Physics Laboratory Report

Lab Number and Title: Lab 223: Faraday's Law

Name: Sundeep Singh **Group Number:** 8

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Course & section number: Physics 121A-010 **Instructor's Name:** Kai Qian

Partner's names: Saga Elsekhely, Redhwan Rahi, Katherine Thai

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Introduction:

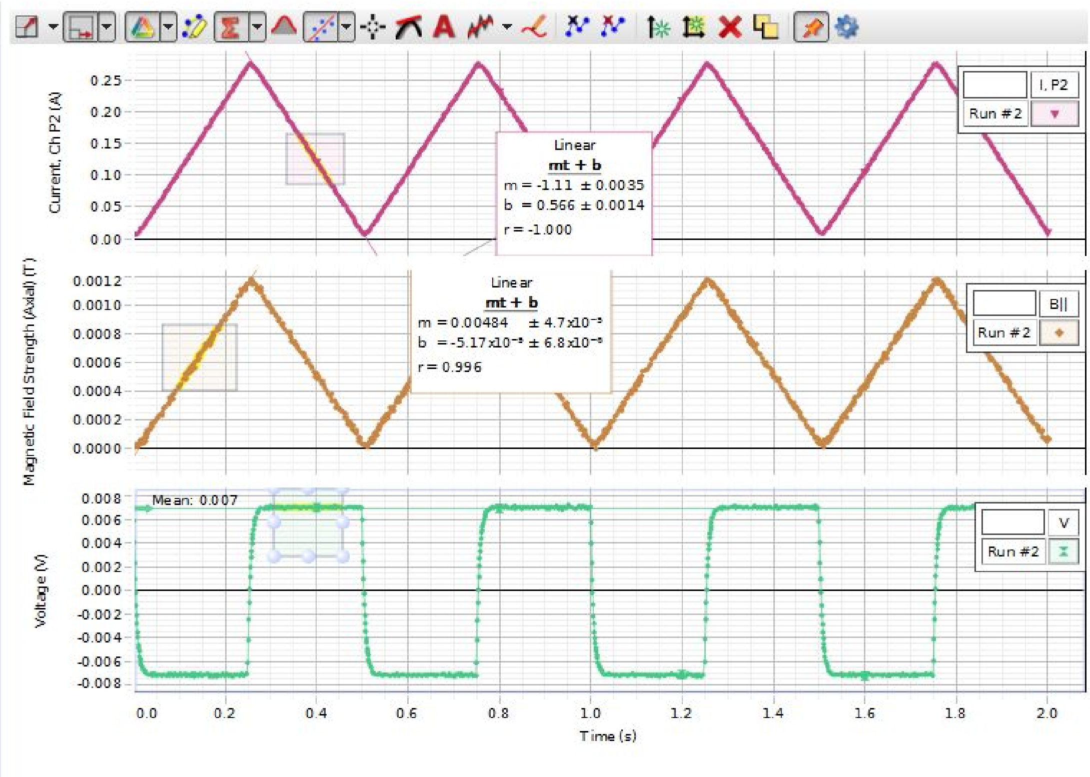
In Lab 223, the objective was to demonstrate Faraday's law of electromagnetic induction. Additionally, a second objective was to become familiar with the concepts of changing magnetic flux and induced current associated with Faraday's Law of Induction. In theory, Faraday's law of induction states that a changing magnetic flux through a coil generates an electromotive force in the wire, which is called electromagnetic induction.

Experimental Procedure:

The procedure for this lab was more involved compared to some of the previous labs. The first step was to make sure that equipment was set up correctly and that the wires are connected in the right places. For the Helmholtz Coil, the average radius and number of turns was given. Similarly, for the Small induced coil, the cross sectional area and number of turns was given. After logging onto the computer and opening up the file, "Lab 223 Faraday Law of Induction", the magnetic field sensor was zeroed out. On the computer under the measurements page, the frequency was set to 2 Hz, amplitude set to 5V, and voltage offset to 5V. After clicking the record button, the current, magnetic field strength, and induced emf was all recorded in the computer. This was done once again with the frequency set to 4 Hz. For the data given, slope in current vs time graph, slope in magnetic field strength vs time graph, and experimentally measured emf was calculated using the analyze tools.

Results:

2 Hertz:



4 Hertz:

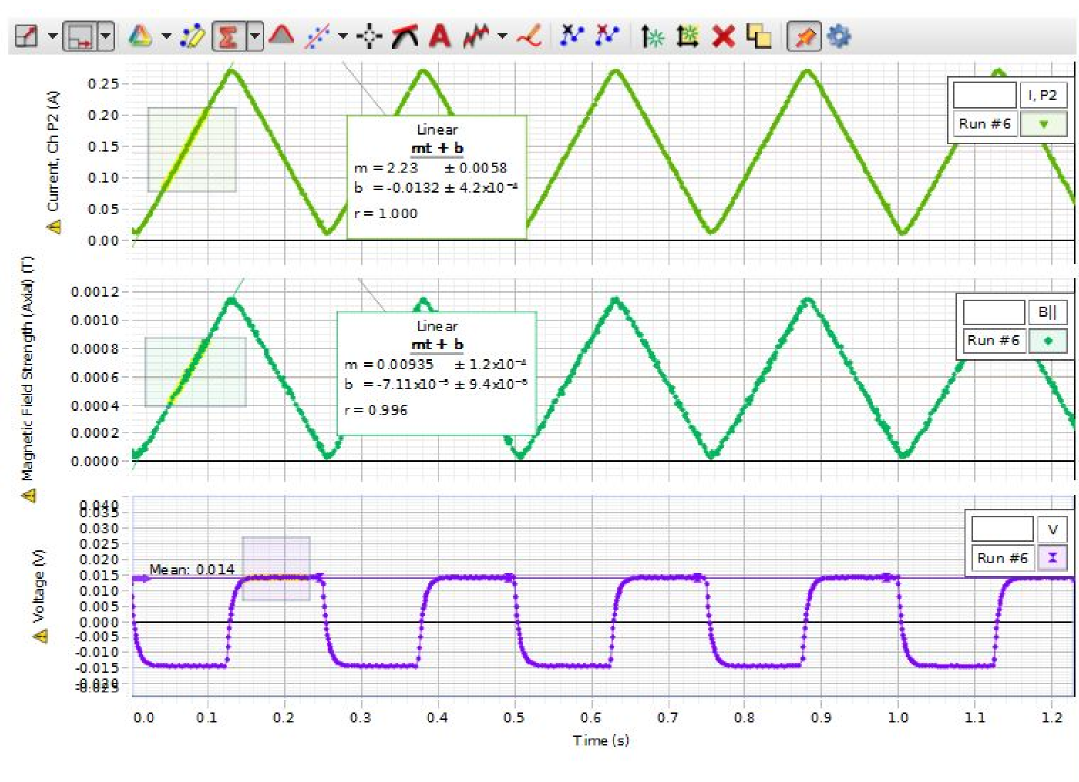


Table 2.

	Frequency = 2 Hz	Current increase region	Current decrease region
1	$\frac{dI(t)}{dt}$: Slope in current vs. time graph [A/sec]	1.11	-1.11
2	$emf: \varepsilon = -8.992 \times 10^{-7} (NA)(\frac{N_h}{R})\frac{dI(t)}{dt}$ [V]	-0.0068	0.0068
3	$\frac{dB(t)}{dt}$: Slope in magnetic field strength vs. time graph [T/sec]	0.00484	-0.00484
4	$emf: \varepsilon = -NA\frac{dB(t)}{dt}$ [V]	-0.00707	0.00707
5	Experimentally measured *emf* [V]	-0.007	0.007

	Frequency = 4 Hz	Current Increase region	Current decrease region
6	$\frac{dI(t)}{dt}$: Slope in current vs. time graph [A/sec]	2.23	-2.23
7	$emf: \varepsilon = -8.992 \times 10^{-7} (NA)(\frac{N_h}{R})\frac{dI(t)}{dt}$ [V]	0.00019	0,00019
8	$\frac{dB(t)}{dt}$: Slope in magnetic field strength vs. time graph [T/sec]	0.00935	-0.00935
9	$emf: \varepsilon = -NA\frac{dB(t)}{dt}$ [V]	0.00019	0.00019
10	Experimentally measured *emf* [V]	-0.014	0.014

Calculations:

$\varepsilon = -8.992 \times 10^{-7}(NA)\frac{N_h}{R}\frac{dI(t)}{dt}[V]$

$\varepsilon = -8.992 \times 10^{-7}(2000 \times 7.3 \times 10^{-4})\frac{500}{10.715 \times 10^{-2}} \times 1.11[-0.007] =$ -0.0068

$\varepsilon = -(NA)\frac{dB(t)}{dt}[V]$

$\varepsilon = -(2000 \times 7.3 \times 10^{-4})(0.00484)[-0.007] =$ -0.00707

$$Percent\ Error = \frac{|\varepsilon_{experimental} - \varepsilon_{current}|}{\varepsilon_{experimental}} \times 100 = \left|\frac{-0.007-(-0.0068)}{-0.007}\right| \times 100 = 2.86\%$$

Analysis and Discussion:

1. Comparing the emfs calculated based on $\frac{dI(t)}{dt}$ and $\frac{dB(t)}{dt}$ with the experimentally measured emf, they are extremely close. The percent error between them is also very small. The percent error between the experimental emf and the the emf calculated from $\frac{dI(t)}{dt}$ is 2.86% and the percent error between the experimental emf and emf calculated from $\frac{dB(t)}{dt}$ is 1.00%, showing that the difference is very small.
2. If the small induced coil is positioned at 45 degrees to the Helmholtz coils, the induced emf will possibly decrease because the magnetic field does field does not hit the small induced coil as much since it is not parallel to the helmholtz coils and will not hit the small induced coil head on.
3. The current direction through the Helmholtz coils and the resulting induced current direction through the small coil showed that when perpendicular to the floor, the emf is at a contrast. If the angle of the small induced coil is lowered, this would result in a lower emf as mentioned above. The direction in which the magnetic field hits the small induced coil will determine the emf.

Conclusion:

Through this experiment, we were able to depict how magnetic fields and current act in a situation in which Helmholtz coil is involved. We learned in the experiment that changing just the frequency of the signal generator makes a huge difference. Additionally, we learned in theory how big of a difference it could make to the emf when the small induced coil is rotated 45 degrees