ELECTRICAL AND COMPUTER ENGINEERING

Undergraduate Program Information
Overview
The undergraduate electrical engineering program of the Klipsch School is accredited by the Engineering Accreditation Commission of ABET, Inc., and stresses the development of analytical tools and physical concepts required to prepare students for immediate employment or graduate study. The program is flexible, allowing students to choose elective coursework towards concentrations in:

• communications and signal processing,
• computers and microelectronics,
• control and power,
• electromagnetics and photonics, or
• space systems.

Alternatively, students can select "no concentration" for the greatest flexibility in course selection.

Undergraduate Electrical Engineering Program Educational Objectives
The Klipsch School is dedicated to providing a quality, hands-on, educational experience for our students. Below are the program educational objectives (PEOs) that describe the expected accomplishments of graduates during their first few years after graduation.

1. Our graduates will obtain relevant, productive employment in the private sector, government and/or pursue an advanced degree.
2. Our graduates will be using their engineering foundation to innovate solutions to the problems of the real world.

Related Areas of Study
Electrical and computer engineering students wishing to broaden their educational experience may elect to earn additional bachelor's degrees in

• Engineering Physics
• Computer Science
• Mathematics
• Physics

Klipsch School students may also choose to earn a minor in one or more of the following fields:

• Computer Engineering
• Computer Science
• Mathematics
• Physics

Students must consult with an academic advisor in the offering department for specific requirements related to additional degrees and minors.

Transfer Credit
Credit earned at other institutions is generally accepted; however the following restrictions apply to transfer credits:

• Engineering credit must be earned at an ABET accredited school.
• Physics must be calculus based.
• If the NMSU requirement includes a lab, the transfer credit must include a lab.
• A grade of C- or better, must have been earned.
• E E Courses numbered 300 or higher, Cornerstone and Capstone courses may not be transferred.

Master's Accelerated (BS/MS) Program (MAP)
Undergraduate students may apply for acceptance to the Master's Accelerated Program (MAP) after completing 60 semester hours of undergraduate coursework of which a minimum of 25 credit hours must be completed at NMSU. The GPA must be 3.0 or above. The students must meet all other requirements as specified by the program. The MAP program allows up to 12 credits of NMSU coursework (450 level or higher) taken during the undergraduate years to be counted toward the master's program of study. Students must receive a grade of B or higher in the courses to be counted for the graduate degree. The courses must logically fit into the master's program. More information and the application for the MAP program can be found at: https://honors.nmsu.edu/masters-accelerated-program-map/

Graduate Program Information
Overview
The Klipsch School of Electrical and Computer Engineering offers graduate work leading to the Master of Science and Doctor of Philosophy degrees. Areas of emphasis for masters and doctoral students are:

• communications,
• computer engineering,
• digital signal processing,
• electromagnetics,
• electric energy systems,
• photonics, and
• microelectronics/VLSI.

Research in the above areas currently being conducted by the faculty ensures that doctoral candidates will work on the frontier of knowledge in these areas. The graduate programs are intended to provide broad graduate-level training in electrical engineering. In addition, appropriate courses in computer science, industrial engineering, mathematics, physics and business management may be integrated into a graduate student's program of study.

Students desiring to work toward an advanced degree in electrical engineering must have completed undergraduate preparation substantially equivalent to that required for the Bachelor of Science in Electrical Engineering degree at this institution. For students with undergraduate degrees in other disciplines, see below. For further information on the Klipsch School of Electrical and Computer Engineering, please consult the web page http://www.ece.nmsu.edu/.

Research Facilities and Highlights
Faculty and staff in communications, telemetry and telemetering are involved in education and research programs focusing on
1. to provide a program of study at the graduate level in the planning, operation, and management of electric power generation, transmission, distribution, and utilization; and the integration of renewable energy and storage;
2. to supply the electric utility industry with the highest caliber of new engineering and management talent; and
3. to provide the university with the required financial and technical support to ensure a quality program.

In addition, faculty in EUMP work with M.S. and Ph.D. students to conduct funded research sponsored by Sandia National Laboratories, EPRI, NSF, DOE, CEC and the electrical utility industry. Much of the current research is focused on renewable energy integration, protection, advanced control and optimization, and customer driven microgrids. Laboratory facilities are available in the El Paso Electric Power Systems laboratory. The program works closely with the Institute for Energy and Environment (IEE) and with Southwest Technology Development Institute (SWTDI) which host the solar energy experiment station. The director of the EUMP and PNM Chair for Utility Management is Dr. Satish Ranade.

Faculty and students in the VLSI Laboratory are involved in the design and analysis of analog and mixed-signal microelectronic circuits and systems. Current research areas include

- wireless bio-circuits and sensors;
- green computing;
- intelligent sensing, sigma-delta sensing;
- low-voltage, low-power circuits;
- high performance operational amplifiers and operational transconductance amplifiers;
- energy harvesting and power management circuits; and
- analog machine vision and image processing.

Research sponsors include the National Science Foundation, Los Alamos National Laboratories and Agilent technologies. The director of the VLSI Laboratory is IEEE Fellow Dr. Jaime Ramirez-Angulo.

The Photonics program at NMSU offers unique opportunities to undergraduate and graduate students interested in pursuing a career in electro-optics, applied optics, photonics, or optical engineering by combining the optics resources of the Klipsch School and the Physics Department. Most of the optics classes are cross-listed in the two departments. The Klipsch School's Electro-Optics Research Laboratory (EORL) provides a variety of research opportunities in areas such as

- multispectral and polarimetric imaging,
- free-space optical communications,
- adaptive optics,
- nanophotonics and
- integrated electro-optic sensors and systems.

Sponsors include the Air Force Office of Scientific Research, Sandia National Laboratories, Air Force Research Laboratory, Army Research Laboratory, NASA, National Geospatial-Intelligence Agency and the National Science Foundation. SPIE Fellow Dr. David G. Voelz is the director of the EORL and NMSU's Photonics program.

The Computer Networking Lab (CNL) supports teaching and research in Internet and wireless sensor networks. The mission of CNL is to provide students with the opportunity to do cutting-edge research that has high practical relevance. Currently, research projects in CNL include secure
data dissemination in wireless sensor networks, solar-powered sensor networks, and RFID sensor networks. CNL is directed by Dr. Hong Huang.

Students and faculty associated with the Performance Evaluation and Architecture Research Laboratory (PEARL) conduct research in the areas of

- performance modeling and simulation techniques,
- micro-architecture power optimization,
- performance analysis and optimization of large-scale scientific applications, and
- heterogeneous HPC computing for field-deployable systems.

PEARL sponsors include the Army Research Labs (ARL), High Performance Computing Research Center (AHPCRC), Sandia National Laboratories, and Los Alamos National Laboratories. The laboratory’s director is Dr. Hameed Badawy.

Support for Graduate Students

A number of teaching assistantships, research assistantships and fellowships are available. Teaching assistants are recommended by individual faculty for selection by the ECE Department’s Graduate Studies Committee. International students must pass university screening prior to being eligible for selection as a TA. Nominations for new TAs are made by the advisor after a student is admitted. Research assistants are hired directly by the faculty member who has received a contract or grant for research.

The College of Engineering awards graduate scholarships and fellowships on behalf of Electrical and Computer Engineering. These include:

- the MIT/Lincoln Laboratory Fellowship,
- the Paul and Valerie Klipsch Grad Scholarship,
- the Admiral Paul Arthur Grad Scholarship, and
- the Barry Neil Rappaport Grad Scholarship.

Applications can be completed on-line at https://scholarships.nmsu.edu/. The priority deadline for the Scholar Dollars is March 1st. The Electrical Utility Management Program has a limited number of fellowships for students interested in pursuing master’s degrees in electrical engineering systems.

Admission

Prospective graduate students for the Master of Science or Doctor of Philosophy in Electrical Engineering must first meet the entrance requirements of the Graduate School. The prospective US graduate student should make formal application to the Graduate Student Services office (http://gradschool.nmsu.edu). International graduate students must start with the Admissions Office (https://issss.nmsu.edu/admissions). Official transcripts from all undergraduate and graduate institutions must be sent directly to the Graduate School. In addition, the student must arrange to have an official copy of the GRE (Graduate Record Examination) General Test scores sent to the Graduate School. International students must also submit their TOEFL (Test of English as a Foreign Language) scores. If the applicant meets the Graduate School’s minimum requirements, the application is sent to the Klipsch School’s Graduate Studies Committee for review. U.S. residents are given every chance of being successful in the pursuit of a graduate degree. If they do not meet the requirements of the Klipsch School, they can enter the Graduate School as “undeclared” where they must demonstrate competence in two or more graduate-level EE courses before they re-apply.

Requirements for Students Without BSEE Degree or Equivalent

Students without a BSEE degree or equivalent preparation will be expected to take classes covering the core knowledge required in our BSEE program. This includes mathematics through differential equations and basic engineering physics. The student’s graduate advisor will prepare an individualized deficiency schedule, based on the student’s academic background and work experience.

The following courses from our undergraduate program will be considered deficiencies for students without a BSEE

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<thead>
<tr>
<th>Prefix</th>
<th>Title</th>
<th>Credits</th>
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<tbody>
<tr>
<td>E   E 100</td>
<td>Introduction to Electrical and Computer Engineering</td>
<td>4</td>
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<tr>
<td>E   E 112</td>
<td>Linear Algebra, Probability and Statistics Applications</td>
<td>4</td>
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<tr>
<td>E   E 200</td>
<td>Circuit Analysis and Introduction to Electronics</td>
<td>4</td>
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<tr>
<td>E   E 212</td>
<td>Multivariate and Vector Calculus Applications</td>
<td>3</td>
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<td>E   E 317</td>
<td>Semiconductor Devices and Electronics I</td>
<td>4</td>
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<td>E   E 320</td>
<td>Signals and Systems I</td>
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<td>E   E 325</td>
<td>Signals and Systems II</td>
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<td>E   E 333</td>
<td>AC Circuit Analysis and Introduction to Power Systems</td>
<td>3</td>
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<td>E   E 340</td>
<td>Fields and Waves</td>
<td>4</td>
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Degrees for the Department

Electrical Engineering (No Concentration) - Bachelor of Science in Electrical Engineering (http://catalogs.nmsu.edu/nmsu/engineering/electrical-engineering/bachelor-science-electrical-engineering)

Electrical Engineering (Communications & Signal Processing) - Bachelor of Science in Electrical Engineering (http://catalogs.nmsu.edu/nmsu/engineering/electrical-engineering/bachelor-science-electrical-engineering)

Electrical Engineering (Computers & Microelectronics) - Bachelor of Science in Electrical Engineering (http://catalogs.nmsu.edu/nmsu/engineering/electrical-engineering/bachelor-science-electrical-engineering)

Electrical Engineering (Control & Power) - Bachelor of Science in Electrical Engineering (http://catalogs.nmsu.edu/nmsu/engineering/electrical-engineering/bachelor-science-electrical-engineering)

Electrical Engineering (Electromagnetics & Photonics) - Bachelor of Science in Electrical Engineering (http://catalogs.nmsu.edu/nmsu/engineering/electrical-engineering/bachelor-science-electrical-engineering)

Electrical Engineering (Space Systems) - Bachelor of Science in Electrical Engineering (http://catalogs.nmsu.edu/nmsu/engineering/electrical-
computer-science-electrical-engineering)

Electrical Engineering - Master of Engineering (Coursework) (http://catalogs.nmsu.edu/nmsu/engineering/electrical-computer-engineering/electrical-engineering-master-engineering)


Engineering - Doctor of Philosophy (http://catalogs.nmsu.edu/nmsu/engineering/electrical-computer-engineering/engineering-doctor-philosophy)

Minors for the Department

Computer Engineering - Undergraduate Minor (http://catalogs.nmsu.edu/nmsu/engineering/electrical-computer-engineering/computer-engineering-undergraduate-minor)

Electrical Engineering - Undergraduate Minor (http://catalogs.nmsu.edu/nmsu/engineering/electrical-computer-engineering/electrical-engineering-undergraduate-minor)

Graduate Certificates in the Department

Digital Communications - Graduate Certificate (http://catalogs.nmsu.edu/nmsu/engineering/electrical-computer-engineering/digital-communications-certificate)

Digital Signal Processing - Graduate Certificate (http://catalogs.nmsu.edu/nmsu/engineering/electrical-computer-engineering/digital-signal-processing-certificate)

Electric Energy Systems - Graduate Certificate (http://catalogs.nmsu.edu/nmsu/engineering/electrical-computer-engineering/electric-energy-systems-certificate)

Telemetry - Graduate Certificate (http://catalogs.nmsu.edu/nmsu/engineering/electrical-computer-engineering/telemetry-certificate)

Interim Department Head, Steve Stochaj

Professors Borah, Creusere, DeLeon, Ng, Ramirez-Angulo, Ranade, Stochaj, Voelz;

Associate Professors Boucheron, Cho, Dawood, Furth, Huang, Prasad, Tang;

Assistant Professors Badawy, Che, Lavoira, Mitchell, Sandoval;

College Assistant Professors Boehmer;

Emeritus Professors Carden, Giles, Sheila Horan, Stephen Horan, Johnson¹, Jordan, Kersting, Ludeman, Merrill, Reinfelds, Smolleck¹, Steelman¹, Taylor

¹ Registered Professional Engineer (NM)

Electrical Engineering Courses

E E 100. Introduction to Electrical and Computer Engineering
4 Credits (3+3P)
Introduction to analog (DC) and digital electronics. Includes electric component descriptions and equations, Ohm's law, Kirchhoff's voltage and current laws, ideal op-amp circuits, Boolean algebra, design of combinational and sequential logic circuits and VHDL or VERILOG.
Prerequisite(s)/Corequisite(s): C- or better in MATH 190G.

E E 112. Embedded Systems
4 Credits (3+3P)
Introduction to programming through microcontroller-based projects. Extensive practice in writing computer programs to solve engineering problems with microcontrollers, sensors, and other peripheral devices.
Prerequisite(s)/Corequisite(s): E E 100.

E E 200. Linear Algebra, Probability and Statistics Applications
4 Credits (3+3P)
The theory of linear algebra (vectors and matrices) and probability (random variables and random processes) with application to electrical engineering. Computer programming to solve problems in linear algebra and probability.
Prerequisite(s): C- or better in E E 112 and MATH 192G.

E E 212. Introduction to Computer Organization
4 Credits (3+3P)
Concepts of modern computer organization, CPU control, pipelining, memory hierarchies, memory mapping, hardware-software interface, and operating systems.
Prerequisite(s)/Corequisite(s): E E 112. Prerequisite(s): C- or better in E E 100 and MATH 190G.

E E 230. Circuit Analysis and Introduction to Electronics
4 Credits (3+3P)
Circuit analysis techniques, RLC transients, phasors, filter response, and an introduction to discrete electronic devices.
Prerequisite(s)/Corequisite(s): PHYS 216G. Prerequisite(s): C- or better in E E 100 and MATH 192G.

E E 240. Multivariate and Vector Calculus Applications
3 Credits
Vector algebra, cylindrical and spherical coordinates, partial derivatives, multiple integrals. Calculus of vector functions through electrostatic applications. Divergence, gradient, curl, divergence theorem, Stokes's theorem, Coulomb's Law, Gauss's Law, electric field, electric potential. Applications in Matlab.
Prerequisite(s): C- or better in MATH 192G and E E 112.

E E 300. Cornerstone Design
2 Credits (1+3P)
Application and realization of engineering principles to a guided team-based design project. Formulation and implementation of test procedures, evaluation of alternate solutions and oral and written communication of the design and test results. Restricted to: E E majors. Restricted to Las Cruces campus only.
Prerequisite(s): C- or better in E E 112, E E 212 and E E 230.

E E 317. Semiconductor Devices and Electronics I
4 Credits (3+3P)
Analysis and design of opamp circuits, diode circuits and single-transistor MOS and BJT amplifiers. Introduction to solid-slate semiconductor devices.
Prerequisite(s): C- or better in E E 230 and CHEM 111G.
E E 320. Signals and Systems I
3 Credits
Introduction to the modeling and analysis of continuous- and discrete-time signals and systems using time- and frequency-domain methods suitable for both mathematical approaches and computer-aided simulations.
Prerequisite(s)/Corequisite(s): MATH 392. Prerequisite(s): C- or better in E E 200 and E E 230.

E E 325. Signals and Systems II
4 Credits (3+3P)
Introduction to communication systems including amplitude and frequency modulation. Introduction to control systems including linear feedback systems, root-locus analysis, and graphical representations. Introduction to digital signal processing including sampling, digital filtering, and spectral analysis. May be repeated up to 4 credits.
Prerequisite(s): C- or better in E E 320 and MATH 392.

E E 333. AC Circuit Analysis and Introduction to Power Systems
3 Credits (2+3P)
Steady-state analysis of AC circuits, three-phase circuits, and an introduction to power systems.
Prerequisite(s): C- or better in E E 230.

E E 340. Fields and Waves
4 Credits (3+3P)
Static electromagnetic field. Maxwell's equation and time-varying electromagnetic fields. Generalized plane wave propagation, reflection, transmission, superposition and polarization. Transmission line theory. Extensions to optical wave propagation. Applications including Time Domain Reflectrometry (TDR) and fiber optic transmission. Laboratory experience with RF/microwave test equipment and optical apparatus.
Prerequisite(s): C- or better in E E 230, E E 240 and PHYS 216G.

E E 395. Introduction to Digital Signal Processing
3 Credits
Introduction to digital signal processing including sampling, digital filtering, z-transforms, transfer functions, digital filter realizations, discrete Fourier transform (DFT) and fast Fourier transform (FFT), finite impulse response (FIR) and infinite impulse response (IIR) filter design, and digital signal processing (DSP) applications. Laboratory work will emphasize practical implementation of signal processing including real-time signal processing.
Prerequisite(s): C- or better in E E 325.

E E 400. Undergraduate Research
1-3 Credits
Directed undergraduate research. May be repeated for a maximum of 9 credits.
Prerequisite: consent of the department head.

E E 402. Capstone Design I
3 Credits (2+3P)
Application and realization of engineering principles to a significant team-based design project with significant student management and autonomy. Determination of performance requirements, including safety, economics, ethics and manufacturability; extensive communication of design choices and test results to broad audiences; and interfacing of design with other hardware and software. Restricted to: E E majors.
Prerequisite(s): C- or better in E E 300, E E 317, E E 325, E E 333 and E E 340.

E E 404. Capstone Design II
3 Credits (2+3P)
Realization of design project from E E 402 within time and budget constraints. Restricted to: E E majors.
Prerequisite(s): C- or better in E E 300, E E 317, E E 325, E E 333, E E 340 and E E 402.

E E 412. ASIC Design
3 Credits
This course provides students with experiential knowledge of modern application specific integrated circuits. Topics include ASIC packaging and testing, I/O pads and ESD, Verilog programming and simulation, FPGA verification, Register-transfer level synthesis, timing and area optimization, floorplanning and routing, digital interfaces, full custom and standard cell design, post-layout simulation, and PCB schematics and layout. Crosslisted with: E E 512.
Prerequisite(s)/Corequisite(s): E E 480.

E E 425. Introduction to Semiconductor Devices
3 Credits
Energy bands, carriers in semiconductors, junctions, transistors, and optoelectronic devices, including light-emitting diodes, laser diodes, photodetectors, and solar cells. Crosslisted with: E E 525.
Prerequisite(s): C- or better in E E 317 and E E 340.

E E 431. Power Systems II
3 Credits
Analysis of a power system in the steady-state. Includes the development of models and analysis procedures for major power system components and for power networks. Crosslisted with: E E 542.
Prerequisite(s): C- or better in E E 333.

E E 432. Power Electronics
3 Credits (2+3P)
Basic principles of power electronics and its applications to power supplies, electric machine control, and power systems.
Prerequisite(s)/Corequisite(s): E E 325. Prerequisite(s): C- or better in E E 317 and E E 333.

E E 443. Mobile Application Development
3 Credits
Introduction to mobile application development. Students will develop applications for iOS devices including iPhone and iPad. Topics include object-oriented programming using Swift, model-view-controller (MVC) pattern, view controllers including tables and navigation, graphical user interface (GUI) design, data persistence, GPS and mapping, camera, and cloud and web services. Crosslisted with: E E 593.
Prerequisite(s): C- or better in C S 151 or C S 152 or C S 172 or C S 271 or C S 451 or C S 452.

E E 444. Advanced Image Processing
3 Credits
Advanced topics in image processing including segmentation, feature extraction, object recognition, image understanding, big data, and applications. Crosslisted with: E E 588.
Prerequisite(s): C- or better in E E 446.

E E 446. Digital Image Processing
3 Credits
Two-dimensional transform theory, color images, image enhancement, restoration, segmentation, compression and understanding. Crosslisted with: E E 596.
Prerequisite(s): E E 395.
**E E 447. Neural Signal Processing**  
3 Credits  
Cross-disciplinary course focused on the acquisition and processing of neural signals. Students in this class will learn about basic brain structure, different brain signal acquisition techniques (fMRI, EEG, MEG, etc.), neural modeling, and EEG signal processing. To perform EEG signal processing, students will learn and use Matlab along with an EEG analysis package. Crosslisted with: E E 597.  
**Prerequisite(s):** C- or better in E E 325.

**E E 449. Smart Antennas**  
3 Credits  
Smart antenna and adaptive array concepts and fundamentals, uniform and planar arrays, optimum array processing. Adaptive beamforming algorithms and architectures: gradient-based algorithms, sample matrix inversion, least mean square, recursive least mean square, sidelobes cancellers, direction of arrival estimations, effects of mutual coupling and its mitigation. Crosslisted with: E E 549.  
**Prerequisite(s):** C- or better in E E 325 and E E 340.

**E E 452. Introduction to Radar**  
3 Credits  
**Prerequisite(s):** C- or better in E E 325 and E E 340.

**E E 453. Microwave Engineering**  
3 Credits  
Techniques for microwave measurements and communication system design, including transmissions lines, waveguides, and components. Microwave network analysis and active device design. Crosslisted with: E E 521.  
**Prerequisite(s):** C- or better in E E 340.

**E E 454. Antennas and Radiation**  
4 Credits (3+3P)  
**Prerequisite(s):** C- or better in E E 340.

**E E 458. Hardware Security and Trust**  
3 Credits  
This course introduces and investigates recent technology development for the design and evaluation of secure and trustworthy hardware and embedded systems. Topics include IoT security, cryptography, hardware security primitives, authentication and key generation, invasive and non-invasive attacks and countermeasures, IC piracy and intellectual property protection, hardware trojans, and secure boot. Crosslisted with: E E 558.  
**Prerequisite(s):** C- or better in E E 212.

**E E 460. Space System Mission Design and Analysis**  
3 Credits  
Satellite system design, including development, fabrication, launch, and operations. A systems engineering approach to concepts, methodologies, models, and tools for space systems.  
**Prerequisite:** junior standing.

**E E 461. Systems Engineering and Program Management**  
3 Credits  
Modern technical management of complex systems using satellites as models. Team projects demonstrate systems engineering disciplines required to configure satellite components.  
**Prerequisite(s):** Junior standing.

**E E 462. Computer Systems Architecture**  
3 Credits  
The course covers uniprocessors, caches, memory systems, virtual memory, storage systems, with introduction to multiprocessor and distributed computer architectures; models of parallel computation; processing element and interconnection network structures, and nontraditional architectures. Crosslisted with: E E 562.  
**Prerequisite(s):** C- or better in E E 212.

**E E 465. MACHINE LEARNING I**  
3 Credits  
An undergraduate-level introduction to machine learning algorithms, including supervised and unsupervised learning methods. Topics covered include clustering, linear regression models, linear discriminant functions, feed-forward neural networks, statistical pattern classification and regression, maximum likelihood, naive Bayes, non-parametric density estimation, mixture models, decision trees, and ensemble learning. Crosslisted with: E E 565.  
**Prerequisite(s):** E E 200.

**E E 467. ARM SOC Design**  
3 Credits  
The course aims to produce students who are capable of developing ARM-based SoCs from high level functional specifications to design, implementation and testing on real FPGA hardware using standard hardware description and software programming languages. Crosslisted with: E E 567.  
**Prerequisite(s):** C- or better in E E 212 and E E 317.

**E E 469. Communications Networks**  
3 Credits  
Introduction to the design and performance analysis of communications networks with major emphasis on the Internet and different types of wireless networks. Covers network architectures, protocols, standards and technologies; design and implementation of networks; networks applications for data, audio and video; performance analysis. Crosslisted with: E E 569.  
**Prerequisite(s):** C- or better in E E 100, E E 112 and (E E 200 or STAT 371).

**E E 473. Introduction to Optics**  
3 Credits  
The nature of light, geometrical optics, basic optical instruments, wave optics, aberrations, polarization, and diffraction. Elements of optical radiometry, lasers and fiber optics. Crosslisted with: PHYS 473.  
**Prerequisite(s):** C- or better in PHYS 216G or PHYS 217.

**E E 475. Automatic Control Systems**  
3 Credits  
**Prerequisite(s):** C- or better in E E 325.

**E E 476. Computer Control Systems**  
3 Credits  
Representation, analysis and design of discrete-time systems using time-domain and z-domain techniques. Microprocessor control systems.  
**Prerequisite(s):** C- or better in E E 325.
E E 478. Fundamentals of Photonics
4 Credits (3+3P)
Prerequisite(s): PHYS 216G or PHYS 217.

E E 479. Lasers and Applications
4 Credits (3+3P)
Prerequisite(s): C- or better in E E 340 or in PHYS 461.

E E 480. Introduction to Analog and Digital VLSI
3 Credits
Prerequisite(s): C- or better in E E 212 and E E 317.

E E 482. Electronics II
3 Credits
Feedback analysis, application of operational amplifiers, introduction to data converters, analog filters, and oscillator circuits.
Prerequisite(s): C- or better in E E 317.

E E 485. Analog VLSI Design
3 Credits (2+3P)
Analysis, design, simulation, layout and verification of CMOS analog building blocks, including references, opamps, switches and comparators. Teams implement a complex analog IC. Crosslisted with: E E 523.
Prerequisite(s): C- or better in E E 320 and E E 480.

E E 490. Selected Topics
1-3 Credits
May be repeated for a maximum of 9 credits. Graduate students may not use credits of E E 490 toward an M.S. or Ph.D. in electrical engineering.
Prerequisite: consent of instructor.

E E 493. Power Systems III
3 Credits
Analysis of a power system under abnormal operating conditions. Topics include symmetrical three-phase faults, theory of symmetrical components, unsymmetrical faults, system protection, and power system stability. Taught with E E 543.
Prerequisite(s)/Corequisite(s): E E 431. Prerequisite(s): C- or better in E E 333 or E E 391.

E E 496. Introduction to Communication Systems
3 Credits
Introduction to the analysis of signals in the frequency and time domains. A study of baseband digital transmission systems and digital/analog RF transmission systems. Introduction to telecom systems as well as satellite systems.
Prerequisite(s): C- or better in E E 325.

E E 497. Digital Communication Systems I
3 Credits
Prerequisite(s): C- or better in E E 200 and E E 325.

E E 501. Research Topics in Electrical and Computer Engineering
1 Credit
Ethics and methods of engineering research; contemporary research topics in electrical and computer engineering.

E E 510. Introduction to Analog and Digital VLSI
3 Credits

E E 512. ASIC Design
3 Credits
This course provides students with experiential knowledge of modern application specific integrated circuits. Topics include ASIC packaging and testing, I/O pads and ESD, Verilog programming and simulation, FPGA verification, Register-transfer level synthesis, timing and area optimization, floorplanning and routing, digital interfaces, full custom and standard cell design, post-layout simulation, and PCB schematics and layout. Recommended foundation: E E 480. Crosslisted with: E E 412.

E E 514. Biosensor Electronics
3 Credits
Course provides students with knowledge of basic integrated analog and RF blocks and how to combine these circuits into sensory systems for biomedical applications. Target areas are in physiology, brain-machine interfaces, neural recording and stimulation. Lecture includes details on amplifiers, current-mode circuits, A/D converters, low-power radio transmitters and receivers, and simulation and layout of VLSI circuits. Lectures are in the form of recent paper reviews and discussion. Includes teamwork, written and oral communication, and realistic technical requirements. Recommended foundation: E E 480 and E E 485.

E E 515. Electromagnetic Theory I
3 Credits

E E 516. Electromagnetic Theory II
3 Credits
Continuation of E E 515.

E E 518. Integrated Power Management Circuits
3 Credits
Design and analysis of power management integrated circuits, including linear voltage regulators, voltage references, buck, boost, and buck-boost DC-DC converters, and charge pumps. Extensive use of CAD tools are used to simulate these circuits. Recommended foundation: E E 480 and E E 485.
E E 519. RF Microelectronics
3 Credits
Prerequisite(s): E E 485 or E E 523.

E E 520. A/D and D/A Converter Design
3 Credits
Practical design of integrated data converters in CMOS/BJT technologies, OP-AMPS, comparators, sample and holds, MOS switches, element mismatches. Nyquist rate converter architectures: flash, successive approximation, charge redistribution, algorithmic, two step, folding, interpolating, pipelined, delta-sigma converters. Restricted to: Main campus only.
Prerequisite(s): E E 523.

E E 521. Microwave Engineering
3 Credits
Techniques for microwave measurements and communication system design, including transmission lines, waveguides, and components. Microwave network analysis and active device design. Recommended foundation: E E 340. Crosslisted with: E E 453.

E E 522. Advanced Analog VLSI Design
3 Credits
Design of high-performance operational amplifiers; class-AB, rail-to-rail, low-voltage, high-bandwidth, fully-differential. Design of linear operational transconductance amplifiers, high-frequency integrated filters, four-quadrant multipliers, and switched-capacitor circuits.
Prerequisite(s): E E 523.

E E 523. Analog VLSI Design
3 Credits (2+3P)
Analysis, design, simulation, layout and verification of CMOS analog building blocks, including references, opamps, switches and comparators. Teams implement a complex analog IC. Recommended foundation: E E 320 and E E 480. Crosslisted with: E E 485.

E E 525. Introduction to Semiconductor Devices
3 Credits

E E 528. Fundamentals of Photonics
4 Credits (3+3P)
Ray, wave and guided optics, lasers and thermal sources, radiometry, photon detection and signal-to-noise ratio. Elements of photonic crystals, polarization, acousto-optics, electro-optics, and optical nanostructures. Taught with E E 478 with differentiated assignments for graduate students. Recommended foundation: (PHYS 216 or PHYS 217) and E E/PHYS 473. Crosslisted with: PHYS 528.

E E 529. Lasers and Applications
4 Credits (3+3P)
Laser operating principles, characteristics, construction and applications. Beam propagation in free space and fibers. Laser diode construction and characteristics. Hands-on laboratory. Recommended foundation: E E 351 or PHYS 461. Taught with: E E 479 with differentiated assignments for graduate students. Crosslisted with: PHYS 529

E E 532. Dynamics of Power Systems
3 Credits
Transient and dynamic stability of power systems; synchronous machine modeling and dynamics; prediction and stabilization of system oscillations. Recommended foundation: E E 493.

E E 533. Power System Operation
3 Credits
AGC, economic dispatch, unit commitment, operations planning, power flow analysis and network control, system control centers. Recommended foundation: E E 493.

E E 534. Power System Relaying
3 Credits

E E 537. Power Electronics
3 Credits (2+3P)
Basic principles of power electronics and its applications to power supplies, electric machine control, and power systems. Recommended foundation: E E 325, E E 317, and E E 333. Crosslisted with: E E 432.

E E 541. Antennas and Radiation
4 Credits (3+3P)

E E 542. Power Systems II
3 Credits

E E 543. Power Systems III
3 Credits
Analysis of a power system under abnormal operating conditions. Topics include symmetrical three-phase faults, theory of symmetrical components, unsymmetrical faults, system protection, and power system stability. Recommended foundation: E E 431. Crosslisted with: E E 493.

E E 544. Distribution Systems
3 Credits
Concepts and techniques associated with the design and operation of electrical distribution systems. Recommended foundation: E E 542 and E E 543.

E E 545. Digital Signal Processing II
3 Credits
Non-ideal sampling and reconstruction, oversampling and noise shaping in A/D and D/A, finite word length effects, random signals, spectral analysis, multirate filter banks and wavelets, and applications. Recommended foundation: E E 395.

E E 546. Introduction to Smart Grid
3 Credits
The course will serve as an introduction to the technologies and design strategies associated with the Smart Grid. The emphasis will be on the development of communications, energy delivery, coordination mechanisms, and management tools to monitor transmission and distribution networks. Crosslisted with: E E 426 and C S 514.
E E 548. Introduction to Radar
3 Credits

E E 549. Smart Antennas
3 Credits

E E 551. Control System Synthesis I
3 Credits
An advanced perspective of linear modern control system analysis and design, including the essential algebraic, structural, and numerical properties of linear dynamical systems.

E E 558. Hardware Security and Trust
3 Credits
This course introduces and investigates recent technology development for the design and evaluation of secure and trustworthy hardware and embedded systems. Topics include IoT security, cryptography, hardware security primitives, authentication and key generation, invasive and noninvasive attacks and countermeasures, IC piracy and intellectual property protection, hardware trojans, and secure boot. Recommended foundation: E E 212. Crosslisted with: E E 458.

E E 562. Computer Systems Architecture
3 Credits
The course covers uniprocessors, caches, memory systems, virtual memory, storage systems, with introduction to multiprocessor and distributed computer architectures; models of parallel computation; processing element and interconnection network structures, and nontraditional architectures. Recommended foundation is E E 212. Crosslisted with: E E 462.

E E 563. Computer Performance Analysis I
3 Credits
Issues involved and techniques used to analyze performance of a computer system. Topics covered include computer system workloads; statistical analysis techniques such as principal component analysis, confidence interval, and linear regression; design and analysis of experiments; queuing system analysis; computer system simulation; and random number generation. Recommended foundation: E E 200 and E E 462.

E E 564. Advanced Computer Architecture I
3 Credits
Multiprocessor and distributed computer architectures; models of parallel computation; processing element and interconnection network structures, and nontraditional architectures. Recommended foundation: E E 462. Crosslisted with: C S 573.

E E 565. Machine Learning I
3 Credits
A graduate-level introduction to machine learning algorithms, including supervised and unsupervised learning methods. Topics covered include clustering, linear regression models, linear discriminant functions, feedforward neural networks, statistical pattern classification and regression, maximum likelihood, naive Bayes, non-parametric density estimation, mixture models, decision trees, and ensemble learning. Recommended foundation: E E 571 and MATH 480. Crosslisted with: E E 465.

E E 566. ARM SOC Design
3 Credits
The course aims to produce students who are capable of developing ARM-based SoCs from high level functional specifications to design, implementation and testing on real FPGA hardware using standard hardware description and software programming languages. Recommended foundation is E E 212 and E E 317. Crosslisted with: E E 467.

E E 569. Communications Network
3 Credits
Introduction to the design and performance analysis of communications networks with major emphasis on the Internet and different types of wireless networks. Covers network architecture, protocols, standards and technologies; design and implementation of networks; networks applications for data, audio and video; performance analysis. Recommended foundation: E E 100, E E 112 and (E E 200 or STAT 371). Crosslisted with: E E 469.

E E 571. Random Signal Analysis
3 Credits
Application of probability and random variables to problems in communication systems, analysis of random signal and noise in linear and nonlinear systems.

E E 572. Modern Coding Theory
3 Credits
Error control techniques for digital transmission and storage systems. Introduction to basic coding bounds, linear and cyclic block codes, Reed-Solomon codes, convolutional codes, maximum likelihood decoding, maximum a posteriori probability decoding, factor graphs, low density parity check codes, turbo codes, iterative decoding. Applications to data networks, space and satellite transmission, and data modems. Recommended foundation: E E 200 and E E 496.

E E 573. Signal Compression
3 Credits
Fundamentals of information source encoding and decoding. Includes information theory bounds on source coding, lossless coding algorithms, scalar quantizing and vector quantizing. 
Prerequisite: E E 571.

E E 575. Machine Learning II
3 Credits
Prerequisite(s): E E 565.
E E 577. Fourier Methods in Electro-Optics
3 Credits
Linear systems theory, convolution and Fourier transformation are applied to one-dimensional and two-dimensional signals encountered in electro-optical systems. Applications of diffraction, coherent and incoherent imaging, and optical signal processing. Recommended foundation: E E 320 and E E 528. Crosslisted with: PHYS 577.

E E 578. Optical System Design
3 Credits
Optical design software is used to study optical systems involving lenses, mirrors, windows and relay optics. Systems considered include camera lenses, microscopes and telescopes. Recommended foundation: E E/PHYS 473, E E/PHYS 528 and E E/PHYS 577. Crosslisted with: PHYS 578.

E E 580. Digital Image Processing
3 Credits

E E 581. Digital Communication Systems I
3 Credits

E E 581. Digital Communication Systems I
3 Credits

E E 583. Wireless Communication
3 Credits
Cellular networks, wireless channels and channel models, modulation and demodulation, MIMO, diversity and multiplexing, OFDM, wireless standards including LTE and WiMAX. Recommended foundation: E E 571 and E E 325.

E E 584. Mathematical Methods for Communications and Signal Processing
3 Credits
Applications of mathematical techniques from estimation theory, optimization principles and numerical analysis to the problems in communications and signal processing. Recommended foundation: MATH 480.
Prerequisite(s): E E 571.

E E 585. Telemetering Systems
3 Credits
Covers the integration of components into a command and telemetry system. Topics include analog and digital modulation formats, synchronization, link effects, and applicable standards. Recommended foundation: E E 395, E E 496, and E E 497.

E E 586. Information Theory
3 Credits
This class is a study of Shannon's measure of information and discusses mutual information, entropy, and channel capacity, the noiseless source coding theorem, the noisy channel coding theorem, channel coding and random coding bounds, rate-distortion theory, and data compression. Restricted to: Main campus only. Crosslisted with: MATH 509
Prerequisite(s): E E 571 or STAT 515.

E E 588. Advanced Image Processing
3 Credits
Advanced topics in image processing including segmentation, feature extraction, object recognition, image understanding, big data, and applications. Crosslisted with: E E 444.
Prerequisite(s): E E 444 or E E 596.

E E 590. Selected Topics
1-9 Credits
May be repeated for a maximum of 18 credits.

E E 591. Selected Topics
1-9 Credits
May be repeated for a maximum of 18 credits.

E E 593. Mobile Application Development
3 Credits
Introduction to mobile application development. Students will develop applications for iOS devices including iPhone and iPad. Topics include object-oriented programming using Swift, model-view-controller (MVC) pattern, view controllers including tables and navigation, graphical user interface (GUI) design, data persistence, GPS and mapping, camera, and cloud and web services. Recommended foundation: C S 451 or C S 452. Crosslisted with: E E 443.

E E 596. Digital Image Processing
3 Credits

E E 597. Neural Signal Processing
3 Credits
Cross-disciplinary course focused on the acquisition and processing of neural signals. Students in this class will be learn about basic brain structure, different brain signal acquisition techniques (fMRI, EEG, MEG, etc.), neural modeling, and EEG signal processing. To perform EEG signal processing, students will learn and use Matlab along with an EEG analysis package. Crosslisted with: E E 447.

E E 598. Master's Technical Report
1-9 Credits (1-9)
Individual investigation, either analytical or experimental, culminating in a technical report. May be repeated for a maximum of 18 credits. Graded PR/S/U. May be repeated up to 18 credits. Thesis/Dissertation Grading.

E E 599. Master's Thesis
1-15 Credits (1-15)

E E 600. Doctoral Research
1-15 Credits
Research.

E E 615. Computational Electromagnetics
3 Credits
The numerical solution of electromagnetics problems. Topics include differential equation techniques, integral equation methods, hybrid techniques, algorithm development and implementation, and error analysis. Particular algorithms, including FEM, finite differences, direct solvers, and iterative solvers, are studied.

E E 675. Machine Learning III
3 Credits
A research-oriented treatment of machine learning algorithms, including supervised, unsupervised, and reinforcement learning methods. Topics covered include Markov decision processes, deep reinforcement learning, neural logic networks, genetic algorithms, genetic programs, generative adversarial networks, and adaptive resonance theory models.
Prerequisite(s): E E 575.

E E 690. Selected Topics
1-9 Credits
May be repeated for a maximum of 9 credits.

E E 700. Doctoral Dissertation
1-15 Credits (1-15)
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Las Cruces, NM 88003

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