

Michael Faraday in the 1830s, at about the time he was first demonstrating magnetic induction.

Lab 08: Electromagnetic Induction

INTRODUCTION

We know quite a bit about magnets, simply from our everyday experience. We know that a magnet has poles, and that likes repel while opposites attract (wow, just like the electrostatic force...). We also know that the magnetic force is an action-at-distance force (which is why we can slide one or two sheets of paper between the magnet and the fridge, but not an entire notebook). We may be less aware, however, of the relationship between electricity and magnetism. In the 19th century, men like Oersted and Faraday were able to show quite clearly that a relationship existed. Neither of these men, though, were quite able to develop the theory to explain exactly how or why. Lucky for them (and us), along came Maxwell. He was able to show, using just a few equations, exactly how this relationship worked. Without delving into any complicated math, we can show ourselves qualitatively, but convincingly, that electricity and magnetism are fundamentally related, using the same experiments as Oersted and Faraday over 150 years ago.

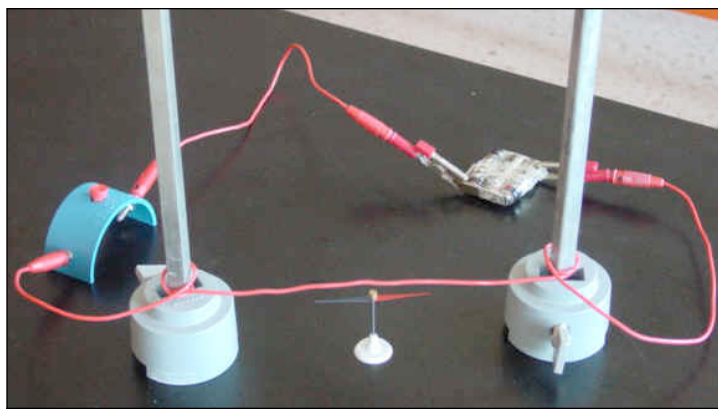
OBJECTIVES

- Observe the force exerted by a magnet on a current-carrying wire
- Establish the parameters which affect the magnitude and direction of the observed force
- Use a magnet to create an electric current through a wire
- Determine the parameters which affect the magnitude and direction of the observed current
- Demonstrate the magnetic field generated by an electric current
- Learn the basic principles of motors and generators

ACTIVITY 1: OERSTED'S EUREKA

Oersted was the first to make the connection between electric current and magnetic field. He noticed that a magnet could induce a current in a wire, and that a magnet brought near a current-carrying wire caused a deflection in the wire.

- There is only one demonstration model of this; please take turns observing.
- Set the dial to 2 and turn the power supply on, causing a current through the wire. Observe what happens to the wire.
- Turn the power off, and adjust the dial to 4. Turn the power back on and observe.
- Power off, adjust the power supply back down to about 2. Turn the magnet upside down. Power on, note the deflection of the wire.
- Change the direction of the current by swapping the positive and negative leads at the power source (turn the power off before swapping). Again, note what happens.



Not precisely the same set up as we have in lab, but precisely the same idea: an electric current creates a magnetic field.



Which ways do the compass needles point? Why?

QUESTIONS

1. Sketch the directions of the magnetic field, current, and deflection in relation to each other.
2. What effect does increasing the current in the wire have on its deflection?
3. What happened when the magnet was turned upside down? Why?
4. What effect does reversing the direction of the current have on the deflection of the wire?

ACTIVITY 2: LONG, STRAIGHT WIRE

- Use the small magnetic compasses to plot the magnetic field lines created when a current passes through a long straight wire.
- Reverse the direction of the current, and note what happens to the compass needles.
- Use sketches in your lab notebook to document your observations.

ACTIVITY 3: FARADAY'S LAW OF INDUCTION

- Attach the galvanometer to the 100-turn coil, and pass the bar magnet inside of the loop of wire. Record the reading on the galvanometer dial (this measures the impressed voltage; do not worry about the units for this).
- Repeat for the 25-turn and 1-turn coils. Try to use the same magnet speed each time.
- Choose the coil for which you got the best results, and attach the galvanometer. Compare the readings when you change the magnet speed from very slow to very fast.

QUESTIONS

5. For the same magnet speed, how does increasing the number of coils affect the impressed voltage?
6. For the same number of coils, how does increasing the magnet speed affect the impressed voltage?
7. For the same number of coils and the same speed, what effect would you expect if you replaced the magnet with a stronger one and repeated the experiment?



How do you have to move that magnet with respect to the loop to create a current?



What changes when you crank the other way?

ACTIVITY 4: ELECTROMAGNETIC INDUCTION, AGAIN

- Wind one lead from the hand crank generator around the magnetic compass several times, and secure with a bit of clear tape.
- Clip the end of the lead to the clip on the other lead. Position the compass so that the needle aligns parallel with the windings.
- Turn the generator crank clockwise and observe. Reverse the direction and crank counterclockwise.

QUESTIONS

- What happens when you crank clockwise? Why?
- What effect does reversing the direction of the crank have on the compass needle? Why?

ACTIVITY 5: MOTORS AND GENERATORS

- Connect the leads of the generator to either side of the bulb.

- Turn the crank clockwise and note what happens. Turn the crank counter-clockwise and note.
- Observe what happens as you crank the handle (either direction) faster or slower.
- Clip the leads of one generator to the leads of another. Turn the crank of one generator clockwise and observe the other crank. Adjust the speed with which you turn the crank and observe.
- Turn the crank counterclockwise and repeat the above observation.
- Reverse the leads and observe.

QUESTIONS

8. Does changing the direction you crank change the effect on the bulb? Why or why not?
9. What is the effect of cranking slower or faster? Explain.
10. What happens to the second crank when you turn the first? Why?
11. What is the relationship between the speed of first crank and the speed of the second crank?
12. Explain what happens to the second crank when you reverse the direction of the first.
13. What happens if you reversed the leads instead of the direction of the crank?