Wilkes Electrical Engineering Curriculum
A Description for Advisees

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February 2, 2017

Purpose:

The required courses for the Bachelor's of Science Degree with a major in Electrical Engineering are listed in the Wilkes University Undergraduate Bulletin, which can be found online at:

< http://www.wilkes.edu/bulletin/current/undergraduate/degrees-programs/department-engineering-physics/electric-engineering/index.aspx>

Descriptions of the various required courses can be found in the Undergraduate Bulletin as well, by clicking on the course number in the list of required courses. (The descriptions are rather terse.) The listing of courses is given in the order that a fully qualified entering freshman would normally take them, absent unusual circumstances. So, why the need for this document?

The remaining question is, "Why these particular courses?" Some of the answers to that question may seem obvious, but others are decidedly less so. This document attempts to give an explanation for why the curriculum includes what it does.

A caveat is necessary. Even the faculty members seldom discuss among themselves why particular courses are in the curriculum. Often they just seem to know they are necessary. There is no one document that collects together all the reasons why the curriculum is as it is. So, in trying to articulate the reasons for the particulars of the curriculum, some degree of assumption is necessary on my part. It is possible, even likely, that other faculty members may see things differently. Thus, the views expressed in this document are my own, and do not reflect the official position of fellow faculty members, the Department, or Wilkes University.

This document is particularly intended to be a help to entering students, my freshman advisees, in understanding the road ahead of them over the next four years.

Engineering as a Discipline:

There are some guiding principles behind the structure of the Electrical Engineering curriculum. Engineering is a field that requires well-structured reasoning to achieve physical products that are useful. That is true of many fields, including practice of law and analysis of literature. What further distinguished Engineering is the central role of mathematics, a quantitative and symbolic system of reasoning, as well as the connection to the real world in the sciences that define the substance and effects that engineers build upon. Electrical Engineering focuses particularly on electricity, that is more abstract than some other branches of engineering, in that human beings are not equipped to directly perceive electrical phenomena short of an electrical shock. So, it should not be surprising that the curriculum includes numerous courses in mathematics and science, as well as others which develop those principles as applicable to engineering in the electrical domain. Yet, why these specific math, science, and engineering courses, and not others? That's what is described below. The descriptions are organized by the respective four years of the recommended sequence.

The First Year:

MTH 111 Calculus I, MTH 112 Calculus II

It may be common sense that mathematics is a foundation for engineering, but why calculus? Calculus is the mathematics of the real world. If everything went at constant speeds, and other phenomena were likewise characterized as constant, calculus would not be so necessary. If an automobile drives at a constant speed, it is easy to calculate how far it has gone knowing the time duration. But what if the speed is continuously varying? In the real physical world, almost everything is continuously varying. Calculus is the mathematics necessary to understand such things quantitatively and with precision. That began with observations of the movement of planets, and ultimately it took calculus to explain that. Almost everything in classical physics depends on calculus for explanation, and the same is true in the electrical domain. A firm understanding of the basic principles of calculus is needed for any engineer. Yes, use of calculus allows us to abstract out practical design rules and guiding formulas that are often algebraic. But it takes appreciation of calculus to understand the reasons. Engineers should never be unthinking appliers of formulas; they need to be able to understand what they are doing and why, and that understanding stands on a foundation of calculus.

Looked at from the perspective of a student planning a course of study at Wilkes, notice that most science and engineering courses have prerequisites tracing back to calculus. You must have MTH111 to take MTH112. You must be in or have taken MTH112 to take EE211, the basic circuits course. EE211 is needed for the electronics sequence, EE251 and EE252. EE252 is needed to take EE382, Modern Communications Systems, needed to graduate with the EE degree. That chain of prerequisites is six courses long! Getting through the mathematics sequence is of utmost importance. If you slip behind in math and fail to catch up, it is very difficult to finish in four years.

It is assumed that an incoming freshman student is prepared to take the calculus, English, and Chemistry courses prescribed for the first semester in the recommended sequence. If that is not the case, other preparatory courses may be necessary, including Math 100 for those unprepared for Calculus. If you fall behind that way, say, taking MTH100 Pre-calculus instead of MTH111 the first semester, you need to take MTH111 during the following summer if at all possible to stay on track. It is possible to graduate on time taking MTH112 during the third semester simultaneous with EE211, but that makes the EE course more difficult, and you will have more trouble with physics as well.

CHM 118 Chemistry for Engineers and CHM117 (Laboratory)

These two courses should be viewed as a unit and are normally taken together. So, why chemistry? The physical world is made up of material, stuff, that is made up of individual atoms of various kinds. Chemistry is the science that describes how materials made up of these different atoms, grouped in molecules and mixtures, behave. For example, the understanding of semiconductor devices, diodes and transistors, the basic devices of modern electronics, requires understanding of chemistry. Why is silicon, a column 4 material, “doped” (mixed with small quantities of) column 3 or 5 materials like Boron, Aluminum, or Arsenic, to form those devices? How does an aluminum electrolytic capacitor work? All that depends on chemistry. Chemistry is the science of the substance of the real world. It’s the right place to start in the sciences.

You must be in at least MTH100 to take these chemistry courses. Thus, they should be accessible to most students during the first semester. It is possible to fail either CHM118 or CHM117 and not the other. This will not preclude going on with physics, but you would need to catch up as soon as possible, perhaps the following summer.

ME180 CADD Lab

CADD stands for "Computer Aided Design and Drafting." In engineering, we use symbols to represent the physical objects from which we make systems. There is a language of specific symbols, of terms, and the of way to use them, that ensures that concepts are communicated clearly and precisely, often in the form of drawings. In the age of craftsmen, it might have been possible for someone like a gunsmith to craft a machine by working on it and refining the object in an ad-hoc manner without resort to precise drawings and descriptions. In the modern world, precise and well defined drawings are needed, and they are typically executed on the computer. This course is an introduction to the world of engineering, and the English and Symbolic usage of the profession.

ENG101 Composition

Freshman engineering students, and even some approaching graduation, underestimate the importance of writing. Just as using the correct terms, symbols, and drawings are necessary to modern engineering communication, the use of language correctly, typically in written form, is crucial to effective exchange of ideas. The computer has not changed that. Even if you are putting up web pages, the material on those web pages is largely expressed in English, and that means writing. Many critical aspects of engineering communication, including reports, specifications, proposals, and documentation of other sorts are built on good English composition.

This course is general, in that it develops "composition," that is, writing skills, for all majors. It is very important that you can correctly construct sentences, paragraphs, and larger compositions that effectively convey what you mean to communicate. The degree of professional competence people will assume of you in the real world of engineering is often judged by what a person writes. Later on, you will need to develop your facility for expressing technical ideas and concepts in laboratory reports and other written assignments in engineering courses. But, that further development of your technical writing ability depends on a solid foundation in English composition. That's why we start with this important course in the first semester; it is important to much of what will follow.

FYF 101 First Year Foundations

The purpose of this course is to help you adjust to college life. The course description in the Bulletin describes well what the course is intended to do. It is not specific to any one major. Given the choice, you would like to be in a section that focuses on topics of interest to you, since your enthusiasm for the subject is important to success, and getting as much out of the course as possible. Indeed, that's a fairly universal principle. That's why you are going into engineering, is it not? Enthusiasm for the subject, and ideas of what you might eventually design and build, or share in the creation of? If you can find an FYF course relevant to engineering, so much the better.

PHY 210 General Physics I

This course is the foundation of your analytic understanding of the behavior of physical things in the real world. It is rooted in calculus. Yes, there are physics courses that are not "calculus based", but they will not develop the concepts and principles with enough analytic rigor for engineering. This course focuses on "mechanical" physics, concerning objects having mass, and their motion individually and in systems. The basic principle is Newton's famous equation, F=ma, an object accelerates in proportion to the force on it. But, what is force exactly? Knowing it when you see it and being able to express it precisely and analytically are different, and an engineer of any sort needs to be able to do the latter. Physics further develops formally the idea of attaching "units" to numbers that characterize real world objects and their behavior. Numbers are not used in isolation, as they might be in mathematics, but will have attached units of seconds, or meters, or some other term defining their relevance to the real world.

Understanding physics is critical to all engineering. A science, physics in this case, seeks to understand the world and the things in it. Engineering harnesses that knowledge to assemble those things together to make systems of practical value, it's concerned with the creation of new things. But you have to understand the components you are making things from, and hence physics is the start of doing engineering.

This course requires that you at least be in Calculus I, but it is better to have already completed Calculus I. That may not be an option if you had to start in MTH 100. That means that you will need to work harder to catch up with principles and concepts others have already become familiar with.

EGR140 Scientific Programming

Computer use is ubiquitous in the modern world, and that is no less true in engineering. What does an engineering practitioner actually need to know? People use automobiles, cellular telephones, and microwave ovens, all routinely, without caring or knowing anything about the computers within. Does an engineer need to understand more? The answer is yes. This is true because engineers routinely use computers to solve non-routine problems. They also create systems in which computers are components. Both require going beyond an "if you do this, it does that," understanding.

"Programming" is the act of giving a computer instructions that it is to follow to do something useful. A digital computer follows very specific instructions one at a time. These act on objects such as numbers, character strings, or files, and control the sequencing of other instructions. Understanding the details of what the computer does on a hardware level is nontrivial, and not necessary to understand basics of what a computer can do. "Higher Level Languages" form the medium that practical engineers use to communicate with a computer, to instruct it what to do. Learning to program in one of these languages is essential to problem solving and understanding what a computer is capable of, and perhaps more important, what its limitations are.

This course has been taught using different programming languages. MATLAB is a language and environment meant for solving engineering problems. Python is a general-purpose programming language. Both have and are being used. There are differences in the languages, how they are used, and what they cost in practice to use. But learning either will give you an appreciation of what computers are, what they can do, and how they can be used for practical problem solving in the engineering domain.

EGR 200 Introduction to Materials

While chemistry focuses on the fundamental constituents of the material world, this course starts to consider the implications of those materials' properties in the material world. For example, Iron may be an element that reacts with others in particular ways defined by its chemistry. But to a mechanical engineer, the crystal structure, the presence of impurities (particularly carbon), and its susceptibility to corrosion are of great practical importance, since iron is such a fundamental building material. Things like strength, hardness, density, melting point, thermal conductivity, and the practicality of machining are examples of materials properties that are of tremendous practical importance. For the electrical engineer, there are additional important properties such as the ability of a material to carry electrical current, or be an insulator that does not carry current. This beginning engineering course helps the student achieve an engineering perspective on the materials that are being studied from other perspectives in chemistry and physics.

Distribution Requirement

This entry in the list of required courses refers to a course that is in the university's "core", or "general education," requirements. Those requirements may be found in the Undergraduate Bulletin at:

< http://www.wilkes.edu/bulletin/current/undergraduate/introduction/degree-programs-curricula/general-education-the-first-component.aspx>

This section of the Bulletin is difficult to find in the online structure, and not easy to fully understand. So, in this section of this document, I will briefly walk through what's important to the typical EE student.

There are two basic parts to the General Education Requirements courses. One is "skill requirements." Most students satisfy these by taking CS115, ENG101 (true for engineering students too), COM101, some math course MTH101 or above, and FYF101 (true for engineering students too). As an EE student, you still need to take ENG101 and FYF101, for reasons described earlier for those courses. You do not need the others. It's not that they are not good courses, they are. But EE students can satisfy the computer literacy requirement by taking two "Computer Intensive" (CI) courses. Those courses are the required EGR140 and EGR222. So, CS115 is not a required course for engineering students. Similarly, engineering students satisfy the Oral Presentation requirement by taking EE391 and EE392 (instead of COM101). The calculus course satisfies the Math requirement. So, typically an entering EE student gets skill courses taken care of in the first semester by taking FYF101 and ENG101.

The second part is the "Distribution Requirements." These are courses in the Humanities, Natural and Social sciences, and arts. Sooner or later you must take:

I ENG120, HST101, and either PHL101 or some foreign language course

II Six credits of science courses (as an EE student, you more than satisfy that.)

III Two of: ANT101, EC102 (recommended), PS111, PSY101, SOC101

IV Any one of: ART101, DAN100, MUS101, THE100

So, that means there are slots for six courses on the required list labeled "Distribution Requirements," and into each of those slots you plug in one of these courses. The Bulletin section cited above describes what the point is to requiring you to take these courses. I will elaborate a bit on that from the perspective of an entering engineering student.

Be careful with the history course. At Wilkes, the History Department requires "World" history, meaning, you cannot take a course about the United States and get credit for it as satisfying this requirement. That's different from a lot of other schools. I believe the idea is to give you a bit of diversity. If you take HST101 at Wilkes you will be OK, but beware of this if you plan to transfer in credits from elsewhere. Another thing to consider is that there are usually numerous HST101 sections. In later semesters where you typically have only one section available for a required course, it helps to be filling a distribution requirement where there's lots of flexibility. (In contrast, there are typically only two sections of ECON102.)

You can take either PHL101 Philosophy or a foreign language. If you are going to go the foreign language route, you might want to do that early, during freshman year, while you still remember what you learned in High School, if you are going to stay with the same language. The selection of languages available at Wilkes is limited.

You might be wondering, why the choice of either Philosophy or Foreign language? That issue has been debated. My perspective on it is that either way, you are dealing with the issue of how to represent information about the real world. In a natural language, we do that with nouns, verbs, adjectives and so forth, formed into sentences to communicate ideas. Studying this in a foreign language is helpful, because in your native language communication is so natural that you don't normally have to think about it and recognize what a marvelous thing language is. Philosophers approach things more abstractly, or, well, philosophically. But they, too, are dealing with issues of the world, humanity, and the relations among and between the two.

As a freshman, you probably should not take ENG120, PHL101, or ECON102. Save those for later. While the core requires any two social sciences, we recommend that one of those two courses be ECON102, Microeconomics. Engineering takes place in a real world of economic transactions, and having some understanding of economics is very helpful in comprehending how engineering fits into society. For the other social science, find something that's interesting, hopefully that you will enjoy.

A course satisfying the Arts distribution requirement usually can be found during any semester, many should be available from which one can be found to fit your schedule. But if there is a particular one you want to take, grab it when you can. The Arts requirement can also be satisfied by participating in music groups, theater performances and other activities. If you want to participate in the Arts in those ways, diving in and participating in those is much better than just taking one of the four listed introductory courses. Ask if you think you might want to do so.

Second Year:

MTH 211 Differential Equations, MTH 212 Multivariable Calculus

Differential Equations express the rate at which some variable changes as a function of that and perhaps other variables. The engineering world is filled with problems and processes that are characterized as differential equations. For example, the rate at which a rocket rises depends not only on its thrust, but also the current mass of the rocket, which is changing as fuel is expended. Many problems are formulated as differential equation systems, which must then be solved to understand how the system in question behaves. This is a critical course. You would like to be in it as you begin the EE211 Circuits course, since circuits is largely an application of differential equations.

Multivariable calculus extends the concepts of calculus to more dimensions. Many engineering problems are physically constrained to one dimension, such as electrons constrained to move along a wire. These can be solved with scalar calculus. But for electrical engineers, the understanding of electromagnetic fields is inherently a three-dimensional time varying problem. You will need multivariable calculus in your toolkit. Multivariable calculus is also needed to address problems in probability and many other domains.

PHY 202 General Physics II

Where Physics I focused on the mechanical domain, this physics course addresses the electrical (and optics) domain. Many of the same principles apply. Instead of mechanical movement, you have current, the movement of electrons. Instead of gravity, you have electrostatic fields and forces. Instead of mass you have inductance, which in effect imparts a "momentum" to current. And so on. There are different units, but it is still physics, the science of the material world focused on dynamics and relationships, with a focus on the electromagnetic aspects. This is essential to truly understanding electrical systems. In the recommended sequence, this course is simultaneous with EE211 Circuits. It would be nice to have it first, but that's not practical. The difference is this course focuses on the fundamentals, while the circuits course focuses on applying those principles to build more complex functional systems. So, taking them at the same time may not be ideal, but is practical.

EE 211 Electrical Circuits and EE283 Electrical Measurement Lab

This is the fundamental Electrical Engineering course. Physics defines the basic elements from which electrical systems are composed. The most fundament are the electrical conductor (wire), connections of wires (nodes or junctions) and components such as resistors, capacitors, inductors, and sources of electromotive force (Voltage sources such as batteries). How do systems composed of such things behave? How do you construct a circuit to obtain desired behavior? All that starts with the theory of circuits. Importantly, this course addresses not just Direct Current (DC) but also Alternating Current (AC). It is in AC systems that we can represent signals, such as those representing music, speech, and digital ones and zeros. Going beyond the basic concepts of physics, in Circuits we distinguish between power (the source of energy) and signal (the information being conveyed). This course is an essential for most of the other EE courses in the curriculum.

EE283 is the laboratory course that is normally taken at the same time as EE211. Circuits are built in the laboratory, at first simple ones that just demonstrate basic circuit principles, but later things like power supplies, digital counter, and others.

ME 231 Statics

This is the fundamental mechanical engineering course that takes the principles of mechanical physics and begins to apply them to systems. For example, a bridge is composed of many elements, but the forces at each point in the bridge (especially where strength members join) must balance, or the bridge will not be rigid, and will move or deform. Many mechanical principles are analogous to electrical ones, but the domain is different. It is inherently more than one dimensional. On the other hand, this course only addresses "Statics," comparable to electrical "DC", leaving "Dynamics" for later.

EE251 Electronics I

Electronic components are those which behave nonlinearly and add considerable functionality beyond the basic circuit elements studied in EE211 and Physics. In particular, it becomes possible to build amplifiers – systems of components that increase the amplitude and power of a signal. Electronics I considers the properties of these electronic components, diodes and transistors, and how they can be harnessed to make various kinds of useful circuits. The circuits studied operate in the "analog" domain; they can vary continuously over time and represent specific information, such as the pressure of air at a speaker that will be part of a sound wave at some instant. In this course, most circuits studied have just one electronic component. These circuits are building blocks for the more complex systems studied in EE252 Electronics II.

An important feature of this course and the following EE252 is that the calculus content, which is especially important to understand frequency response and stability of feedback systems, has been concentrated in EE252. This allows transfer students from technology programs that did not have calculus based circuits and electronics to nevertheless be able to get credit for some of their courses towards some or all of EE211, EE241, and EE251. Thus, having credit for EE251 alone is not sufficient for the following, much more critical Electronics II course.

EGR222 Mechatronics

Mechatronics is the combination of mechanical, electrical, and computer components together to make systems that cross these domain boundaries. Such systems are common and of enormous importance, such as the modern automobile, aircraft, and even such smaller things as microwave ovens and ink jet printers.

This course is unusual in addressing these topics at a second-year level. Many schools wait for Mechatronics until later, when students have had important theory classes such as Controls. It is also different in focusing on practical projects in the laboratory. You may hear in other courses that the lab work reinforces the theory in the classroom. This one works the other way, the classroom is to help you in the laboratory. At Wilkes, we believe in doing this early. We want to get your hands on the toys early, and see the phenomena that you will study in greater depth later on. Yes, you won't have all the theory to understand everything now. You will see instability in the lab, but later you will have the Controls course that will help you understand it better analytically. But you've seen it, so it the theory will be more meaningful when you get to it.

The laboratory exercises walk through sensing things in the mechanical domain and representing that as an electrical signal, actuation to go from electrical signal to control things in the mechanical world with a motor, and finally the use of microcontrollers and the integration with sensing and a motor to do digital speed control.

EE241 Digital Design

Where Electronics I looks at the representation of information with analog circuits, Digital Design is about the representation and manipulation of digital signals. This is important because digital computers have become essential components of many real-world systems that engineers design. This course addresses the hardware components from which computers are built. It doesn't quite bridge the gap between computer components (such as registers, memory, multiplexors, and adders) all the way up to computer languages; the rest of that is in the elective Computer Organization course. But Digital Design does show how the fundamental elements called "gates" work that perform binary operations, up to more complex systems (more components) than students will do in other classes. So, dealing with complexity, boundaries between disciplinary domains in the form of specifications, and finally learning about sequencing and state machines, are valuable contributions of the course. EE241 includes a laboratory component, and includes digital electronics, the latter is missing from most digital design courses elsewhere. (That's an issue if you are wanting to transfer in a digital design course; check before you try to take this course elsewhere.)

Distribution Requirement

See the earlier discussion. Another of the core courses goes here.

Third Year:

EE252 Electronics II

This course is a critical component of the EE curriculum. The essentials it teaches are pervasive not just to electronics but many digital systems as well: Frequency response, feedback, and stability. Many classical applications of electronics concern the control of signals with respect to frequency, such as the tuning of a radio to a particular station and the elimination of signals from other, nearby frequencies. Understanding the mathematical basis of representing frequency response with Laplace transforms and transfer functions requires a calculus foundation. It is essential to understand the relationship between circuit components such as capacitors, features of the frequency response, and the mathematical structure (such as poles and zeros) of the circuit transfer function. The principles developed here for analog circuits are extrapolated to digital processes in more advanced EE topics such as digital controls and digital signal processing, which lie beyond what this one course can address. Feedback is the use of an output from a system to correct its behavior. In this course feedback is examined in the context of electronics, with "two-port" models used as a fairly rigorous tool for extending circuit theory beyond that of EE211 to adequately model feedback systems. These can be unstable, with issues dependent on frequency response. The principles of feedback, like frequency response, are widely applicable to many problems far beyond the domain of electronics.

Another important feature of this course is its laboratory component. Moving from Electronics I to Electronics II means moving from relatively simple single transistor circuits to systems of circuits including several circuits each. For example, the power amplifiers to be designed by the students need to include a preamplifier stage to present an appropriate impedance to the input, a gain stage to produce a sufficiently high Voltage to power a speaker with several Watts of power, and a current gain output stage to provide the necessary current at that Voltage. Similarly, the radio circuit requires tuning, demodulation, and amplification. The step from designing single circuits to systems means dealing with the design of the interfaces between the components, a nontrivial development in professional sophistication.

Also, Wilkes is committed to "Writing Across the Curriculum." That means, every program, including EE, needs to include experience in writing appropriate to the discipline. The formal laboratory reports in this course have served in this important role during the last several years. The importance of report writing cannot be overestimated for engineering in the real world, where reports of various kinds are how engineers communicate with clients, suppliers, management, and each other. The writing in this course is intended to help you become a capable professional communicator.

EE 271 Semiconductor Devices

Semiconductor devices are the fundamental building block of almost all electronic devices, including computers to communications devices, that have become pervasive in the modern world. Where Electronics and Digital Design courses looked at how these devices are used to achieve circuits and systems, this course focuses on the devices themselves, and how materials are engineered to achieve those useful semiconductor devices, especially diodes and transistors. Thus, the student is looking at principles based on chemistry and materials science, together with the physics principles of electric fields, electron mobility and current flow, to the engineering of the properties necessary to build devices having specified characteristics. Specialized computer simulation is a very useful tool for modeling the behavior of these complex devices. While the contents of this course are essential for someone expecting to be employed in the semiconductor industry, it is very useful knowledge of any Electrical Engineer.

EE 381 Microfabrication Lab

This course is a very special and unique feature of the EE program at Wilkes University. Students, over the course of the semester long course, actually fabricate their own semiconductor devices on silicon wafers, following most of the same steps that are used in the huge, expensive semiconductor plants that provide the devices that make electronics so ubiquitous in the modern world. Students start with bare wafers and build up their devices step by step using photolithography, and test the fabricated devices using probes to characterize their behavior.

The opportunity to do this is very uncommon. At best, most schools merely let students develop designs, which might be manufactured elsewhere by someone else. To actually do this in the lab is unique. Even in most semiconductor plants, automation means that these steps are normally all done by machines, with human beings primarily providing oversight. Big universities may have some fabrication facilities, but they are usually reserved for graduate level research, not undergraduate teaching.

The experience gained from this course will be very valuable for someone going into the semiconductor industry. For others, it also provides valuable insights into why semiconductors are manufactured and priced as they are. Students will be able to appreciate the importance of future developments in the semiconductor business, which will open and close opportunities in the rest of the field.

PHY 214 Modeling of Physical Systems

Engineers don’t just build things. They design them using analytic techniques so that when the systems are built, they predictably meet expected behavior and performance goals. “Modeling” using the computer is an essential component of that. A plastic “model” airplane may be useful in envisioning how a real, full scale aircraft would look, or in planning how many could fit into a hangar. A model aircraft that flies in a manner similar to the real aircraft might be useful for assessing performance. But it would be much more expensive, and troublesome to maintain, than the plastic model. A full-scale prototype of the real aircraft could be useful for flight testing, but extremely expensive. Computer simulation and modeling is increasingly a supplement or substitute for more classical forms of modeling. That's the focus of this course. How can a system be represented on a computer? One method is to derive a set of mathematical equations that characterize a system, usually differential equations, and solve those to understand the system behavior. Another is to "simulate" the system by building analogous processes that mimic what the parts of the system do. Ultimately, many real-world systems are characterized by randomness, and analytic methods derived from probability and statistics are needed. This course introduces analytic tools useful for doing these things.

Distribution Requirements (two of them)

EGR -399 Cooperative Education

This isn't exactly a "course" in the traditional sense, but an immersion in industry doing a technical job for a real-world company. While there are reporting requirements (which is why it counts as a course), the idea is to go out and see what life as an engineer is like. You will report to a supervisor, be expected to carry out assignments, and those assignments will be different from normal school assignments. Is school, assignments are just for educational value. They don't matter in any wider sense, just in what you learn. A coop assignment is different – the company needs the work done as part of their business. The products and the profitability of the company depend on your work. That's different. The gain in perspective from the coop experience is very valuable.

In addition, many students that do coops are often offered part time jobs during the remainder of their academic residence, or even full time jobs after graduation. A coop can, in a sense, serve as an extended, immersive, job interview. You get to know the company much better than as someone just visiting for the day on a normal job interview, and they get to know you better as well.

The coop can be done locally or elsewhere. If you do a coop somewhere remote, the additional credits needed during this semester can be found as local courses taken for distribution credits to be transferred to Wilkes, or in online classes. The critical EGR210 and EGM 320 courses for this semester can be taken in an online format.

Don't wait until the sixth semester to start trying to get a coop! You should start considering opportunities during your sophomore year, and perhaps even take some technical electives which would make you a more attractive candidate for a particular coop position. Work diligently to keep your grades high and present yourself as a competent professional in training. Just because you may meet the minimum qualifications to do a coop, does not mean that some company has to take you. It's competitive. You will need to show why they should take you as a coop student rather than someone else. During the fifth semester, you should be applying for particular positions.

The coop experience can count as one or two six-hour technical electives (explained below). You don't have to do a coop. You might want to take technical electives instead towards earning a minor in some subject, for example.

Technical Electives

These are courses that allow you to focus your studies in particular directions. Any science (including computer science), engineering or mathematics course of 200 level or above qualifies as a technical elective, so there are lots of opportunities. By the time you are choosing technical electives, you should have some idea what your interests are. What do you get excited about? Well, whatever that is, find technical electives that will strengthen your knowledge of that domain, perhaps helping qualify you for the job you hope to find after graduation. For example, students might take technical electives that would qualify them for a minor in physics, computer engineering, mathematics, or computer science, strengthening their credentials. Or, a student might take courses in mechanical engineering such as thermodynamics, fluid mechanics and combustion engines to give breadth needed for entering the world of automotive design. Take something you want to know more about. It's hard to go wrong.

PHY 203 Modern Physics and PHY 206 Modern Physics Lab

The twentieth century brought about a revolution in the understanding of the universe. This "modern" physics introduced the notion of the atom, atomic and nuclear phenomena, relativity, quantum mechanics, and more. That is the world we live in. Yes, classical physics dominates what we see daily, but increasingly the devices we routinely use depend on principles from modern physics. That makes this course very important to a student in electrical engineering; our semiconductor devices depend on this modern understanding of the world. The laboratory experience provides some hands-on experience including some of the classical experiments foundational to modern physics.

EGR 201 Professionalism and Ethics

Engineering takes place in the context of society. Engineers have obligations to their employers as would anyone with a job. But engineers are also professionals. That means that they have wider obligations, to the profession and to society, that go beyond and may even be more important than obligations to the employer. Sometimes these principles come into conflict, just as a student might be tempted with dishonesty. This course looks at these issues and others concerning professionalism and ethics.

EGM 320 Engineering Project Management

Just as EGR210 looks at the professional and ethical aspects of the engineering profession in a society context, this course looks at the business aspects of engineering in a project context, which is what an engineer can expect to be typical of real world employment. Businesses and jobs exist in the context of a modern economic society. The costs of things and the cost of labor are inevitably key issues in practical engineering. All these things come together in the context of managing a project, which is what this course is about. This is a prerequisite for the fourth year "Senior Projects" class in which students will do just that.

Note that the "Junior Standing in Engineering" prerequisite for this course means that you must have completed and passed all of the required courses on the recommended sequence that are designated for freshman and sophomore years.

Fourth Year:

EE314 Control Systems

This is perhaps the single most important analytic course in the EE curriculum. The mathematics, physics, and modeling knowledge are brought together for a rigorous understanding of systems, which could be mechanical, electric, a combination of both, or indeed almost any complex system. It is difficult to describe the principles taught here. Perhaps it can be said that in this course the math and physics that to this point have been studied in relatively small, simple systems are put in a systematic framework that can be applied to large, real world systems. A simple electronic circuit might be "3rd order", in the sense that you could characterize it with three equations that could, without too much difficulty, be solved by hand with pencil and paper. But, a real-world problem might be of 100th order or much more. How can such complex things be represented mathematically? While the coursework examples are done with limited complexity, the techniques and principles apply to much bigger things. This course is a foundation for further work at the graduate level.

EE 337 Engineering Electromagnetics I and
EE339 Engineering Electromagnetics II

If electrical phenomena were limited to what could be done with wires, the world would be a much more limited place. But radio was invented around the dawn of the 20th century, made practical and important by World War 1, and by now is an ever-present part of our every-day lives in the form of cellular phones, satellite television, GPS receivers, and more. These courses take electromagnetism beyond the constraints of wires, looking at how electromagnetic fields and waves behave, antennas, and the practical aspects of these for engineering electromagnetic systems. Electromagnetism is inherently a three-dimensional phenomenon, so the mathematics to do this requires multivariable calculus. The conventions and analytic tools are pretty involved. The course includes practical work in the laboratory, which helps take the abstractions of this unseen medium and helps make it real.

EE391 Senior Projects I and EE392 Senior Projects II

This is a year-long capstone project in which teams of students undertake a practical project. Some projects originate with industry sponsors, some with professors having particular research or development interests, and others are originated by students themselves. Some students have used this as a start for doing things that they plan to make into a business. This is your chance to do something neat and interesting.

The projects actually start in EGM 320, where students choose projects and begin to define their goals. A project is more than a hack; it needs to be organized into tasks for the various team members to do. The project must be proposed, designed, built, and then finally tested or characterized. The cost of doing it needs to be estimated, the money raised or allocated, and ultimately justified. There's a lot more to building something than you'd imagine! Yet, this is the kind of things engineers are paid, and paid well, to do after graduation. This is a chance to start doing that, albeit on limited scale. It is also a chance to do something that you can get excited about and talk about on job interviews. A good senior project can help you land a job!

EE 325 Energy Conversion Devices

Have you ever wondered where electricity comes from? That is, the power that the utility company provides? You no doubt know it comes from power plants, specifically "generators", but just how does all of that work? That's what this course is about. Even if you don't plan to go into the power utility industry, it's valuable to know a bit about large scale electrical principles and operations. In contrast to the kinds of things you do in Electronics and Digital courses, at the Volts and milliAmperes scale, Electrical Power distribution goes into Kilo-Volts and Kilo-Amperes domain. Distribution is typically three phase – have you ever noticed that utility poles carrying higher Voltages usually have multiples of three heavy conductors? Sometimes these similar principles are applied on smaller scale, such as the alternator in an automobile, the motors that drive electric cars, and even the small-scale transformers in electronic equipment. All this is expected professional knowledge for the graduating EE engineer.

EE382 Modern Communications Systems

This capstone communications course applies the theory learned in electromagnetics and other earlier courses to communications systems. Traditionally communications meant radio (at first using Morse Code), then television, and more recently so much, much more. The system structure of communications transmitters and receivers are studied, such as modulators and demodulators, which can produce or decode different kinds of signals. Wireless systems like cellular telephones and all sorts of modern communications depend on these techniques. The course is structured around a laboratory experience where students gain hands-on experience with these things.

Distribution Requirement

These are described earlier. Note that distribution requirements and Technical electives may be moved around freely, so that you could substitute one for another as convenient. This is the last distribution requirement. You don't want to be having to find one of only two ECON 102 sections, neither of which fits your schedule of required courses! Get that ECON 102 in earlier!

Technical Elective

See earlier description.

Free Elective

This can be anything! Take a course you are interested in, something you will enjoy. If you needed to take MTH100 earlier before calculus, you can count it as your free elective.