A Brief Overview of the BSE (EE) and BSE (CPE) Curricula for Students in ECE 123

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"Scientists are men who dream about doing things. Engineers do them. If you want to be an engineer but find you have ten thumbs, become a scientist." - James A. Michener

The quotation above is widely use in engineering circles. It concisely captures much of the reason that we become engineers. The quotation comes from one of Michener's epic novels, *Space*. The setting for the statement involved a young engineer [Mott] being introduced to the wind tunnels. He had started to fancy himself "quite a scientist." One of the older engineers [Crampton] took him to task. The complete dialogue went as follows:

> [Mott – upon viewing the inside of the wind tunnel for the first time]: Some scientist did a good job here.
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> [Crampton stopped, stiffened, and in the gloom of the great tunnel, said]: Scientists are men who dream about doing things. Engineers do them. This [wind tunnel] was designed by engineers, built by engineers, and is run by engineers. You're an engineer, young fellow, and you're to be proud of it.
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> [Mott]: I'm sorry.
>
> [Crampton]: You thought that if an engineer was real good, he became a scientist. It's the other way around. If you want to be an engineer but find you have ten thumbs, you become a scientist.

Please excuse Crampton's lack of PC (Political Correctness). Engineers often get caught up in the process and have long assumed that "man" meant mankind. Regrettably, that assumption has cost the profession the able talents of many women who were able and willing to be engineers, but were unwilling to tolerate the dismissive attitude that we engineers often display. Yet we can still learn from Crampton.

What is inherent in Crampton's statement, "It's the other way around" is that in order to be an engineer, you must understand the science involved with the process you are trying to build.

ECE 123 – Mobile Robots – is attempting to help you decide whether you are "all thumbs" or whether you have the manual dexterity and abilities to become an engineer. At the same time, it should be pointing you toward the science and mathematics that is the backbone of understanding what is taking place in the processes that you will analyze during your career as an electrical engineer or a computer engineer.

Webster defines a spline as "a key that is fixed to one of two connected mechanical parts and fits into the keyway in the other." Metaphorically, all engineering disciplines, including Electrical Engineering (EE) and Computer Engineering (CPE) have two main splines in their curricula – Physics and Mathematics. Mathematics is the language and grammar of science. Physics describes the world that we, as engineers, seek to control.

These splines of Mathematics and Physics connect the students understanding of the world as the student comes out of high school with the tools that we, as engineers, use in our professions. Most students come to the study of engineering with a background in algebra, geometry, and trigonometry. A student that lacks one or more of these disciplines will be required to take remedial work to bring them up to that entry level.

The first two years of an engineering curriculum will contain four courses (12 credit hours) in mathematics, specifically: differential calculus, integral calculus, multivariate calculus, and differential equations. Sometimes a student will ask to bypass one or more of these because, "I already know that topic." In order to adequately study the advanced engineering topics at the junior and senior level, the student must have more than a passing acquaintance with these topics. Therefore, a student that feels they have command of one of these topics is required to go to the Mathematics Department and "Test Out" of the course.

The Physics spline (10 credit hours) generally begins concurrently with the integral calculus course. Integral calculus is used as a tool in the study of Physics. Many students will have already taken Physics in high school. Their understanding at that level used algebra to describe how processes work. This understanding can certainly help the student's intuitive understanding of the process. However, to actually comprehend what is taking place in a process, one must have all the tools of integral and differential calculus at their disposal. This understanding is essential to the engineer that wishes to then control or modify the processes.

In addition to these main splines, the engineering curricula contains courses determined by the engineering faculty and approved by ABET (the Accreditation Board for Engineering and Technology – a national organization that reviews and approves the curricula for all engineering schools in the United States) to prepare students for the practice of engineering in the appropriate discipline.

For electrical and computer engineering, these required courses include:

CHEM 110/111 (4);
IME 102; (3)
IME 310; (3)
IME 316; (3)
ME elective (3);
CS 111; (4)
ECE 210; (3)
ECE 221; (3)
ECE 250; (3)
ECE 251; (3)
ECE 310; (3)
ECE 380; (3)
ECE 371; (3)
ECE 481 (2);
ECE 482 (3); and
the University General Education Distribution Requirements (17).

One may note that eighty-five (85) of the one hundred and thirty credit hours in electrical engineering and computer engineering are identical! There is much similarity between the professions of electrical engineering and computer engineering. In fact, with an appropriate choice of electives, the two curricula become even closer. For now, let us examine these identical requirements and the logic behind them.

The University General Education Distribution Requirement is an area that many engineering students dread. A very talented engineer in the workplace once observed over coffee, "You know, the courses that I took in college that I wanted to take are what I use to make my living. The courses that I didn't want to take are what make my living worth while." That was a very astute observation. The General Education Requirements are a major part of what it means for an engineer to have a college education rather than simply technical training.

Engineers fulfill the Proficiencies, Distribution Area VI (Natural Sciences), and Distribution Area VII (Technology) through required courses in the curriculum. In order to complete the Distribution Requirements, each student must choose one course from each of the other areas: Distribution Area I (Fine Arts); Distribution Area II (Humanities); Distribution Area III (US culture); Distribution Area IV (Other cultures); Distribution Area V (Social & Behavioral Science); and Distribution Area VIII (Health & well being). Students must take at least six credit at the 300/400 level within the Distribution Areas; two courses must be from the same department (first at the 100/200 level then at the 300/400 level; and no more than two courses may be from the same department. These requirements are in place to ensure that the student has a breadth and depth of education in the various areas that will make their lives worth-while. Many students choose courses for the distribution areas based only upon a convenient time schedule. When they do this, they are cheating themselves. The wise student would use

this requirement to explore topics that they believe may interest them as they progress through life.

CHEM 110/111 is basic inorganic chemistry. An electrical or computer engineer must have a grasp of the chemical properties of the materials with which they are working if they wish to understand the electrical properties.

Many engineering students come to the discipline enthralled by technical studies, but uncomfortable with the writing requirements. Upon graduation, they learn that engineers spend more time writing than most English majors. But the writing is very specific. When an engineer develops a process or product, it would be useless unless the engineer could tell others how to use it. Therefore, the engineer's time writing is aimed at technical writing. IME 102 and IME 316 address these skills. IME 102 should be taken early in the student's career so that they can write more effective laboratory reports as they progress through their engineering studies. IME 316 is most effective when it is taken the semester immediately before the student takes ECE 481.

The third common course from the IME department is IME 310 – Engineering Economy. This course teaches the student how to assess the time value of money, when working with projects that will take months, years, or sometimes decades. Many electrical and computer engineers have trouble with this course. The mathematics is simple enough that many decide they "don't need to do the work" associated with the course. Students that approach this course with a determination to do the work and keep up with it on a regular basis do quite well in the course.

All electrical and computer engineering students are required to take an engineering science elective from mechanical engineering. When the electrical or computer engineer works in the profession, they will most commonly be working side by side with mechanical engineers. This requirement is to help the student acquire a basic understanding of the way mechanical engineers frame their problems. The approved electives for this requirement vary, depending upon whether the student is an electrical engineer or a computer engineer. Either discipline may take ME 232 (Thermodynamics) or ME 250 (Materials Science). Computer engineers may take ME 256 (Statics). However, electrical engineers (who must take Statics over and above the ME engineering science elective) may take ME 257 (Mechanics of Materials) or ME 362 (Theory of Engineering Experimentation).

CS 111 is a basic programming course in C++. The course helps provide the student with the tools that they will need as they progress through their engineering studies. This course should be taken as early in the student's academic career as possible.

ECE 210 is the basic circuits course; ECE 221 is the basic electronics course; ECE 310 is the course where students learn to analyze networks of circuits; ECE 371 is where students learn to use the networks of circuits to control external devices; and ECE 380 is where students learn to use the networks of circuits for signal processing.

ECE 250 exposes the student to digital electronics and ECE 251 follows this up with the study of microprocessors.

ECE 481 and ECE 482 are the capstone design courses for the ECE department. As such, the student is to take ECE 482 in their final semester at the university. This course is an open ended course where the student brings **all** the tools at their disposal to accomplish a significant engineering design problem. If a student takes ECE 482 before their final semester, they come to the table short some marbles. ECE 481 is the course where the student develops the proposal for the project that will be built in ECE 482. If ECE 482 does not immediately follow ECE 481, the student would need to retake ECE 481.

With eighty-five hours discussed, that leaves forty-five credit hours (approximately fifteen courses) unaccounted. These forty-five credit hours are the basis for the differences between the study of electrical engineering and computer engineering.

Computer engineering students take more courses aimed at digital and microprocessor based applications as well as more computer science and programming courses. The only "free" elective in the computer engineering curriculum allows the student to take a course from the ECE department (such as ECE 123) or from the CS department, subject to approval of the student's advisor.

The electrical engineering curriculum directs the student into the more traditional areas such as electromagnetic fields and electrical machinery. The student also takes Statics (ME 256) and Dynamics (ME 258) plus nine hours of "directed" electives from the ECE department. These "directed" electives allow the electrical engineer to pursue in more depth three areas from among six: ECE 420 (Power Electronics); ECE 430 (Electrical Power Systems); ECE 451 (Microcontroller Applications); ECE 455 (Digital Signal Processing; ECE 460 (Communications Systems); and ECE 470 (Feedback Systems).

Finally, the electrical engineering student takes a "Mathematics or Science Elective" from the following PHYS 309/310 (Modern Physics – aka Quantum Physics); CHEM 112/113 (General Chemistry II – aka Inorganic Chemistry); or STAT 364 (Statistical Methods). Before the engineer's career is over, they will have obtained a command of all three of these topics, plus many more. This requirement is to begin the student along the path of acquiring knowledge that can be applied to solving engineering problems.

The electrical engineering curriculum also allows the student to take a course from the ECE department (such as ECE 123) or the CS department, subject to approval of the student's advisor.

With all of these hours and courses, it is sometimes easy for the student to loose sight of what an engineering education is all about. Early in the academic career, the student sometimes wonders why they are taking all these math and physics courses – why can't they take the engineering courses that they want. As pointed out earlier, many

engineering courses require the depth of mathematical and physical understanding in order to adequately approach the engineering study.

Other students fall into the trap of "simply jumping through hoops" and loose sight of the fact that engineering is more than just the science and mathematics. There is a design to the engineering curriculum to produce a person that has both the tools and a method of thinking that will lead to effective solutions. Engineers, you will learn are truly self made persons.

Your professors give you the assignments and the tasks to help you mold yourself into an individual that is highly prized in society – an engineer. To achieve this goal, you must understand the science; you must have command of the mathematics; then, if you don't have ten thumbs, you may become an engineer, and, as Crampton said in *Space*, "you're to be proud of it."

Acknowledgement

This report is based upon work supported by the National Science Foundation under Grant No. 0088158. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the authors and do not necessarily reflect the views of the National Science Foundation.