INDUCED EMF

OBJECTIVE

To obtain a qualitative understanding of Faraday's Law of Electromagnetic Induction and Lenz's Law of Induced Current by constructing a simple transformer.

EQUIPMENT

Two identical coils, laminated iron bar, power supply, galvanometer, a SPST (single-pole, single-throw) switch, bar magnet, compass, 1-MΩ decade resistance box, patch wires (at least 4)

THEORY

According to Faraday's Law, an *emf* $\mathcal{E}$ is induced in a coil (or coils) of wire whenever there is a change in the magnetic flux through the coil. Mathematically,

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

where $\mathcal{E}$ is the average induced *emf*, N is the number of turns of coil, $\Delta\Phi$ is the change in magnetic flux, and Δt is the duration of the change. Magnetic flux Φ is calculated using the formula $\Phi = BA\cos\theta$, where B is the magnitude of the applied field, A is the area of a coil, and θ is the angle between the field and the normal to the area.

Lenz's Law states that induced current flows in a way to *oppose* the change in magnetic flux.

PROCEDURE

Part I – Primary Coil

1) Use the bar magnet in the vicinity of the compass. Answer Question I-1 on your data sheet.

2) Place the iron bar inside a coil. Place the coil horizontally on the lab table with the side labeled TOP on the left. Connect the power supply as shown in Figure 1 on your data sheet.

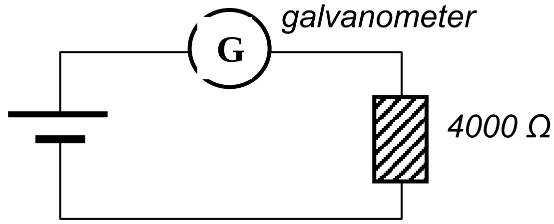
3) Use the compass to determine the *north* and *south* poles of the coil. (You've created a simple *electromagnet*!) Label the poles in Figure 1 and sketch the corresponding *magnetic field lines* that pass through the coil.

4) Draw the direction of *conventional* (positive) current as arrows along the wires of the coil in Figure 1. Answer Question I-2 on your data sheet.

5) Remove the iron bar from the coil. Answer Question I-3 on your data sheet.

6) Switch off the power supply. Answer Question I-4 on your data sheet.

Part II – Galvanometer



1) Construct the circuit shown in the above diagram. Set the resistance box to 4000 Ω. Connect the *right* terminal of the galvanometer to the (+) terminal of the power supply. Answer Question II-1 on your data sheet.

2) Now connect the *left* terminal of the galvanometer to the (+) terminal of the power supply. Answer Question II-2 on your data sheet.

Part III – Secondary Coil

1) Insert the iron bar into the second coil. Connect the galvanometer to the coil as shown in Figure 2 on your data sheet.

2) Move the *south* pole of the bar magnet *quickly toward* the left end of the secondary coil. Draw the direction of the magnetic field due to the bar magnet and the direction of the induced current (as arrows) in Figure 2. Answer Questions III-1 and III-2 on your data sheet.

3) Hold the *south* pole of the bar magnet next to the left end of the secondary coil. *Do not move the magnet*. Answer Question III-3 on your data sheet.

4) Move the *south* pole of the bar magnet *quickly away from* the left end of the secondary coil. Draw the direction of the magnetic field due to the bar magnet and the direction of the induced current (as arrows) in Figure 3. Answer Questions III-4 and III-5 on your data sheet.

5) Hold the bar magnet along the axis of the secondary coil (horizontal position), the *south* pole facing the left end of the coil. Now rotate the magnet quickly to the vertical position. Answer Question III-6 on your data sheet.

6) Answer Question III-7 on your data sheet.

Part IV – Transformer

1) Build the circuit as shown in Figure 4 on your data sheet.
2) Close the switch. Answer Question IV-1 on your data sheet.
3) Leave the switch closed. Answer Question IV-2 on your data sheet.
4) Open the switch. Answer Question IV-3 on your data sheet.
5) Complete the graph of the secondary current I_S using your results in Steps #2–4.

Name ____ **Date** ____________

Partners ____

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I-1) Which end of the compass needle points toward the south magnetic pole?

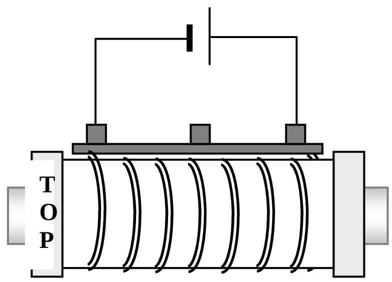


FIGURE 1

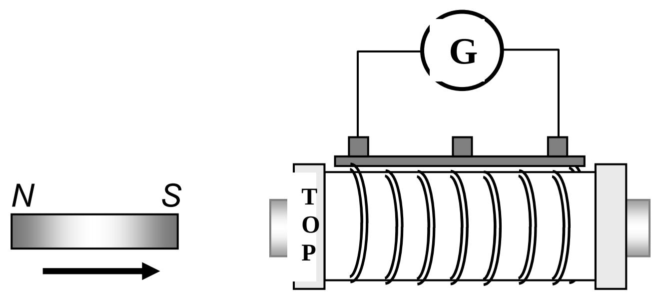
I-2) Explain how you determined the direction of the current using a right-hand rule.

I-3) Compare the strength of the magnetic field inside the coil with and without the iron bar. Explain the reason for your results.

I-4) Does the coil behave as a magnet when there is no current flowing? Explain your answer.

II-1) To which direction (*right*/*left*) does the galvanometer needle deflect?

II-2) To which direction (*right*/*left*) does the galvanometer needle deflect?



iron bar

FIGURE 2

III-1) How does the galvanometer initially respond? Explain your result using Faraday's Law.

III-2) To which direction (*right*/*left*) does the galvanometer deflect? Explain your result using Lenz's Law.

III-3) Explain what happens to the galvanometer using Faraday's Law.

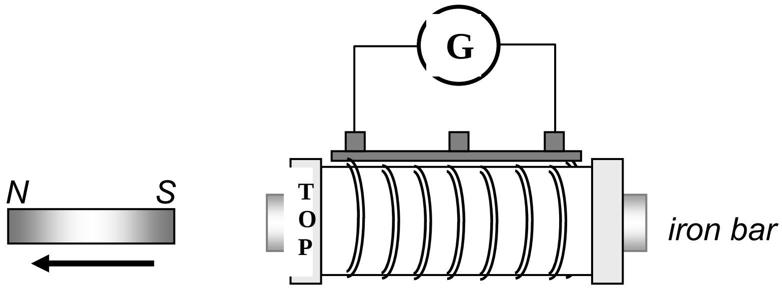


FIGURE 3

III-4) How does the galvanometer initially respond? Explain your result using Faraday's Law.

III-5) To which direction (*right*/*left*) does the galvanometer deflect? Explain your result using Lenz's Law.

III-6) How does the galvanometer respond? Explain your result using Faraday's Law.

III-7) How would your results in Steps #2–5 change if you used the *north* pole of the bar magnet. Try it and describe your results in detail.

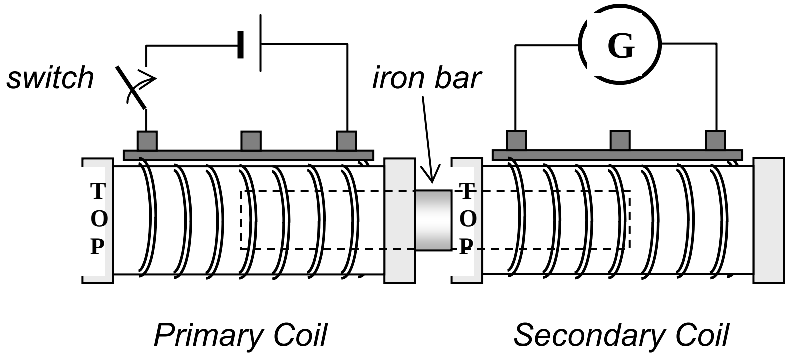


FIGURE 4

IV-1) How does the galvanometer initially respond? Explain your result using Faraday's Law and Lenz's Law.

IV-2) How does the galvanometer respond? Explain your result using Faraday's Law and Lenz's Law.

IV-3) How does the galvanometer initially respond? Explain your result using Faraday's Law and Lenz's Law.