# Electromagnetic Induction

Guided Inquiry

Driving Question | Objective

How is the emf induced in a wire coil affected by the total area of the coil and the rate of change of magnetic flux through the coil? Investigate how the number of loops in a coil, and the rate of change of magnetic flux through the coil affect the coil’s maximum induced emf voltage.

Design and Conduct Your Experiment

It is your group’s responsibility to design and conduct an experiment whose data will support your answer to the driving question above. Use the answers to the guiding questions below to help guide your experiment design. After you have answered the guiding questions, write an outline of the equipment setup and procedure you will use to collect data, identifying the steps in sequence and the points at which each piece of equipment will be used.

Suggested Materials and Equipment

Although you have the freedom to design your procedure using any reasonable equipment at your disposal, the following equipment is recommended for your experimental setup.

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| --- | --- |
| * Data collection system | * Magnet wire or enameled wire, fine gauge, 80 cm |
| * PASCO Wireless Voltage Sensor1 | * Strong magnet, cylindrical, 13 mm dia × 5 mm (4) |
| * 4-mm banana plug patch cord with | * Clear rigid plastic tubing, 3/4" inner-diameter, 30 cm |
| alligator clip1 (2) | * No-bounce pad, or similar padding |
|  | * Sandpaper |
|  | * Tape |

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| 1[www.pasco.com/ap41](http://www.pasco.com/ap41) |
|  |
| PASCO Wireless Voltage Sensor |

Guiding Questions

* 1. List two factors that will affect the induced emf in a coil.

* 2. Do either of the factors listed above change the magnetic flux through a coil? If yes, how does each factor change the magnetic flux through the coil?

* 3. How will you set up your equipment to produce a changing magnetic flux through the coil?

* 4. Assuming each factor listed above can be tested experimentally, what should the dependent and independent variables be when testing each factor?

* 5. What equipment do you have at your disposal to measure each variable, and how can you set up this equipment to measure them?

* 6. How will you change each independent variable while collecting data? What steps will you take, and should you change more than one variable at a time? Explain your answer.

Experimental Design

Your goal is to experimentally determine how the rate of change of magnetic flux through a coil affects the magnitude and direction of the average emf induced in the coil. Use the responses to the Guiding Questions to help finalize your procedure and equipment configuration.

Once you are convinced that your procedure will accomplish the experiment's objectives, record your experimental setup and procedure in the following sections.

Setup

Draw and/or describe your experimental setup such that a third party could recreate the same setup in an attempt to reproduce your experiment.

Procedure

Outline the procedure you will use in your experiment, listing all of the steps below. Your outline should be written such that a third party could follow the same procedure in an attempt to reproduce your experiment.

Collect Data

Perform your experiment and record all relevant data. Present your data below (or in an attached document) in a form that best suits the experiment format, such that a third party can understand your experimental results in an attempt to reproduce them.

Analysis Questions

* 1. In this experiment, what steps did you take to change the magnetic flux through the coil of wire?

* 2. Did the rate of magnetic flux change ∆ΦB/∆t affect the induced emf in the coil? If yes, how did it affect it?

* 3. Faraday's Law of Electromagnetic Induction is written:

 (3)

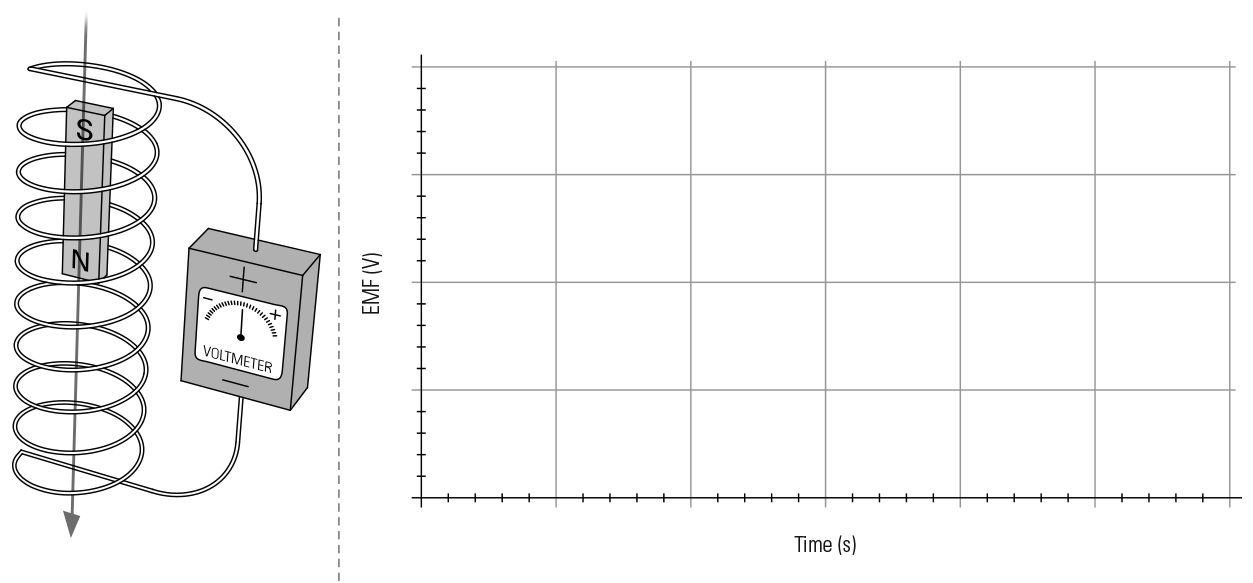
where N is the number of loops in the coil. How does your data support Faraday's Law?

* 4. How was the emf different when the magnetic flux through the coil was increasing versus when it was decreasing?

* 5. The negative sign in Faraday's Law is due to Lenz's Law, which states that the emf induced in a coil will generate current in the coil that produces a magnetic field opposing the change in flux. How does your data support Lenz's Law?

Synthesis Questions

* 1. A 4-cm long bar magnet is dropped from 2 cm above a coil of wire. If the falling bar magnet passes through the coil, north pole first (as in the diagram below), what would the graph of emf versus time look like? Sketch your answer in the blank graph axes below, starting from the time at which the magnet is dropped, and ending after the magnet has fallen out of the coil.



* 2. A maximum emf of 4 V is induced when a permanent bar magnet is dropped through a round coil of wire with 10 loops in it.

a. What would be the maximum emf voltage if the same magnet fell through the same coil, but in half the time? Explain your answer.

b. What would be the maximum emf voltage if the same magnet fell through the coil at the original speed, but the coil had had 30 loops instead of 10? Explain your answer.

c. What would be the maximum emf voltage if the same magnet fell through the original coil at the original speed, but you dropped the opposite end of the magnet through the coil first? Explain your answer.