Lab 9: Electromagnetic Induction

You will work on this lab with your regular group partners. Use google hangouts, facebook messenger or any other tool that allows you to communicate in real time. Submit your lab report as you normally do using google docs, but this time it will be a group report. Please at the end of the report indicate contributions of individual people. The report will be graded using rubrics F1 and F2 for every experiment.

RUBRIC F: Ability to communicate scientific ideas					
	Scientific Ability	Missing	Inadequate	Needs improvement	Adequate
F1	**Is able to communicate the details of an experimental procedure clearly and completely**	Diagrams are missing and/or experimental procedure is missing or extremely vague.	Diagrams are present but unclear and/or experimental procedure is present but important details are missing. It takes a lot of effort to comprehend.	Diagrams and/or experimental procedure are present and clearly labeled but with minor omissions or vague details. The procedure takes some effort to comprehend.	Diagrams and/or experimental procedure are clear and complete. It takes no effort to comprehend.
F2	**Is able to communicate the purpose of the experiment clearly and completely**	No discussion of the purpose of the experiment is present.	The experiment and findings are discussed but vaguely. There is no reflection on the quality and importance of the findings.	The experiment and findings are discussed adequately but reflection on their quality and significance is minimal.	The experiment and findings are discussed clearly. There is deep reflection on the quality and importance of the findings.

Learning goals of this lab:

1. Use video experiments to devise and test a rule for inducing electric current in a coil that is not connected to a battery.
2. Use video experiments to devise and test a rule for the direction of the induced current through a coil that is not connected to a battery.

I. OBSERVATIONAL EXPERIMENT: HOW TO INDUCE A CURRENT IN A COIL NOT CONNECTED TO A BATTERY

The goal of this experiment is to observe 2 sets of videos to find a pattern for the conditions under which there is a current through a coil of wire that is not connected to a battery.

Available equipment: Video experiments at https://mediaplayer.pearsoncmg.com/assets/_frames.true/sci-phys-egv2e-alg-21-1-1

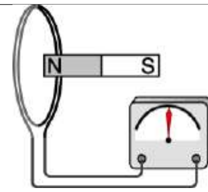
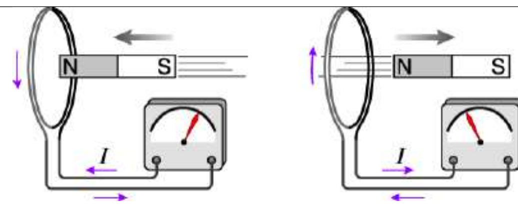
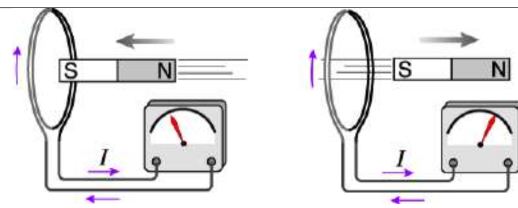
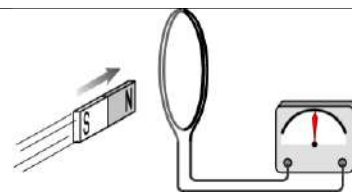
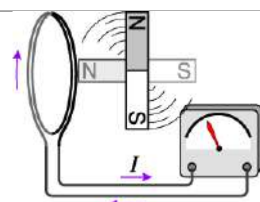
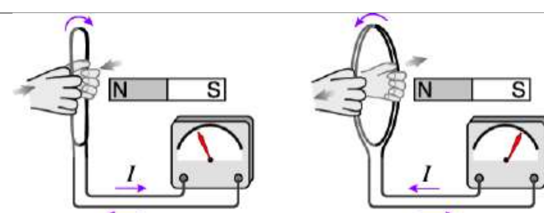
and at http://islephysics.net/pt3/experiment.php?topicid=10&exptid=91

a) Before you proceed watching the experiments, review what a galvanometer is. A galvanometer is a device that registers electric current through it. It has a coil connected to an arrow with a spring, and a magnet (look at the photo on the right to identify these elements). When the current flows through the coil, the magnet exerts a torque on it and the coils starts turning pulling on the spring. The spring exerts an opposite torque on the coil. When these two torques are equal in magnitude, the coil stops rotating and the arrow attached to it shows a reading on the scale. The larger the current, the more force the magnet exerts on the coil, the greater the magnetic torque, the larger deflection of the arrow. As the current can flow in two directions, the scale of the galvanometer is set up with the zero in the middle, so that the needle can deflect to the right and to the left. The video of the device and its calibrations is at http://islephysics.net/pt3/experiment.php?topicid=10&exptid=90

b) After you learn how a galvanometer works, view both videos listed in the *Available equipment* and record your observations. How many patterns can you identify in each video? Are these patterns the same in both videos or there is a difference?

c) Using the patterns in both experiments devise a preliminary rule that summarizes the condition(s) needed to induce a current in a coil. Write it in your report.

d) Examine more experiments in the table below. Is your rule consistent with their outcomes? Explain.

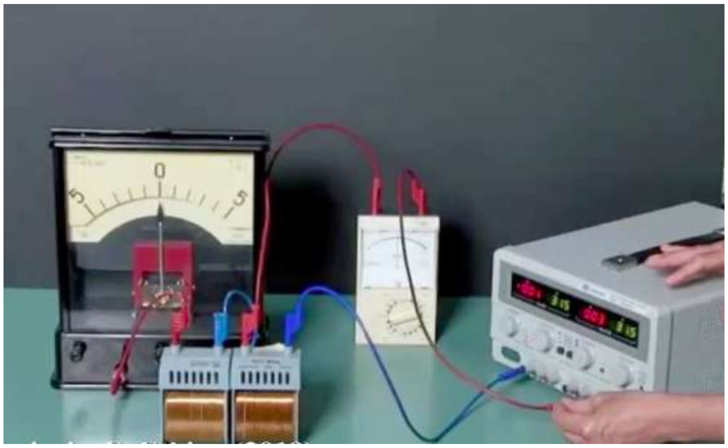
Experiment	**Illustration**
Experiment 1: Hold the magnet motionless in front of the coil, with any orientation.	
Experiment 2: Hold the magnet perpendicular to the coil with the N pole facing the coil. Move the magnet quickly toward the coil. Then pull it away quickly.	
Experiment 3: Repeat experiment 2, but this time with the S pole facing the coil.	
Experiment 4: Align the magnet in the same plane as the coil, and move either pole toward or away from the coil.	
Experiment 5: Hold the magnet in front of the coil and rotate it 90° as shown. (The magnet starts out perpendicular to the coil and ends up parallel to it.)	
Experiment 6: Position the magnet as in experiment 2, but this time grasp the sides of the coil and collapse the coil quickly. Then pull it back open.	

II. TESTING EXPERIMENT: IS MOTION NECESSARY FOR INDUCING ELECTRIC CURRENT IN A COIL NOT CONNECTED TO A BATTERY?

The goal of this experiment to test the rule you invented in Experiment I.

Available equipment: Video experiments at https://mediaplayer.pearsoncmg.com/assets/_frames.true/sci-phys-egv2e-alg-21-1-2]

a) This time you have two coils: one (coil A on the left) connected to a large galvanometer and one (coil B on the right) connected to a power supply and current indicator (another small galvanometer). Use the rule you invented in Experiment I to predict what happens to the reading of the galvanometer connected to coil when two coils are positioned next to each other as shown in the photo below:



Experiment 1. Use the rule devised in Experiment I to predict what will happen if you move coil 1 relative to coil 2.

Experiment 2. Use your current rule to predict what will happen if you place a coil connected to a galvanometer next to the coil connected to the battery/power supply (so that axis of the coils coincide) and (1) close the switch without moving either coil, then (2) let the current run for a period of time, and then (3) open the switch.

b) Now watch the videos of the experiments at https://mediaplayer.pearsoncmg.com/assets/_frames.true/sci-phys-egv2e-alg-21-1-2

Did the outcomes match the predictions? If not, how do you need to revise the rule? Propose a revised rule here.

c) Now open the textbook on page 650, Section 21.1 of Chapter 21. Read the section very carefully and answer Review Question 21.1. Write your answer here.

III. OBSERVATIONAL EXPERIMENT: WHAT AFFECTS THE DIRECTION OF THE INDUCED CURRENT?

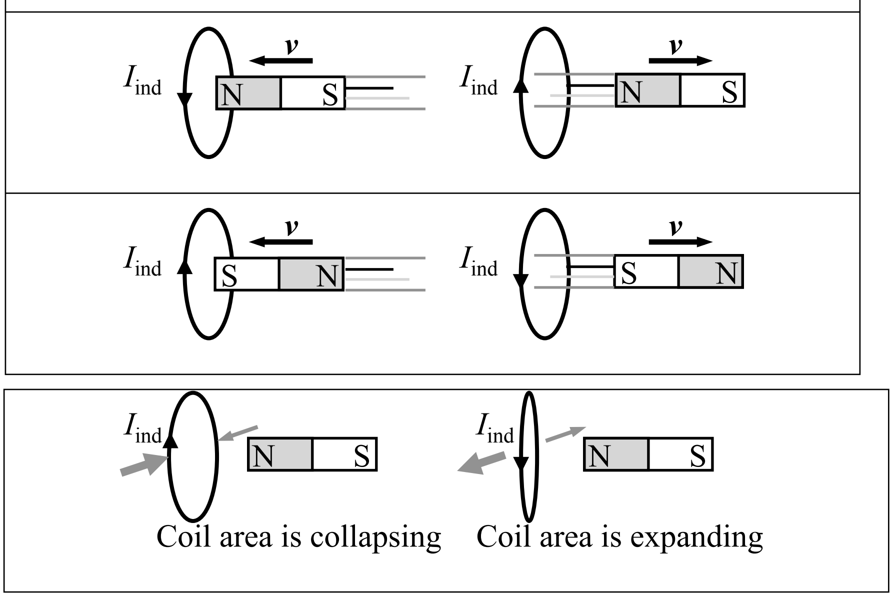
The goal of this experiment is to decide what factors affect the direction of the induced current

Available equipment: video at http://islephysics.net/pt3/experiment.php?topicid=10&exptid=123
a) Read the description of the experiments below to find a relationship between the changes in the external magnetic field through a coil and the direction of the induced current through it.

The experiments repeat earlier experiments that used a galvanometer, a bar magnet, and a coil and in which a current was induced. The direction of the induced current is shown in the illustrations.

a. Analyze the 6 experimental scenarios in the table below. For *each* case, in your notes, draw $\vec{B}_{\text{ext}}$ field vectors through the coil caused by the moving magnet. Indicate whether the external B field vectors through the coil are decreasing or increasing in length. Draw induced magnetic field vectors $\vec{B}_{\text{ind}}$ created by the induced current in the coil.

Experiments:



b) Use the data in your notes to devise a rule relating the direction of the induced current in the coil and the change of external magnetic flux through it. *Hints:* (1) Focus on the direction in which $\vec{B}_{\text{ext}}$ is changing rather than the direction of $\vec{B}_{\text{ext}}$ itself. (2) Compare the direction of the induced magnetic field vectors $\vec{B}_{\text{ind}}$ in relation to $\Delta\vec{B}_{\text{ext}}$.

c) Formulate a general rule: How does the direction of the induced current in a coil relate to the *change* of external magnetic flux through it?

d) Watch the video at http://islephysics.net/pt3/experiment.php?topicid=10&exptid=123

Explain whether the rule you created is consistent with the outcomes of the experiments in the video. Provide the details from the video to support your argument.

e) Read parts of the Section 21.3 on pages 656-657 and answer Review Question 21.3