ILLINOIS INSTITUTE OF TECHNOLOGY - PHYS 221 L03

Lab Report - Lab 11: Faraday's Law of Induction

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Introduction

In this lab we explored how Faraday's Law interacts with induction in a conducting loop. A changing magnetic field through a current loop produces an emf in the loop, and using Faraday's Law, we can observe and record how this interaction occurs.

Equations:

1. $$\mathcal{E} = -\frac{d\Phi_B}{dt}$$
2. $$\mathcal{E} = -\frac{d}{dt}(BA\ cos(\theta))$$
3. $$\mathcal{E} = -N\frac{d\Phi_B}{dt}$$
4. $$\mathcal{E} = -NA\frac{\Delta B}{\Delta t}$$

Experimental Methods

For Part 1, a conducting loop was set up to observe Faraday's Law by having a magnet passing through the center of the loop. Connecting a multimeter to the loop while manually moving the magnet through, observe the sign change of the emf by using the voltmeter.

For Part 2, we measured the induced current using an inducting wand, a horseshoe magnet, and PASCO software. The set up will be a pendulum that passes through the magnet, which produces an emf. Record the emf as well as the initial and final times of when the pendulum passes through the magnet.

Results and Discussion

Part 1:

1. When does the sign of the emf change? Does it only depend on whether the North or South side of the magnet is brought near the coil? What happens to the emf if you bring one side of the magnet near the coil and then pass it through to the other side?
    a. The sign of the emf changes when we take the magnet through the center of the coil. To change the signs just turn around the magnet or the loop.
2. What happens if you bring the magnet toward the center of the coil and then suddenly bring it to rest?

    a. The emf is zero because there is no movement that can produce an emf.
3. Does the magnitude of the emf depend on the speed at which the magnet is traveling?
    a. Yes, the magnitude of the emf depends on the speed of the magnet passing through.
4. What orientation of the magnet gives you the largest emf?
    a. Emf is greatest when the south pole approaches the coil
5. Which end of the magnet is north? Verify this using the reference magnet (WARNING pinch hazard! do not bring the reference magnet too close to your magnet).
    a. Using the reference magnet, put both through the loop, and take note of the sign change of the voltage. From there, you can then determine which end of the magnet is north.

Part 2:

Below is Table 1, which contains the angle of release, average emf, and change in time.

Table 1:

Angle of Release	Average EMF (V)	delta t (s)
15	0.031	0.225
15	0.037	0.22
15	0.04	0.23
25	0.058	0.12
25	0.06	0.145
25	0.058	0.16
35	0.078	0.105
35	0.078	0.125
35	0.078	0.12
45	0.102	0.095
45	0.102	0.09
45	0.102	0.11
55	0.112	0.09
55	0.112	0.075
55	0.111	0.095
65	0.133	0.075
65	0.134	0.07
65	0.134	0.08

Questions

1. Why is the sign of the emf of the second peak opposite to the sign of the first peak?
    a. When the magnet enters the coil, it creates a positively changing magnetic field, which means a negative rate of change is caused
2. Why is the emf zero when the coil is passing through the center of the magnetic plates?
    a. Because when close to the magnet the field is uniform, so the rate of change is zero.

3. Calculate the average emf using Equation 4. Compare your calculations to the emf value measured from the graphs.
    a.

Angle of Release	Average EMF (V)	delta t (s)	delta B (T)	avg EMF (eq 4)	% Error
15	0.031	0.225	0.0699	-0.03049962868	1.640581683
15	0.037	0.22	0.0699	-0.03119280206	18.61710895
15	0.04	0.23	0.0699	-0.02983659327	34.06356294
25	0.058	0.12	0.0699	-0.05718680377	1.421999787
25	0.06	0.145	0.0699	-0.04732701002	26.77749973
25	0.058	0.16	0.0699	-0.04289010283	35.22933305
35	0.078	0.105	0.0699	-0.06535634717	19.34571527
35	0.078	0.125	0.0699	-0.05489933162	42.07823246
35	0.078	0.12	0.0699	-0.05718680377	36.39510316
45	0.102	0.095	0.0699	-0.07223596266	41.20390488
45	0.102	0.09	0.0699	-0.0762490717	33.77212041
45	0.102	0.11	0.0699	-0.06238560412	63.49925828
55	0.112	0.09	0.0699	-0.0762490717	46.88703417
55	0.112	0.075	0.0699	-0.09149888604	22.40586181
55	0.111	0.095	0.0699	-0.07223596266	53.66307295
65	0.133	0.075	0.0699	-0.09149888604	45.3569609
65	0.134	0.07	0.0699	-0.09803452075	36.68654569
65	0.134	0.08	0.0699	-0.08578020566	56.21319507

    b. Since the percent error values are relatively small or mediocre, ranging from 1.64% to as high as 56.213%, and seeing little discrepancies within the values, we know that our data is relatively accurate. The error that present could be due to improper readings from the PASCO software or a possible calculation error.

Conclusion

Through the usage of magnets and current loops, we were able to see how emf were produced by moving a magnet through the current loop by using Faraday's Law of Induction. By conducting two different experiments of sliding the magnet through the current loop via by hand and by pendulum, we were able to verify that Faraday's Law of Induction does hold true.