ELECTRICAL ENGINEERING

Emphasis areas at all levels in circuits and electronics, power and energy, communications and signal processing, controls and systems, electromagnetics, optics and devices, and computer engineering.

Electrical engineers are involved in channeling natural resources into uses for society such as heating, lighting, home appliances, consumer products, computing, sensing, control, and communication. They contribute to systems and devices for power, instrumentation, measurement, communication, management, manufacturing, transportation, etc. They are primarily concerned with the processes of generation, transmission, transformation, control, and utilization of energy or information.

Students who are interested in electrical engineering begin in the Freshman Engineering Program, thus obtaining fundamental skills and an overview of the various degree programs at Missouri S&T, before entering the main program. They commit to a given degree program after exposure to the different career options. Once in the program, students gain knowledge in the main areas of electrical engineering, learn to use hardware and software tools in numerous laboratories, and apply engineering concepts in both freshman and capstone design experiences. Educational options include dual major programs (such as electrical and computer engineering degrees), minor programs, emphasis areas, and honors activities (such as the Honors Scholar Program in electrical engineering). They may supplement their education with participation in design competitions, professional societies, work internships, research experiences, etc.

The curriculum exposes students to the breadth of electrical engineering and allows them to pursue electives in several areas or to emphasize a specialty. The areas are defined as circuits and electronics, power and energy, communications and signal processing, controls and systems, electromagnetics, optic and devices, and computer engineering.

In circuits and electronics, courses provide study of basic electrical devices – energy sources, resistors, inductors, capacitors, diodes, and transistors – and their interconnection in operational networks. Circuits design and analysis techniques are covered with both analog and digital applications.

In power and energy, courses emphasize the design and applications of motors, generators, transformers, distribution systems, high-voltage devices, and power electronics.

In communications and signal processing, courses include concepts required for the characterization and manipulation of information-bearing signals, modulation systems, wireless networks, image processing, and detection hardware.

In controls and systems, courses emphasize the design and application of circuits and systems to automatically monitor and regulate devices, machines, and processes. Advanced technologies using digital control, intelligent processing, neural networks, and programmable logic controllers are included.

In electromagnetics, courses provide instruction in the interaction, propagation, and transmission of high-frequency waves and signals through space and in conductors. Topics include grounding and shielding, antennas, microwaves, and systems.

In optic and devices, courses provide study of solid-state materials, electronic devices, and optoelectronics. Applications are microfabrication, telecommunications, computing, instrumentation, lasers and fiber optics, nanotechnologies, sensing, and smart technologies.

In computer engineering, courses are offered in computers and architecture, integrated circuits and logic design, embedded computer systems, computational intelligence, networks and software engineering, and software security and reliability.

The electrical engineering program and the related computer engineering program are administered in the same department. Degree programs for B.S., M.S., and Ph.D. are offered. The classrooms and laboratories are located in Emerson Electric Company Hall. Additional research activities are being conducted in various research centers on campus. The department supports chapters for the following student groups: the Institute for Electrical and Electronics Engineers; IEEE-Eta Kappa Nu, the Electrical and Computer Engineering Honor Society; and the Amateur Radio Club. Various faculty and students participate in other campus organizations and are active in professional societies, design competitions, and technical conferences.

Educational Mission

The electrical and computer engineering department strives to contribute to the state, nation, and world through the education of outstanding professionals and leaders in engineering. Our educational focus is on a broad, rigorous education in all areas of electrical and computer engineering with significant hands-on experiences. The program will provide students with an understanding of engineering problem solving at all levels and an appreciation for engineering as a profession.

Objectives

The electrical and computer engineering degree programs seek to prepare its graduates to attain the following accomplishments a few years after graduation:

- Succeed in professional career placement and practice as ethical engineers, scholars, and entrepreneurs;
- Grow their career through technical and professional activities and leadership roles;
- Contribute to society and the economy through technical products, services, communication and knowledge; and
- Adapt to an ever-changing world through continued education, through graduate study, professional development activities, independent learning, or pursuit of follow-on degrees.

In order to attain these objectives, students graduating from the electrical and computer engineering degree programs should have the following attributes:

- **Technical Competency.** Graduates will have a sound knowledge of the fundamentals in electrical or computer engineering that allows them to analyze and solve technical problems, to apply hardware and software tools, to create and evaluate technical products, to learn independently, and to succeed in the workplace and in graduate school.

- **An Engineering Perspective.** Graduates will be capable of understanding complex projects and the creative process required to find innovative problem solutions, including project evolution and abstraction and the optimization of associated decisions and risk, both locally and globally.
- **Professional Skills and Knowledge.** Graduates will have the ability to communicate well in both oral and written form, to interact in teams, to manage and lead technical projects, to manage their career, and to conduct themselves with an understanding of ethics, economics, and intellectual property.

Objectives approved by the ECE faculty in October 2017.

Student Outcomes

Students graduating from the electrical engineering program should 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

Bachelor of Science Electrical Engineering[1]

Entering freshmen desiring to study Electrical Engineering will be admitted to the Foundational Engineering and Computing Program. They will be permitted to state a Electrical Engineering preference, which will be used as a consideration for available freshman departmental scholarships. The focus of the Foundational Engineering and Computing Program is on enhanced advising and career counseling, with the goal of providing to the student the information necessary to make an informed decision regarding the choice of a major.

For the Bachelor of Science degree in Electrical Engineering a minimum of 128 credit hours is required. These requirements are in addition to credit received for algebra, trigonometry, and basic ROTC courses. An average of at least two grade points per credit hour must be attained. At least two grade points per credit hour must also be attained in all courses taken in Electrical Engineering.

Electrical and Computer Engineering degree programs will require a minimum of 21 credit hours of humanities/social-sciences as specified below:

- ENGLISH 1120
- HISTORY 1200 **or** HISTORY 1300 **or** HISTORY 1310 **or** POL SCI 1200
- ECON 1100 **or** ECON 1200
- Technical Communication Elective: ENGLISH 1160 **or** ENGLISH 3560
- SP&M S 1185
- The remaining minimum of 6 additional credit hours must be three-credit hour lecture courses offered in disciplines in the humanities and social sciences. Humanities courses are defined as those in: Art, English and Technical Communication, Etymology, Foreign Languages, Music, Philosophy, Speech and Media Studies, and Theatre. Social Sciences courses are defined as those in: Economics, History, Political Science, and Psychology. Study abroad courses may count as H/SS courses. H/SS courses numbered 2001, 3001, and 4001 (experimental courses) may also be used to complete these elective requirements.

Courses in business, education, information science and technology, or any other discipline not listed above will **not** satisfy the humanities/social sciences elective requirement, although such courses may count toward general education requirements. Transfer credits from other universities in sociology and general humanities may count as humanities or social science electives.

The Electrical Engineering program at Missouri S&T is characterized by its focus on the scientific basics of engineering and its innovative application; indeed, the underlying theme of this educational program is the application of the scientific basics to engineering practice through attention to problems and needs of the public. The necessary interrelations among the various topics, the engineering disciplines, and the other professions as they naturally come together in the solution of real world problems are emphasized as research, analysis, synthesis, and design are presented and discussed through classroom and laboratory instruction.

Free Electives Footnote:

Students are required to take five hours of free electives in consultation with their academic advisor. Credits which do not count towards this requirement are deficiency courses (such as algebra and trigonometry), and extra credits in required courses. Any courses outside of engineering and science must be at least three credit hours.

Freshman Year

First Semester	Credits	Second Semester	Credits
FR ENG 1100[2]	1	MECH ENG 1720	3
CHEM 1310	4	MATH 1215[3]	4
CHEM 1319	1	PHYSICS 1135[3,4]	4
MATH 1214[3]	4	ECON 1100 or 1200	3
HISTORY 1200, or 1300, or 1310, or POL SCI 1200	3	Elective-Hum or Soc Sci (any level)[5]	3
ENGLISH 1120	3		
	16		17

Sophomore Year

First Semester	Credits	Second Semester	Credits
ELEC ENG 2100[3,6,7]	3	ELEC ENG 2200[3,6,7,10]	3
ELEC ENG 2101[3,6]	1	ELEC ENG 2201[3,6,7]	1
MATH 2222[3]	4	ELEC ENG 2120[3,7,9]	3
COMP ENG 2210[3,6,8]	3	MATH 3304[3]	3
COMP ENG 2211[3,6]	1	Engineering Science Elective[11]	3
PHYSICS 2135[3,4]	4	COMP SCI 1570	3

		COMP SCI 1580[12]	1
	16		17

Junior Year

First Semester	Credits	Second Semester	Credits
ELEC ENG 3100[3,6,9,10]	3	ELEC ENG 3600[3,9]	4
ELEC ENG 3101[3,6,9,10]	1	El Eng Elective A[10,14,19]	3
ELEC ENG 3320	3	ELEC ENG 3430	3
ELEC ENG 3321	1	ELEC ENG 3431	1
SP&M S 1185[13]	3	STAT 3117[12]	3
MATH 3108	3	Communication Elective [13]	3
	14		17

Senior Year

First Semester	Credits	Second Semester	Credits
El Eng Power Elective[3,6,9,15]	3	El Eng Elective C[10,14]	3
El Eng Power Elective Lab[3,6,9,15]	1	El Eng Elective E[17,19]	3
El Eng Elective B[10,14]	3	ELEC ENG 4097	3
El Eng Elective D[10,16,19]	3	Professional Development Elective[20]	3
ELEC ENG 4096[3]	1	Free Elective[18]	3
Free Elective[18]	2		
Elective-Hum or Soc Sci (any level)[5]	3		
	16		15

Total Credits: 128

Note: Student must satisfy the common freshman year academic requirements and be admitted into the department. See Foundational Engineering and Computing Program.

1 The minimum number of hours required for a degree in Electrical Engineering is 128.

2 Students that transfer after their freshman year are not required to enroll in FR ENG 1100.

3 A minimum grade of "C" must be attained in MATH 1214, MATH 1215, MATH 2222, and MATH 3304, PHYSICS 1135 and PHYSICS 2135 (or their equivalents), ELEC ENG 2100, ELEC ENG 2101, ELEC ENG 2120, ELEC ENG 2200, ELEC ENG 2201, ELEC ENG 3320, ELEC ENG 3321, ELEC ENG 3430, ELEC ENG 3431, ELEC ENG 3100, ELEC ENG 3101, and ELEC ENG 3600, the ELEC ENG power elective (ELEC ENG 3500 and ELEC ENG 3501 or ELEC ENG 3540 and ELEC ENG 3541), ELEC ENG 4096 and COMP ENG 2210 and COMP ENG 2211. Also, students may not enroll in other courses that use these courses as prerequisites until the minimum grade of "C" is attained.

4 Students may take PHYSICS 1111 and PHYSICS 1119 in place of PHYSICS 1135. Students may take PHYSICS 2111 and PHYSICS 2119 in place of PHYSICS 2135.

5 All electives must be approved by the student's advisor. Students must comply with the general education requirements with respect to selection and depth of study. These requirements are specified in the current catalog.

6 Students who drop a lecture course prior to the last week to drop a class must also drop the corequisite lab.

7 Students must earn a passing grade on the ELEC ENG Advancement Exam I (associated with ELEC ENG 2100) before they enroll in ELEC ENG 2120 or ELEC ENG 2200 and ELEC ENG 2201.

8 Students must earn a passing grade on the COMP ENG Advancement Exam (associated with COMP ENG 2210) before they enroll in any course with COMP ENG 2210 and/or COMP ENG 2211 as prerequisites.

9 Students must earn a passing grade on the ELEC ENG Advancement Exam II (associated with ELEC ENG 2120) before they enroll in ELEC ENG 3500, ELEC ENG 3540, ELEC ENG 3501, ELEC ENG 3541, ELEC ENG 3320,ELEC ENG 3321, ELEC ENG 3430,ELEC ENG 3431, ELEC ENG 3100, ELEC ENG 3101, or ELEC ENG 3600, or other courses with ELEC ENG 2120 as a prerequisite.

10 Students must earn a passing grade on the ELEC ENG Advancement Exam III (associated with ELEC ENG 2200) before they enroll in ELEC ENG 3100 and ELEC ENG 3101 or other courses with ELEC ENG 2200 as a prerequisite.

11 Students must take MECH ENG 2340, MECH ENG 2519, MECH ENG 2527, PHYSICS 2305, PHYSICS 2311, PHYSICS 2401, NUC ENG 3103, CHEM 2210, BIO SCI 2213, or BIO SCI 2223. The following pairs of course are substitutions: CIV ENG 2200 and MECH ENG 2350 or ENG MGT 2110 and ENG MGT 3310.

12 Students may replace STAT 3117 with STAT 3115 or STAT 5643. Students may replace COMP SCI 1580 with ELEC ENG 3001 Circuits and Systems Laboratory.

13 Students must take ENGLISH 3560 or ENGLISH 1160. Students may replace SP&M S 1185 with the ROTC sequence of MIL ARMY 4250 and MIL ARMY 4500 or MIL AIR 4110 and MIL AIR 4120.

14 ELEC ENG Electives A, B, and C must be chosen from ELEC ENG 56XX, ELEC ENG 3500, ELEC ENG 3540, ELEC ENG 3410, ELEC ENG 3250, ELEC ENG 3340, ELEC ENG 3440, ELEC ENG 3120, and COMP ENG 3150. Only one ELEC ENG 56XX course may be used.

15 The ELEC ENG Power Elective may be satisfied with ELEC ENG 3500 and ELEC ENG 3501 or ELEC ENG 3540 and ELEC ENG 3541.

16 ELEC ENG Elective D must be a 4XXX-level or above ELEC ENG or COMP ENG course with at least a 3-hour lecture component. ELEC ENG 4000 , ELEC ENG 5000, COMP ENG 4000, COMP ENG 5000, ELEC ENG 4099, COMP ENG 4099, ELEC ENG 4096, COMP ENG 4096, ELEC ENG 4097, COMP ENG 4097, ELEC ENG 5070, COMP ENG 5070, ELEC ENG 58XX, and COMP ENG 58XX may not be used for Elective D.

17 ELEC ENG Elective E may be any 3XXX-level or above ELEC ENG or COMP ENG course except ELEC ENG 3002, ELEC ENG 38XX, ELEC ENG 4096, ELEC ENG 4097, and ELEC ENG 5070 and COMP ENG 3002, COMP ENG 38XX, COMP ENG 4000, COMP ENG 4096, COMP ENG 4097, and COMP ENG 5070.

18 Students are required to take five hours of free elective in consultation with their academic advisors. Credits that do not count toward this requirement are deficiency courses (such as algebra and trigonometry) and extra credits from courses meeting other requirements. Any courses outside of engineering and science must be at least three credit hours. ELEC ENG 28XX, ELEC ENG 38XX, ELEC ENG 4096, ELEC ENG 4097, COMP ENG 28XX, COMP ENG 38XX, COMP ENG 4096 and COMP ENG 4097 may not be used for free electives. No more than one credit hour of ELEC ENG 3002 or COMP ENG 3002 may be applied to the BS degree for free electives.

19 Students that pursue an optional degree emphasis area have restricted options for El Eng Electives A, D, and E. Students admitted to the accelerated BS/MS program must satisfy El Eng Electives D and E with 5xxx or 6xxx-level courses and a minimum grade of B.

20 Students must take one of the following courses: BUS 5980, ECON 4430, ECON 5337, ENG MGT 2310, ENG MGT 3320, ENG MGT 4110, ENG MGT 5514, or PHILOS 3225.

All Electrical Engineering students are encouraged to take the fundamentals of Engineering Examination prior to graduation. It is the first step toward becoming a registered professional engineer.

An accelerated BS/MS program and a formal emphasis in circuits and electronics, optics and devices, controls and systems, communications and signal processing, power and energy, electromagnetics, or computer engineering are optional.

Emphasis Areas for Electrical Engineering

Circuits and Electronics, Communications and Signal Processing, Computer Engineering, Controls and Systems, Electromagnetics, Optics and Devices, Power and Energy

A declared emphasis area is not required. A student may choose to obtain an Electrical Engineering degree without a formal emphasis or may choose to obtain an Electrical Engineering degree with a declared emphasis in one or more of the emphasis areas of electrical engineering. A major change request is required to add the emphasis area option to the degree program.

For students who seek an Electrical Engineering degree without a formal emphasis, these emphasis areas may guide the choice of their ELEC ENG Electives A, B, C, D, and E as well as their free electives. Students should consult with their advisors on such course selections.

For students who seek an Electrical Engineering degree with a declared emphasis, courses in the declared emphasis area will be applied to ELEC ENG Electives A, D, and E in the degree requirements. For students who choose to have multiple emphasis areas, the additional courses will apply to ELEC ENG Elective B or C and free elective requirements. Students should seek guidance from their advisors on emphasis areas and on courses that are relevant to more than one emphasis area. Students may have an emphasis area or emphasis areas listed on their transcript by completing three three-credit-hour courses in electrical and computer engineering from the designated lists with at least one of the courses being at the 4XXX-level or above. This requirement will be satisfied by completing the relevant ABC Elective course, a 4XXX-level or above course for Elective D, and another 3XXX-level or above course for Elective E from the designated listing. The required ELEC ENG courses ELEC ENG 3320, ELEC ENG 3430, ELEC ENG 3100, and ELEC ENG 3600 and the course used to satisfy the power requirement (ELEC ENG 3500 or ELEC ENG 3540) may not be used to meet the three course requirement. Transfer courses do not apply to emphasis areas. A co-listed course may count toward both areas. Experimental courses ELEC ENG 3001, ELEC ENG 4001, ELEC ENG 5001, COMP ENG 3001, COMP ENG 4001, or COMP ENG 5001 require departmental approval to apply toward an emphasis area.

Circuits and Electronics		
ELEC ENG 3120	Electronics II	3
ELEC ENG 41XX and ELEC ENG 51XX Courses		
Communications and Signal Processing		
ELEC ENG 3410	Digital Signal Processing	3
ELEC ENG 3440	Digital Communications II	3
ELEC ENG 44XX and ELEC ENG 54XX Courses		
Computer Engineering		
ELEC ENG 3410, COMP ENG 3XXX-level or above Courses (Excluding COMP ENG 3000, COMP ENG 4000, COMP ENG 5000, COMP ENG 3002, COMP ENG 4096, COMP ENG 4097, and COMP ENG 5070) See the COMP ENG degree program for details on COMP ENG areas.		
Controls and Systems		
ELEC ENG 3340	Basic Programmable Logic Controllers	3
ELEC ENG 43XX and ELEC ENG 53XX Courses		
Electromagnetics		
ELEC ENG 46XX and ELEC ENG 56XX Courses		
Optics and Devices		
ELEC ENG 3250	Electronic And Photonic Devices	3
ELEC ENG 42XX and ELEC ENG 52XX Courses		
Power and Energy		
ELEC ENG 3500	Electromechanics	3
ELEC ENG 3540	Power System Design And Analysis	3
ELEC ENG 5150	Photovoltaic Systems Engineering	3
ELEC ENG 5520	Power Electronics	3
ELEC ENG 5521	Power Electronics Laboratory	2
ELEC ENG 45XX and ELEC ENG 55XX Courses		

Accelerated BS/MS Program Option for EE and CpE Majors

Electrical engineering or computer engineering undergraduates in ECE at Missouri S&T may opt to apply for an accelerated BS/MS ECE program where a student can achieve both degrees faster than if pursuing the degrees separately. The degrees may be BS EE and MS EE, BS CpE and MS CpE, BS EE and MS CpE, or BS CpE and MS EE. The benefits of the program for admitted students are:

- Undergraduate and graduate courses may be chosen with greater flexibility,
- Up to six hours of 5000-level or above ECE coursework may apply to both the BS and MS requirements,
- The classes taken for shared BS/MS credit may be taken at the lower undergraduate tuition rate,
- The GRE is not required for admission,
- Other graduate credit courses may be taken anytime after entering the program, and
- Work on a thesis project may begin before the BS requirements are completed.

The BS-degree requirements are modified for admitted students such that EE Electives D and E or CpE Electives B and C will be satisfied by six-credit-hours of 5000-level or above ECE coursework. To be eligible for the accelerated BS/MS ECE program, an EE or CpE undergraduate must be at or beyond the junior level with a minimum of 60 credit hours and must have completed 18 credit hours of EE and/or CpE courses at Missouri S&T with at least a 3.50 GPA in the ECE courses. To be admitted, the student must complete the program application and must have the recommendation of an ECE faculty member who agrees to serve as the graduate thesis advisor. No other MS degree requirements are changed. The MS degree must be for the thesis option. The program may be combined with existing honors research and emphasis area options. Admitted students will have both undergraduate and graduate records in the Registrar's Office.

The Accelerated program application must be completed within one semester after the shared-credit courses are completed. Courses taken for shared credit will be identified on the application form and on Graduate Form 1, which is submitted after the student enters the graduate program. The six hours of shared-credit coursework will be taken as undergraduate credit, must be approved by the academic advisor, and may not be undergraduate research, special problems, or transfer courses (a co-listed course can only apply for these undergraduate requirements if it is under an EE or CpE registration. Note that the choice of EE or CpE registration may affect how a course can apply within an MS program.) An additional six credit hours of

coursework for graduate credit (beyond the shared BS/MS credits) can be taken while in the undergraduate program by applying for dual undergraduate/graduate enrollment. Taking additional courses for graduate credit will require formal application to the graduate program. Acceptance to the MS degree program from the Accelerated program is automatic so long as the student meets ECE graduate student academic performance requirements. To remain in the Accelerated program, the student must maintain good standing within the undergraduate EE or CpE program and must maintain continuous enrollment at Missouri S&T. If the student exits the program before completion of the MS degree requirements or fails to maintain continuous enrollment at Missouri S&T, the shared-credit courses may not apply toward graduate requirements in the event of future readmission.

The student is responsible for checking on how dual-enrollment status and graduate coursework will affect scholarships and other financial aid. Once you become a graduate student, you **are not** eligible for Federal Pell Grants, though are still eligible for Federal Financial Aid and will be eligible for fellowships and teaching/research assistantships. International students should check with international affairs during completion of an accelerated BS/MS to ensure immigration status will be maintained throughout the program.

Minor in Electrical Engineering

A minor in electrical engieering will require the following:

Pass the ELEC ENG Advancement Exam I (ELEC ENG 2100 final) with a "C" grade or better. *
Pass ELEC ENG 2120 and ELEC ENG Advancement Exam II with a "C" grade or better.
Pass 12 additional hours of ELEC ENG coursework excluding ELEC ENG 28XX, 38XX, ELEC ENG 4096, ELEC ENG 4097, and ELEC ENG 4099. At least 3 lecture hours at the 4XXX-level or above are required. A "C" grade or better is required for all 12 hours. No transfer courses and no more than 3 hours of ELEC ENG 3000, ELEC ENG 4000, or ELEC ENG 5000 may be used to meet the requirements. The course choice for the 12 additional hours are subject to the approval of the minor advisor.

*One opportunity will be given to pass the ELEC ENG Advancement Exam I if a student has prior circuit coursework or experience. Otherwise, the student must pass ELEC ENG 2100.

Minor in Automation Engineering

A minor in automation engineering will require the following:

- Pass ELEC ENG 3340 Basic Programmable Logic Controllers with a "C" or better
- Pass one of the following courses with a "C" or better:
  - ELEC ENG 3320 Control Systems
  - MECH ENG 4479 Automatic Control Of Dynamic Systems
  - CHEM ENG 4110 Chemical Engineering Process Dynamics And Control
- Pass 9 additional hours of coursework from the following list. A "C" or better is required for all 9 hours.
  - CHEM ENG 4140 Chemical Process Safety
  - CHEM ENG 4241 Process Safety in Chemical & Biochemical Industries
  - CHEM ENG 5190/ELEC ENG 5350 Plantwide Process Control
  - CHEM ENG 4310/MECH ENG 5644 Interdisciplinary Problems In Manufacturing Automation
  - ELEC ENG 4380 Practicum in Automation Engineering (no more than one can be applied to the Automation Engineering Minor)
  - ELEC ENG 5340 Advanced PLC
  - ELEC ENG 5345 PLC Motion Control
  - ELEC ENG 5870/MECH ENG 5478 Mechatronics
  - MECH ENG 5420 Signal Processing for Instrumentation and Control
  - MECH ENG 5449 Robotic Manipulators and Mechanisms
  - MECH ENG 5655 Manufacturing Equipment Automation

Automation Engineering Certificate

An undergraduate certificate in Automation Engineering will require the following:

Required courses:		
ELEC ENG 3340	Basic Programmable Logic Controllers (must pass with a "C" or better)	3
Pass one of the following courses with a "C" or better:		
ELEC ENG 3320	Control Systems	3
MECH ENG 4479	Automatic Control Of Dynamic Systems	3
CHEM ENG 4110	Chemical Engineering Process Dynamics And Control	3
Pass 6 additional hours of coursework from the following list: (A "C" or better is required for all 6 hours)		
CHEM ENG 4140	Chemical Process Safety	3
CHEM ENG 4241	Process Safety in the Chemical and Biochemical Industries	3
CHEM ENG 4310	Interdisciplinary Problems In Manufacturing Automation	3
or MECH ENG 5644	Interdisciplinary Problems In Manufacturing Automation	
CHEM ENG 5190	Plantwide Process Control	3
or ELEC ENG 5350	Plantwide Process Control	
ELEC ENG 4380	Practicum in Automation Engineering (no more than one can be applied to the Automation Engineering Minor)	3
ELEC ENG 5340	Advanced PLC	3
ELEC ENG 5345	PLC Motion Control	3
ELEC ENG 5870	Mechatronics	3
or MECH ENG 5478	Mechatronics	
MECH ENG 5420	Signal Processing for Instrumentation and Control	3
MECH ENG 5449	Robotic Manipulators and Mechanisms	3
MECH ENG 5655	Manufacturing Equipment Automation	3

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PHD Lehigh University

ELEC ENG 1010 Transfer Student Seminar (LEC 0.50)
Discussion of current topics. Prerequisite: First semester transfer student.

ELEC ENG 2001 Special Topics (LEC 0.0-6.0)
This course is designed to give the department an opportunity to test a new course. Variable title.

ELEC ENG 2100 Circuits I (LEC 3.0)
Circuit elements, signals, Kirchhoff's laws, network theorems, mesh and nodal analysis, transient and complete response of RL, RC, and RLC circuits. Prerequisites: Math 1215 (or 1221) with a grade of "C" or better. Students should enroll in Elec Eng 2100 and Elec Eng 2101 simultaneously.

ELEC ENG 2101 Circuit Analysis Laboratory I (LAB 1.0)
Safety, basic measurements and meters, oscilloscopes, resistor networks, measurement of capacitors and inductors, RLC circuit response. Prerequisite: Preceded or accompanied by Elec Eng 2100. A student who drops Elec Eng 2100 must also drop Elec Eng 2101.

ELEC ENG 2120 Circuits II (LEC 2.5 and RSD 0.50)
Analysis of steady state AC circuits, phasor notation, polyphase circuits, complex frequency and frequency response, magnetically coupled circuits. Prerequisites: Elec Eng 2100 and Math 2222 each with grade of "C" or better; passing the Elec Eng Advancement Exam I.

ELEC ENG 2200 Introduction to Electronic Devices (LEC 3.0)
Materials and device structures for applications in analog and digital electronics. Topics include characteristics and basic circuits for diodes, field-effect transistors, bipolar junction transistors, and operational amplifiers. Prerequisites: Elec Eng 2100, Elec Eng 2101, and Physics 2135 each with grade of "C" or better; passing the Elec Eng Advancement Exam I. Students should enroll in Elec Eng 2200 and Elec Eng 2201 simultaneously.

ELEC ENG 2201 Electronic Devices Laboratory (LAB 1.0)
Laboratory tools and measurement techniques for basic electronic circuits using diodes, field-effect transistors, bipolar junction transistors, and operational amplifiers. Topics include DC biasing and applications in analog and digital electronics. Prerequisites: Elec Eng 2100, Elec Eng 2101, and Physics 2135 each with grade of "C" or better; passing the Elec Eng Advancement Exam I. Preceded or accompanied by Elec Eng 2200.

ELEC ENG 2800 Electrical Circuits (LEC 3.0)
Taught primarily as an alternating current (AC) circuits course with direct current (DC) circuits as a special case. Current, voltage, and power relations; complex algebra; voltage and power relations in polyphase circuits with an emphasis on Transformers and Induction Machines. Not for electrical engineering majors. Prerequisites: Math 3304 or 3329; Physics 2135.

ELEC ENG 3000 Special Problems (IND 1.0-6.0)
Problems or readings on specific subjects or projects in the department. Consent of instructor required.

ELEC ENG 3001 Special Topics (LAB 0.0 and LEC 0.0)
This course is designed to give the department an opportunity to test a new course. Variable title.

ELEC ENG 3002 Cooperative Engineering Training (IND 1.0)
On-the-job experience gained through cooperative education with industry, with credit arranged through departmental cooperative advisor. Grade received depends on quality of reports submitted and work supervisor's evaluation. Pass-fail grading option only. Prerequisite: Consent of the Electrical and Computer Engineering Department required.

ELEC ENG 3100 Electronics I (LEC 3.0)
Diode and transistor circuits, small signal analysis, amplifier design, differential and operational amplifiers, flipflop circuits and waveshaping. Prerequisites: Elec Eng 2120, Elec Eng 2200, Elec Eng 2201, and Comp Eng 2210 each with a grade of "C" or better. Passing grade on Elec Eng Advancement Exam II and III. Elec Eng 3101 is a corequisite.

ELEC ENG 3101 Electronics I Laboratory (LAB 1.0)
Experiments in design with diodes, transistors, differential and operational amplifiers, and logic components. Prerequisites: Elec Eng 2120, Elec Eng 2200, Elec Eng 2201, and Comp Eng 2210 each with a grade of "C" or better. Passing grade on Elec Eng Advancement Exam II and III. Elec Eng 3100 is a corequisite.

ELEC ENG 3120 Electronics II (LEC 3.0)
Continuation of Elec Eng 3100. Diode and transistor circuits, small signal analysis, amplifier design, differential and operational amplifiers, flipflop circuits and waveshaping. Prerequisites: Elec Eng 3100 and Elec Eng 3101 each with a grade of "C" or better. Elec Eng 3121 is optional, but recommended.

ELEC ENG 3121 Electronics II Laboratory (LAB 1.0)
Experiments in design with diodes, power transistors, integrated circuits, advanced bipolar and FET logic gates, flipflops and registers. Prerequisites: Elec Eng 3100 and Elec Eng 3101 each with a grade of "C" or better. Elec Eng 3120 is a corequisite.

ELEC ENG 3250 Electronic And Photonic Devices (LEC 3.0)
Semiconductor materials and devices for electronic and photonic applications. Topics include crystal physics, electron and photon behavior, pn junctions, heterojunctions, junction diodes, optoelectronic devices, and ohmic and rectifying contacts. Prerequisite: Elec Eng 2200 and Elec Eng 2120 each with grade of "C" or better; passing the Elec Eng Advancement Exams II and III.

ELEC ENG 3320 Control Systems (LEC 3.0)
Laplace transforms, formulation of the control problem, system equations and models, time and frequency domain analysis, stability, and design of linear control systems. Prerequisites: ELEC ENG 2120 and MATH 3304 each with a grade of "C" or better; passing the ELEC ENG Advancement Exam II; accompanied by ELEC ENG 3321.

ELEC ENG 3320H Control Systems-Honors (LEC 3.0)

ELEC ENG 3321 Control Systems Laboratory (LAB 1.0)
Software tools for control systems analysis. Prerequisites: ELEC ENG 2120 and MATH 3304 with a grade of "C" or better; passing the ELEC ENG Advancement Exam II; preceded or accompanied by ELEC ENG 3320.

ELEC ENG 3340 Basic Programmable Logic Controllers (LEC 2.0 and LAB 1.0)
Introduction to programmable automation in manufacturing, programmable logic controller (PLC) hardware, programming languages and techniques, PID closed-loop control, electrical code. Case studies. Laboratory exercises. Prerequisite: Preceded or accompanied by either Elec Eng 2120 or Elec Eng 2800.

ELEC ENG 3410 Digital Signal Processing (LEC 3.0)
Analysis methods for discrete-time signals and systems in the time and frequency-domains including signal models and Fourier techniques. Continuous-time concepts are included as introductory material. Prerequisites: ELEC ENG 2120 with a grade of "C" or better; passing the ELEC ENG Advancement Exam II.

ELEC ENG 3411 Discrete Linear Systems Laboratory (LAB 1.0)
Software tools for signal and system representation and for time and frequency-domain systems analysis. Prerequisites: Elec Eng 2120 with a grade of "C" or better; passing the Elec Eng Advancement Exam II. Preceded or accompanied by Elec Eng 3410.

ELEC ENG 3430 Digital Communications I (LEC 3.0)
Signals and systems for digital communications. Topics include signals and their spectra, source formatting and source coding, digital baseband data communication, and digital pass-band modulation and demodulation. Prerequisites: ELEC ENG 2120 with a grade of "C" or better; passing the ELEC ENG Advancement Exam II; accompanied by ELEC ENG 3431.

ELEC ENG 3431 Digital Communication Laboratory (LAB 1.0)
Laboratory and software tools for the analysis of communications and for linear and non-linear signals and systems. Topics include spectral analysis, transforms, and applications. Prerequisites: ELEC ENG 2120 and ELEC ENG 2101 with a grade of "C" or better; passing the ELEC ENG Advancement Exam II; preceded or accompanied by ELEC ENG 3430.

ELEC ENG 3440 Digital Communications II (LEC 3.0)
Continuation of Elec Eng 3430. Signals and their spectra with application to digital communication systems. Prerequisites: ELEC ENG 3430 with a grade of "C" or better.

ELEC ENG 3500 Electromechanics (LEC 3.0)
Magnetics and magnetically coupled circuits, electromechanical energy conversion, rotating magnetic fields, stepper motors, DC machines, induction machines, synchronous machines, and brushless DC machines. Prerequisites: Physics 2135 with a grade of "C" or better; Elec Eng 2120 with a grade of "C" or better; passing grade on the Elec Eng Advancement Exam II.

ELEC ENG 3501 Electromechanics Laboratory (LAB 1.0)
Experiments with power measurement, transformers, magnetically coupled circuits, rotating magnetic fields, stepper motors, DC machines, induction machines, synchronous machines, and brushless DC machines. Credit will only be given for one of Elec Eng 3501 or Elec Eng 3541. Prerequisites: Elec Eng 2120 with a grade of "C" or better; passing grade on the Elec Eng Advancement Exam II. Preceded or accompanied by Elec Eng 3500.

ELEC ENG 3540 Power System Design And Analysis (LEC 3.0)
Power system components and transmission lines, three phase balanced power system theory, analysis and design including economic and reliability considerations, and fault analysis. A power system design project using a graphical power flow program is included. Prerequisites: Elec Eng 2120 with a grade of "C" or better; passing grade on the Elec Eng Advancement Exam II.

ELEC ENG 3540H Power System Design And Analysis-Honors (LEC 3.0)

ELEC ENG 3541 Power System Design And Analysis Laboratory (LAB 1.0)
Computer-aided analysis of voltage regulation, power flow, compensation, and economic analysis. Individual projects are required. Credit will only be given for one of Elec Eng 3501 or Elec Eng 3541. Prerequisites: Elec Eng 2120 with a grade of "C" or better; passing grade on the Elec Eng Advancement Exam II. Preceded or accompanied by Elec Eng 3540.

ELEC ENG 3600 Electromagnetics (LEC 4.0)
Static electric and magnetic fields using vector analysis and time-varying electromagnetic fields using Maxwell's equations. Topics include Coulomb's law, Gauss's law, Ampere's law, dielectric and magnetic materials, plane waves, and transmission lines. Prerequisites: Elec Eng 2120, Elec Eng 2101, Physics 2135, and Math 3304 each with a grade of "C" or better. Passing grade on Elec Eng Advancement Exam II.

ELEC ENG 4000 Special Problems (IND 0.0-6.0)
Problems or readings on specific subjects or projects in the department. Consent of instructor required.

ELEC ENG 4001 Special Topics (LEC 0.0 and LAB 0.0)
This course is designed to give the department an opportunity to test a new course. Variable title.

ELEC ENG 4010 Senior Seminar (RSD 0.50)
Discussion of current topics. Prerequisite: Next to last semester senior.

ELEC ENG 4096 Electrical Engineering Senior Project I (LAB 0.50 and RSD 0.50)
A complete design cycle. Working in small teams, students will design, document, analyze, implement and test a product. Topics include: Iteration in design, prototyping, group dynamics, design reviews, making effective presentations, concurrent design, designing for test, ethics and standards, testing and evaluation. Prerequisites: Comp Eng 2210, Econ 1100 or Econ 1200, English 3560 or English 1160, and at least three of the following: Elec Eng 3500 or Elec Eng 3540; Elec Eng 3320, Elec Eng 3430, Elec Eng 3600 or Elec Eng 3100.

ELEC ENG 4097 Electrical Engineering Senior Project II (LAB 3.0)
A continuation of El Eng 4096. Prerequisite: Elec Eng 4096 with a grade of "C" or better; Stat 3117 or Stat 3115 or Stat 5643; Sp&M S 1185.

ELEC ENG 4099 Undergraduate Research (IND 0.0-6.0)
Designed for the undergraduate student who wishes to engage in research. Not for graduate credit. Not more than six (6) credit hours allowed for graduation credit. Subject and credit to be arranged with the instructor.

ELEC ENG 4380 Practicum in Automation Engineering (LAB 3.0)
Students on an approved internship or cooperative education assignment with industry will complete a project designed by the advisor and employer. The project selected must be related to topics in one or more of the other courses in the Automation Engineering Minor program. The same work period cannot receive credit for both Elec Eng 3002 and Elec Eng 4380. Prerequisites: Elec Eng 3340.

ELEC ENG 5000 Special Problems (IND 0.0-6.0)
Problems or readings on specific subjects or projects in the department. Consent of instructor required.

ELEC ENG 5001 Special Topics (LAB 0.0 and LEC 0.0)
This course is designed to give the department an opportunity to test a new course. Variable title.

ELEC ENG 5040 Oral Examination (IND 0.0)
After completion of all other program requirements, oral examinations for on-campus M.S./Ph.D. students may be processed during intersession. Off-campus M.S. students must be enrolled in oral examination and must have paid an oral examination fee at the time of the defense/ comprehensive examination (oral/ written). All other students must enroll for credit commensurate with uses made of facilities and/or faculties. In no case shall this be for less than three (3) semester hours for resident students.

ELEC ENG 5070 Teaching Engineering (LEC 3.0)
Introduction to teaching objectives and techniques. Topics include: using course objectives to design a course; communication using traditional and cutting-edge media; textbook selection; assessment of student learning; grading; student learning styles; cooperative/active learning; and student discipline. Prerequisite: Graduate standing. (Co-listed with Eng Mgt 5070, Env Eng 5070, Comp Eng 5070, Civ Eng 5070).

ELEC ENG 5099 Special Research And Thesis (IND 0.0-15)
Investigations of an advanced nature leading to the preparation of a thesis or dissertation. Consent of instructor required.

ELEC ENG 5100 Advanced Electronic Circuits (LEC 3.0)
Application of feedback theory, oscillators and frequency standards, precision analog techniques, low-power circuit design, interfacing sensors, designing for high reliability, electronics for harsh environments. Prerequisite: Elec Eng 3120.

ELEC ENG 5120 Communication Circuits (LEC 3.0)
Analysis and design of circuits used in communication systems. Topics include RF semiconductor devices, low-noise amplifiers, mixers, modulators, crystal oscillators, AGC circuits, highpower RF amplifiers, phase-locked loops, impedence matching, and frequency-selective networks and transformers. Prerequisites: Elec Eng 3120.

ELEC ENG 5140 High-Frequency Amplifiers (LEC 3.0)
Analysis and design of high frequency amplifiers. Topics include parameter conversions, activity and passivity, stability criteria, device operating conditions, Smith chart usage, matching networks, microstrip, scattering parameters, and practical applications. Prerequisites: Elec Eng 3120, 3600.

ELEC ENG 5150 Photovoltaic Systems Engineering (LEC 3.0)
Physics and characteristics of photovoltaic (solar) cell technologies, electronic control of alternative energy sources, site selection, array design, energy storage methods, electrical code compliance, stand-alone systems, grid-intertie systems, legal and economic considerations. Prerequisite: Senior or graduate standing in Science or Engineering.

ELEC ENG 5160 Computer-Aided Network Design (LEC 3.0)
Analysis and design of active and passive electric networks. Theory and computer application, including methods for automatic formulation of network state equations, network tolerance, network optimization, and device modeling. Prerequisites: Elec Eng 3100.

ELEC ENG 5170 Introduction To Circuit Synthesis (LEC 3.0)
Fundamentals of linear circuit theory. Matrix formulation, and topological methods as applied to circuit analysis. Properties of network functions and introductory network synthesis. Prerequisites: Elec Eng 3430.

ELEC ENG 5200 Classical Optics (LEC 3.0)
Physical optics and advanced topics in geometrical optics. Topics include ray propagation, electromagnetic propagation, mirrors, lenses, interference, diffraction, polarization, imaging systems, and guided waves. Prerequisites: Math 2222 and Physics 2135 or 2111. (Co-listed with Physics 4503).

ELEC ENG 5210 Fourier Optics (LEC 3.0)
Applications of Fourier analysis and linear systems theory to optics. Topics include scalar diffraction theory, Fourier transforming properties of lenses, optical information processing, and imaging systems. Prerequisites: Both Elec Eng 3430 and Elec Eng 3600 or Physics 4211. (Co-listed with PHYSICS 5503).

ELEC ENG 5220 Fiber And Integrated Optics (LEC 3.0)
Introduction to optical waveguides and their applications to communication and sensing. Topics include dielectric waveguide theory, optical fiber characteristics, integrated optic circuits, coupled-mode theory, optical communication systems, and photonic sensors. Prerequisite: Elec Eng 3600 or Physics 4211. (Co-listed with Physics 5513).

ELEC ENG 5250 Optical Computing (LEC 3.0)
Introduction to the principles, subsystems, and architectures of optical computing. Topics include characteristics of optical devices; optical implementations of memory, logic elements, and processors; and computational structures. Prerequisite: Comp Eng 2210 or equivalent. (Co-listed with Comp Eng 5230).

ELEC ENG 5270 Smart Materials And Sensors (LEC 2.0 and LAB 1.0)
Smart structures with fiber reinforced polymer (FRP) composites and advanced sensors. Multidisciplinary topics include characterization, performance, and fabrication of composite structures; fiber optic, resistance, and piezoelectric systems for strain sensing; and applications of smart composite structures. Laboratory and team activities involve manufacturing, measurement systems, instrumented structures, and performance tests on a large-scale smart composite bridge. Prerequisites: Senior standing and Math 3304. (Co-listed with Aero Eng 5529, Mech Eng 5229 and Civ Eng 5118).

ELEC ENG 5300 Digital Control (LEC 3.0)
Analysis and design of digital control systems. Review of ztransforms; root locus and frequency response methods; state space analysis and design techniques; controllability, observability and estimation. Examination of digital control algorithms. Prerequisite: Elec Eng 3320.

ELEC ENG 5320 Neural Networks Control and Applications (LEC 3.0)
Introduction to artificial neural networks and various supervised and unsupervised learning techniques. Detailed analysis of some of the neural networks that are used in control and identification of dynamical systems. Applications of neural networks in the area of Control. Case studies and a term project. Prerequisites: Elec Eng 3320.

ELEC ENG 5325 Applied Nonlinear Control (LEC 3.0)
Review of State Variable Models, Nonlinear Model and Phenomena, Lyapunov Stability, Phase Plane Analysis, Feedback Linearization, Sliding Mode and Backstepping Control, and Control Applications Prerequisite: Elec Eng 3320 or graduate standing.

ELEC ENG 5330 Fuzzy Logic Control (LEC 3.0)
A mathematical introduction to the analysis, synthesis, and design of control systems using fuzzy sets and fuzzy logic. A study of the fundamentals of fuzzy sets, operations on these sets, and their geometrical interpretations. Methodologies to design fuzzy models and feedback controllers for dynamical systems. Various applications and case studies. Prerequisite: Elec Eng 3320.

ELEC ENG 5340 Advanced PLC (LAB 1.0 and LEC 2.0)
Advanced programmable logic controller (PLC) programming, function block, structured text, function chart, sequencer. Factory communications, system simulation, human-machine interface (HMI) programming. Advanced PID control. Network security and reliability. Class-wide project. Prerequisite: Elec Eng 3340.

ELEC ENG 5345 PLC Motion Control (LEC 2.0 and LAB 1.0)
Factory automation motion control integrated with programmable logic controllers, servo control, variable-speed drive control, PackML state model, sizing motors and drives, machine safety, and experience with commercial hardware/software. Laboratory exercises on small-scale standard applications such as coordinated motion of multiple axes and camming. Prerequisite: Elec Eng 3340.

ELEC ENG 5350 Plantwide Process Control (LEC 3.0)
Synthesis of control schemes for continuous and batch chemical plants from concept to implementation. Mulitloop control, RGA, SVD, constraint control, multivariable model predictive control, control sequence descriptions. Design project involving a moderately complicated multivariable control problem. Prerequisites: Chem Eng 4110 or Elec Eng 3320 or Elec Eng 3340 or graduate standing. (Co-listed with Chem Eng 5190).

ELEC ENG 5360 System Simulation And Identification (LEC 3.0)
Computationally efficient methods of digital simulation of linear systems. Non-parametric identification. Parametric identification with least squares and recursive least squares algorithms. Algorithms programmed using MATLAB. Prerequisite: Elec Eng 3320.

ELEC ENG 5370 Introduction to Neural Networks and Applications (LEC 3.0)
The course provides an introduction to basic neural network architectures and their applications. Students learn to construct neural networks and train them to solve engineering problems, specifically pattern recognition and function approximation. Mathematical analysis of network architectures, training algorithms and practical applications of neural nets. Prerequisites: Graduate Standing. (Co-listed with Sys Eng 5212).

ELEC ENG 5380 Autonomous Mobile Robots (LEC 3.0)
This course will provide an introduction to mobile robots and current approaches to robot autonomy. Topics include mobile robot systems, modeling and control, sensors and estimation, localization and mapping, and motion planning. Prerequisites: Elec Eng 3320 or equivalent and Stat 3117 or equivalent.

ELEC ENG 5400 Digital Signal Processing II (LEC 3.0)
Spectral representations, sampling, quantization, z-transforms, digital filters and discrete transforms including the Fast Fourier transform. Prerequisites: Elec Eng 3410.

ELEC ENG 5420 Communications Systems II (LEC 3.0)
Random signals and their characterization; noise performance of amplitude, angle and pulse modulation systems; digital data transmission; use of coding for error control. Prerequisite: Elec Eng 3430.

ELEC ENG 5430 Wireless Networks (LEC 2.0 and LAB 1.0)
Introduction to wireless communications and networking. Topics include transmission fundamentals, wireless channel, coding techniques and error control, satellite and cellular networks, cordless systems, mobile IP and management, multiple access techniques and wireless protocols, wireless LAN, IEEE 802.11, and adhoc and sensor networks. Prerequisites: Elec Eng 3430 or Comp Eng 3150. (Co-listed with Comp Eng 5430 and Sys Eng 5323).

ELEC ENG 5440 Stochastic Signal Analysis I (LEC 3.0)
Introduction to the application of probabilistic models to typical electrical engineering problems. Topics include: methods for describing random voltages, random digital signals, correlation, linear mean-square estimation, linear transformation of random digital signals, and bit-error rate calculation for communication systems. Prerequisites: Math 3304 and Elec Eng 2120.

ELEC ENG 5450 Digital Image Processing (LEC 3.0)
Fundamentals of human perception, sampling and quantization, image transforms, enhancement, restoration, channel and source coding. Prerequisites: Elec Eng 3430.(Co-listed with Comp Eng 5450).

ELEC ENG 5460 Machine Vision (LEC 3.0)
Image information, image filtering, template matching, histogram transformations, edge detection, boundary detection, region growing and pattern recognition. Complementary laboratory exercises are required. Prerequisites: Elec Eng 3430. (Co-listed with Comp Eng 5460).

ELEC ENG 5500 Electric Drive Systems (LEC 3.0)
Course content is roughly 1/3 power electronics, 1/3 applied control and 1/3 electric machinery and focuses on analysis, simulation, and control design of electric drive based speed, torque, and position control systems. Prerequisites: Elec Eng 3500 and Elec Eng 3320.

ELEC ENG 5510 Electric-Drive Vehicles (LEC 3.0)
Course covers introductory topics related to understanding/analysis of electric, hybrid/plug-in hybrid power trains. Classification of hybrid drivetrains, driving cycles, energy storage systems, mechanical coupling devices, automotive applications of fuel cells and introduction to power converters. Prerequisite: Senior standing and Physics 2135.

ELEC ENG 5520 Power Electronics (LEC 3.0)
Analysis, design, modeling, and control of switching mode power converter circuits for ac-dc, dc-dc, dc-ac, and ac-ac conversion. Power semiconductor devices, passive components, and non-ideal sources and loads. Applications to industry, consumer goods, electric vehicles, and alternative energy. Prerequisite: Elec Eng 3100.

ELEC ENG 5521 Power Electronics Laboratory (LAB 2.0)
An introduction to power electronic circuits is presented. Students will construct several dc/dc, dc/ac and ac/dc converters. Various switching algorithms, including pulse width modulation, delta modulation, and hysteresis control will be developed to regulate and control the respective circuits. Prerequisite: Co-requisite Elec Eng 5520.

ELEC ENG 5540 Power Systems Engineering (LEC 3.0)
Network analysis applied to power systems; the load flow concept; economic operation of power systems; synchronous machine reactances and transient stability; symmetrical components and asymmetrical faults; protective relaying. Prerequisite: Elec Eng 3540.

ELEC ENG 5550 Electric Power Quality (LEC 3.0)
Definitions of power quality, types of power quality problems; sources of sags, transient overvoltages and harmonics; distribution overcurrent protection methods and their effect on power quality and reliability; harmonic analysis, principles of controlling harmonics, devices for filtering harmonics; power quality improvement methods. Prerequisite: Elec Eng 3500 or Elec Eng 3540.

ELEC ENG 5570 Extra High Voltage Engineering (LEC 2.0 and LAB 1.0)
The physical phenomena associated with high voltage dielectric breakdown are presented. Methods of generating and measuring high voltages and currents are explained. Demonstration of design and performance. Field trips to companies for laboratory testing of high voltage according to industry standards will serve as the lab part of the course. Prerequisite: Senior standing.

ELEC ENG 5600 Interference Control in Electronic Systems (LEC 3.0)
Principles of high frequency effects in PCBs and components, generation of unwanted radio-frequency (RF) signals by ICs, RF radiation mechanisms, shielding, and immunity against electrostatic discharge and RF signals. Prerequisites: Elec Eng 3430 and 3600.

ELEC ENG 5620 Signal Integrity in High-Speed Digital & Mixed Signal Design (LEC 3.0)
Signal integrity ensures signals transmitted over a propagation path maintain sufficient fidelity for proper receiver operation. Compromised signal integrity is often associated with parasitics (e.g. unintentional inductance, capacitance). Theory and CAD tools used for signal integrity analysis of functioning designs. Prerequisites: Elec Eng 3600 or Comp Eng 3150, and Senior standing. (Co-listed with Comp Eng 5620).

ELEC ENG 5630 Wave Propagation and Transmission Lines (LEC 3.0)
The materials in this course are intended to provide a) follow up electromagnetics related courses, b) electromagnetics related career including RF design and c) a graduate degree in electromagnetic related fields an in-depth understanding of the basics of wave propagation and transmission lines. Prerequisite: Elec Eng 3600.

ELEC ENG 5640 Antennas and Propagation (LEC 3.0)
Propagated fields of elemental dipole, directivity and gain, radiation resistance, the half-wave dipole, wire antennas, arrays, broadband antennas, aperture antennas, horn antennas, and antenna temperature. Prerequisite: Elec Eng 3600.

ELEC ENG 5650 Microwave and Millimeter Wave Engineering and Design (LEC 3.0)
Introduce senior and graduate students to the concept of microwave and millimeter wave engineering and passive component design such as waveguide, cavities, couplers, detectors, mixers, etc., including network theory and scattering matrix. Finally, their specific application in the design of various microwave circuits will be discussed. Prerequisites: Elec Eng 3600.

ELEC ENG 5660 Microwave Principles For Mixed-Signal Design (LEC 3.0)
Transmission lines; coupled transmission lines; microwave network analysis; impedance matching and tuning; design of microwave amplifiers and oscillators. Prerequisite: Elec Eng 3600.

ELEC ENG 5670 Nondestructive Testing (LEC 3.0)
Principles and applications of various means of non-destructive testing of metallic materials. Radiological inspection methods, ultrasonic testing, magnetic methods, electrical and eddy current methods and others. Prerequisite: Physics 2135 or 2111. (Co-listed with Met Eng 5510).

ELEC ENG 5680 Introduction to Radar Systems (LEC 3.0)
The objective of this course is to introduce senior and graduate students to various radar system principles, designs and applications (e.g., pulse, frequency-modulated, chirp, Doppler radars). Topics related to signals, systems, noise, resolution, multiple sampling, different imaging modalities, and remote sensing will also be discussed. Prerequisites: Elec Eng 3400 and Elec Eng 3600.

ELEC ENG 5810 Computational Intelligence (LEC 3.0)
Introduction to Computational Intelligence (CI), Biological and Artificial Neuron, Neural Networks, Evolutionary Computing, Swarm Intelligence, Artificial Immune Systems, Fuzzy Systems, and Hybrid Systems. CI application case studies covered include digital systems, control, power systems, forecasting, and time-series predictions. Prerequisite: Graduate Standing. (Co-listed with Comp Eng 5310 and Sys Eng 5211).

ELEC ENG 5870 Mechatronics (LAB 1.0 and LEC 2.0)
This course will introduce students to the basics of mechatronics (i.e., the integration of mechanical, electrical, computer, and control systems). Students will learn the fundamentals of sensors and actuators for mechanical systems, computer interfacing, microcontrollers, real-time software, and control. Prerequisite: Mech Eng 4479 or equivalent. (Co-listed with Mech Eng 5478, Aero Eng 5478 and Comp Eng 5820).

ELEC ENG 5880 Introduction to Robotics (LEC 3.0)
This course provides an introduction to robotics, covering robot hardware, fundamental kinematics, trajectories, differential motion, robotic decision making, and an overview of current topics in robotics. Prerequisite: A grade of "C" or better in both Math 3108 and Comp Sci 1575. (Co-listed with Comp Sci 5403 and Comp Eng 5880).