**Electrical Engineering (EE)**

**Courses**

**EE 101. Introduction to Electrical Engineering. 1 Credit.**
An introduction to the electrical engineering discipline. Recent technologies and practices in electronics, computers, controls, power systems, robotics, communication, and microwaves. F.S.

**EE 201. Introduction to Digital Electronics. 2 Credits.**
Introduction to the fundamentals of digital circuits design. Logic gates; Boolean algebra; Karnaugh maps; Mathematical operations; Flip Flops; Counters. Corequisite: EE 201L. F.S.

**EE 201L. Digital Electronics Laboratory. 1 Credit.**
Introduction to design and implementation of digital electronic circuits. Corequisite: EE 201. F.S.

**EE 206. Circuit Analysis. 3 Credits.**
Introduces the foundations of electrical engineering, applying these concepts in developing the fundamentals of energy conversion, electronics and circuit theory. Prerequisite: MATH 165 with a grade of C or better; EE Major should be declared. F.

**EE 206L. Circuits Laboratory I. 1 Credit.**
Introduction to methods of experimental circuit analysis and to proper uses of laboratory equipment. Prerequisite: EE major should be declared. Corequisite: EE 206. F.S.S.

**EE 304. Computer Aided Measurement and Controls. 3 Credits.**
The principles of the use of a computer in a measurement and control environment are presented. Software is designed to drive interfaces to perform measurement and control algorithms. The software and concepts presented are evaluated in a laboratory environment. Prerequisites: Electrical Engineering major and MATH 165. F.

**EE 313. Linear Electric Circuits. 3 Credits.**
Linear electric circuits in the steady state and transient conditions; two-port circuits; Fourier Series single and polyphase systems. Prerequisites: Electrical Engineering major and EE 206 with a grade of C or better. Corequisite: EE 313L. S.

**EE 313L. Circuits Laboratory II. 1 Credit.**
Experimental circuit analysis and proper uses of laboratory equipment. Prerequisites: Electrical Engineering major and EE 206L. Corequisite: EE 313. S.S.S.

**EE 314. Signals and Systems. 3 Credits.**
Passive filters; Laplace transform applications; Fourier transform; Z-transform; Nyquist sampling theorem; other topics as time permits (state variables; introduction to control and communications theory; discrete Fourier transform). Prerequisite: EE 313. Corequisite: MATH 266 and EE 314L. F.

**EE 314L. Signal and Systems Laboratory. 1 Credit.**
In this laboratory course, students will conduct simulations and experiments related to theory covered in EE 314. The topics include implementation of passive filters, Laplace transform, and z-transform. Corequisite: EE 314. F.

**EE 316. Electric and Magnetic Fields. 3 Credits.**
Field produced by simple distributions of electric charges and magnetic poles, field mapping and application to engineering problems. Prerequisites: EE 206 with a grade of C or better. Corequisite: MATH 266. F.

**EE 318. Engineering Data Analysis. 3 Credits.**
This course will provide undergraduate electrical engineering students with an understanding of the principles of engineering data analysis using basic probability theory and basic statistics theory. Students will have the opportunity to apply these concepts to actual engineering applications and case studies. Prerequisites: EE 206 with a grade of C or better. Corequisite: EE 313. F.

**EE 321. Electronics I. 3 Credits.**
Fundamentals of semiconductors, nonlinear discrete components such as diodes and transistors, and integrated circuits; analysis and synthesis of simple electronic circuits, including amplifiers. Prerequisite: EE 313. Corequisite: EE 321L. F.

**EE 321L. Electronics Laboratory I. 1 Credit.**
Practical electronics application and design using theory studied in concurrent third year electrical engineering courses. Prerequisite: EE 313L. Corequisite: EE 321. F.

**EE 397. Cooperative Education. 1-2 Credits.**
A practical work experience with an employer closely associated with the student's academic area. Arranged by mutual agreement among student, department, and employer. Repeatable to 24 credits. Prerequisite: Admission to the electrical engineering degree program; a cumulative GPA of 2.0 or higher is required. Repeatable to 24 credits. S/U grading. F.S.S.S.

**EE 401. Electric Drives. 3 Credits.**
A study of variable speed drives and their electronic controls; analysis and synthesis of power electronics through computer simulations and laboratory implementations. Prerequisite: EE 314. Corequisite: EE 401L. S.

**EE 401L. Electric Drives Laboratory. 1 Credit.**
The course provides the basic knowledge required for the usage and the design of the most common electrical drives. This lab focuses on the Electric Drives and their control in a real time environment using dSPACE and/or similar digital signal processing based methods and simulations. Corequisite: EE 401. S.

**EE 405. Control Systems I. 3 Credits.**
Mathematical modeling and dynamic response of linear control systems; stability analysis; design of linear controllers using the root locus and frequency response techniques. Prerequisite: EE 314 and MATH 266. Corequisite: EE 405L. S.

**EE 405L. Control Systems Laboratory. 1 Credit.**
Experiments and simulations related to theory discussed in EE 405 are implemented in this laboratory course. The topics included mathematical modeling and dynamic response of linear systems; stability analysis; and design of controllers. Corequisite: EE 405. S.

**EE 409. Distributed Networks. 3 Credits.**
Fundamentals of transmission lines. Prerequisite: EE 313 and EE 316. S.

**EE 411. Communications Engineering. 3 Credits.**
Mathematical definition of random and deterministic signals and a study of various modulation systems. Prerequisite: EE 314. On demand.

**EE 421. Electronics II. 3 Credits.**
Analysis of electronic circuits and systems using discrete components and integrated circuits, digital circuits, active filters, and power amplifiers. Prerequisite: EE 314 and EE 321. Corequisite: EE 421L. S.

**EE 421L. Electronics Lab II. 1 Credit.**
Practical electronics application and design using theory studied in concurrent third year electrical engineering courses. Prerequisite: EE 321L. Corequisite: EE 421. S.

**EE 423. Power Systems I. 3 Credits.**
Electric power systems operation, control and economic analysis. Prerequisite: EE 313. On demand.

**EE 424. Electronic Circuits. 3 Credits.**
Principles, applications, and design of electronic equipment studied from viewpoint of complete systems. Prerequisite: EE 321. On demand.

**EE 428. Robotics Fundamentals. 3 Credits.**
Fundamentals of robotic systems: modeling, analysis, design, planning, and control. The project provides hands-on experience with robotic systems. Prerequisite: MATH 266 or consent of instructor. On demand.

**EE 430. Introduction to Antenna Engineering. 3 Credits.**
Review of vector analysis and Maxwell's equations, wave propagation in unbounded regions, reflection and refraction of waves, fundamental antenna concepts, wire- and aperture-type antennas, wave and antenna polarization, antenna measurements, and computer-aided analysis. Prerequisite: EE 409 or consent of instructor. On demand.

**EE 434. Microwave Engineering. 3 Credits.**
Review of transmission lines and plane waves, analysis of microwave networks and components using scattering matrices, analysis of periodic structures, transmission and cavity type filters, high frequency effects, microwave oscillators, amplifiers, and microwave measurement techniques. Prerequisite: EE 409 or consent of instructor. On demand.
EE 451. Computer Hardware Organization. 3 Credits.
The study of complete computer systems including digital hardware
interconnection and organization and various operation and control methods
necessary for realizing digital computers and analog systems. Prerequisite:
EE 201 and EE 304; or consent of instructor. On demand.

EE 452. Embedded Systems. 3 Credits.
A study of microcontroller hardware and software, with an emphasis on
interfacing the microcontroller with external electronic devices such as
transceivers, sensors, and actuators for communications and control within
an embedded system. Prerequisite: EE 201, EE 304 and EE 321. Corequisite:
EE 452L. S.

EE 452L. Embedded Systems Design Laboratory. 1 Credit.
This introductory laboratory course provides students with the hands-on
activities in order to learn and gain more experiences in designing embedded
systems (smart systems) using microcontrollers, actuators, and sensors.
Prerequisites: EE 201 and EE 304 or consent of instructor. Prerequisite or
corequisite: EE 452. S.

EE 456. Digital Image Processing. 3 Credits.
Digital image retrieval, modification, enhancement, restoration, and storage.
Image transformation and computer vision. The associated laboratory provides
hands-on experiences. Prerequisite: EE 304 and EE 314. On demand.

EE 480. Senior Design I. 3 Credits.
First course in the two-semester capstone design experience for the electrical
engineering undergraduate degree, emphasizing design methodologies,advanced
communication, and teamwork. Student teams will select an
electronic system to design, capture end-user requirements, and perform
component trade studies, resulting in an oral and written critical design review
at the end of the semester. Prerequisites: EE 421 and two out of the four
following classes: EE 401, EE 405, EE 409, EE 452. F.

EE 481. Senior Design II. 3 Credits.
Second course in the two-semester capstone design experience for the electrical
engineering undergraduate degree, emphasizing design methodologies, oral
communication, and teamwork. Student teams will be required to build and test a prototype of the electronic systems designed in
EE 480 Senior Design I, and they will prepare written reports and deliver oral
presentations on their design choices with critique by the instructor. EE 481
Senior Design II meets the Essential Studies Special Emphasis requirement for
Oral Communication (O). Prerequisite: EE 480. S.

EE 489. Senior Honors Thesis. 1-8 Credits.
Supervised independent study culminating in a thesis. Repeatable to 9 credits.
Repeatable to 9 credits. F.S.S.

EE 490. Electrical Engineering Problems. 1-9 Credits.
Repeatable to maximum of 9 credits. Prerequisite: Approval by departmental
faculty member under whom the electrical engineering problem is studied.
Repeatable to 9 credits. F.S.

EE 505. Control Systems II. 3 Credits.
Advanced topics in control systems including nonlinear systems, robust control,
optimal control, and pole placement techniques; selective topics from the state
of the art. Prerequisite: EE 405.

EE 506. Digital Control Systems. 3 Credits.
Digital systems representation, analysis and simulation; Z-transform;
digital controllers design and realization; microprocessor based controllers.
Prerequisite: EE 405.

EE 508. Intelligent Decision Systems. 3 Credits.
Systems and networks will be designed to work in an uncertain environment.
Systems will be optimized using Neural Networks and Fuzzy Logic concepts.
Prerequisite: EE 314 or consent of instructor.

EE 509. Signal Integrity. 3 Credits.
Fundamental concepts of signal integrity are presented. Topics include
propagation of digital signals, electrical noise, and system timing. Prerequisite:
EE 409 or consent of instructor.

EE 511. Power Electronics. 3 Credits.
Principles of power electronics switching control circuits. Including AC/DC,
DC/DC, DC/AC converters, their harmonics and filtering techniques, and their
application in switching power supplies, electric drives, renewable energy
systems, etc. Prerequisite: EE 321 or consent of instructor. On demand.

EE 512. Wireless Communications. 3 Credits.
Key concepts, underlying principles, and practical applications of ever-growing
wireless and cellular communication technologies. Prerequisite: EE 411 or
consent of instructor.

EE 521. Digital Signal Processing. 3 Credits.
Modern methods of digital signal processing will be studied. Techniques that
will be used include the recursive and nonrecursive discrete-time filters and the
Fourier Transform. Prerequisite: EE 314.

EE 522. Renewable Energy Systems. 3 Credits.
This course will provide engineering students with an understanding of the
principles of renewable energy conversion systems. Emphasis is on wind,
photo-voltaic, hydrogen fuel, and fuel cell energy conversion and storage
systems, along with their associated design and control issues.

EE 523. Power Systems II. 3 Credits.
Electric power systems analysis and control. Power flow; system response and
stability; voltage and frequency control; computer methods in system analysis.
Prerequisite: EE 423.

EE 524. Application Specific Integrated Circuit (ASIC) Design. 3 Credits.
To gain an historic perspective of ASIC Design. To familiarize students
with the existing IC technology and their attributes. To recognize basic
fabrication process, layout, circuit extraction and performance analysis. To
understand CAD tools, hardware, systems engineering, and operational issues.
Prerequisite: EE 421 or consent of instructor.

EE 525. Electromagnetic Fields. 3 Credits.
Static electric and magnetic fields, field mapping, and applications to
transmission lines, wave-guides, and antennas. Prerequisite: EE 316.

EE 526. Engineering Systems Reliability. 3 Credits.
This course teaches the basics of reliability engineering concepts and
techniques applicable to all engineering disciplines including electrical,
mechanical, chemical, geological, aeronautical, and civil. To benefit the most
from this course, some basic knowledge of probability and statistics would
be helpful but is not necessary as the required background and tools are
presented and discussed in the class. Prerequisite: Consent of the instructor.
On demand.

EE 532. Antenna Theory. 3 Credits.
Physical principles underlying antenna behavior and design as applied to
antennas. Prerequisite: EE 316 or consent of instructor.

EE 534. Advanced Wireless Communications Engineering. 3 Credits.
A combination of theory and practice underlying principles and practical
applications of Wireless Communications. Prerequisite: Consent of Instructor.
On demand.

EE 536. Optical Fiber Communications. 3 Credits.
Propagation in optical fibers, optical receivers, amplifiers, detectors, sources,
transmission links, noise consideration, optical fiber communication systems,
applications and future developments. Prerequisite: EE 434 or consent of
instructor.

EE 537. Graduate Cooperative Education. 1-2 Credits.
The is course is a practical research experience under supervision of an
employer that is closely associated with the student's academic area. A written
report which includes a literature survey and research findings and an oral
presentation are required. Prerequisite: Approval of the Electrical Engineering
Graduate Committee or Electrical Engineering Department Graduate Director,
completion of the program of study. Repeatable to 3 credits. S/U grading.
F.S.S.

EE 539. Electromagnetic Compatibility. 3 Credits.
Introduction to design considerations and techniques used to ensure
electromagnetic compatibility. Prerequisite: EE 409 or consent of instructor.

EE 540. Computer Networks Communications. 3 Credits.
Computer Communications is an undergraduate/graduate course that
introduces fundamental concepts in the design and implementation of computer
communication networks and their protocols. Prerequisite: Consent of the
instructor. On demand.

EE 542. Network Architectures. 3 Credits.
Several network architectures are used today for transporting data and
providing a good network service and performance. This course explains
the fundamental network architecture concepts and their communications
protocols. Prerequisite: Consent of the instructor. On demand.
EE 544. Advanced Microwave Engineering. 3 Credits.
Analysis of passive microwave components including power dividers, resonators, filters, ferromagnetic and MEMS components. On demand. Prerequisites: EE 409 and EE 434, or consent of instructor. On demand.

EE 545. Introduction to Biomedical Engineering. 3 Credits.
This course introduces biomedical engineering and several systems of the human physiology. Signals of biological origin obtained from these systems, biosensors, transducers and bioelectrodes used to acquire such signals, along with medical quality amplifiers for measuring biopotentials, are discussed. Prerequisite: EE 314, EE 421 or consent of instructor.

EE 546. Biomedical Signal Processing. 3 Credits.
This course presents the several fundamental of digital signal processing methods applied to biomedical signals. Topics include data acquisition and related issues, filtering, feature extraction, classification, and decision making. The course is based on a series of labs and experiments of applying different methods to real biomedical signals. Lectures cover signal processing topics relevant to the lab exercises. Prerequisite: Consent of the instructor. On demand.

EE 547. Deep Learning Applications in Biomedical Engineering. 3 Credits.
Applications of different machine learning techniques to biomedical image and signal processing are evaluated. Prerequisite: EE 314 or the consent of the instructor. On demand.

EE 550. Biomedical Instrumentation. 3 Credits.
Introduction to circuits and systems that allow electrical technology to interface with biological systems. Prerequisite: EE 314, EE 316 and EE 421, or consent of instructor.

EE 551. Cryptography Techniques and their VLSI Implementations. 3 Credits.
Modern cryptography algorithms are necessary for protecting data storage and communication streams from disclosure and manipulation of information by hackers. This course exposes students to the standard cryptography algorithms and their implementation in VLSI chips, Field Programmable Array devices, using VHDL language. Prerequisite: Consent of the instructor. On demand.

EE 552. Advanced Embedded Systems Design. 3 Credits.
This course provides students with cutting-edge techniques in the design and implementation of advanced embedded systems that involve analog/digital conversion, interrupts, timers, CCP modules, and parallel/serial communications. Prerequisite: EE 452 or consent of instructor.

EE 560. Engineering Computation. 3 Credits.
Development and application of optimization techniques in practical problems encountered in electrical engineering, Downhill and probabilistic optimization techniques, Modeling of complex systems by partial differential equations and their numerical solution by finite difference and finite element methods. Prerequisite: Consent of instructor. On demand.

EE 595. Design Project. 3-6 Credits.
A three to six credit course of engineering design experience involving individual effort and a formal written report. Repeatable to 6 credits. Prerequisites: Restricted to Master of Engineering student candidates and subject to approval by the student's advisor. Repeatable to 6 credits.

EE 599. Doctoral Research in Electrical Engineering. 1-15 Credits.
Doctoral Research. Repeatable. F,S,SS.

EE 601. Foundations of Cyber Security. 3 Credits.
This course provides a solid foundation for further study in cyber security. The course incorporates numerous topics that are fundamental to the field beginning with a high-level overview of cyber security and continuing into the topics of calculus and computer programming. These topics are presented utilizing real-world cyber security applications. Prerequisite: Students enrolled/admitted in the MS in Cyber Security program. F,S,SS.

EE 611. Emerging Threats and Defenses. 3 Credits.
Cyber-attacks are a serious economic and security threat. To combat both immediate and future dangers, businesses and governments are investing in cyber security. Understanding trends in cyber-security and how machine-learning techniques defenses can respond to threats is a critical component of protecting networks, infrastructure and users. This course explores the growing challenges of securing sensitive data, networks to defend against malicious acts. Prerequisite: Consent of the instructor. On demand.

EE 613. Advanced Cyber Security Principles. 3 Credits.
This course is a comprehensive study of the principles and practices of computer system security including operating system security, network security, software security and web security. Topics include common attacking techniques such as virus, trojan, worms and memory exploits; the formalisms of information security such as the access control and information flow theory; the common security policies such as BLP and Biba model; the basic cryptography, RSA, cryptographic hash function, and password system; the real system implementations, with case study of UNIX, SE-Linux, and Windows; network intrusion detection; software security theory; web security; legal and ethical issues in computer security. Prerequisite: Consent of the instructor. On demand.

EE 614. Applied Cryptography. 3 Credits.
This course brings students up-to-date in key concepts, underlying principles and practical applications of Spread Spectrum Technology. A course that presents timely information that student can immediately put to use in tackling real world cyber threats. Prerequisite: Consent of the instructor. On demand.

EE 615. Cyber Forecasting. 3 Credits.
There are literally millions of enterprises and organizations that already conduct business on the World Wide Web and millions more that will in the future. Many are not sure on how much to spend to defend themselves against Internet Security attacks and many are afraid to conduct business on the Web because of the lack of security in their infrastructure and information systems. Prerequisite: Consent of the instructor. On demand.

EE 616. Cyber-Physical Energy Systems Security. 3 Credits.
This course discusses the basics of integrated power and communication infrastructures in cyber-physical electrical energy and power systems. In order to understand planning, design and operation of such systems, this course includes both cyber and physical topics related to modern power systems, such as technologies for storing and generating electric power (including renewable energy), layering, networking, packets routing, coding, cellular networks, WLAN, and sensors. Approaches for an integrated operation, management and control of such systems, as well as the application of signal processing techniques in electric power grids are also explored in this course. Implication of such integrated power and communications cyber-physical systems in terms of sustainability, security, resiliency, and reliability will also be reviewed. Prerequisites: EE 313 and EE 423 or consent of the instructor. On demand.
EE 617. Data Operations and Security. 3 Credits.
This course explains the key concepts used in database systems and
demonstrates the features of a Database management software. The course
will discuss the different types of commercial database systems and will explain
the concepts used to design a database. Also this course will teach how to
implement a database using the relational DBMS. The course also illustrates
the usage of database management systems. The course will also discuss
data base attacks, ACID properties. Prerequisite: Consent of the instructor. On
demand.

EE 623. Introduction to Smart Grid I. 3 Credits.
This course is an in-depth study of the ways in which information and
communication technologies (ICT) are being deployed to modernize the electric
energy infrastructure, i.e. ‘Smart Grid.’ In this course we will define Smart Grid
as the use of ICT (in combination with power electronics and policy) to make
electricity cleaner, less costly, and more reliable. Prerequisite: EE 313 or
graduate student standing. On demand.

EE 624. Introduction to Smart Grid II. 3 Credits.
This is the next sequence of smartgrid course is an in-depth study of the
ways in which information and communication technologies (ICT) are being
deployed to modernize the electric energy infrastructure, i.e. ‘Smart Grid.’ In
this course we will define Smart Grid as the use of ICT (in combination with
power electronics and policy) to make electricity cleaner, less costly, and more
reliable. Prerequisite: EE 623. On demand.

3 Credits.
Communication between computers and networks uses protocols. This course
introduces students to the OSI model and TCP/IP protocol stack. Functions
of each layer in the network are explained and their security analyzed.
Prerequisite: Consent of the instructor. On demand.

EE 740. Intrusion Detection Algorithms. 3 Credits.
With the increasing number of cyber-attacks, intrusion detection systems
become crucial tools for detecting anomalies and enhancing computers and
networks security. This course exposes students to the existing intrusion
detection techniques and algorithms, including signature-based and anomaly-
based approaches. Prerequisite: Consent of the instructor. On demand.

EE 750. Internet of Things and Security. 3 Credits.
Internet of Things (IoT) is an emerging field where computing devices are
interconnected through the existing internet infrastructure. The IoT has
changed the world with new innovative products such as autonomous vehicles,
smart home, and smart wearables devices. This course explains the concept of
IoT, its applications, networks and communication architectures, and security
threats. Prerequisite: Consent of the instructor. On demand.

EE 751. Wireless Sensor Networks. 3 Credits.
This class provides a hands-on introduction to wireless sensor networking.
We will start with a discussion of the WSN+ubiquitous computing vision and
applications, and also discuss emergent/swarm behavior in distributed and
networked systems. We will provide a tutorial on programming wireless sensor
network applications in Tinyos. Finally, we will quickly cover protocols for MAC
layer, Localization, Routing, Querying, and Tracking. Prerequisite: Consent of
the instructor. On demand.

EE 752. Introduction to Autonomous Systems. 3 Credits.
Advanced topics in autonomous and intelligent mobile robots, with emphasis
on planning algorithms and cooperative control. Robot kinematics, path and
motion planning, formation strategies, cooperative rules and behaviors. The
application of cooperative control spans from natural phenomena of groupings
such as fish schools, bird flocks, deer herds, to engineering systems such
as mobile sensing networks, vehicle platoon. Prerequisite: Consent of the
instructor. On demand.

EE 994. Capstone. 3 Credits.
This course is intended for students enrolled in a graduate program, who need
to complete a semester long project. The class will emphasize applied learning
to demonstrate real world problem solving skills. F,S,SS.

EE 996. Continuing Enrollment. 1-12 Credits.
Repeatable. S/U grading.

EE 997. Independent Study. 3 Credits.
This course is independent study for MS Non-Thesis Students. Prerequisite:
Consent of Advisor.

EE 998. Thesis. 1-6 Credits.
Repeatable to 9 credits.

EE 999. Dissertation in Electrical Engineering. 1-18 Credits.
Dissertation for Ph.D. EE students. Repeatable to 18 credits. F,S,SS.