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Class: AP Physics II

Period: 2

Group #: 6

Lab # and Title: Electromagnetic Induction and Transformers

Laboratory Report

Purpose

The purpose of this lab is to determine what factors affect how efficiently a transformer can pass an induced magnetic field from one coil to another. This will be done by testing different configurations for the transformer set-up, the voltage being supplied to the primary coil, and the frequency at which the power supplier changes the direction of the current. The end goal will be to compare the input voltage going into the primary coil and the output voltage from the secondary coil.

Equipment Used

PASCO Capstone, PASCO 550 Universal Interface, two AC voltage sensors, two SF-8610 400-turn coils, one SF-8614 U-shaped core, and two SF-8615 E-shaped cores.

Background

Alternating currents are currents that rapidly switch the direction of their current multiple times per second. Thus, when an alternating current is run through a coil of wire, or the primary coil, it results in a magnetic field that is also constantly changing. Transformers take this one step further by wrapping the coil around a conductor, as the changing magnetic fields magnetize the metal. As the magnetic field passes through a secondary coil wrapped around the same conductor, this coil experiences a changing magnetic flux. The changing magnetic flux results in an electromotive force (*emf*) defined by Faraday's Law of Induction, which states that:

$$\varepsilon = \frac{\Delta\phi}{\Delta t}$$

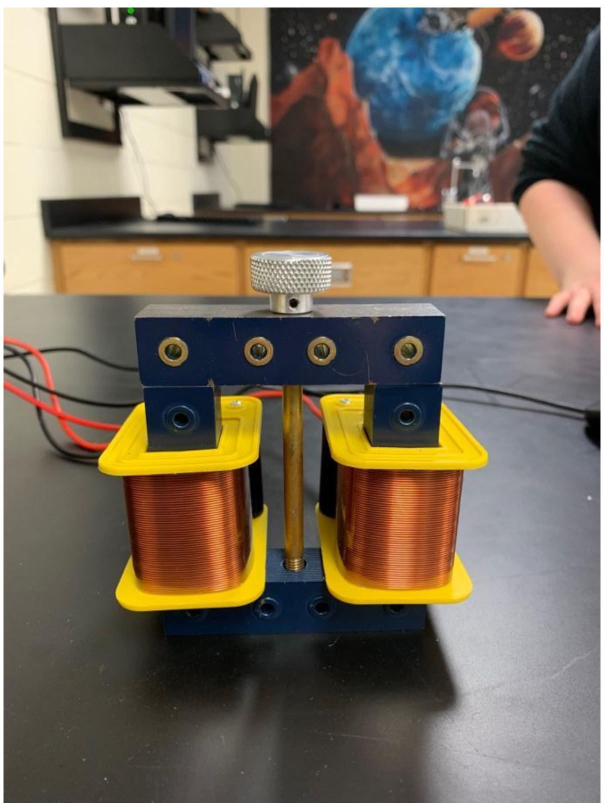
In this equation, ε is the *emf*, $\Delta\phi$ is the change in flux, and Δt is the change in time. The changing magnetic flux and the subsequent *emf* allows a current to be induced within the secondary coil despite not being directly attached to the primary coil.

Procedure

Part 0: Setting up the lab

1. Connect the two voltage sensors to the PASCO 550 Universal Interface. One should plug into the A Analog Input, whereas the other two individual wires (one red, one black) should plug into the inputs on the far right. Make sure to turn the machine on before continuing.
2. Log into the computer and open up PASCO Capstone.

3. To create a new experiment, drag the “Scope” icon located in the toolbox on the far right onto the screen.
4. Click on “Hardware Setup” (located on the far left). Configure the output sensors by clicking on the yellow circle located on the far right of the interface and choose “Output Voltage Sensor”.
5. Click on the yellow circle with the letter A above it (this corresponds to the A Analog Input), scroll down, and choose “Voltage Sensor”.
6. To configure the x-axis, click on “Select Measurement” located below the x-axis and choose “Time (s)”.
7. To configure the y-axis, click “Select Measurement” located on the side of the y-axis and choose “Voltage. Ch A (V)”. Then, go to “Add Similar Measurement” located in the same menu and choose “Output Voltage. Ch V (V)”.
8. Set up the coils and cores in the configuration shown below. Use the 400-turn coils from the box.



Part 1: Power supplier voltage

1. Click on “Signal generation” and set the frequency to 60 Hz and the amplitude to 1 V.

2. Click “Record”. You should see two sine waves being generated.
3. Click on the Delta Tool in the toolbox (Tip: it’s an icon resembling a cross). This will pull up a box that you can then drag around and use to measure the values of the sine waves.
4. Measure the crest of each sine wave. This value will be used to represent the voltage of the coil associated with that given sine wave.
5. Repeat 3 times with an amplitude of 3, 5, and 7 V.
6. Record your data in the table below. The voltage closest to the initial amplitude is the primary voltage.

Amplitude (V)	Primary (Input) Voltage (V)	Secondary (Output) Voltage (V)	$\frac{Output\ Voltage}{Input\ Voltage}$
1	0.996 V	0.643 V	.646
3	2.986 V	2.207 V	.739
5	4.982 V	3.941 V	.791
7	6.977 V	5.764 V	.826

Part 2: Current frequency

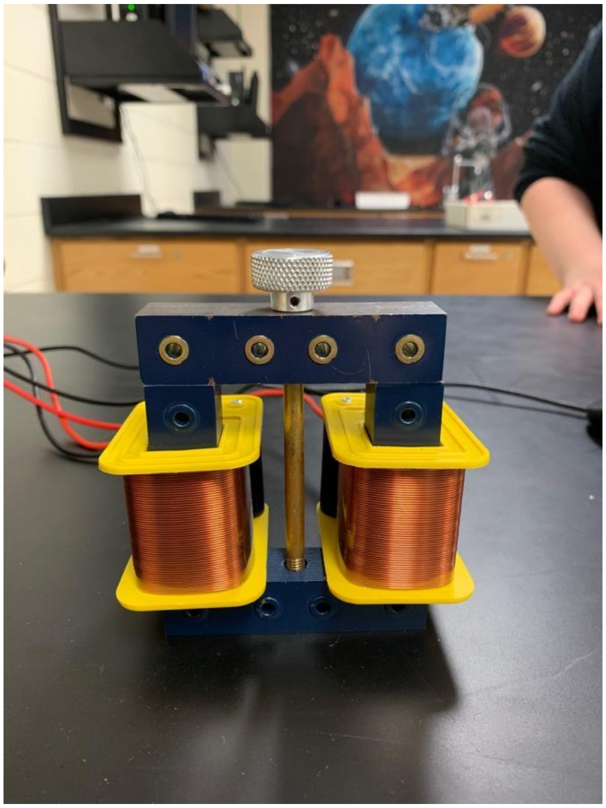
1. Set the frequency to 30 Hz and the amplitude to 3 V.
2. Repeat steps 2 - 4 of Part 1.
3. Repeat 3 times with a frequency of 60, 120, and 240 Hz.
4. Record your data in the table below.

Frequency (Hz)	Primary (Input) Voltage (V)	Secondary (Output) Voltage (V)	$\frac{Output\ Voltage}{Input\ Voltage}$
30	2.985 V	2.370 V	.794
60	2.987 V	2.219 V	.743
120	2.983 V	2.055 V	.689
240	2.984 V	1.903 V	.638

Part 3: Transformer configuration

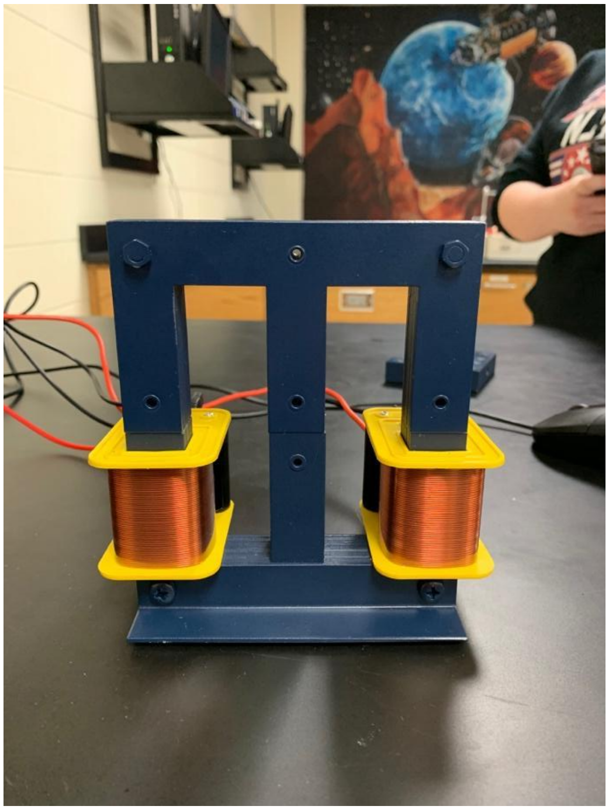
1. Set the frequency to 60 Hz and the amplitude to 3 V.

2. The coils should already be set up in the configuration below. This will be “Configuration 1”.



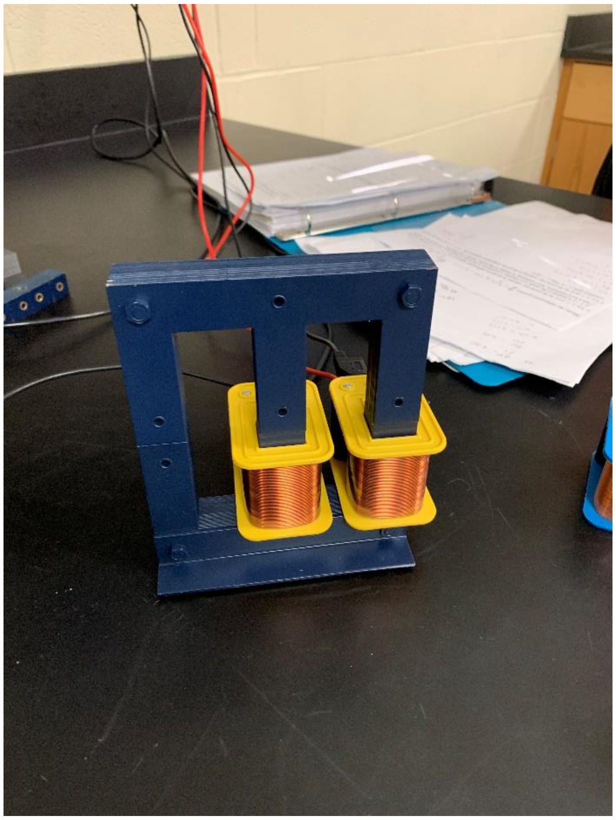
3. Repeat steps 2 - 4 of Part 1.

4. Set up the coils in the configuration below. This will be “Configuration 2”.

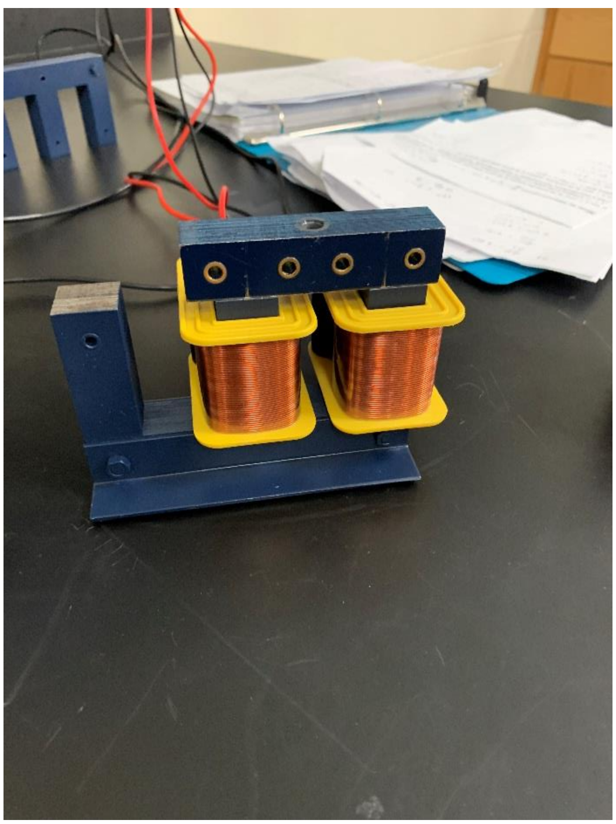


5. Repeat steps 2 - 4 of Part 1.
6. Repeat 2 more times; for these trials, set up your own configurations for the coils with the goal of maximizing the efficiency of the transformer (i.e. minimizing the ratio between the output voltage and the input voltage).
7. Attach pictures of your configuration for trials 3 and 4.

Configuration 3



Configuration 4



8. Record your data in the table below.

Configuration	Primary (Input) Voltage (V)	Secondary (Output) Voltage (V)	$\frac{Output\ Voltage}{Input\ Voltage}$
1	2.987 V	2.200 V	.737
2	2.987 V	0.762 V	.255
3	2.988 V	1.193 V	.399
4	2.989 V	2.203 V	.737

Analysis Questions

1. The power supplier used in this lab passes an alternating current (AC) through the primary coil. Had it instead used a direct current (DC), how would the output voltage of the secondary coil be affected?

If we used a direct current, the second coil would output more voltage

2. Consider the ratio between the output voltage and the input voltage in all 3 parts. How does changing the amplitude affect this ratio? The frequency? The configuration?

When the amplitude increases, the ratio between the output voltage and the input voltage also increases. The frequency is also directly correlated. Putting the configuration to direct the current back into the coil increases the ratio as well.

3. You may notice that the values for the ratio between the output voltage and the input voltage is never precisely 1. Using data from this lab and your own knowledge of electromagnetic fields, develop a theory for why this discrepancy occurs.

This is because of resistance in the wires

4. Based on the data from Part 3, which configuration had the highest efficiency when passing an induced magnetic field? Why was it more efficient than the others? Use the theory you developed in Question 2 to support your answer.

Configuration 4 has the coils connected next to each other on the 3-prong block with the last peg unconnected. It had the highest efficiency in passing the current because the current easily loops in the form of a circle.