ECEN 210 Computer Programming and Algorithms  
Credits 4. 3 Lecture Hours. 3 Lab Hours.  
Introduction to C language and common algorithms; computer systems;  
simple C programs; basic language constructs; file I/O; modular  
programming and functions; arrays and matrices; pointers and strings;  
simple data structures; searching, sorting, and numerical algorithms;  
algorithmic complexity.  
Prerequisite: Sophomore classification in an engineering major; Qatar  
campus.

ECEN 214 Electrical Circuit Theory  
Credits 4. 3 Lecture Hours. 3 Lab Hours.  
Resistive circuits including circuit laws, network reduction, nodal  
analysis, mesh analysis; energy storage elements; sinusoidal steady  
state; AC energy systems; magnetically coupled circuits; the ideal  
transformer; resonance; introduction to computer applications in circuit  
analysis.  
Prerequisites: Grade of C or better in PHYS 207 or PHYS 208; grade of C  
or better in CHEM 107, CHEM 102, or CHEM 120; grade of C or better  
in MATH 308, or concurrent enrollment.

ECEN 215 Principles of Electrical Engineering  
Credits 3. 2 Lecture Hours. 2 Lab Hours.  
Fundamentals of electric circuit analysis and introduction to electronics  
for engineering majors other than electrical and computer engineering.  
Prerequisites: Grade of C or better in MATH 251 or MATH 253; Grade of C  
or better in PHYS 207 or PHYS 208.

ECEN 222/CSCE 222 Discrete Structures for Computing  
Credits 3. 3 Lecture Hours.  
Provide mathematical foundations from discrete mathematics for  
analyzing computer algorithms, for both correctness and performance;  
introduction to models of computation, including finite state machines  
and Turing machines.  
Prerequisite: MATH 151.  
Cross Listing: CSCE 222/ECEN 222.

ECEN 248 Introduction to Digital Systems Design  
Credits 4. 3 Lecture Hours. 3 Lab Hours.  
Combinational and sequential digital system design techniques; design  
of practical digital systems.  
Prerequisite: Grade of C or better in MATH 152; grade of C or better  
in PHYS 207 or PHYS 208, or concurrent enrollment.

ECEN 285 Directed Studies  
Credits 0 to 4. 0 to 4 Other Hours.  
Problems of limited scope approved on an individual basis intended to  
promote independent study.  
Prerequisite: Approval of department head.

ECEN 289 Special Topics in...  
Credits 1 to 4. 1 to 4 Other Hours.  
Selected topics in an identified area of electrical engineering. May be  
repeated for credit.  
Prerequisite: Approval of instructor.
Prerequisites include testing, evaluation and report writing. The process; completion of project based on proposal from ECEN 403; engineering as practiced in industry; team approach to the design process; development of an execution and validation plan; project execution will cover topics in engineering, optimization and economic concepts; modular view of individual electric energy processing components; physical and market operations in electricity industry in support of sustainable energy integration; computer simulations and demonstrations to create and evaluate examples of power systems.

Prerequisites: Grade of C or better in ECEN 403; senior classification.

ECEN 404 Electrical Design Laboratory II
Credits 3. 2 Lecture Hours. 3 Lab Hours.
Continuation of ECEN 403; application of the design process and project engineering as practiced in industry; team approach to the design process; completion of project based on proposal from ECEN 403; includes testing, evaluation and report writing.

Prerequisites: Grade of C or better in ECEN 403; senior classification.
ECEN 416/CSCE 416 Hardware Design Verification
Credits 3. 3 Lecture Hours.
Hardware functional verification; case studies on verification in integrated circuit design; introduction to industry best practices; introduction to logic functional verification.
Prerequisites: CSCE 312, CSCE 350/ECEN 350, or ECEN 350/CSCE 350, or equivalent in computer architecture; familiarity with C/C++/Verilog/VHDL programming.
Cross Listing: CSCE 416/ECEN 416.

ECEN 419 Genomic Signal Processing
Credits 3. 3 Lecture Hours.
Fundamentals of molecular biology; application of engineering principles to systems biology; topics include unearthing intergene relationships, carrying out gene-based classification of disease, modeling genetic regulatory networks, and altering their dynamic behavior.
Prerequisites: Grade of C or better in ECEN 314; junior or senior classification.

ECEN 420 Linear Control Systems
Credits 3. 3 Lecture Hours.
Application of state variable and frequency domain techniques to modeling, analysis and synthesis of single input, single output linear control systems.
Prerequisites: Grade of C or better in ECEN 314 and MATH 308; junior or senior classification.

ECEN 421 Digital Control Systems
Credits 3. 3 Lecture Hours.
Feedback systems in which a digital computer is used to implement the control law; Z-transform and time domain methods serve as a basis for control systems design. Effects of computer word length and sampling rate.
Prerequisite: ECEN 420 or equivalent.

ECEN 422 Control Engineering and Design Methodology
Credits 3. 2 Lecture Hours. 3 Lab Hours.
Modeling, specifications, rating and operating principles of sensors, actuators and other control system components; experiments on conceptual design, simulation and physical implementation of control systems.
Prerequisite: ECEN 420 or equivalent.

ECEN 423 Computer and Wireless Networks
Credits 3. 3 Lecture Hours.
Prerequisite: Grade of C or better in MATH 311; junior or senior classification.

ECEN 424 Fundamentals of Networking
Credits 3. 3 Lecture Hours. 1 Lab Hour.
Foundations of computer networking; layered architecture of the Internet, analysis of protocols, new-age networks such as the Web and social networks; computer network programming and offline analysis of real network data.
Prerequisites: Grade of C or better in ECEN 303 or STAT 211; junior or senior classification.

ECEN 425 Radio Frequency and Microwave Engineering
Credits 3. 3 Lecture Hours.
Fundamental Radio Frequency (RF) and microwave circuit analysis including scattering and ABCD matrices, return loss, insertion loss; transmission lines, lumped elements, impedance matching; theory, analysis and design of basic RF and microwave passive circuits; use of commercial CAD programs for RF and microwave circuit design and simulation.
Prerequisites: Grade of C or better in ECEN 322; junior or senior classification.

ECEN 434 Optimization for Electrical and Computer Engineering Applications
Credits 3. 3 Lecture Hours.
Principles of optimization including linear and nonlinear optimization as well as electrical and computer engineering applications in signal estimation, routing in communication networks, flows in wireless networks, wafer fabrication plants, and economic dispatch in power systems.
Prerequisites: Grade of C or better in MATH 304 or MATH 309 or MATH 311; grade of C or better in MATH 251; junior or senior classification.

ECEN 438 Power Electronics
Credits 4. 3 Lecture Hours. 3 Lab Hours.
Electric power conditioning and control; characteristics of solid state power switches; analysis and experiments with AC power controllers, controlled rectifiers, DC choppers and DC-AC converters; applications to power supplies, airborne and spaceborne power systems.
Prerequisite: Grade of C or better in ECEN 214; junior or senior classification.

ECEN 440 Thin Film Technology and Device Application
Credits 3. 3 Lecture Hours. 1 Lab Hour.
Thin film fundamentals, processing and industrial applications; topics include crystal structures in thin films, deposition techniques, thin film characterizations and several advanced topics related to electrical and optical devices; lab or tour sessions provided to promote teaching and learning.
Prerequisite: Grade of C or better in ECEN 370; junior or senior classification.

ECEN 441 Electronic Motor Drives
Credits 4. 3 Lecture Hours. 3 Lab Hours.
Application of semiconductor switching power converters to adjustable speed DC and AC motor drives; steady state theory and analysis of electric motion control in industrial, robotic and traction systems; laboratory experiments in power electronic motor drives and their control.
Prerequisite: Grade of C or better in ECEN 214; junior or senior classification.

ECEN 442 DSP Based Electromechanical Motion Control
Credits 3. 2 Lecture Hours. 3 Lab Hours.
Overview of energy conversion and basic concepts on electromechanical motion devices; different control strategies including the solid-state drive topologies; for every electromechanical motion device, its DSP control implementation discussed and implemented in the lab.
Prerequisites: Grade of C or better in ECEN 314; junior or senior classification.
ECEN 444 Digital Signal Processing
Credits 4. 3 Lecture Hours. 3 Lab Hours.
Digital signal processing; discrete-time signals and systems, linear shift-invariant systems, the discrete Fourier transform and fast Fourier transform algorithm, and design of finite impulse response and infinite impulse response digital filters.
Prerequisites: Grade of C or better in ECEN 314; junior or senior classification.

ECEN 445 Applied Electromagnetic Theory
Credits 3. 3 Lecture Hours.
Guided wave and wireless methods; applications of Maxwell's equations and electromagnetic wave phenomena to radiation, antennas and microwave circuit design; digital transmission line analysis and design.
Prerequisites: Grade of C or better in ECEN 322; junior or senior classification.

ECEN 447 Digital Image Processing
Credits 4. 3 Lecture Hours. 3 Lab Hours.
Improvement of pictorial information using spatial and frequency domain techniques; two-dimensional discrete Fourier transform; image filtering, enhancement, restoration, compression; image processing project.
Prerequisites: Grade of C or better in ECEN 314; junior or senior classification.

ECEN 448 Real-Time Digital Signal Processing
Credits 3. 2 Lecture Hours. 3 Lab Hours.
Features and architectures of digital signal processing (DSP) chips; fundamental compromises amongst computational accuracy, speed and cost; real-time implementation of filtering, audio, image and video processing algorithms; rapid prototyping via MATLAB/Simulink.
Prerequisites: ECEN 444; junior or senior classification.

ECEN 449 Microprocessor Systems Design
Credits 3. 2 Lecture Hours. 2 Lab Hours.
Introduction to microprocessors; 16/32 bit single board computer hardware and software designs; chip select equations for memory board design, serial and parallel I/O interfacing; ROM, static and dynamic RAM circuits for no wait-state design; assembly language programming, stack models, subroutines and I/O processing.
Prerequisites: Grade of C or better in ECEN 248; junior or senior classification.

ECEN 451 Antenna Engineering
Credits 3. 3 Lecture Hours.
Introduction to antenna theory and design; includes antenna performance parameters, analysis of radiation from sources using Maxwell's equations, theory and design of wire antennas, arrays and frequency independent antennas; computer methods for antenna design.
Prerequisite: Grade of C or better in ECEN 322; junior or senior classification.

ECEN 452 Ultra High Frequency Techniques
Credits 3. 2 Lecture Hours. 3 Lab Hours.
Introduction to theory and practice of ultra high frequency radio wave generation, transmission and radiation; application of Maxwell's equations to transmission of electrical energy in wave guides.
Prerequisites: ECEN 322 with a grade of C or better; junior or senior classification.

ECEN 453 Microwave Solid-State Circuits and Systems
Credits 3. 3 Lecture Hours.
Microwave solid-state devices and circuits; theory and design of various types of active circuits; applications of these devices and circuits in radar, communication and surveillance systems.
Prerequisites: Grade of C or better in ECEN 322; junior or senior classification.

ECEN 454 Digital Integrated Circuit Design
Credits 3. 2 Lecture Hours. 2 Lab Hours.
Analysis and design of digital devices and integrated circuits using MOS and bipolar technologies and computer aided simulation.
Prerequisites: Grade of C or better in ECEN 214 and ECEN 248; junior or senior classification.

ECEN 455 Digital Communications
Credits 4. 3 Lecture Hours. 3 Lab Hours.
Digital transmission of information through stochastic channels; analog-to-dialog conversion, entropy and information, Huffman coding; signal detection, the matched-filter receiver, probability of error; baseband and passband modulation, signal space representation of signals, PAM, QAM, PSK, FSK; block coding, convolutional coding; synchronization; communication through fading channels; spread-spectrum signaling; simulation of digital communication systems.
Prerequisites: Grade of C or better in ECEN 314 and ECEN 303 or STAT 211; junior or senior classification.

ECEN 457 Operational Amplifiers
Credits 4. 3 Lecture Hours. 3 Lab Hours.
Analysis of basic operational amplifier and operational transconductance amplifier (OTA) circuits; noise analysis in Op amp and OTA circuits; nonlinear OTA and Op amp circuits; instrumentation amplifiers; transducer circuits; function generators; oscillators and D/A converters and basics of switched-capacitor circuits.
Prerequisite: Grade of C or better in ECEN 325; junior or senior classification.

ECEN 458 Active Filter Analysis and Design
Credits 4. 3 Lecture Hours. 3 Lab Hours.
Systematic analysis and design for active RC filters; continuous-time; switched-capacitor circuits; filter approximations; synthesis techniques; sensitivity; practical considerations for monolithic integrated filters; experimental and computer-simulation verification.
Prerequisite: Grade of C or better in ECEN 325; junior or senior classification.

ECEN 459 Power System Fault Analysis and Protection
Credits 4. 3 Lecture Hours. 2 Lab Hours.
General considerations in transmission and distribution of electrical energy as related to power systems; calculation of electric transmission line constants; general theory of symmetrical components and application to analysis of power systems during fault conditions.
Prerequisite: Grade of C or better in ECEN 215 or ECEN 314; junior or senior classification.

ECEN 460 Power System Operation and Control
Credits 4. 3 Lecture Hours. 2 Lab Hours.
Load flow studies; power system transient stability studies; economic system loading and automatic load flow control.
Prerequisite: Grade of C or better in ECEN 215 or ECEN 314; junior or senior classification.
ECEN 462 Optical Communication Systems
Credits 3. 3 Lecture Hours.
Principles of optical communication systems; characteristics of optical fibers, lasers and photodetectors for use in communication systems; design of fiber-optic digital systems and other optical communication systems.
Prerequisites: Grade of C or better in ECEN 322 and ECEN 370; junior or senior classification.

ECEN 463 Magnetic Resonance Engineering
Credits 3. 2 Lecture Hours. 3 Lab Hours.
Design, construction and application of instrumentation for MR imaging; fundamentals of the architecture of an MR spectrometer and the gradient subsystem used for image localization; emphasis on the radiofrequency sensors and systems used for signal generation and reception.
Prerequisites: Grade of C or better in ECEN 322 or BMEN 420; junior or senior classification.

ECEN 464 Optical Engineering
Credits 3. 3 Lecture Hours.
Ray optics; wave optics; propagation, reflection, refraction and diffraction of light; passive optical components, polarization, optical modulators, interferometers and lasers.
Prerequisites: Grade of C or better in ECEN 322 or ECEN 370; junior or senior classification.

ECEN 465 Experimental Optics
Credits 4. 2 Lecture Hours. 7 Lab Hours.
In-depth study of experimental optic techniques; opto-mechanical assemblies; passive optics; interferometers; opto-electronics; basic op-amp circuits; feedback and control of optics with electronics.
Prerequisite: Grade of C or better in ECEN 370; junior or senior classification.

ECEN 466/CYBR 466 Unconditionally Secure Electronics
Credits 3. 3 Lecture Hours.
Data security; cryptography; key exchange; conditional security; unconditional (information-theoretic) security; quantum key distribution; the Kirchhoff-law-Johnson-noise (KLJN) key exchange, electronic noise; advanced issues of KLJN; schemes, protocols, attacks, defense, privacy amplification, credit cards, PUF, autonomous vehicles and smart grids.
Prerequisites: Grade of C or better in ECEN 214; grade of C or better in ECEN 303 or STAT 211; junior or senior classification.
Cross Listing: CYBR 466/ECEN 466.

ECEN 467 Harnessing Solar Energy: Optics, Photovoltaics and Thermal Systems
Credits 4. 3 Lecture Hours. 3 Lab Hours.
Solar radiation characteristics and measurement; optical coatings including reflection, transmission, absorption and emissivity; concentrating optics, tracking and etendue limit; photovoltaic cells, modules and systems overview; introduction to solar thermal systems.
Prerequisites: Grade of C or better in ECEN 322 and ECEN 370; junior or senior classification.

ECEN 468 Advanced Digital System Design
Credits 4. 3 Lecture Hours. 3 Lab Hours.
Design, modeling and verification of complex digital systems using hardware description language and electronic system level language.
Prerequisite: Grade of C or better in ECEN 248; junior or senior classification.

ECEN 469 Advanced Computer Architecture
Credits 3. 3 Lecture Hours.
Advanced computer architectures including memory designs, pipeline techniques, and parallel structures such as vector computers and multiprocessors.
Prerequisite: Grade of C or better in ECEN 350/CSCE 350 or CSCE 350/ECEN 350; junior or senior classification.

ECEN 470 Laser Principles and Applications
Credits 3. 3 Lecture Hours.
Working understanding of the basic principles of laser science, the major components of laser system and their function; examples of laser applications to science, engineering, medicine and industry.
Prerequisites: Grade of C or better in ECEN 322 and ECEN 370; junior or senior classification.

ECEN 471 Power Management Circuits and Systems
Credits 4. 3 Lecture Hours. 3 Lab Hours.
Overview of modern semiconductor power devices, DC-DC linear regulators, switching regulators and battery chargers; emphasis on mathematical foundations, feedback theory, stability and root locus, multi-stage amplifiers, analysis and design of power electronic circuits including DC-DC and AC-DC converters and power supplies; applications on power electronics and power management circuits.
Prerequisites: Grade of C or better in ECEN 325; junior or senior classification.

ECEN 472 Microelectronic Circuit Fabrication
Credits 4. 3 Lecture Hours. 3 Lab Hours.
Fundamentals of MOS and bipolar microelectronic circuit fabrication; theory and practice of diffusion, oxidation, ion implantation, photolithography; etch; yield and reliability considerations; statistical process control; integrated process design, simulation and characterization.
Prerequisites: Grade of C or better in ECEN 325 and ECEN 370; junior or senior classification.

ECEN 473 Microelectronic Device Design
Credits 3. 3 Lecture Hours.
General processes for the fabrication of microelectronic devices and integrated circuits; a review of the electronic properties of semiconductors and carrier transport and recombination; analysis and characterization of p-n junctions, bipolar transistors, and MOS capacitors and transistors; design considerations for achieving optimum performance and practical structures are discussed.
Prerequisites: Grade of C or better in ECEN 325 and ECEN 370; junior or senior classification.

ECEN 474 VLSI Circuit Design
Credits 4. 3 Lecture Hours. 3 Lab Hours.
Analysis and design of monolithic analog and digital integrated circuits using NMOS, CMOS and bipolar technologies; device modeling; CAD tools and computer-aided design; design methodologies for LSI and VLSI scale circuits; yield and economics; test and evaluation of integrated circuits.
Prerequisite: ECEN 326.

ECEN 475 Introduction to VLSI Systems Design
Credits 4. 3 Lecture Hours. 3 Lab Hours.
Introduction to design and fabrication of microelectronic circuits; emphasis on very large scale integration (VLSI) digital systems; use of state-of-the-art design methodologies and tools; design of small to medium scale integrated circuits for fabrication.
Prerequisites: Grade of C or better in ECEN 248 and ECEN 325; junior or senior classification.
ECEN 477 Photonics: Fiber and Integrated Optics  
**Credits 4. 3 Lecture Hours. 3 Lab Hours.**
Photonics lab including optical power and spectral measurements of singlemode and multimode optical fibers, hands-on arc fusion splicing, lasers, amplifiers, interferometers, photodetectors, integrated optics, fiber-optic devices, optical modulators.  
**Prerequisite:** Grade of C or better in ECEN 322 and ECEN 370; junior or senior classification.

ECEN 478 Wireless Communications  
**Credits 3. 3 Lecture Hours.**
Overview of wireless applications, models for wireless communication channels, modulation formats for wireless communications, multiple access techniques, wireless standards.  
**Prerequisites:** ECEN 455; junior or senior classification.

ECEN 479 Wireless Communication Laboratory  
**Credit 1. 3 Lab Hours.**
Application of theoretical concepts learned in ECEN 478; includes weekly experiments using NI PXI and Matlab.  
**Prerequisites:** ECEN 478 or registration therein; junior or senior classification; Qatar campus.

ECEN 480 RF and Microwave Wireless Systems  
**Credits 3. 3 Lecture Hours.**
Introduction to various RF and microwave system parameters, architectures and applications; theory, implementation, and design of RF and microwave systems for communications, radar, sensor, surveillance, navigation, medical and optical applications.  
**Prerequisite:** Grade of C or better in ECEN 322; junior or senior classification.

ECEN 484 Professional Internship  
**Credits 0-1. 0-1 Lecture Hours.**
Professional internship in a private company, government agency or laboratory, university or organization to provide work and/or research experience related to the student's major and career objectives. May be taken three times for credit.  
**Prerequisites:** Grade of C or better in ECEN 214 or ECEN 248; junior or senior classification; approval of instructor and internship agency.

ECEN 485 Directed Studies  
**Credits 0 to 6. 0 to 6 Other Hours.**
Problems of limited scope approved on an individual basis intended to promote independent study.  
**Prerequisites:** Senior classification; approval of department head.

ECEN 489 Special Topics in...  
**Credits 1 to 4. 1 to 4 Lecture Hours. 0 to 7 Lab Hours.**
Selected topics in an identified area of electrical engineering. May be repeated for credit.  
**Prerequisite:** Approval of instructor.

ECEN 491 Research  
**Credits 0 to 4. 0 to 4 Other Hours.**
Research conducted under the direction of faculty member in electrical engineering. May be repeated 3 times for credit.  
**Prerequisites:** Junior or senior classification and approval of instructor.