Electrical and Computer Engineering

Web Site: http://www.odu.edu/ece (http://www.odu.edu/ece/)

Oscar González, Chair

The Department of Electrical and Computer Engineering offers undergraduate four-year degree programs leading to the Bachelor of Science in Electrical Engineering and the Bachelor of Science in Computer Engineering. These programs are accredited by the Engineering Accreditation Commission of ABET, http://www.abet.org. The undergraduate programs provide a broad foundation in electrical and/or computer engineering through combined lecture and laboratory work and prepare the student for entering the profession of electrical and/or computer engineering. In addition, these programs prepare the students for further study at the graduate level.

The department also offers programs of graduate study leading to the degrees of Master of Engineering, Master of Science, Doctor of Engineering, and Doctor of Philosophy. Faculty members in electrical and computer engineering are actively engaged in research, and the department maintains extensive laboratory facilities to support the research work. Areas of specialization include biomedical engineering, bioelectrics, plasmas, microelectronics/nanotechnology, photovoltaics, atomic layer deposition, laser processing, multivariable systems/nonlinear control, computational intelligence and machine vision, signal and image processing, modeling/simulation/visualization, medical modeling, computer hardware, computer networks, and communications.

Students majoring in either electrical engineering or computer engineering may fulfill the upper-level General Education requirements through completion of a minor in the other discipline. Computer engineering students automatically meet this requirement with the built-in minor in computer science.

Mission Statement

The Department of Electrical and Computer Engineering at Old Dominion University is a partnership among students, faculty and staff in Service to the profession of Electrical and computer engineering through academic excellence, Research and real-world experiences, dedicated to a Vision of the future that includes Industry and community, Continuous improvement, and personal Enrichment and growth (SERVICE).

Bachelor of Science in Electrical Engineering

Vishnu K. Lakdawala, Chief Departmental Advisor

The electrical engineering undergraduate curriculum begins with a solid foundation in math, science, English, circuits, signals and linear systems, electronics, electromagnetics, digital systems, and microelectronics. Adequate elective freedom is available to the student to allow specialization in one or more of the five concentration areas: systems and automation engineering, physical electronics, computer hardware systems, power and renewable energy, or data analytics engineering. Emphasis is placed on understanding principles through theoretical investigation and experimental verification. In addition, course work in General Education Skills and Ways of Knowing are required to assure a well-rounded program of study.

Electrical Engineering Program Concentration Areas

The systems and automation engineering concentration requires completion of four courses selected from the following: ECE 381, ECE 451, ECE 455, ECE 458, and ECE 461.

The physical electronics concentration requires completion of four courses selected from the following: ECE 403, ECE 454, ECE 464, ECE 471, ECE 472, ECE 473, and ECE 474.

The computer hardware systems concentration requires completion of four courses selected from the following: ECE 341, ECE 346, ECE 441, ECE 443, and ECE 483.

The power and renewable energy concentration requires completion of four courses selected from the following: ECE 303, ECE 403, ECE 404, ECE 405, ECE 408, ECE 461, and ECE 471.

The data analytics engineering concentration requires completion of the following four courses: ECE 346, ECE 350, ECE 445, and ECE 450.

Electrical Engineering Program Educational Objectives

The electrical engineering program seeks to prepare graduates who, after the first few years of their professional career, have:

1. established themselves as practicing engineering professionals in industry or government, or engaged in graduate study
2. demonstrated their ability to work successfully as members of a professional team and function effectively as responsible professionals
3. demonstrated their ability to adapt to new technology and career challenges

Student Outcomes

The electrical engineering student outcomes are as follows. Graduates must attain:

1. An ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics.
2. An ability to apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors.
3. An ability to communicate effectively with a range of audiences.
4. An ability to recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts.
5. An ability to function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives.
6. An ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions.
7. An ability to acquire and apply new knowledge as needed, using appropriate learning strategies.

Accreditation

The Bachelor of Science in Electrical Engineering is accredited by the Engineering Accreditation Commission of ABET, http://www.abet.org. (http://www.abet.org)

Four-Year Plan - Electrical Engineering - BSEE (http://catalog.odu.edu/undergraduate/frankbattencollegeofengineeringandtechnology/electricalcomputerengineering/electricalengn-bsee-fouryearplan/)

This is a suggested curriculum plan to complete this degree program in four years. Please consult information in this Catalog, Degree Works, and your academic advisor for more specific information on course requirements for this degree.

Electrical Engineering Four-Year Plan*

Freshman			
First Term	**Hours**	**Second Term**	**Hours**
ENGN 110	2	ECE 111	2
CHEM 121N	3	CHEM 123N	3
CHEM 122N	1	MATH 212	4
MATH 211	4	PHYS 231N	4
ENGL 110C	3	ENGN 150	4
COMM 101R	3		
	16		17

Sophomore			
First Term	**Hours**	**Second Term**	**Hours**
MATH 307	3	ECE 202	3
ECE 201	3	ECE 287	2
ECE 241	4	Non-major Engineering Elective**	3
PHYS 232N	4	MATH 312	4
Interpreting the Past Way of Knowing	3	ENGL 231C	3
	17		15

Junior			
First Term	**Hours**	**Second Term**	**Hours**
ECE 302	3	ECE 304	3
ECE 303	3	ECE 323	3
ECE 313	4	ECE 381	3
ECE 332	3	ECE 387	3
Human Creativity Way of Knowing	3	Literature Way of Knowing	3
	16		15

Senior			
First Term	**Hours**	**Second Term**	**Hours**
ECE 485W	3	ECE 487	2
ECE 486	2	Technical Elective***	3
Technical Elective***	3	Technical Elective***	3
Technical Elective***	3	Human Behavior Way of Knowing	3
ENMA 480	3	Upper-Division General Education course	3
Upper-Division General Education course	3		
	17		14

Total credit hours: 127

*	Does not include the University's General Education language and culture requirement. Additional hours may be required.
**	Non-major Engineering Elective includes options of any three-credit course from BME, CEE, CS, ENMA (except ENMA 480), MAE, & MSIM.
***	Electrical Engineering students need four technical elective courses selected from one of two options: (1) four 400-level ECE technical elective courses; (2) three 400-level ECE technical elective courses and one 300-level ECE technical elective course or one approved 300- or 400-level CS/MATH/Engineering course.

The General Education requirements in information literacy and research, impact of technology, and philosophy and ethics are met through the major.

Electrical engineering majors must earn a grade of C or better in all 200-level ECE courses prior to taking the next course in the sequence.

This is a suggested curriculum plan to complete this degree program in four years. Please consult information in this Catalog, Degree Works, and your academic advisor for more specific information on course requirements for this degree.

Bachelor of Science in Computer Engineering

Vishnu K. Lakdawala, Chief Departmental Advisor

The computer engineering undergraduate degree program is designed to provide both a broad engineering background and a comprehensive foundation in the technical principles underlying the computer area. Students develop a background through course work in mathematics, the basic sciences, and general engineering. The technical core consists of course work from electrical engineering to address hardware aspects of computer engineering and course work from computer science to address software aspects. Adequate elective freedom is available to students to allow specialization in one or more of the four concentration areas: computer hardware systems, computer networks, cyber security, or data analytics engineering. In addition, course work in General Education Skills and Ways of Knowing is required to assure a well-rounded program of study.

Computer Engineering Program Concentration Areas

The computer hardware systems concentration requires completion of four courses selected from the following: ECE 341, ECE 346, ECE 441, ECE 443, and ECE 483.

The computer networks concentration requires completion of four courses selected from the following: ECE 355, ECE 451, ECE 452, ECE 455, and CS 472.

The cyber security concentration area requires completion of four courses selected from the following: ECE 346, ECE 355, ECE 416, ECE 419, ECE 455, ECE 470, and ECE 483.

The data analytics engineering concentration requires completion of the following four courses: ECE 350, ECE 445, ECE 450, and ECE 441.

Computer Engineering Program Educational Objectives

The computer engineering program seeks to prepare graduates who, after the first few years of their professional career, have:

1. established themselves as practicing engineering professionals in industry or government, or engaged in graduate study
2. demonstrated their ability to work successfully as members of a professional team and function effectively as responsible professionals
3. demonstrated their ability to adapt to new technology and career challenges.

Student Outcomes

The computer engineering student outcomes are as follows. Graduates must attain:

1. An ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics.
2. An ability to apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors.
3. An ability to communicate effectively with a range of audiences.
4. An ability to recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts.
5. An ability to function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives.
6. An ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions.
7. An ability to acquire and apply new knowledge as needed, using appropriate learning strategies.

Accreditation

The Bachelor of Science in Computer Engineering is accredited by the Engineering Accreditation Commission of ABET, http://www.abet.org. (http://www.abet.org)

Four-Year Plan - Computer Engineering (http://catalog.odu.edu/undergraduate/frankbattencollegeofengineeringandtechnology/electricalcomputerengineering/computerengn-bscome-fouryearplan/)

This is a suggested curriculum plan to complete this degree program in four years. Please consult information in this Catalog, Degree Works, and your academic advisor for more specific information on course requirements for this degree.

Computer Engineering Four-Year Plan*

Freshman			
First Term	**Hours**	**Second Term**	**Hours**
ENGN 110	2	ECE 111	2
CHEM 121N	3	CHEM 123N	3
CHEM 122N or 120**	1	MATH 212	4
MATH 211	4	PHYS 231N	4
ENGL 110C	3	ENGN 150	4
COMM 101R	3		
	16		17
Sophomore			
First Term	**Hours**	**Second Term**	**Hours**
MATH 307	3	ECE 202	3
ECE 201	3	ECE 287	2
ECE 241	4	CS 250	4
PHYS 232N	4	CS 252	1
Literature Way of Knowing	3	CS 381	3
		ENGL 231C	3
	17		16
Junior			
First Term	**Hours**	**Second Term**	**Hours**
ECE 302	3	ECE 304	3
ECE 313	4	ECE 346	3
ECE 341	3	ECE 381	3
CS 361	3	CS 350	3
Human Creativity Way of Knowing	3	Technical Elective***	3
	16		15
Senior			
First Term	**Hours**	**Second Term**	**Hours**
ECE 484W	3	ECE 487	2
ECE 486	2	CS 471	3
ECE 443	3	Technical Elective***	3
Technical Elective***	3	Technical Elective***	3
ENMA 480	3	Human Behavior Way of Knowing	3
Interpreting the Past Way of Knowing	3		
	17		14

Total credit hours: 128

*	Does not include the University's General Education language and culture requirement. Additional hours may be required.
**	CHEM 120 is for online program students only.
***	Computer Engineering students need four technical elective courses selected from one of three options: (1) four 400-level ECE technical elective courses; (2) three 400-level ECE technical elective courses and one 300-level ECE technical elective course or one approved 300- or 400-level CS/MATH/ENGN course; (3) two 400-level ECE technical elective courses and one approved 300- or 400-level CS course and one approved 300- or 400-level CS/MATH/Engineering course.

The General Education requirements in information literacy and research, impact of technology, and philosophy and ethics are met through the major. The upper-division General Education requirement is met through a built-in minor in computer science.

Computer engineering majors must earn a grade of C or better in all 200-level ECE courses prior to taking the next course in the sequence.

This is a suggested curriculum plan to complete this degree program in four years. Please consult information in this Catalog, Degree Works, and your academic advisor for more specific information on course requirements for this degree.

Continuance Regulations

It is the policy of the Department of Electrical and Computer Engineering to deny a student eligibility to enroll in program courses after it becomes evident that he or she is either unable or unwilling to maintain reasonable standards of academic achievement. Courses in the electrical and computer engineering major are defined as courses with an ECE prefix.

1. A student will be placed on departmental academic probation whenever his or her major grade point average (GPA) falls below 2.00 (after six or more hours have been attempted in the major).

2. Students on academic probation are expected to improve their major GPA by achieving a semester GPA of 2.0 or better during the next semester of attendance. A student on academic probation will have two consecutive semesters to improve their major GPA to 2.0 before termination from the program.
3. Following two consecutive semesters of academic probation, a student is subject to termination from the program if his or her major GPA is below 2.0 and the semester GPA is below 2.0 in the major at the end of either the Fall or Spring semester.

Appeals of termination from the program are in order if extenuating circumstances warrant. Appeals are to be made in writing to the chair of the department. Once the appeal is submitted, it is considered by the faculty of the department.

Minor in Computer Engineering

An undergraduate minor in computer engineering may be obtained by successful completion of 13 or more semester credit hours of approved electrical or computer engineering or computer science course work at the 200, 300 or 400 level. In addition, a student seeking a minor in computer engineering must satisfy all pre- or corequisite requirements for the courses selected. CS 150 or ENGN 150, CS 250, and CS 252 are prerequisites for the minor and are not included in the calculation of the GPA for the minor. The chief departmental advisor must approve the precise course of study.

The basic course requirements are as follows:

ECE 241	Fundamentals of Computer Engineering	4
CS 361	Data Structures and Algorithms	3
Select two of the following: *		6
ECE 341	Digital System Design	
ECE 346	Microcontrollers	
ECE 355	Introduction to Networks and Data Communications	
ECE 381	Introduction to Discrete-time Signal Processing **	
ECE 406	Computer Graphics and Visualization	
ECE 407	Introduction to Game Development	
ECE 441	Advanced Digital Design and Field Programmable Gate Arrays	
ECE 455	Network Engineering and Design	
ECE 483	Embedded Systems	
Total Hours		13

*	Course substitutions may be approved by the chief departmental advisor.
**	Class not permitted for Electrical Engineering majors due to being a requirement in the major.

For completion of a minor, a student must have a minimum overall cumulative grade point average of 2.00 in all courses specified as a requirement for the minor exclusive of lower-level courses (except for ECE 241), prerequisites and corequisites and complete a minimum of six hours of upper-division courses in the minor through courses offered by Old Dominion University. Completion of a minor in computer engineering with a GPA of 3.00 or greater partially satisfies the leveling requirements for graduate degrees in computer engineering.

Minor in Electrical Engineering

An undergraduate minor in electrical engineering may be obtained by successful completion of 12 or more semester credit hours of approved electrical or computer engineering or computer science course work at the 200, 300 or 400 level. In addition, a student seeking a minor in electrical engineering must satisfy all pre- or corequisite requirements for the courses selected. Tracks in systems science, physical electronics, digital design, and electrical power are available. The chief departmental advisor must approve the precise course of study. The basic course requirements for the three main tracks are as follows:

Systems Science Track

ECE 202	Circuit Analysis II	3
ECE 302	Linear System Analysis	3
ECE 304	Probability, Statistics, and Reliability	3
Select one of the following:		3
ECE 451	Communication Systems	
ECE 455	Network Engineering and Design	
ECE 461	Automatic Control Systems	
Total Hours		12

Physical Electronics Track

ECE 304	Probability, Statistics, and Reliability	3
ECE 323	Electromagnetics	3
ECE 332	Microelectronic Materials and Processes	3
Select one of the following:		3
ECE 471	Introduction to Solar Cells	
ECE 472	Plasma Processing at the Nanoscale	
ECE 473	Solid State Electronics	
ECE 474	Optical Fiber Communication	
Total Hours		12

Digital Design Track*

ECE 241	Fundamentals of Computer Engineering	4
ECE 304	Probability, Statistics, and Reliability	3
ECE 341	Digital System Design	3
Select one from the following:		3
ECE 346	Microcontrollers	
ECE 441	Advanced Digital Design and Field Programmable Gate Arrays	
ECE 443	Computer Architecture	
ECE 483	Embedded Systems	
Total Hours		13

*The digital design track is not available for computer engineering majors.

Electrical Power Track

ECE 303	Introduction to Electrical Power	3
ECE 323	Electromagnetics	3
Select two of the following		6
ECE 403	Power Electronics	
ECE 404	Electric Drives	
ECE 405	Power System Design & Analysis	
ECE 471	Introduction to Solar Cells	
Total Hours		12

For completion of a minor, a student must have a minimum overall cumulative grade point average of 2.00 in all courses specified as a requirement for the minor exclusive of lower-level courses, prerequisites and corequisites and complete at least six hours of upper-level courses in the minor requirement through courses offered by Old Dominion University. Completion of a minor in electrical engineering with a GPA of 3.00 or greater partially satisfies the leveling requirements for graduate degrees in electrical engineering.

Biomedical Engineering Interdisciplinary Minor

Anna Bulysheva, Department of Electrical and Computer Engineering, Coordinator

This interdisciplinary minor is for students who would like to learn about processes encountered in biomedical engineering innovation and enhance their ability to integrate knowledge from different disciplines with principles used in biomedical engineering. The minor offers an opportunity for students to be recognized for study in this growing multidisciplinary field and to enhance competitiveness for job opportunities upon graduation.

Course prerequisites for BME 403, BME 404 and BME 406 are BIOL 240 or BIOL 250 and MATH 200, MATH 205 or MATH 211. Prerequisite courses are not included in the calculation of the grade point average for the minor.

Course requirements are as follows:

Select two of the following BME courses:		6
BME 403	Introduction to Mathematical Modeling in Physiology	
BME 404	Introduction to Biomaterials	
BME 406	Transport Phenomena in Biomedical Systems	
Select two elective courses from the following:		6
BIOL 446	Comparative Biomechanics	
BIOL 460	Frontiers in Nanoscience and Nanotechnology	
BIOL 490	Advanced Human Physiology	
BIOL 496	Topics in Biological Sciences (approved by minor advisor)	
CHEM 443	Intermediate Biochemistry	
ECE 454	Introduction to Bioelectrics	
ECE 462	Introduction to Medical Image Analysis (MIA)	
ECE 464	Biomedical Applications of Low Temperature Plasmas	
or BIOL 464	Biomedical Applications of Low Temperature Plasmas	
EXSC 322	Anatomical Kinesiology	
EXSC 417	Biomechanics	
HLSC 405	Interprofessional Study Abroad on Global Health	
MAE 303	Mechanics of Fluids	
MAE 440	Introduction to Finite Element Analysis	
MLS 324	Clinical Instrumentation and Electronics	
MSIM 451	Analysis for Modeling and Simulation	
NMED 331	Fundamental Concepts in Nuclear Medicine Technology	
NURS 456	Global Health Perspectives	
Students have the option to substitute one course from those that satisfy their major requirements for one of the minor electives with approval of the minor coordinator.		
Students interested in medical simulation are encouraged to select their electives from ECE 462 and MAE 440.		
Total Hours		12

The interdisciplinary minor in biomedical engineering requires 12 credit hours of 300/400-level courses selected from at least two different disciplines with a maximum of six credits from any one discipline. For completion of the interdisciplinary minor, students must have a minimum overall cumulative grade point average of 2.00 in all courses specified as a requirement for the minor exclusive of lower-level courses and prerequisite courses. At least six hours of upper-level courses must be taken through courses offered by Old Dominion University. Three credit hours may be in the major, if a major course is listed as an option for the interdisciplinary minor. As such, it will be credited toward both the major and the interdisciplinary minor.

BIOMEDICAL ENGINEERING Courses

BME 403. Introduction to Mathematical Modeling in Physiology. 3 Credits.
This course introduces model development and model formulation with differential equations in physiology. Students will learn how to use Matlab to solve differential equations and visualize their results. The physiological focus will be on cellular physiology, particularly ion channel dynamics and homeostasis. Prerequisites: BIOL 240 or BIOL 250 and MATH 200 or MATH 205 or MATH 211.

BME 404/504. Introduction to Biomaterials. 3 Credits.
This course will introduce the properties of biomedical materials used as implants, prostheses, orthosis, and tissue-engineered materials as medical devices in contact with tissues and organs. Biocompatibility, immunological responses, wound healing, clotting cascade, surface compatibility and characterization of materials used for implantable medical devices will be introduced. Other topics such as ethical considerations and medical device regulatory mechanisms will be presented. Prerequisites: BIOL 240 or BIOL 250 and MATH 200 or MATH 205 or MATH 211.

BME 406. Transport Phenomena in Biomedical Systems. 3 Credits.
The course focuses on basic principles of mass transport and biochemical reactions in biological systems. Topics include phase and reaction equilibrium, conservation relations, physiological transport in tissue-organ systems, transport of gases between blood and tissue, and designing of bioreactors and devices for biomedical engineering applications. Prerequisites: BIOL 240 or BIOL 250 and MATH 200 or MATH 205 or MATH 211.

BME 454/554. Introduction to Bioelectrics. 3 Credits.
This course covers the electrical properties of cells and tissues as well as the use of electrical and magnetic signals and stimuli in the diagnosis and treatment of disease. Typical topics to be covered include basic cell physiology, endogenous electric fields in the body, electrocardiography, cardiac pacing defibrillation, electrotherapy, electroporation, electrotherapy in wound healing. In addition ultra-short electrical pulses for intracellular manipulation and the application of plasmas to biological systems will be covered. Prerequisites: PHYS 111N or higher and MATH 200 or higher.

BME 462/562. Introduction to Medical Image Analysis. 3 Credits.
Introduction to basic concepts in medical image analysis. Medical image registration, segmentation, feature extraction, and classification are discussed. Basic psychophysics, fundamental ROC analysis and FROC methodologies are covered. Cross-listed with ECE 462/MSIM 462. Prerequisites: a grade of C or better in MATH 212.

BME 464/564. Biomedical Applications of Low Temperature Plasmas. 3 Credits.
This course is cross listed with ECE and Biology. It is designed to be taken by senior undergraduate students and first year graduate students. The course contents are multidisciplinary, combining materials from engineering and the biological sciences. The course covers an introduction to the fundamentals of non-equilibrium plasmas, low temperature plasma sources, and cell biology. This is followed by a detailed discussion of the interaction of low temperature plasma with biological cells, both prokaryotes and eukaryotes. Potential applications in medicine such as wound healing, blood coagulation, sterilization, and the killing of various types of cancer cells will be covered. Prerequisites: Senior standing.

ELECTRICAL AND COMPUTER ENGINEERING Courses

ECE 111. Information Literacy and Research for Electrical and Computer Engineering. 2 Credits.
An introductory course for ECE students that explores information literacy in terms of information basics, information need, searching, locating, and evaluating information sources, citing and ethics of information in relation to development and implementation of electrical and computer engineering projects. Prerequisites: ENGN 110 and MATH 162M.

ECE 201. Circuit Analysis I. 3 Credits.
An introduction to the analysis and theory of linear electrical circuits, including relevant mathematical background. Topics include: passive component definitions and connection rules; independent and dependent sources, concepts of power & energy; Kirchhoff’s laws; development of network reduction techniques; formulation of mesh-current and node-voltage equations; network theorems including Thevenin, Norton, Maximum power transfer, and superposition Theorem, Operational Amplifiers, Two Port Networks (resistive), Energy Storage Elements, and initial conditions. Basics of matrices and linear algebra with Gaussian elimination; matrix applications to linear circuit analyses; MATLAB & PSPICE with analyses and applications to passive circuits. (offered fall, spring, summer) Prerequisites: ECE 111 or equivalent and a grade of C or better in MATH 212. Pre- or corequisite: PHYS 232N or PHYS 262N.

ECE 202. Circuit Analysis II. 3 Credits.
Time domain analysis of first-order and second-order electrical circuits; Sinusoidal steady state analysis; Phasor representation of AC Circuits, Maximum power transfer and Thevenin-Norton theorems for AC circuits; Frequency response of circuits (with R, L, and C components), Laplace Transforms and transfer functions of linear circuits; extension to frequency domain circuit analysis including Bode plots; operational amplifiers with relevant circuit examples; two-port networks including Z- and Y-parameters; transformer concepts. PSPICE and MATLAB for DC and transient circuit analyses; theory & solution of linear ordinary differential equations with constant coefficients, complex numbers, Euler's formula and complex arithmetic; PSPICE and MATLAB implementation of AC response and analyses. (offered fall, spring, summer) Prerequisites: MATH 280 or MATH 307 and a grade of C or better in ECE 201.

ECE 241. Fundamentals of Computer Engineering. 4 Credits.
This course develops the foundation of computer engineering for computer engineers as well as an introductory breadth appropriate for electrical engineers. Class topics include computer information, digital design (combinational and sequential circuits), computer organization, and assembly language. The laboratory includes building digital circuits (focusing on programmable logic), assembly language programming, and system interfacing. The use of a hardware description language is employed in class and the laboratory to specify, simulate and synthesize digital circuits. Prerequisites: CS 150 or ENGN 150 and MATH 211 with a grade of C or above for both.

ECE 242. Fundamentals of Computer Engineering Lab. 1 Credit.
Available for pass/fail grading only. The laboratory includes building digital circuits (focusing on programmable logic), assembly language programming, and system interfacing. The use of a hardware description language is employed in the laboratory to specify, simulate and synthesize digital circuits. This course is only for students who do not have the laboratory component in ECE 241. Prerequisites: CS 150 or ENGN 150 and MATH 211 with a grade of C or better for both, and written permission of the Chief Departmental Advisor of the Electrical & Computer Engineering Department.

ECE 287. Fundamental Electric Circuit Laboratory. 2 Credits.
Objective of course is to provide students in electrical and computer engineering with a 'hands-on' introduction to selected topics in electrical engineering. Students will use basic circuit analysis skills and programming skills to design, build, and test electrical networks interfacing to an Arduino Uno micro-controller. Labs will also provide an introduction to basic measurement techniques and electrical laboratory equipment (power supplies, oscilloscopes, voltmeters, etc). Prerequisites: A grade of C or better in both CS 150 or ENGN 150 and ECE 201. Pre- or corequisite: ENGL 211C or ENGL 221C or ENGL 231C and ECE 202.

ECE 300. Math Review for Graduate Engineering Analysis. 3 Credits.
Complex algebra, linear algebra and matrix methods, aspects of multivariable calculus, Boolean logic and numbering systems, differential equations, Laplace transforms, and aspects of probability. Applications and examples in the field of electrical engineering will be used. The use of Matlab in engineering problem solving will be presented. Course not available to ECE undergraduate majors. Prerequisites: Departmental approval.

ECE 301. Review of Electrical Engineering Analysis. 3 Credits.
Electrical engineering problems, including time-domain and frequency-domain circuit analysis, analysis of networks with electronic components. The use of Matlab and Simulink in electrical engineering problem solving will be presented. Course not available to ECE undergraduate majors. Prerequisites: Departmental approval.

ECE 302. Linear System Analysis. 3 Credits.
This course covers the fundamental concepts of signal and linear system representation and analysis in continuous time. Topics include: Operations with sinusoids and complex exponentials. Signal properties, operations, and models. System properties, classification, and models. Time-domain system analysis, including impulse response, total system response, stability, and convolution. Fourier analysis of continuous-time signals and signal transmission through linear time-invariant systems. Ideal and practical filters. Advanced matrix operations and linear algebra with applications to signal and system analysis. Characteristic equation of a matrix, eigenvalues and eigenvectors. Performing time and frequency domain analysis using MATLAB. (offered fall, spring). Prerequisites: MATH 280 or MATH 307 and a grade of C or better in ECE 202. Pre- or corequisite: ECE 287.

ECE 303. Introduction to Electrical Power. 3 Credits.
AC steady state power, single-phase and three-phase networks, electric power generation, transformers, transmission lines, electric machinery and the use of power. Energy resources, power plants, renewable energy, electric safety. (offered fall, summer) Prerequisites: a grade of C or better in ECE 201.

ECE 304. Probability, Statistics, and Reliability. 3 Credits.
Introduction to probability, probability models, discrete and continuous random variables, statistics, reliability, and stochastic processes. Applications include modeling of physical systems, data analysis, communications, designed engineering experiments, control charts, and hypothesis testing. Prerequisites: a grade of C or better in MATH 212.

ECE 313. Electronic Circuits. 4 Credits.
Introduction to junction diodes, bipolar junction transistors (BJTs), MOS field-effect transistors (MOSFETs) and operational amplifiers (op-amps). Design concepts for discrete analog circuits with diodes, BJTs, MOSFETs and op-amps. The lab component introduces design and techniques for implementation of analog circuits. Prerequisites: CHEM 123N, a grade of C or better in ECE 202 and ECE 287. Pre- or corequisite: ECE 241.

ECE 323. Electromagnetics. 3 Credits.
This course provides an introduction to the basic concepts of electromagnetics. Topics include math fundamentals for electromagnetic studies, Maxwell’s equations, electromagnetic waves, polarization, wave propagation in various media and across interfaces, waveguides and transmission lines. This fundamental course is to build an electrical engineering/physics foundation for students and enable them to identify, formulate, and solve future engineering problems. Prerequisites: MATH 285 or MATH 312 and a grade of C or better in ECE 202 and ECE 287.

ECE 332. Microelectronic Materials and Processes. 3 Credits.
An introduction to fundamental properties of semiconductors and device fabrication processes. The topics include crystal structure, bonding, energy bands, doping, carrier densities, mobility, resistivity, recombination, drift, and diffusion. Basic structure of p-n junctions, BJTs and MOSFETs and their fabrication processes, including solid state diffusion, thermal oxidation of silicon, ion implantation, chemical vapor deposition, thin film deposition, photolithography and etching are reviewed. (offered fall and spring) Prerequisites: a grade of C or better in ECE 202 and in ECE 287.

ECE 341. Digital System Design. 3 Credits.
Tools and methodologies for top-down design of complex digital systems. Important topics include minimization, mixed logic, algorithmic state machines, microprogrammed controllers, creating and using a gold model, data and control path design and data movement and routing via buses. Design methodologies covered include managing the design process from concept to implementation, verification using a gold model, and introduction to design flow. A hardware description language is used extensively to demonstrate models and methodologies, and is also used in design exercises and projects. (offered fall, spring) Prerequisites: a grade of C or better in ECE 241.

ECE 346. Microcontrollers. 3 Credits.
A hands-on approach to microprocessor and peripheral system programming, I/O interfacing, and interrupt management. A sequence of projects requiring the programming and integration of a microcontroller-based system is conducted. Project assignments require a microcontroller evaluation board and accessories supplied by the student. (offered spring) Prerequisites: a grade of C or better in ECE 241.

ECE 350. Mathematics for Data Analytics Engineering. 3 Credits.
Mathematical concepts for data analytics engineering including linear algebra, matrix operations, linear spaces, and advanced differential calculus. Prerequisites: Grade of C or better in MATH 212.

ECE 355. Introduction to Networks and Data Communications. 3 Credits.
This course introduces the basic concepts of computer networks and data communications. Topics include protocol layers, the application layer, the transport layer, the network layer, the data link layer, and the physical layer. Students will learn how to use network packet analyzer tools to do simple network analysis. Emphasis is on gaining an understanding of network engineering as it relates to hardware configuration, system operation and maintenance. (offered fall) Prerequisites: ECE 304 and a grade of C or better in ECE 241.

ECE 368. Student Internship/Cooperative Education. 1-3 Credits.
Student participation for credit based on the academic relevance of the work experience, criteria, and evaluative procedures as formally determined by the department and Career Development Services prior to the semester in which the work experience is to take place. (offered fall, spring, summer) Prerequisites: Approval by department and Career Development Services.

ECE 381. Introduction to Discrete-time Signal Processing. 3 Credits.
This course covers fundamental digital signal processing techniques that form the basis for a wide variety of application areas. Topics include discrete-time signals and systems, time domain analysis, solutions of difference equations, Z-transform analysis, discrete Fourier transforms (DFT), sampling theorem, transform analysis of linear time-invariant systems, structure of discrete-time systems and introduction to power spectrum estimation. (offered fall and spring) Prerequisites: ECE 302 and a grade of C or better in ECE 241.

ECE 387. Microelectronics Fabrication Laboratory. 3 Credits.
The laboratory course will enable students to fabricate MOSFETs, MOS capacitors, diffused resistors and p-n diodes. Students will be trained to operate the equipment required for wet and dry oxidation, thin film deposition, solid state diffusion, photolithography, and etching. Students will fabricate and analyze the devices by current-voltage characteristic, capacitance-voltage characteristic, film thickness and conductivity measurements. (offered fall and spring). Prerequisites: ECE 332.

ECE 395. Topics in Electrical and Computer Engineering. 1-3 Credits.
Study of topics in electrical and computer engineering. Prerequisites: departmental approval.

ECE 396. Topics in Electrical and Computer Engineering. 1-3 Credits.
Study of topics in electrical and computer engineering. Prerequisites: departmental approval.

ECE 403/503. Power Electronics. 3 Credits.
Power electronics provides the needed interface between an electrical source and an electrical load and facilitates the transfer of power from a source to a load by converting voltages and currents from one form to another. Topics include: alternating voltage rectification, Pulse Width Modulation (PWM), DC converters (Buck, Boost, Buck-Boost, Cuk and SEPIC converters), negative feedback control in power electronics, isolated switching mode power supply, flyback and forward power supply, solid state power switches, AC inverter. Prerequisites: ECE 303, ECE 313 and a grade of C or better in ECE 202 and ECE 287.

ECE 404/504. Electric Drives. 3 Credits.
Electric drives efficiently control the torque, speed and position of electric motors. This course has a multi-disciplinary nature and includes fields such as electric machine theory, power electronics, and control theory. Topics include: switch-mode power electronics, magnetic circuit, DC motor, AC motor, Brushless DC motor, induction motor, speed control of induction motor, vector control of induction motor, stepper-motor. (offered fall) Prerequisites: ECE 303 and a grade of C or better in ECE 202.

ECE 405/505. Power System Design & Analysis. 3 Credits.
This course covers basic power circuit analysis and introductory power system engineering and focuses on the transmission line design, power flow study, short circuit protection, and power distribution in electric power systems, followed by a survey of several applications and case studies. Prerequisites: ECE 303 and a grade of C or better in ECE 202 and ECE 287, or equivalent knowledge in electric machines and circuits.

ECE 406/506. Computer Graphics and Visualization. 3 Credits.
The course provides a practical treatment of computer graphics and visualization with emphasis on modeling and simulation applications. It covers computer graphics fundamentals, visualization principles, and software architecture for visualization in modeling and simulation. (Cross listed with MSIM 441.) Prerequisites: a grade of C or better in CS 250.

ECE 407/507. Introduction to Game Development. 3 Credits.
An introductory course focused on game development theory and modern practices with emphasis on educational game development. Topics include game architecture, computer graphics theory, user interaction, audio, high level shading language, animation, physics, and artificial intelligence. The developed games can run on a variety of computer, mobile, and gaming platforms. (Cross listed with MSIM 408.) Prerequisites: CS 361 or MSIM 331.

ECE 408/508. Fundamentals of Electric Vehicles. 3 Credits.
This course covers the fundamentals of electric vehicles and focuses on the components, power control, energy management, power train dynamics and other related topics in purely electric and hybrid electric vehicle systems, including a survey of several applications and case studies. Prerequisites: ECE 303 and ECE 403, or instructor approval.

ECE 410/510. Model Engineering. 3 Credits.
The goal of this course is to develop understanding of the various modeling paradigms appropriate for capturing system behavior and conducting digital computer simulation of many types of systems. The techniques and concepts discussed typically include UML, concept graphs, Bayesian nets, Markov models, Petri nets, system dynamics, Bond graphs, etc. Students will report on a particular technique and team to implement a chosen system model. (Cross-listed with MSIM 410.) Prerequisites: MSIM 205. Pre- or corequisite: MSIM 320.

ECE 411/511. Networked System Security. 3 Credits.
Course presents an overview of theory, techniques and protocols that are used to ensure that networks are able to defend themselves and the end-systems that use networks for data and information communication. Course will also discuss industry-standard network security protocols at application, socket, transport, network, VPN, and link layers, popular network security tools, security, performance modeling and quantification and network penetration testing. Discussion will be based on development of system level models and simulations of networked systems. Crosslisted with MSIM 411. Prerequisites: CS 150 or ENGN 150, and junior standing or permission of the instructor.

ECE 416/516. Cyber Defense Fundamentals. 3 Credits.
This course focuses on cybersecurity theory, information protection and assurance, and computer systems and networks security. The objectives are to understand the basic security models and concepts, learn fundamental knowledge and tools for building, analyzing, and attacking modern security systems, and gain hands-on experience in cryptographic algorithms, security fundamental principles, and Internet security protocol and standards. Prerequisites: ECE 355 or permission of the instructor.

ECE 419/519. Cyber Physical System Security. 3 Credits.
Cyber Physical Systems (CPS) integrate computing, networking, and physical processes. The objectives of this course are to learn the basic concepts, technologies and applications of CPS, understand the fundamental CPS security challenges and national security impact, and gain hands-on experience in CPS infrastructures, critical vulnerabilities, and practical countermeasures. Prerequisites: ECE 355 or permission of the instructor.

ECE 441/541. Advanced Digital Design and Field Programmable Gate Arrays. 3 Credits.
Course will provide a description of FPGA technologies and the methods using CAD design tools for implementation of digital systems using FPGAs. It provides advanced methods of digital circuit design, specification, synthesis, implementation and prototyping. It introduces practical system design examples. (Offered spring) Prerequisites: ECE 341.

ECE 443/543. Computer Architecture. 3 Credits.
An introduction to computer architectures. Analysis and design of computer subsystems including central processing units, memories and input/output subsystems. Important concepts include datapaths, computer arithmetic, instruction cycles, pipelining, virtual and cache memories, direct memory access and controller design. (offered fall) Prerequisites: ECE 341 and ECE 346.

ECE 445/545. Introduction to Computer Vision. 3 Credits.
Overview of digital image processing including visual perception, image formation, spatial transformations, image enhancement, color image representation and processing, edge detection, image segmentation, and data processing method for computer vision applications. Hand-on projects will be introduced to better understand computer vision applications. Prerequisites: A grade of C or better in ENGN 150 or CS 150. Pre- or corequisite: ECE 350 and ECE 381.

ECE 450/550. Introduction to Machine Learning for Data Analytics Engineering. 3 Credits.
Machine Learning provides a practical treatment of design, analysis and implementation of algorithms, which learn from examples. Topics include multiple machine learning models: linear regression, logistic regression, neural networks, support vector machines, deep learning, Bayesian learning and unsupervised learning. Students are expected to use popular machine learning tools and algorithms to solve real data engineering problems. Prerequisites: A grade of C or better in ENGN 150 or CS 150, and ECE 350.

ECE 451/551. Communication Systems. 3 Credits.
Fundamentals of communication systems engineering. Modulation methods including continuous waveform modulation (amplitude, angle). Design and analysis of modulation systems and performance in the presence of noise. Communication simulation exercises through computer experiments. Prerequisites: ECE 304 and ECE 302.

ECE 452/552. Introduction to Wireless Communication Networks. 3 Credits.
Introduction to current wireless network technologies and standards. The radio frequency spectrum and radio wave propagation models (pathloss, fading, and multipath). The radio link and link budgets. Modulation, diversity, and multiple access techniques. Wireless network planning and operation. Current and emerging wireless technologies (satellite systems, vehicular/sensor networks). Prerequisites: ECE 304 and ECE 302.

ECE 454/554. Introduction to Bioelectrics. 3 Credits.
Covers the electrical properties of cells and tissues as well as the use of electrical and magnetic signals and stimuli in the diagnosis and treatment of disease. Typical topics to be covered include basic cell physiology, endogenous electric fields in the body, electrocardiography, cardiac pacing, defibrillation, electrotherapy, electroporation, electrotherapy in wound healing. In addition, ultrashort electrical pulses for intracellular manipulation and the application of plasmas to biological systems will be covered. Prerequisites: PHYS 111N or higher; MATH 200 or higher.

ECE 455/555. Network Engineering and Design. 3 Credits.
This course is an extension of ECE 355 into a semester long project. Emphasis is on gaining an understanding of networking design principles that entails all aspects of the network development life cycle. Topics include campus LAN models and design, VLANs, internetworking principles and design, WAN design, design of hybrid IP networks, differentiated vs. integrated services, traffic flow measurement and management. (offered spring) Prerequisites: ECE 355 or permission of the instructor.

ECE 458/558. Instrumentation. 3 Credits.
Computer interfacing using a graphical programming language with applications involving digital-to-analog conversion (DAC), analog-to-digital conversion (ADC), digital input output (DIO), Virtual Instrument System Architecture (VISA) and universal Service Bus (USB). Analysis of sampled data involving use of probability density function, mean and standard derivations, correlations, and the power spectrum. (offered spring, summer) Prerequisite: ECE 302 or permission of instructor.

ECE 461/561. Automatic Control Systems. 3 Credits.
Analysis and design of control systems via frequency and time domain techniques. Root locus, Bode and Nyquist techniques. Stability, sensitivity, and performance specifications. Cascade and feedback compensation. Computer-aided analysis and design. Pole placement through state variable feedback. Prerequisites: ECE 302.

ECE 462/562. Introduction to Medical Image Analysis (MIA). 3 Credits.
Introduction to basic concepts in medical image analysis. Medical image registration, segmentation, feature extraction, and classification are discussed. Basic psychophysics, fundamental ROC analysis and FROC methodologies are covered. Prerequisites: a grade of C or better in MATH 212.

ECE 464/564. Biomedical Applications of Low Temperature Plasmas. 3 Credits.
This course is cross listed between ECE, BME and BIOL. It is designed to be taken by senior undergraduate students and first year graduate students. The course contents are multidisciplinary, combining materials from engineering and the biological sciences. The course covers an introduction to the fundamentals of non-equilibrium plasmas, low temperature plasma sources, and cell biology. This is followed by a detailed discussion of the interaction of low temperature plasma with biological cells, both prokaryotes and eukaryotes. Potential applications in medicine such as wound healing, blood coagulation, sterilization, and the killing of various types of cancer cells will be covered. Prerequisites: Senior standing.

ECE 470/570. Foundations of Cyber Security. 3 Credits.
Course provides an overview of theory, tools and practice of cyber security and information assurance through prevention, detection and modeling of cyber attack and recovery from such attacks. Techniques for security modeling, attack modeling, risk analysis and cost-benefit analysis are described to manage the security of cyber systems. Fundamental principles of cyber security and their applications for protecting software and information assets of individual computers and large networked systems are explored. Anatomy of some sample attacks designed to compromise confidentiality, integrity and availability of cyber systems are discussed. (Cross-listed with MSIM 470) Prerequisites: junior standing. Pre- or corequisite: MSIM 410 or permission of the instructor.

ECE 471/571. Introduction to Solar Cells. 3 Credits.
This course is designed to provide the fundamental physics and characteristics of photovoltaic materials and devices. A focus is placed on i) optical interaction, absorption, and design for photovoltaic materials and systems, ii) subsequent energy conversion processes in inorganic/organic semiconductor such as generation, recombination, and charge transport, and iii) photovoltaic testing and measurement techniques to characterize solar cells including contact and series resistance, open circuit voltage, short circuit current density, fill factor, and energy conversion efficiency of photovoltaic devices. (Offered fall) Prerequisites: ECE 332.

ECE 472/572. Plasma Processing at the Nanoscale. 3 Credits.
The science and design of partially ionized plasma and plasma processing devices used in applications such as etching and deposition at the nanoscale. Gas phase collisions, transport parameters, DC and RF glow discharges, the plasma sheath, sputtering, etching, and plasma deposition. Prerequisites: ECE 323.

ECE 473/573. Solid State Electronics. 3 Credits.
The objective of this course is to understand basic semiconductor devices by understanding semiconductor physics (energy bands, carrier statistics, recombination and carrier drift and diffusion) and to gain an advanced understanding of the physics and fundamental operation of advanced semiconductor devices. Following the initial introductory chapters on semiconductor physics, this course will focus on p-n junctions, metal-semiconductor devices, MOS capacitors, MOS field effect transistors (MOSFET) and bipolar junction transistors. Prerequisites: ECE 313, ECE 323 and ECE 332.

ECE 474/574. Optical Fiber Communication. 3 Credits.
This course introduces seniors and first year graduates to the physics and design of optical fiber communication systems. The topics covered are: electromagnetic waves; optical sources including laser diodes; optical amplifiers; modulators; optical fibers; attenuation and dispersion in optical fibers; photodetectors; optical receivers; noise considerations in optical receivers; optical communication systems. Prerequisite: ECE 323.

ECE 483/583. Embedded Systems. 3 Credits.
This course covers fundamentals of embedded systems: basic architecture, programming, and design. Topics include processors and hardware for embedded systems, embedded programming and real time operating systems. Prerequisites: ECE 346.

ECE 484W. Computer Engineering Design I. 3 Credits.
Emphasis is on the design of a complex digital circuit and microcontroller interfacing. A semester-long project involves the design, simulation and testing of a digital architecture and software GUI. Several moderate scale digital modules are designed, simulated, implemented and tested during the semester. Design methods incorporate CAD design tools, implementation with advanced integrated circuit technology and contemporary software tools. Oral and written communication skills are stressed. This is a writing intensive course. (offered fall and spring) Prerequisites: A grade of C or better in ENGL 211C or ENGL 221C or ENGL 231C; ECE 341; ECE 346 and ECE 381. Pre- or corequisite: ECE 304 and ECE 313.

ECE 485W. Electrical Engineering Design I. 3 Credits.
Part one of the senior capstone design experience for electrical engineering majors. Lectures focus on providing professional orientation and exploration of the design process. Small group design projects focus on the development of electronic subsystems. Oral and written communication skills are stressed. This is a writing intensive course. (offered fall, spring) Prerequisites: ECE 313 and ECE 381 and a grade of C or better in ENGL 211C or ENGL 221C or ENGL 231C. Pre- or corequisite: ECE 303, ECE 304, ECE 323, and ECE 332.

ECE 486. Preparatory ECE Senior Design II. 2 Credits.
The course is the preparatory, proposal development section of part two of the senior capstone design experience for electrical and computer engineering majors. The course will focus on developing a proposal for a group design project. The senior design projects aim at developing engineering design skills of a complete computer/electrical system. Elements of developing a successful proposal are emphasized along with written communication skills. Industry-sponsored multi-disciplinary design projects are an option. Prerequisites: senior standing. Pre- or corequisite: ECE 484W or ECE 485W.

ECE 487. ECE Senior Design II. 2 Credits.
Part two of the senior capstone design experience for electrical and computer engineering majors. In this course, students will implement the design proposal developed in ECE 486. The senior design projects aim at developing engineering design skills of a complete computer/electrical system. Oral and written communication skills are emphasized. Industry-sponsored multi-disciplinary design projects are an option. Prerequisites: ECE 486.

ECE 488. ECE Senior Design III. 3 Credits.
Part three of the senior capstone design experience for electrical and computer engineering majors. Individual and group design projects focus on the development of complete electrical and computer systems. Oral and written communication skills are stressed. Industry-sponsored multi-disciplinary design projects are an option. Prerequisites: ECE 487.

ECE 491. Microelectronics Design Experience. 3 Credits.
This is a Virginia Microelectronics Consortium (VMEC) hands-on, state-of-the-art summer research internship experience. This is not a regular class, but a summer research internship open only to those undergraduate students who apply and win a VMEC Summer Research Scholarship. The VMEC internship provides excellent technical knowledge as well as industrial and academic contacts for career development. Students complete a 10-13 week summer project on a microelectronics research or design activity at an engineering school or in the State-of-the-Art Cleanroom of industry members of the VMEC. Details regarding eligibility and report requirements are available in the department. Prerequisites: Junior standing in electrical or computer engineering and department approval.

ECE 495/595. Topics in Electrical and Computer Engineering. 1-3 Credits.
Study of topics in electrical and computer engineering. Prerequisites: departmental approval.

ECE 496/596. Topics in Electrical and Computer Engineering. 1-3 Credits.
Study of topics in electrical and computer engineering. Prerequisites: departmental approval.