## ECE—Electrical and Computer Engineering

### College of Engineering

#### Department of Electrical and Computer Engineering

<table>
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<tr>
<th>Course Code</th>
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<th>Semester</th>
<th>Credits</th>
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<td>201</td>
<td>Circuits and Systems I</td>
<td>Fall, Spring</td>
<td>3</td>
<td>ECE 131 or CSE 231 or CSE 232 and ECE 302 or ECE 303</td>
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<tr>
<td>202</td>
<td>Circuits and Systems II</td>
<td>Fall, Spring</td>
<td>3</td>
<td>ECE 201 and (MTH 235 or concurrently) or (LBS 119 or concurrently) or (MTH 255H or concurrently)</td>
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<tr>
<td>280</td>
<td>Digital Logic Fundamentals</td>
<td>Fall, Spring</td>
<td>3</td>
<td>CSE 131 or CSE 231 or CSE 232 and ECE 302 or ECE 303</td>
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<td>281</td>
<td>Electrical Engineering Analysis</td>
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<td>301</td>
<td>Electronic Circuits</td>
<td>Fall, Spring</td>
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<td>ECE 202 R: Open only to students in the Department of Electrical and Computer Engineering</td>
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<td>302</td>
<td>Electronics Laboratory</td>
<td>Fall, Spring</td>
<td>3</td>
<td>ECE 202 R: Open only to students in the Department of Electrical and Computer Engineering or Department of Computer Science and Engineering, ECE 302</td>
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<td>303</td>
<td>Electromagnetic Fields and Waves I</td>
<td>Fall, Spring</td>
<td>4</td>
<td>MTH 235 or concurrently or (LBS 119 or concurrently) or (MTH 255H or concurrently) and (PHY 184 or PHY 184B or PHY 234B)</td>
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<td>313</td>
<td>Control Systems</td>
<td>Fall, Spring</td>
<td>3</td>
<td>ECE 202 or ECE 345 R: Open only to juniors or seniors or graduate students in the Department of Electrical and Computer Engineering and Department of Computer Science and Engineering, ECE 413</td>
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<td>320</td>
<td>Energy Conversion and Power Electronics</td>
<td>Fall, Spring</td>
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<td>ECE 302 and ECE 303 or ECE 305 SA: ECE 320</td>
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<td>331</td>
<td>Microprocessors and Digital Systems</td>
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<td>CSE 231 and ECE 230 R: Open only to juniors or seniors or graduate students in the Department of Electrical and Computer Engineering, ECE 331</td>
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<tr>
<td>341</td>
<td>Electronic Instrumentation and Systems</td>
<td>Fall, Spring</td>
<td>3</td>
<td>ECE 202 R: Open only to students in the Department of Electrical and Computer Engineering, ECE 345</td>
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<tr>
<td>366</td>
<td>Introduction to Signal Processing</td>
<td>Fall of even years, Spring, Summer</td>
<td>3</td>
<td>ECE 202 R: Open only to students in the Department of Electrical and Computer Engineering, ECE 360</td>
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<td>380</td>
<td>Electromagnetic Fields and Waves II</td>
<td>Fall, Spring</td>
<td>4</td>
<td>ECE 302 or ECE 303 or ECE 230 R: Open only to juniors or seniors or graduate students in the Department of Electrical and Computer Engineering, ECE 331</td>
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<td>402</td>
<td>Applications of Analog Integrated Circuits</td>
<td>Spring</td>
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<td>ECE 302 and ECE 303 R: Open only to juniors or seniors or graduate students in the Department of Electrical and Computer Engineering, ECE 402</td>
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<td>405</td>
<td>Electromagnetic Fields and Waves II</td>
<td>Fall, Spring</td>
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<td>ECE 305 R: Open only to juniors or seniors or graduate students in the Department of Electrical and Computer Engineering, ECE 405</td>
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<td>408</td>
<td>Electromagnetic Compatibility</td>
<td>Spring</td>
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<td>ECE 202 and ECE 305 and ECE 366 R: Open only to juniors or seniors or graduate students in the Department of Electrical and Computer Engineering, ECE 408</td>
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<td>410</td>
<td>VLSI Design</td>
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<td>411</td>
<td>Electronic Design Automation</td>
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<td>ECE 320 or ECE 331 R: Open only to juniors or seniors or graduate students in the Department of Electrical and Computer Engineering or Department of Computer Science and Engineering, ECE 411</td>
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<td>415</td>
<td>Computer Aided Manufacturing</td>
<td>Fall, Spring</td>
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<td>ECE 313 or ME 451 R: Open only to juniors or seniors in the Manufacturing Engineering major, ECE 415</td>
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**Notes:**
- ECE—Electrical and Computer Engineering
- Courses marked with **R:** Open only to students in the Department of Electrical and Computer Engineering or Department of Computer Science and Engineering.
- Courses marked with **P:** Open only to ECE 202 R: Open only to juniors or seniors or graduate students in the Department of Electrical and Computer Engineering.
- Courses marked with **M:** Open only to juniors or seniors or graduate students in the Electrical Engineering major.
- Courses marked with **ECE:** Open only to juniors or seniors or graduate students in the Electrical Engineering major and to ECE 410.
- Courses marked with **CSE:** Open only to juniors or seniors or graduate students in the Computer Engineering major.
- Courses marked with **G:** Open only to students in the Department of Computer Science and Engineering.

**Additional Information:**
- **313 Control Systems**
- **320 Energy Conversion and Power Electronics**
- **330 Digital Logic Fundamentals**
- **331 Microprocessors and Digital Systems**
- **341 Electronic Instrumentation and Systems**
- **366 Introduction to Signal Processing**
  - Fall of even years, Spring, Summer. Fourier and spectral analysis. Signals. Elementary modulation techniques. Filter and channel models. The z-transform. Introduction to random processes and noise in discrete time. Application examples.
416 Digital Control
Spring, 3(2-3) P:M: ECE 303 and ECE 313
R: Open only to juniors or seniors in the Electrical Engineering major or Computer Engineering major.

418 Algorithms of Circuit Design
Fall, 3(3-0) P:M: ECE 302 and ECE 303 and ECE 366 R: Open only to juniors or seniors or graduate students in the Department of Electrical and Computer Engineering. SA: EE 418

420 Machines and Power Laboratory
Spring, 1(3-0) P:M: (ECE 320 or concurrently) or (ECE 423 or concurrently) R: Open only to juniors or seniors in the Department of Electrical and Computer Engineering. Experimental investigation of machines, power electronics and power systems. Experimental verification of material found in introductory courses on energy conversion with extension to power electronics and power systems.

423 Power System Analysis
Spring, 3(3-0) P:M: ECE 320 or concurrently) or (ECE 423 or concurrently) R: Open only to juniors or seniors or graduate students in the Department of Electrical and Computer Engineering. SA: EE 421

457 Communication Systems
Spring, 3(3-0) P:M: ECE 302 and ECE 366 R: Open only to juniors or seniors or graduate students in the Department of Electrical and Computer Engineering. SA: EE 457

468 Communication Systems Laboratory
Spring, 1(3-0) P:M: ECE 303 and (ECE 457 or concurrently) SA: EE 458
A projects laboratory in communication systems.

466 Digital Signal Processing and Filter Design
Fall, 3(3-0) P:M: ECE 366 R: Open only to seniors or graduate students in the Department of Electrical and Computer Engineering. SA: EE 466

472 Principles of Electronic Devices
Fall, Spring, 3(3-0) P:M: ECE 302 and ECE 305 SA: EE 474
Energy levels in atoms. Crystal properties, energy bands and charge carriers, semiconductors, transport properties of bulk materials, P-n junction diodes, bipolar transistors, field effect transistors.

474 Electronic Optics
Fall, Summer, 4(3-3) P:M: ECE 302 and ECE 303 and ECE 305 R: Open only to juniors or seniors or graduate students in the Electrical Engineering major and juniors or seniors in the Computer Engineering major. SA: EE 476
Operational theory, characteristics and applications of optical components, light emitting diodes, lasers, laser diodes, photodetectors, photovoltaics, fiber optics, optical modulators and non-linear optical devices.

477 Microelectronic Fabrication
Fall, 3(3-2) P:M: ECE 474 or concurrently R: Open only to juniors or seniors in the Department of Electrical and Computer Engineering SA: EE 479
Microelectronic processing fundamentals and simulations. Comparison of current microfabrication technologies and their limitations.

480 Senior Design
Fall, Spring, 5(3-6) P:M: ECE 303 and ECE 313 and ECE 320 and ECE 331 and ECE 366 or (CSE 410 and CSE 420 and completion of Tier I writing requirement) R: Open only to seniors in the Department of Electrical and Computer Engineering. SA: EE 481, ECE 482, ECE 483
Electrical engineering and computer engineering senior design experience involving contemporary design tools and practices, engineering standards, ethics, cross-functional teaming, oral and written technical communication, lifelong learning.

490 Independent Study
Fall, Spring, Summer. 1 to 3 credits. A student may earn a maximum of 3 credits in all enrollments for this course. R: Approval of department. SA: EE 490
Independent study of a topic in electrical engineering or computer engineering.

491 Special Topics
Fall, Spring, Summer. 1 to 4 credits. A student may earn a maximum of 6 credits in all enrollments for this course. R: Open only to students in the Department of Electrical and Computer Engineering. SA: EE 491
Investigation of special topics in electrical engineering or computer engineering.

499 Undergraduate Research
Fall, Spring, Summer. 1 to 3 credits. A student may earn a maximum of 4 credits in all enrollments for this course. R: Approval of department. SA: EE 499
Independent undergraduate research in contemporary areas of electrical engineering or computer engineering.

801 Independent Study
Fall, Spring, Summer. 1 to 3 credits. A student may earn a maximum of 3 credits in all enrollments for this course. R: Approval of department. SA: EE 801
Independent investigation of a topic in electrical engineering compatible with the student's prerequisites, interest, and ability.

802 Selected Topics
Fall, Spring. 1 to 4 credits. A student may earn a maximum of 21 credits in all enrollments for this course. SA: EE 802
Investigation of special topics in electrical engineering.

807 Computer System Performance and Measurement
Spring of odd years. 3(3-0) Interdepartmental with Computer Science and Engineering. Administered by Computer Science and Engineering. RB: CSE 410 and STT 411 R: Open only to Computer Science or Electrical Engineering majors. SA: CPS 807

808 Modelling and Discrete Simulation
Spring of even years. 3(3-0) Interdepartmental with Computer Science and Engineering. Administered by Computer Science and Engineering. SA: EE 808
Arithmetic, signal processing, and image processing algorithms. Array structures: systolic architecture, data flow structure, neural network architecture, performance analysis.

810 Radio Frequency Integrated Circuits
Fall, 3(3-0) RB: Electrical and Computer Engineering and Computer Science and Engineering.
Transceiver architecture designs with emphasis on hardware building blocks. Integrated radio frequency designs for various communication standards. Basic building blocks including low noise and power amplifiers, mixers, voltage control oscillators, and frequency synthesizers. Integrated circuit designs of basic building blocks.

813 Advanced VLSI Design
Spring, 3(3-0) Interdepartmental with Computer Science and Engineering. Administered by Electrical and Computer Engineering. P:M: ECE 410 SA: EE 813

814 Embedded Wireless RF Transceivers
Fall of even years, 3(3-0) Transceiver architecture designs. Software components. Realtime computing and synchronization on digital signal processing platforms, embedded software transceivers, receiver hardware and software considerations, signal structures and CDMA codes, real-time acquisitions and tracking, synchronization, software receivers.
816 Cryptography and Network Security
Fall. 3(3-0) Major security techniques, including authenticity, confidentiality, message integrity, non-repudiation, and the mechanisms to achieve them. Network security, and system security practices, including authentication practice, e-mail security, IP security, Web security, and firewalls.

818 Robotics
Spring. 3(3-0) RB: ECE 313 or ME 451 R: Open only to graduate students in the College of Engineering. Robot modeling, kinematics, dynamics, trajectory planning, programming, sensors, controller design.

820 Advanced Computer Architecture
Fall, Spring. 3(3-0) Interdepartmental with Computer Science and Engineering. Administered by Computer Science and Engineering. RB: CSE 410 and CSE 420 R: Open only to Computer Science or Electrical Engineering majors. SA: CPS 420 Instruction set architecture. Pipelining, vector processors, cache memory, high bandwidth memory design, virtual memory, input and output. Benchmarking techniques. New developments related to single CPU systems.

821 Advanced Power Electronics and Applications
Fall. 3(3-0) RB: Power and computer engineering areas. Power semiconductor devices, circuits, control, and applications. Converter and inverter analysis and design, DSP (Digital Signal Processor) control and implementation. Automotive and utility applications.

823 Power System Stability and Control
Fall of even years. 3(3-0) RB: ECE 826 SA: EE 823 Analysis and simulation of small and large disturbance stability of power systems. Generator, exciter, voltage regulator models. Design of excitation systems and power system stabilizers.

824 Power System Operation and Control
Fall of odd years. 3(3-0) RB: ECE 421 and STT 351 SA: EE 824 Operation and planning of power systems including loadflow, unit commitment, production cost methods. On-line operation and control including automatic generation control, economic dispatch, security assessment, state estimation.

825 Alternating Current Electrical Machines and Drives
Spring of even years. 3(3-0) RB: ECE 320 SA: EE 825 Analysis, modeling and design of synchronous, induction, and switched reluctance machines. Design drives for motion control and power system applications.

826 Linear Control Systems
Fall. 3(3-0) RB: MTH 314 SA: EE 826 Vector spaces, representation, system description, solution to the state equations, stability, controllability and observability. Adjoints of linear maps. Eigenstructure assignment. Partial and full order observers. Disturbance decoupling.

831 Analog Circuit Theory

832 Analog Integrated Circuit Design

835 Advanced Electromagnetic Fields and Waves II

836 Advanced Electromagnetic Fields and Waves II

841 Fourier Optics

850 Electrodynamics of Plasmas
Spring of odd years. 3(3-0) Interdepartmental with Astronomy and Astrophysics and Physics. Administered by Electrical and Computer Engineering. RB: ECE 835 or PHY 488 SA: EE 850 Plasma kinetic and macroscopic plasma transport theory. Electromagnetic wave propagation and charged particle diffusion processes in plasma. Electromagnetic energy absorption via elastic and inelastic collisions. DC, RF, and microwave discharges.

851 Linear Systems and Control
Fall. 3(3-0) Interdepartmental with Mechanical Engineering. Administered by Electrical and Computer Engineering. RB: Undergraduate coverage of linear algebra, differential equations and control systems. State models and their stability, controllability, and observability properties. Finding minimal realizations of transfer functions. Design of state and output feedback controllers. Design of state observers. LQ regulator and the Kalman filter. Time-varying systems.

853 Optimal Control
Spring of odd years. 3(3-0) Interdepartmental with Mechanical Engineering. Administered by Electrical and Computer Engineering. Static optimization. Nonlinear optimal control of discrete and continuous systems, with specialization to the LQ regulator and tracking. Extending the deterministic results to the Kalman filter and the LQG regulator. Dynamic programming and inequality constraints. Convex optimization and LMI’s.

854 Robust Control

856 Adaptive Control

859 Nonlinear Control

859 Nonlinear Systems and Control
Spring. 3(3-0) Interdepartmental with Mechanical Engineering. Administered by Mechanical Engineering. RB: ECE 826 and ME 857 SA: ECE 827 Second-order systems and fundamental properties of solutions. Lyapunov stability, input-output stability, passivity, absolute stability, and linearization. Design of feedback controllers using integral control, feedback linearization, sliding mode control, Lyapunov redesign, passivity-based control, and recursive methods. Applications to electrical and mechanical systems.

863 Analysis of Stochastic Systems
Fall. 3(3-0) RB: STT 441 SA: EE 863 Advanced topics in random variable theory. Stochastic processes and stochastic calculus. Optimal systems for filtering and detection.

864 Detection and Estimation Theory
Spring. 3(3-0) RB: ECE 863 SA: EE 864 Analysis and implementation of statistical estimation and detection methods used in signal processing, communications, and control applications. Bayesian, Neyman-Pearson, and minimax detection schemes. Bayesian, mean-square-error, and maximum-likelihood estimation methods.

865 Analog and Digital Communications
Fall of odd years. 3(3-0) RB: ECE 457 and ECE 865 SA: EE 865 Optimum signal design in noisy channels, matched filters, quadrature sampling of band-pass signals in noise. Coherent and non-coherent binary modulation such as PSK, FSK, DPSK, M-ary modulation, intersymbol interference, spread spectrum.
870 Introduction to Micro-Electro-Mechanical Systems
Fall, 3(3-0) RB: ECE 477 and ECE 474

871 Micro-electro-mechanical Systems Fabrication
Spring, 3(3-0) P:M: ECE 870 or ECE 477
Development of a complete integrated microsystem from the design to the test. Design, fabrication and testing of integrated Microsystems. Development of a complete multichip microsystem containing sensors, signal processing, and an output interface. Basic EOS device and circuit processes, wafer bonding and micromachining, low power portable devices and diamond MEMS chips.

874 Physical Electronics
Fall, 3(3-0) SA: EE 874

875 Electronic Devices
Spring, 3(3-0) RB: ECE 874 SA: EE 875
Operating properties of semiconductor devices including DC, AC, transient and noise models of FET, BJT, metal-semiconductor contact, heterostructure, microwave and photonic devices.

885 Artificial Neural Networks
Fall, 3(3-0) Interdepartmental with Computer Science and Engineering, Administered by Electrical and Computer Engineering. SA: EE 885

899 Master's Thesis Research
Fall, Spring, Summer. 1 to 8 credits. A student may earn a maximum of 24 credits in all enrollments for this course. SA: EE 899
Master's thesis research.

900 Selected Topics in High Performance Computer Systems
Spring of odd years, 3(3-0) A student may earn a maximum of 9 credits in all enrollments for this course. Interdepartmental with Computer Science and Engineering. Administered by Computer Science and Engineering. SA: EE 822 R: Open only to students in the Computer Science and Engineering major or approval of department. SA: CPS 920
Design of high performance computer systems. Seminar format.

921 Advanced Topics in Digital Circuits and Systems
Fall, Spring, 3(3-0) A student may earn a maximum of 6 credits in all enrollments for this course. Interdepartmental with Computer Science and Engineering. Administered by Electrical and Computer Engineering. SA: EE 921
Topics vary each semester.

921B Embedded Architectures
Fall of odd years, Spring of odd years. 3(3-0) Interdepartmental with Computer Science and Engineering. Administered by Electrical and Computer Engineering. RB: ECE 809 and ECE 813 SA: EE 921B
Embedded computers and architectures for real-time computation and/or robust control. ASICs, Bit-slice architectures. Systolic arrays. Neural networks. Genetic algorithms. Implementation technologies and design issues.

925 Advanced Topics in Power
Spring, 3(3-0) A student may earn a maximum of 9 credits in all enrollments for this course. SA: EE 925
Topics vary each semester.

925C Advanced Machine Drives
Fall of odd years, Spring of odd years. 3(3-0) RB: ECE 825 and ECE 829 SA: EE 925C
Nonlinear drives based on state reconstruction and nonlinear and adaptive control. Sensors, implementation, special computer architectures.

929 Advanced Topics in Electromagnetics
Fall, Spring. 3 to 4 credits. A student may earn a maximum of 10 credits in all enrollments for this course. SA: EE 929
Topics vary each semester.

929A Planar Waveguides and Circuits
Fall of odd years, Spring of odd years. 3(3-0) RB: ECE 835 SA: EE 929A

929B Antenna Theory
Fall of odd years, Spring of odd years. 4(4-0) RB: ECE 835 SA: EE 929B

929C Geometrical Theory of Diffraction
Fall of odd years, Spring of odd years. 3(3-0) RB: ECE 835 SA: EE 929C

931 Advanced Topics in Electronic Devices and Materials
Fall, Spring. 1 to 4 credits. A student may earn a maximum of 12 credits in all enrollments for this course. SA: EE 931
Topics vary each semester.

931A VLSI Technology
Fall of odd years, Spring of odd years. 3(3-0) RB: ECE 875 SA: EE 931A
Oxidation, doping techniques, simulation techniques, film deposition and etching, epitaxial growth, lithography, passivation, and packaging.

931B Microdevices and Microstructures
Fall of odd years. Spring of odd years. 3(3-0) RB: ECE 874 SA: EE 931B

931C Properties of Semiconductors
Fall of odd years. Spring of odd years. 3(3-0) RB: ECE 874 SA: EE 931C
Carrier scattering, single particle and collective transport, quantum effects, hot electron effects, electron-photon and electron-phonon interactions.

932 Advanced Topics in Analog Circuits
Spring of odd years. 3(3-0)
Variable topics in advanced circuit analysis.

960 Advanced Topics in Control
Fall, Spring, 3(3-0) A student may earn a maximum of 6 credits in all enrollments for this course. RB: ECE 827 and ECE 829 SA: EE 960
Topics vary each semester.

969B Nonlinear Control
Fall of odd years, Spring of odd years. 3(3-0) RB: ECE 827 and ECE 829 SA: EE 960B

963 Advanced Topics in Systems
Fall, Spring. 3(3-0) A student may earn a maximum of 9 credits in all enrollments for this course. SA: EE 963
Topics vary each semester.

966 Advanced Topics in Signal Processing
Fall, Spring. 3(3-0) A student may earn a maximum of 9 credits in all enrollments for this course. SA: EE 966
Topics vary each semester.

966A Discrete Time Processing of Speech Signals
Fall of odd years, Spring of odd years. 3(3-0) RB: ECE 466 and ECE 863 and ECE 864 SA: EE 966A

966B Multidimensional Signal Processing
Fall of odd years, Spring of odd years. 3(3-0) RB: ECE 466 and ECE 864 SA: EE 966B
966C  **Advanced Topics in Statistical Signal Processing**
Fall of odd years, Spring of odd years. 3(3-0) RB: ECE 466 and ECE 863 and ECE 864
SA: EE 966C
Communication channels, noise models, hypothesis testing of signals by Bayesian minimax, and Neyman-Pearson criteria. Performance evaluation using ROC. Bayesian and maximum likelihood parameter estimation. Kalman-Bucy filtering.

989  **Advanced Topics in Plasma**
Fall of odd years, Spring of odd years. 3(3-0) A student may earn a maximum of 6 credits in all enrollments for this course. SA: EE 989
Topics vary each semester.

989A  **Plasma Processing for IC Fabrication**
Fall of odd years, Spring of odd years. 3(3-0) RB: ECE 835 and ECE 850 SA: EE 989A
Process requirements. Plasma reactors. Etching and deposition applications. Broad ion beam processing.

999  **Doctoral Dissertation Research**
Fall, Spring, Summer. 1 to 24 credits. A student may earn a maximum of 72 credits in all enrollments for this course. SA: EE 999
Doctoral dissertation research.