B S DEGREE
PROGRAM HANDBOOK

ELECTRICAL ENGINEERING

AT

THE PENNSYLVANIA STATE UNIVERSITY

BLUE PROGRAM

PROGRAM YEAR: 2024-2025

Electrical Engineering
Educational Objectives of the BSEE Program

Goal Statement
The mission of our undergraduate program is to provide quality education in electrical engineering for our students and to instill in them the attitude, values, and vision that will prepare them for a lifetime of continued learning and leadership in their chosen careers where they will generate new knowledge through research, utilize such knowledge to improve quality of life, and facilitate technology transfer for the benefit of the Commonwealth, our nation, and the global community.

Program Educational Objectives
The BSEE Program provides undergraduates with a broad technical education important for employment in the private or public sector, and it teaches them the fundamentals, current issues, and creative problem-solving skills essential for future years of learning. At three to five years after graduation, we foresee our graduates being capable of exhibiting:

- Electrical engineering practice in technical assignments such as design, product development, research, manufacturing, consulting, testing, sales, and management.
- An ability to learn new instrumentation and design tools.
- Effective written and oral communication skills.
- Continued learning through such activities as graduate school, distance education, professional training, and membership in professional societies.
- Participation and leadership on teams comprised of individuals with diverse professional and cultural backgrounds.
- Appreciation of the implications of design in a global, societal, and ethical context.

Student Outcomes
Student outcomes describe what students are expected to know and be able to do by the time of graduation. The Electrical Engineering program is designed to enable students to have:

1. An ability to identify, formulate and solve complex engineering problems by applying principles of engineering, science and mathematics.
2. An ability to apply engineering design to produce solutions that meet specified needs with consideration of public health, safety and welfare as well as global, cultural, social, environmental and economic factors.
3. An ability to communicate effectively with a range of audiences.
4. An ability to recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental and societal contexts.
5. An ability to function effectively on a team, whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks and meet objectives.
6. An ability to develop and conduct appropriate experimentation, analyze and interpret data and use engineering judgment to draw conclusions.
7. An ability to acquire and apply new knowledge as needed using appropriate learning strategies.

THE BSEE DEGREE IN ELECTRICAL ENGINEERING

For Juniors in Program Year 2024-2025

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WELCOME EE MAJORS! August, 2024

Now that you have officially achieved status of “Electrical Engineering major”, we are happy to welcome you to the BSEE program. This booklet has been prepared for your use as a guide for your studies and as a means of providing you with much of the information that you may need as you continue to work towards your BSEE degree. We hope that you read it carefully, and we invite your inquiries about any of the questions or issues that are related to your program. The Academic Affairs staff in 121 Electrical Engineering East is here to serve you.

Please watch the monitors in the lobby of Electrical Engineering East for announcement of special courses, news related to scheduling, and other special opportunities. We will also keep in contact with you about many important matters via a departmental email list.

Again, welcome to Electrical Engineering. We wish you well in your studies and offer our services to assist you.

Tom LaPorta
Director of School of Electrical Engineering and Computer Science

Madhavan Swaminathan
Electrical Engineering Department Head

David Salvia
Director of Academic Affairs, School of Electrical Engineering and Computer Science

Mark Mahon
Faculty Advisor, School of Electrical Engineering and Computer Science

Angel Welch
Primary Academic Advisor, Electrical Engineering Department

I. DEGREE REQUIREMENTS FOR THE BLUE BSEE PROGRAM

I. 1. Program Requirements Summary Chart

This is a recommended academic plan. With careful planning, you may arrange courses in many different ways. For example, the General Education electives may be moved to accommodate technical electives, which may only be offered in a particular semester. **When moving courses, however, be careful to meet all prerequisites.**

	FIRST SEMESTER	
§	MATH 140 Calculus w/Analytic Geom. I	(4)____
§	PHYS 211 Mechanics	(4)____
§	CHEM 110 Chemical Principles	(3)____
¨	ENGL 15 Rhetoric and Composition	(3)____
	1st-year Seminar	(1)____
	TOTAL	**15**

	SECOND SEMESTER	
§	MATH 141 Calculus w/Analytic Geom. II	(4)____
¨	PHYS 212 Electricity & Magnetism	(4)____
¨	CMPSC 121/131 Intro. Programming	(3)____
§	EDSGN 100 Engineering Design	(3)____
*	ECON 102/104 (counts as GS GenEd elec.)	(3)____
	TOTAL	**17**

	THIRD SEMESTER	
¨	EE 210 Circuits and Devices	(4)____
¨	CMPEN 270 Logic Design	(4)____
	CMPSC 122/132 Intermed. Programming	(3)____
¨	MATH 250 Ordinary Differential Equations	(3)____
	MATH 220 Matrices	(2)____
	TOTAL	**16**

	FOURTH SEMESTER	
	EE 200 Design Tools	(3)____
¨	EE 310 Electronic Circuit Design	(4)____
	MATH 230 Calculus & Vector Analysis	(4)____
	PHYS 214 Waves & Quantum Physics	(2)____
¨	CAS 100A/B Effective Speech	(3)____
	TOTAL	**16**

	FIFTH SEMESTER	
¨	EE 330 Electromagnetics	(4)____
¨	EE 340 Nanoelectronics	(4)____
¨	EE 350 Continuous-time Linear Systems	(4)____
*	General Education elective	(3)____
*	Health & Wellness elective (GHW)	(1.5)____
	TOTAL	**16.5**

	SIXTH SEMESTER	
	EE 300W Design Process	(3)____
&	EE/CMPEN 300-level elective	(3)____
&	EE/CMPEN 300-level elective	(3)____
¨	ENGL 202C Technical Writing	(3)____
*	General Education elective	(3)____
	TOTAL	**15**

	SEVENTH SEMESTER	
	EE 403W Capstone Design	(3)____
&	EE/CMPEN 300/400-level elective	(3)____
@	Statistics elective	(3)____
*	General Education elective	(3)____
%	Related elective	(3)____
	TOTAL	**15**

	EIGHTH SEMESTER	
&	EE/CMPEN 400-level elective	(3)____
&	EE/CMPEN 400-level elective	(3)____
*	General Education elective	(3)____
*	General Education elective	(3)____
%	Related elective	(3)____
*	Health & Wellness elective (GHW)	(1.5)____
	TOTAL	**16.5**

TOTAL PROGRAM CREDITS: 127

§ This course requires a grade of "C" or better for entrance into the Electrical Engineering major

¨ This course requires a grade of "C" or better for graduation in Electrical Engineering

& The EE technical electives are to be chosen from the lists on page 10 of this handbook

@ The statistics elective is to be chosen from the list on page 11 of this handbook

% The related elective may include ROTC credit, co-op credit, and other credit as specified on the lists on pages 11-12 of this handbook

***** General Education electives – see pages 12-13 of this handbook

I. 2. Course Descriptions, Prerequisites and Frequency of Offering

EE/CMPEN REQUIRED COURSES

EE 200 DESIGN TOOLS (3)
A working knowledge of electrical engineering design tools and hardware realization of electrical engineering systems.
Prerequisites: CMPEN 270 or 271/275, CMPSC 201 or 121 or 131. Offered FA, SP.

EE 210 CIRCUITS AND DEVICES (4) (Grade of C or better required)
Introduction to electrical circuit analysis, electronic devices, and time-domain transient analysis.
Prerequisite: PHYS 212. Prerequisite or concurrent: MATH 250. Offered FA, SP, SU.

EE 300 DESIGN PROCESS (3)
Introduction to the electrical engineering design process, project teaming and management, and technical communication.
Prerequisite: EE 200, EE 310. Prerequisite or concurrent: ENGL 202C. Offered FA, SP.

EE 310 ELECTRONIC CIRCUIT DESIGN I (4) (Grade of C or better required)
Properties of fundamental electronic devices; analysis of DC, AC small-signal and nonlinear behavior; analog and digital circuit design applications.
Prerequisite: EE 210. Offered FA, SP.

EE 330 ENGINEERING ELECTROMAGNETICS (4) (Grade of C or better required)
Static electric and magnetic fields; solutions to static field problems; Maxwell's equations; electromagnetic wave boundary conditions; engineering applications.
Prerequisites: EE 210, MATH 230. Offered FA, SP.

EE 340 INTRODUCTION TO NANOELECTRONICS (4) (Grade of C or better required)
Introduction to the physics and technology of nanoelectronic devices.
Prerequisites: PHYS 214, EE 210. Offered FA, SP.

EE 350 CONTINUOUS-TIME LINEAR SYSTEMS (4) (Grade of C or better required)
Introduction to continuous-time linear system theory; differential equation models, sinusoidal steady-state analysis, convolution, Laplace transform and Fourier analysis.
Prerequisites: EE 210, MATH 220, MATH 250. Offered FA, SP.

EE 403 CAPSTONE DESIGN (3)
Design projects in the various areas and subdisciplines of electrical engineering, with an emphasis on technical communication skills.
Prerequisites: EE 300, ENGL 202C. Offered FA, SP.

CMPEN 270 DIGITAL DESIGN: THEORY AND PRACTICE (4) (Grade of C or better required)
Introduction to digital systems and their design. Topics include combinational and sequential devices and circuits, modern design tools and design practices.
Prerequisite or concurrent: PHYS 212. Offered FA, SP.

Note: At non-University Park locations, CMPEN 270 is often taught as 2 separate courses, CMPEN 271 (3 credits) and CMPEN 275 (1 credit).

EE/CMPEN 300-LEVEL TECHNICAL ELECTIVE COURSES

EE 311 ELECTRONIC CIRCUIT DESIGN II (3)
Electronic circuit design with consideration to single and multi-device subcircuits, frequency response characteristics, feedback, stability, efficiency, and IC techniques.
Prerequisites: EE 310. Offered FA, SP.

EE 320 INTRODUCTION TO ELECTRO-OPTICAL ENGINEERING (3)
An introduction covering several fundamental areas of modern optics, optical processes, and devices.
Prerequisites: EE 210, MATH 230 or MATH 232. Offered FA, SP.

EE 337 INTRODUCTION TO QUANTUM INFORMATION SCIENCE AND ENGINEERING (3)
Introduction to quantum information science and engineering, and how it can be used in quantum communication and quantum computing, both in theory and experiment.
Prerequisites: MATH 220, PHYS 214. Offered FA.

EE 351 DISCRETE-TIME LINEAR SYSTEMS (3)
Introduction to discrete-time signal processing: sampling, linear time-invariant systems, discrete-time Fourier transform and discrete Fourier transform, Z transform.
Prerequisite: EE 350. Offered FA, SP.

EE 360 COMMUNICATION SYSTEMS I (3)
Generic communication system; signal transmission; digital communication systems; amplitude modulation; angle modulation.
Prerequisite: EE 350. Offered FA, SP.

EE 362 COMMUNICATION NETWORKS (3)
Data transmission, encoding, link control techniques; communication network architecture, design; computer communication system architecture, protocols.
Prerequisites: CMPEN 270 or 271. Prerequisite or concurrent: STAT 318 or STAT 401 or STAT 414 or STAT 418 or EE 465. Offered FA, SP.

EE 380 LINEAR CONTROL SYSTEMS (3)
State variables; time-domain and frequency-domain design and analysis; design of feedback control systems; root locus. **Course contains a significant laboratory component.**
Prerequisites: EE 350, MATH 220. Offered FA, SP.

EE 387 ENERGY CONVERSION (3)
Electromechanical energy conversion; magnetic circuits; transformers; transducers; commutators; synchronous, induction, and D.C. machines.
Prerequisite: EE 350. Offered FA, SP.

CMPEN 331 COMPUTER ORGANIZATION AND DESIGN (3)
Introduction to major components of a computer system, how they function together in executing a program, how they are designed. **Course contains a significant programming component.**
Prerequisites: CMPSC 121 or CMPSC 131 or CMPSC 201, CMPEN 270 or 271. Offered FA, SP.

EE/CMPEN 400-LEVEL TECHNICAL ELECTIVE COURSES

EE 410 LINEAR ELECTRONIC DESIGN (3)
Linear circuit design via integrated circuit processes; A/D converters, switched capacitor filters, phase lock loops, multipliers, and voltage-controlled oscillators. **Course contains a significant laboratory component.**
Prerequisite: EE 311. Offered FA.

EE 413 POWER ELECTRONICS (3)
Switch-mode electrical power converters. Electrical characteristics and thermal limits of semiconductor switches. **Course contains a significant laboratory component.**
Prerequisite: EE 310. Offered FA.

EE 416 (CMPEN) DIGITAL INTEGRATED CIRCUITS / VLSI DESIGN (3)
Design and analysis of digital integrated circuits employed in very large scale integrated (VLSI) chips. **Course contains a significant laboratory component.**
Prerequisite: EE 310. Offered FA.

EE 417 (CMPEN) DIGITAL DESIGN USING FIELD PROG. DEVICES (3)
Field programmable device architectures and technologies; rapid prototyping using top down design techniques; quick response systems.
Prerequisite: CMPEN 331. Offered SP.

EE 420 ELECTRO OPTICS – PRINCIPLES AND DEVICES (3)
Spatially linear system and transform. Diffraction theory, partial coherence theory, optical image detection, storage and display, holography.
Prerequisite: EE 320 or EE 330. Offered FA.

EE 421 OPTICAL FIBER COMMUNICATIONS (3)
(Sometimes offered as EE 497: Applications of Optics in Communications & Lighting)
Operational principles of optical components, including sources, fibers and detectors, and the whole systems in optical fiber communications.
Prerequisites: EE 320 or EE 330. Offered SP.

EE 422 OPTICAL ENGINEERING LABORATORY (3)
Hands-on experience covering areas of optical transforms, electro-optics devices, signal processing, fiber optics transmission, and holography. **Course contains a significant laboratory component.**
Prerequisite: EE 320. Offered FA.

EE 424 PRINCIPLES AND APPLICATIONS OF LASERS (3)
Principles of lasers--generation, propagation, detection and modulation; applications in fiber optics communication, remote sensing, holography, optical switching and processing.
Prerequisite: EE 320 or EE 330. Offered SP.

EE 430 PRINCIPLES OF ELECTROMAGNETIC FIELDS (3)
This course provides the grounding in fundamental laws of electromagnetics and provides practical training in the solution of engineering electromagnetics problems. It investigates polarization and magnetization effects in material media, propagation of electromagnetic waves in lossy and lossless media, and applications to optics and fiber optics. The transmission lines, antennas and antenna arrays are also considered.
Prerequisite: EE 330. Offered SP.

EE 432 UHF AND MICROWAVE ENGINEERING (3)
Transmission line and wave guide characteristics and components; design of UHF-microwave amplifiers, oscillators, and filters; measurement techniques; design projects. **Course contains a significant laboratory component.**
Prerequisites: EE 330, EE 310. Offered FA.

EE 437 PHYSICAL IMPLEMENTATION OF QUBITS (3)
Introduction to the physical implementation of quantum bits (qubits) based on state-of-the-art technologies.
Prerequisite: EE 337. Offered SP.

EE 438 ANTENNA ENGINEERING (3)
Radiation from small antennas, linear antenna characteristics, arrays of antennas, impedance concepts and measurements, multifrequency antennas, and aperture antennas. **Course contains a significant laboratory component.**
Prerequisite: EE 330. Offered FA.

EE 441 SEMICONDUCTOR INTEGRATED CIRCUIT TECHNOLOGY (3)
An overview of fundamentals of processes involved in silicon integrated circuit fabrication through class lectures and hands-on laboratory. **Course contains a significant laboratory component.**
Prerequisite. EE 340. Offered SP.

EE 442 SOLID STATE DEVICES (3)
The physics of semiconductors as related to the characteristics and design of solid state electronic devices.
Prerequisite: EE 340. Offered FA.

EE 453 FUNDAMENTALS OF DIGITAL SIGNAL PROCESSING (3)
Design of FIR and IIR filters; DFT and its computation via FFT; applications of DFT; filter implementation, finite arithmetic effects. **Course contains a significant laboratory component.**
Prerequisite: EE 351. Offered SP.

EE 454 (CMPEN) FUNDAMENTALS OF COMPUTER VISION (3)
Introduction to topics such as image formation, segmentation, feature extraction, shape recovery, object recognition, and dynamic scene analysis. **Course contains a significant programming component.**
Prerequisites: MATH 230, CMPSC 201 or CMPSC 121 or CMPSC 131. Offered FA.

EE 455 (CMPEN) INTRODUCTION TO DIGITAL IMAGE PROCESSING (3)
Overview of digital image processing techniques and their applications; image sampling, enhancement, restoration, and analysis; computer projects. **Course contains a significant programming component.**
Prerequisites: CMPSC 201 or CMPSC 121 or CMPSC 131, EE 350. Offered FA.

EE 456 (ESC) (EGEE) INTRODUCTION TO NEURAL NETWORKS (3)
Introduction to a variety of Artificial Neural Networks (ANN) used as a solving tool for difficult problems for which conventional methods are not applicable. **Course contains a significant programming component.**
Prerequisites: MATH 220, CMPSC 201 or CMPSC 121 or CMPSC 131. Offered FA.

EE 460 COMMUNICATION SYSTEMS II (3)
Probability fundamentals, digital/analog modulation/demodulation, system noise analysis, SSNR and BER calculations, optimal receiver design concepts, introductory information theory.
Prerequisite: EE 360, STAT 414 or STAT 418. Offered FA.

EE 466 SOFTWARE-DEFINTED RADIO (3)
An overview of the principles of software-defined radio systems with laboratory component. **Course contains a significant laboratory component.**
Prerequisites: EE 351, EE 360. Offered SP

EE 471 (AERSP)(NUC E) INTRODUCTION TO PLASMAS (3)
This course introduces models for describing plasma phenomena relevant to plasma confinement, plasma-assisted materials processing, astrophysical plasmas, and near-Earth space plasmas. Topics include electrostatic and electromagnetic waves in non-magnetized and magnetized plasmas, non-linear effects near plasma confining walls, plasma equilibrium and stability, and models of unstable plasma motions with a focus on plasma confinement.
Prerequisite: EE 330. Offered FA.

EE 472 (AERSP) SPACE ASTRONOMY & INTRO TO SPACE SCIENCE (3)
The physical nature of the objects in the solar system; the earth's atmosphere, ionosphere, radiation belts, magnetosphere, and orbital mechanics.
Prerequisite: EE 330. Offered SP.

EE 474 SATELLITE COMMUNICATIONS (3)
Overview of satellite communications systems, principles, space platforms, orbital mechanics, up/down links and link budgets, modulation techniques.
Prerequisite: EE 330, EE 360. Offered SP.

EE 477 (**METEO**) **FUNDAMENTALS OF REMOTE SENSING (3)**
The review of fundamental physical properties leads into discussions of various techniques, including imaging, spectroscopy, radiometry, and active sensing.
Prerequisite: EE 330. Offered FA.

EE 482 INTRODUCTION TO DIGITAL CONTROL SYSTEMS (3)
Sampling and hold operations; A/D and D/A conversions; modeling of digital systems; response evaluation; stability; basis of digital control; examples. **Course contains a significant laboratory component.**
Prerequisites: EE 380, EE 351. Offered SP.

EE 483 – INTRODUCTION TO AUTOMATION AND ROBOTICS SYSTEMS (3)
Introduction to robotics systems with emphasis on robotic motion and control, and robotic components such as actuators and sensors.
Prerequisites: CMPSC 131, MATH 220, MATH 250. Offered FA.

EE 486 SUSTAINABLE ENERGY SYSTEM INTEGRATION (3)
Renewable energy units and their integration and control strategies, including photovoltaic devices, wind power, batteries, supercapacitors, flywheels, and micro-turbines.
Prerequisites: EE 210, CMPSC 201 or CMPSC 121 or CMPSC 131. Offered FA.

EE 488 POWER SYSTEMS ANALYSIS I (3)
Fundamentals, power transformers, transmission lines, power flow, fault calculations, power system controls.
Prerequisite: EE 387. Offered SP.

CMPEN 431 INTRODUCTION TO COMPUTER ARCHITECTURE (3)
Principles of computer architecture: memory hierarchies and design, I/O organization and design, CPU design and advanced processors. **Course contains significant programming component.**
Prerequisite: CMPEN 331. Offered FA, SP

CMPEN 462 WIRELESS COMMUNICATIONS SYSTEMS AND SECURITY (3)
Explores the fundamental concepts and engineering processes of wireless communication systems, sensors, and security algorithms through the design, implementation, and evaluation of next generation wireless network architecture, and cryptographic protocols.
Prerequisite: EE/CMPEN 362. Offered SP.

CMPEN 472 MICROPROCESSORS AND EMBEDDED SYSTEMS (3)
Microprocessors; architecture, design, assembly language, programming, interfacing, bus structure, and interface circuits and their use in embedded systems.
Prerequisite: CMPEN 331. Offered FA, SP.

CMPEN 473 MICROCOMPUTER LABORATORY (3)
Design of digital system using microprocessors. **Course contains a significant laboratory component.**
Prerequisite: CMPEN 472. Offered SP.

CMPEN 475 FUNCTIONAL VERIFICATION (3)
Introduces concepts, methods, and technology for effective functional verification of modern on-chip electronic systems.
Prerequisite: CMPEN 331. Offered FA.

Frequency of Offering of Electrical Engineering Courses

Although the EE Department attempts to offer every course during its planned semester(s) of offering as listed above, we can **only** guarantee that **required** courses are offered every Fall and Spring semester**.** Due to possible unforeseen circumstances (sabbaticals, faculty departures, budget concerns, etc.), the offering of elective courses and the summer offering of *all* courses is subject to change without warning.

Electrical Engineering Departmental Prerequisite Policy

The Electrical Engineering Department takes course prerequisites very seriously. The EE core courses and subsequent electives are highly inter-related, as indicated in the numerous prerequisites listed for the various courses. For this reason, students are expected to successfully master material in prerequisite courses before attempting any follow-up courses that build on this material. Note: In the case of courses that require a "C" to graduate, successful mastery of the material means earning a "C" or better, not merely passing the course. Therefore, some courses that have C-required courses as prerequisites, require a grade of C in the prerequisite course in order to count as fulfilling the prerequisite. Such prerequisites are indicated as such in the bulletin.

Prerequisites are automatically enforced at the time of registration. If a student is missing the official prerequisite but feels that they have met the prerequisite through some other means (e.g. transfer course), they need to fill out a Prerequisite Waiver Form on LionPATH.

I. 3. Selection of EE/CMPEN Technical Electives &

The five EE/CMPEN technical electives (15 credits total) may be chosen from the following lists. 6 credits must be chosen from the 300-level elective list, 6 credits must be chosen from the 400-level elective list, and the remaining 3 credits can be chosen from either list. Choose only courses for which you have prerequisites. Many of these courses are offered only one time a year, so plan carefully.

Note #1: You may replace up to 3 credits of a 400-level technical elective with courses EE 494H (Honors Thesis) and EE 497 (special topics) taught by EE faculty.

Note #2: EE 465 is not accepted as a 400-level EE elective – it is a statistics elective.

300-Level EE/CMPEN Technical Electives (6-9 credits required)

EE 311 Electronic Circuit Design II	EE 351 Discrete-time Systems	EE 380 Linear Control Systems
EE 320 Intro to Electro-Optical Engineering	EE 360 Communication Systems I	EE 387 Energy Conversion
EE 337 Quantum Info Science and Engineering	EE 362 Communication Networks	CMPEN 331 Computer Organization and Design

400-Level EE/CMPEN Technical Electives (6 – 9 credits required)

EE 410 Linear Electronic Design	EE 441 Semiconductor Integrated Circuit Device Technology	EE 482 Introduction to Digital Control Systems
EE 413 Power Electronics	EE 442 Solid-state Devices	EE 483 Automation and Robotics Systems
EE 416 Digital Integrated Circuits/VLSI	EE 453 Fundamentals of Digital Signal Processing	EE 486 Sustainable Energy System Integration
EE 417 Digital Design using Field Programmable Devices	EE 454 Fundamentals of Computer Vision	EE 488 Power Systems Analysis I
EE 420 Electro-optics: Principles & Devices	EE 455 Introduction to Digital Image Processing	EE 494H Honors Thesis (3 credit limit)
EE 421 Optical Fiber Communications	EE 456 Artificial Neural Networks	EE 497 Special Topics (3 credit limit)
EE 422 Optical Engineering Laboratory	EE 460 Communication Systems II	CMPEN 431 Computer Architecture
EE 424 Principles and Applications of Lasers	EE 466 Introduction to Software-defined Radio	CMPEN 462 Wireless Security
EE 430 Principles of Electromagnetic Fields	EE 471 Introduction to Plasmas	CMPEN 472 Microprocessors and Embedded Systems
EE 432 UHF and Microwave Engineering	EE 472 Space Astronomy and Introduction to Space Sciences	CMPEN 473 Microcomputer Laboratory
EE 437 Physical Implementation of qubits	EE 474 Satellite Communications	CMPEN 475 Functional Verification
EE 438 Antenna Engineering	EE 477 Fund. of Remote Sensing Systems	

I. 4 . Selection of Statistics Elective @

Take one 3-credit statistics course from the following list:

STAT 418 - Probability - This elective, taught by the Statistics Department, provides adequate probability and statistics background for EE students. This is one of the two statistics elective alternatives (also see EE 465 below) that is **strongly recommended** for students planning to take signal processing, control, communications or networking electives, and/or those planning to attend graduate school in Electrical Engineering. It is also the most appropriate statistics elective if you are planning to get a math minor because it counts as a 400-level math course.

STAT 414 - Probability Theory - This course is similar to STAT 418, but intended for STAT majors. Compared to STAT 418, it will have more emphasis on theory rather than application.

EE 465 - Probability for Electrical and Computer Engineers – This statistics elective is taught by EE professors, and has a strong emphasis on electrical engineering applications. This is one of the two statistics elective alternatives (also see STAT 418 above) that is **strongly recommended** for students planning to take signal processing, control, communications or networking electives, and/or those planning to attend graduate school in Electrical Engineering.

IE 424 - Process Quality Engineering - This is a more applied statistics elective for students interested in quality control and industrial/manufacturing applications. This course does not cover some of the very important material covered by the electives described above. It is **not** recommended that you take this course as your statistics elective if you're planning to take signal processing, control, communications or networking electives, and/or planning to attend graduate school in Electrical Engineering.

STAT 401 - Experimental Methods – This elective focuses more on statistical tests rather than on probability and random variables. It is not recommended for students interested in Control, Signal Processing or Communications.

I. 5. Selection of Related Electives %

The Related elective is a 6-credit requirement aimed at broadening the knowledge base of our students through additional EE technical electives or courses in some other field that complements the EE Degree, or through professional development. There are numerous ways that this elective can be satisfied – additional technical courses, non-technical Engineering courses (leadership, green engineering, etc.), business courses, language courses, minor courses, ROTC credits, or Co-operative Education credits.

These 6 credits are to be selected from the following list. Any courses not listed here require approval of the Director of Academic Affairs.

- Any additional course from the EE Technical Elective lists (300 or 400 level)
- CMPSC 221 or any technical 300-400 level CMPSC course
- Any technical course from other Engineering majors that is not remedial or does not duplicate material you already learned. See “Courses not allowed” section below for exclusions.
- Any technical course from Science or Earth & Mineral Science majors that is not remedial or does not duplicate material you already learned. See “Courses not allowed” section for exclusions.
- Any EE 496 course

- Any Engineering course in leadership, entrepreneurship, ethics, or conservation such as: ENGR 405, ENGR 407, ENGR 408, ENGR 410, ENGR 412, ENGR 425, EGEE 101, or EGEE 102. There could be other courses that fit this category as well.
- Co-op credit (ENGR 295, 395, 495)
- ROTC credit (only if you complete the ROTC program; 3 credits maximum)
- Any World Language course
- Any course that is used for the completion of a minor
- Any approved business courses; suggested business courses for use as related electives: ACCTG 211, BA 243, BA 250, BA 301, BA 302, BA 303, BA 304, BLAW 243, FIN 100, FIN 108, IB 303, MGMT 100, MGMT 215, MKTG 221.

COURSES NOT ALLOWED TO MEET ANY GRADUATION REQUIREMENTS:

Remedial courses, 2-year and 4-year technology degree courses, and courses that closely resemble other courses taken cannot be used to meet graduation requirements in the BSEE program. This list includes, but is not necessarily limited to, the following courses:

All engineering tech courses (EET, etc.); CMPSC 100, 101, 200, 203; ME 445, 455; NUCE 445; All SC courses; EE 211, 212, 353; ESC 314, ESC 400H and all ESC courses below 300 level; English 004, 005; I E 452; All PLET courses; PHYS 001-200, 250-400, 401, 402, 444, 457, 458; ENGR 195 (Internship Credit); MATH 001-111, 200, 318-319, 470, 471, 475

IF THERE IS ANY QUESTION ABOUT WHETHER A COURSE CAN MEET GRADUATION REQUIREMENTS, CONTACT AN ACADEMIC ADVISOR OR THE DIRECTOR OF ACADEMIC AFFAIRS.

I. 6. Selection of General Education Electives

Penn State requires 45 credits of General Education courses. 27 of these General Education credits are fulfilled automatically through existing EE Degree requirements (e.g. MATH 140 and MATH 141 count as a GQ courses; ECON 102 or 104 counts as a GS course; CHEM 110, PHYS 211, and PHYS 212 count as GN courses; ENGL 15, CAS 100 and ENGL 202C count as GWS courses). However, there are 18 additional credits of General Education electives needed to reach the 45 credit count. These 18 credits must include:

- At least 3 credits of courses designated solely as GA (Arts)
- At least 3 credits of courses designated solely as GH (Humanities)
- At least 3 credits of courses designated solely as GHW (Health and Wellness)
- At least 6 credits of courses that are designated as integrative studies courses. Integrated studies courses are interdomain General Education courses that span two categories (e.g. GA/GH, GS/GN).
- An additional 3 credits of General Education elective courses selected from GA/GH/GS/GN/interdomain). This is called an exploratory Gen Ed elective.

In addition, all PSU students must take at least one 3-credit United States Cultures (**US**) course and at least one 3-credit International Cultures (**IL**) course. These US/IL cultures courses are typically chosen so that they can double-dip as General Education electives. Courses that are listed as both US and IL can be used to meet EITHER requirement, but cannot be used to satisfy BOTH requirements simultaneously. Two distinct courses are needed to satisfy the US and IL requirements.

For more details about the General Education requirements, visit **https://gened.psu.edu**

A general education planning tool is available at **https://genedplan.psu.edu/**

General Education Exceptions That Require Department Petitions

Some common General Education exception are as follows:

1. Foreign Language option: Students who have earned credit for a level 3 (or higher) foreign language (e.g. Spanish 3, French 3) may use 3 credits of this language to count towards 3 credits of general education electives (exploratory category only).

2. Any course that does not carry the general education label, including courses offered at other universities (if they are not direct transfers) and higher-level Gen Ed-type courses (e.g. a 400-level ECON course) requires a petition to be considered as a general education elective. A course syllabus must be included with the petition, along with a justification of how the course satisfies the intent of general education.

For information on submitting petitions, see section II - 5 of this handbook.

II. ACADEMIC ADVISING AND STUDENT SUPPORT

II. 1. EE Advising and Support Personnel

The following Electrical Engineering Academic Affairs Office faculty/staff are your primary resources for advising and other academic issues and questions.

Angel Welch Primary Academic Advisor	113 EE East EWM5361@psu.edu	• Scheduling classes • Long-term academic planning • Academic support such as tutoring resources, time management, & professional development • Initial inquiries about graduate school
Prof. David Salvia Director of Academic Affairs and Undergraduate Officer	114 EE East DSALVIA@psu.edu	• Transfer student advising • Course petition approval • Change of major • Course enrollment issues • Alleged academic integrity violations • Issues with faculty and TAs
Prof. Mark Mahon Faculty Advisor	W209A Westgate MPM114@psu.edu	• Information about graduate school, internships, the co-op program, and full-time employment • Scheduling classes (particularly technical electives)
Mrs. Gabi Rhinehart Undergraduate Program Staff Assistant	115 EE East GBR6@psu.edu	• Degree audit checks • Graduation verification • Questions related to graduation

II. 2. EE Advising Structure

EE advisors, staff, and faculty support students as they navigate class schedules, internships, career paths, University policies, and wellbeing. In Electrical Engineering, we utilize a multi-tiered approach to advising. Academic advisors, staff, and faculty work hand-in-hand to support Electrical Engineering students. The department's goal is to ensure students are receiving the guidance they need in a timely manner.

The primary academic advisor serves as the first point of contact for EE students. In specific situations, the primary academic advisor will refer students to the Director of Academic Affairs, the Faculty Advisor, or the Undergraduate Program Staff Assistant for further assistance.

In addition to the formal advising structure above, our EE faculty serve as a resource that students should utilize. They are very knowledgeable about courses, graduate school, and career opportunities in their areas of specialization. They can help you sort out electives and expand upon the class descriptions provided in this handbook.

II. 3. Transfer Student Advising

Transfer students are defined as:

- Advanced Standing students transferring from another university
- Dual Degree Program students (formerly 3-2 Program)

Students transferring into the BSEE program from another school need to be extra careful about graduation requirements. The courses that you need to graduate will vary from student to student. You **must** meet with the Director of Academic Affairs upon acceptance into the EE program to determine what courses are still needed for graduation. **Failure to do so may lead to improper course selection and subsequent delay in your graduation.**

II. 4. Schreyer Honors College Advising

Students in the Schreyer Honors College are assigned an honors advisor when they are first accepted into the honors program. Honors advisors in the EE Department are Professors Nilanjan Ray Chaudhuri, Bill Higgins, Greg Huff, Timothy Kane, Morteza Kayyalha, Constantino Lagoa, Mike Pusateri, and Julio Urbina.

Students in the Schreyer Honors College can have certain graduation requirements waived/substituted with the support of their honors advisor, if they can show that the changes are in the best interest of their overall academic plan.

II. 5. Petitions

Department and College Petitions
All requests for exceptions to the degree requirements set forth in this EE program booklet must be submitted electronically at **https://coursesub.psu.edu.** Any petition involving a course taken somewhere other than PSU must include a course syllabus. Likewise, any petition involving a PSU Special Topics Course (x97) must include a course syllabus. **You must file department/college petitions before your last semester!**

Faculty Senate Petitions
All requests for exceptions to the PSU Policy and Rules for Students require the submission of a Faculty Senate petition. Most frequently Faculty Senate petitions are needed for situations such as retroactive late-drop and/or retroactive withdrawal. Faculty Senate petition instructions can be found here: **https://senate.psu.edu/students/petitions/**

Before submitting any Faculty Senate petition, students must meet with their academic advisor to discuss the details. Faculty Senate petitions are submitted through your academic advisor.

Grade Forgiveness Petitions
Grade forgiveness is a policy where a poor grade (D or F) in a course that is later repeated can, in some cases, be excluded from your GPA calculation. The grade forgiveness petition process is different than for other petitions.

For more information about grade forgiveness and the procedure for submitting Grade Forgiveness petitions, go to **https://www.registrar.psu.edu/grades/grade-forgiveness.cfm**

II. 6. Degree Audits

As you progress through the requirements for your degree, you should check periodically to be sure that your course selections will satisfy the degree requirements. At any time, you may make an appointment with Mrs. Rhinehart, the *Undergraduate Program Staff Assistant*, Room 115 EE East, in the Office of Academic Affairs to review (audit) your record. You can also obtain a copy directly on-line by visiting the student portal in LionPATH. Please be aware, however, that these computer-generated degree audits may not necessarily reflect petitions/exceptions that have recently been approved by the EE Department. If you have any questions about your degree audit, please contact the Undergraduate Program Staff Assistant or your advisor.

The semester before you graduate, you should make an appointment to meet with Mrs. Rhinehart, the *Undergraduate Program Staff Assistant,* in 115 EE East (865-7272, gbr6@psu.edu) for a final senior audit.

Though we will help as much as we can, we cannot accept responsibility for your course-scheduling decisions. Senate rules state that the **student has the final responsibility for selecting courses and meeting degree requirements.**

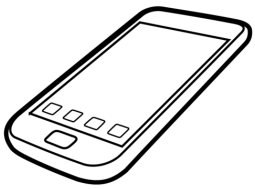
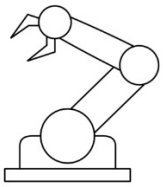
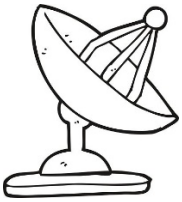
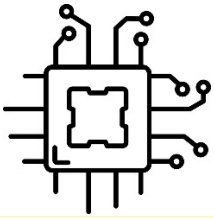
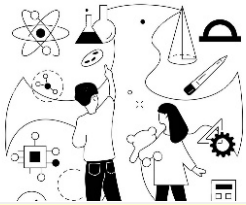
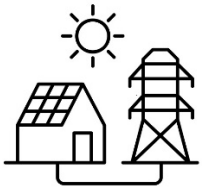
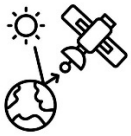
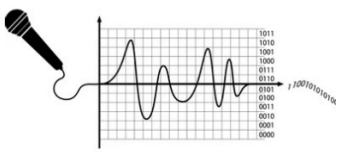
III. CAREER GUIDANCE

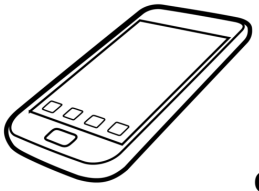
III. 1. CHOOSING AREAS OF SPECIALIZATION

The BSEE program allows students to informally choose an area of specialization by selecting technical electives in a structured way. Students **are not** required to officially select an area of specialization when selecting their technical electives, however.

The following pages identify which courses relate to each general technical interest area (shown below). Some of you may wish to specialize in an area, but there have been many cases where people who specialize in one area find a job in another. Especially for the undergraduate, we recommend a sampling of two or three areas because professional careers often move in unexpected directions.

AREAS OF SPECIALIZATION WITHIN ELECTRICAL ENGINEERING

COMMUNICATIONS 	**COMPUTER HARDWARE** 	**COMPUTER SOFTWARE** 
CONTROL SYSTEMS 	**ELECTROMAGNETICS** 	**ELECTRONIC DESIGN** 
GRAD SCHOOL PREPARATION 	**OPTICS** 	**POWER SYSTEMS** 
REMOTE SENSING & SPACE SYSTEMS 	**SEMICONDUCTOR DEVICES** 	**SIGNAL & IMAGE PROCESSING** 



COMMUNICATIONS

Overview

The transmission of information in a fast, reliable, and secure way is a necessity in the world that we live in. Study in communications involves the analysis and design of information transmission systems. Principles such as different modulation schemes (such as AM and FM), noise suppression, various transmission media and computer networking are discussed in detail. Different examples of some communications systems include radio, television, the telephone system, computer networks, GPS satellite systems, and microwave transmission lines.

Pertinent Required Courses

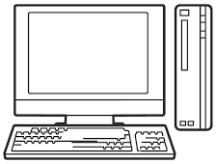
- EE 350 - Continuous-time Linear Systems
- EE 330 - Engineering Electromagnetics
- A statistics course (EE 465 or STAT 418 recommended)

Suggested Electives

- EE 360 - Communication Systems I: a junior-level elective which provides a broad introduction to both analog and digital communication systems and modulation schemes
- EE 362 - Communication Networks: studies data encoding, network architecture, and the routing of data streams, which are important in the computer communication industry
- EE 421 - Optical Fiber Communications: a follow-up to EE 320 which provides students with a fundamental understanding of the operation of fiber optic systems, including transmitters, receivers, as well as the fibers themselves
- EE 432 - UHF and Microwave Engineering: discusses the analysis and design of microwave transmission lines, amplifiers and filters, which are key elements in many communications systems
- EE 438 - Antenna Engineering: analysis and design of many types of antennas, with laboratory work in AM/FM antenna and array design
- EE 460 - Communication Systems II: a follow-up to EE 360 which focuses on the design of communication systems in the presence of noise and the corresponding statistics-based theoretical analysis
- EE 466 - Software-defined Radio: an applications course that uses digital signal processing to implement the building blocks of a communication system
- EE 474 - Satellite Communications: a follow-up to EE 360 which provides an overview of satellite communication systems, including modulation schemes, satellite components, satellite link design and orbital mechanics
- CMPEN 462 - Wireless Communication Systems and Security: a follow-up to EE/CMPEN 362 that covers hardware and software design concepts associated with wireless access, data transmission, and computational security.

Other courses that are tangentially related to communications

- EE 424 - Lasers: Principles and Applications: a follow-up to EE 320 covering the operation of lasers as well as applications such as optical signal processing, holography, spectroscopy, remote sensing (LIDAR), and optical communications
- EE 453 - Digital Signal Processing: a follow-up to EE 351 that covers both the theory and application of DSP, including A/D and D/A conversion, digital filter design, and implementation of the Discrete Fourier Transform via the Fast Fourier Transform algorithm



COMPUTER HARDWARE

Overview

With the proliferation of digital electronics, most electrical engineering systems will include computer hardware as an integral part of the system. Computer hardware courses are equally split between the Electrical Engineering and Computer Engineering majors. These courses are generally accessible to EE students who have no advanced software courses.

Pertinent Required Courses

- CMPEN 270 - Digital Design: Theory and Practice
- EE 200 - Design Tools

Suggested Electives

- EE 337 - Quantum Information Science and Engineering: provides a broad overview of the emerging area of quantum computing and related applications involving quantum theory
- EE 362 - Data Communications: studies data encoding, network architecture, and the routing of data streams, which are important in the computer communication industry
- EE 416 - Digital Integrated Circuits/VLSI Design: looks at the design of very large scale integrated chips, with a focus on logic gates, volatile and non-volatile memory, and sequential elements
- EE 417 - Digital Design Using Field Programmable Gate Arrays: a lecture/lab course that teaches the fundamentals of programmable gate arrays (PGA's) and VHDL
- EE 437 - Physical Implementation of qubits: a follow-up to EE 337 that examines state-of-the-art use of quantum bits (qubits) to solve engineering problems
- CMPEN 331 - Computer Organization and Design: a junior-level introduction to computer architecture which discusses how the microprocessor, memory, I/O, etc. interact with each other
- CMPEN 431 - Introduction to Computer Architecture: a follow-up to CMPEN 331 which deals more with design issues in computer architecture
- CMPEN 472 - Microprocessors and Embedded Systems: a follow-up to CMPEN 331 which teaches the basics of microprocessor programming and interfacing and using embedded microprocessors in larger systems
- CMPEN 473 - Microcomputer Laboratory: a follow-up to CMPEN 472 in which students are guided through a series of projects dealing with microprocessor-based single-board systems
- CMPEN 475 - Functional Verification: a follow-up to CMPEN 331 which teaches techniques for verifying the functionality of digital electronic circuits

COMPUTER SOFTWARE

Overview

Like computer hardware, computer software is used, to some extent, by almost all electrical engineers. Many EE courses use specialty software packages to assist in the analysis/design of various electrical engineering systems. In addition, however, courses SPECIFICALLY related to computer software are available. For the most part, these courses are taught by the Computer Science and Engineering (CSE) Department for Computer Science and Computer Engineering majors. EE students, however, are allowed to take these courses on a space available basis.

Computer software courses can be divided into 2 areas -- programming courses and applications courses.

Pertinent Required Courses

- CMPSC 131 - Programming and Computation I: Fundamentals
- CMPSC 132 - Programming and Computation II: Data Structures

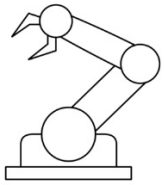
Suggested Electives

General Programming Courses (NOTE: These courses count only as RELATED electives):

- CMPSC 221 - Object-oriented Programming with Web Applications: a follow-up to CMPSC 132 that covers object-oriented programming and introduces graphics, virtual machines, programming language concepts and web-based programming using Java
- CMPSC 311 - Introduction to System Programming: a follow-up to CMPSC 221 which focuses on operating system (UNIX) level programming
- CMPSC 442 - Introduction to Artificial Intelligence: a follow-up to CMPSC 132 which covers the theory, implementation, and application of artificial intelligence
- CMPSC 450 - Concurrent Scientific Programming: a follow-up to CMPSC 131 which teaches the solution to problems encountered with synchronization and concurrent execution in distributed systems
- CMPSC 451 - Numerical Computations: covers algorithm development for Fourier Transforms, interpolation, numerical integration, differential equation solutions, etc.
- CMPSC 455 - Introduction to Numerical Analysis: similar to CMPSC 451 but a bit more mathematical. Students can NOT take both CMPSC 451 and CMPSC 455 for credit

Programming Application Courses (NOTE: These courses count as EE technical electives):

- EE 454 - Fundamentals of Computer Vision: discusses topics such as object recognition, feature extraction from an image, and dynamic image analysis
- EE 455 - Digital Image Processing: overview of image processing techniques and applications such as image enhancement and restoration
- EE 456 - Introduction to Neural Networks: examines the use of artificial neural networks, artificial intelligence, and machine learning to solve a variety of engineering problems
- EE 466 - Software-defined Radio: an applications course that uses digital signal processing to implement the building blocks of a communication system



CONTROL SYSTEMS

Overview

Control systems are encountered every day, from temperature/climate control systems in buildings to navigational control systems in vehicles. Control systems are also an integral part of any manufacturing process -- electronics are used to monitor and regulate assembly lines. A control systems specialization provides students with the necessary mathematical and computer programming background to analyze and design both analog and digital control systems. Associated lab work helps illustrate the control algorithms learned in the classes.

One sub-category of control systems is robotics. At Penn State, robotics is covered more in industrial or mechanical engineering. However, a controls background, in addition to courses in IMAGE PROCESSING and SIGNAL PROCESSING, provides students with many of the fundamentals needed for future work in robotics.

Pertinent Required Courses

- EE 350 - Continuous-time Linear Systems
- A statistics course (EE 465 or STAT 418 recommended)

Suggested Electives

Basic control theory is covered in a 2-course sequence (EE 380/482) following junior-level linear systems courses which provide the mathematical background (EE 350/351):

- EE 351 - Discrete-time Systems: a junior-level elective follow-up to EE 350 which provides a mathematical foundation for subsequent study in digital signal processing, digital control systems, and image processing
- EE 380 - Linear Control Systems: introductory course, with lab, which provides a theoretical and practical overview of classical analog control methods such as PID control and lag-lead control
- EE 482 - Digital Control Systems: a follow-up to both EE 351 and EE 380 which focuses on modern digital control techniques and the corresponding A/D conversion
- EE 483 - Automation and Robotics Systems: a hands-on applications course that focuses on robotic motion and control and robotic components such as sensors and actuators

Other courses that are tangentially related to control systems

- EE 387 - Energy Conversion: modeling and analysis of motors and generators, electromechanical energy conversion machines that are integral parts of industrial applications and other control systems
- EE 413 - Power Electronics: studies high-power semiconductors that interface with mechanical systems or convert electric power between different forms
- EE 454 - Fundamentals of Computer Vision: discusses topics such as object recognition, feature extraction from an image, and dynamic image analysis
- EE 486 - Sustainable Energy System Integration: introduces renewable energy units and their integration and control strategies

ELECTROMAGNETICS

Overview

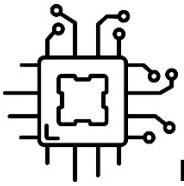
There are many applications of electromagnetics within the electrical engineering field. This area is good for students pursuing careers in antenna design, microwave communications, and in the study of wave propagation. Throughout this area, there is a strong emphasis on Maxwell's equations, Faraday's laws, and wave phenomena, which are often understood much more easily when time varying visual simulations replace equations and static diagrams.

Pertinent Required Courses

- EE 330 - Engineering Electromagnetics

Suggested Electives

- EE 430 - Principles of Electromagnetic Fields: a follow-up to EE 330 which discussed E/M in theoretical detail, along with applications such as transmission lines, wave guides, and signal propagation
- EE 432 - UHF and Microwave Engineering: discusses the analysis and design of microwave transmission lines, amplifiers and filters, which are key elements in many communications systems
- EE 438 - Antenna Engineering: analysis and design of many types of antennas, with laboratory work in AM/FM antenna and array design
- EE 471 - Introduction to Plasmas: gives students a basic introduction to electromagnetic properties of plasmas, primarily in astrophysical and geophysical contexts
- any course in REMOTE SENSING AND SPACE SYSTEMS



ELECTRONIC DESIGN

Overview

Although almost every electrical engineering sub-discipline uses electronics to some extent, the term electronic design is generally understood to mean the assembly of basic electronic components to accomplish some fundamental task that is replicated many times over in a practical system. The field of electronic design ranges from the basic design of IC's using discrete semiconductor devices to the fabrication of complex circuits on a single IC chip using VLSI techniques.

Pertinent Required Courses

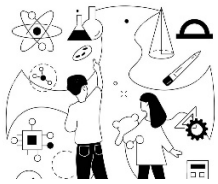
- EE 200 - Design Tools
- EE 210 - Circuits and Devices
- EE 310 - Electronic Circuit Design I
- EE 340 - Nanoelectronics
- CMPEN 270 - Digital Design: Theory and Practice

Suggested Electives

- EE 311 - Electronic Circuit Design II: a follow-up to EE 310 which focuses on multi-stage amplifier design, feedback, and frequency response characteristics of electronic circuits
- EE 410 - Analog Integrated Circuits: looks at the design of analog integrated circuit building blocks such as operational amplifiers, voltage regulators, current sources, and amplifiers
- EE 413 - Power Electronics: studies high-power semiconductors that interface with mechanical systems or convert electric power between different forms
- EE 416 - Digital Integrated Circuits/VLSI Design: looks at the design of very large scale integrated chips, with a focus on logic gates, volatile and non-volatile memory, and sequential elements
- EE 417 - Digital Design using Field Programmable Gate Arrays: a lecture/lab course that teaches the fundamentals of programmable gate arrays (PGA's) and VHDL
- CMPEN 475 - Functional Verification: a follow-up to CMPEN 331 which teaches techniques for verifying the functionality of digital electronic circuits

Other courses that are tangentially related to electronic design

- EE 441 - Semiconductor Integrated Circuit Technology: a practical study of the fabrication of MOS integrated circuits, with a strong laboratory component in which students become familiar with clean room equipment
- EE 442 - Solid State Devices: a follow-up to EE 340 which focuses on the physics of semiconductors and the modeling/design of various semiconductors using BJT, JFET, CMOS, NMOS, and BiCMOS technologies
- EE 432 - UHF and Microwave Engineering: discusses the analysis and design of microwave transmission lines, amplifiers and filters, which are key elements in many communications systems



GRAD SCHOOL PREPARATION

Overview

Unless you know exactly what you are going to do in graduate study, the recommended strategy for an undergraduate intending to study beyond the baccalaureate level is to take a series of foundation courses covering several different areas of technology. Specialization can then come at the graduate level. Two reasons for doing this are 1) most graduate programs have some sort of breadth requirement which requires technical courses in multiple sub-disciplines of electrical engineering and 2) exposing yourself to many facets of electrical engineering as an undergraduate may help you decide WHAT to specialize in during your graduate program.

Pertinent Required Courses:

It is strongly recommended that you take EE 465 or STAT 418 as your statistics elective if you are contemplating graduate study.

Suggested Electives

- Any of the broad 300-level EE Electives (EE 311, 320, 337, 351, 360, 362, 380, 387)
- EE 420 - Electro-optics - Principles and Devices: a follow-up to EE 320 that covers the topics more in-depth, with an emphasis on holography

- EE 430 - Principles of Electromagnetic Fields: a follow-up to EE 330 which discussed E/M in theoretical detail, along with applications such as transmission lines, wave guides, and signal propagation
- EE 442 - Solid State Devices: a follow-up to EE 340 which focuses on the physics of semiconductors and the modeling/design of various semiconductors using BJT, JFET, CMOS, NMOS, and BiCMOS technologies
- EE 453 - Digital Signal Processing: a follow-up to EE 351 that covers both the theory and application of DSP, including A/D and D/A conversion, digital filter design, and implementation of the Discrete Fourier Transform via the Fast Fourier Transform algorithm
- EE 460 - Communication Systems II: a follow-up to EE 360 which focuses on the design of communication systems in the presence of noise and the corresponding statistics-based theoretical analysis
- other courses that are listed in the Graduate Bulletin as prerequisites for 500-level courses

OPTICS

Overview

Optical systems have become increasingly popular for manipulating information (optical signal processing), transmitting information (fiber optics), and remote measurement of electrical properties (LIDAR). Furthermore, electro-optical devices, such as liquid crystal displays (LCDs) are a mainstay in high-tech electronic gadgets and laptop computers. The broad field of optics provides students with knowledge about the many building blocks within an optical system.

Pertinent Required Courses

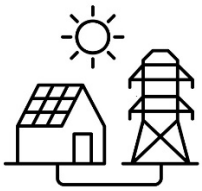
- EE 330 - Engineering Electromagnetics
- EE 340 - Nanoelectronics

Suggested Electives

- EE 320 - Introduction to Electro-optical Engineering: an introductory course in optics/electro-optics which covers lenses, mirrors, polarization, lasers, diffraction, wave motion, and geometric optics
- EE 420 - Electro-optics - Principles and Devices: a follow-up to EE 320 that covers the topics more in-depth, with an emphasis on holography
- EE 421 - Optical Fiber Communications: a follow-up to EE 320 which provides students with a fundamental understanding of the operation of fiber optic systems, including transmitters, receivers, as well as the fibers themselves
- EE 422 - Optical Engineering Laboratory: a laboratory-oriented follow-up to EE 320 providing students with hands-on exposure to lenses, lasers, diffraction, holograms, and other optical devices
- EE 424 - Lasers: Principles and Applications: a follow-up to EE 320 covering the operation of lasers as well as applications such as optical signal processing, holography, spectroscopy, remote sensing (LIDAR), and optical communications

Other courses that are tangentially related to optics

- EE 477 - Fundamentals of Remote Sensing: studies various techniques for atmospheric measuring using both radio frequency approaches (RADAR, radiometry) and optical approaches (LIDAR -- laser radar, spectroscopy)



POWER SYSTEMS

Overview

Once the bread and butter of electrical engineering, the power systems field deals with the generation of electrical power on both the large scale and small scale. Large scale power system study involves the understanding of how power is generated at the power plant and then transmitted to homes, businesses, and factories. On the smaller scale, power systems studies motors and generators, which convert energy from electrical to mechanical form and vice versa, and the associated power electronics

Pertinent Required Courses

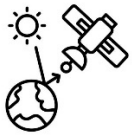
- EE 210 - Circuits and Devices
- EE 310 - Electronic Circuit Design I
- EE 350 - Continuous-time Linear Systems

Suggested Electives

- EE 387 - Energy Conversion: modeling and analysis of motors and generators, electromechanical energy conversion machines that are integral parts of industrial applications and other control systems
- EE 413 - Power Electronics: studies high-power semiconductors that interface with mechanical systems or convert electric power between different forms
- EE 486 – Sustainable Energy System Integration: introduces renewable energy units and their integration and control strategies
- EE 488 - Power Systems Analysis I: an overview of the entire power system process: transformers, transmission lines, power system control, power flow, stability

Other courses that are tangentially related to power systems

- NUC E 401 - Introduction to Nuclear Engineering: an overview of Nuclear Engineering (fission, reactor theory, etc.) that is useful for Electrical Engineers working in the power industry
- AE 311 - Fundamentals of Electrical and Illumination Systems for Buildings: useful elective for Electrical Engineering students working in the construction industry
- AE 456 - Solar Energy Building System Design: teaches analysis and design of solar radiation collection systems
- any course in CONTROL SYSTEMS



REMOTE SENSING & SPACE SYSTEMS

Overview

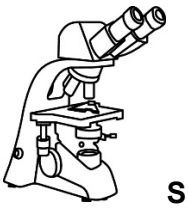
For many years, the largest research group in the EE Department at Penn State, the Communications and Space Sciences Laboratory (CSSL), has studied the ionosphere and related effects such as weather and thunderstorms. Problems of interest include the design of instrumentation as well as the study of natural phenomena. The research interests have influenced undergraduate courses in many ways, especially in COMMUNICATIONS, ELECTROMAGNETICS, and OPTICS. In addition, courses specifically in the area of space sciences have also been developed.

Pertinent Required Courses

- EE 330 - Engineering Electromagnetics

Suggested Electives

- EE 471 - Introduction to Plasmas: gives students a basic introduction to electromagnetic properties of plasmas, primarily in astrophysical and geophysical contexts
- EE 472 - Introduction to Space Sciences: introduces students to the fundamentals of space sciences by providing a background in the physical/chemical properties of the atmosphere and ionosphere and discussing other topics such as solar wind and sun-trapped particle belts
- EE 474 - Satellite Communications: a follow-up to EE 360 which provides an overview of satellite communication systems, including modulation schemes, satellite components, satellite link design and orbital mechanics
- EE 477 - Fundamentals of Remote Sensing: studies various techniques for atmospheric measuring using both radio frequency approaches (RADAR, radiometry) and optical approaches (LIDAR -- laser radar, spectroscopy)



SEMICONDUCTOR DEVICES

Overview

Because semiconductors are the active components inside nearly all modern electronic devices, all advances in electronics ultimately come down to making better semiconductor devices and understanding how they work. Silicon is the basic ingredient in most devices and the primary material studied at the undergraduate level, though the principles are easily extended to other materials.

Pertinent Required Courses

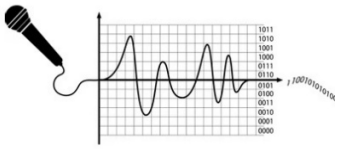
- EE 210 - Circuits and Devices
- EE 310 - Electronic Circuit Design I
- EE 340 - Nanoelectronics

Suggested Electives

- EE 441 - Semiconductor Integrated Circuit Technology: a practical study of the fabrication of MOS integrated circuits, with a strong laboratory component in which students become familiar with clean room equipment
- EE 442 - Solid State Devices: a follow-up to EE 340 which focuses on the physics of semiconductors and the modeling/design of various semiconductors using BJT, JFET, CMOS, NMOS, and BiCMOS technologies
- EE 416 - Digital Integrated Circuits/VLSI Design: looks at the design of very large scale integrated chips, with a focus on logic gates, volatile and non-volatile memory, and sequential elements

Other courses that are tangentially related to semiconductor devices

- E SC 312 and E SC 313: these courses deal with fabrication and application of nano technology.
  (Note: These courses count as ENGINEERING or RELATED electives, not as EE technical electives.)
- any course in ELECTRONIC DESIGN



SIGNAL & IMAGE PROCESSING

Overview

Signals -- both 1-D signals such as speech and audio signals, and 2-D signals such as images and video signals -- represent information. Processing these signals means extracting certain parameters from that information, filtering it to remove undesired components, coding it for efficient transmission, or many other operations. Because digital technology supports extensive manipulation and interpretation of signal/image data, signal processing is increasingly becoming digital. Therefore, a basic understanding of the effects of analog to digital conversion is key in understanding the design of modern signal processing algorithms. The signal and image processing field is a programming-intensive one in which various algorithms to perform these tasks are implemented.

Pertinent Required Courses

- EE 350 - Continuous-time Linear Systems
- CMPSC 131 – Programming and Computation I: Fundamentals
- A statistics course (EE 465 or STAT 418 recommended)

Suggested Electives

- EE 351 - Discrete-time Systems: a junior-level elective follow-up to EE 350 which provides a mathematical foundation for subsequent study in digital signal processing, digital control systems, and image processing
- EE 453 - Digital Signal Processing: a follow-up to EE 351 that covers both the theory and application of DSP, including A/D and D/A conversion, digital filter design, and

implementation of the Discrete Fourier Transform via the Fast Fourier Transform algorithm
- EE 454 - Fundamentals of Computer Vision: discusses topics such as object recognition, feature extraction from an image, and dynamic image analysis
- EE 455 - Digital Image Processing: overview of image processing techniques and applications such as image enhancement, deblurring, and restoration
- EE 456 - Introduction to Neural Networks: examines the use of artificial neural networks, artificial intelligence, and machine learning to solve a variety of engineering problems

Other courses that are tangentially related to signal/image processing
- EE 360 - Communication Systems I: a junior-level elective which provides a broad introduction to both analog and digital communication systems and modulation schemes
- EE 460 - Communication Systems II: a follow-up to EE 360 which focuses on the design of communication systems in the presence of noise and the corresponding statistics-based theoretical analysis
- EE 466 -- Software-defined Radio: an applications course that uses digital signal processing to implement the building blocks of a communication system
- CMPSC 442 - Introduction to Artificial Intelligence: a programming-intensive course which provides the foundations for developing computer algorithms capable of decision making

III. 2. Career Planning

There are multiple resources to assist you in finding employment after graduation. It is suggested that you use these resources to optimize your educational experience.

• **Career Development Placement Service –** Visit Career Services (Bank of America Career Service Center) well in advance of when you plan to start interviewing. Learn their procedures and what services they provide. (e.g., career counseling, information about employers and interview techniques, interest inventory tests, and a computer database on career options.) Over 1000 employers schedule 30-minute interviews from September through April. Their website is **http://studentaffairs.psu.edu/career**.

• **College of Engineering Career Resource Office –** Located in 117 Hammond Building, this office provides engineering specific career guidance. They handle full-time, co-op and internship placements. The Engineering Career Resource Office also manages an online resource, e-career, that connects students with prospective employers. Their website is **http://www.engr.psu.edu/career**.

• **Career Fairs** – PSU hosts a large career fair every fall and spring. Smaller career fairs also appear from time to time. Watch for notices in the Collegian, in the Department office and via the EE listserv.

• **EECS Job Listserv** – The School of EECS will occasionally alert students about job opportunities, via the EECS job Listserv. Current students are automatically subscribed.

III. 3. Applying for Graduate School

If you are considering graduate school, you should start thinking about it during your 3rd year. Your 300-level and 400-level elective courses will help you decide which technical area(s) you may want to pursue in graduate school. You also need to think about which schools to which you may want to apply. Faculty advisors (and faculty members in general) are great resources in

helping you identify both a technical research area and choice of graduate school. Another great resource is Peterson's, which publishes a helpful graduate studies guide and a web page **(http://www.petersons.com)** with links to individual schools. Finally, Career Services has both general and specific information on graduate school as well. Go to **http://studentaffairs.psu.edu/career/students/further_education.shtml**.

Students typically begin graduate school in the fall semester. To be considered for admission and financial aid, you will need to have your application materials on file by the end of the fall semester of the previous year. At most graduate schools, a student's application packet will consist of an application form, letters of reference from 2-3 faculty, official copies of all transcripts, GRE scores (if required by that school), and a personal statement regarding your background and technical interests (to assist the admissions committee in evaluating your application and possibly identifying professors whose research interests match your own). In general, an undergraduate GPA of 3.0 or above is required for admission, although there are exceptions to this rule.

III. 4. Professional Licensure

Engineers who complete a series of standardized examinations and meet other requirements can obtain a Professional Engineer (or PE) license. Whether licensure will be important for your career depends on the nature of your job and your employer.

The PE license process should be started while you are still a student and fresh from your academic studies. The first step is the FE (Fundamentals of Engineering) exam. By itself, it does not qualify you to be licensed, but it starts the process which can then be completed with a practice-oriented exam at a later time. The FE exam is computer-based and will be offered at Pearson VUE testing centers throughout the United States.

For more information about the FE exam and professional licensure and to register for the FE exam, visit the *National Council of Examiners for Engineering* web page at **http://ncees.org.**

IV. MISCELLANEOUS

IV. 1. Electrical Engineering Student Organizations

IEEE -- Institute of Electrical and Electronics Engineers: **http://sites.psu.edu/psuieee/**

- Regular meetings and special events are scheduled throughout the year
  - *Technical workshops*
  - *Company presentations*
  - *Social activities*
  - *Outreach activities*
- Professor Tim Kane (TJK7@psu.edu) is the faculty advisor.
- The IEEE office is located in 323 Electrical Engineering East.

Eta Kappa Nu (HKN) -- EE honor society: **http://sites.psu.edu/hkneecs/**

- Promotes scholarship and serves the EE students through
  - *Weekly tutoring*
  - *Academic and professional development presentations*
- Membership is extended by invitation to EE majors ranked in the top fourth of their junior class or the top third of their senior class.
- Professor Tim Kane (TJK7@psu.edu) is the faculty advisor.
- The HKN office is located in 323 Electrical Engineering East.

IV. 2. Laboratory and Computing Facilities

The BSEE curriculum contains eight required courses with laboratory components: CMPEN 270 (4 cr), EE 200 (3 cr), EE 210 (4 cr), EE 300 (3 cr), EE 310 (4 cr), EE 340 (4 cr), EE 350 (4 cr), and EE 403 (3 cr). Additional laboratory work is included in several of the senior elective courses.

The laboratory facilities for the required courses are located on the third floor of EE West – rooms 301, 302, 304, 309, and 310. You are welcome to use these facilities when they are not scheduled for formal class work. Your ID card gives you 24/7 access to the student labs in the 3rd floor of EE West.

Each of the EE West student laboratories has networked PCs for student use. All EE students will be given accounts to use these PCs. In addition, the EE Department also has a student PC lab in 306 EE West that has 24/7 access with your student ID. Software packages used in various EE courses are available in the PC lab and in the PCs in the student laboratories. Printers are available in some of the labs to print out course-related material.

The EE stockroom (room 307 EE West) has test equipment, soldering irons and test leads that can be signed out for use in the student laboratories. Resistors and wire are provided free in the stockroom. Other electronic components and parts kits for use in the various EE courses can be purchased from the stockroom using Lioncash.

IV. 3. Financial Aid and Scholarships

There are generally two types of undergraduate scholarships: **internal PSU scholarships** (where the money and selection process are controlled by PSU) and **external scholarships** (money/selection not controlled by PSU completely). In addition, there are graduate fellowships if you are considering graduate school.

EE Scholarships and College of Engineering Scholarships
The EE Department and the College of Engineering (CoE) provide both merit and need-based scholarships for undergraduate students. Each summer a scholarship committee reviews student records for disbursement of scholarships to eligible recipients. To be eligible for any EE and CoE scholarships, a student **must** complete an online application form. This form is available at **https://www.engr.psu.edu/academics/scholarships-continuing.aspx**. This application needs to be completed each calendar year, typically early in the spring semester. In addition, to be considered for any of the *need-based* scholarships, you must file a free Application for Federal Student Aid (FAFSA form) through the Office of Student Aid, located in 314 Shields Building, (see **http://studentaid.psu.edu)**. FAFSA forms should also be filed early in the spring semester.

External Scholarships
The College of Engineering maintains a website with links to a large number of external scholarships that are appropriate for engineering students. Some are major-specific, and others are open to any engineering student. This website is continually updated, so visit it often. The website is **https://www.engr.psu.edu/academics/scholarships-current-students.aspx**. In addition, the Undergraduate Research and Fellowship Office has a list of some of the more prominent general fellowships. Visit **https://urfm.psu.edu/** for more information. You may also want to use the web to search for other external scholarships/fellowships.

Graduate Fellowships
If you are considering graduate school, you should start looking for fellowship opportunities while you are still a Junior. As with undergraduate scholarships, the graduate fellowships are divided between internal and external fellowships. Contact the schools to which you are applying for information about internal fellowships and other funding opportunities. The PSU Graduate School has a page devoted to graduate school funding. Even if you aren't considering graduate school at Penn State, you should visit this page: **https://gradschool.psu.edu/graduate-school-funding/ .**

Wage Payroll Jobs
The EE Department hires graders, lab assistants, lab operators and others on an hourly, wage-payroll basis. To be considered for these positions you will need to fill out an on-line application with the EE department at the beginning of each semester. Information regarding this process is available at **http://www.eecs.psu.edu/Students/Graduate/EECS-Students-Job-Opportunities.aspx.**

For other financial aid information, (loans, etc.) please visit the PSU Financial Aid website at **http://studentaid.psu.edu/.**

IV. 4. Academic Integrity and the Code of Conduct

Academic Integrity
Recognizing not only the value of integrity in the academic environment, but also its value for the practicing engineer and for the society at large, we in the Department of Electrical Engineering urge you to act as a responsible professional while you are a student. Academic integrity is defined in PSU Faculty Senate rule 49-20 as follows:

> ***Academic integrity is the pursuit of scholarly activity free from fraud and deception and it is an educational objective of this institution. Academic dishonesty includes, but is not limited to, cheating, plagiarizing, fabricating of information or citations, facilitating acts of academic dishonesty by others, having unauthorized possession of examinations, submitting work***

of another person or work previously used without informing the instructor, or tampering with the academic work of other students.

Each instructor should clarify specific standards for each course.

It is commonly accepted that people learn better if they can interact, discuss, and assist each other in solving problems and understanding concepts. However, persons submitting identical homework papers, computer programs, lab reports or projects overstep the bounds of beneficial interaction. Clearly, professionals share ideas, but they should not use others' work without clear acknowledgement of who did the work. The College of Engineering has online resources related to academic integrity at **https://advising.engr.psu.edu/student-resources/academic-integrity.aspx**

The Code of Conduct
The University identifies and outlines 19 overarching categories of unacceptable student/student organization behavior in the Code of Conduct. Individuals and student organizations are encouraged to review and familiarize themselves with all materials on the Office of Student Conduct website: **https://studentaffairs.psu.edu/conduct**.

Penn State and the Office of Student Conduct are committed to, and accountable for, advancing diversity, equity, and inclusion in all its forms. We embrace individual uniqueness, foster a culture of inclusive excellence that supports both broad and specific diversity initiatives, leverage the educational and institutional benefits of diversity, and engage all individuals to help them thrive.

Institutional Values
Six core institutional values, identified in large part through Penn State's Culture and Values survey in 2014, offer essential context for the successful execution of Penn State's mission.

- **Integrity.** We act with integrity in accordance with the highest academic, professional, and ethical standards.
- **Respect.** We respect and honor the dignity of each person, embrace civil discourse, and foster a diverse, inclusive, and safe community.
- **Responsibility.** We act responsibly and hold ourselves accountable for our decisions, actions, and their consequences.
- **Discovery.** Through advanced research and scholarship, we seek and create new knowledge and understanding, and foster creativity and innovation, for society's benefit.
- **Excellence.** We strive for excellence in all of our endeavors as individuals, an institution, and a leader in higher education and research.
- **Community.** We work together for the betterment of our University, the communities we serve, and the world.

IV. 5. Minors and Certificates

Minors are secondary areas of study intended to complement a student's major. Some popular/appropriate minors for EE students are: Computer Engineering, Computational Sciences,

Engineering Leadership, Entrepreneurship and Innovation, Electronic and Photonic Materials, Math, Music Technology, Nanotechnology, Physics, Bioengineering, Business/LA, Product Realization, Environmental Engineering, and Information Science and Technology. Foreign language minors are also appropriate for EE students. Other available minors are listed in the Undergraduate Bulletin. You will usually, but not always, have to take extra courses to meet the requirements of the minor. Registration for a minor is done through the department or program that offers the minor. They will set forth a list of courses which fulfill the requirements, and then you will seek several signatures on the application form. A minor consists of at least 18 credits with at least 6 of those credits being at the 400-level.

A Certificate Program, like a minor, is a collection of classes that are related in some way. Certificates require fewer courses than a minor, so they are usually very easy to obtain. Currently, the College of Engineering offers certificate programs in Space Systems Engineering, International Engineering, Engineering Design, Housing, Nanotechnology, and Engineering and Community Engagement.

Go to **https://www.eecs.psu.edu/students/undergraduate/Majors-Minors-Certificates.aspx** for more information on available minors and certificates.

IV. 6. Engineering Co-operative Education Program

This is an organized program in which a student alternates periods of academic study and full-time employment with an approved employer. The program calls for entry usually at the beginning of the junior year, and for a cumulative work experience of 3 semesters (and/or summers) before graduation.

Students in the Co-op program can earn up to 6 credits to count as related electives. One credit is awarded for the first co-op rotation, two credits are awarded for the second co-op rotation and three credits are awarded for the third co-op rotation.

For more information on the Co-op program, contact the College of Engineering Career Resources Office at 863-1032 or visit: **https://career.engr.psu.edu/**. You may also contact the Co-op Advisor, Dr. Mike Pusateri, for more information, and/or to plan your work and study schedules.

If you are not a formal Co-op student, you may still take summer jobs with engineering companies. However, you may not claim Co-op credits for jobs you arrange outside of the formal program without approval of the College of Engineering Career Resources Office.

IV. 7. Concurrent Degrees

A student may, with the permission of both departments, simultaneously earn bachelor degrees in two majors. This concurrent degree program (previously called simultaneous degrees or multiple majors), requires careful planning with your faculty advisor. For additional details visit the following website:
https://senate.psu.edu/policies-and-rules-for-undergraduate-students/60-00-completing-more-than-one-undergraduate-program/

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Minghui Zhu	muz16@psu.edu	Control Systems

College of Engineering Resources				
Office	Website	Email	Phone Number	Address
Engineering Advising Center	https://advising.engr.psu.edu/index.aspx	adviser@engr.psu.edu	814-863-1033	208 Hammond Building
Engineering Career Resources	https://career.engr.psu.edu/	career@engr.psu.edu	814-863-1032	117 Hammond Building
Center for Engineering Outreach and Inclusion	https://inclusion.engr.psu.edu/	Contact form online	814-865-4287	112 Hammond Building
University Resources & Student Services				
Office	Website	Email	Phone Number	Address
Career Services	https://studentaffairs.psu.edu/career	AskCS@psu.edu	814-865-2377	101 Bank of America Career
Center for Sexual & Gender Diversity	https://studentaffairs.psu.edu/csgd	lgbtq@psu.edu	814-863-1248	LL011 HUB-Robeson Center
Counseling & Psychological Services (CAPS)	https://studentaffairs.psu.edu/counseling	Contact form online	814-863-0395	501 Student Health Center
Gender Equity	https://studentaffairs.psu.edu/genderequity	genderequity@psu.edu	814-863-2027	222U Boucke Building
International Student Advising	https://global.psu.edu/node/384	Contact form online	814-865-6348	410 Boucke Building
Learning Resource Center	https://pennstatelearning.psu.edu/resources	Contact form online	814-865-2582	220 Boucke Building
Paul Robeson Cultural Center	https://studentaffairs.psu.edu/cultural	prcc@psu.edu	814-865-3776	21 HUB-Robeson Center
Police Services	https://www.police.psu.edu/		814-863-1111 **Emergency call 911**	30 Eisenhower Parking Deck
Psychological Center	https://psych.la.psu.edu/psychological-clinic	psychologypsu@psu.edu	814-865-2191	337 Moore Building
Registrar	https://www.registrar.psu.edu/	registrar@psu.edu	814-865-6357	112 Shields Building
Student Aid	https://studentaid.psu.edu/	Contact form online	814-865-6301	314 Shields Building
Student Care & Advocacy	https://studentaffairs.psu.edu/studentcare	StudentCare@psu.edu	814-863-2020	129 Boucke Building
University Health Services	https://studentaffairs.psu.edu/health	uhs-info@psu.edu	814-865-4847	Student Health Center