AC 2012-3390: HOW MUCH PHYSICS THE FIRST-YEAR ENGINEERING STUDENTS REALLY NEED: A STUDY AND SURVEY

Dr. Bala Maheswaran, Northeastern University

Bala Maheswaran, College of Engineering, Northeastern University, Boston, MA 02115.

How much Physics the First Year Engineering Students really need: A Study and Survey

Abstract

Freshmen engineering courses are the eye opener for engineering students in several institutions. Exploring different ideas and new techniques are always a challenging task. Even though several high schools have rigorous curricula, students' knowledge varies with the courses and the level of the courses they have taken. As a good example, most high schools have physics or physics-related courses, but their students' knowledge of electrical circuit elements such as resistors, capacitors, and inductors varies. For first year engineering students, a background in physics is an important aspect to deal with various activities and projects[1-3].

Incorporating projects with Physics concepts in the freshmen engineering courses, such as dealing with circuit elements and exposing the use of those elements in real applications is one way to build the students' confidence and background in an important subject such as physics. At our institution, Electrical and Mechanical engineering majors take a circuit based course after their freshmen year. This report analyzes and addresses the issues pertaining to concerns of whether freshmen engineering students can handle projects involving substantial amount of electrical circuit elements such as breadboard, battery, pre-bent wires, three-pronged connector, switch, LED, LCD, resistor, capacitor, seven-segment display, microcontroller, temperature sensor, light sensor, and speaker.

As part of a problem solving and programming course in the freshmen engineering program at our institution, the circuit elements based activities was introduced to demonstrate the use of software.

This report will present the outcome of a survey and physics concepts, which involves dealing with circuit element concepts. Eighty four students participated in this study, various types of questions were asked including the following two:

- Rate your knowledge / background in electrical circuit Physics concepts
- Do you think more background in physics would have helped you to better understand the circuit concepts?

The data was analyzed using an excel spread sheet and the out outcome will be reported in this paper.

Introduction

Physics is a key element for the first year engineering programs and how much physics that they need is a worthwhile idea to explore.

Our first year engineering students take Engineering Physics courses starting in the second semester. Most of our first years have high school physics, but their skills are

highly dependent on the high school they attended and the level of physics that they have taken[4].

Understanding the proper operation of the circuit elements requires the knowledge of Ohms law, diode and capacitor concepts, LED and LCD function, and the workings of light and temperature sensors. For several students these are totally new conceptual issues to deal with. Our students take mainly Engineering physics 2 in the second year, and Physics 2 deals with circuits, elements used in circuits, and the concepts of various electromagnetic systems.

Project Approach

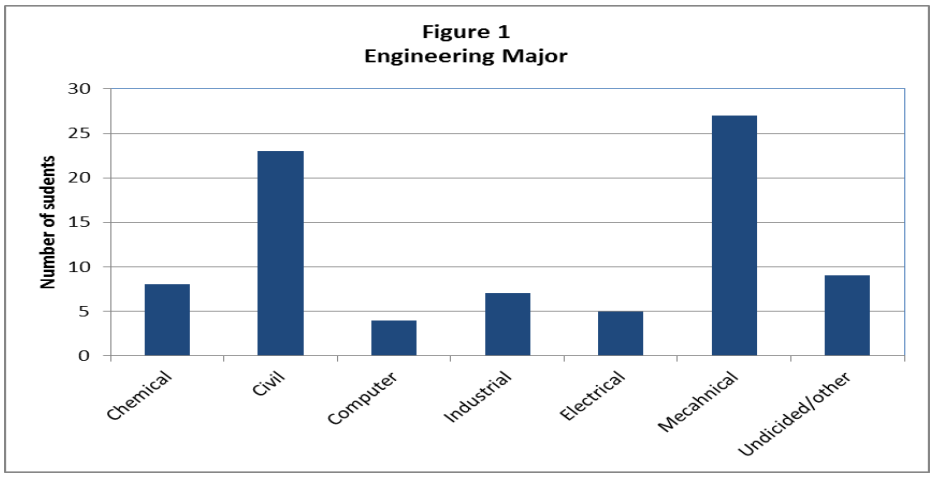
As part of our problem solving and programming course, we have assigned projects to deal with circuit elements[5] and to control the functions of the circuits via computer. For this purpose we have used c++ to create source codes. The objective of this study is to determine the student's extent of knowledge in physics when it comes to circuit elements and to decipher whether it would have an effect on the outcome.

Upon completion of this process at the end of the semester, several survey questions were asked. Appendix 1 shows the list of questions. Eighty four students took part in the survey of nine questions. The data obtain for each question was analyzed using a basic excel spread sheet.

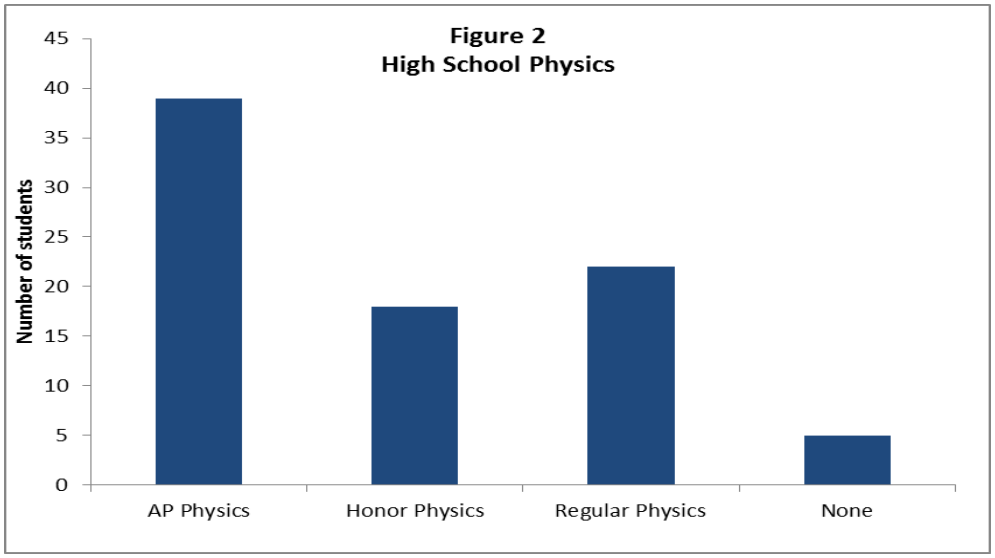
Data and Analysis

Figures 1 through 8 below show the outcome of the survey. For all graphs, the title is the content of the survey question, the y-axis represents the number of students, the x-axis represents the specific category asked in the survey, or the rating range (from 1 to 10). The numerical survey results are summarized in appendix 2.

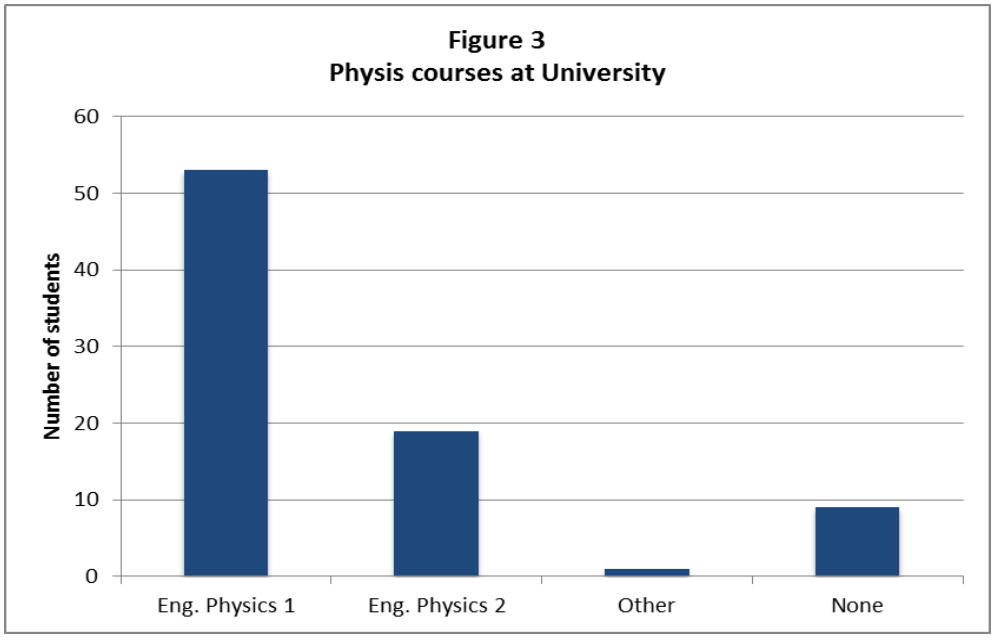
The responses to question 1 are shown in figure 1. Most of the students who participated in this survey were non-electrical engineering students and represented a good sample to study; most of the students were civil and mechanical engineering students.



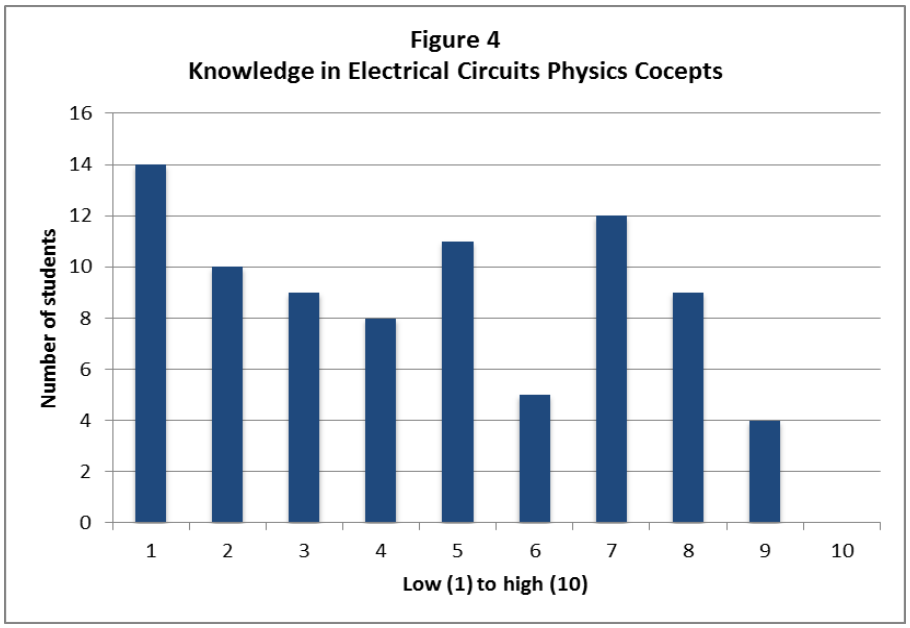
Responses to question 2 are shown in figure 2. Our students are generally exposed to some form of high school physics. A strong percentage has taken AP physics or honors physics, which is not unusual for the engineering programs.



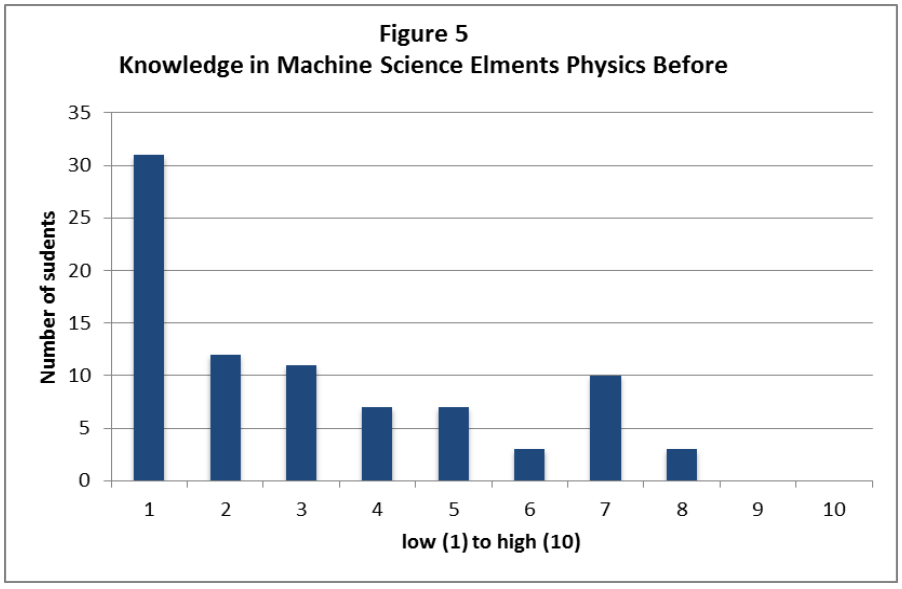
Responses to question 3 are shown in figure 3. The physics courses are what they had taken or are currently taking at college. Based on the response, only about 23% of the students who participated in the survey were exposed to Engineering physics 2.



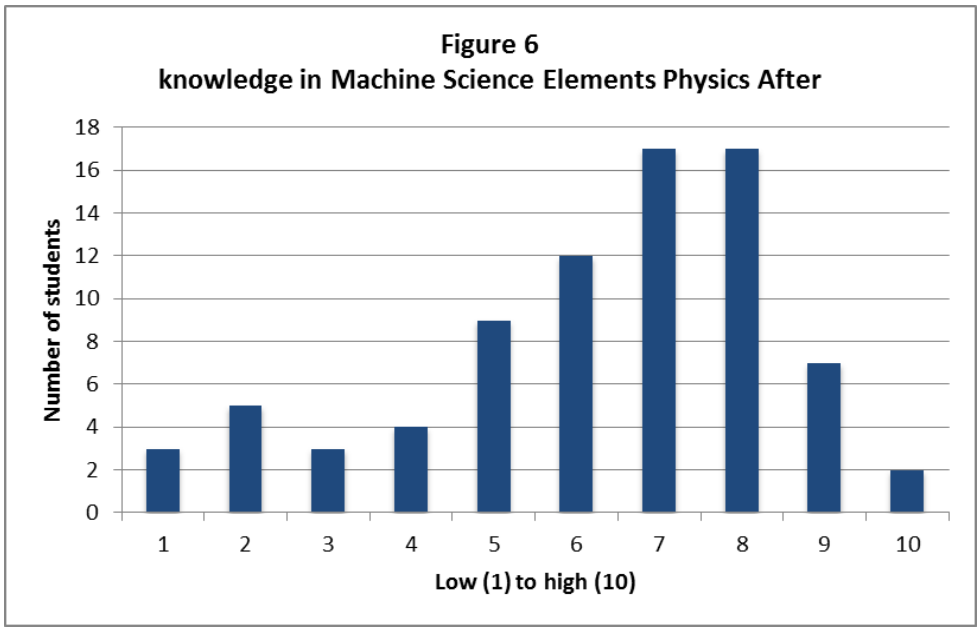
Responses to question 4 are shown in figure 4. The students' knowledge about electrical circuit elements generally varies. Over 60% rated their knowledge at 5 or below, within which half (28%) rated their knowledge as very low, that is, 2 or below. This is represents a considerable number that need to learn new concepts, which is not the main focus of the problem solving and programming course.



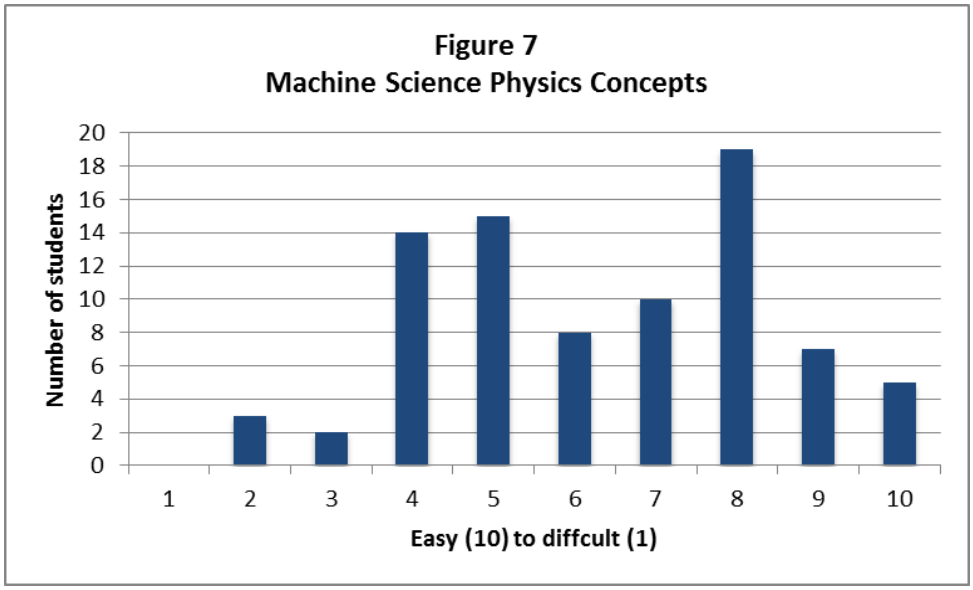
The student's knowledge about the specific electrical circuit elements before they did the project, responses to question 5, is shown in figure 5. This shows that about 80% rated their knowledge at 5 or below, within which about 51% rated their knowledge as very low, that is, 2 or below. Interestingly students' positive attitude towards the new ideas and approaches made the tasks easier in the class. We were able to help them to learn thing faster.



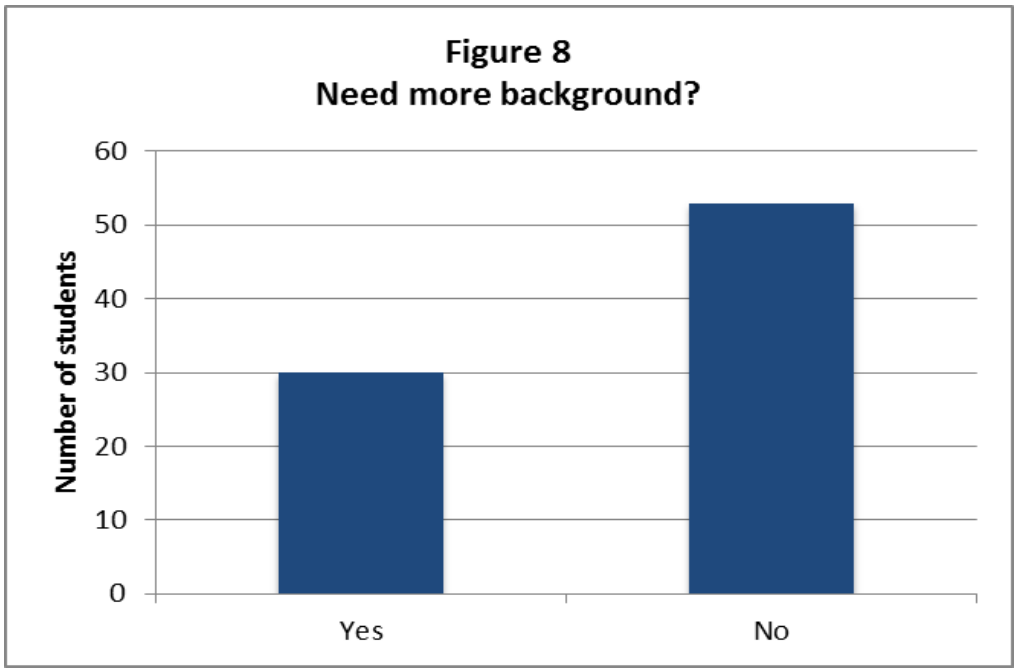
The students' knowledge about specific electrical circuits elements after they did the projects, responses to question 6, is shown in figure 6. This figure shows that about 65% rated their knowledge at 6 or above, within which about 11% rated their knowledge as very high: that is 9 or 10. These results show that the students who participated in the survey are not fully confident about the concepts that we introduced during this process.



Responses to question 7 shown in figure 7. The question requires the students to rate how easy (10) or difficult (1) machine science physics concepts are. The responses were scattered. The majority stayed in the middle between 4 to 8.



Responses to question 8 are shown in figure 8. This question, "do you think more background in physics would have helped you to better understand the machine science circuit concepts?" reflects the students' view regarding the physics background needed for this work. The majority of the students, about 64% felt that additional physics background was not needed to deal with new and more challenging physics concepts.



The responses to the last survey question, #9, "how many elements in the following list were you familiar with before doing the machines tutorials?" were on average at about 6.5 elements out of 15.

Conclusion

On average, students were familiar with about 43% (6.5 out of 15) of the elements used in the project. This number is surprisingly low in this electronic era. This detailed survey shows that the freshmen engineering students are up to any challenge in physics-related conceptual problems. The survey analysis also shows that freshmen engineering students with proper guidance can handle new concepts on physics-related topics. This type of approach builds their self-confidence to face new and demanding missions in the future. Based on this particular study, the answer to the title question, "How much Physics do the First Year Engineering Students really need" is partially answered. Knowledge gained from their high school physics courses is sufficient to handle new and challenging issues in their first year. This study is only a sample, additional studies needed to reach concrete conclusions regarding physics requirement for first year engineering students.

References

1. Connections Physics Review (CPR) Program, Amanda Funai, Allie Interrante, Rachelle Reisberg, Sara Wadia-Fascetti, Bala Maheswaran, ASEE Conference Proceeding, 2006 -1764.

2. Summer Bridge: a step into the engineering gap, Richard Harris and Bala Maheswaran, ASEE Conference Proceeding, AC 2009 - 570.

3. Supplemental freshman physics/chemistry programs to support women in engineering. Rachelle Reisberg, Amanda Funai and Bala Maheswaran, ASEE Conference Proceeding, AC 2009 -1851.

4. A Study of Physics-Based Problem Solving Approaches in the Freshmen Engineering Course, Bala Maheswaran, ASEE Conference Proceeding, AC 2011 – 292.

5. Machine Science, http://www.machinescience.com

Appendix 1:

GE1111 – Spring 2011
Machine Science Kit Survey
Instructor: _____
Class Time: _____

1. What is your engineering major or intended engineering major (circle).

Chemical	Civil	Computer	Industrial	Electrical	Mechanical	Undecided

2. Your high school physics background, or courses taken equivalent to (circle):

AP Physics	Honor Physics	Regular Physics	None

3. Physics course/courses taken or currently taking at NU (circle):

Engineering Physics 1	Engineering Physics 2	Other:	None

Respond to questions 4 to 8 below by using the following rating scale: 10 (high) to 1 (low).

4. Rate your knowledge / background in electrical circuit Physics concepts.

5. Rate your knowledge / background in Machine Science Elements Physics before doing the tutorials.

6. Rate your knowledge / background in Machine Science Circuit Elements Physics after doing the tutorials.

7. Rate how easy (10) or difficult (1) machine science physics concepts are

8. Do you think more background in physics would have helped you to better understand the machine science circuit concepts? (Circle one)

Yes	No

9. How many elements in the following list were you familiar with before doing the machines tutorials? Breadboard, battery, pre-bent wires, three-pronged connector, switch, LED, LCD, resistor, capacitor, seven-segment display, microcontroller, temperature sensor, light sensor, speaker

Appendix 2:

1. What is your engineering major or intended engineering major (circle).	Chemical	8
	Civil	23
	Computer	4
	Industrial	7
	Electrical	5
	Mechanical	27
	Undecided/other	9
2. Your high school physics background, or courses taken equivalent to (circle):	AP Physics	39
	Honor Physics	18
	Regular Physics	22
	None	5
3. Physics course/courses taken or currently taking at NU (circle):	Eng. Physics 1	53
	Eng. Physics 2	19
	Other	1
	None	9
4. Rate your knowledge / background in electrical circuit Physics concepts.	1	14
	2	10
	3	9
	4	8
	5	11
	6	5
	7	12
	8	9
	9	4
	10	0

5. Rate your knowledge / background in Machine Science Elements Physics before doing the tutorials.	1	31
	2	12
	3	11
	4	7
	5	7
	6	3
	7	10
	8	3
	9	0
	10	0
6. Rate your knowledge / background in Machine Science Circuit Elements Physics after doing the tutorials.	1	3
	2	5
	3	3
	4	4
	5	9
	6	12
	7	17
	8	17
	9	7
	10	2
7. Rate how easy (10) or difficult (1) machine science physics concepts are	1	0
	2	3
	3	2
	4	14
	5	15
	6	8
	7	10
	8	19
	9	7
	10	5
8. Do you think more background?	Yes	30
	No	53
9. How many elements? Average		6.48