Electrical Engineering

Nature of Program

Electrical engineers design, develop, test, and oversee the manufacture and maintenance of equipment that uses electricity, including subsystems for power generation and transmission, sensors, electronics, instrumentation, controls, communications and signal processing. The electrical engineering program is accredited by the Engineering Accreditation Commission (EAC) of ABET, http://www.abet.org.

Program Educational Objectives

The Program Educational Objectives (PEO) of the Electrical Engineering (EE) program at West Virginia University is to produce graduates who will apply their knowledge and skills to achieve success in their careers in industry, research, government service or graduate study. It is expected that in the first five years after graduation our graduates will achieve success and proficiency in their profession, be recognized as leaders, and contribute to the well-being of society.

Student Outcomes

Upon graduation, all Bachelor of Science students in Electrical Engineering will have:

- An ability to apply knowledge of mathematics, science, and engineering
- An ability to design and conduct experiments, as well as to analyze and interpret data
- An ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability
- An ability to function on multidisciplinary teams
- An ability to identify, formulate, and solve engineering problems
- An understanding of professional and ethical responsibility
- An ability to communicate effectively
- The broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context
- A recognition of the need for, and an ability to engage in life-long learning
- A knowledge of contemporary issues
- An ability to use the techniques, skills, and modern engineering tools necessary for engineering practice

In the first two years of electrical engineering, coursework is limited to those subjects that are essential as preparatory courses for more technical courses in the third and fourth years. Fundamental courses in electrical engineering are introduced in the second year. In the third and fourth years, the curriculum provides advanced instruction through required courses and electives. These electives are included in the curriculum to allow the student to acquire additional depth in the student's selected field of electrical engineering. Five technical electives are required for a total of fifteen credits. At least three must come from one of the EE emphasis areas. Two additional technical electives may be selected from upper-division engineering, science, or math areas. However, a student with special career objectives may petition the Lane Department through his/her advisor for prior written permission to select one upper division course meeting those objectives.

The mathematics/science elective and engineering science elective are selected from department-approved lists. Students should consult with their advisors to select a course from this list. To be eligible for graduation in electrical engineering, a student must attain a grade point average of 2.0 or better for all required courses. If a required EE course is repeated, only the hours credited and the grade received for the last completion of the course is used in computing the grade point average.

A total of five humanities and social science electives (GEF electives) must be selected. The humanities and social science electives must be chosen so as to meet University General Education Foundations requirements.

Concentration Areas

Each student must have an concentration area from the list below. Students should check with instructors of the newly developed courses that are being offered under EE/CpE/CS 493 to determine their emphasis areas. Students should also be certain that this information is being recorded in their advising file.

1. Power Systems: The cost and reliability of electricity plays a critical role in the quality of life and price of all manufactured goods. Advances in power electronics devices and computers are improving the efficiency of electromechanical devices. Electric deregulation in many states is offering retail customers an opportunity to select their electricity supplier and reduce cost. Improvements in technologies such as fuel cells, micro-turbines, wind turbines and photovoltaic systems offer new choices for power generation. Siting of distributed generation sources near the loads and operating power system under deregulation offer new challenges for power engineers.
2. Control Systems: Control theory is fundamental to any system that is required to behave in a desired manner. Such systems include all engineering systems such as mechanical, chemical, electrical and computer systems as well as many other dynamical systems such as economic markets.

Control theory therefore has a broad range of applications. This track interests those students who wish to apply technology to control dynamical systems. Signals from sensors, usually processed by a computer, are necessary for proper control of a system. Consequently, the student interested in the control systems track will take a course in digital control and at least two additional courses in control systems, digital signal processing and/or applications such as control of power systems. Additional courses that are useful are mathematical courses such as linear algebra and complex variable analysis.

3. Electronics: Electronics spans a number of large technical specialties within CSEE. A solid understanding of device operation and their limitations is key to good electronic design, be it the design of individual devices or the design of complex electronic systems. Several programming tools will be introduced to the students during their training in this emphasis area to support the development of this understanding. In the core course required in this emphasis area, the students will model devices using pSpice and layout electronic circuits using VLSI design rules. Additional electronic design concepts will be introduced in the technical electives. The following areas within electronics are emphasized at WVU based upon the expertise of the LCSEE faculty members: electronic device design and fabrication, analog electronic circuit design and applications, and optical device design and applications.
4. Communications and Signal Processing: Communications and signal processing are interrelated fields that play an important role in today's information driven economy. Signal processing involves the use of programmable computer architectures to operate on physical-world signals. Signal processors are found within modern control systems, biomedical applications, and communication devices. Communications is the conveyance of information from one location to another. The capacity of a communications system is limited by the random noise in the channel. The communication channel may be a fiber optic cable, a local or wide area computer network, or the radio frequency spectrum.
5. Bioengineering and Biometrics: Bioengineering is the multidisciplinary application of engineering to medicine and biology, including such areas as biomedical signal and image processing, medical informatics, and biomedical instrumentation. Bioengineering work can include the development of new technologies for use in medicine and biology or the use of engineering techniques to study issues in biology and medicine. Biometrics is a specific area of bioengineering in which biological signatures (fingerprint, voice, face, DNA) is used for identification or authentication in criminal justice, e-commerce, and medical applications. Specific LCSEE projects in these areas include signal processing for prediction of sudden cardiac death in an animal model of heart failure, development of algorithms for arrhythmia detection in implanted medical devices, telemedicine for rural health care delivery in West Virginia, analysis of temporal fingerprint images for determination of vitality, CMOS fingerprint sensor design and modeling, neural net fingerprint matching, and 3-D craniofacial reconstruction. At the undergraduate level, these projects impact courses and create opportunities for senior design projects and undergraduate research experiences.
6. Computers: Computers have become an important part of the technology used by engineers and a very important part of many technological systems and products. The computer emphasis area is designed to provide an electrical engineer with the basic understanding of how to use computers and microprocessors. When this track is completed, the electrical engineer should be able to develop, program, and use systems with embedded microcomputers.

Click here to view the Suggested Plan of Study (p. 6)

Curriculum in Electrical Engineering

GENERAL EDUCATION FOUNDATIONS

Please use this link to view a list of courses that meet each GEF requirement. (http://registrar.wvu.edu/gef)

NOTE: Some major requirements will fulfill specific GEF requirements. Please see the curriculum requirements listed below for details on which GEFs you will need to select.

General Education Foundations		
F1 - Composition & Rhetoric		3-6
ENGL 101	Introduction to Composition and Rhetoric	
& ENGL 102	and Composition, Rhetoric, and Research	
or ENGL 103	Accelerated Academic Writing	
F2A/F2B - Science & Technology		4-6
F3 - Math & Quantitative Skills		3-4
F4 - Society & Connections		3
F5 - Human Inquiry & the Past		3
F6 - The Arts & Creativity		3
F7 - Global Studies & Diversity		3
F8 - Focus (may be satisfied by completion of a minor, double major, or dual degree)		9
Total Hours		31-37

Please note that not all of the GEF courses are offered at all campuses. Students should consult with their advisor or academic department regarding the GEF course offerings available at their campus.

Curriculum Requirements

To receive a bachelor of science in electrical engineering, a student must meet the University's undergraduate degree requirements, take all the courses indicated below, and attain a grade point average of 2.25 or better for all Lane Department of Computer Science and Electrical Engineering designated courses, in all WVU courses, and overall. If a Lane Department of Computer Science and Electrical Engineering course is repeated, only the last grade received is used to compute the major grade point average, and the course credit hours are counted only once. This requirement assures that the student has demonstrated overall competence in the major.

Freshman Engineering Requirements		
ENGR 101	Engineering Problem Solving 1	2
Engineering Problem Solving:		3
CHE 102	Introduction to Chemical Engineering	
ENGR 102	Engineering Problem-Solving 2	
ENGR 103	Introduction to Nanotechnology Design	
MAE 102	Introduction to Mechanical and Aerospace Engineering Design	
ENGR 191	First-Year Seminar	1
Non-Electrical Engineering Core		
CHEM 115	Fundamentals of Chemistry (GEF 2B)	4
ECON 201	Principles of Microeconomics (GEF 4)	3
ECON 202	Principles of Macroeconomics	3
Calculus I (GEF 3):		4
MATH 155	Calculus 1 (Minimum grade of C- is required)	
MATH 153 & MATH 154	Calculus 1a with Precalculus and Calculus 1b with Precalculus (Minimum grade of C- is required)	
MATH 156	Calculus 2 (GEF 8 - Minimum grade of C- is required)	4
MATH 251	Multivariable Calculus (Minimum grade of C- is required)	4
MATH 261	Elementary Differential Equations	4
PHYS 111	General Physics (GEF 8)	4
PHYS 112	General Physics (GEF 8)	4
STAT 215	Introduction to Probability and Statistics	3
Engineering Science Elective (choose one of the following:)		3
CE 443	Environmental Science and Technology	
CHE 201	Material and Energy Balances 1	
CHE 366	Materials Science	
IENG 316	Industrial Quality Control	
IENG 377	Engineering Economy	
MAE 241	Statics	
MAE 320	Thermodynamics	
Math/Science Elective (Choose one of the following)		3
BIOL 115	Principles of Biology	
CHEM 116	Fundamentals of Chemistry	
MATH 343	Introduction to Linear Algebra	
MATH 375	Applied Modern Algebra	
MATH 367	Applied Mathematical Analysis	
MATH 420	Numerical Analysis 1	
MATH 441	Applied Linear Algebra	
MATH 456	Complex Variables	
MATH 465	Partial Differential Equations	
PHYS 211	Introduction to Mathematical Physics	
PHYS 314	Introductory Modern Physics	
PHYS 321	Optics	
PHYS 331	Theoretical Mechanics 1	
PSIO 241	Elementary Physiology	
PSIO 441	Mechanisms of Body Function	

STAT 312	Intermediate Statistical Methods	
STAT 331	Sampling Methods	
STAT 461	Theory of Probability	
Electrical Engineering Requirements (Minimum GPA of 2.0 required in BIOM, CPE, CS, and EE courses)		
CPE 271	Introduction to Digital Logic Design	3
CPE 272	Digital Logic Laboratory	1
CPE 310	Microprocessor Systems	3
CPE 311	Microprocessor Laboratory	1
CS 110	Introduction to Computer Science	4
EE 221	Introduction to Electrical Engineering	3
EE 222	Introduction to Electrical Engineering Laboratory	1
EE 223	Electrical Circuits	3
EE 224	Electrical Circuits Laboratory	1
EE 327	Signals and Systems 1	3
EE 328	Signals and Systems Laboratory	1
EE 329	Signals and Systems 2	3
EE 335	Electromechanical Energy Conversion and Systems	3
EE 336	Electromechanical Energy Conversion and Systems Lab	1
EE 345	Engineering Electromagnetics	3
EE 251	Digital Electronics	3
EE 252	Digital Electronics Laboratory	1
EE 355	Analog Electronics	3
EE 356	Analog Electronics Laboratory	1
EE 480	Capstone Project - Design (Fulfills Writing and Communications Skills Requirement)	2
EE 481	Capstone Project - Implementation	3
Concentration Area (CA) Technical Electives (Selected from one of the CAs below)		9
CA1: Power Systems		
EE 435	Introduction to Power Electronics	
Choose one of the following:		
EE 431	Electrical Power Distribution Systems	
EE 436	Power Systems Analysis	
Choose one of the following:		
CS 453	Data and Computer Communications	
CS 465	Cybersecurity Principles and Practice	
EE 411	Fundamentals of Control Systems	
EE 413	Introduction to Digital Control	
EE 431	Electrical Power Distribution Systems	
EE 436	Power Systems Analysis	
EE 461	Introduction to Communications Systems	
CA2: Control Systems		
Choose one of the following:		
EE 411	Fundamentals of Control Systems	
EE 413	Introduction to Digital Control	
Choose two of the following:		
EE 411	Fundamentals of Control Systems	
EE 413	Introduction to Digital Control	
EE 435	Introduction to Power Electronics	
EE 461	Introduction to Communications Systems	
EE 463	Digital Signal Processing Fundamentals	
CA3: Electronics		
EE 450	Device Design and Integration	
Choose two of the following:		

EE 435	Introduction to Power Electronics
EE 437	Fiber Optics Communications
EE 445	Introduction to Antennas
EE 455	Introduction to Microfabrication
EE 457	Fundamentals of Photonics
PHYS 321	Optics
PHYS 471	Solid State Physics
CA4: Communications & Signal Processing	
Choose one of the following:	
EE 437	Fiber Optics Communications
EE 461	Introduction to Communications Systems
EE 463	Digital Signal Processing Fundamentals
Choose two of the following:	
BIOM 426	Biometric Systems
CPE 442	Introduction to Digital Computer Architecture
CPE 462	Wireless Networking
CS 453	Data and Computer Communications
EE 411	Fundamentals of Control Systems
EE 413	Introduction to Digital Control
EE 437	Fiber Optics Communications
EE 445	Introduction to Antennas
EE 461	Introduction to Communications Systems
EE 463	Digital Signal Processing Fundamentals
EE 465	Introduction to Digital Image Processing
EE 467	Digital Speech Processing
CA5: Bioengineering and Biometrics	
EE 425	Bioengineering
Choose one of the following:	
BIOM 426	Biometric Systems
EE 463	Digital Signal Processing Fundamentals
EE 465	Introduction to Digital Image Processing
Choose on eof the following:	
BIOM 426	Biometric Systems
CHEM 231	Organic Chemistry: Brief Course
CHEM 233	Organic Chemistry
CHEM 234	Organic Chemistry
EE 463	Digital Signal Processing Fundamentals
EE 465	Introduction to Digital Image Processing
PSIO 241	Elementary Physiology
or PSIO 441	Mechanisms of Body Function
CA6: Computers	
Option 1	
CPE 312	Microcomputer Structures and Interfacing
CPE 313	Microcomputer Structures and Interfacing Laboratory
Choose two of the following:	
CPE 435	Computer Incident Response
CPE 442	Introduction to Digital Computer Architecture
CPE 484	Real-Time Systems Development
Option 2	
CPE 435	Computer Incident Response
CPE 442	Introduction to Digital Computer Architecture
CPE 484	Real-Time Systems Development

Technical Electives (300 level or higher in BIOM, BMEG, CE, CHE, CPE, CS, EE, IENG, MAE, MINE, PNGE, BIOL, CHEM, PHYS, STAT, OR MATH courses - Excluding Non-LCSEE 493)	9
Free Elective	3
GEF Electives 1, 5, 6, 7 *	15
Total Hours	132

Suggested Plan of Study

It is important for students to take courses in the order specified as closely as possible; all prerequisites and concurrent requirements must be observed. A typical B.S.E.E. degree program that completes degree requirements in four years is as follows.

First Year

Fall	Hours	Spring	Hours
CHEM 115 (GEF 2)	4	ENGR 102	3
ENGL 101 (GEF 1)	3	MATH 156 (GEF 8)	4
ENGR 101	2	PHYS 111 (GEF 8)	4
ENGR 191	1	GEF 6	3
MATH 155 (GEF 3)	4	GEF 7	3
GEF 5	3		
	17		17

Second Year

Fall	Hours	Spring	Hours
CPE 271	3	CS 110	4
CPE 272	1	ENGL 102 (GEF 1)	3
EE 221	3	EE 223*	3
EE 222	1	EE 224*	1
MATH 251	4	EE 251	3
PHYS 112 (GEF 8)	4	EE 252*	1
		MATH 261	4
	16		19

Third Year

Fall	Hours	Spring	Hours
EE 327*	3	CPE 310	3
EE 335*	3	CPE 311	1
EE 336*	1	ECON 201 (GEF 4)	3
EE 345*	3	EE 329*	3
EE 355	3	EE 328*	1
EE 356	1	Engr. Science Elective	3
STAT 215	3	Math/Science Elective	3
	17		17

Fourth Year

Fall	Hours	Spring	Hours
ECON 202	3	EE 481	3
EE 480	2	CA Technical Elective	3
Two CA Technical Electives	6	Free Elective	3
Technical Elective	3	Two Technical Electives	6
	14		15

Total credit hours: 132

* Offered once per year in semester shown.

Major Learning Outcomes

ELECTRICAL ENGINEERING

Program Educational Objectives

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- An ability to function on multidisciplinary teams
- An ability to identify, formulate, and solve engineering problems
- An understanding of professional and ethical responsibility
- An ability to communicate effectively
- The broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context
- A recognition of the need for, and an ability to engage in life-long learning
- A knowledge of contemporary issues
- An ability to use the techniques, skills, and modern engineering tools necessary for engineering practice

EE 221. Introduction to Electrical Engineering. 3 Hours.
PR: WVU and PSC sections require PHYS 111 and MATH 156, WVUIT sections require MATH 156. Electrical engineering units, circuit elements, circuit laws, measurement principles, mesh and node equations, network theorems, operational amplifier circuits, energy storage elements, sinusoids and phasors, sinusoidal steady state analysis, average and RMS values, complex power. Pre-requisite(s) and/or co-requisite(s) may differ on regional campuses.

EE 222. Introduction to Electrical Engineering Laboratory. 1 Hour.
CoReq: EE 221. Design and experimental exercises basic electrical circuits. Use of the digital computer to solve circuit problems. (3 hr. lab.).

EE 223. Electrical Circuits. 3 Hours.
PR: WVU and PSC sections require EE 221 and EE 222 and PHYS 112 and MATH 251 all with a grade of C- or better, WVUIT sections require EE 221 and EE 222 and MATH 251 all with a grade of C- or better. Time response of RC and RL circuits, unit step response, second order circuits, poly-phase systems, mutual inductance, complex frequency, network frequency response, two-port networks and transformers. Fourier methods and Laplace Transforms.

EE 224. Electrical Circuits Laboratory. 1 Hour.
CoReq: EE 223. Design and experimental exercises in circuits. Transient circuits, steady state AC circuits, frequency response of networks. Use of digital computer to solve circuit problems. (3 hr. lab.).

EE 251. Digital Electronics. 3 Hours.
PR: EE 221 and CPE 271 and PHYS 112. Diode and bipolar and field-effect transistor device operation and switching models. Use of bipolar and field-effect transistors and diodes in switching and logic circuits. Switching circuits and logic gates including logic levels, circuit configuration, and interfacing. (3 hr. lec.).

EE 252. Digital Electronics Laboratory. 1 Hour.
CoReq: EE 251. Design, fabrication, and measurement of digital electronic circuits. Modeling and use of discrete devices, logic gates, display devices in switching circuits and timer circuits, Interfacing with integrated logic gates. (3 hr. lab.).

EE 293. Special Topics. 1-6 Hours.
PR: Consent. Investigation of topics not covered in regularly scheduled courses.

EE 327. Signals and Systems 1. 3 Hours.
PR: MATH 261 and EE 223. Introduction to linear system models and solutions in the time and frequency domains. Balanced emphasis is placed on both continuous and discrete time and frequency methods. (3 hr. lec.).

EE 328. Signals and Systems Laboratory. 1 Hour.
PR: EE 327 and CoReq: EE 329. Laboratory experiments in measurement and analysis of systems and signals. (3 hr. lab.).

EE 329. Signals and Systems 2. 3 Hours.
PR: EE 327 and (STAT 215 or MATH 448). Analysis of continuous and discrete time systems. Block diagrams, stability, feedback control. Statistical description of nondeterministic signals, correlation functions, and spectral density, concepts applied to communication and feedback systems. (3 hr. lec.).

EE 335. Electromechanical Energy Conversion and Systems. 3 Hours.
PR: WVU sections require EE 223 and EE 224 and PHYS 112, WVUIT sections require EE 223 and EE 224 and a co-requisite of EE 345. Electric energy sources, fundamentals of electromechanical energy conversion, transformers and rotating machinery.

EE 336. Electromechanical Energy Conversion and Systems Lab. 1 Hour.
Transformers, DC motors and generator performance and characteristics, synchronous machine performance and characteristics.

EE 345. Engineering Electromagnetics. 3 Hours.
PR: WVU sections require MATH 261 and PHYS 112, WVUIT sections require MATH 261 and PHYS 112 and EE 223. Continued use of vector calculus, electrostatics, magnetoststics, Maxwell's Equations, and boundary conditions. Introduction to electromagnetic waves, transmission lines, and radiation from antennas.

EE 355. Analog Electronics. 3 Hours.
PR: EE 223 and EE 251. Electronic devices in analog circuits. Small-signal and graphical analysis of BJT and FET circuits; frequency response, feedback, and stability. Linear and nonlinear operational amplifier circuits. Power amplifiers and power control by electronic devices. (3 hr. lec.).

EE 356. Analog Electronics Laboratory. 1 Hour.
CoReq: EE 355. Design, fabrication, and measurement of analog electronic circuits. Use of discrete devices, integrated circuits, operational amplifiers, and power electronic devices. Study of biasing and stability, frequency response, filters, analog computation circuits, and power control circuits. (3 hr. lab.).

EE 411. Fundamentals of Control Systems. 3 Hours.
PR: EE 327. Introduction to classical and modern control; signal flow graphs; state-cariable characterization; time-domain, root locus, and frequency techniques; stability criteria. (3 hr. lec.).

EE 413. Introduction to Digital Control. 3 Hours.
PR: EE 327. Sampling of continuous-time signals and transform analysis. Stat-variable analysis for linear discrete-time systems and design of digital controller. (3 hr. lec.).

EE 425. Bioengineering. 3 Hours.
Introduction to human anatomy and physiology using an engineering systems approach. Gives the engineering student a basic understanding of the human system so that the student may include it as an integral part of the design. Co-listed with MAE 473. (3 hr. lec.).

EE 426. Biometric Systems. 3 Hours.
PR: STAT 215 and MATH 261 and CS 111. It is also suggested (not required) that EE 327 and CS 350 also be taken prior to enrolling in this course. This course presents an introduction to the principles of operation, design, testing, and implementation of biometric systems, and the legal, social and ethical concerns associated with their use.

EE 431. Electrical Power Distribution Systems. 3 Hours.
PR: EE 335 and EE 336 or consent. General considerations; load characteristics; subtransmission and distribution substations; primary and secondary distribution, secondary network systems; distribution transformers; voltage regulation and application of capacitors; voltage fluctuations; protective device coordination. (3 hr. lec.).

EE 435. Introduction to Power Electronics. 3 Hours.
PR: EE 335 and EE 355 and EE 356 or consent. Application of power semiconductor components and devices to power system problems; power control; conditioning processing, and switching. Course supplemented by laboratory problems. (3 hr. lec.).

EE 436. Power Systems Analysis. 3 Hours.
PR: EE 335 and EE 336. Power system network modeling, network calculations by matrices, node equations, node elimination, bus admittance, impedance matrices, and fault calculations. Transmission line inductance, capacitance, network models, and power circle diagrams. Symmetrical and unsymmetrical faults. Load flow and economic dispatch.

EE 437. Fiber Optics Communications. 3 Hours.
PR: EE 329 and EE 345. Fundamentals of optics and light wave propagation, guided wave propagation and optical wave guides, light sources and light detectors, couplers, connections, and fiber networks, modulation noise and detection in communication systems. (3 hr. lec.).

EE 445. Introduction to Antennas. 3 Hours.
PR: EE 345 or equivalent. Development of Maxwell's equations and general electromagnetic theory underpinning broadcast communication systems, wave propagation, antennas and antenna arrays.

EE 450. Device Design and Integration. 3 Hours.
PR: EE 345 and EE 355. Fundamentals of semiconductor materials, p-n junctions, metal-semiconductor junctions, JFET's, MESFET's, MOSFET's, physical device design, device simulation, gate level CMOS design and layout. (3 hr. lec.).

EE 455. Introduction to Microfabrication. 3 Hours.
PR: EE 355 or consent. Introduction to the physical processes underlying current and emerging microfabrication technology and their selective use in the technology computer aided design (TCAD) and fabrication of electrical, optical, and micromechanical devices and systems.

EE 457. Fundamentals of Photonics. 3 Hours.
PR:EE 345 or equivalent. Basic physics and optical engineering concepts necessary to understand the design and operation of photonic -based systems, including communications, nanophotonics, sensing and display technologies. Scaling, integration, and packaging of optical approaches and their compatibility with micro/nanosystems.

EE 461. Introduction to Communications Systems. 3 Hours.
PR: EE 329. Application of random processes and spectral analysis to the design and analysis of communication systems. Analysis and comparison of standard modulation techniques relative to bandwidth, noise, threshold, and hardware constraints.

EE 463. Digital Signal Processing Fundamentals. 3 Hours.
PR: MATH 251 and EE 327. Theories, techniques, and procedure used in analysis, design, and implementation of digital and sampled data filters. Algorithms and computer programming for software realization. Digital and sampled data realizations, switched capacitor and charge-coupled device IC's. (3 hr. lec.).

EE 465. Introduction to Digital Image Processing. 3 Hours.
PR: EE 251 and EE 327. Introduction to the vision process fundamental mathematical characterization of digitized images, two-dimensional transform methods used in image processing, histogram analysis and manipulation, image and filtering techniques, image segmentation, and morphology. (3 hr. lec.).

EE 467. Digital Speech Processing. 3 Hours.
PR: EE 327 and EE 329. Covers fundamentals in digital speech processing including production, speech analysis, speech coding, speech enhancement, speech recognition and speaker recognition. Emphasize hand-on experience of processing speech signals using MATLAB.

EE 480. Capstone Project - Design. 0-3 Hours.
PR: ENGL 102 or ENGL 103 and consent. Penultimate semester. Group senior design projects with individual design assignments appropriate to student's discipline. Complete system-level designs of the subsequent semester's project presented in written proposals and oral presentations. (Equivalent to BIOM 480, CPE 480, CS 480) (2 hr. lec., 1 hr. conf.) Note: WVU Tech course is 3 credit hours.

EE 481. Capstone Project - Implementation. 3 Hours.
PR: EE 480. Detailed design and implementation of the system including choice of components, algorithm development, interfacing, trouble shooting, working in groups, and project management. Also covers professional topics, including ethics, liability, safety, socio-legal issues, risks and employment agreements. (1 hr. lec., 1 hr. conf., 2 hr. lab.).

EE 490. Teaching Practicum. 1-3 Hours.
PR: Consent. Teaching practice as a tutor or assistant.

EE 491. Professional Field Experience. 1-18 Hours.
PR: Consent. (May be repeated up to a maximum of 18 hours.) Prearranged experiential learning program, to be planned, supervised, and evaluated for credit by faculty and field supervisors. Involves temporary placement with public or private enterprise for professional competence development.

EE 492. . 1-6 Hours.
Directed study, reading, and/or research.

EE 493. Special Topics. 1-6 Hours.
PR: Consent. Investigation of topics not covered in regularly scheduled courses.

EE 494. Seminar. 1-3 Hours.
PR: Consent. Presentation and discussion of topics of mutual concern to students and faculty.

EE 495. Independent Study. 1-6 Hours.
Faculty supervised study of topics not available through regular course offerings.

EE 496. Senior Thesis. 1-3 Hours.
PR: Consent.

EE 497. Research. 1-6 Hours.
Independent research projects.

EE 498. Honors. 1-3 Hours.
PR: Students in Honors Program and consent by the honors director. Independent reading, study or research.