

Lab 06 - Magnetic and Electric

Interaction NAME: _____

Time spent on Lab 06 = approximately 2 hours, does not need to be done at one sitting

Materials needed = Access to computer and high speed internet, Java installed on the computer

Learning Objectives:

- Discover Faraday's Law of Induction and the corresponding equations
- Apply this principle to a form of power generation commonly used by power companies

Virtual Lab:

To begin this experiment, proceed to:

<https://phet.colorado.edu/en/simulation/faraday>

And download the Faraday's lab experiment Java file. Once it's downloaded, open it and you should see something similar to the lab from last week. Understanding magnetic fields is a great primer for understanding how they interact with electric fields. We are already experts in magnetic fields, so proceed straight to the "Pickup Coil" tab at the top, where you will see a screen similar to the one below:

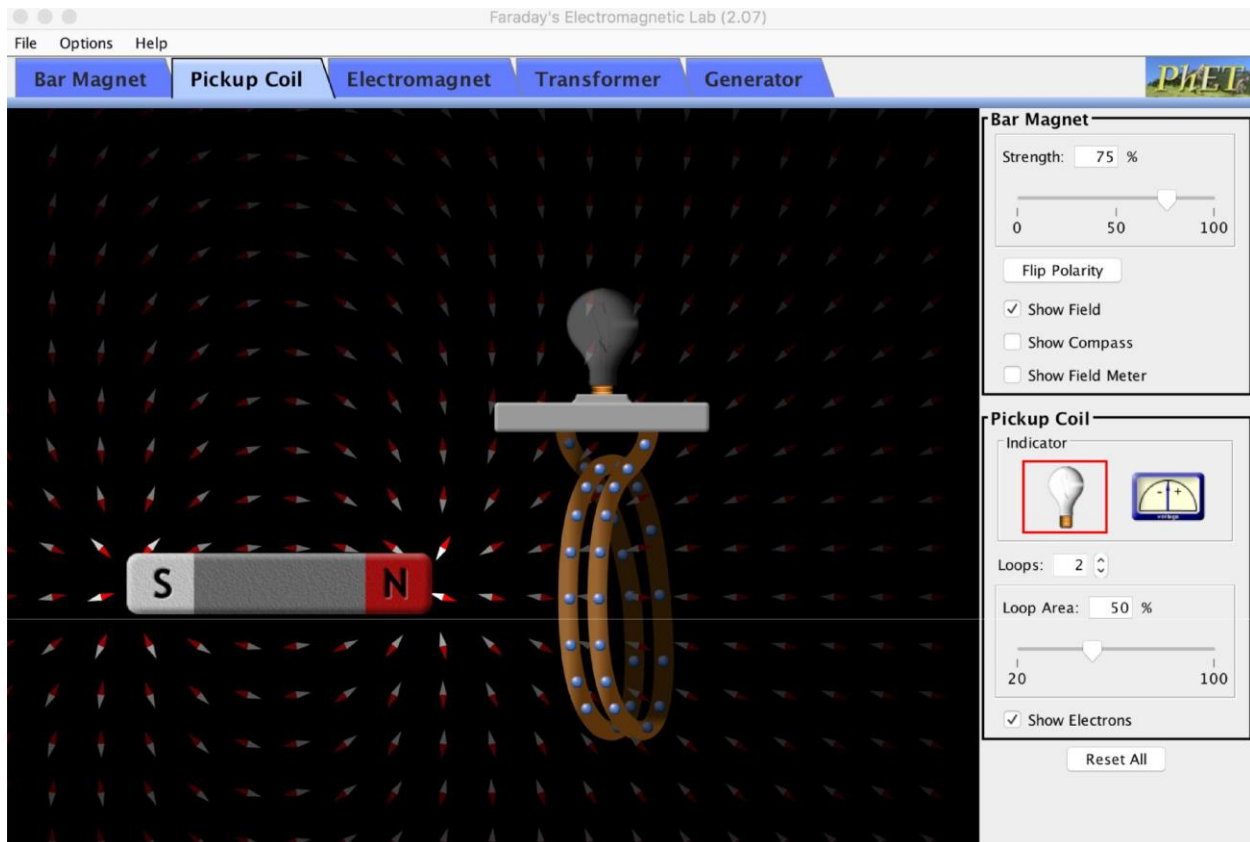


Figure #1

1. Click and drag the bar magnet inside and back outside the loop of metal wire, quickly and repeatedly, through the center of the loop. Describe what happens below.

The bulb lights as the bar magnet moves in and out of the loop. This is due to the change in the magnetic flux of the loop which produces a voltage. The voltage makes current to flow through the loop and thus the bulb lights.

Hopefully you notice the light bulb lighting up! This happens because the metal wire is a conductor and is connected to the light bulb such that if there is current flow, then the bulb will glow. It did glow, so there MUST have been current flow. What generates current flow? A voltage! So could it be that dragging a magnet through a conductor generates voltage? The answer is yes, IF the conductor forms a closed loop around the magnet.

2. What did you change when dragging the magnet through the conductor loop? Describe this in terms of what we learned last week.

The magnetic flux changes

3. Now click on the “Field Meter” option in the simulator and change from a light bulb to a voltmeter. Repeat your procedure for #1, only now make special note of the voltmeter reading as compared to the magnetic field sensor reading. Try leaving the magnet VERY close to the loop, and compare it to the voltmeter. Then try moving the compass very rapidly through the loop and compare the two readings.

When the reading of the field sensor increases, the reading of the voltmeter increases. When the compass is rapidly moved through the loop, there is a big deflection on the voltmeter.

4. Describe in detail what caused the voltmeter to spike, peak. This is a very short answer, so please be precise.

A change in magnetic flux produced a voltage.

5. Increase the number of coils to three, repeat the procedure to #3, and relate the strength of the voltmeter peak to that found in #3.

When the number of coils is increased to three, the voltage reading is greater than when the coils are two

6. Now lower the area of the conducting loop to 20%. Repeat #3, making note of the voltmeter reading in general. Then increase the area of the conducting loops to 100% and repeat the procedure making a general note of the voltmeter reading while moving the magnet. Write down a comparison between a large area and small area below.

When the area is increased, the voltmeter reading increases.

7. Now, leaving everything the same, take the magnet and move it back and forth in the loop but move VERY slowly. As in the entire process should take you several nearly 30 seconds to move the magnet into the loop and back out. Write down your observations below.

When it moved slowly, the reading is very small.

8. In VERY brief statements, summarize how the voltage varied with each of the characteristics that changed it.

Increasing the number of coils increased the magnetic flux and consequently the voltage. Increasing the area of the loop increases the voltage reading while reducing it, reduces the voltage. When moving the bar magnet at a higher speeds, increases the voltmeter reading.

You have just discovered Faraday's Law of induction! This law states that for any magnetic field entering an enclosed area, the change in the magnetic field over time will INDUCE a voltage to counteract the change in the magnetic field. In summary,
 $\mathcal{E} = -\frac{d\Phi_B}{dt}$, where $\mathcal{E}$ is the induced voltage, Φ_B is the magnetic flux, and t is time.

9. Think about this theory for a moment, if we have a magnet that is sitting inside of a metal loop, but NOT moving, then what would we expect the induced voltage to be and why?

There will be no voltage produced as the induction process requires motion in and out of the loop to create a change in the magnetic flux

10. If we have a bar magnet, whose magnetic field strength is dependent on the distance, then as soon as we move it, closer to the loop, then what are we changing and how would it affect the induced voltage?

The rate of change of the magnetic flux is being changed. The

11. When we increased the area of the loop, what did we increase, and how did it affect the induced voltage?

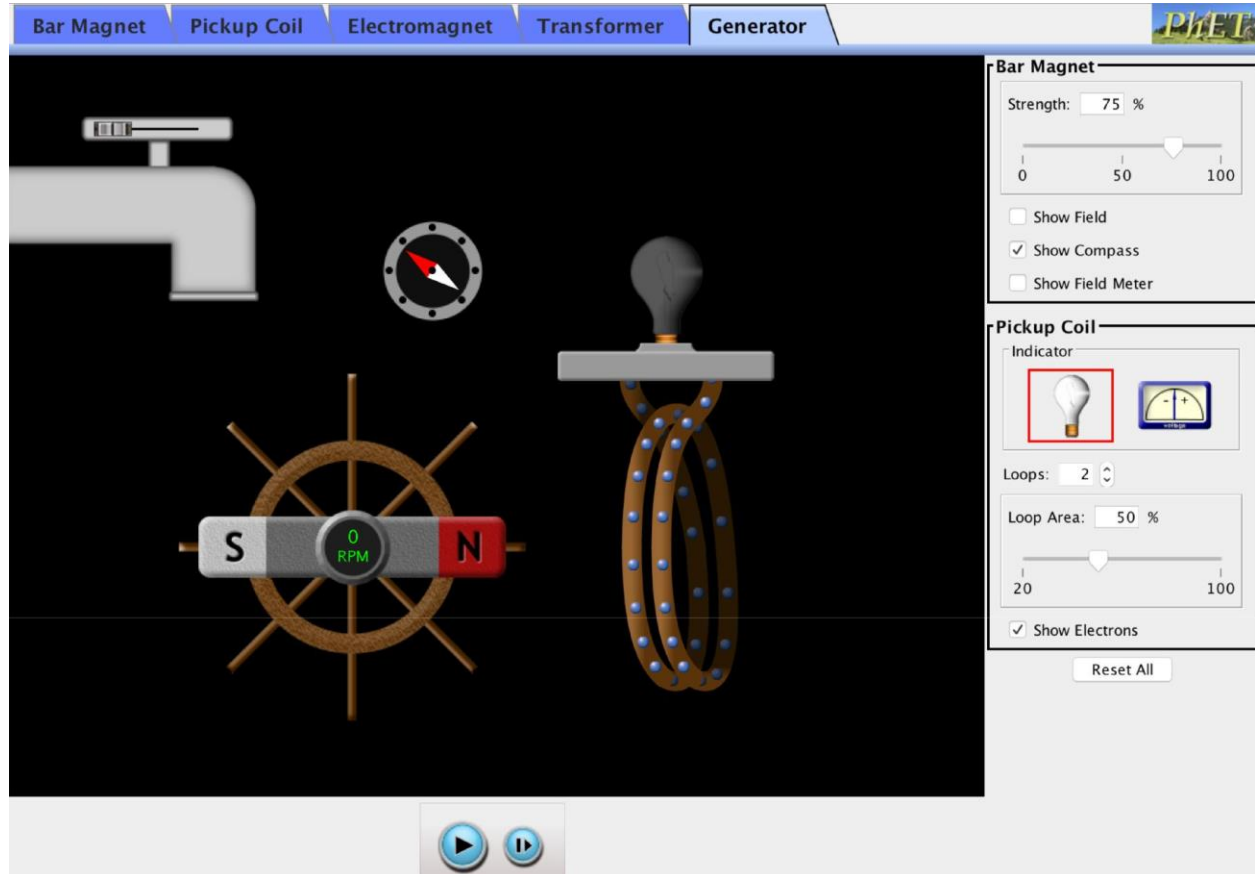
This increased the amount of electromotive force produced which increases the voltage

12. When we moved the magnet VERY slowly through the metal loop, did it have an effect on the induced voltage, why or why not?
The

The loop cuts the magnetic flux at a lesser rate thus reducing the electromotive force produced and the voltage

As you can see, the observational evidence supports Faraday's law of induction! So if we follow this law all the way to the conclusion, we can assume that if we have a constantly changing magnetic field, we might even be able to ... power a CITY's worth of light bulbs, or more likely, TV's and cell phones! That's exactly what we do!

If we oversimplify the power company's job in every city, we can make a model of the generators that produce the power for all of us. This is done by the simulator under the tab entitled "generator". Click on it, and you should see something like the screenshot below.



13. Click on the "show field" option and the "show field meter" option, then turn on the water faucet, and describe what happens below.

Water creates a force that rotates the turbine with magnet and the voltage produced as seen on the voltmeter lights the bulb.

14. The first thing you may note is that the magnet is rotating, not translating! So how is the magnetic flux changing to create a magnetic field? HINT: Recall the magnetic field is a vector!

When the magnet is rotating, the direction of the dipoles changes and as the dipoles changes direction, the magnetic flux changes creating a magnetic field.

15. As you let the generator run and stare at it in complete awe, note that the voltage is constantly changing from some positive number to some negative number. Read more about [AC power](#), and then comment below on how this generator simulator is a good analogy to how the electric company generates power to your home.

The scenario displayed by the generator simulator where alternating voltage is produced due to change in magnetic flux, is the same phenomenon that happens in power companies. The rotation can be actuated by prime movers such as water, diesel engines, and wind. The speed of rotation influences the amount of power produced.

Through lecture and the textbook readings, you have already caught onto this, but we can very simply state that *a changing magnetic field induces an electric field*, and a corresponding voltage!, and *a changing electric field induces a magnetic field*. What is the reason for these two rules? *Nature works to prevent a change in flux in electric and magnetic field lines.*

Once you have completed all lab questions, please download this document as a PDF only! Then upload this PDF to Blackboard under the assignment “Lab 06”, for grading.