Course and Section________ Names ______________________________

Date____________ ____________________________________

INDUCED EMF PH 102 EXPERIMENT

Introduction

The purpose of this experiment is to study how currents can be induced in conductors by the presence of magnetic fields that change with time.

Equipment

Galvanometer, larger solenoid, two banana cables, bar magnet.

Theory

According to Faraday's Law of induction a changing magnetic field induces an electric field. For a solenoid of N loops the induced emf ΔV is proportional to the number of turns N and to the rate at which the magnetic flux is changing

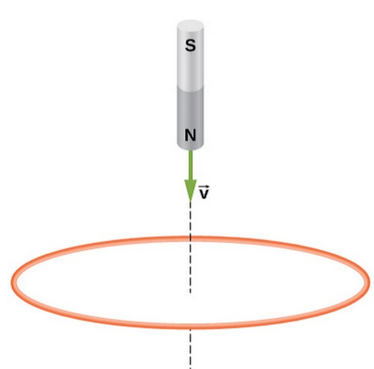
$$\Delta V = -N\frac{\Delta \Phi_B}{\Delta t}$$

where $\Phi_B = BA\cos\theta$ is the total flux: B is the magnetic field strength, A is the area of the coil, and θ is the angle between B and the normal to the coil area. The minus sign (Lenz's Law) indicates that the induced current produces an induced magnetic field which opposes the change in flux.

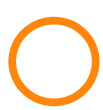
The galvanometer is device very sensible in the measuring of currents.

Preliminary Questions

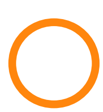
A bar magnet is dropped, north pole down, so that it falls through a circular piece of wire as shown. As you see it from above,



1. draw the direction of the induce current before it passes through?



2. draw the direction of the induce current after it passes through?



PART 1 – Solenoid and Bar Magnet

Procedure

Step 1. Connect the solenoid to the galvanometer (G) as shown in Fig. 1 below.

Step 2. Thrust the N-pole of the bar magnet in and out of one end of the solenoid.

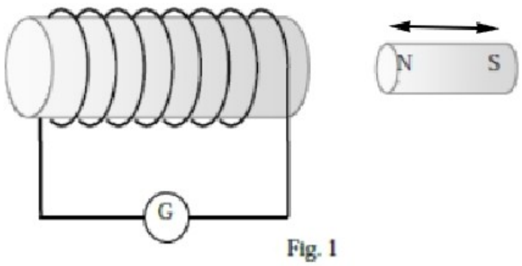


Fig. 1

3. Does the galvanometer read a current when the magnet is moving?

4. Does the galvanometer read a current when the magnet stay at rest inside the solenoid?

5. How does the intensity of the current depend on the speed of the magnet?

6. How does the direction of the the current depend on the direction in/out of the magnet?

7. Reverse the magnet, S pole to enter the solenoid. How are the directions of the current when compared to the previous question?

Step 3. Move the bar magnet back and forth outside to the solenoid as shown in Fig. 2 to the right. Move it along the direction parallel to the axis of the solenoid.

8. Describe the reading of the galvanometer

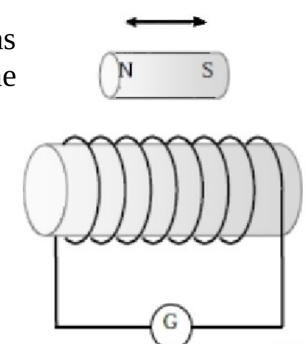


Fig. 2

Step 4. This time hold the magnet stationary and move quickly the solenoid back and forth toward the bar magnet

9. Does the galvanometer read a current?

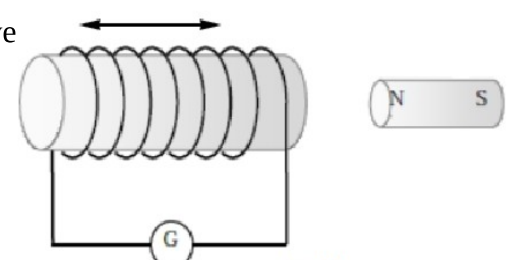
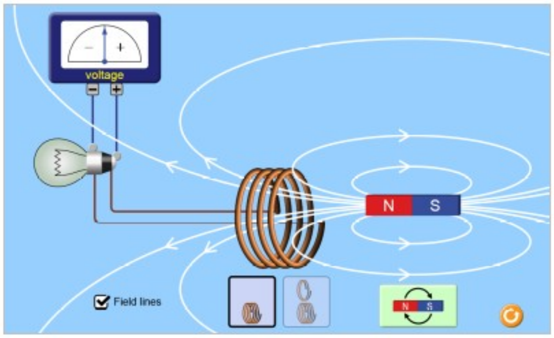


Fig. 3

Step 5. Open the simulation (https://phet.colorado.edu/en/simulation/faradays-law).



10. What happens to the voltage as the *N* pole moves in and out the coil from the right?

11. How does your answer to the question above compares to your answer to question 3?

12. Reverse the magnet, *S* pole to enter the solenoid. How are the signs of the voltage compares to question 10?

13. If the magnet moves at a slower speed than in question 12, how is the voltage different?

14. Use this simulation to move the bar magnet back and forth outside to the solenoid as shown in Fig. 2. Move it along the direction parallel to the axis of the solenoid. Compare the your simulated observations with your experimental observations of step 3.

15. What happens to the light bulb when the magnet goes up and down outside the coil?

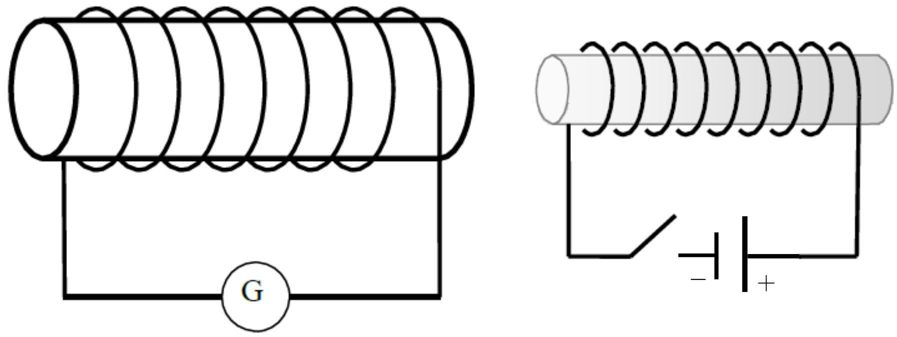
16. What happens to the light bulb when the magnet goes up and down inside the coil? (make sure that the magnet is in the center of the coil and only moves a small distance up and down. Do not touch the coil with the magnet).

Put the magnet inside the coil and spin it several times.
17. What happens to the voltage?

18. What type of current is produced?

PART 2 – Mutual Inductance

The figure below shows on the left a solenoid connected to a galvanometer (G). On the right another solenoid connected to a battery.



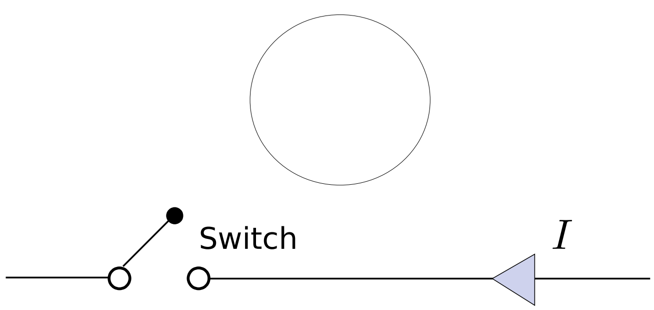
19. Which end of the coil with the battery becomes the North pole if the switch is closed?

20. Which end of the coil with the galvanometer becomes the North pole if the switch is closed?

21. What will be the direction of the current through the galvanometer (G) immediately after the switch connecting the battery is closed?

PART 3 - Ampere and Faraday

A loop of wire is place above a long straight wire which has a switch. The switch is suddenly closed and a current *I* flows through the wire toward the left.



22. What is the direction of the *B* field generated by the straight wire in the center of the loop?

23. What is the direction of the induced *B* field in the center of the loop?

24. What is the direction of the induced current in the loop?

25. What is the direction of induced *B* field on the straight wire?

26. What is the direction of the magnetic force acting on the straight wire?