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Lab – Transformers

AP Physics C – E&M

Objective: I can calculate the magnitude and direction of an induced current in a conductive loop by deriving an expression for the inductance of a solenoid.

A transformer is a machine that can transform from a humanoid-like shape into a vehicle.

While true, these are not the transformers we are looking for. Instead, we are going to learn about the types of transformers that can be used to provide the power that you need to do this assignment.

Transformers are used to change the voltage in between two electrical circuits using the concept of magnetic flux and induced current. They are used to transmit power across long distances and connect the distribution lines to the actual transmission lines in a full power grid. Eventually, another transformer is used to decrease the voltage for use in buildings. This is part of the reason why electrical energy can be carried so far but why it doesn't overload our own devices!

Today, you will be working with solenoids with different numbers of turns in order to gain an understanding of what happens to the voltage/current in the secondary coil and how it relates to the number of turns in each coil.

<u>Please answer the Prelab question before scrolling further.</u>

Prelab Questions

1. You will be putting a known voltage through the primary coil and therefore could calculate the current through the primary coil. Predict how the voltage through the secondary coil (secondary voltage) may relate to the voltage supplied through the primary coil (primary voltage) and the number of turns in each coil.

The voltage through the secondary coil is probably directly proportional to the voltage supplied in the primary coil as well as the number of turns in each coil. This is because as voltage increases, so does the magnetic field produced by a solenoid. In addition, the magnetic field also increases proportionally to the number of turns in the solenoid.

2. You will have 5 options of cores to try: a line, a “U” shape, a square, an “E” shape, and an “8” shape (2 “E” shapes together). Which core do you expect to be the most efficient with transmission and why?

We expect that the 8 shape will be the most efficient with transmissions because there are more connections/loops than the other two shapes. Also it looks like an infinity so it is pretty cool.

Materials Needed

- PASCO Interface and Capstone
- Coil set with cores
- Red/black cords
- Current Sensor

Procedure

This lab consists of two parts. In Part 1, you will determine the efficiency of each core type listed in the Prelab Questions. In Part 2, you will use the most efficient core to relate the primary/secondary voltages with the number of turns in the coils.

Part 1 – Efficiency

1. Connect the red and black cords to the PASCO interface and open Capstone with the interface connected to your laptop. Connect the Current Sensor to Analog Port A. Select the display to show a Scope (do this on the very right hand side of screen).

2. In PASCO Capstone, go to “Signal Generator” under the Tools menu on the left. Set the waveform to be a sine wave with Amplitude 1 V and Frequency 1000 Hz.

3. Under “Hardware Setup”, select “Output Voltage Sensor” on the farthest circle to the right. On Port A, select “Voltage Sensor”.

4. Connect the interface to a Primary Coil of 400 turns and the current sensor to the Secondary Coil also of 400 turns.

5. For the scope, plot both types of voltage values vs. time. In addition, change the reading type to “Fast Monitor Mode” and click “Monitor”.

6. Try all 4 core types and record the secondary voltage in each case. Note the Primary voltage is 1 V (the amplitude).

Table 1. Values for the secondary voltage in different core types.

Core Type	**Secondary Voltage**	**% efficiency (Secondary/Primary voltage)**
Line	0.49	49%
U-shape	0.25	25%
Square	0.56	56%
E-shape	0.1	10%
8-shape	0.2	20%

Part 2 – Relating Secondary Voltage to Turns

7. For the rest of the lab, you will be using only the core for which you had the most efficient transformation.

8. Fill out the data table below with the designated values.

9. Measure the output voltage using the voltmeter.

10. Repeat for different numbers of turns as indicated in the table.

11. Repeat for different core configurations: U-shaped and full square.

12. Fill out the graph in the Results/Discussion section. Your dependent variable is the output voltage, but you will want to use your prediction and try something related to number(s) of turns in the coil(s) for independent to get a graph that is linear without linearization.

Data

Table 2. Values for the number of turns and secondary voltage in the most efficient transformer

Primary voltage = Amplitude * Percent efficiency = ______.56______ V

Most efficient Core Type	Number of Turns on Primary Coil	Number of Turns on Secondary Coil	Ratio of N2/N1	Secondary Voltage (V)
square	400	800	2	1.1
quares	400	1600	4	2.25
uaresq	800	1600	2	1.1
aresqu	800	400	0.5	0.29
resqua	400	3200	8	4.5

esquar	200	3200	16	9.21

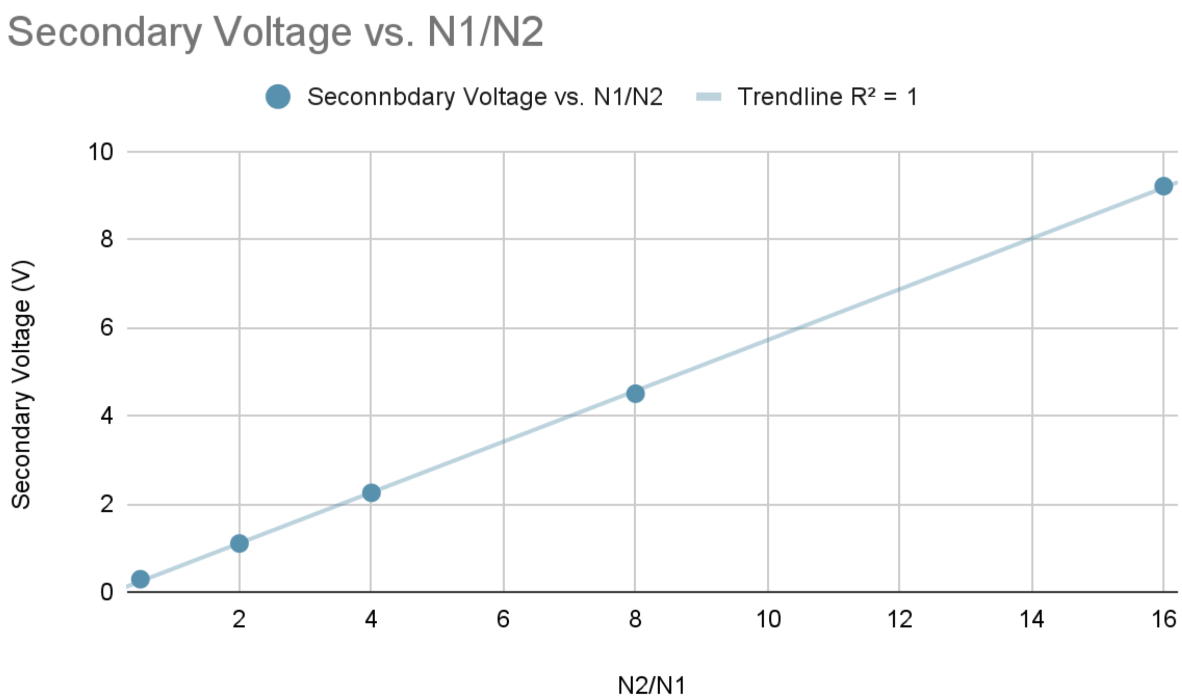

Figure 1. Graph of Secondary Voltage vs. N2/N1

Results and Discussion

Discuss which type of core was most efficient and why this may be. Use your graph to formulate an equation relating input/output voltages and numbers of turns. Describe why it may or may not be expected. Speculate on the direction of current in the secondary coil, and also discuss sources of error.

The square shape was the most efficient. This is because the square shape forms a complete, non-parallel circuit that allows the current to travel uniformly in one direction. For example, because the 8-shape technically is composed of two loops, the amount of flux flowing on the outer two bars is equal to half of the flux flowing on the outer two bars of a loop, which decreases efficiency for the 8-shape. Also, in the real world this material has some degree of resistance which means that the 8 leads to more paths that causes the current to be reduced artificially, while the loop reduces this effect.

Our graph of secondary voltage vs N2/N1 confirms a linear relationship between the values - that the secondary voltage is directly proportional to the ration between the number of loops in the secondary coil and the first coil.