PHY 242

Lab 8: Magnetic Induction/Faraday's Law

No discussion of uncertainty is required for this lab.

Introduction

In this lab we will be exploring Faraday's Law of magnetic induction. Our goal is to make a connection between the equation

$$\varepsilon = -\frac{\Delta\Phi_B}{\Delta t}$$

and the following interpretation:

Any change in the magnetic flux within a coil must create an <u>induced voltage</u> in the coil. The resulting voltage usually creates an <u>induced current</u> and therefore an <u>induced magnetic field</u>. The induced magnetic field will oppose the <u>change</u> in the magnetic flux.

We will begin our experiment with a simulation that will help us visualize the magnetic field.

Equipment

2 inductors-

One coil with many turns

and a second coil with fewer turns that can fit inside the first

we will use the following symbol for these coils.

1 Osciloscope

1 computer with Java already installed.

1 magnet

1 iron bar

1 function generator

The website phet.colorado.edu has a whole collection of physics simulations that are wonderful for seeing how experiments are supposed to work. Today we will be using the Faraday's Electromagnetic Lab simulation. To get there either

Click Play with Simulations, on the left column click Physics, click Electricity, Magnets & Circuits. Then find Faraday's Electromagnetic Lab

OR

Type: http://phet.colorado.edu/en/simulation/faraday into your browser.

If using your personal computer, you might need to download Java from https://java.com/en/download/ to get the lab to work.

A few notes about this simulation:

1) The Magnetic field is represented by tiny compass needles, showing the direction a compass will point if a compass is placed at that location. The strength of the magnetic field is represented by how opaque the compass needles appear.
2) There are five different mini-labs in this simulation as represented by the blue tabs across the top which you should explore.
3) For all coils, the wire is wrapped such that represents the direction of the area vector $\vec{A}$ is to the left. And the blue dots represent ELECTRONS.
4) You have a great deal of control over things like the magnet's strength, number of coils, power sources and types of sensors that are available using the checkbox's along the right side of the screen.

Procedure

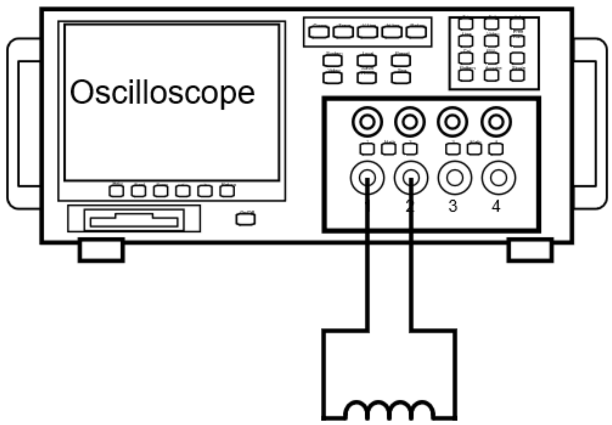
1) Spend 5 minutes playing with the "Bar Magnet" and the "Electromagnet." Make sure that you thoughtfully connect the things that you are seeing in these simulations with the lab you completed last week.
2) Go to the "pickup coil" tab. Find five distinctly different ways to get the lightbulb to light up. For example if the magnet and coil are placed appropriately you can get a *brief* pulse of light if you quickly change the loop area from 20% to 100% (moving the slider from 100% to 20% does not count as "distinctly different." Note: four wasy of lighting the bulb involve the control panel's buttons and sliders, while two others involve moving objects in the simulation.

DA1: Record your groups five situations. (If you are going to use my example as one of your five, the researcher should carefully explain what "placed appropriately" means specifically.)

R1: Apply Faraday's Law to each situation to explain why light bulb lights in each case. (Minimize the simulation for now… you might want to go back to it to reference what is happening when you can not see the field.)

3) Now that we an understanding of how Faraday's law works in the simulation, build the following circuit.

Circuit 1



Big coil

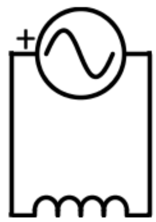
4) We will be looking for fairly small signals, so set the vertical scale for channel 1 to 10 or 50 mV (you may adjust it if needed). You should also start with the horizontal scale on approximately 500 ms. After you get your data you will probably want to hit the "run/stop" button so it is not overwritten as soon as you get it.
5) Using the magnets and maybe the iron bar, find a way to make as large a voltage pulse as possible without banging the magnet into the the iron bar.
6) DA2: Capture the data from your largest pulse to add to your worksheet. Options for aquireing this data include: a thumb drive and the "Print" button, a cable from Oscope to the computer and the "OpenChoice Desktop" app, or a camera. Note, you will be graded based on style and clarity so a fuzzy cell phone pic with poor labelling will not earn full points. +1 point to the group with the largest voltage pulse.

7) R2: record your group's procedure for creating the DA2's voltage pulse.

8) PI1: Refine the answers to R1 and R2 to explain what aspects of your group's procedure were responisible for the large size of the voltage pulse recorded in DA2.

9) Do NOT dissasemble the circuit with the Oscope and large coil. Build the following circuit with the Sine button (∿) pressed in on the function generator. We need to keep our **Frequencies below 2 kHz** for accuracy of the results.

Circuit 2



small coil

Feel free to use equipment available to validate your answers to these questions to ensure you get them correct.

R3a: What effect does the **amplitude** setting have on voltage/current in the **small coil** of circuit 2?

R3b: What effect does the **frequency** setting have on the voltage/current the **small coil** of circuit 2?

10) Without removing or adjusting any wires, slide the small coil from circuit 2 inside the large coil for circuit 1. The DA is responsible for recording the results from the Oscope:
DA3a: What effect does the **amplitude** setting on the function generator have on Oscope display of the voltage in the big coil?

DA3b: What effect does the **frequency** setting on the function generator have on the Oscope display of the voltage in the big coil?

11) PI2: Why does the oscilloscope register a non-zero voltage for the large coil? Pretend you are explaining how there can be no electical connection between the two circuits and energy can transfer from one coil to the other.
12) PI3: The answers to R3a and DA3a should be similar. However the answers to R3b and DA3b should be different in one important aspect. Use the Faraday's Law **equation** to explain why the frequency has this different effect on the two coils.

Before leaving for the day make sure you return your equipment to the proper cabinet/drawer and email out your data to the entire group.