Faraday and Lenz' Law Worksheet

Safety First!: The magnets provided in your kit are strong and should be handled with caution. Keep away from sensitive electronics and be careful to control magnets as they come together and keep fingers and other objects clear. You can use a multimeter to take many kinds of measurements but precautions should be taken when working on circuits. Please read the manual before starting; it can be found in the References below.

Introduction: In this activity you will be recreating an experiment first performed in 1831 by Michael Faraday, a British scientist who studied chemistry and physics. It led to the discovery of electromagnetic induction, or the movement of electrons generated by a changing magnetic field. It was this discovery that eventually led to the use of electricity that we have come to depend on today!

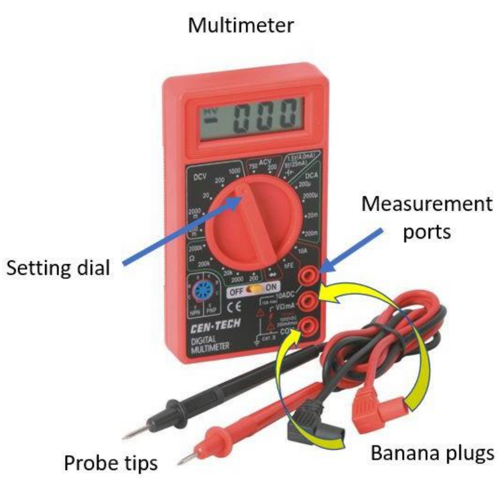
Martin Lab YouTube Channel: https://www.youtube.com/channel/UC2hQgPunfCTqFHJhCIqAJJg

Need:

1. Multimeter
2. Alligator clips
3. 26 gauge bare copper wire (~ 8.5 ft)
4. 22 gauge insulated copper wire (~ 17 ft)
5. Neodymium bar magnet
6. PVC pipe pieces
7. Boba straw piece
8. Tape (optional)

Procedure:

1. Your multimeter should have come with batteries, so it should be ready to go out of the box!
2. Take out the multimeter and plug in the banana plug side of the leads (the ones with the sheath) into the measurement terminals. Because we will be measuring voltage (V), the red probe should go into the port labeled VΩmA and the black should go into the port labeled COM. By convention, red goes to what we are measuring and black goes to COM or common which serves as a reference for voltage measurements.



3. Put the alligator clips onto the probe tips. Ensure that the tip is connected inside. You may be able to peel back the covering or look inside to see the connector inside the alligator clip. If you can give it a little tug and it is secure then the connection is good.

4. Next, choose one of the pieces of PVC pipe and one of the strands of copper wire to start with. Ensure you have about 2-3 inches of copper wire hanging off the end of the PVC. Tape may help to secure this in place as you get started. Now begin wrapping the wire around the piece of pipe keeping the turns tight around the cylinder and as close together as possible. Keep wrapping until you have about 2-3 inches of wire on the other side. Again, you may need tape to keep it in place.

5. Connect an alligator clip to each end of the copper wire. If it is the insulated wire, make sure that the clip is on the bare metal so that it is a complete electrical circuit.
6. Turn on the multimeter. This style of meter has what is called manual ranging, meaning that you have to tell it what to measure. The setting dial indicates where it is at by the small circle on the dial. Luckily, we know that today you will be measuring very small voltages. Rotate the dial until it is set to 200m under the DCV selection area on the top left. 200m indicates that the meter can now measure voltages up to 200 millivolts or 0.2 volts. DCV stands for direct current volts.
7. Now, take the bar magnet and move it in and out of the hole in the center of the PVC pipe (essentially inside of the copper coil you have made). It may take a little adjusting to get the speed where you can see a voltage change on the meter. This is because the sampling rate for this instrument is a little slower and less refined than more expensive versions.

What you are witnessing is Faraday's Law in action!

8. Now try this on your own by changing variables like the number of turns in the coil, insulated vs. bare copper wire, diameter of the coil using different PVC pipe/straw, magnet size (can you do this with the weaker magnet from the electromotor experiment?), and speed of moving the magnet. Remember that it is good scientific practice to only change one variable at a time in order to observe its individual impact on the outcome.

Observations / Discussion:

1. Does the direction that you move your magnet (in or out) of the coil change anything about the voltage? If so, why is that happening? *(Hint, think about Lenz's law from the video)*

2. What follow-up experiments did you conduct and what were they testing?

3. What variables did you find contributed to the most induced current (seen as voltage on the multimeter)?

4. Using what you have learned, what are other experiments that you could design with the materials in the kit?

Contact us at martinlabuci@gmail.com Find out more about our research at www.probemonkey.com

Further Resources:

1. Manual for your multimeter https://manuals.harborfreight.com/manuals/98000-98999/98025.pdf
2. Electromagnetic Induction by the National High Magnetic Field Laboratory https://nationalmaglab.org/education/magnet-academy/watch-play/interactive/electromagnetic-induction
3. Lenz's Law Video https://www.youtube.com/watch?v=QwUq8xM_8bY