Induction-Magnet through a coil
(Photogate, Voltage Sensor)

Object:

Measure the *electromotive force* (*emf*) induced in a coil by a moving magnet.

Apparatus:

Science Workshop Interface, Voltage Sensor, Photogate, RLC circuit board, two Alnico magnets

Theory:

When a magnet is passed through a coil there is a changing magnetic flux through the coil. This changing flux induces an *electromotive force* (*emf*) in the coil. According to Faraday's law of induction:

$$\varepsilon = -N\frac{\Delta\phi}{\Delta t}$$

Where ε is the induced *emf* , N is the number of turns of wire in the coil, and $\Delta\phi/\Delta t$ is the rate of change of flux through the coil. In this experiment you will plot emf vs. time and find the area beneath the curve. The area represents the flux through the coil since:

$$\varepsilon\Delta t = -N\Delta\phi$$

Procedure:

In this lab, a voltage sensor measures the voltage (V) induced in a coil as a magnet falls through the coil. Date collection begins when the falling magnet breaks the beam of the photogate. The science workshop program records and displays the induced voltage as a function of time, and integrates the area under the curve of voltage vs. time.

Part I: Computer Setup

1. Connect the Science Workshop interface to the computer, turn on the interface, and turn on the computer.

2. Connect the voltage sensor DIN plug into Analog Channel A.

3. Connect the photogate stereo phone plug into digital channel 1.

4. Open the Science Workshop document titled: P41_INDU.SWS

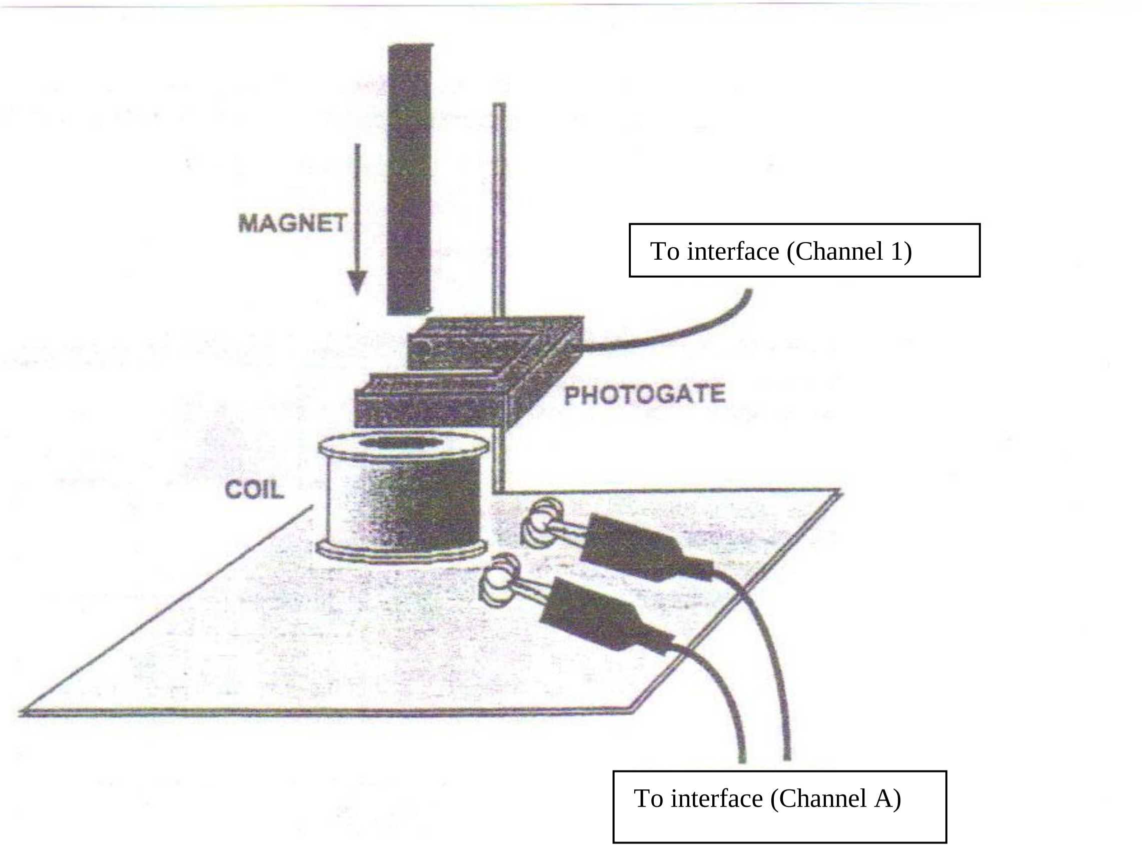
5. The instrument opens displaying a graph of voltage vs. time as well as a meter display of voltage.

6. Check that your Sampling options are set as: Periodic sample = fast at 200 Hz, Start condition = Ch1, low (blocked), and stop condition= Time at 0.5 seconds.

Part II: Sensor Calibration and Equipment Setup

1. No calibration is required. Attach banana plugs to the terminals of the voltage sensor.

2. Attach the other end of the banana plugs across the coil in the LCR circuit board.



3. Arrange the circuit board so that the coil hangs over the edge of the lab table or is balanced on an empty cup. The dropped magnet must pass freely and completely through the coil.

4. Turn the photogate head so that it is horizontal. Position the photogate above the coil so that the falling magnet will break the beam.

5. The magnet will be dropped through the coil. Make sure to catch the magnet so that it does not hit the floor.

Part III: Data Recording

1. Hold the magnet so that the south end is about 2cm above the photogate. The south end is designated by the narrow groove near the end.

2. Click the “Start” button and drop the magnet through the photogate head and the coil

3. Data recording will begin when the magnet breaks the beam of the photogate. Recording will end automatically after 0.5 seconds.

5. Run #1 will appear in the data list in the experimental setup window.

<u>Analyzing the Data</u>:

1. Click the graph to make it active.

2. Click the statistics button to open the statistics area on the right hand side of the graph. Click on the Autoscale button to rescale the graph to fit the data. In the statistics panel click statistics menu button. Select integration from the menu.

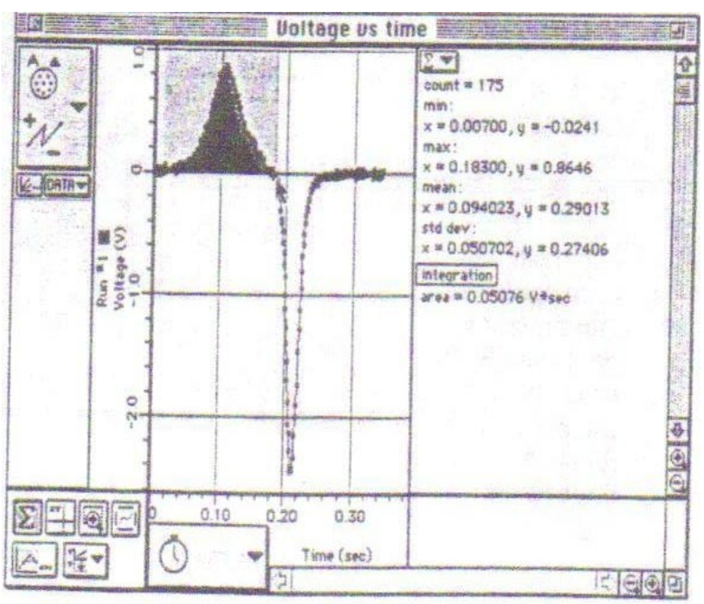
3. In the graph display, use the cursor to click and draw a rectangle around the first peak of the plot. The area under the curve for the first will appear in the statistics area.

4. Record the value of the integration for the first peak.

   Integration first peak = _________ (VoltSec)

5. Repeat the process to find the area under the second peak. Record the value.

   Integration second peak = _________ (VoltSec)



<u>Questions</u>:

1. Is the incoming flux equal to the outgoing flux?

2. Why does the outgoing peak (the second peak) have a greater magnitude than the incoming peak?

3. Why are the peaks in opposite directions?

<u>For fun:</u>

1. Tape two magnets together so both south ends are together.

2. Tape two magnets together such that south end and north ends are together.