduate Computing Laboratory** has extensive computational capabilities to support student's research and studies. Industry standard packages such as Cadence tools, Synopsys, Matlab, and many others are available.

**The Hardware Generation and Optimization (HGO) Laboratory** is dedicated to the design and optimization of digital systems, with a focus on field-programmable gate arrays (FPGAs). The lab is equipped with FPGA development systems (furnished in part through donations from Xilinx, Altera, and Intel), with all related tools.

**The High-Performance Computing and Networking Research Laboratory** is equipped to conduct research in the broad area of networking and parallel/distributed computing with emphasis on wireless/mobile networks, cloud computing, data center networks, optical networks, high-speed networks, interconnection networks and multicast communication.

**The Integrated Microsystems Laboratory** focuses on advancing the performance of CMOS IC at analog sensor interfaces. We investigate design of miniature, low-power, highly accurate sensing microsystems, that have a significant and pervasive impact on a large number of applications, ranging from new generation of biomedical devices for personal health monitors, hearing aids or implantable neural prostheses to communication devices and radiation detectors.

**The Nanoscale Circuits and Systems (NanoCAS) Laboratory** focuses on developing design methodologies for high performance as well as energy efficient integrated circuits with a variety of applications ranging from future processors to ultra-low power Internet-of-things (IoT) based devices. The NanoCAS Lab is equipped with a high performance processing and storage server, workstations, and all necessary EDA tools for modeling, design, and analysis.

**The Mixed-Domain Embedded System Laboratory** is equipped for research in the broad area of electronic system design and design automation. Current research projects involve design automation for mixed analog-digital systems and embedded systems for multimedia, sensor network applications and emerging technologies.

**The Mobile Computing and Applications Laboratory** conducts research in mobile, embedded computing systems, infrastructure, AI/ML algorithms for various applications such as healthcare, edge computing, and Internet-of-Things. The laboratory has various latest mobile embedded, and edge devices, and access to cloud computing facilities.

**The Mobile Systems Design Laboratory** conducts research in the broad areas of VLSI system designs for signal processing, communication, and heterogeneous mobile sensors. The laboratory is equipped for design and simulation of complex hardware and software systems.

**The Optoelectronics Laboratory** possesses the infrastructure for molecular beam epitaxial semiconductor heterostructure growth, advanced material characterization as well as fabrication (clean room) and sophisticated characterization and modeling of optoelectronics devices. The recent research projects include design and development of the novel infrared lasers, light emitting diodes, photodetectors and modulators. The laboratory is actively working on metamorphic epitaxial growth techniques to develop the new class of narrow and ultra-low bandgap alloys and superlattices for long-wave infrared photodetector and other applications.

**Spellman Power Electronics Lab** is an engineering teaching lab designed to accelerate research and educational programs in alternative energy and power conversion systems.

**The Ultra-High-Speed Computing Laboratory** conducts research in high performance energy-efficient flux quantum computing and cybersecurity. It is equipped with powerful computing, networking, and storage facilities and advanced CAD tools for superconductor circuit design.

**The Wireless and Networking Systems Laboratory** conducts research in the area of wireless networking and mobile computing. The lab has extensive computing capabilities, a set of Crossbow sensors, professional sensor test bed development kit, and other equipment for network and system research.

**The Wireless Sensor and RFID Network (WSRN) Laboratory** focuses on network design and performance analysis for wireless sensor networks and RFID networks. The laboratory is equipped with state-of-art computing equipment, wireless sensor nodes by Crossbow Technologies, Inc. and MotelV (now Sentilla), and RFID equipment. Current projects include novel RFID Tag Identification algorithms, RFID anti-collision algorithms and Consensus protocols.

**The Wireless Sensing and AUTO ID Laboratory (WSAID)** - The research at the laboratory focuses on Radio Frequency Identification (RFID), wireless sensor networks, and indoor localization. The lab contains facilities and equipment to carry out cutting edge research and small-scale prototyping and evaluation of technologies in real world scenarios. Current projects at the laboratory include development of a novel UHF RFID system for enhanced performance, development of indoor localization systems based on technologies such as RFID, WiFi and Zigbee, and development of customized RFID systems for use in healthcare settings.

# FACULTY

Faculty with research interest in computer engineering are underlined.

## Distinguished Professors

***Djuric, Petar M.***, Chairperson, Ph.D., 1990, University of Rhode Island: Signal analysis, modeling and processing; wireless communications and sensor networks.

***Yang, Yuanyuan***, Ph.D., 1992, Johns Hopkins University: Wireless and mobile networks, cloud computing, data center networks, optical networks, high speed networks, parallel and distributed computing systems, multicast communication, high performance computer architecture, and computer algorithms.

## Professors

***Bugallo, Monica***, Ph.D., 2001, Universidade da Coruna (Spain): Statistical signal processing with the emphasis in the topics of Bayesian analysis, sequential Monte Carlo methods, adaptive filtering, and stochastic optimization.

***Doboli, Alex***, Ph.D., 2000, University of Cincinnati: VLSI CAD and design, synthesis and simulation of mixed analog-digital systems, hardware/software co-design of embedded systems, and high-level synthesis of digital circuits.

***Hong, Sangjin***, Ph.D., 1999, University of Michigan: Low-power VLSI design of multimedia wireless communications and digital signal processing systems, including SOC design methodology and optimization.

***Parekh, Jayant P.***, Ph.D., 1971, Polytechnic Institute of Brooklyn: Microwave acoustics; microwave magnetics; microwave electronics; microcomputer applications.

***Robertazzi, Thomas G.***, Ph.D., 1981, Princeton University: Computer networking; grid computing; performance evaluation; parallel processing; e-commerce technology.

***Salman, Emre***, Ph.D. 2009, University of Rochester: Nanoscale integrated circuit design, emerging technologies for future electronic systems, highly heterogeneous integrated systems, digital and mixed-signal circuits.

***Singer, Andrew***, Ph.D., 1996, Massachusetts Institute of Technology: Signal Processing, Communication Systems, Machine Learning algorithms and systems, Sonar/Lidar/Optical Signal Processing, financial modeling and algorithms, optical communications, wireline/wireless communications, underwater acoustic communications sensing and localization, decision making/aggregation systems, augmented listening and audio processing, robotics.

***Shamash, Yacov***, Ph.D., 1973, Imperial College of Science and Technology in London, England: Control Theory & Systems, Energy Systems, and Industry/University Partnerships.

***Short, Kenneth L.***, Ph.D., 1973, Stony Brook University: Digital system design; microprocessors; instrumentation.

***Shterengas, Leon,*** Ph.D. 2004, Stony Brook University: Semiconductor photonic devices, nanofabrication, molecular beam epitaxy.

***Stanacevic, Milutin***, Ph.D., 2005, Johns Hopkins University: Analog and mixed-signal VLSI integrated circuits and systems; adaptive Microsystems; implantable electronics.

***Subbarao, Murali***, Ph.D., 1986, University of Maryland: Computer vision; image processing; pattern recognition.

***Ye, Fan***, Graduate Program Director, Ph.D., 2004, UCLA: mobile and embedded sensing systems and infrastructure, AI/ML analytics and algorithms for computational screening and surveillance (CSS) and smart aging, data-centric wireless communication, edge computing, Internet-of-Things

***Zhang, Peng***, Ph.D., 2009, University of British Columbia, Vancouver, BC, Canada: Power system, microgrids, quantum-engineered smart grids, AI-enabled resilient power systems, energy resiliency, offshore wind energy, power system stability and control.

## Associate Professors

***Dhadwal, Harbans***, Ph.D., 1980, University of London, England: Laser light scattering; fiber optics; optical signal processing and instrumentation.

***Donetski, Dmitri***, Ph.D., 2000, Stony Brook University: Design and technology of optoelectronic devices and systems including photovoltaic and photoconductive detectors, diode lasers and diode laser arrays.

***Dorojevets, Mikhail***, Ph.D., 1988 Siberian Division of the USSR Academy of Sciences, Novosibirsk: Computer architectures, systems design.

***Gorfinkel, Vera***, Ph.D., 1980, Ioffe Physical-Technical Institute, Russia: Semiconductor devices, including microwave and optoelectronics, DNA sequencing instrumentation, single photon counting techniques.

***Kamoua, Ridha***, Undergraduate Program Director, Ph.D., 1992, University of Michigan: Solid-state devices and circuits; microwave devices and integrated circuits.

***Lin, Shan***, Ph.D., 2010, University of Virginia: Cyber physical systems, networked information systems, wireless networks, sensing and control systems.

***Luo, Fang,*** Ph.D., 2010, Huazhong University of Science and Technology, Wuhan, China (Jointly supervised by Virginia Tech, Blacksburg, VA, USA): Power electronic devices and circuits, energy conversion systems.

***Milder, Peter,*** Ph.D. 2010, Carnegie –Mellon University: Digital hardware design, generation, and optimization focusing on signal processing, computer vision, and related domains; design for FPGA.

***Suchalkin, Sergey***, Ph.D., 1998, Ioffe Physical Technical Institute, Russia: Design and development of optoelectronic devices. Far- and Mid-infrared spectroscopy of solids. Physics of semiconductors and nanostructures.

***Tang, K. Wendy***, Ph.D., 1991, University of Rochester: Interconnection networks, parallel computing, and neural networks.

***Wang, Xin***, Ph.D., 2001, Columbia University: Mobile and ubiquitous computing, wireless communications and networks, grid and distributed computing, advanced applications and services over Internet and wireless networks.

***Zhao, Yue***, Ph.D., 2011, UCLA: Smart energy systems, renewable energy integration, electricity market, infrastructure security, sensing and signal processing, optimization theory, information theory, communication networks.

## Assistant Professors

***Liu, Ji***, Ph.D., 2013, Yale University: Distributed control and computation, multi-agent systems, social networks, epidemic networks, and power networks.

***Zhou, Yifan***, Ph.D., 2019, Tsinghua University: Networked Microgrids, Formal Analysis, AI-Driven Smart Grid, Quantum Computing

**Professors of Practice**

***Westerfeld, David***, Ph.D. 2005, Stony Brook University: Design and characterization of high-performance mid-infrared semiconductor light sources (LEDs and lasers).

## COURSE LISTING

**ESE 500 Introduction to Engineering Education** ***Non-Regular Course***
This graduate course provides an in-depth examination of engineering knowledge and practices in the context of secondary science content and instruction. The focus is on engineering design principles and how they may be applied to biology, chemistry, and physics disciplinary domains. Key concepts of effective engineering education will be introduced: design-based approaches, optimization, STEM integration, assessment, and transfer of science principles to technology solutions. Students will participate in engineering education opportunities through project design, research, and/or curriculum opportunities at the secondary and post-secondary levels. Fall, Spring, Summer, 3 credits, grading ABCF

**ESE 501 System Specification and Modeling**
A comprehensive introduction to the field of System-on-Chip design. Introduces basic concepts of digital system modeling and simulation methodologies. Various types of hardware description language (HDL) will be studied, including Verilog, VHDL and System C. Topics include top-down and bottom-up design methodology, specification language syntax and semantics, RTL, behavioral and system-level modeling, and IP core development. Included are three projects on hardware modeling and simulation. Fall, 3 credits, grading ABCF.

**ESE 502 Linear Systems**
Development of transfer matrices and state-space equations from the concepts of linearity, time-invariance, causlity and lumpedness. Op-amp circuit implementations, solutions and equivalent state equations. Companion and modal forms, Stability and Lyapunov equations. Controllability, observability, and their applications in minimal realization, state feedback and state estimators. Coprime fraction of transfer functions and their designs in pole-placement and model matching. Both the continuous-time and discrete-time systems will be studied. Fall, 3 credits, grading ABCF.

**ESE 503 Stochastic Systems**
Basic probability concepts and application. Probabilistic bounds, characteristic functions and multivariate distributions. Central limit theorem, normal random variables. Stochastic processes in communications, control and other signal processing systems. Stationarity, ergodicity, correlation functions, spectral densities and transmission properties. Optimum linear filtering, estimation and prediction. Fall, 3 credits, grading ABCF.

**ESE 504 Performance Evaluation of Communication and Computer Systems**
Advanced queuing models and algorithms for communication and computer systems. Mean value analysis and convolution algorithm. Transient analysis and M/G/1 queue. Models for traffic characterization in broadband integrated networks. Buffer sizing calculations. Bursty and self-similar traffic. Prerequisite: ESE 503 or permission of instructor. Spring, 3 credits, grading ABCF.

**ESE 505 Wireless Communications**
This course covers first year graduate level material in the area of wireless communications: wireless channels, overview of digital communications and signal processing for wireless communications, voice and data applications, and design basics for wireless modems. Analysis of system issues like resource management and handoff, cellular and wireless LAN systems. Fall and Spring, 3 credits, grading ABCF.

**ESE 506 Wireless Network**
This course will examine the area of wireless and mobile computing, looking at the unique network

protocol challenges and opportunities presented by wireless communications and host or router mobility. The course will give a brief overview of fundamental concepts in mobile wireless systems and mobile computing, it will then cover system and standards issues including second generation circuit switches and third generation packet switched networks, wireless LANs, mobile IP, ad-hoc networks, sensor networks, as well as issues associated with small handheld portable devices and new applications that can exploit mobility and location information. This is followed by several topical studies around recent research publications in mobile computing and wireless networking field. This course will make the system architecture and applications accessible to the electrical engineer. Prerequisite: ESE 505 and ESE 546 or ESE 548 or permission of instructor. Fall, 3 credits, grading ABCF.

## ESE 507 Advanced Digital System Design & Generation

This course focuses on languages, tools, and abstractions for design and implementation of digital systems. Course material is divided roughly into three categories: Limitations and constraints on modern digital systems; Hardware design abstractions, languages, and tools (including the SystemVerilog hardware description language); and new architectures and paradigms for digital design. Coursework will be primarily project and assignment based; there will also be reading and discussion of published papers in these areas. Students should have experience with hardware description languages (VHDL, Verilog, or SystemVerilog,) and software (C, C++ or Java). Fall, 3 credits, grading ABCF.

## ESE 509 Modern Energy Technologies

This course will cover a broad array of technologies that are essential to the modern energy industry, specifically focusing on the most contemporary topics and "hot" areas of research, development, and deployment. Students will gain a quantitative understanding of selected energy generation technologies, energy storage technologies, and pollution control technologies. For each of these topics, we will cover the physical principle of operation, as well as the economics and environmental impact. Fall, 3 credits, grading ABCF.

## ESE 510 Electronic Circuits – **This course is only for students in the Optoelectromechanical Systems Eng. Program and cannot be used to fulfill any ESE degree requirement.**

This is a course in the design and analysis of analog circuits, both discrete and integrated. The first part of the course presents basic topics related to circuit analysis: laws, theorems, circuit elements, and transforms. Fundamental semiconductor devices are introduced next. A number of aspects of circuit design beginning with basic device operation through the design of large analog functional blocks including amplifiers, oscillators, and filters are discussed. Fall, 3 credits, grading ABCF.

## ESE 511 Solid-State Electronics

The course provides an introduction to physics of semiconductor devices. It covers fundamental aspects of semiconductor physics necessary for understanding operation principles and characteristics of semiconductor diodes and transistors. Fall, 3 credits, grading ABCF.

## ESE 512 Introduction to Quantum Systems Engineering

A study of fundamental properties of homojunction and heterojunction semiconductor devices. Derivation of the characteristic equation for p-n junction diodes, for the bipolar junction transistor (BJT) and for the heterojunction bipolar transistor (HBT); the device parameters for low- and high-frequency operation, the effects on the device characteristics of fabrication methods and of structural arrangements. The development of the large-signal and small-signal equivalent circuits for the p-n diode and the BJT and HPT devices, with emphasis on models used in prevalent computer-aided analysis (e.g., SPICE). Consideration of the devices in integrated-circuit applications. Spring, 3 credits, grading ABCF.

## ESE 513 Introduction to Photovoltaics

Introduction to the basic concepts of photovoltaic solar energy conversion, including: 1. The solar resource in the context of global energy demand; 2. The operating principles and theoretical limits of photovoltaic devices; 3. Device fabrication, architecture, and primary challenges and practical limitations for the major technologies and materials used for photovoltaic devices. Students will gain knowledge of: the device physics of solar cells, the operating principles of the major commercial photovoltaics, and a basic understanding of the role of photovoltaics in the context of the global energy system. Pre/co –requisites ESE 231. Spring, 3 credits, grading ABCF.

## ESE 514 MOS Transistor Modeling

An overview of the metal-oxide semiconductor (MOS) transistor and its models for circuit analysis. The course is modular in structure. In a common first part, CMOS fabrication, device structure and operation are introduced. Starting from basic concepts of electrostatics, MOS field-effect transistor operation is presented in an intuitive fashion, and no advanced background in solid-state theory is required. Analytical models of increasing complexity and their SPICE implementations are discussed. The second part of the course allows students to focus on their field of preference: Device physics; Digital circuits; Analog circuits. The course includes a project in one of these subtopics. Fall, 3 credits, grading ABCF.

## ESE 515 Quantum Electronics I

Physics of microwave and optical lasers. Topics include introduction to laser concepts; quantum theory; classical radiation theory; resonance phenomena in two-level systems: Bloch equations, Kramers-Kronig relations, density matrix; rate equation and amplification; $CO_2$ lasers; discharge lasers; semiconductor lasers. Fall, 3 credits, grading ABCF.

## ESE 516, 517 Integrated Electronic Devices and Circuits I and II

Theory and applications: elements of semiconductor electronics, methods of fabrication, bipolar junction transistors, FET, MOS transistors, diodes, capacitors and resistors. Design techniques for linear digital integrated electronic components and circuits. Discussion of computer-aided design. MSI and LSI. Fall, Spring, 3 credits each semester, grading ABCF.

## ESE 518 Advanced Design of Low-Noise and Low-Power Analog Circuits

Design of advanced low-noise and low-power analog and mixed-signal integrated circuits for radiation sensors. Students will learn state-of-the-art circuit techniques for low-noise and low-power amplification and processing of signals from sensors. Examples of circuits are low-noise amplifiers, filters, peak detectors and discriminators. Applications range from medical, to security, safety, industrial measurements and physics research. As a course project, students will develop part of a front-end circuit from transistor level to physical layout using industry-standard CAD tools, and will participate in the experimental characterization of those or similar circuits. At the end of the course the student will own a solid background and the basic instruments to design low-noise and low-power amplifiers and processing circuits. Fall, 3 Credits, grading ABCF.

## ESE 519 Semiconductor Lasers and Photodectors

The course provides an introduction to performance, testing and fabrication techniques for semiconductor lasers and photodetectors. The topics include fundamentals of laser and detector operation, devices band diagram, device characteristics, and testing techniques for analog and digital edge emitting and surface emitting lasers, avalanche and PIN photodetectors. Special attention is given to the design and working characteristics of transmitters and pumping lasers for telecommunication networks. Prerequisite: BS in Physical sciences or Electrical or Computer Engineering. Spring, 3 credits, grading ABCF.

**ESE 520 Applied Electromagnetics**

Wave phenomena and their importance in electromagnetic engineering. Harmonic waves. Phase and group velocities. Dispersive and nondispersive propagation. Transmission lines. Maxwell Equations. Uniform plane waves. Poynting's theorem, waveguides, resonators. Scattering matrix theory. Introduction to antenna theory. Electrostatics and magnetostatics as special cases of Maxwell equations. Prerequisite: Bachelor's degree in Physical Sciences. Spring, 3 credits, grading ABCF.

**ESE 522 Fiber Optic Systems**

This course covers the essential components of a modern optical fiber communication system. Following a brief review of optical sources and characterization of optical fiber waveguides the remainder of the course examines the design of digital fiber optic links, single wavelength fiber-optic networks and wavelength division multiplexing. Fall, 3 credits, grading ABCF.

**ESE 523 Quantum Computing and Applications**

This course is an introduction to and survey of the Quantum Computing, an emerging interdisciplinary field of science which has the potential to revolutionize computation over the next ten years, to transform chemistry, medicine, engineering and communications, as well as to change our understanding of physical world. The course will build intuitive approach to quantum computation and algorithms, but also will advance relevant vocabulary and skills for faculties and graduate students in engineering, computing, applied mathematics, chemistry, physics, and related sciences. The key questions of the quantum computing will be introduced. How to describe quantum systems and quantum operations? What is a quantum computer and what are the limits of quantum power? What is the difference between classical and quantum computation? Quantum teleportation? Quantum entanglement and superposition? How to mitigate errors and decoherence and transmit information through noisy channels? What are business applications and engineering challenges of the quantum computers? What are the gains in running quantum vs. classical algorithms? What are the physical principles of the current quantum computers hardware and what are technology requirements for realistic quantum computers? Fall, 4 credits, grading ABCF.

**ESE 524 Microwave Acoustics**

Continuum acoustic field equations. Wave equation, boundary conditions and Poynting vector. Waves in isotropic elastic media: Plane-wave modes, reflection and refraction phenomena, bulk-acoustic-wave (BAW) waveguides, surface acoustic waves (SAW's). Plane and guided waves in piezoelectric media. BAW transduction and applications: delay-line and resonator structures, the Mason equivalent circuit, monolithic crystal filters, IM CON dispersive delay lines, acoustic microscopes, SAW transduction and applications: the interdigital transducer, band-pass filters, dispersive filters, convolvers, tapped delay lines, resonators. Prerequisite: ESE 319. Fall, 3 credits, grading ABCF.

**ESE 525 Modern Sensors in Artificial Intelligence Applications**

Sensors are devices that convert physical values into electrical signals. This course will provide practical information on diversified subjects related to the operation principles, design and use of various sensors. Established and novel sensor technologies as well as problems of interfacing various sensors with electronics are discussed. Fall, 3 credits, grading ABCF.

**ESE 526 Silicon Technology for VLSI**

This course introduces the basic technologies employed to fabricate advanced integrated circuits. These include epitaxy, diffusion, oxidation, chemical vapor deposition, ion implantation lithography and etching. The significance of the variation of these steps is discussed with respect to its effect on device performance. The electrical and the geometric design rules are examined together with the integration of these fabrication techniques to reveal the relationship between circuit design and the fabrication process. Fall, 3 credits, grading ABCF.

**ESE 528 Communication Systems**

This course provides a general overview of communication theory and addresses fundamental concepts in this field. After a review of signals and systems representations, various continuous and digital modulation schemes are analyzed. Spread spectrum systems and their application to multiuser communications are also addressed. Advanced communication systems are described and general concepts of wide and local area networks are introduced. Fall, 3 credits, grading ABCF.

**ESE 530 Computer-Aided Design**

The course presents techniques for analyzing linear and nonlinear dynamic electronic circuits using the computer. Some of the topics covered include network graph theory, generalized tableau and hybrid analysis, companion modeling, Newton's method in n-dimensions, numerical integration, sensitivity analysis, and optimization. Prerequisite: B.S. in electrical engineering. Spring, 3 credits, grading ABCF.

**ESE 531 Statistical Learning and Inference**

Minimum variance unbiased estimation, Cramer- Rao lower bounds, learning and inference with linear models, maximum likelihood estimation, least squares estimation, Bayesian inference, statistical decision theory, hypothesis testing with deterministic and random signals, composite hypothesis testing, model selection. Prerequisite: ESE 503 or permission of instructor. Spring, 3 credits, grading ABCF.

**ESE 532 Theory of Digital Communication**

Optimum receivers, efficient signaling, comparison classes of signal schemes. Channel capacity theorem, bounds on optimum system performance, encoding for error reduction, and the fading channel. Source coding and some coding algorithms. Prerequisite: ESE 503 or permission of instructor. Fall, 3 credits, grading ABCF.

**ESE 533 Convex Optimization and Engineering Applications**

Introduction to convex optimization and its applications; Convex sets, function, and basics of convex analysis; Linear and quadratic programs, second-order cone and semidefinite programming, geometric programming. Duality theory and optimality conditions; unconstrained minimization methods; Interior-point methods; Non-differentiable problems; Decomposition methods. Applications in engineering fields including statistical signal processing, communications, networking, energy systems, circuit design, and machine learning. Spring, 3 credits, grading ABCF.

**ESE 534 Cyber Physical Systems**

This course covers important areas from the research literature on cyber-physical systems. Three application domains are emphasized: medical devices for health care, smart transportation systems, and smart buildings. Several key cross-cutting principles, independent of the application domain are also covered, including formal modeling, embedded systems, real time systems, feedback control, and sensor networks. Prerequisite: Background in embedded systems and computer networking is necessary. Fall, 3 credits, grading ABCF.

**ESE 535: Power System Analysis**

The course focuses on fundamental analytics of power systems. It will help students understand major problems in power system static, dynamic, and stability analysis, as well as fundamental optimization issues in power system operation. The course covers power system steady-state modeling with emphasis on admittance and impedance matrix, power system dynamics modeling with emphasis on the functional state-space model, power system analytics with emphasis on power flow analysis, eigenvalue analysis, and time-domain transient simulation, as well as fundamental power system operation issues with emphasis on optimal power flow, unit commitment, and power system control. Emphasis is on using applied mathematics and computer-based methods to analyze power system problems. Prerequisites: AMS 210, ESE 271 or equivalent courses. Spring, 3 credits, grading ABCF.

**ESE 536/*CSE 626* Switching and Routing in Parallel and Distributed Systems (cross listed)**
This course covers various switching and routing issues in parallel and distributed systems. Topics include message switching techniques, design of interconnection networks, permutation, multicast and all-to-all routing in various networks, non-blocking and re-arrangeable capability analysis and performance modeling. Prerequisites: ESE 503 and 545 or CSE 502 and 547, or permission of the instructor. Fall, 3 credits, grading ABCF.

**ESE 537 Mobile Sensing Systems & Applications**
This is a graduate course focusing on recent advances and developments in mobile sensing systems and their applications, especially those leveraging modern mobile devices and embedded sensors. Topics include: conventional mote-class sensor networks, participatory sensing leveraging mobile devices, intelligent hardware and Internet-of-Things, location sensing, future information centric networking, and applications in smart homes, buildings, transportation, environment and health/fitness. Students need to read latest literature and write reviews, work on research problems and develop solutions, present their work and write formal reports. The practice of the basic research skills are major components. The course intends to be self-sufficient and prior experiences in programming, mobile devices and embedded systems is a plus. Fall, 3 credits, grading ABCF.

**ESE 538 Nanoelectronics**
The major goals and objectives are to provide graduate students with knowledge and understanding of physical background and applications of nanoelectronics. The course will cover electrical and optical properties of materials and nanostructures, fabrication of nanostructures, nanoelectronic devices including resonant-tunneling devices, transistors, and single-electron transfer devices, as well as applications of nanotechnologies in molecular biology and medicine. Spring, 3 credits, grading ABCF.

**ESE 539 Power Electronics and Motor Drives**
This course is designed to cover the basic concepts of motor control, motor drive design and power electronics inverters. The objective of this course is to give a basic introduction of motor control and power electronics-based motor drive design. The course requirements include homework and projects. It involves motor drive simulation, control strategy design, switching circuit simulation and circuit performance evaluation. There will a building-in project using lab equipment to validate students' design. Spring, 3 credits, grading ABCF.

**ESE 540 Reliability Theory**
Theory of reliability engineering. Mathematical and statistical means of evaluating the reliability of systems of components. Analytical models for systems analysis, lifetime distributions, repairable systems, warranties, preventive maintenance and inspection. Software reliability and fault tolerant computer systems. Prerequisite: ESE 503 or permission of instructor. Fall, 3 credits, grading ABCF.

**ESE 541 Digital System Design** - **This course is only for students in the Optoelectromechanical Systems Eng. Program and cannot be used to fulfill any ESE degree requirement.**
This course provides an introduction to digital and computer systems. The course follows a top-down

approach to presenting design of computer systems, from the architectural-level to the gate-level. VHDL language is used to illustrate the discussed issues. Topics include design hierarchy and top-down design, introduction to hardware description languages, computer-aided design and digital synthesis, basic building blocks like adders, comparators, multipliers, latches, flip-flops, registers etc., static and dynamic random access memory, data and control buses, fundamental techniques for combinational circuit analysis and design, sequential circuit design procedures, and programmable logic devices. Testing of digital designs is addressed throughout the course. A mini project will complement the course. Spring, 3 credits, grading ABCF.

**ESE 542/*MEC 525* Product Design Concept Development and Optimization (cross listed)**

This course will concentrate on the design concept development of the product development cycle, from the creative phase of solution development to preliminary concept evaluation and selection. The course will then cover methods for mathematical modeling, computer simulation and optimization. The concept development component of the course will also cover intellectual property and patent issues. The course will not concentrate on the development of any particular class of products, but the focus will be mainly on mechanical and electromechanical devices and systems. As part of the course, each participant will select an appropriate project to practice the application of the material covered in the course and prepare a final report. Prerequisite: Undergraduate electrical or mechanical engineering and/or science training. Fall, 3 credits, grading ABCF.

**ESE 543 Mobile Cloud Computing**

Introduction to the basic concepts of mobile cloud computing, including: 1. the mobile computing technology used in modern smart phones; 2. the cloud computing technologies used in existing data centers; 3. the synergy of mobile and cloud computing and its applications; 4. Programming on smart phone utilizing data center services. Students will gain knowledge of: the fundamental principles, the major technologies that support mobile cloud computing, the current challenges and primary areas of research within the field, and a basic understanding of the role of mobile cloud computing in the context of the everyday living. Spring, 3 credits, grading ABCF.

**ESE 544 Network Security Engineering**

An introduction to computer network and telecommunication network security engineering. Special emphasis on building security into hardware working with software. Topics include encryption, public key cryptography, authentication, intrusion detection, digital rights management, firewalls, trusted computing, encrypted computing, intruders and virus. Some projects. Prerequisite or co-requisite: ESE 546 OR ESE 548 Fall, alternate years, grading ABCF.

**ESE 545 Computer Architecture**

This course focuses on the design, quantitative analysis and evaluation of modern computer systems. The emphasis is on instruction set design, processor design, pipelining, static and dynamic instruction scheduling, speculative execution, different types of parallelism (instruction, data, and thread level), caches, memory systems, and basics of memory technology. Students will undertake a design project on the multimedia processor design related to the course contents. The project is to be done with a use of hardware description languages, such as VHDL/Verilog/SystemVerilog, as well as modern CAD systems, such as Cadence, Mentor Graphics, etc. Prerequisite: ESE 218 or equivalent. Spring, 4 credits, grading ABCF.

**ESE 546 Networking Algorithms and Analysis**

An introduction to algorithms and analysis for computer and telecommunication networks. Continuous time and discrete time single queue analysis. Algorithms for public key cryptography, routing, protocol verification, multiple access, error, codes, data compression, search. Prerequisite: ESE 503 or permission of instructor.  Fall, 3 credits, grading ABCF.

**ESE 547 Digital Signal Processing**
A basic graduate course in Digital Signal Processing.  Sampling and reconstruction of Signals.  Review of Z-Transform theory.  Signal flow-graphs.  Design of FUR and IIR filters.  Discrete and fast Fourier transforms.  Introduction to adaptive signal processing.  Implementation considerations.  Prerequisites:  Senior level course in signals and systems.  Fall, 3 credits, grading ABCF.

**ESE 548 Computer Networks**
To present basic network principles and methods in a top-down approach. The course will introduce the material of high-level network applications and motivate students to find out about networking aspects inside these applications. The course will provide the details of network services from the top layer (TCP/UDP) to lower layer (Ethernet). The areas to be covered are computer networks introduction, network applications, transport layer, network layer, link layer (LAN), wireless networks, and network security. Students are required to implement two projects for date transfer. Students will also use network tools to inspect communication networks in action.  Spring 3 credits, grading ABCF.

**ESE 549 Advanced VLSI System Testing**
This course is designed to acquaint students with fault diagnosis of logic circuits.  Both combinatorial and sequential circuits are considered.  Concepts of faults and fault models are presented.  Emphasis is given to test generation, test selection, fault detection, fault location, fault location within a module and fault correction.  Spring, 3 credits, grading ABCF.

**ESE 550 Network Management and Planning**
This course provides an introduction to telecommunications and computer network management and planning.  Network management is concerned with the operation of networks while network planning is concerned with the proper evolution of network installations over time.  Network management topics include meeting service requirements, management operations, management interoperability and specific architectures such as Telecommunications Management Network (TMS), and Simple Network Management Protocol (SNMP).  Network planning topics include planning problem modeling, topological planning design, heuristic and formal solution techniques.  Fall, 3 credits, grading ABCF.

**ESE 551: Electronics and Radiation Effects**
A study of the effects of radiation on electronic circuit operation.  Radiation may come from space or man-made sources such as nuclear reactors or CAT scan machines.  Coverage includes types of radiation, types of effects on circuits such as SEE (Single Event Effects), designing circuits to mitigate radiation effects and testing of circuits prior to deployment.  Applications include electronics for space and for use in nuclear reactors and certain medical imaging machines.  Spring, 3 credits, grading ABCF.  Pre-req: ESE 272 or ESE 273 or equivalent electronics course.

**ESE 552 Interconnection Networks**
Formation and analysis of interconnect processing elements in parallel computing organization.  Topics include:  SIMD/MIMD computers, multiprocessors, multicomputers, density, symmetry, representations, and routing algorithms.  Topologies being discussed include:  Benes, Omega, Banyan, mesh, hypercube, cube-connected cycles, generalized chordal rings, chordal rings, DeBruijn, Moebius graphs, Cayley graphs and Borel Cayley graphs.  Prerequisite:  ESE 545 or equivalent.  Fall, 3 credits, grading ABCF.

**ESE 553 A/D and D/A Integrated Data Converters**
This is an advanced course on analog integrated circuit design aspects for data converters. Topics include: continuous and discrete-time signals and systems; sampling theorem; ideal A/D and D/A converters; specifications and testing of data converters; basic building blocks in data converters: current sources and mirrors, differential gain stages, voltage references, S/H circuits, comparators:
Nyquist D/A and A/D converters: principles of data conversion and circuit design techniques; over sampling data converters: low-pass and band-pass delta-sigma modulators, decimation and interpolation for delta-sigma data converters. The attending students must be acquainted with principles of transistor operation, function of simple analysis. Familiarity with SPICE is required. Fall, 3 credits, grading ABCF.

**ESE 554 Computational Models for Computer Engineers**
This course covers mathematical techniques and models used in the solution of computer engineering problems. The course heavily emphasizes computer engineering application. Topics covered include set theory, relations, functions, graph theory and graph algorithms, computational complexity, ordering relations, lattices, Boolean algebras, combinations and algebraic structures. Fall, 3 credits, grading ABCF.

**ESE 555 Advanced VLSI System Design**
Techniques of VLSI circuit design in the MOS technology are presented. Topics include MOS transistor theory, CMOS processing technology, MOS digital circuit analysis and design and various CMOS circuit design techniques. Digital systems are designed and simulated throughout the course using an assortment of VLSI design tools. Prerequisite: BS in Electrical Engineering or Computer Science. Spring, 3 credits, grading ABCF.

**ESE 556 VLSI Physical and Logic Design Automation**
Upon completion of this course, the students will be able to develop state-of-the-art CAD tools and algorithms for VLSI logic and physical design. Tools will address design tasks such as floor planning, module placement and signal routing. Also, automated optimization of combinational and sequential circuits will be contemplated. Prerequisite: BS in Computer Engineering/Science or Electrical Engineering. Spring, 3 credits, grading ABCF.

**ESE 557 Digital Signal Processing II: Advanced Topics**
A number of different topics in digital signal processing will be covered, depending on class and current research interest. Areas to be covered will include the following: parametric signal modeling, spectral estimation, multirate processing, advanced FFT and convolution algorithms, adaptive signal processing, multidimensional signal processing for inverse problems. Students will be expected to read and present current research literature. Prerequisite: ESE 547 or permission of instructor. Spring, 3 credits, grading ABCF.

**ESE 558 Digital Image Processing I**
Covers digital image fundamentals, mathematical preliminaries of two-dimensional systems, image transforms, human perception, color basics, sampling and quantization, compression techniques, image enhancement, image restoration, image reconstruction from projections, and binary image processing. Prerequisite: BS in engineering or physical or mathematical sciences. Spring. 3 credits, grading ABCF.

**ESE 561 Theory of Artificial Intelligence**
Problem solving by searching, game trees, constraint satisfaction problems, uncertain knowledge and reasoning, probabilistic reasoning, probabilistic reasoning over time, Markov decision processes, partially observable Markov decision processes, reinforcement learning, generalized reinforcement learning. Fall, 3 credits, grading ABCF.

## ESE 562 Artificial Intelligence Driven Smart Grids

The course focuses on artificial intelligence (AI) applications to power system analysis, planning and operation. Topics include basics of AI and smart grid, data preprocessing, predictive analytics, AI driven static analytics such as optimal dispatch, state estimation and security assessment, and AI-based dynamical analytics such as transient stability assessment, dynamic model discovery and emergency control. Emerging topics, including transfer learning, data-driven formal methods, learning-based cybersecurity and big data platform, are also discussed. Fall, 3 credits, grading ABCF.

## ESE 563 Fundamentals of Robotics I

This course covers: homogenous transformations of coordinates; kinematic and dynamic equations of robots with their associated solutions; control and programming of robots. Prerequisite: Permission of instructor. Fall, 3 credits, grading ABCF.

## ESE 564 Artificial Intelligence for Robotics

Artificial Intelligence (AI) is intelligence demonstrated by machines, unlike the natural intelligence displayed by humans and animals. Research in AI focuses on the development and analysis of algorithms that learn and perform intelligent behavior with minimal human intervention. This course aims to introduce students some basic techniques and algorithms in AI including probabilistic inference, planning and search, localization, tracking and control, and their applications to robotics. Pre-/Co-requisite: Probability and Random Processes, Linear Algebra, Feedback Control. Success in this course also requires some mathematical fluency with background in linear systems (e.g., ESE 502 or instructor approval) and programming experience (fluent in at least one programming language, e.g., Python and MATLAB). Spring, 3 credits, grading ABCF.

## ESE 565 Parallel Processing Architectures

The goal of this course is to provide in-depth understanding of modern parallel computer architectures and the introduction to parallel programming with ISPC, Pthreads, OpenMP, MPI, and CUDA. We will seek to understand the fundamental design issues, engineering tradeoffs, and essential interplay of hardware and software that cut across parallel machines, rather than simply consider a descriptive taxonomy. The emphasis is on shared memory and data parallel systems. Students will undertake a system design/analysis/parallel programming project either of their own choice (that has to be approved by Instructor) or an HDL design project suggested by the Instructor. Spring, 3 credits, grading ABCF.

## ESE 566 Hardware-Software Co-Design of Embedded Systems

This course will present state-of-the-art concepts and techniques for design of embedded systems consisting of hardware and software components. Discussed topics include system specification, architectures for embedded systems performance modeling and evaluation, system synthesis, and validation. The course is complemented by three mini-projects focused on designing and implementing various co-design methods. Prerequisite: ESE 545, ESE 554 and ESE 333.
Fall, 3 credits, grading ABCF.

## ESE 568 Computer and Robot Vision

Principles and applications of computer and robot vision are covered. Primary emphasis is on techniques and algorithms for three-dimensional machine vision. The topics include image sensing of three-dimensional scenes, a review of two-dimensional techniques, image segmentation, stereo vision, optical flow, time-varying image analysis, shape-from-shading, texture, depth-from- defocus matching, object recognition, shape representation, interpretation of line drawings, and representation and analysis of 3D range data. The course includes programming projects on industrial applications of robot vision.

Prerequisite: BS in Engineering or Physical or Mathematical Sciences. Fall, 3 credits, grading ABCF.

## ESE 569 Translational Bioinformatics

Advanced technologies have driven rapid increases in the quantities of biomedical data. Translational bioinformatics develops the specified computational and analytic methods to transform these large-scale datasets into biomedical applicable information and knowledge. It is one of major applications of machine learning and data mining. This course introduces large-scale biomedical data resources and management, data processing and modeling, data mining and machine learning approaches in translational bioinformatics, and provides the hands-on projects for students to practice these approaches for real-world biomedical data. Fall, 3 credits, grading ABCF.

## ESE 575 Advanced VLSI Signal Processing Architecture

This course is concerned with advanced aspects of VLSI architecture in digital signal processing and wireless communications. The first phase of the course covers the derivation of both data transformation and control sequencing from a behavioral description of an algorithm. The next phase reviews the general purpose and dedicated processor for signal processing algorithms. This course focuses on low-complexity high-performance algorithm development and evaluation, system architecture modeling, power-performance tradeoff analysis. The emphasis is on the development of application-specific VLSI architectures for current and future generation of wireless digital communication systems. An experimental/research project is required. Prerequisite: ESE 355 or equivalent. ESE 305 or ESE 337 or equivalent. ESE 306 or ESE 340 or equivalent. ESE 380 or equivalent. Spring, 3 credits, grading ABCF.

## ESE 576 Power System Dynamics

The course provides the background for understanding power system dynamics and numerical simulation techniques. Topics include the numerical integration for large scale power networks, numerical oscillation and its solution, power system component modeling, frequency-dependent transmission network, nonlinear elements, network equivalents, power network stability, simulation of power electronic inverters, and microgrid stability & control. The area of real-time simulation for cyber-physical power infrastructures will also be discussed. The course involves term project. Fall, 3 credits, grading ABCF.

## ESE 577 Deep Learning Algorithms and Software

This course is an introduction to deep learning which uses neural networks to extract layered high-level representations of data in a way that maximizes performance on a given task. Deep learning is behind many recent advances in AI, including Siri's speech recognition, Facebook's tag suggestions and self-driving cars. Topics covered include basic neural networks, convolutional and recurrent network structures, deep unsupervised and reinforcement learning, and applications to problem domains like speech recognition and computer vision.
Fall, 3 credits, grading ABCF.

## ESE 578: Quantum-Engineered Power Grids

The course focuses on the applications of quantum information science (QIS) to power system analysis, operation and communication. Topics will cover basics of QIS and smart grid, quantum computing, quantum circuits, quantum-enabled power grid steady-state/transient/stochastic analysis, application of quantum optimization and quantum machine learning in power grids, quantum control, quantum security, quantum Internet. Emphasis of the course is the practical quantum algorithms in power system applications and hands-on experiments on IBM Quantum platform. Prerequisites: any one of ESE435, ESE576, ESE586, or an equivalent course (such as electrical power systems, power and energy systems, power system analysis, power system operation and control). Fall, 3 credits, grading ABCF

## ESE 579 Advances Topics in Translational Bioinformatics

This course introduces the current applications of machine learning and data mining techniques in biomedical data science, discusses the latest translational research areas and progresses, and provides the hands-on team projects for graduate students to explore, design and practice their “data-driven” solutions for the cutting-edge research topics in biomedical data science. Fall, 3 credits, grading ABCF.

## ESE 580, 581 Microprocessor-Based Systems, Engineering I and II

This course is a study of methodologies and techniques for the engineering design of microprocessor-based systems. Emphasis is placed on the design of reliable industrial quality systems. Diagnostic features are included in these designs. Steps in the design cycle are considered. Specifically, requirement definitions, systematic design implementation, testing, debugging, documentation and maintenance are covered. Laboratory demonstrations of design techniques are included in this course. The students also obtain laboratory experience in the use of microprocessors, the development of systems, circuit emulation and the use of signature and logic analyzers. Fall, Spring, 4 credits, each semester, grading ABCF.

## ESE 585 Nanoscale Integrated Circuit Design

This course describes high performance and low power integrated circuit (IC) design issues for advanced nanoscale technologies. After a brief review of VLSI design methodologies and current IC trends, fundamental challenges related to the conventional CMOS technologies are described. The shift from logic-centric to interconnect-centric design is emphasized. Primary aspects of an interconnect-centric design flow are described in four phases: (1) general characteristics of on-chip interconnects, (2) on-chip interconnects for data signals, (3) on-chip power generation and distribution, and (4) on-chip clock generation and distribution. Existing design challenges faced by IC industry are investigated for each phase. Tradeoffs among various design criteria such as speed-power-noise-area are highlighted. In the last phase of the courses, several post-CMOS devices, emerging circuit styles, and architectures are briefly discussed. At the end of the course, the students will have a thorough understanding of the primary circuit and physical level design challenges with application to industrial IC design. Prerequisite: ESE 555 or ESE 330 and ESE 355. Spring, 3 credits, grading ABCF.

## ESE 586 Microgrids

Advanced modeling, control, resilience and security technologies useful for the grid modernization from a unique angle of microgrid design, analysis and operation. Smart inverters, microgrid architectures, distributed energy resources modeling, microgrid hierarchical control, microgrid stability, fault management, resilient microgrids through programmable networks, reliable networked microgrids, and cyber security. The course involves term project. Spring, 3 credits, grading ABCF.

## ESE 587 Hardware Architectures for Deep Learning

This course focuses on the design and implementation of specialized digital hardware systems for executing deep learning algorithms. The course is divided into three sections. First, students will study field-programmable gate arrays (FPGAs) and related tools. Second, the course will present an overview of modern deep learning algorithms and applications (e.g., visual object recognition, or speech recognition). Third, students will apply this knowledge to complete a significant design project implementing and optimizing a deep learning algorithm on an FPGA. Prerequisite: ESE 507 or equivalent. Spring, 3 credits, grading ABCF.

## ESE 588 Fundamentals of Machine Learning

The fundamentals of machine learning are introduced including learning with parametric models, online learning: stochastic gradient descent family of methods; classification; logistic regression; the naïve Bayes classifier; the nearest neighbor rule; classification trees; boosting methods; sparsity aware learning: concepts and methods; learning in reproducing kernel Hilbert spaces; Bayesian learning; variational approximation, sparse Bayesian learning, relevance vector machines; neural networks and deep learning;

the backpropagation algorithm; convolutional neural networks; recurrent neural networks; adversarial training; dimensionality reduction; PCA; ICA; nonlinear dimensionality reduction. Prerequisite: Stochastic Processes and Data Structures. Spring, 3 credits, grading ABCF.

### ESE 589 Learning Systems for Engineering Applications

The course presents the main methods used in automated (machine) learning for engineering applications. The course discusses representation models for learning, extraction of frequent patterns, classification, clustering and application of these techniques for diverse engineering applications, such as Intranet-of-Things, electronic design automation, and healthcare. The covered topics include an overview of learning systems, learning representations i.e. ontologies, regression models, stochastic models and symbolic models, data preparing techniques, different frequent pattern extraction methods, supervised and unsupervised classification, and basic and advanced clustering algorithms. The course is organized as three modules, each module being centered on a specific theme. Students will learn the characteristics of the enumerated topics, and devise and implement software programs for discussed techniques as part of their project work for the course. Student projects will be assessed using standard benchmarks. Spring, 3 credits, grading ABCF.

### ESE 590 Practical Machine Learning and Artificial Intelligence

This course provides a broad introduction to the state-of-the-art of machine learning methods through lectures and labs, where the lectures summarize the theoretical foundations of the methods and the emphasis is on their practical use. Students work in teams and utilize modern tools to develop a specific application in artificial intelligence. Fall, 3 credits, grading ABCF.

### ESE 591 Industrial Project in OEMS Engineering

Students must carry out a detailed design of an industrial project in Optoelectromechanical Systems engineering. A comprehensive technical report of the project and an oral presentation are required. Fall, 3 credits, grading ABCF.

### ESE 592 Distributed Computation, Control and Learning over Networks

Network science is an interdisciplinary research area, which typically deals with large- scale complex networks. This course covers fundamental problems in distributed computation and control, including consensus and distributed averaging, distributed optimization, discusses the rendezvous problem and formation control, and explores recent development in distributed machine learning over networks. Pre- or Corequisite: Linear Algebra, Applied Calculus. Spring, 3 credits, grading ABCF.

### ESE 593/PHY693 High Power RF Engineering

The course provides an essential review of the properties of low and medium power RF waves and components including transmission lines, waveguides and cavities, and then proceeds to highlight the properties and limitations under high power RF conditions. The principal deleterious effects taking place at high power levels are caused by arcing (a high peak power effect) and the ohmic dissipation in the metal walls (a high average power effect). Exceeding the power handling capacity of the RF components can result in expensive repairs. Methods of mitigating or avoiding these expensive repairs are discussed. Important applications of high power rf are discussed in depth. The course involves project. Prerequisite: A basic course in microwaves. Fall, 3 credits, grading ABCF.

### ESE 597 Practicum in Engineering (Internship) *Non-Regular Course*

This course is for part-time and full-time students who will be on Curricular Practical Training (CPT). CPT is defined as training that is an integral part of an established curriculum. Participation is in private corporations, public agencies or non-profit institutions. Students will be required to have a faculty coordinator as well as a contact in the outside organization, to participate with them in regular consultations on their project and to submit a final report to both. Registration must have the prior approval of the Graduate Program Director. This course can only be taken once by master's students and the credits must count towards the degree completion. variable credit (1-3), grading, S/U.

### ESE 599 Research (for students in the Master's program) *Non-Regular Course*
Fall and Spring, variable and repetitive credit, Grading S/U.

### ESE 610 Seminar in Solid-State Electronics
Current research in solid-state devices and circuits and computer-aided network design. Fall and Spring, 3 credits, grading ABCF.

### ESE 670 Topics in Electrical Sciences
Varying topics selected from current research topics. This course is designed to give the necessary flexibility to students and faculty to introduce new material into the curriculum before it has attracted sufficient interest to be made part of the regular course material. Topics include: a) Biomedical Engineering; b) Circuit Theory; c) Controls; d) Electronics Circuits; e) Digital Systems and Electronics; f) Switching Theory and Sequential Machines; g) Digital Signal Processing; h) Digital communications; i) Computer Architecture; j) Networks; k) Systems Theory; l) Solid State Electronics; m) Integrated Electronics; n) Quantum Electronics and Lasers; o) Communication Theory; p) Wave Propagation; q) Integrated Optics; r) Optical Communications and Information Processing; s) Instrumentation; t) VLSI Computer Design and Processing. Fall and Spring, variable and repetitive credit, grading ABCF.

### ESE 691 Seminar in Electrical Engineering
This course is designed to expose students to the broadest possible range of the current activities in electrical engineering. Speakers from both on and off campus discuss topics of current interest in electrical engineering. Fall and Spring, 1 credit, repetitive, grading S/U.

### ESE 697 Ph.D. Practicum in Teaching – * 3 credits required for Ph.D. degree - *Non-Regular Course*
This course provides hands-on experience in classroom teaching. Other activities may include preparation and supervision of laboratory experiments, exams, homework assignments, and projects.
Final report that summarizes the activities and provides a description of the gained experience and a list of recommendations is required. 3 credits, grading ABCF.
***Prerequisite: Advanced to candidacy status and Permission of Graduate Program Director. Students must inform the Department TWO weeks prior to the beginning of each semester, if they plan on taking ESE 697. The Graduate Program Director will then assign you to a course.**

### ESE 698 Practicum in Teaching *Non-Regular Course*
This course enables graduate students to gain experience in teaching and interacting with students enrolled in an electrical and computer engineering courses. Students enrolled in ESE 698 are expected to perform various teaching duties required by the course instructor, such as attending lectures, providing office hours, holding review/recitation sessions, assisting in lab sections, grading, etc. Fall, Spring and Summer, variable and repetitive, grading ABCF.

### ESE 699 Dissertation (Research on Campus) *Non-Regular Course*
Students should register for this if the major portion of their research will take place on Stony Brook University campus, Cold Spring Harbor or Brookhaven National Lab.
Fall and Spring, variable and repetitive credit, grading S/U.

**ESE 700 Dissertation Research (Off Campus – Domestic)** ***Non-Regular Course***

Students should register for this when a major portion of their research will take place off-campus but in the United States and/or U.S. provinces (please note that Brookhaven National Labs and Cold Spring Harbor are considered on-campus). All international students who register for ESE 700 must enroll in one of the graduate student employee insurance plans and should be advised by an International Advisor. Fall and Spring, variable and repetitive credit, grading S/U.

**ESE 701 Dissertation Research (Off Campus – INTERNATIONAL)** ***Non-Regular Course***

Students should register for this when a major portion of their research will take place outside of the United States and/or U.S. provinces. In these cases, domestic students have the option of the health plan and may also enroll in MEDEX. Fall and Spring, variable and repetitive credit, grading S/U.

**International students should note the following**:

- International students who are in their home country are NOT covered by the mandatory health plan and must contact the Insurance Office for the insurance charge to be removed.
- International students who are not in their home country ARE charged for the mandatory health insurance. If they are to be covered by another insurance plan, they must file a waiver by the second week of classes. The charge will only be removed if the other plan is deemed comparable.
- All international students must receive clearance from an International Advisor.

**ESE 800 Full-Time Summer Research**

0 Credits, grading S/U.

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# OUTSIDE OF DEPARTMENT: COURSE LISTING

Please Note: The following are courses from outside of the ECE department that may be used by Computer Engineering majors toward achieving their degree. The enrollment of the ECE students to the outside of the department courses cannot be guaranteed.

## CSE 504 Compiler Design

Advanced topics in compilation, including memory management, dataflow analysis, code optimization, just-in-time compilation, and selected topics from compilation of object-oriented and declarative languages. Prerequisite: CSE 304 and CSE 307. 3 credits.

## CSE 506 Operating Systems

This course is an in-depth study of important concepts and techniques found in modern computer operating systems. An undergraduate course in operating systems is a prerequisite. The course focuses on in-depth study of such important issues as virtual memory, filesystems, networking, and multiprocessor support, with an eye to recent directions in these areas. Textbook readings are supplemented, where appropriate, by papers from the research literature. An important part of the course is the case study of an actual operating system. Students study the source code for this operating system and do programming exercises and projects that involve modifying the operating system and measuring its performance. Prerequisite: CSE 306. 3 credits.

## CSE 510 Hybrid Systems

Hybrid Systems combine discrete state-machines and continuous differential equations and have been used as models of a large number of applications such as real-time software, embedded systems, robotics, mechatronics, aerospace systems, process control and biological systems. The course will cover modeling, design, analysis, and verification methods for hybrid systems. Topics may include SAT/SMT solvers, timed automata, formal logics for system specification, verification algorithms and closed-loop neural network control systems. 3 credits.

## CSE 526 Principles of Programming Languages

Programming language concepts and design, with emphasis on abstraction mechanisms. Topics include: language paradigms (procedural, object-oriented, functional and logic), language concepts (values, bindings, types, modules), and foundations (lambda calculus, denotational semantics). Examples will be drawn from several representative languages, such as C, Java, Standard ML and Prolog. Prerequisite: CSE 307. 3 credits.

## CSE 533 Network Programming

Socket and client-server programming, remote procedure calls, data compression standards and techniques, real-time protocols (e.g: audio chat, etc,) security and cryptography (specifically, application layer security issues (e.g., authentication), web-related programming (CGI, Java/Java Script, HTTP, etc.,) network management (SNMP-based management, dynamic/CORBA-based management). Prerequisite: CSE 306 and CSE 310. 3 credits.

## CSE 548/AMS542 Analysis of Algorithms

Techniques for designing efficient algorithms, including choice of data structures, recursion, branch and bound, divide and conquer, and dynamic programming. Complexity analysis of searching, sorting, matrix multiplication, and graph algorithms. Standard NP-complete problems and polynomial transformation techniques. Prerequisite: CSE 373. 3 credits.