# Good example of method report

Technology, Development

Abstract— Faraday's Law is used to estimate the magnetic field of the magnet from the maximum induced voltage. This paper presents the report of the experiment on Faraday’s Law of induction. In this experiment Faraday's Law and Lenz's Law are examined, along with the concepts of magnetic flux and conservation of energy. The experiment was carried out by using a wand having a coil at its end. This coil is made to swing through the magnetic field of a horse magnet. The induced EMF stated by Faraday and the reason for the minus sign added to it by Lenz has been duly justified experimentally. Also, the concepts of magnetic flux and that of the conservation of energy have been duly experimented.

# INTRODUCTION

The Faraday's law of induction is an elementary law in the field of electromagnetism that predicts the way the magnetic field will act together with an electric circuit to produce an electromotive force (EMF). The phenomenon is termed electromagnetic induction. This phenomenon is the basic operating principle of solenoids, generators, inductors, transformers, and various types of electrical motors. [3]

Faraday’s law of induction states that, in any closed circuit, the induced electromotive force (EMF) in volts (V), is of the same magnitude with the negative rate of change of the magnetic flux across the circuit. [2]

The experiment is aimed at examining Faraday's law as a swinging coil pendulum cuts through the poles of a magnet. In the first part of the experiment, the strength of the magnetic field between the poles is estimated by making use of the induced EMF across the coil’s terminals. Faraday's Law is used to estimate the magnetic field of the magnet from the maximum induced voltage. Also, the direction of the induced voltage as the coil enters and leaves the magnetic field is examined and analyzed using Lenz' Law. In the second part of the experiment, the power dissipated through a load resistor, connected across the terminals of the coil, is calculated and compared to the energy loss of the pendulum.

A rigid pendulum having coils at its end is made to swing through a horseshoe magnet. A resistive load is attached across the coil, and the induced voltage is measured and recorded by making use of a Voltage Sensor. Also, the angle of the pendulum is measured using a Rotary Motion Sensor which also doubles as a pivot for the pendulum. The values of the induced voltage recorded are plotted against the time and angle. Also, the power versus time graph was plotted. The area under the power versus time curve is used to determine the energy that was converted to thermal energy while the power loss in the resistor is calculated from the voltage.
Firstly, the coil, located at one side of a wand, is made to freely swing like a pendulum between the modifiable poles of a magnet at first without the pole plates, thereby cutting the lines of the magnetic field flux and inducing an EMF. According to Lenz’s law, this induced EMF should have a direction opposite to that of the change in flux’s direction. The other part of the experiment involved the placement of a resistive load between the open jack terminals in order to make the current flow. This direction of this current, according to Lenz's law, should be in opposition to the change in flux. The magnetic field B is calculated using the area of the coil. For each part of the experiments, the appropriate readings were recorded, and the corresponding graphs were created.

# RESULTS

Using

E= - 0. 043754 V (calculated voltage)

## For the first part: with Resistor

hi = 0. 00890, hf = 0. 00491

Therefore, ΔU= 0. 000307 Nm

## For the second part: without Resistor

hi = 0. 00890, hf = 0. 00788

Therefore, ΔU= 0. 00007854 Nm

Power lost across the resistance (from curve of power) = 1. 04 mWs

Area under power/ time curve = 1. 04 mill watts/s × 10-3 watt.

## The value of ΔU when a resistor was used appears to be greater that when no resistor was used.

F

Figure the plot of voltage against time for the first experiment.

Figure showing the angular plot of the SHM

Figure showing the voltage plot gotten from matlab

Figure showing the graph of power vs. time

# DISCUSSION

The calculated voltage was 0. 043754 while the value of the measured EMF was 0. 0263 meaning that the voltage measured has a lesser magnitude. The first experiment has clearly shown that a change in the magnetic environment of a coil of wire will result into the production of EMF. An increase in the angular position of such a coil will make the rate of change of the magnetic flux also to increase. As a result of this, there would be an increase in the value of the induced EMF generated by the generator. This also leads to the increase of the frequency of the induced voltage. No matter how the change is produced, a voltage will be produced. This point is what makes both the Faraday’s and Lenz laws so relevant.

The EMF of the first peak is positive. Considering the direction with which the wire is wound around the coil the sign of the induced EMF corresponds to the expected direction if Lenz law is to be followed.

The EMF of the second peak has a sign that is opposite to that of the first peak due to the change in the direction of motion and polarities of magnet as it comes back.

The EMF is observed to be zero when the coil is swinging through the precise center of the magnet. This is because as straight wire cuts the flux, it also sweeps out an area. The value of the flux magnitude is same as that of the magnitude that swings through the swept out area. The moving wire cut a part of the flux contained in the area swept in that time. For a short period, the EMF is zero as the magnet cuts through the exact center. Since, on approach, the direction of the EMF is in an opposite direction to that of the one on separation. Then a point must exist where the EMF would briefly equal zero as it swaps over. [1]

## Part Two

As the angular position of the Simple harmonic motion gets reduced the magnitude of the induced EMF also reduces accordingly. This means that the induced EMF is directly proportional to the angular position. As the pendulum swings into the magnets' gap it experiences a $\Delta\Phi/\Delta t$ as a motional EMF generated by the gap field B. Consequently, a current that opposes the gap field, known as eddy currents, are induced in the plate, conforming to Lenz's law. The relationship that has been shown between the position of the simple harmonic motion and the induced EMF has been able to show the relevance of the Faraday and Lenz law. It also verifies the unique effect of the magnet on the motion of the pendulum.

Since the power loss through the resistor has been shown to decrease exponentially as e-αt and α= 2(R/L). Then the loss rate must be proportional to -2(R/L). This means that the power lost through the resistor is proportionally related with that of the pendulum's motion.

# CONCLUSIONS

A voltage is induced in a coil swinging through a magnetic field. Faraday's Law and Lenz' Law has been examined and the energy dissipated in a load resistor has been compared to the loss of amplitude of the coil pendulum. The experiment has provided me the opportunity to model the magnetic flux and induced voltage and to acquire results that remarkably concur with both the Faraday's and Lenz laws. The induced EMF stated by Faraday and the reason for the minus sign added to it by Lenz has been duly justified experimentally. Also, the concepts of magnetic flux and that of the conservation of energy have been duly experimented.

# References

[1] Faraday's Law, In Physics for Scientists and Engineers 2013, pp. 935-970.

[2] R. Kingsman, C. Rowland, & S. Popescu, An Experimental Observation of Faraday’s Law of Induction. Am. J., 2002, 595.

[3] M. N. Sadiku, Elements of Electromagnetic. New York: University Press, 2007.