Generating Student Interest In Physics: Using Relevant And Exciting Curriculum Additions

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ABSTRACT

As physics teachers at the collegiate level, we are faced with the difficulty of lack of interest in science among non-science majors. An example of this occurred in a conceptual physics course at West Virginia University, where we taught mostly students attending the education college. A poll taken of the class found 62% of the students wrote they did not want to teach science. A difficulty presented by this is that the students, who are mostly aspiring elementary level teachers, will go into the teaching field with a lack of enthusiasm toward teaching science. It is our goal then to excite these students, and all students, towards science and therefore exhibit eagerness when applying their knowledge in the classroom and elsewhere. One method for accomplishing this is to give these students hands-on, relevant, stimulating, and interesting curriculum in a laboratory environment. We have created several alterations to the course that succeed in meeting these goals and have proven to truly excite the students toward physics and science in general.

Keywords: Lorentz force, DC motor, and curriculum

INTRODUCTION

A course at West Virginia University focuses on teaching students in the education college a conceptual understanding of physics. Many of these students are aspiring elementary school teachers, and therefore do not necessarily have a thorough appreciation of science due to the variety of course work required for teaching elementary school. A poll taken in the course shows that 62% of the students do not wish to teach science at all when they become teachers, where 28% will teach science at the elementary level, 6% will teach science at the middle school level, and 4% will teach only biology, as seen in Figure 1.

This data raises the concern that future teachers may not be excited in the sciences, and therefore not pass that enthusiasm on to their students. One method for addressing this issue is to then design a curriculum that interests and challenges these education students and provides them with a means to incorporate a level of eagerness when learning and eventually teaching science to future engineers, scientists and health professionals. An alteration to the curriculum that has proven successful is providing these students with relevant and interesting hands-on activities that relate science to their everyday lives. In the conceptual physics course, we have implemented activities that the students have found interesting and thought-provoking. The labs have provided them with a new perspective of physics that they may not have necessarily seen before. We have detailed here some of the labs that have been implemented and we strive to find new, interesting ideas for future implementation with the goal of student excitement and relevance in the field of physics. Further, our focus is not solely on the education students, but on the other courses of study as well, including engineering students. We wish to excite all students with these activities and reach a large population of students.

The approach taken here is to demonstrate how equations in physics translate well into creation of devices. Here we show students that by using one equation, called the Lorentz equation, they will be able to understand the basics of microwave ovens and a motor.

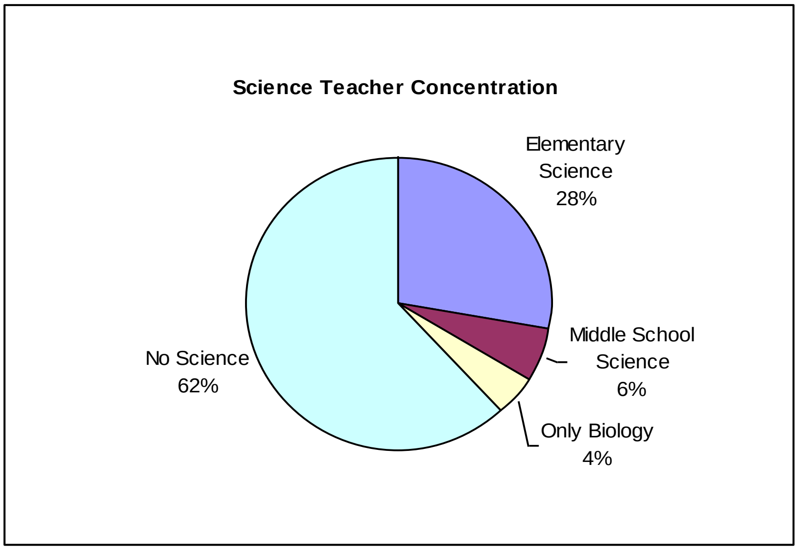

Figure 1

THE MICROWAVE OVEN

Most students know how to use a microwave oven, but may have not considered how it works and what concepts in physics can be applied. In lab based format, a student can understand by dissection of a microwave and observing microwave leakage the basic mechanics of microwave ovens, how food is cooked, as well as their contribution to the concept of electromagnetic wave pollution. We developed an experiment that is not in any traditional lab manual. Within this experiment, we gave the students some background into the history of the microwave oven and detailed how a microwave oven works, with particular focus on the magnetron which generates the microwaves. The magnetron consists of a tungsten cathode supplied with a pulsating negative voltage from the transformer. The anode is a cylinder made from copper. Steel plates and covers are welded to the cylinder. Within, there is a set of 10 copper vanes that are silver soldered to the inside wall of the cylinder. Copper shorting rings short the even numbered vanes to each other and the odd numbered vanes to each other. Figure 2 is an actual picture of a microwave oven magnetron taken in one of our physics labs.

Figure 2

A magnetic field from powerful permanent ceramic magnets across the top and bottom of the cylinder (several thousand Gauss, compare that to Earth's magnetic field of 0.5 Gauss) applies a force to the electrons away from the cathode and causes them to spiral within the cylinder with help from the electric field. The magnetic force is described as the Lorentz force by the equation

$$\mathbf{F} = q\mathbf{v} \times \mathbf{B} \qquad \text{(Eq. 1)}$$

Where q is the charge of the electron, **v** is the velocity of the electron, and it is moving through the magnetic field **B**. This combined with the force exerted by the electric field **E**, described by the equation

$$\mathbf{F} = q\mathbf{E} \qquad \text{(Eq. 2)}$$

yields complex circular motion within the cylinder. By describing these equations, the students are attracted to the fact that the above equations are stated in physics text books studied in their lecture environment.

The students are then introduced to the method microwave ovens cook food. We introduce how the magnetron generates electromagnetic waves via an antenna in the cylinder. These waves are then propagated into the cooking chamber, where water molecules in the food align themselves with the electric field component of the electromagnetic wave. The sinusoidal wave causes the water molecules to rotate, generating friction and therefore thermal energy. We then have the students measure the leakage from the microwave oven and how this leakage follows the inverse square law. The students are asked to measure the leakage of microwaves from the microwave oven door and sides using inexpensive devices. The students are required to measure the intensity as a function of distance using a ruler and the device. They then make intensity (I) measurements for distances (r) of 5, 10, 15, 20, 25, 30, 35, 40, 45, and 50 cm. They then tabulate their results and plot a graph of I versus r by hand. On a separate graph paper, they then plot $1/r^2$ on the vertical axis for r = 5, 10, 15, 20, 25, 30, 35, 40, 45, and 50 cm by hand. Comparison is made between the two graphs. The student should understand what the effect was of plotting the inverse square of distance on the second graph. Given the inverse square law, they make a conclusion about the behavior of the microwaves leaking from the microwave oven as a function of distance, i.e. in what way does the theory help them understand the graph of the leaked microwaves? In their answer, they should include discussion about the assumptions made and their applicability to this situation. They compare the leak intensity they measured with the allowed leak intensity as provided by the Food and Drug Administration[1]. Lastly, they compare their graphs to those who used a different microwave oven and answer the questions: Are there any differences due to the manufacturer, size of the oven cavity or power rating? Can they think of other factors that might affect their results? They should explain their answers.

CREATING A DC MOTOR ALSO BY USING THE LORENTZ FORCE[2]

The Lorentz force concept can also be used to build another device, namely a DC motor. We have developed a lab experiment that allows students to build a non-traditional DC motor out of easily acquired materials. Basic electricity and magnetism concepts are joined together in a simple and enjoyable experiment that allows the students to demonstrate physics first-hand and without the use of complex materials. A simple arrangement of a magnet, iron, and an electric current in water can be easily constructed into a motor using materials found at local hardware stores. Allowing the students to construct their own experiment with simple materials lets them apply a concept they might have difficulty with, understand the intended application, and interests them with hands-on learning.

In the following description of a procedure to be implemented in a lab environment, the students will discover how an arrangement of a magnet and an applied current can cause water in a Petri dish to rotate, thereby creating a motor. They will also see how a difference in current can affect the speed of rotation.

The students dissolve baking soda in water to make a baking soda / water solution. This solution is then to be added to the ring of the Petri dish system, such that the solution fills the "doughnut" up to the rim of the dishes. Copper foil should then be cut into two small rectangles approximately 1" x 1 ½" and folded over the rims of the inner and outer Petri dishes, enough so that the foil reaches the bottom of the dish inside the doughnut and is able to cling to the rim of the dishes. Using wire, make a circuit with the foil and a 9V battery, leaving one part of the circuit open for now. An easy way to do this is to use wire that has alligator clips soldered to the ends. If these are used, then five of these wires should be made available to the students.

The students should keep in mind the concept behind this experiment during construction of the motor, so at this point they should be able to draw the Petri dish and label the + and – ends of the foil. This will give them a visual representation of the current used in the observation of the Lorentz force.

The next portion of the experiment is to construct the magnet. Six small bar magnets should be joined together to make one large rectangular magnet, or the students could simply use one large magnet. The six smaller magnets were used because they are not costly and can be found easily at a hardware store, whereas larger magnets are more difficult to find. This experimental procedure was used because the idea behind this lab is to make the concept accessible to students, and they will be able to perform this experiment at home without having to order any supplies. The students then use soft iron plates to construct a magnet. The magnetic field should be uniform. The students will then use a Gaussmeter to measure the magnetic field in between the two pieces of iron. They then record that value and observe whether or not the magnetic field is uniform. If it is not, they should observe and record the deviation. As the students measure closer to the bar magnets, they should see the magnetic field fluctuate, and it is important for them to understand why subject to the magnetic field lines. This is a good exploratory question for them at this point in the experiment.

The students then place the Petri dish in between the two sheets of iron. The experimental setup should look like the schematic seen in Figure 3. They should add a parsley flake into the water, which will be used to find the angular velocity of the water. Then connect the circuit with one 9V battery and verify the potential difference is 9V with a Voltmeter. Using a stop watch, record how long it takes for the parsley flake to make one complete rotation. Then the students will calculate the angular velocity of the motor. Wire more 9V batteries in different arrangements to obtain different voltages. Verify each voltage with a voltmeter. Record the voltages and associated rotation times. Disconnect the 9V batteries and disconnect the copper in the Petri dish. Finally, the students plot Voltage vs. Rotation Time for Baking Soda Water.

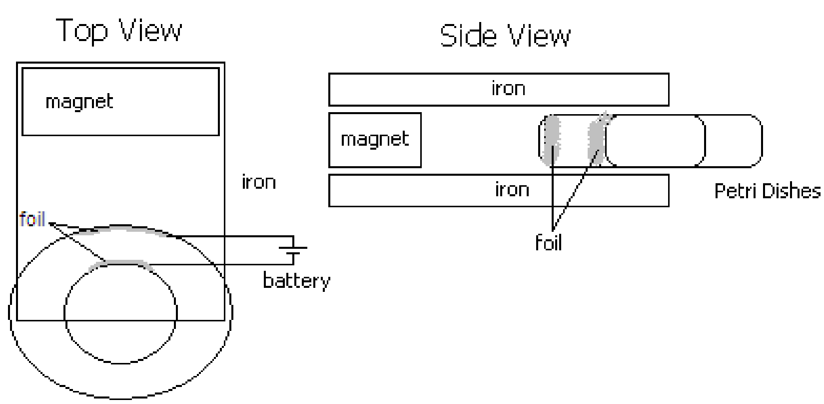

Figure 3

Using the Lorentz equation (Eq. 1), the students can understand why the water with the baking soda rotates. Here, q is the charge of the sodium ion in the dissolved baking soda/water solution, B is the strength of the magnet, and v is the velocity of the charged ion due to movement across the potential difference as provided by the copper foil and battery circuit.

CONCLUSION

Our goal is to excite students towards physics which is the basis of all sciences. This goal relies on providing students hands-on, relevant, stimulating, and interesting curriculum in a laboratory environment. Feedback from each of these labs has been supportive and encouraging toward achieving this goal. The students and the lab teacher's assistants were excited about these experiments. They were able to view physical concepts in real-life situations, and this even intrigued some to explore above and beyond the experiments to get an even better understanding. The goal of these experiments was to do exactly that, in that the students' interest was piqued, and physics became more understandable to them.

AUTHOR INFORMATION

Dr. Abdul-Razzaq received his PhD in 1986 from the University of Illinois at Chicago. He completed his post-doctorate work at Michigan State University. Currently he is Professor of Physics and Director of Introductory Physics Curriculum at West Virginia University. In recent years he has had research activities in diverse areas including studies of magnetic and transport properties of thin films and multilayers, studies of magnetic nanoparticles, and applied studies related to health and environment. In addition, he does research in education.

Mr. Bushey received his Bachelor of Science in Physics from the University of Vermont in 2001, where his course work focus was in biophysics, specifically protein dynamics. Upon graduation he became a lead software engineer and then decided to pursue a graduate degree in order to become a high school physics teacher. He currently assists Dr Abdul-Razzaq in performing research in education as well as electromagnetic radiation. He has also taught biology and physics laboratories at West Virginia University.

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