Physics Extended Essay

Contents

Introduction

This paper aims to find out about the correlation between the temperature of a magnet and the electricity produced when it's dropped through a copper coil tube. The magnet will be heated using a hair dryer held at 0.1, 0.2, 0.3, 0.4, and 0.5 meters from the magnet for 60 seconds each. For each temperature, the test will be redone for 5 times for the means of broader data collection. The electricity produced by the drop will be measured with the use of a voltmeter and the data will be attempted to correlate with physical laws such as Faraday's Law. Both the processed and raw data will be graphed using the application; "Logger Pro", and the found correlation will be described.

This paper aims to find out about the correlation between the temperature of a magnet and the electricity produced when it's dropped through a copper coil tube. The magnet will be heated to 5 different temperatures, and dropped through the tube 5 times for each temperature. The electricities produced will be noted down for each drop, and analysed for the correlation with the use of Faraday's Law.

Background Information

When a magnet is dropped through a copper coil tube, by Faraday's law, it induces a current within the coil. The induces voltage can be calculated with the formula;

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

where ε is the induced voltage, N is the number of loops, $\Delta\phi$ is the change in magnetic flux, and Δt is the change in time.

The electromagnetic force induced by the falling magnet is spiked when the first pole (South) enters the coil, then it starts to decrease. When the middle of the magnet has entered, the electromagnetic force will drop to its minimum throughout the fall, and the maximum electromagnetic force is obtained when the second pole of the magnet aligns with the top of the coil. Therefore the induced voltage will be measured just as the magnet enters the coil.

Another crucial physical law we should consider is Lenz's law. Lenz's law states that an induced electric current flows in a direction such that the current opposes the change that induced it. Since as the electromagnetic force increases the magnetic flux will increase, the magnets acceleration will continually decrease by the induced opposing force created.

We should finally consider the fact that at relatively low temperatures, a neodymium magnets strength constantly decreases. This face is relevant when the temperature is lower than the Curie temperature of the materials the magnet is made out of.

Variables

Dependent variables: Amount of current generated

Independent variables: Temperature of magnet

Controlled variables: Length of the coil tube, temperature of coil tube

Uncontrolled variables: Room temperature, heating method

Hypothesis

The faster moving particles in the magnet will cause a slight increase in the current generated, causing a direct correlation between the temperature of the magnet and the electricity produced.

Materials

- Neodymium magnets

- A copper coil

- A Voltmeter

- A tool to heat up the magnet (eg. a hair dryer)

- Infrared thermometer

Methodology

To start with, a 1cmx1cmx1cm cube magnets initial heat will be measured with the use of an infrared thermometer, then, the magnet will be heated to 30° Celsius using a hair dryer. The hair dryer will be held 50 centimeters away from the magnet, pointing straight at it at a constant angle for a set duration of 60 seconds. Immidiately after the 60 seconds is done, the magnets temperature will be measured using an infrared thermometer and the magnet will be dropped from 10 centimeters above the copper coil, falling through it, and the electricity produced will be measured with the use of a voltmeter connected to the copper coil through its ends. These steps will be repeated 5 times for each temperature of the magnet in the same location, using the same equipment and consecutively with minimum time in between so as to keep the uncontrolled variable of room temperature from fluctuating, changing only the distance of which the magnet is held away from the hair dryer. The distances used throughout the experiment will be 0.5, 0.4, 0.3, 0.2, and 0.1 meters respectively. The exact phrasing of the steps printed out to be used in the experiment are;

- Connect the copper coil to an voltmeter.

- Heat up the magnet to the required temperature.

- Measure the magnets temperature and record it.

- Hold the copper coil and the magnet at the required distance from each other with the help of a ruler.

- Drop the magnet, record the measurement of the voltmeter.

- Repeat for all the distances and temperatures for a total of 25 measurements.

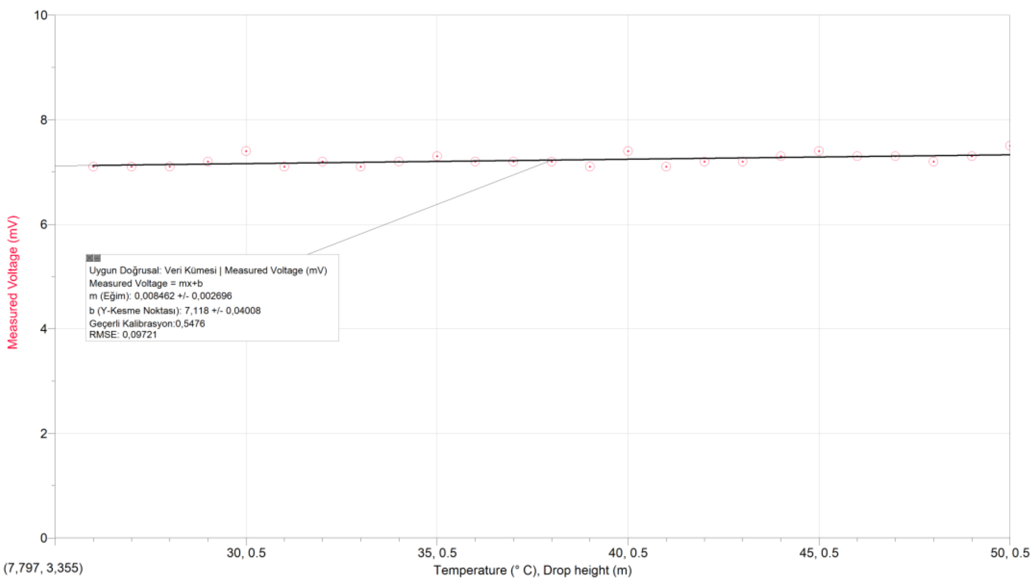
So to start with, the magnet will be dropped through a copper coil tube that is constant in temperature 5 times and the generated current will be measured. Then, using the hair dryer, the magnet will be heated, and the drops will be measured again. There will be 5 different temperatures in which the magnet will be dropped 5 times each. Finally, the expected current will be calculated using Faraday's Law, and the potential current losses to the environment will be considered to reach a conclusion.

Raw Data

	0.1m	0.2m	0.3m	0.4m	0.5m
30° C	7.1mV	7.1mV	7.1mV	7.2mV	7.4mV
35° C	7.1mV	7.2mV	7.1mV	7.2mV	7.3mV
40° C	7.2mV	7.2mV	7.2mV	7.1mV	7.4mV
45° C	7.1mV	7.2mV	7.2mV	7.3mV	7.4mV
50° C	7.3mV	7.3mV	7.2mV	7.3mV	7.5mV

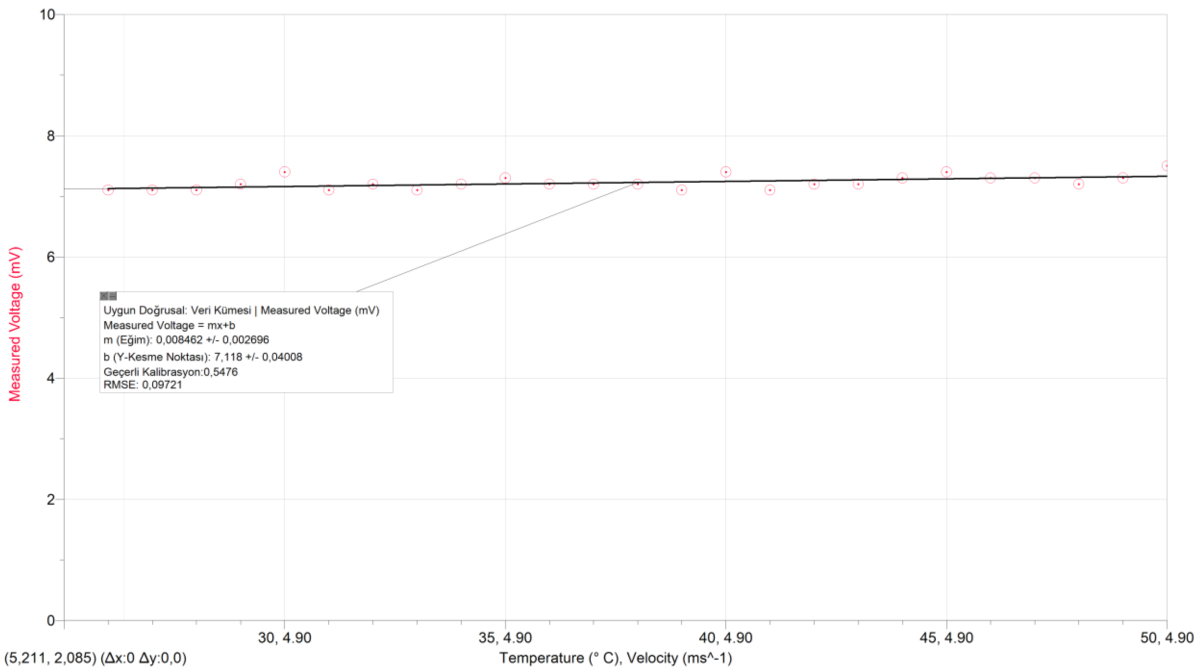
The Drop Height of The Magnet and The Temperature of the magnet Versus the Produced Voltage

Processed Data:



	$0.98ms^{-1}$	$1.96ms^{-1}$	$2.94ms^{-1}$	$3.92ms^{-1}$	$4.90ms^{-1}$
30° C	7.1mV	7.1mV	7.1mV	7.2mV	7.4mV
35° C	7.1mV	7.2mV	7.1mV	7.2mV	7.3mV
40° C	7.2mV	7.2mV	7.2mV	7.1mV	7.4mV
45° C	7.1mV	7.2mV	7.2mV	7.3mV	7.4mV
50° C	7.3mV	7.3mV	7.2mV	7.3mV	7.5mV

Velocity of magnet at the time of entering the coil and The Temperature of the magnet Versus the Produced Voltage



Analysis

As seen in the processed data section above, the voltage induced on the coil showed little to no change when heated to the specified temperatures.

The height of the drops are directly proportional to the voltages induced. This is because the as the velocity of the magnet increases, by Faraday's law, the induced voltage will increase;

$$\varepsilon = \frac{1}{t}$$

since we dropped the magnet from 5 different heights, this change helps us obtain more data about the induced voltages dependancy on temperature of the magnet. All in all; the external factors that may have affected our measurements could have been unspottable changes that blend in with the datas pattern, though considering the different heights makes our measurements, which could have been affected by external factors, more precise by having more information on the external factors.

Using the processed data we can calculate the expected voltages for the given velocities, and compare them with the measured data, keeping in mind the different temperatures. This can help us see whether the temperature of the magnet actually creates a difference, from the slopes of the graphs which are non zero. Though the slopes are negligible, the temperatures effect on this scale would be pretty close to these values.

Conclusion

Although there was no statistically meaningful data obtained, it still seemed to fit the theoretical results quite well. This was presumably because the effect is really small at viable temperatures.

References

Griffiths, David. Introduction to Electrodynamics

Hayt, William. Engineering Electromagnetics

Sunasu Türk. The Susu Lectures on Electromagnetics

Feynman, Richard P. "The Feynman Lectures on Physics Vol. II"

Schmitt, Ron. Electromagnetics explained

Maxwell, James C. A treatise on electricity and magnetism, Volume 2