Experiment P41: Induction – Magnet through a Coil (Photogate, Voltage Sensor)

Concept	Time	SW Interface	Macintosh® file	Windows® file
circuits	30 m	500/700	P41 Induction - Magnet	P41_INDU.SWS

EQUIPMENT NEEDED	
• *Science Workshop Interface*	• AC/DC Electronics Lab* circuit board
• Photogate	• (2) Alnico Bar Magnet
• Voltage Sensor	

(*The AC/DC Electronics Laboratory is PASCO EM-8656.)

PURPOSE

The purpose of this laboratory activity is to measure the *electromotive force (emf)* induced in a coil by a magnet dropping through the center of a coil.

THEORY

When a magnet is passed through a coil there is a changing magnetic flux through the coil which 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 $\frac{\Delta\phi}{\Delta t}$ is the rate of change of the flux through the coil.

In this experiment, a plot of the *emf* vs. time is made and the area under the curve is found by integration. This area represents the flux since:

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

PROCEDURE

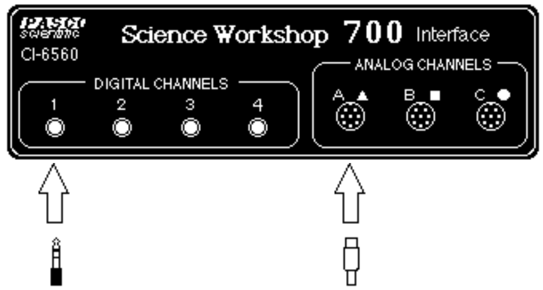
In this activity, the Voltage Sensor measures the voltage (EMF) induced in a coil by a magnet as the magnet falls through the coil. The Photogate acts as a trigger; data collecting begins when the falling magnet breaks the Photogate's beam.

The *Science Workshop* program records and displays the induced voltage versus 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. Connect the Photogate stereo phone plug into Digital Channel 1.

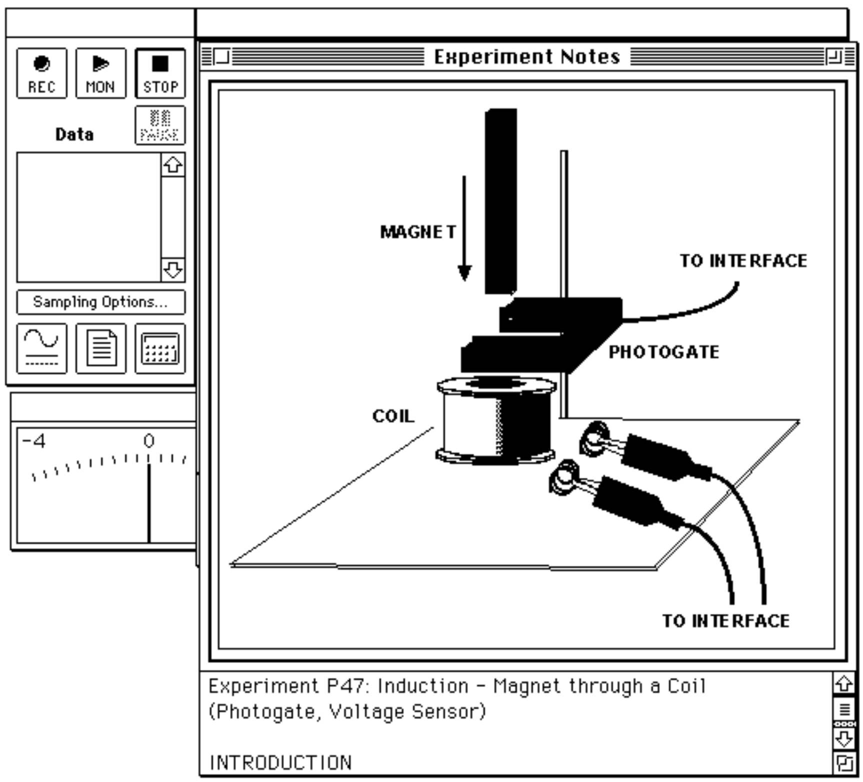


3. Open the *Science Workshop* document titled as shown:

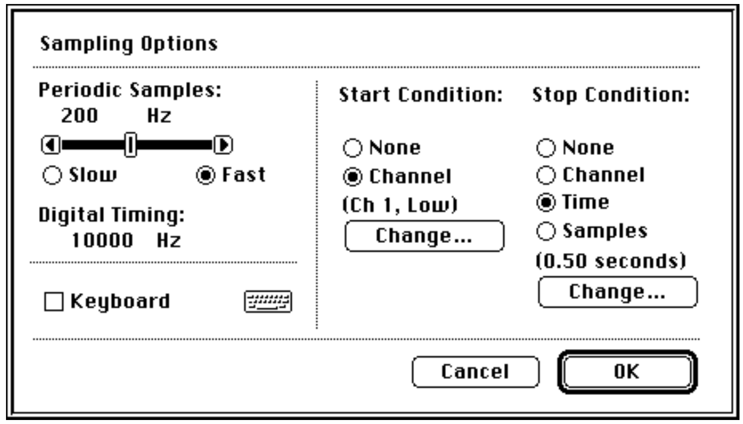
Macintosh	Windows
P41 Induction - Magnet	P41_INDU.SWS

- The document opens with a Graph display of Voltage vs. Time and a Meter display of Voltage.

- Note: For quick reference, see the Experiment Notes window. To bring a display to the top, click on its window or select the name of the display from the list at the end of the Display menu. Change the Experiment Setup window by clicking on the **Zoom** box or the **Restore** button in the upper right hand corner of that window.)



4. The **Sampling Options…** for this activity are: **Periodic Samples = Fast** at 200 Hz, **Start Condition = Ch 1, Low** (blocked), and **Stop Condition = Time** at 0.5 seconds.



PART II: Sensor Calibration and Equipment Setup

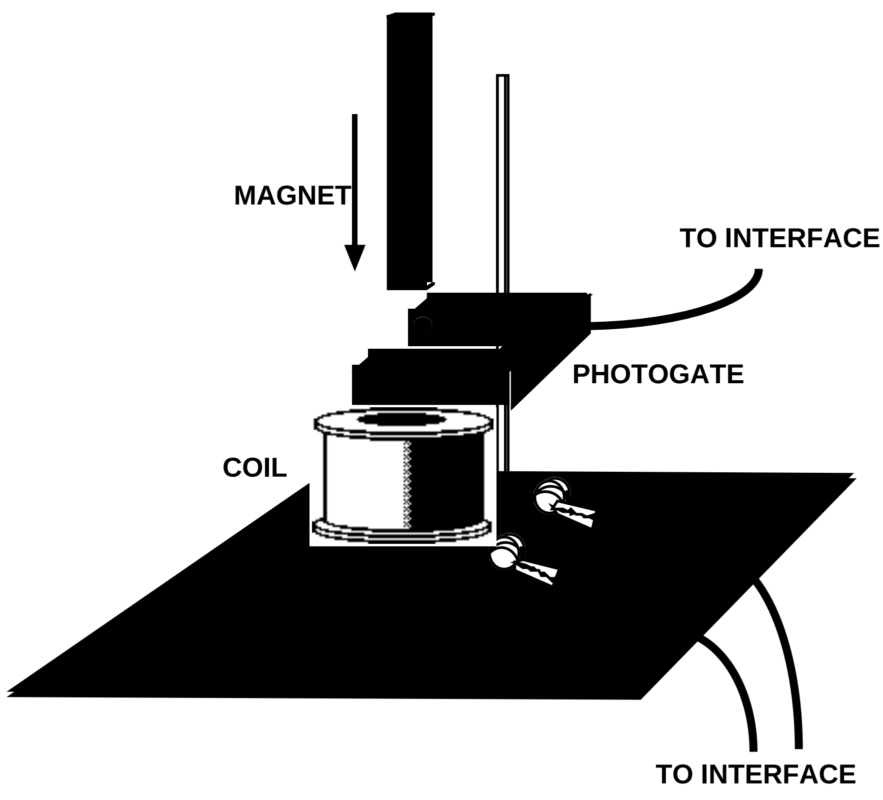
- You do not need to calibrate the Voltage Sensor or the Photogate.

1. Put alligator clips on the ends of the Voltage Sensor leads.

2. Attach a clip to one component spring next to the coil on the AC/DC Electronics Lab circuit board. Attach the other clip to the other component spring next to the coil.

3. Arrange the lab board so the corner with the coil is beyond the edge of the table and a magnet dropped through the coil can fall freely.

4. Turn the photogate head so it is horizontal. Position the Photogate so the magnet will interrupt the photogate beam when the magnet is dropped through the coil.



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

Part III: Data Recording

1. Hold the magnet so that the south end is about 2 cm above the photogate head.

- Note: If you are using the PASCO Model EM-8620 Alnico Bar Magnets the south end is indicated by the narrow groove near one end.

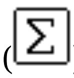
2. Click the **REC** button (

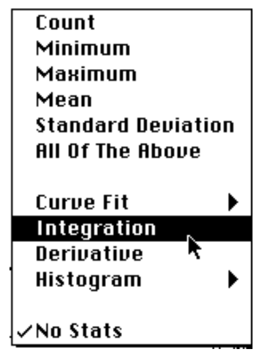
). Let the magnet drop through the photogate head and the coil.

- Data recording will begin when the magnet falls throught the photogate beam. Data recording will end automatically after 0.5 seconds.
- **Run #1** will appear in the Data list in the Experiment Setup window.

ANALYZING THE DATA

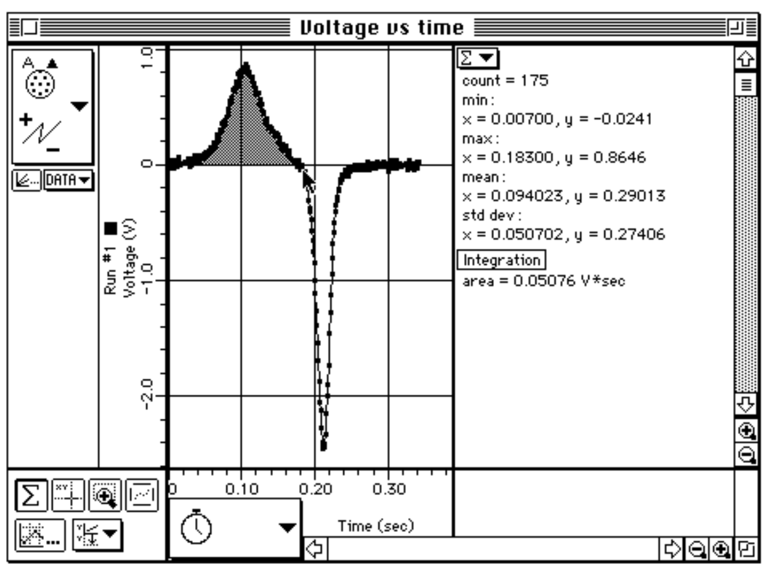
1. Click the Graph to make it active. (Optional: Select **Save As…** from the File menu to save your data.)

2. Click the **Statistics** button () to open the Statistics area on the right side of the graph. Click the **Autoscale** button () to rescale the graph to fit the data. In the Statistics area, click the **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 voltage plot.

- The area under the curve for the first peak will appear in the Statistics area.



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

Integration (first peak) = __________ V• s

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

Integration (second peak) = __________ V• s

QUESTIONS

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

2. Why is the outgoing peak higher than the incoming peak?

3. Why are the peaks opposite in direction?

OPTIONAL

Repeat the data recording and data analysis procedures for the following optional setups:

1. Tape two bar magnets together so both south ends are together.
2. Re-arrange the two bar magnets so that the south end of one is with the north end of the other.