

Research Experiences for Teachers (RET) – 2011
LESSON PLAN TEMPLATE

MODULE TOPIC: Electromagnetic Induction

RATIONALE: Many instruments used in research are electronic, with complex circuits. An understanding of electrical circuits allows for a better understanding of the function of an electronic instrument. This lesson will allow students to study and analyze the voltage induced in an electrical circuit by a magnet moving through a coil.

STANDARD(S) & INDICATOR(S):

5.1.12.A.1. Refine interrelationships among concepts and patterns of evidence found in different central scientific explanations.

5.2.6.D.1. Use simple circuits involving batteries and motors to compare and predict the current flow with different circuit arrangements.

OBJECTIVE(S):

Students will be able to:

Evaluate the effect of a changing magnetic flux on the induced voltage in a loop using one and two bar magnets.

Student will compare the flux and induced voltage as the bar enters the loop to the flux and voltage as the bar exits the loop by analyzing the voltage versus time graph. They will also compare the voltage induced by a single magnet to the voltage induced by two magnets.

MATERIALS:

Equipment

Qty	Items	Part Numbers
1	PASCO Interface	
1	Voltage Sensor	CI-6503
1	AC/DC Electronics Lab	EM-8656
1	Bar Magnet, Alnico	EM-8620
1	Pad (for stopping the bar magnet when it falls)	

LIST OF HANDOUTS (attach original copies of each handout - teacher & student edition)

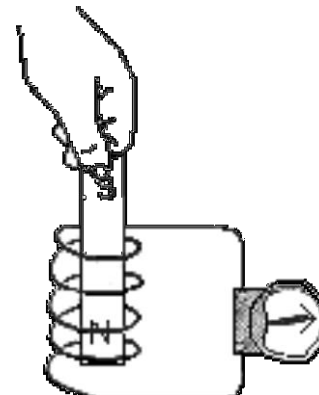
Lab: Electromagnetic Induction, Formal Lab Report Guidelines

BACKGROUND INFORMATION (from PASCO):

When electricity is passed through a conducting wire a magnetic field can be detected near the wire. Micheal Faraday was one of the first scientists to reverse the process. The essence of his work is decribed in the following statement:

A changing magnetic field in the presence of a conductor induces a voltage in the conductor.

When a magnet is passed through a coil there is a changing magnetic flux through the coil that induces an Electromotive Force (EMF) in



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the coil. This EMF is the induced voltage. According to Faraday's Law of Induction:

$$\mathcal{E} = -N \frac{\Delta\phi}{\Delta t}$$

where \mathcal{E} is the induced EMF, N is the number of turns of wire in the coil, and $\frac{\Delta\phi}{\Delta t}$ is the rate of change of the flux through the coil.

In this activity, a plot of the EMF versus time is made and the area under the curve is found by integration. This area represents the flux since:

$$\mathcal{E}\Delta t = -N\Delta\phi$$

CLASSROOM ACTIVITY DESCRIPTION (LABORATORY/EXERCISES/PROBLEMS) including detailed procedures:

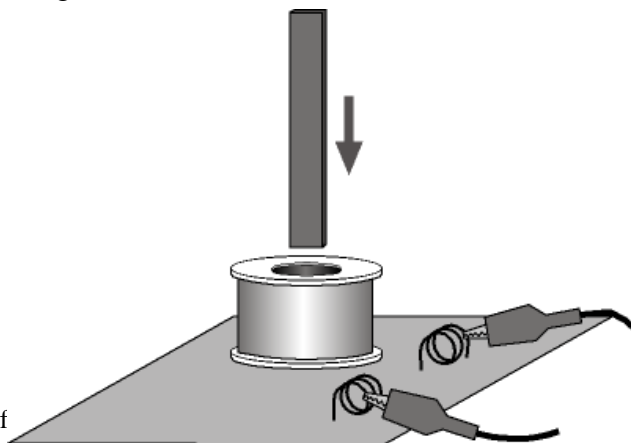
In the experiment you will drop a bar magnet through a wire coil. This will generate an induced voltage that will be measured by the voltage sensor. You will find the area under the voltage vs time graph. This area represents the magnetic flux. You will evaluate the effect of the changing magnetic flux on the voltage by measuring the area using the software tool. You will compare the magnetic flux and induced voltage as the bar enters the coil to the flux and voltage as the bar exits the coil.

You will repeat the experiment while dropping two magnets through the coil simultaneously. Once with two magnets taped with their poles on the same side and a second time with their poles at opposite ends.

The following procedure and set-up is from PASCO.

Setup

1. Set up the PASCO Interface and the computer and start *DataStudio*.
 2. Connect the Voltage Sensor to the PASCO Interface
 3. Open the *DataStudio* file: **79 Induction - Magnet.ds**
- The *DataStudio* file has a Graph display of Voltage versus Time and a Meter display of Voltage. Data recording is set at 200 Hz. The Start Condition is set to begin recording when voltage is at 0.005 V. The Stop Condition is set to stop data recording when Time = 0.4 seconds. (NOTE: The data recorded for 0.3 seconds prior to the Start Condition are kept as well.)
4. Put alligator clips on the ends of the Voltage Sensor leads.
 5. Attach a Voltage Sensor lead to one component spring next to the inductor coil on the AC/DC Electronics circuit board. Attach the other lead to the other component spring next to the coil.
 6. Arrange the circuit board so the corner with the coil is beyond the



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edge of the table, and the bar magnet dropped through the coil can fall freely. Place a pad on the floor below.

- The bar magnet will be dropped through the coil. Make sure that the magnet does not strike the floor, or it may break.

Procedure

7. Hold the magnet so that the south end is about 2 cm above the coil.

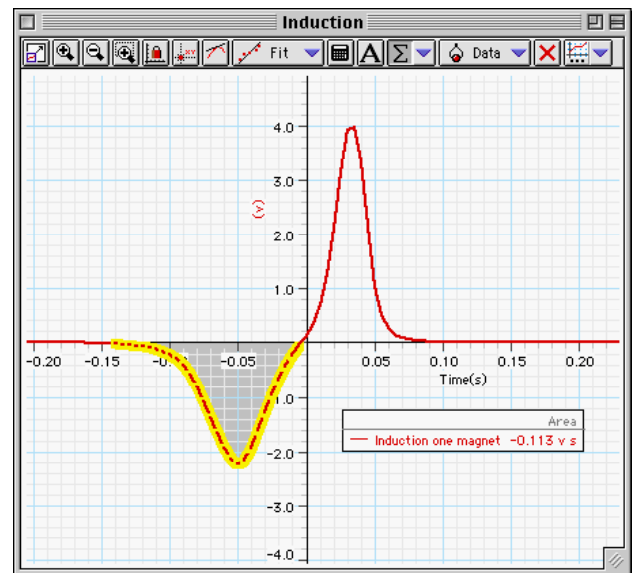
- Note: If you are using the PASCO Model EM-8620 Alnico Bar Magnet the North end is indicated by the narrow groove near one end. For the first run, hold the magnet with groove end ‘up’.


8. Click ‘Start’ in *DataStudio*. Let the magnet drop through the coil.

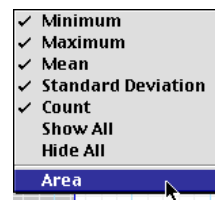
- Data recording will begin when the magnet falls through the coil and the voltage from the coil reaches 0.05 V. Data recording will end automatically after 0.4 seconds.

Analysis

- Examine the graph of the voltage versus time.
 1. Rescale the Graph display to fit the data if necessary.
 2. In the Graph display, use the cursor to select a rectangle around the first peak of the voltage plot.
 3. Set up the Graph to show the area in the selected area of the curve of voltage versus time.



- In *DataStudio*, click the Statistics menu button () and select ‘Area’. The value for ‘Area’ appears in the legend in the Graph.
 4. Record the value of ‘Area’ for the left hand peak in the Lab Report section.
 5. Repeat the process to find the area for the second peak. Record the value of ‘Area’ for the right hand peak.
 6. Repeat the data recording and data analysis procedures for the following setups:
- Tape two bar magnets together so both south ends are together.
- Re-arrange the two bar magnets so that the south end of one is with the north end of the other.



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SAMPLE QUESTIONS TO ELICIT CLASS DISCUSSION:

1. Compare the flux created as the magnet enters the coil to the outgoing flux?
2. Compare the size and sign of the outgoing voltage peak to that of the incoming voltage?
3. What is the effect of a changing magnetic flux on the voltage in a wire coil?

HOMEWORK ACTIVITY/EXERCISES/PROBLEMS:

Students will write a lab report according to the formal lab report guidelines.

PARAMETERS TO EVALUATE STUDENT WORK PRODUCTS:

A written report that discusses the effect of a changing magnetic flux on the induced voltage in a loop using one and two bar magnets, including analyses of data and graphs.

REFERENCES:

- Serway and Jewett, Physics for Scientists and Engineers
- PASCO

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