**ELECTRICAL AND COMPUTER ENGINEERING (ECE)**

### 100 Level Courses

**ECE 101: Introduction to Electrical and Computer Engineering.** 3 credits. Introduces fundamental concepts in Electrical and Computer engineering and provides insight to the various careers in each field. Both theory and practical applications of electronic components are covered through examples of real world applications. Topics are reinforced through hands-on laboratory experiments. Offered by Electrical & Comp. Engineering. Limited to two attempts.

**Registration Restrictions:**
**Required Prerequisites:** (minimum score of 13 in 'Math Placement Algebra I', minimum score of 07 in 'Math Placement Algebra II' and minimum score of 07 in 'Math Placement Transcendentals') or (MATH 105\(^c\), 113\(^c\), 115\(^c\) or 123\(^c\)).
\(^c\) Requires minimum grade of C.

Students with the terminated from VSE major attribute may **not** enroll.

**Schedule Type:** Laboratory, Lecture

**Grading:**
This course is graded on the Undergraduate Regular scale.

### 200 Level Courses

**ECE 201: Introduction to Signals and Systems.** 3 credits. Provides an introduction to key concepts for the description and analysis of signals and systems with an emphasis on discrete-time signals and systems. Specific topics include sinusoidal and complex exponential signals, sampling, spectrum representation of signals via DTFT and DFT, system properties, convolution, impulse response and frequency response. The associated computer lab provides opportunities to apply concepts to physical reality. Note: Students must register for both lecture and lab. Offered by Electrical & Comp. Engineering. Limited to two attempts.

**Specialized Designation:** Discovery of Scholarship.

**Registration Restrictions:**
**Required Prerequisites:** (MATH 114\(^c\) or 116\(^c\)) and ECE 101\(^c\).
\(^c\) Requires minimum grade of C.

Students with the terminated from VSE major attribute may **not** enroll.

**Schedule Type:** Laboratory, Lecture

**Grading:**
This course is graded on the Undergraduate Regular scale.

**ECE 202: Continuous-Time Signals and Systems.** 3 credits. Introduction to the processing and analysis of continuous-time signals and systems in the time-domain via differential equations and in the transform-domain using Laplace and Fourier transforms. Specific topics include the frequency response of LTI systems, Bode plots, system functions, block diagrams, filter design, and a rigorous treatment of sampling and aliasing. Includes applications to communications, circuits, control, and signal processing. Students must register for lecture, lab, and recitation. Offered by Electrical & Comp. Engineering. Limited to two attempts.

**Specialized Designation:** Discovery of Scholarship.

**Registration Restrictions:**

**ECE 203: Electric Circuit Analysis I.** 3 credits. Covers the second half of electric circuit theory and practice. Topics include AC analysis of circuits including Ohm’s and Kirchhoff’s laws, Thevenin and Norton equivalents, and analysis of circuits with resistors, capacitors, inductors, and operational amplifiers. Includes lab experiments to reinforce topics covered in the course. Offered by Electrical & Comp. Engineering. Limited to two attempts.

**Specialized Designation:** Scholarly Inquiry.

**ECE 204: Electric Circuit Analysis II.** 3 credits. Covers the second half of electric circuit theory and practice. Topics include AC analysis of circuits including phasors, frequency response, power analysis, and transformers. Includes a project and lab experiments to reinforce topics covered in the course. Offered by Electrical & Comp. Engineering. Limited to two attempts.

**Specialized Designation:** Scholarly Inquiry.

**ECE 205: Electric Circuit Analysis III.** 3 credits.

**Registration Restrictions:**
**Required Prerequisites:** (PHYS 260\(^c\), 261\(^c\) and ECE 101\(^c\)) and (MATH 214\(^c\) or 216\(^c\)).
\(^c\) Requires minimum grade of C.

Students with the terminated from VSE major attribute may **not** enroll.

**Schedule Type:** Laboratory, Lecture, Recitation

**Grading:**
This course is graded on the Undergraduate Regular scale.

### 300 Level Courses

**ECE 301: Digital Electronics.** 3 credits. Introduces digital systems, circuits, and computers. Topics include binary systems and codes, digital logic gates and circuits, microelectronics and integrated circuits, coding and multiplexing, multivibrators, shift registers, counters, A/D converters, and elementary computer architecture. Notes: Not intended for those majoring in electrical or computer engineering.
Offered by Electrical & Comp. Engineering. Limited to two attempts. Equivalent to CYSE 301.

Registration Restrictions:
Required Prerequisites: MATH 125\(^C\), 114\(^C\), IT 102\(^C\) or MATH 116\(^C\).
\(^C\) Requires minimum grade of C.

Students with a class of Freshman may not enroll.

Students with the terminated from VSE major attribute may not enroll.

Schedule Type: Laboratory, Lecture
Grading:
This course is graded on the Undergraduate Regular scale.

ECE 305: Electromagnetic Theory. 3 credits.
Static and time varying electric and magnetic fields, dielectrics, magnetization, Maxwell’s Equations, and introduction to transmission lines. Course uses vector calculus and algebra of complex numbers. Offered by Electrical & Comp. Engineering. Limited to two attempts.

Registration Restrictions:
Required Prerequisites: (MATH 214\(^C\) or 216\(^C\)) and PHYS 260\(^C\).
\(^C\) Requires minimum grade of C.

Students with the terminated from VSE major attribute may not enroll.

Schedule Type: Lecture, Recitation
Grading:
This course is graded on the Undergraduate Regular scale.

ECE 320: Signals and Systems II. 3 credits.
Second of two-semester sequence providing mathematical background for many ECE courses taken in junior, senior years. Provides methods of representing and analyzing discrete-time signals and systems. Studies effects of converting from continuous-time to discrete time, and presents Z-transform as convenient analysis tool. Emphasizes powerful concept of frequency response of systems developed in first semester. Presents application examples from communications, circuits, control, and signal processing. Offered by Electrical & Comp. Engineering. Limited to two attempts.

Specialized Designation: Scholarly Inquiry.

Registration Restrictions:
Required Prerequisites: (ECE 220\(^C\)) and (MATH 203\(^C\)).
\(^C\) Requires minimum grade of C.

Students with the terminated from VSE major attribute may not enroll.

Schedule Type: Lecture
Grading:
This course is graded on the Undergraduate Regular scale.

ECE 330: Circuit Theory. 3 credits.
This course introduces circuit analysis and design for non-ECE majors. Students develop an understanding of circuit analysis concepts such as nodal, mesh, and source transformation. Circuits with inductors, capacitors, resistors, and operational amplifiers are analyzed. Two projects are designed and built by students. A circuit simulation environment is used to simulate and analyze circuits. Offered by Electrical & Comp. Engineering. Limited to two attempts.

Registration Restrictions:
Required Prerequisites: PHYS 260\(^C\), 261\(^C\) and MATH 214\(^C\) and (MATH 203\(^C\) or ME 351\(^C\)).
\(^\ast\) May be taken concurrently.
\(^C\) Requires minimum grade of C.

Schedule Type: Lecture
Grading:
This course is graded on the Undergraduate Regular scale.

ECE 331: Digital System Design. 3 credits.
Covers principles of digital logic and digital system design and implementation in VHDL. Topics include number systems; Boolean algebra; analysis, design, and minimization of combinational logic circuits; analysis and design of synchronous and asynchronous finite state machines; and introduction to VHDL and behavioral modeling of combinational and sequential circuits. Notes: ECE 332 should be taken concurrently with ECE 331. Credit may not be received for ECE 301 and 331. Offered by Electrical & Comp. Engineering. Limited to two attempts.

Registration Restrictions:
Required Prerequisites: (CS 112\(^C\) or CDS 130\(^C\)) and (ECE 101\(^C\) or PHYS 261\(^C\)) and ECE 332\(^C\).
\(^\ast\) May be taken concurrently.
\(^C\) Requires minimum grade of C.

Students with a class of Freshman may not enroll.

Enrollment is limited to students with a major in Computer Engineering, Computer Science or Electrical Engineering.

Students with the terminated from VSE major attribute may not enroll.

Schedule Type: Lecture, Recitation
Grading:
This course is graded on the Undergraduate Regular scale.

ECE 332: Digital Electronics and Logic Design Lab. 1 credit.
Lab associated with ECE 331. Offered by Electrical & Comp. Engineering. Limited to two attempts.

Registration Restrictions:
Required Prerequisites: (CS 112\(^C\) or CDS 130\(^C\)) and (ECE 101\(^C\) or PHYS 261\(^C\)) and ECE 331\(^C\).
\(^\ast\) May be taken concurrently.
\(^C\) Requires minimum grade of C.

Students with a class of Freshman may not enroll.

Enrollment is limited to students with a major in Computer Engineering, Computer Science or Electrical Engineering.

Students with the terminated from VSE major attribute may not enroll.

Schedule Type: Laboratory
Grading:
This course is graded on the Undergraduate Regular scale.

ECE 333: Linear Electronics I. 3 credits.
Principles of operation and application of electron devices and linear circuits. Topics include semiconductor properties, diodes, bipolar and field effect transistors, biasing, amplifiers, frequency response, operational amplifiers, and analog design. Notes: ECE 334 is usually
taken concurrently with ECE 333. Offered by Electrical & Comp. Engineering. Limited to two attempts.

Specialized Designation: Writing Intensive in Major

Registration Restrictions:
Required Prerequisites: (ECE 280C) or (ECE 285C).
C Requires minimum grade of C.

Enrollment is limited to students with a major in Computer Engineering or Electrical Engineering.

Students with the terminated from VSE major attribute may not enroll.

Schedule Type: Lecture, Recitation

Grading:
This course is graded on the Undergraduate Regular scale.

ECE 334: Linear Electronics Lab I. 1 credit.
Lab associated with ECE 333. Offered by Electrical & Comp. Engineering. Limited to two attempts.

Registration Restrictions:
Required Prerequisites: (PHYS 261C or 265C) and (ECE 333C*).
* May be taken concurrently.
C Requires minimum grade of C.

Enrollment is limited to students with a major in Computer Engineering or Electrical Engineering.

Students with the terminated from VSE major attribute may not enroll.

Schedule Type: Laboratory

Grading:
This course is graded on the Undergraduate Regular scale.

ECE 350: Embedded Systems and Hardware Interfaces. 3 credits.
This course introduces embedded systems design through project-based activities. The platform runs on Linux and students design their own IoT (Internet of Things) system as well as demonstrate dashboards with cloud-based data. Hardware interfaces and several types of sensors and actuators are incorporated as part of the projects. Students also learn how to simulate and test signal-conditioning circuits, eventually integrating those as part of their projects. Offered by Electrical & Comp. Engineering. Limited to two attempts.

Registration Restrictions:
Required Prerequisites: (CS 222C or 262C) and (ECE 280C or 285C) and (ECE 301C or (ECE 331C and 332C)).
C Requires minimum grade of C.

Enrollment is limited to students with a major in Computer Engineering, Computer Science or Electrical Engineering.

Students with the terminated from VSE major attribute may not enroll.

Schedule Type: Lecture

Grading:
This course is graded on the Undergraduate Regular scale.

ECE 370: Robot Design. 3 credits.
Introduces the concept of robot design and implementation. The focus will be on electrical design philosophies, mechanical design philosophies, and controller design. Assignments are heavily based on the design, simulation and implementation of real-world robotic applications. Assessments are primarily in project form and make use of 3D printing and other manufacturing techniques. Offered by Electrical & Comp. Engineering. Limited to two attempts.

Registration Restrictions:
Required Prerequisites: ECE 220C and CS 222C and (ECE 280C, 285C or BENG 380C) and (ECE 301C or (ECE 331C and 332C)).
C Requires minimum grade of C.

Enrollment is limited to students with a major in Computer Engineering or Electrical Engineering.

Students with the terminated from VSE major attribute may not enroll.

Schedule Type: Lecture

Grading:
This course is graded on the Undergraduate Regular scale.

ECE 390: Engineering Design and Fabrication. 3 credits.
Project based course where students will design projects containing analog and digital components as well as mechanical parts. Students will simulate, build, and test their projects. Offered by Electrical & Comp. Engineering. Limited to two attempts. Equivalent to BENG 390.

Registration Restrictions:
Required Prerequisites: (BENG 380C, ECE 280C or 285C).
C Requires minimum grade of C.

Students with the terminated from VSE major attribute may not enroll.

Schedule Type: Lecture

Grading:
This course is graded on the Undergraduate Regular scale.

ECE 392: Engineering Design Studio. 1 credit.
Identification and feasibility study of advanced engineering problems. Application of math, physics and engineering methods to challenging projects. Preliminary design, modeling, simulation and prototyping of projects. This course should be taken the semester preceding ECE/BENG 492. Offered by Electrical & Comp. Engineering. May be repeated within the degree for a maximum 2 credits.

Recommended Prerequisite: 75 hours of completed coursework applicable to the EE, CpE, or BIOE degree and permission of instructor.

Registration Restrictions:
Students with the terminated from VSE major attribute may not enroll.

Schedule Type: Lecture

Grading:
This course is graded on the Undergraduate Regular scale.

400 Level Courses

ECE 410: Applications of Discrete-Time Signal Processing. 3 credits.
Introduces fundamental concepts of digital signal processing. Emphasis on the theoretical and numerical tools used for frequency domain analysis of sampled signals. Topics covered include sampling, the discrete Fourier transform, fast transform algorithms, spectral analysis, and digital filtering. Offered by Electrical & Comp. Engineering. Limited to two attempts.

Registration Restrictions:


**Required Prerequisites:** ECE 220<sup>C</sup> and STAT 346<sup>C</sup>.  
<sup>C</sup> Requires minimum grade of C.

Enrollment is limited to students with a major in Computer Engineering or Electrical Engineering.

Students with the terminated from VSE major attribute may **not** enroll.

**Schedule Type:** Lecture

**Grading:**  
This course is graded on the Undergraduate Regular scale.

**ECE 415:** Power System Analysis. 3 credits.  
Introduces the concepts of power system analysis commonly encountered in the study and practice of electric power engineering. Emphasis is on topics of modern power system modeling, operation and protection, power flow studies, symmetrical and unsymmetrical fault calculations, economic dispatch, and power system stability. Students will use interactive power system simulation tools to complete homework assignments and a comprehensive term project. Offered by Electrical & Comp. Engineering. Limited to two attempts.

**Registration Restrictions:**  
**Required Prerequisite:** ECE 286<sup>C</sup>.  
<sup>C</sup> Requires minimum grade of C.

Enrollment is limited to students with a major in Computer Engineering or Electrical Engineering.

**Schedule Type:** Lecture

**Grading:**  
This course is graded on the Undergraduate Regular scale.

**ECE 421:** Classical Systems and Control Theory. 3 credits.  
Introduces analysis and synthesis of feedback systems, including functional description of linear and nonlinear systems, block diagrams and signal flow graphs, state-space representation of dynamical systems, frequency response methods, Root Locus, Nyquist, and other stability criteria; performance indices and error criteria; and applications to mechanical and electromechanical control systems. Offered by Electrical & Comp. Engineering. Limited to two attempts. Equivalent to SYST 421.

**Registration Restrictions:**  
**Required Prerequisite:** (ECE 220<sup>C</sup>).  
<sup>C</sup> Requires minimum grade of C.

Enrollment is limited to students with a major in Computer Engineering or Electrical Engineering.

Students with the terminated from VSE major attribute may **not** enroll.

**Schedule Type:** Lecture

**Grading:**  
This course is graded on the Undergraduate Regular scale.

**ECE 422:** Digital Control Systems. 3 credits.  
Introduces analysis, design of digital control systems, Z-transform, discrete linear systems, frequency domain, and state variable techniques. Discusses use of microcomputers in control systems. Offered by Electrical & Comp. Engineering. Limited to two attempts.

**Registration Restrictions:**  
**Required Prerequisite:** ECE 421<sup>C</sup>.  
<sup>C</sup> Requires minimum grade of C.

Enrollment is limited to students with a major in Computer Engineering or Electrical Engineering.

Students with the terminated from VSE major attribute may **not** enroll.

**Schedule Type:** Lecture

**Grading:**  
This course is graded on the Undergraduate Regular scale.

**ECE 424:** Modern Control Systems Design. 3 credits.  
Introduces state-space modeling, analysis, and control of feedback systems using time-domain methods rather than frequency-domain methods, and the connections between the two. In particular the course will emphasize the connections between physical real-world systems and mathematical control problems. Specific topics include modeling and realization theory, stability analysis and control of linear systems, controllability and observability, introductions to digital control, linear optimal control, and nonlinear control. Students will demonstrate their obtained knowledge through the design of a complete control system including choices of sensors/actuators in addition to the controller. The course will include extensive use of Matlab and Simulink. Offered by Electrical & Comp. Engineering. Limited to two attempts.

**Registration Restrictions:**  
**Required Prerequisites:** ECE 421<sup>C</sup> or ME 432<sup>C</sup>.  
<sup>C</sup> Requires minimum grade of C.

Enrollment is limited to students with a major in Bioengineering, Computer Engineering, Electrical Engineering, Mechanical Engineering or Systems Engineering.

**Schedule Type:** Lecture

**Grading:**  
This course is graded on the Undergraduate Regular scale.

**ECE 425:** Secure RF Communications. 3 credits.  
Reviews current systems of Radio Frequency (RF) communications and related cyber security issues. This course focuses on security issues in wireless networks, such as cellular networks, wireless LANs, Bluetooth, NFC, RFID, mobile security, anti-jamming communication, and physical layer security. The course will first present an overview of wireless networks, then focus on attacks and discuss proposed solutions and their limitations. Offered by Electrical & Comp. Engineering. Limited to two attempts.

**Registration Restrictions:**  
**Required Prerequisites:** (CS 222<sup>C</sup> or 262<sup>C</sup>) and (ECE 465<sup>C</sup>, CYSE 230<sup>C</sup> or CS 455<sup>C</sup>).  
<sup>C</sup> Requires minimum grade of C.

Enrollment is limited to students with a major in Computer Engineering, Computer Science, Cyber Security Engineering or Electrical Engineering.

**Schedule Type:** Lecture

**Grading:**  
This course is graded on the Undergraduate Regular scale.
ECE 429: Control Systems Lab. 1 credit.
Laboratory experiments for topics in control systems analysis, design, and implementation with emphasis on using microcomputers. Offered by Electrical & Comp. Engineering. Limited to two attempts.

Registration Restrictions:
Required Prerequisite: ECE 421 C.
C Requires minimum grade of C.

Enrollment is limited to students with a major in Computer Engineering or Electrical Engineering.

Students with the terminated from VSE major attribute may not enroll.

Schedule Type: Laboratory

Grading:
This course is graded on the Undergraduate Regular scale.

ECE 430: Principles of Semiconductor Devices. 3 credits.
Introduces solid-state physics and its application to semiconductors and semiconductor devices. Topics include band theory, doping, p-n junctions, diffusion theory, low-frequency circuits, devices including bipolar transistor, MOSFET, CMOS, and photo transistors. Offered by Electrical & Comp. Engineering. Limited to two attempts.

Registration Restrictions:
Required Prerequisites: ECE 333 C and 305 C and (MATH 214 C or 216 C).
C Requires minimum grade of C.

Enrollment is limited to students with a major in Computer Engineering or Electrical Engineering.

Students with the terminated from VSE major attribute may not enroll.

Schedule Type: Lecture

Grading:
This course is graded on the Undergraduate Regular scale.

ECE 431: Digital Circuit Design. 3 credits.
Analysis and design of CMOS digital integrated circuits. Topics include: MOSFET transistor design equations for "hand" analysis and models for computer (SPICE) simulations; static and dynamic characteristics of inverters; fabrication, mask layout, and simulation; static and dynamic CMOS, pass transistor and transmission gate integrated circuit styles; combinational and sequential integrated circuits; semiconductor memory cell types and memory cell arrays. Offered by Electrical & Comp. Engineering. Limited to two attempts.

Registration Restrictions:
Required Prerequisites: ECE 331 C and 333 C.
C Requires minimum grade of C.

Enrollment is limited to students with a major in Computer Engineering or Electrical Engineering.

Students with the terminated from VSE major attribute may not enroll.

Schedule Type: Lecture

Grading:
This course is graded on the Undergraduate Regular scale.

ECE 432: Control Systems II Laboratory. 1 credit.
Second laboratory course in control systems design with emphasis on implementation with emphasis on using microcomputers. Offered by Electrical & Comp. Engineering. Limited to two attempts.

Registration Restrictions:
Required Prerequisites: ECE 286 C and 333 C.
C Requires minimum grade of C.

Enrollment is limited to students with a major in Computer Engineering or Electrical Engineering.

Students with the terminated from VSE major attribute may not enroll.

Schedule Type: Laboratory

Grading:
This course is graded on the Undergraduate Regular scale.

ECE 433: Linear Electronics II. 3 credits.
Second course in linear electronics. Covers differential amplifiers, feedback circuits, power amplifiers, feedback amplifier frequency response, analog integrated circuits, operational amplifier systems, oscillators, wide band and microwave amplifiers, and computer-aided design. Offered by Electrical & Comp. Engineering. Limited to two attempts.

Registration Restrictions:
Required Prerequisites: ECE 286 C and 333 C.
C Requires minimum grade of C.

Enrollment is limited to students with a major in Computer Engineering or Electrical Engineering.

Students with the terminated from VSE major attribute may not enroll.

Schedule Type: Lecture

Grading:
This course is graded on the Undergraduate Regular scale.

ECE 434: Principles of Solid State Devices Laboratory. 1 credit.
Laboratory experiments for topics covered in ECE 433. Offered by Electrical & Comp. Engineering. Limited to two attempts.

Registration Restrictions:
Required Prerequisites: ECE 286 C and 333 C.
C Requires minimum grade of C.

Enrollment is limited to students with a major in Computer Engineering or Electrical Engineering.

Students with the terminated from VSE major attribute may not enroll.

Schedule Type: Laboratory

Grading:
This course is graded on the Undergraduate Regular scale.

ECE 435: Digital Circuit Design Laboratory. 1 credit.
Lab experiments for topics covered in ECE 431. Offered by Electrical & Comp. Engineering. Limited to two attempts.

Recommended Corequisite: ECE 431.

Registration Restrictions:
Required Prerequisite: ECE 334 C.
C Requires minimum grade of C.

Enrollment is limited to students with a major in Computer Engineering or Electrical Engineering.

Students with the terminated from VSE major attribute may not enroll.

Schedule Type: Laboratory

Grading:
This course is graded on the Undergraduate Regular scale.

ECE 436: Computer Organization. 3 credits.
General overview of operating a digital computer. Topics include computer arithmetic, arithmetic unit, hardwired and microprogrammed control, memory, register-to-register, input-output operations, and behavioral modeling of computer organization using VHDL. Offered by Electrical & Comp. Engineering. Limited to two attempts. Equivalent to INFS 515.
Registration Restrictions:
Required Prerequisites: (ECE 331\(^C\) and 332\(^C\)) and (CS 262\(^C\) or 222\(^C\)).
\(^C\) Requires minimum grade of C.

Enrollment is limited to students with a major in Computer Engineering or Electrical Engineering.

Students with the terminated from VSE major attribute may not enroll.

Schedule Type: Laboratory, Lecture

Grading:
This course is graded on the Undergraduate Regular scale.

**ECE 446: Device Driver Development.** 3 credits.
Addresses device driver and kernel level software programming and development. The C programming language and program trouble shooting are reviewed. Basics of device driver software, Character driver operations and data structures, concurrency and race conditions, kernel timers, memory allocation, communications with hardware, interrupt handling, kernel data types, memory mapping and Direct Memory Access concepts are explored. Offered by Electrical & Comp. Engineering. Limited to two attempts.

Registration Restrictions:
Required Prerequisites: ECE 445\(^C\) or CS 465\(^C\).
\(^C\) Requires minimum grade of C.

Enrollment is limited to students with a major in Computer Engineering, Computer Science or Electrical Engineering.

Students with the terminated from VSE major attribute may not enroll.

Schedule Type: Lecture

Grading:
This course is graded on the Undergraduate Regular scale.

**ECE 447: Single-Chip Microcomputers.** 4 credits.
Explores designing with single-chip microcomputers and microcomputer interfacing. Topics include role of microcomputers compared with microprocessors and other computers, microcomputer architecture and organization, real-time control issues, assembly language programming for control, design of control software, input/output methods, design tools, and available single-chip microcomputers. Students select project and design, and construct system including single-chip microcomputer and ancillary hardware to implement control system. Notes: This course is highly recommended for ECE 492/493 students interested in using microcontroller technology in their senior design projects. It should be taken before ECE 493. Offered by Electrical & Comp. Engineering. Limited to two attempts.

Registration Restrictions:
Required Prerequisites: ECE 445\(^C\) and (CS 222\(^C\) or 367\(^C\)).
\(^C\) Requires minimum grade of C.

Enrollment is limited to students with a major in Computer Engineering or Electrical Engineering.

Students with the terminated from VSE major attribute may not enroll.

Schedule Type: Laboratory, Lecture

Grading:
This course is graded on the Undergraduate Regular scale.

**ECE 448: FPGA and ASIC Design with VHDL.** 4 credits.
Practical introduction to modeling of digital systems with VHDL for logic synthesis. Overview and comparative analysis of design flow and tools for FPGAs and standard-cell ASICs. Discusses verification of digital systems using testbenches, prototyping boards and modern testing equipment, and illustrates VHDL-based design methodology with multiple examples from communications, control, DSP and cryptography. Laboratory experiments create link between simulation and actual hardware implementation based on FPGA boards. Offered by Electrical & Comp. Engineering. Limited to two attempts.

Registration Restrictions:
Required Prerequisite: (ECE 445\(^C\)).
\(^C\) Requires minimum grade of C.

Enrollment is limited to students with a major in Computer Engineering or Electrical Engineering.

Students with the terminated from VSE major attribute may not enroll.

Schedule Type: Laboratory, Lecture

Grading:
This course is graded on the Undergraduate Regular scale.

**ECE 450: Mobile Robots.** 3 credits.
Introduces mobile robotic systems. Topics include overview of power systems, motors, behavior-based programming, sensors, and sensor integration. Design projects conceived, developed, implemented, and presented. Offered by Electrical & Comp. Engineering. Limited to two attempts.

Registration Restrictions:
Required Prerequisite: ECE 350\(^C\).
\(^C\) Requires minimum grade of C.

Enrollment is limited to students with a major in Computer Engineering or Electrical Engineering.

Students with the terminated from VSE major attribute may not enroll.

Schedule Type: Lecture

Grading:
This course is graded on the Undergraduate Regular scale.

**ECE 460: Communication and Information Theory.** 3 credits.
Introduction to analog and digital communications. Topics include review of important concepts from signals and systems theory and probability theory; Gaussian processes and power spectral density; digital transmission through additive white Gaussian channels; sampling and pulse code modulation; analog signal transmission and reception using amplitude, frequency and phase modulation; and effects of noise on analog communication systems. Offered by Electrical & Comp. Engineering. Limited to two attempts.

Registration Restrictions:
Required Prerequisites: (ECE 220\(^C\) and STAT 346\(^C\)).
\(^C\) Requires minimum grade of C.

Enrollment is limited to students with a major in Computer Engineering or Electrical Engineering.

Students with the terminated from VSE major attribute may not enroll.
Schedule Type: Lecture

Grading: This course is graded on the Undergraduate Regular scale.

ECE 461: Communication Engineering Laboratory. 1 credit.
Lab experiments in analog and digital communication areas covered in ECE 460. Offered by Electrical & Comp. Engineering. Limited to two attempts.

Registration Restrictions:
Required Prerequisites: ECE 334\(^C\) and 460\(^C\).
\(^C\) Requires minimum grade of C.

Enrollment is limited to students with a major in Computer Engineering or Electrical Engineering.

Students with the terminated from VSE major attribute may not enroll.

Schedule Type: Laboratory

Grading: This course is graded on the Undergraduate Regular scale.

ECE 462: Data and Computer Communications. 3 credits.
Introduces modern data communications and computer networks. Topics include point-to-point communication links and transmission of digital information, modems, and codecs; packet switching, multiplexing, and concentrator design; multiaccess and broadcasting; local area and wide area networks; architectures and protocols for computer networks; OSI reference model and seven layers; physical interfaces and protocols; and data link control layer and network layer. Provides examples of data networks. Offered by Electrical & Comp. Engineering. Limited to two attempts.

Registration Restrictions:
Required Prerequisites: (STAT 344\(^C\) or 346\(^C\)) and (ECE 220\(^C\)) and (ECE 331\(^C\) or 301\(^C\)).
\(^C\) Requires minimum grade of C.

Enrollment is limited to students with a major in Computer Engineering or Electrical Engineering.

Students with the terminated from VSE major attribute may not enroll.

Schedule Type: Lecture

Grading: This course is graded on the Undergraduate Regular scale.

ECE 463: Digital Communications Systems. 3 credits.
Introduces digital transmission systems. Topics include quantization, digital coding of analog waveforms, PCM, DPCM, DM, baseband transmission, digital modulation schemes, ASK, FSK, PSK, MSK, QAM, pulse shaping, intersymbol interference, partial response, voice-band and wideband modems, digital cable systems, regenerative repeaters, clock recovery and jitter, multipath fading, digital radio design, optimal receiver design, MAP receiver, and probability of error. Offered by Electrical & Comp. Engineering. Limited to two attempts.

Registration Restrictions:
Required Prerequisite: ECE 460\(^C\).
\(^C\) Requires minimum grade of C.

Enrollment is limited to students with a major in Computer Engineering or Electrical Engineering.

Students with the terminated from VSE major attribute may not enroll.
Required Prerequisites: (CS 112\textsuperscript{C}) and (ECE 280\textsuperscript{C}, 285\textsuperscript{C} or BENG 380\textsuperscript{C}) and (ECE 301\textsuperscript{C} or (ECE 331\textsuperscript{C} and 331\textsuperscript{I})).

\textsuperscript{C} Requires minimum grade of C.

Enrollment is limited to students with a major in Computer Engineering or Electrical Engineering.

Students with the terminated from VSE major attribute may not enroll.

Schedule Type: Lecture

Grading:
This course is graded on the Undergraduate Regular scale.

\textbf{ECE 476: Cryptography Fundamentals.} 3 credits.
Covers basic concepts of cryptology, types of cryptosystems, security services, and key management. Gradually introduces mathematical background required for understanding cryptography. Discusses modern secret-key stream and block ciphers, modes of operation, public key cryptosystems (RSA, elliptic curve, and post-quantum cryptography), hash functions, message authentication codes, and digital signature schemes. Covers key cracking machines, side-channel attacks, and fault attacks. Discusses popular cryptographic modules, such as True Random Number Generators and Physical Unclonable Functions, used for key generation and device authentication. Introduces educational and public domain software implementing modern cryptographic algorithms. Offered by Electrical & Comp. Engineering. Limited to two attempts.

Registration Restrictions:
Required Prerequisites: CYSE 330\textsuperscript{C}, ECE 465\textsuperscript{C} or CS 455\textsuperscript{C}.
\textsuperscript{C} Requires minimum grade of C.

Enrollment is limited to students with a major in Computer Engineering, Computer Science, Cyber Security Engineering or Electrical Engineering.

Schedule Type: Lecture

Grading:
This course is graded on the Undergraduate Regular scale.

\textbf{ECE 492: Senior Advanced Design Project I.} 1 credit.
Conception of senior design project and determination of feasibility of proposed project. Work includes developing preliminary design and implementation plan. Students planning to use microcontroller technology in their projects should enroll in ECE 447 before taking ECE 493. Note: Registration is allowed only after completion of at least 90 credits applicable to the electrical engineering or computer engineering program. Offered by Electrical & Comp. Engineering. Limited to two attempts.

Mason Core: Capstone, Synthesis

Specialized Designation: Impact Associated.

Registration Restrictions:
Required Prerequisites: (((COMM 100\textsuperscript{C} or 101\textsuperscript{C}) and (ENGH 302\textsuperscript{C} or ENGL 302\textsuperscript{I})) or HNRS 353\textsuperscript{C}) and ECE 220\textsuperscript{C} and 286\textsuperscript{C}.
\textsuperscript{C} Requires minimum grade of C.

Enrollment is limited to students with a major in Computer Engineering or Electrical Engineering.

Students with the terminated from VSE major attribute may not enroll.

Schedule Type: Lecture

Grading:
This course is graded on the Undergraduate Regular scale.

\textbf{ECE 493: RS: Senior Advanced Design Project II.} 2 credits.
Implementation of project for which preliminary work was done in ECE 492. Project includes designing and constructing hardware, writing required software, conducting experiments or studies, and testing complete system. Requires oral and written reports during project and at completion. Notes: Students planning to use microcontroller technology in their projects should enroll in ECE 447 before taking ECE 493. If meeting time conflicts with other courses, come directly to the ECE department for registration. Offered by Electrical & Comp. Engineering. Limited to two attempts.

Mason Core: Capstone, Synthesis

Specialized Designation: Research/Scholarship Intensive

Registration Restrictions:
Required Prerequisite: ECE 492\textsuperscript{C}.
\textsuperscript{C} Requires minimum grade of C.

Enrollment is limited to students with a major in Computer Engineering or Electrical Engineering.

Students with the terminated from VSE major attribute may not enroll.

Schedule Type: Lecture

Grading:
This course is graded on the Undergraduate Regular scale.

\textbf{ECE 498: Independent Study in Electrical and Computer Engineering.} 1-3 credits.
Directed self-study of special topics of current interest in ECE. Topic must be arranged with an instructor and approved by department chair before registering. Offered by Electrical & Comp. Engineering. May be repeated within the term for a maximum 3 credits.

Registration Restrictions:
Students with the terminated from VSE major attribute may not enroll.

**Schedule Type:** Independent Study

**Grading:**
This course is graded on the Undergraduate Regular scale.

**ECE 499: Special Topics in Electrical and Computer Engineering.** 0-4 credits. Topics of special interest to undergraduates. Notes: May be repeated if topics substantially different. Offered by Electrical & Comp. Engineering. May be repeated within the term for a maximum 11 credits.

**Registration Restrictions:**
Students with a class of Freshman or Sophomore may not enroll.

Enrollment is limited to students with a major in Computer Engineering or Electrical Engineering.

Students with the terminated from VSE major attribute may not enroll.

**Schedule Type:** Lecture

**Grading:**
This course is graded on the Undergraduate Regular scale.

### 500 Level Courses

**ECE 505: Hardware Security.** 3 credits.
Covers security and trust in hardware, in relation to both ASIC and FPGA technologies. Topics include ASIC and FPGA manufacturing supply chain, threats and security challenges such as IP piracy, overproduction, counterfeiting, Trojan insertion, reverse engineering, etc. Discusses various attacks against hardware, including physical, invasive, destructive, logical, and side channel attacks. Spans various hardware defense solutions including metering, locking, obfuscation, watermarking, access control, Trojan testing, IP core isolation, and the theory and practice of physical unclonable functions. Offered by Electrical & Comp. Engineering. May not be repeated for credit.

**Recommended Prerequisite:** (ECE 301 or ECE 331) and (CS 211 or CS 222) or permission of instructor

**Registration Restrictions:**
Enrollment limited to students with a class of Advanced to Candidacy, Graduate, Non-Degree or Senior Plus.

Students in a Non-Degree Undergraduate degree may not enroll.

**Schedule Type:** Lecture

**Grading:**
This course is graded on the Graduate Regular scale.

**ECE 508: Internet of Things.** 3 credits.
Introduces the principles, technologies, challenges, and required expertise needed for building the Internet of Things (IoT) solutions. It provides a big picture of what is involved in IoT. Topics covered in this course include analog and digital sensing, interfacing sensors with microcontrollers, digital communication protocols, microcontroller choices and capabilities, gateways, fog computing, networking, cloud computing, need and challenges for cryptography and compression, security issues, and low power/energy challenges. The listed topics are covered only to the extent required to understand the challenges and to the point that the role of a given topic in IoT solutions is comprehended. While briefly covering the technologies involved at the various hierarchal levels of IoT solutions, the course introduces other courses at GMU where students could build further expertise in the topics of interest. Offered by Electrical & Comp. Engineering. May not be repeated for credit.

**Recommended Prerequisite:** ECE 350 or (ECE 301 or ECE 331) and CS 222) or equivalent

**Registration Restrictions:**
Enrollment limited to students with a class of Advanced to Candidacy, Graduate, Non-Degree or Senior Plus.

Students in a Non-Degree Undergraduate degree may not enroll.

**Schedule Type:** Lecture

**Grading:**
This course is graded on the Graduate Regular scale.

**ECE 510: Real-Time Concepts.** 3 credits.
Presents design methodology, principles and practice for the development of real-time embedded systems and their application to robotics, mechatronics, sensing, signal processing, and control. Topics include system decomposition, multi-tasking, task communication and synchronization, system modeling, time analysis, principles of filter and controller implementation, 'fuzzy' engineering, and multi-microcontroller systems. Offered by Electrical & Comp. Engineering. May not be repeated for credit.

**Recommended Prerequisite:** ECE 450 or ECE 447 or permission of instructor.

**Registration Restrictions:**
Enrollment limited to students with a class of Advanced to Candidacy, Graduate, Non-Degree or Senior Plus.

Enrollment is limited to Graduate, Non-Degree or Undergraduate level students.
Students in a Non-Degree Undergraduate degree may not enroll.

Enrollment limited to students in the College of Science, Schar School of Policy and Gov or Volgenau School of Engineering colleges.

**Schedule Type:** Lecture

**Grading:**
This course is graded on the Graduate Regular scale.

**ECE 511: Computer Architecture.** 3 credits.
Introduces the concepts of a processor microarchitecture, from a pipelined processing unit, through a superscalar, to a multicore multithreaded computing system. Topics include instruction set architecture, single cycle processor, MIPS pipeline processor, precise state, parallel processing, superscalars, memory and cache organization, branch prediction, multicore processors, memory consistency, multi- and many-core cache coherence, and heterogeneous computing. Offered by Electrical & Comp. Engineering. May not be repeated for credit.

**Recommended Prerequisite:** ECE 445 or CS 465 or permission of instructor

**Registration Restrictions:**
Enrollment limited to students with a class of Advanced to Candidacy, Graduate, Non-Degree or Senior Plus.

Enrollment is limited to Graduate, Non-Degree or Undergraduate level students.

Students in a Non-Degree Undergraduate degree may not enroll.

Enrollment limited to students in the College of Science, Schar School of Policy and Gov or Volgenau School of Engineering colleges.

**Schedule Type:** Lecture

**Grading:**
This course is graded on the Graduate Regular scale.

**ECE 513: Applied Electromagnetic Theory.** 3 credits.
Maxwell's Equations, electromagnetic wave propagation, wave guides, transmission lines, radiation, and antennas. Offered by Electrical & Comp. Engineering. May not be repeated for credit.

**Recommended Prerequisite:** ECE 305 or equivalent.

**Registration Restrictions:**
Enrollment limited to students with a class of Advanced to Candidacy, Graduate, Non-Degree or Senior Plus.

Enrollment is limited to Graduate, Non-Degree or Undergraduate level students.

Students in a Non-Degree Undergraduate degree may not enroll.

Enrollment limited to students in the College of Science, Schar School of Policy and Gov or Volgenau School of Engineering colleges.

**Schedule Type:** Lecture

**Grading:**
This course is graded on the Graduate Regular scale.

**ECE 521: Linear Systems and Control.** 3 credits.
Introduces linear systems theory and design of linear feedback control systems. Reviews linear algebra, state variables, state-space description of dynamic systems, analysis of continuous-time and discrete-time linear systems, controllability and observability of linear systems, and stability theory. Offered by Electrical & Comp. Engineering. May not be repeated for credit.

**Recommended Prerequisite:** ECE 421

**Registration Restrictions:**
Enrollment limited to students with a class of Advanced to Candidacy, Graduate, Non-Degree or Senior Plus.

Enrollment is limited to Graduate, Non-Degree or Undergraduate level students.

Students in a Non-Degree Undergraduate degree may not enroll.

Enrollment limited to students in the College of Science, Schar School of Policy and Gov or Volgenau School of Engineering colleges.

**Schedule Type:** Lecture

**Grading:**
This course is graded on the Graduate Regular scale.

**ECE 526: Neural Engineering.** 3 credits.
Provides an overview of topics in Neural Engineering. Topics covered range from sensory and motor prosthetic devices, stimulation of biological tissue, bioelectrodes and characterization techniques, brain-machine interfaces, and engineered devices to ameliorate neurodisorders. Prior knowledge in electrical or computer engineering disciplines required. Offered by Electrical & Comp. Engineering. May not be repeated for credit. Equivalent to BENG 525.

**Registration Restrictions:**
Enrollment limited to students with a class of Advanced to Candidacy, Graduate, Non-Degree or Senior Plus.

Enrollment is limited to Graduate, Non-Degree or Undergraduate level students.

Students in a Non-Degree Undergraduate degree may not enroll.
enrollment limited to students in the College of Science, Schar School of Policy and Gov or Volgenau School of Engineering colleges.

Schedule Type: Lecture

Grading:
This course is graded on the Graduate Regular scale.

ECE 527: Learning From Data. 3 credits.
This is an introductory course in machine learning and pattern recognition that covers basic theory, algorithms, and applications. Machine learning is the science of getting computers to act without being explicitly programmed. This course balances theory and practice, and covers the mathematical as well as the heuristic aspects. It provides a broad introduction to machine learning and pattern recognition. Topics include: (i) supervised learning (parametric/non-parametric algorithms, support vector machines, kernels, neural networks), (ii) unsupervised learning (clustering, dimensionality reduction, recommender systems, autoencoders), (iii) learning theory (bias/variance tradeoffs, VC theory, generalization), (iv) ensemble methods (boosting and bagging, random forests), (v) deep learning (deep belief networks, convolutional neural networks, deep autoencoders). The course will draw from numerous case studies and applications. Offered by Electrical & Comp. Engineering. May not be repeated for credit. Equivalent to DAEN 527.

Recommended Prerequisite: (MATH 203 and STAT 346) or equivalent

Registration Restrictions:
Enrollment limited to students with a class of Advanced to Candidacy, Graduate, Non-Degree or Senior Plus.

Students in a Non-Degree Undergraduate degree may not enroll.

Schedule Type: Lecture

Grading:
This course is graded on the Graduate Regular scale.

ECE 528: Introduction to Random Processes in Electrical and Computer Engineering. 3 credits.
Probability and random processes are fundamental to communications, control, signal processing, and computer networks. Provides basic theory and important applications. Topics include probability concepts and axioms; stationarity and ergodicity; random variables and their functions; vectors; expectation and variance; conditional expectation; moment-generating and characteristic functions; random processes such as white noise and Gaussian; autocorrelation and power spectral density; linear filtering of random processes, and basic ideas of estimation and detection. Offered by Electrical & Comp. Engineering. May not be repeated for credit.

Recommended Prerequisite: ECE 220 and STAT 346, or permission of instructor.

Registration Restrictions:
Enrollment limited to students with a class of Advanced to Candidacy, Graduate, Non-Degree or Senior Plus.

Enrollment is limited to Graduate, Non-Degree or Undergraduate level students.

Students in a Non-Degree Undergraduate degree may not enroll.

Schedule Type: Lecture

Grading:
This course is graded on the Graduate Regular scale.

ECE 531: Introduction to Wireless Communications and Networks. 3 credits.
This course presents the fundamentals of modern wireless communications and wireless networking at the first-year graduate level. Topics include wireless signal design, channel characterization, receiver structure, multiple access technologies, cellular concepts, capacity enlargement, mobility management, and wireless/wireless interworking. Offered by Electrical & Comp. Engineering. May not be repeated for credit.

Recommended Prerequisite: ECE 460 or equivalent

Registration Restrictions:
Enrollment limited to students with a class of Advanced to Candidacy, Graduate, Non-Degree or Senior Plus.

Enrollment is limited to Graduate, Non-Degree or Undergraduate level students.

Students in a Non-Degree Undergraduate degree may not enroll.

Schedule Type: Lecture

Grading:
This course is graded on the Graduate Regular scale.

ECE 535: Digital Signal Processing. 3 credits.
This course presents the fundamentals of digital signals and systems. Covers sampling and quantization, z-transform and discrete Fourier transform, digital filter realizations, design techniques for recursive and non-recursive filters, fast Fourier transform algorithms, and spectral analysis. Additional topics may include adaptive filtering, homomorphic digital signal processing, digital interpolation and decimation. Offered by Electrical & Comp. Engineering. May not be repeated for credit.
**Recommended Prerequisite:** ECE 460 or permission of instructor

**Registration Restrictions:**
Enrollment limited to students with a class of Advanced to Candidacy, Graduate, Non-Degree or Senior Plus.

Enrollment is limited to Graduate, Non-Degree or Undergraduate level students.

Students in a Non-Degree Undergraduate degree may not enroll.

Enrollment limited to students in the College of Science, Schar School of Policy and Gov or Volgenau School of Engineering colleges.

**Schedule Type:** Lecture

**Grading:**
This course is graded on the Graduate Regular scale.

**ECE 537: Introduction to Digital Image Processing (DIP).** 3 credits.
First course in digital-image processing; introduces scanning systems, focal plane array detectors, data acquisition methods, display hardware, image preprocessing algorithms, feature extraction, and basic image processing methods. Semester-long image processing project includes utilizing modern image processing system prototyping software. Offered by Electrical & Comp. Engineering. May not be repeated for credit.

**Registration Restrictions:**
Enrollment limited to students with a class of Advanced to Candidacy, Graduate, Non-Degree or Senior Plus.

Enrollment is limited to Graduate, Non-Degree or Undergraduate level students.

Students in a Non-Degree Undergraduate degree may not enroll.

Enrollment limited to students in the College of Science, Schar School of Policy and Gov or Volgenau School of Engineering colleges.

**Schedule Type:** Lecture

**Grading:**
This course is graded on the Graduate Regular scale.

**ECE 538: Medical Imaging.** 3 credits.
Provides an introduction to the physical, mathematical and engineering foundations of modern medical imaging systems, medical image processing and analysis methods. In addition, this course introduces engineering students to clinical applications of medical imaging. The emphasis is on diagnostic ultrasound and magnetic resonance imaging methods, although several other modalities are covered. The course also provides an overview of recent developments and future trends in the field of medical imaging, discusses some of the challenges and controversies, and involves hands-on experience applying the methods learned in class to real-world problems. Offered by Electrical & Comp. Engineering. May not be repeated for credit. Equivalent to BENG 538.

**Recommended Prerequisite:** ECE 220 or equivalent

**Registration Restrictions:**
Enrollment limited to students with a class of Advanced to Candidacy, Graduate, Non-Degree or Senior Plus.

Enrollment is limited to Graduate, Non-Degree or Undergraduate level students.

Students in a Non-Degree Undergraduate degree may not enroll.

Enrollment limited to students in the College of Science, Schar School of Policy and Gov or Volgenau School of Engineering colleges.

**Schedule Type:** Lecture

**Grading:**
This course is graded on the Graduate Regular scale.

**ECE 542: Computer Network Architectures and Protocols.** 3 credits.
Introduction to architectures and protocols of computer networks and concept of packet switching. Topics include ISO standard layer model, physical interfaces and protocols, data link control, multiaccess techniques, packet switching, routing and flow control, network topology, data communication subsystems, error control coding, local area network, satellite packet broadcasting, packet radio, interconnection of packet-switching networks, network security and privacy, and various examples of computer networks. Offered by Electrical & Comp. Engineering. May not be repeated for credit.

**Recommended Prerequisite:** STAT 344 or equivalent.

**Registration Restrictions:**
Enrollment limited to students with a class of Advanced to Candidacy, Graduate, Non-Degree or Senior Plus.

Enrollment is limited to Graduate, Non-Degree or Undergraduate level students.

Students in a Non-Degree Undergraduate degree may not enroll.

Enrollment limited to students in the College of Science, Schar School of Policy and Gov or Volgenau School of Engineering colleges.

**Schedule Type:** Lecture

**Grading:**
This course is graded on the Graduate Regular scale.

**ECE 545: Digital System Design with VHDL.** 3 credits.
Introduction to the design of complex digital systems using hardware description languages. Emphasizes the design methodology based on the partitioning of a digital system into a datapath and control unit. Introduces a clear sequence of steps leading from specification to synthesizable, register transfer level (RTL), and fully verified HDL code. Covers VHDL for digital circuit design, including dataflow, structural, and behavioral coding styles. Introduces and illustrates the concepts of VHDL simulation, verification, synthesis, mapping, placing, routing, timing analysis and performance optimization. Requires semester long project devoted to the design of a complex digital system using VHDL as a hardware description language and FPGA as an implementation platform. Offered by Electrical & Comp. Engineering. May not be repeated for credit.

**Registration Restrictions:**
Enrollment limited to students with a class of Advanced to Candidacy, Graduate, Non-Degree or Senior Plus.

Enrollment is limited to Graduate, Non-Degree or Undergraduate level students.

Students in a Non-Degree Undergraduate degree may not enroll.
Enrollment limited to students in the College of Science, Schar School of Policy and Gov or Volgenau School of Engineering colleges.

**Schedule Type:** Lecture

**Grading:**
This course is graded on the Graduate Regular scale.

**ECE 548: Sequential Machine Theory.** 3 credits.
Theoretical study of sequential machines. Topics include sets, relations and lattices, switching algebra, functional decomposition, iterative networks, representation, minimization and transformation of sequential machines, state identification, state recognizers, and linear and stochastic sequential machines. Offered by Electrical & Comp. Engineering. May not be repeated for credit.

**Recommended Prerequisite:** ECE 331 or permission of instructor.

**Registration Restrictions:**
Enrollment limited to students with a class of Advanced to Candidacy, Graduate, Non-Degree or Senior Plus.

Enrollment is limited to Graduate, Non-Degree or Undergraduate level students.

Students in a Non-Degree Undergraduate degree may not enroll.

Enrollment limited to students in the College of Science, Schar School of Policy and Gov or Volgenau School of Engineering colleges.

**Schedule Type:** Lecture

**Grading:**
This course is graded on the Graduate Regular scale.

**ECE 550: System Engineering Design.** 3 credits.
System engineering design methods are studied and practiced, including object-oriented and structured analysis based techniques. Design Description languages such as UML, SysML, IDEF0 and IDEF1x are introduced and used in carrying out complete system designs. Teams make presentations of their designs. Offered by Electrical & Comp. Engineering. May not be repeated for credit. Equivalent to SYST 520.

**Registration Restrictions:**
Enrollment limited to students with a class of Advanced to Candidacy, Graduate, Non-Degree or Senior Plus.

Enrollment is limited to Graduate, Non-Degree or Undergraduate level students.

Students in a Non-Degree Undergraduate degree may not enroll.

Enrollment limited to students in the College of Science, Schar School of Policy and Gov or Volgenau School of Engineering colleges.

**Schedule Type:** Lecture

**Grading:**
This course is graded on the Graduate Regular scale.

**ECE 565: Introduction to Optical Electronics.** 3 credits.
Introduces optoelectronic devices for generation, detection, and modulation of light. Topics include electro-optic modulators, gas, solid state and semiconductor lasers, photodetectors, and detector arrays. Offered by Electrical & Comp. Engineering. May not be repeated for credit.

**Recommended Prerequisite:** ECE 305 and 333.

**Registration Restrictions:**
Enrollment limited to students with a class of Advanced to Candidacy, Graduate, Non-Degree or Senior Plus.

Enrollment is limited to Graduate, Non-Degree or Undergraduate level students.

Students in a Non-Degree Undergraduate degree may not enroll.

Enrollment limited to students in the College of Science, Schar School of Policy and Gov or Volgenau School of Engineering colleges.

**Schedule Type:** Lecture

**Grading:**
This course is graded on the Graduate Regular scale.

**ECE 567: Optical Fiber Communications.** 3 credits.
Studies components and integration of fiber-optic transmission systems. Topics include optical fibers, signal degradation, optical sources, power launching and coupling, photodetectors, receiver circuits, link analysis, and optical measurements. Offered by Electrical & Comp. Engineering. May not be repeated for credit.

**Recommended Prerequisite:** ECE 462 or TCOM 500 or permission of instructor

**Registration Restrictions:**
Enrollment limited to students with a class of Advanced to Candidacy, Graduate, Non-Degree or Senior Plus.

Enrollment is limited to Graduate, Non-Degree or Undergraduate level students.

Students in a Non-Degree Undergraduate degree may not enroll.

Enrollment limited to students in the College of Science, Schar School of Policy and Gov or Volgenau School of Engineering colleges.

**Schedule Type:** Lecture

**Grading:**
This course is graded on the Graduate Regular scale.

**ECE 580: Small Spacecraft Engineering.** 3 credits.
Comprehensive study of small spacecraft design, operations, bus, communications, computing hardware, software, sensors, power, attitude control, testing, and other topics needed for successful engineering of a spacecraft and its ground station. Review of ultra-small CubeSats, their hardware, software, and missions. Offered by Electrical & Comp. Engineering. May not be repeated for credit.

**Registration Restrictions:**
Enrollment limited to students with a class of Advanced to Candidacy, Graduate or Senior Plus.

Students in a Non-Degree Undergraduate degree may not enroll.

Enrollment limited to students in the College of Science or Volgenau School of Engineering colleges.

**Schedule Type:** Lecture

**Grading:**
This course is graded on the Graduate Regular scale.

**ECE 584: Semiconductor Device Fundamentals.** 3 credits.  
Studies principals of operation of semiconductor devices based on solid state physics. Topics include band theory of solids, intrinsic and extrinsic semiconductor properties, pn junction diode, bipolar junction transistor, Schottky diode, metal insulator semiconductor junctions, field-effect transistors, and hetero-structures. Offered by Electrical & Comp. Engineering. May not be repeated for credit.

**Recommended Prerequisite:** ECE 430 or permission of instructor.

**Registration Restrictions:**  
Enrollment limited to students with a class of Advanced to Candidacy, Graduate, Non-Degree or Senior Plus.

Enrollment is limited to Graduate, Non-Degree or Undergraduate level students.

Students in a Non-Degree Undergraduate degree may not enroll.

Enrollment limited to students in the College of Science, Schar School of Policy and Gov or Volgenau School of Engineering colleges.

**Schedule Type:** Lecture

**Grading:**  
This course is graded on the Graduate Regular scale.

**ECE 586: Digital Integrated Circuits.** 3 credits.  
Studies design and analysis of digital integrated circuits, emphasizing CMOS technology. Reviews MOSFET operation and SPICE modeling. Covers analysis and design of basic inverter circuits, structure and operation of combinational and sequential logic gates, dynamic logic circuits, chip I/O circuits, and brief introduction to VLSI methodologies. Offered by Electrical & Comp. Engineering. May not be repeated for credit.

**Recommended Prerequisite:** ECE 331 and ECE 430 or permission of instructor.

**Registration Restrictions:**  
Enrollment limited to students with a class of Advanced to Candidacy, Graduate, Non-Degree or Senior Plus.

Enrollment is limited to Graduate, Non-Degree or Undergraduate level students.

Students in a Non-Degree Undergraduate degree may not enroll.

Enrollment limited to students in the College of Science, Schar School of Policy and Gov or Volgenau School of Engineering colleges.

**Schedule Type:** Lecture

**Grading:**  
This course is graded on the Graduate Regular scale.

**ECE 587: Design of Analog Integrated Circuits.** 3 credits.  
Studies design methodologies of CMOS-based analog integrated circuits. Topics include differential amplifiers, current sources, output stages, operational amplifiers, comparators, frequency response, noise, and computer-aided design. Offered by Electrical & Comp. Engineering. May not be repeated for credit.

**Recommended Prerequisite:** ECE 333 and ECE 430 or 433 or permission of instructor.

**Registration Restrictions:**  
Enrollment limited to students with a class of Advanced to Candidacy, Graduate, Non-Degree or Senior Plus.

Enrollment is limited to Graduate, Non-Degree or Undergraduate level students.

Students in a Non-Degree Undergraduate degree may not enroll.

Enrollment limited to students in the College of Science, Schar School of Policy and Gov or Volgenau School of Engineering colleges.

**Schedule Type:** Lecture

**Grading:**  
This course is graded on the Graduate Regular scale.

**ECE 590: Selected Topics in Engineering.** 3 credits.  
Selected topics from recent developments, and applications in various engineering disciplines. Designed to help professional engineering community keep abreast of current developments. Offered by Electrical & Comp. Engineering. May be repeated within the term for a maximum 15 credits.

**Registration Restrictions:**  
Enrollment limited to students with a class of Advanced to Candidacy, Graduate, Non-Degree or Senior Plus.

Enrollment is limited to Graduate, Non-Degree or Undergraduate level students.

Students in a Non-Degree Undergraduate degree may not enroll.

Enrollment limited to students in the College of Science, Schar School of Policy and Gov or Volgenau School of Engineering colleges.

**Schedule Type:** Lecture

**Grading:**  
This course is graded on the Graduate Regular scale.

**600 Level Courses**

**ECE 611: Advanced Computer Architecture.** 3 credits.  
Qualitatively and quantitatively examines power, performance and security trade-offs in architecting computing systems. Explores three major components of modern general-purpose architectures: processors, memories, and networks. Enables students to understand how these components can be integrated to build complex multicore, manycore, and multithreaded architectures. Covers the architectural trade-offs in IoT, embedded, and high-performance processors. Topics include processor and system architecture in single core, multicore, multithreaded and heterogeneous architectures; memory architecture, network topology, routing, and flow control. Offered by Electrical & Comp. Engineering. May not be repeated for credit.

**Recommended Prerequisite:** ECE 511 or permission of instructor.

**Registration Restrictions:**  
Enrollment limited to students with a class of Advanced to Candidacy, Graduate, Non-Degree or Senior Plus.

Enrollment is limited to Graduate, Non-Degree or Undergraduate level students.

Students in a Non-Degree Undergraduate degree may not enroll.
Enrollment limited to students in the College of Science, Schar School of Policy and Gov or Volgenau School of Engineering colleges.

**Schedule Type:** Lecture

**Grading:**
This course is graded on the Graduate Regular scale.

**ECE 612: Real-Time Embedded Systems.** 3 credits.
Study of real-time operating systems and device drivers for embedded computers. Emphasizes microprocessor systems and associated input device sampling strategies, including interrupt driven and polled I/O. Covers basic input/output operations, analog to digital conversion methods, I/O programming techniques and process, and communication control methodologies. Involves design project. Offered by Electrical & Comp. Engineering. May not be repeated for credit.

**Recommended Prerequisite:** ECE 511 or permission of instructor.

**Registration Restrictions:**
Enrollment limited to students with a class of Advanced to Candidacy, Graduate, Non-Degree or Senior Plus.

Enrollment is limited to Graduate, Non-Degree or Undergraduate level students.

Students in a Non-Degree Undergraduate degree may not enroll.

Enrollment limited to students in the College of Science, Schar School of Policy and Gov or Volgenau School of Engineering colleges.

**Schedule Type:** Lecture

**Grading:**
This course is graded on the Graduate Regular scale.

**ECE 615: Software/Hardware Codesign.** 3 credits.
Introduces software/hardware codesign for modern all-programmable system on chip platforms. Covers profiling, design partitioning, interfacing, debugging using integrated logic analyzers, and optimizing performance and resource utilization. Demonstrates the development of hardware accelerators using existing intellectual property cores and establishing efficient communication between software and hardware parts of complex embedded systems. Introduces high-level synthesis for improved efficiency of the development process. Offered by Electrical & Comp. Engineering. May not be repeated for credit.

**Registration Restrictions:**
**Required Prerequisites:** ECE 511<sup>B</sup> and 545<sup>B</sup>.
<sup>B</sup>Requires minimum grade of B.

Enrollment limited to students with a class of Advanced to Candidacy, Graduate, Non-Degree or Senior Plus.

Students in a Non-Degree Undergraduate degree may not enroll.

**Schedule Type:** Lecture

**Grading:**
This course is graded on the Graduate Regular scale.

**ECE 616: Advanced Mobile Systems and Applications.** 3 credits.
Advanced study of mobile systems and applications, with the focus on system architecture, computing paradigms, and optimization methods. Most lectures are dedicated to case studies based on the most influential research publications and best-known industry products. Special topics include the most cutting-edge applications, such as virtual and augmented reality, machine learning, and cloud computing. For each topic, the design concepts are presented from the perspective of the application performance and system design considerations. Lectures are enhanced with the comprehensive literature review and a group-based, semester-long project. Offered by Electrical & Comp. Engineering. May not be repeated for credit.

**Recommended Prerequisite:** ECE 516 or permission of instructor

**Registration Restrictions:**
Enrollment limited to students with a class of Advanced to Candidacy, Graduate, Non-Degree or Senior Plus.

Students in a Non-Degree Undergraduate degree may not enroll.

**Schedule Type:** Lecture

**Grading:**
This course is graded on the Graduate Regular scale.

**ECE 619: Nonlinear Systems and Control.** 3 credits.
Includes motivating examples; analysis techniques include basic fixed-point theory, implicit function theorem, and dependence of trajectories on initial data and parameters. Also covers computational simulation techniques; stability theory including Lyapunov’s direct method; nonlinear control systems of input-output and absolute stability; strong positive real transfer functions; feedback linearization of nonlinear systems; nonlinear canonical forms; nonlinear decoupling; sliding control; and applications to adaptive control, neural networks, and robotics. Offered by Electrical & Comp. Engineering. May not be repeated for credit.

**Recommended Prerequisite:** ECE 521 or equivalent

**Registration Restrictions:**
Enrollment limited to students with a class of Advanced to Candidacy, Graduate, Non-Degree or Senior Plus.

Students in a Non-Degree Undergraduate degree may not enroll.

**Schedule Type:** Lecture

**Grading:**
This course is graded on the Graduate Regular scale.

**ECE 620: Optimal Control Theory.** 3 credits.
Detailed treatment of optimal control theory and its applications. Topics include system dynamics and performance criteria, calculus of variations and Pontryagin’s minimum principle, computational methods in optimal control, and applications of optimal control. Offered by Electrical & Comp. Engineering. May not be repeated for credit.

**Recommended Prerequisite:** ECE 521 or permission of instructor

**Registration Restrictions:**
Enrollment limited to students with a class of Advanced to Candidacy, Graduate, Non-Degree or Senior Plus.

Enrollment is limited to Graduate, Non-Degree or Undergraduate level students.

Students in a Non-Degree Undergraduate degree may not enroll.

Enrollment limited to students in the College of Science, Schar School of Policy and Gov or Volgenau School of Engineering colleges.
Schedule Type: Lecture

Grading:
This course is graded on the Graduate Regular scale.

ECE 621: Systems Identification. 3 credits.

Recommended Prerequisite: ECE 521 and 528 or permission of instructor.

Registration Restrictions:
Enrollment limited to students with a class of Advanced to Candidacy, Graduate, Non-Degree or Senior Plus.

Enrollment is limited to Graduate, Non-Degree or Undergraduate level students.

Students in a Non-Degree Undergraduate degree may not enroll.

Enrollment limited to students in the College of Science, Schar School of Policy and Gov or Volgenau School of Engineering colleges.

Schedule Type: Lecture

Grading:
This course is graded on the Graduate Regular scale.

ECE 622: Kalman Filtering with Applications. 3 credits.
Detailed treatment of Kalman Filtering Theory and its applications, including some aspects of stochastic control theory. Topics include state-space models with random inputs, optimum state estimation, filtering, prediction and smoothing of random signals with noisy measurements, all within the framework of Kalman filtering. Additional topics are nonlinear filtering problems, computational methods, and various applications such as global positioning system, tracking, system control, and others. Stochastic control problems include linear-quadratic-Gaussian problem and minimum-variance control. Offered by Electrical & Comp. Engineering. May not be repeated for credit.

Recommended Prerequisite: ECE 521 and 528, or permission of instructor.

Registration Restrictions:
Enrollment limited to students with a class of Advanced to Candidacy, Graduate, Non-Degree or Senior Plus.

Students in a Non-Degree Undergraduate degree may not enroll.

Schedule Type: Lecture

Grading:
This course is graded on the Graduate Regular scale.

ECE 631: Software-Defined Radio. 3 credits.
Design and implementation of the essential building blocks of a software-defined radio, including sampling, pulse shaping, modulation/demodulation, synchronization, equalization, and coding. Focus is on software implementation and integration of the building blocks in a software-defined radio platform. Other topics include software-defined radio architectures, application development on software radio platforms, and hardware acceleration for software-defined radio. Offered by Electrical & Comp. Engineering. May not be repeated for credit.

Recommended Prerequisite: ECE 531 or ECE 535 or permission of instructor.

Registration Restrictions:
Enrollment limited to students with a class of Advanced to Candidacy, Graduate, Non-Degree or Senior Plus.

Students in a Non-Degree Undergraduate degree may not enroll.

Schedule Type: Lecture

Grading:
This course is graded on the Graduate Regular scale.
ECE 633: Error Control Coding. 3 credits.
Introduction to error control coding techniques, which enable the
detection and correction of errors that arise in the transmission and
storage of digital data. Provides the necessary background in discrete
mathematics, algebra, and number theory. Topics include classical linear
block codes, convolutional codes, and modern sparse-graph codes;
hardware and software implementation of encoders and decoders;
and applications of error control coding to modern and emerging
technologies, such as contemporary and proposed wireless networking
standards, quantum communications, quantum computing, post-
quantum cryptography, physically unclonable functions, and secure
distributed storage media. Offered by Electrical & Comp. Engineering.
May not be repeated for credit.

Recommended Prerequisite: ECE 511 or ECE 528 or ECE 535 or ECE 542
or permission of instructor

Registration Restrictions:
Enrollment limited to students with a class of Advanced to Candidacy,
Graduate, Non-Degree or Senior Plus.

Enrollment is limited to Graduate, Non-Degree or Undergraduate level
students.

Students in a Non-Degree Undergraduate degree may not enroll.

Enrollment limited to students in the College of Science, Schar School of
Policy and Gov or Volgenau School of Engineering colleges.

Schedule Type: Lecture

Grading:
This course is graded on the Graduate Regular scale.

ECE 635: Adaptive Signal Processing. 3 credits.
Introduces adaptive systems and adaptive signal processing. Topics
include correlation functions and matrices; performance functions;
search of minimum; steepest descent and Newton algorithms; least
mean squares algorithm; noise perturbed search and misadjustment;
sequential regression algorithm and convergence issues; recursive least
squares algorithm and forgetting factor; frequency domain algorithms;
adaptive equalization; pseudorandom binary sequences and system
identification; adaptive interference cancellation; and adaptive beam
forming and arrays. Simulates adaptive algorithms. Offered by Electrical
& Comp. Engineering. May not be repeated for credit.

Recommended Prerequisite: ECE 528.

Registration Restrictions:
Enrollment limited to students with a class of Advanced to Candidacy,
Graduate, Non-Degree or Senior Plus.

Enrollment is limited to Graduate, Non-Degree or Undergraduate level
students.

Students in a Non-Degree Undergraduate degree may not enroll.

Enrollment limited to students in the College of Science, Schar School of
Policy and Gov or Volgenau School of Engineering colleges.

Schedule Type: Lecture

Grading:
This course is graded on the Graduate Regular scale.

ECE 639: Satellite Communications. 3 credits.
Comprehensive study of satellite communication systems. Topics include
link budget and quality of service considerations, basics of information
transmission, digital modulation and demodulation, channel coding
and coded modulation, multiple access, networking services for voice,
broadcasting and Internet access over satellites, payload and reliability
issues, and technological applications. Understanding of satellite system
architectures, propagation link characteristics, key communication
techniques, power and bandwidth requirements, and various satellite
communications systems and applications. Offered by Electrical & Comp.
Engineering. May not be repeated for credit.

Recommended Prerequisite: ECE 528 or ECE 542 or ECE 580

Registration Restrictions:
Enrollment limited to students with a class of Advanced to Candidacy,
Graduate, Non-Degree or Senior Plus.

Students in a Non-Degree Undergraduate degree may not enroll.

Schedule Type: Lecture

Grading:
This course is graded on the Graduate Regular scale.

ECE 642: Design and Analysis of Computer Communication Networks. 3
credits.
Introduces queuing theory. Other topics include concentrator design,
multiplexing, capacity assignments, random access schemes, polling
and probing techniques, topology design, flow control and routing, packet
radio, protocol specification, and validation. Offered by Electrical & Comp.
Engineering. May not be repeated for credit.

Recommended Prerequisite: ECE 542 and 528 or equivalent.

Registration Restrictions:
Enrollment limited to students with a class of Advanced to Candidacy,
Graduate, Non-Degree or Senior Plus.

Enrollment is limited to Graduate, Non-Degree or Undergraduate level
students.

Students in a Non-Degree Undergraduate degree may not enroll.

Enrollment limited to students in the College of Science, Schar School of
Policy and Gov or Volgenau School of Engineering colleges.

Schedule Type: Lecture

Grading:
This course is graded on the Graduate Regular scale.

ECE 643: Network Switching and Routing. 3 credits.
Fundamentals of switching and routing with application to
communications networks, both wireline and wireless. Topics include
concepts of space and time for switching and forwarding of data,
scalability and performance, label swapping, algorithms for routing
and path computation, constrained route optimization, traffic theory,
control and signaling, and traffic engineering. The course also covers
the concepts and issues underlying the design and implementation of
the contemporary switched networks. Offered by Electrical & Comp.
Engineering. May not be repeated for credit.

Recommended Prerequisite: ECE 528 and ECE 542.

Registration Restrictions:
Enrollment limited to students with a class of Advanced to Candidacy, Graduate, Non-Degree or Senior Plus.

Enrollment is limited to Graduate, Non-Degree or Undergraduate level students.

Students in a Non-Degree Undergraduate degree may not enroll.

Enrollment limited to students in the College of Science, Schar School of Policy and Gov or Volgenau School of Engineering colleges.

Schedule Type: Lecture

Grading:

This course is graded on the Graduate Regular scale.

ECE 645: Computer Arithmetic. 3 credits.
Covers computer arithmetic as applied to the design of general-purpose microprocessors and application-specific integrated circuits for cryptography, coding, and digital signal processing. Focuses on efficient implementations of all basic arithmetic operations in three major domains: integers, real numbers, and elements of Galois Fields GF(2^n).
Illustrates tradeoffs among various hardware algorithms and architectures depending on primary optimization criteria, such as speed, area, and power consumption. Demonstrates the use of software implementations as a source of test vectors for verification of hardware implementations and for evaluating hardware versus software speed-up.
Offered by Electrical & Comp. Engineering. May not be repeated for credit.

Recommended Prerequisite: ECE 545 or permission of instructor.

Registration Restrictions:
Enrollment limited to students with a class of Advanced to Candidacy, Graduate, Non-Degree or Senior Plus.

Enrollment is limited to Graduate, Non-Degree or Undergraduate level students.

Students in a Non-Degree Undergraduate degree may not enroll.

Enrollment limited to students in the College of Science, Schar School of Policy and Gov or Volgenau School of Engineering colleges.

Schedule Type: Lecture

Grading:

This course is graded on the Graduate Regular scale.

ECE 650: Robotics. 3 credits.
Introduces robotics and advanced automation from electrical engineering standpoint. Topics include hardware overview; coordinate systems and manipulator kinematics; differential motion and inverse Jacobian; manipulator path control and motion planning; design and control of articulated hands; sensory feedback; machine vision; and applications to industrial automation. Offered by Electrical & Comp. Engineering. May not be repeated for credit.

Recommended Prerequisite: ECE 521 or permission of instructor.

Registration Restrictions:
Enrollment limited to students with a class of Advanced to Candidacy, Graduate, Non-Degree or Senior Plus.

Enrollment is limited to Graduate, Non-Degree or Undergraduate level students.

Students in a Non-Degree Undergraduate degree may not enroll.

Enrollment limited to students in the College of Science, Schar School of Policy and Gov or Volgenau School of Engineering colleges.

Schedule Type: Lecture

Grading:

This course is graded on the Graduate Regular scale.

Provides broad introduction to fundamental principles of command, control, communication, computing, and intelligence (C4I). Applies principles, techniques to wide range of civilian and military situations. Discusses modeling, simulation of combat operations; studies sensing, fusion, and situation assessment processes. Derives optimal decision-making rules. Discusses concepts of C4I architectures and tools to evaluate and design systems such as queueing theory. Offered by Electrical & Comp. Engineering. May not be repeated for credit. Equivalent to SYST 680.

Recommended Prerequisite: ECE 528 or SYST 611 or OR 542, or equivalent.

Registration Restrictions:
Enrollment limited to students with a class of Advanced to Candidacy, Graduate, Non-Degree or Senior Plus.

Enrollment is limited to Graduate, Non-Degree or Undergraduate level students.
ECE 674: 

**Systems Architecture Design.** 3 credits.

Architecture design and representation and the methodologies used to obtain them. Approaches based on system engineering constructs such as object orientation and service oriented architectures are used to design architectures and then represent them in conformance with an architecture framework such as DoDAD. Executable models of the architecture are derived to be used for architecture evaluation. Examples from current practice are used.

**Course covers elements of discrete mathematics and then focuses on Petri Net models and their basic properties.** Relation to other discrete event models of dynamical systems. Offered by Electrical & Comp. Engineering. May not be repeated for credit. Equivalent to SYST 620.

**Recommended Prerequisite:** ECE 521, or SYST 611 or permission of instructor.

**Registration Restrictions:**
Enrollment limited to students with a class of Advanced to Candidacy, Graduate, Non-Degree or Senior Plus.

Enrollment is limited to Graduate, Non-Degree or Undergraduate level students.

Students in a Non-Degree Undergraduate degree may not enroll.

Enrollment limited to students in the College of Science, Schar School of Policy and Gov or Volgenau School of Engineering colleges.

**Schedule Type:** Lecture

**Grading:**
This course is graded on the Graduate Regular scale.

ECE 673: 

**Discrete Event Systems.** 3 credits.

Introduces modeling and analysis of discrete event dynamical systems. Course covers elements of discrete mathematics and then focuses on Petri Net models and their basic properties. Relation to other discrete event models of dynamical systems. Offered by Electrical & Comp. Engineering. May not be repeated for credit. Equivalent to SYST 620.

**Recommended Prerequisite:** ECE 521, or SYST 611 or permission of instructor.

**Registration Restrictions:**
Enrollment limited to students with a class of Advanced to Candidacy, Graduate, Non-Degree or Senior Plus.

Enrollment is limited to Graduate, Non-Degree or Undergraduate level students.

Students in a Non-Degree Undergraduate degree may not enroll.

Enrollment limited to students in the College of Science, Schar School of Policy and Gov or Volgenau School of Engineering colleges.

**Schedule Type:** Lecture

**Grading:**
This course is graded on the Graduate Regular scale.

ECE 675: 

**System Integration and Arch. Evaluation.** 3 credits.


**Recommended Prerequisite:** ECE 674 or SYST 621.

**Registration Restrictions:**
Enrollment limited to students with a class of Advanced to Candidacy, Graduate, Non-Degree or Senior Plus.

Enrollment is limited to Graduate, Non-Degree or Undergraduate level students.

Students in a Non-Degree Undergraduate degree may not enroll.

Enrollment limited to students in the College of Science, Schar School of Policy and Gov or Volgenau School of Engineering colleges.

**Schedule Type:** Lecture

**Grading:**
This course is graded on the Graduate Regular scale.

ECE 690: 

**Physical VLSI Design.** 3 credits.

Introduces NMOS, CMOS, and BiCMOS integrated circuit technology and fabrication. Reviews MOS and BiCMOS inverter structures and operation, MOS and BiCMOS circuit design processes, MOS layers, stick diagrams, design rules, and layout. Covers subsystem design and layout illustration of design process through design of 4bit arithmetic processor and its parts, adder, multiplier, register, and memory cells; and aspects of system timing, test and testability. Reviews currently available VLSI CAS tools. Offered by Electrical & Comp. Engineering. May not be repeated for credit.

**Recommended Prerequisite:** ECE 586 or permission of instructor.

**Registration Restrictions:**
Enrollment limited to students with a class of Advanced to Candidacy, Graduate, Non-Degree or Senior Plus.

Enrollment is limited to Graduate, Non-Degree or Undergraduate level students.

Students in a Non-Degree Undergraduate degree may not enroll.

Enrollment limited to students in the College of Science, Schar School of Policy and Gov or Volgenau School of Engineering colleges.

**Schedule Type:** Lecture

**Grading:**
This course is graded on the Graduate Regular scale.

ECE 681: 

**VLSI Design for ASICs.** 3 credits.

Introduces VLSI design of application-specific integrated circuits (ASICs) from front-end to back-end using HDL and modern design automation software. Covers simulation, synthesis of digital circuits using standard cells, static timing analysis, formal verification, power analysis, test generation/fault simulation, and physical design including floor planning, placement, routing, and design rule checking. Addresses deep submicron CMOS scaling issues and other advanced topics. Offered by Electrical & Comp. Engineering. May not be repeated for credit.
**ECE 684:** Nano-Electronics. 3 credits.
Topics include MOS capacitor, MOSFETs, CMOS, charge coupled devices, scaling, hot carrier effects, latchup, radiation effects, and isolation techniques. Offered by Electrical & Comp. Engineering. May not be repeated for credit.

**Registration Restrictions:**
Enrollment limited to students with a class of Advanced to Candidacy, Graduate, Non-Degree or Senior Plus.

**Recommended Prerequisite:** ECE 584 or permission of instructor.

**Recommended Corequisite:** ECE 586 or permission of instructor.

**Recommended Prerequisite:** ECE 584.

**Recommended Corequisite:** ECE 586, or permission of instructor.

**Registration Restrictions:**
Enrollment limited to students with a class of Advanced to Candidacy, Graduate, Non-Degree or Senior Plus.

**Enrollment is limited to Graduate, Non-Degree or Undergraduate level students.**

**Students in a Non-Degree Undergraduate degree may not enroll.**

**Enrollment limited to students in the College of Science, Schar School of Policy and Gov or Volgenau School of Engineering colleges.**

**Schedule Type:** Lecture

**Grading:**
This course is graded on the Graduate Regular scale.

**ECE 685:** Nanoelectronics. 3 credits.
Emphasizes the fundamental concepts and principles that govern the operation of nano-electronic devices (100 nm down to 1 nm.). Addresses basic device building blocks such as quantum dot (QD), single electron tunneling transistor (SETT), carbon nanotube (CNT), nanowire, etc. Considers the design and analysis of a variety of nano-devices ("quantum" or "mesoscopic" devices) and examine some notable applications. Offered by Electrical & Comp. Engineering. May not be repeated for credit.

**Registration Restrictions:**
Enrollment limited to students with a class of Advanced to Candidacy, Graduate, Non-Degree or Senior Plus.

**Enrollment is limited to Graduate, Non-Degree or Undergraduate level students.**

**Students in a Non-Degree Undergraduate degree may not enroll.**

**Enrollment limited to students in the College of Science, Schar School of Policy and Gov or Volgenau School of Engineering colleges.**

**Schedule Type:** Lecture

**Grading:**
This course is graded on the Graduate Regular scale.

**ECE 682:** VLSI Test Concepts. 3 credits.
Broad introduction to basic concepts, techniques, and tools of modern VLSI testing. Fundamentals of defect modeling, fault simulation, design for testability, built-in self-test techniques, and failure analysis. Test economics, physical defects and fault modeling, automated test pattern generation, fault simulation, design for test, built-in self test, memory test, PLD test, mixed-signal test, Iddq test, boundary scan and related standards, test synthesis, diagnosis and failure analysis, automated test equipment, embedded core test. Offered by Electrical & Comp. Engineering. May not be repeated for credit.

**Recommended Prerequisite:** ECE 586

**Registration Restrictions:**
Enrollment limited to students with a class of Advanced to Candidacy, Graduate, Non-Degree or Senior Plus.

**Enrollment is limited to Graduate, Non-Degree or Undergraduate level students.**

**Students in a Non-Degree Undergraduate degree may not enroll.**

**Enrollment limited to students in the College of Science, Schar School of Policy and Gov or Volgenau School of Engineering colleges.**

**Schedule Type:** Laboratory, Lecture

**Grading:**
This course is graded on the Graduate Regular scale.

**ECE 691:** CubeSat Design. 1.5 credit.
First phase of a project course focused on design and early prototyping. Design and implementation of a project related to CubeSats, satellite communication ground and space systems, satellite bus modules, embedded hardware and software. Offered by Electrical & Comp. Engineering. Limited to two attempts.

**Registration Restrictions:**
Enrollment limited to students with a class of Advanced to Candidacy, Graduate, Non-Degree or Senior Plus.

**Students in a Non-Degree Undergraduate degree may not enroll.**

**Enrollment limited to students in the College of Science, Schar School of Policy and Gov or Volgenau School of Engineering colleges.**

**Schedule Type:** Laboratory

**Grading:**
This course is graded on the Graduate Regular scale.

**ECE 692:** CubeSat Engineering. 1.5 credit.
Second phase of a project course dedicated to project implementation and testing. Design and implementation of a project related to CubeSats, satellite communication ground and space systems, satellite bus modules, embedded hardware and software. Offered by Electrical & Comp. Engineering. Limited to two attempts.
Registration Restrictions:
Required Prerequisite: ECE 691^B.
B: Requires minimum grade of B.

Enrollment limited to students with a class of Advanced to Candidacy, Graduate, Non-Degree or Senior Plus.

Students in a Non-Degree Undergraduate degree may not enroll.

Enrollment limited to students in the College of Science or Volgenau School of Engineering colleges.

Schedule Type: Laboratory

Grading:
This course is graded on the Graduate Regular scale.

ECE 699: Advanced Topics in Electrical and Computer Engineering. 1-6 credits.
Advanced topics of current interest in electrical and computer engineering. Topics chosen so they do not duplicate other courses in department. Active participation encouraged in form of writing and presenting papers in research areas. Offered by Electrical & Comp. Engineering. May be repeated within the degree for a maximum 3 credits.

Recommended Prerequisite: At least two core courses and permission of instructor.

Registration Restrictions:
Enrollment limited to students with a class of Advanced to Candidacy, Graduate, Non-Degree or Senior Plus.

Enrollment is limited to Graduate, Non-Degree or Undergraduate level students.

Students in a Non-Degree Undergraduate degree may not enroll.

Enrollment limited to students in the College of Science, Schar School of Policy and Gov or Volgenau School of Engineering colleges.

Schedule Type: Research

Grading:
This course is graded on the Graduate Regular scale.

ECE 722: Nonlinear Systems. 3 credits.
Includes motivating examples; analysis techniques include basic fixed-point theory, implicit function theorem, and dependence of trajectories on initial data and parameters. Also covers computational simulation techniques; stability theory including Lyapunov's direct method; nonlinear control systems of input-output and absolute stability; strong positive real transfer functions; feedback linearization of nonlinear systems; nonlinear canonical forms; nonlinear decoupling; sliding control; and applications to adaptive control, neural networks, and robotics. Offered by Electrical & Comp. Engineering. May not be repeated for credit.

Recommended Prerequisite: ECE 620 or ECE 621.

Registration Restrictions:
Enrollment is limited to Graduate or Non-Degree level students.

Students in a Non-Degree Undergraduate degree may not enroll.

Enrollment limited to students in the College of Science, Schar School of Policy and Gov or Volgenau School of Engineering colleges.

Schedule Type: Lecture

Grading:
This course is graded on the Graduate Regular scale.

ECE 721: Nonlinear Systems. 3 credits.
Includes motivating examples; analysis techniques include basic fixed-point theory, implicit function theorem, and dependence of trajectories on initial data and parameters. Also covers computational simulation techniques; stability theory including Lyapunov's direct method; nonlinear control systems of input-output and absolute stability; strong positive real transfer functions; feedback linearization of nonlinear systems; nonlinear canonical forms; nonlinear decoupling; sliding control; and applications to adaptive control, neural networks, and robotics. Offered by Electrical & Comp. Engineering. May not be repeated for credit.

Recommended Prerequisite: ECE 620 or ECE 621.

Registration Restrictions:
Enrollment is limited to Graduate or Non-Degree level students.

Students in a Non-Degree Undergraduate degree may not enroll.

Enrollment limited to students in the College of Science, Schar School of Policy and Gov or Volgenau School of Engineering colleges.

Schedule Type: Lecture

Grading:
This course is graded on the Graduate Regular scale.

ECE 728: Kalman Filtering with Applications. 3 credits.
Detailed treatment of Kalman Filtering Theory and its applications, including some aspects of stochastic control theory. Topics include state-space models with random inputs, optimum state estimation, filtering, prediction and smoothing of random signals with noisy measurements, all within the framework of Kalman filtering. Additional topics are nonlinear filtering problems, computational methods, and various applications such as global positioning system, tracking, system control, and others. Stochastic control problems include linear-quadratic-Gaussian problem and minimum-variance control. Offered by Electrical & Comp. Engineering. May not be repeated for credit.

Recommended Prerequisite: ECE 521 and 528 or equivalent, or permission of instructor.

Registration Restrictions:
Enrollment is limited to Graduate or Non-Degree level students.

Students in a Non-Degree Undergraduate degree may not enroll.

Enrollment limited to students in the College of Science, Schar School of Policy and Gov or Volgenau School of Engineering colleges.

Schedule Type: Lecture

Grading:
This course is graded on the Graduate Regular scale.

ECE 728: Random Processes in Electrical and Computer Engineering. 3 credits.
Recommended for advanced master's and doctoral students. Provides background in random processes needed for pursuing graduate studies and research in statistical signal processing, communications, control, and computer networks. Covers probability spaces, random variables, Lebesgue integration, conditional mean on a sigma field, convergence of random variables, limit and ergotic theorems, Markov processes, and

This course is graded on the Graduate Regular scale.
Martingales. Offered by Electrical & Comp. Engineering. May not be repeated for credit.

**Recommended Prerequisite:** ECE 528 or permission of instructor.

**Registration Restrictions:**
Enrollment is limited to Graduate or Non-Degree level students.

Students in a Non-Degree Undergraduate degree may not enroll.

Enrollment limited to students in the College of Science, Schar School of Policy and Gov or Volgenau School of Engineering colleges.

**Schedule Type:** Lecture

**Grading:**
This course is graded on the Graduate Regular scale.

**ECE 731:** Digital Communications. 3 credits.
Digital transmission of voice, video, and data signals. Covers signal digitization, pulse code modulation, delta modulation, low bit-rate coding, multiplexing, synchronization, intersymbol interference, adaptive equalization, frequency spreading, encryption, transmission codes, digital transmission using band-width compression techniques, and satellite communications. Offered by Electrical & Comp. Engineering. May not be repeated for credit.

**Recommended Prerequisite:** ECE 630 or equivalent.

**Registration Restrictions:**
Enrollment is limited to Graduate or Non-Degree level students.

Students in a Non-Degree Undergraduate degree may not enroll.

Enrollment limited to students in the College of Science, Schar School of Policy and Gov or Volgenau School of Engineering colleges.

**Schedule Type:** Lecture

**Grading:**
This course is graded on the Graduate Regular scale.

**ECE 732:** Mobile Communication Systems. 3 credits.
Topics include modeling of mobile communication channel, signal set and receiver design for mobile communication channel, access and mobility control, mobile network architectures, connection to fixed network, and signaling protocols for mobile communication systems. Examples of mobile communication systems are presented, including pan-European GSM, North American D-AMPS, and personal communication systems. Offered by Electrical & Comp. Engineering. May not be repeated for credit.

**Recommended Prerequisite:** ECE 542 and 630.

**Registration Restrictions:**
Enrollment is limited to Graduate or Non-Degree level students.

Students in a Non-Degree Undergraduate degree may not enroll.

Enrollment limited to students in the College of Science, Schar School of Policy and Gov or Volgenau School of Engineering colleges.

**Schedule Type:** Lecture

**Grading:**
This course is graded on the Graduate Regular scale.

**ECE 734:** Detection and Estimation Theory. 3 credits.
Introduces detection and estimation theory with communication and radar and sonar applications. Topics include classical detection and estimation theory, detection of known signals in Gaussian noise, signal parameter and linear waveform estimation, and Wiener and Kalman filters. Offered by Electrical & Comp. Engineering. May not be repeated for credit.

**Recommended Prerequisite:** ECE 528.

**Registration Restrictions:**
Enrollment is limited to Graduate or Non-Degree level students.

Students in a Non-Degree Undergraduate degree may not enroll.

Enrollment limited to students in the College of Science, Schar School of Policy and Gov or Volgenau School of Engineering colleges.

**Schedule Type:** Lecture

**Grading:**
This course is graded on the Graduate Regular scale.

**ECE 738:** Advanced Digital Signal Processing. 3 credits.
Theory and practice of advanced digital signal processing techniques. Topics may include efficient high-speed algorithms for convolution, correlation, orthogonal transforms, multirate processing of digital signals, multiresolution time-frequency and time-scale analysis of one- and two-dimensional signals, and multitaper spectral estimation. Offered by Electrical & Comp. Engineering. May not be repeated for credit.

**Recommended Prerequisite:** ECE 528 and ECE 535.

**Registration Restrictions:**
Enrollment is limited to Graduate or Non-Degree level students.

Students in a Non-Degree Undergraduate degree may not enroll.

Enrollment limited to students in the College of Science, Schar School of Policy and Gov or Volgenau School of Engineering colleges.

**Schedule Type:** Lecture

**Grading:**
This course is graded on the Graduate Regular scale.

**ECE 740:** Digital Signal Processing Hardware Architectures. 3 credits.
Addresses topics that include high-level DSP optimizations, such as pipelining, unfolding, and parallel processing; common DSP structures such as FFTs, filters, direct digital frequency synthesizers, and correlators; modeling of DSP algorithms in MATLAB and conversion of MATLAB models into fixed-point VHDL blocks; platform implementation issues: hardware vs. software, FPGA vs. ASIC, power, area, throughput, and applications of DSP hardware. Offered by Electrical & Comp. Engineering. May not be repeated for credit.

**Recommended Prerequisite:** ECE 535 and ECE 545 or equivalents or permission of instructor.

**Registration Restrictions:**
Enrollment is limited to Graduate or Non-Degree level students.

Students in a Non-Degree Undergraduate degree may not enroll.

Enrollment limited to students in the College of Science, Schar School of Policy and Gov or Volgenau School of Engineering colleges.
processors, and other platforms. Discusses side channel attacks against
Covers implementations of cryptosystems using smart cards, network
to understand, implement, and break modern cryptoalgorithms.
Provides mathematical background necessary
Discusses complex cryptographic algorithms and their implementations
in software and hardware. Ranges from high-performance to
Discusses efficient implementations of cryptographic algorithms and
protocols in hardware and software, ranging from high-performance to
low-power, as well as resistance to side-channel and fault attacks. Covers
code breaking algorithms and practical implementations of side-channel
attacks. Introduces research techniques. Requires semester-long project
devoted to study of a cryptographic engineering problem, including a
comprehensive literature review, problem definition, and research plan.
Notes: Course will be partially lecture style, partially seminar. Students
will give hour long, in-depth presentations on their research topics.
Offered by Electrical & Comp. Engineering. May not be repeated for credit.
Recommended Prerequisite: ECE 642 or equivalent.
Registration Restrictions:
Enrollment is limited to students in the College of Science, Schar School of
Policy and Gov or Volgenau School of Engineering colleges.
Schedule Type: Lecture
Grading:
This course is graded on the Graduate Regular scale.
ECE 747: Cryptographic Engineering. 3 credits.
Discusses efficient implementations of cryptographic algorithms and
protocols in hardware and software, ranging from high-performance to
low-power, as well as resistance to side-channel and fault attacks. Covers
code breaking algorithms and practical implementations of side-channel
attacks. Introduces research techniques. Requires semester-long project
devoted to study of a cryptographic engineering problem, including a
comprehensive literature review, problem definition, and research plan.
Notes: Course will be partially lecture style, partially seminar. Students
will give hour long, in-depth presentations on their research topics.
Offered by Electrical & Comp. Engineering. May not be repeated for credit.
Recommended Prerequisite: ECE 642 or permission of instructor.
Registration Restrictions:
Enrollment is limited to Graduate or Non-Degree level students.
Students in a Non-Degree Undergraduate degree may not enroll.
Enrollment limited to students in the College of Science, Schar School of
Policy and Gov or Volgenau School of Engineering colleges.
Schedule Type: Lecture
Grading:
This course is graded on the Graduate Regular scale.
ECE 751: Information Theory. 3 credits.
Introduces information theory, which is mathematical theory of
communication systems. Topics include measures of information such as
entropy, relative entropy, and mutual information; Shannon-McMillan-
Breiman theorem and applications to data compression; entropy rate
and source coding theorem; Huffman, arithmetic and Lempel-Ziv codes;
method of types, channel capacity, and channel-coding theorem; joint
source-channel coding theorem; differential entropy; Gaussian channel;
rate distortion theory; and vector quantization. Offered by Electrical &
Comp. Engineering. May not be repeated for credit.
Recommended Prerequisite: ECE 528 or permission of instructor.
Registration Restrictions:
Enrollment is limited to Graduate or Non-Degree level students.

Students in a Non-Degree Undergraduate degree may not enroll.

Enrollment limited to students in the College of Science, Schar School of Policy and Gov or Volgenau School of Engineering colleges.

**Schedule Type:** Lecture

**Grading:**
This course is graded on the Graduate Regular scale.

ECE 754: Optimum Array Processing I. 3 credits.

**Recommended Prerequisite:** ECE 528 and ECE 535.

**Registration Restrictions:**
Enrollment is limited to Graduate or Non-Degree level students.

Students in a Non-Degree Undergraduate degree may not enroll.

Enrollment limited to students in the College of Science, Schar School of Policy and Gov or Volgenau School of Engineering colleges.

**Schedule Type:** Lecture

**Grading:**
This course is graded on the Graduate Regular scale.

ECE 780: Radio Frequency Electronics. 3 credits.
This course addresses the design of electronic building blocks for radio frequency (RF) microelectronic circuits. Topics include trade-offs in RF design, transceiver architectures, low-noise amplifiers, mixers, oscillators, frequency-synthesizers, phase-locked loops, and power amplifiers. Offered by Electrical & Comp. Engineering. May not be repeated for credit.

**Recommended Prerequisite:** ECE 587, 684, or permission of instructor.

**Registration Restrictions:**
Enrollment is limited to Graduate or Non-Degree level students.

Students in a Non-Degree Undergraduate degree may not enroll.

Enrollment limited to students in the College of Science, Schar School of Policy and Gov or Volgenau School of Engineering colleges.

**Schedule Type:** Lecture

**Grading:**
This course is graded on the Graduate Regular scale.

ECE 795: Engineering Seminar. 0 credits.
Fulfills seminar requirement for MS in electrical and computer engineering programs. Invited speakers, faculty, and ECE graduate students lecture on current topics and research. Notes: Students must enroll in ECE 795 the final semester they file to graduate. Once the department verifies that the seminar requirement has been met, a grade of S (satisfactory) will be submitted. Students who have not met the seminar requirement in their final semester must continue to register for ECE 795 in subsequent semesters until the requirement is met. Offered by Electrical & Comp. Engineering. May be repeated within the degree.

**Registration Restrictions:**
Enrollment is limited to Graduate or Non-Degree level students.

Students in a Non-Degree Undergraduate degree may not enroll.

Enrollment limited to students in the College of Science, Schar School of Policy and Gov or Volgenau School of Engineering colleges.

**Schedule Type:** Seminar

**Grading:**
This course is graded on the Graduate Special scale.

ECE 797: Scholarly Paper. 0 credits.
Student must develop a rigorous, technical report (called Scholarly Paper) on a topic of current interest in Electrical and Computer Engineering and make an oral presentation of this report. Students fulfill this requirement through and individual project in a 600-level or above ECE graduate course. Offered by Electrical & Comp. Engineering. May be repeated within the degree.

**Recommended Prerequisite:** Completed 18 credit hours of graduate work.

**Registration Restrictions:**
Enrollment is limited to Graduate or Non-Degree level students.

Students in a Non-Degree Undergraduate degree may not enroll.

Enrollment limited to students in the College of Science, Schar School of Policy and Gov or Volgenau School of Engineering colleges.

**Schedule Type:** Research

**Grading:**
This course is graded on the Graduate Special scale.

ECE 798: Research Project. 1-6 credits.
Student must complete a one-semester long research project on an ECE technical topic under the guidance of a faculty advisor, and write a research report that will be presented as a departmental seminar. Notes: No more than a combined total of 3 credits may be taken towards satisfying the master’s degree, although students may register for more credits. Students may not count both ECE 799 and ECE 798 for master’s degree. Offered by Electrical & Comp. Engineering. May be repeated within the degree for a maximum 6 credits.

**Recommended Prerequisite:** Completed 18 credit hours of graduate work.

**Registration Restrictions:**
Enrollment is limited to Graduate or Non-Degree level students.

Students in a Non-Degree Undergraduate degree may not enroll.

Enrollment limited to students in the College of Science, Schar School of Policy and Gov or Volgenau School of Engineering colleges.

**Schedule Type:** Thesis

**Grading:**
This course is graded on the Satisfactory/No Credit scale.

ECE 799: Master’s Thesis. 1-6 credits.
Research project chosen and completed under guidance of graduate faculty member that results in technical report and oral defense
acceptable to thesis committee of three faculty members. Offered by Electrical & Comp. Engineering. May be repeated within the degree.

Recommended Prerequisite: 9 graduate credits, and permission of instructor.

Registration Restrictions:
Enrollment is limited to Graduate or Non-Degree level students.

Students in a Non-Degree Undergraduate degree may not enroll.

Enrollment limited to students in the College of Science, Schar School of Policy and Gov or Volgenau School of Engineering colleges.

Schedule Type: Thesis

Grading:
This course is graded on the Satisfactory/No Credit scale.

800 Level Courses

ECE 899: Research Topics in ECE. 3 credits.
Studies advanced research areas in Electrical and Computer Engineering within a course format. Students will develop specialized research skills, which will also involve the presentation of their own work, developed individually and within groups. This course may be repeated for credit if the research areas differ. Notes: This will be an irregularly scheduled course intended for advanced master’s students who want to pursue a specific topic to more depth than a typical course offers at the master’s level. It will prepare students to undertake their individual research topics when they move on to pursue a Ph.D. program, or enter a research environment in their chosen professional careers. Offered by Electrical & Comp. Engineering. May be repeated within the degree for a maximum 9 credits.

Recommended Prerequisite: Completion of at least one 600 or 700 level course in the Research Topic area; and permission of instructor.

Registration Restrictions:
Enrollment is limited to Graduate level students.

Enrollment limited to students in the College of Science, Schar School of Policy and Gov or Volgenau School of Engineering colleges.

Schedule Type: Research

Grading:
This course is graded on the Graduate Regular scale.

900 Level Courses

ECE 998: Doctoral Dissertation Proposal. 1-12 credits.
Work on research proposal that forms basis for doctoral dissertation. Notes: No more than 24 credits of ECE 998 and 999 may be applied to doctoral degree requirements. Offered by Electrical & Comp. Engineering. May be repeated within the degree.

Registration Restrictions:
Enrollment is limited to Graduate level students.

Enrollment limited to students in the College of Science, Schar School of Policy and Gov or Volgenau School of Engineering colleges.

Schedule Type: Dissertation

Grading:
This course is graded on the Satisfactory/No Credit scale.

ECE 999: Doctoral Dissertation. 1-12 credits.
Formal record of commitment to doctoral dissertation research under direction of ECE faculty member. Notes: Students must complete minimum 12 credits of doctoral proposal (ECE 998) and doctoral dissertation research (ECE 999) Maximum of 24 credits of ECE 998 and 999 may be applied to degree. Students who choose to take less than 24 credits of ECE 998 and 999 may earn remaining credits from approved course work. Students cannot enroll in ECE 999 before research proposal accepted and approved by dissertation committee. Offered by Electrical & Comp. Engineering. May be repeated within the degree.

Registration Restrictions:
Enrollment limited to students with a class of Advanced to Candidacy.

Enrollment is limited to Graduate level students.

Enrollment limited to students in the Volgenau School of Engineering college.

Schedule Type: Dissertation

Grading:
This course is graded on the Satisfactory/No Credit scale.