INTRODUCTION TO ELECTRICAL ENGINEERING: A NEW FRESHMAN COURSE AT UPR-MAYAGUEZ

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I. Introduction

A course introducing electrical engineering to freshman students has been created at University of Puerto Rico Mayaguez (UPRM). The course consists of one-hour lecture followed by a two hours lab experience once a week. The students are introduced to five areas of specialization through discussion of basic concepts in class and real life applications in the laboratory. The laboratory experiments are focused in five specialization areas: Power, DSP and Communications, Control Systems, Electronics and Applied Electromagnetics.

The laboratories are carefully designed so that freshman students have an understanding of the different applications in electrical engineering early in their college career. In addition to the familiarization with basic laboratory equipment (multimeters, oscilloscopes, signal generators, etc.) during their freshman year, the students will be introduced to other important software tools such as Matlab, Excel, Power Point, and Cool Edit. The students will also attend seminars on effectives oral and poster presentations as part of the requirements of the course.

In this work, the course is briefly discussed, including the laboratory experiments. It is expected that with this experience, the students will choose their concentration area before their junior year, and will help coordinate future courses in the ECE Department. The laboratory experiments are performed in the facilities of the High-Tech Tools and Toys Laboratory, created with the support of NSF CenSSIS.

II. EE Department Background

The University of Puerto Rico at Mayagüez, the third largest campus of the state-owned university system of Puerto Rico, homes the daily activities of about 765 faculty and almost 15,000 students. According to the American Society for Engineering Education's (ASEE) 2000 edition of *Profiles of Engineering and Engineering Technology Colleges* UPRM ranks 14th in the U.S. in terms of undergraduate engineering enrollment, 18th in awarded engineering degrees and 3rd in engineering degrees awarded to women. It is also the largest Hispanic engineering schools in the country, and has been fully accredited by the Middle State Association of Schools and Colleges since 1946.

The student population of the ECE department consists of about 1500 fulltime undergraduates (11% of the campus´ total), 60% of which major in Electrical Engineering and 40% in Computer

Engineering. Around 30% of the undergraduate students are females. The B.S. electrical and computer engineering programs were established in 1928 and 1981, respectively, and gained ABET accreditation in 1960 and 1994.

The undergraduate Electrical Engineering curriculum at UPRM consists of up to168 credit-hours which are distributed trough a five year program. During their 4th and 5th year, the students will take up to six technical elective courses in the specialization area of their choice. At least four of the six courses have to be in a particular specialization area within Electrical Engineering. There are currently five areas of specialization at the Department, these are: Power, DSP and Communications, Control Systems, Electronics and Applied Electromagnetics. Each of the areas has introductory courses that are suppose to be taken by the students previous to the technical electives. For this reason, it is expected that the student will make a wise decision at the moment that he or she decides to specialize in a specific area.

Unfortunately, in the last few years it has been observed a tendency of students trying to take technical electives before taking all the introductory courses. As a result, some students realize later on that they prefer to specialize in a different area causing graduation delay and overcrowding technical electives intended for a small professor-student ratio.

In order to tackle this problem, an Introduction to Electrical Engineering course has been developed. The course was offered for the first time during the 2002 Fall Semester. The course consists of one-hour lecture followed by a two hours lab experience every week. Professors of each area are invited to give the students a 30-45 minutes presentation before the particular area is introduced. This is a chance for the students to meet the professors from different areas and ask them specific questions. Due to space and equipment limitations only seven students were invited to participate in the pilot-course. The laboratory experiments are performed in the facilities of the High-Tech Tools and Toys Laboratory, created with the support of NSF CenSSIS. See figure 1.

FIGURE 1 - High-Tech Tools and Toys Laboratory facilities at UPRM

An exit questionnaire was distributed to the students by the end of the semester and results to key questions about the course were answered.

III. Introduction to Electrical Engineering Course

It is expected that after completing the course the student should have a clear idea of the EE curriculum and applications of the different specialization areas. The understanding of simple EE concepts and familiarization with measurement equipment is also expected. In addition, the students will learn the use of tools such as Matlab, Power Point, and Excel and be prepared to make an effective oral/poster presentation.

By the end of the semester the student should be able to have a good idea of which of the five specialization areas he or she will choose. If a high percentage of the students do not change their mind about the specialization area, a good estimate of future courses and faculty with specific background can be established. It is also expected that by making a wise decision early on, the students will have a better chance to complete their BSEE degree on time. Table-1 summarizes the material discussed in the 15 weeks semester.

TABLE 1 – Topics discussed in course

Number of Weeks	Topic
1	*Introduction to EE – General Information*
	Electrical Measurements Lab – Basic Circuits
1.5	*Matlab Practice*
2	*DSP and Communications Lab*
2	*Electronics Lab*
1.5	*Applied Electromagnetics Lab*
1	*Effective oral/poster presentation*
1.5	*Control Systems Lab*
2	*Power Systems Lab*
1	*Exams*

EE General Information - The first week the students are basically informed about campus and EE facilities (computer labs, library, educational labs, research labs, etc.) and opportunities available for them (undergraduate research, COOP, fellowships, exchange program, etc.) to enhance their educational experience in college. The students are then introduced to the EE curriculum where basic and technical courses are briefly discussed. The different specialization areas are also presented focusing in applications and employment opportunities in Puerto Rico and USA.

Electrical Measurements Lab – Basic Circuits - During the second week the students are introduced to basic electrical measurement such as current, voltage and power. Basic circuit analysis is discussed using the Ohm's and Kirchhoff's laws. Basic resistive circuits (parallel and series) are built in the lab and different measurements are taken with the available equipment. These basic concepts and familiarization with measurement equipment such as the multimeter, signal generator, and oscilloscope are essential for the following labs. The students are introduced to spreadsheet software by plotting the data collected during the lab.

Matlab Practice - During the next class the students will learn the basics of Matlab[1]. This package is widely used in different EE courses and students are introduced to the same through a series of simple exercises. The students start with basic math operations and simple matrix problems. Next, the software is used to plot data files and different functions. Finally, a digital camera is used so that they can take their own picture which is loaded in Matlab, noise is introduced and filtering tools are used to recover the original image.

DSP and Communications Lab - The next topic is the introduction and lab experiment of the DSP area. In this lab the students used a commercially available software called Cool Edit[4] (the software is used in DSP courses). This software is capable of recording a digital audio signal from a CD and different signal processing can be easily performed. First, the software is used to introduce the students to the time and frequency domain by analyzing a tone controlled and generated with the software. Next, a sample from a music CD is recorded and the students can listen to any change in the music by trying different compression factors. This is also easily illustrated by looking at the spectrum of the signal. The students also have the opportunity to record their own voices under noisy conditions, and using the filtering tools of the software they can recover the voice signal. This laboratory finishes with a simple introduction to modulation and radio wave propagation, where they use the signal generator and a CD player to transmit the signal into space and the use of a receiver to listen to the music.

Electronics Lab - For the electronics lab the students are first introduced to the OP-AMP and inverting and non-inverting amplifiers configurations are built and tested in the lab. The students are also introduced to the design of a low pass filter using the OP-AMP and they learn to measure the cut-off frequency. For this particular lab, the students will build an audio amplifier. Figure 2 shows the final design of the amplifier, the circuit is built in stages, and each stage is independently tested before the final integration.

Applied Electromagnetics Lab - During the Applied Electromagnetics week, the students will learn the basic concepts in wave propagation, polarization and wave reflection. For this experiment, a network analyzer was configured as a two antennas scatterometer. Using the time domain option of the analyzer a target (metal sphere) can be easily observed and parameters such as range and received power can be easily measured. Figure 3, shows a basic block diagram of the scatterometer configuration. The standard gain horns can be rotated to change the polarization and the student can observe in the network analyzer the effect on the received power. The configuration is also used to propagate the signal through different mediums (dry –to-wet sand) and how the signal is attenuated for the different cases.

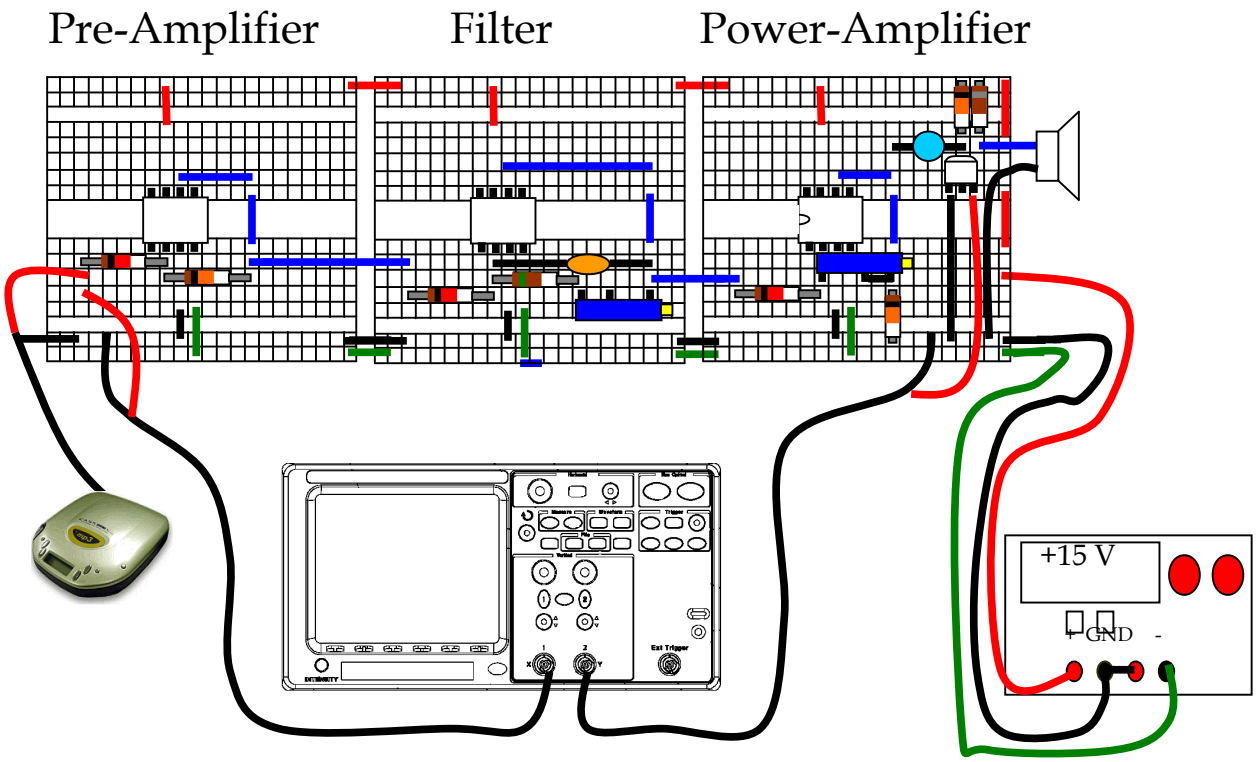

FIGURE 2 – Audio amplifier build by students in electronics laboratory

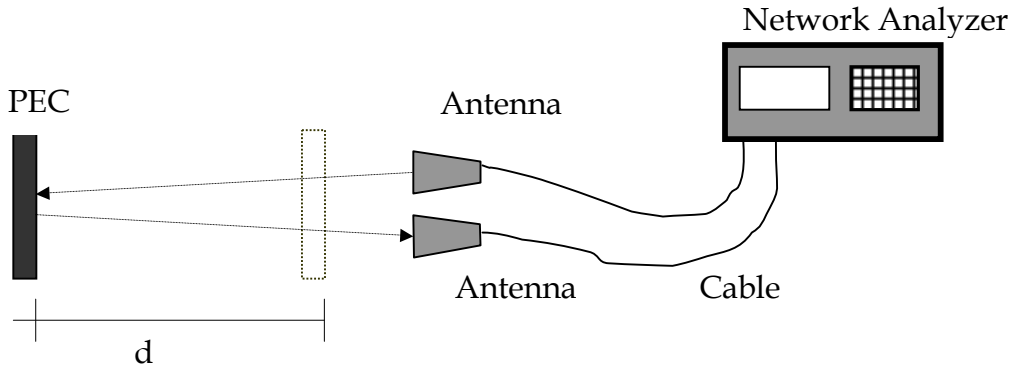

FIGURE 3 – Scatterometer configuration using network analyzer.

Control Systems Lab - The students are also introduced to the control systems area by using the *MindStorm*[2] Lego robot kit. The robots are easily constructed and the students have the freedom to add to their machine different light and touch sensors. The students can easily program the robot using the software provided by *MindStorm* and the instructions are loaded to the unit using an infrared interface. The purpose is to program the robot to avoid different obstacles using the sensors and to follow specific paths following colored lines draw on a test table. Figure 4 shows a picture of the students working with the robots, while figure 5 shows

the instructions of a one step program. The students also visited the robotics lab and talked to graduate students involved in the design and fabrication of robots.

Power Systems Lab - In this practice the student is familiarized with the use of transformers in power circuits. They learn to identify the terminals and coils of the transformer and the configuration to increase or lower voltages. Connections between coils and efficiency computations using different loads are also performed. On the other hand, the student can analyze the visual effect that produces the form and frequency of the electric signal applied to a low voltage light bulb[3]. The students also had the opportunity to visit the electric machinery lab and received a talk about the importance of power engineering.

FIGURE 4 – Students working with robots in the laboratory.

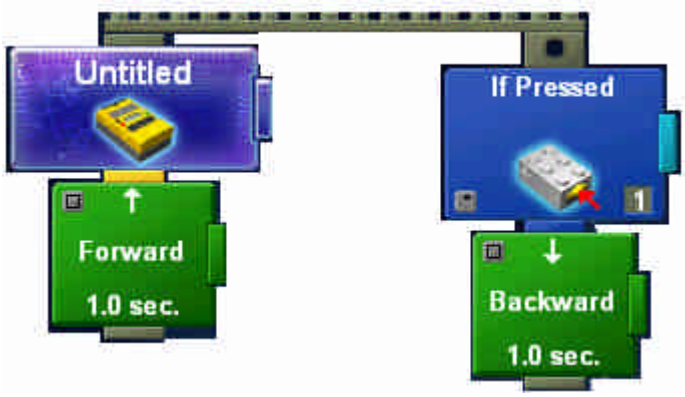

FIGURE 5 – Example of simple program to control the robot. The robot moves forward for one second and if finds an obstacle will move back for one second

IV. Questionnaire Results

By the end of the semester the students were asked to evaluate the course. It is obseved from the results in Table 2 below, except for the Matlab laboratory,that the students considered all the labs important or extremely important. Most of the comments were very positive, indicating that they enjoyed the course and will not change anything. One suggestion was to eliminate Matlab from the course to dedicate more time to the EE experiments, and another suggestion was to visit more research labs and to bring more professors from the different areas to talk.

TABLE 2 - Questionnaire Results

Lab/Experiment	Not Important	Less Important	Relatively Important	Important	Extremely Important
Matlab		1	2	3	1
Oral/Poster Presentation				1	6
Electronics				1	6
DSP				2	5
Communications				1	6
Applied Electromagnetics				1	6
Control Systems				3	4
Power Systems				1	6
Should this course be added to the EE Curriculum ?					7
Do you have a better idea of what EE is about?					7
Do you feel capable of deciding a Specialization area now ?				2	5

V. Conclusions

According to the questionnaire results, the students enjoyed the course and they feel ready to decide about specialization area. Even though they can change later on their decision, it gives the EE Department an idea of the student preferences. For this small student sample we asked the students to select two specialization areas. The results shows that *all* of them will consider DSP and Communications as a possible specialization area, 3 in control systems, 2 in applied electromagnetics, 2 in power systems, and 1 in electronics. If new facilities are assigned and more equipment is acquired, the course can be taught to a large sample of students (ideally all of freshmen) and feedback from students can be used to plan future courses and faculty hiring positions. Besides the technical laboratories, the students also found very important the seminar for effective oral and poster presentations.

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