**Magnetic Field Mapping and Induction Name: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_**

**Course:\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_Time:\_\_\_\_\_\_\_\_\_\_    Partner(s):\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_**

1. **Magnetic Field Lines**

Purpose: To map the magnetic field lines of permanent magnets.

Apparatus: Two magnets: bar & horseshoe, compass, sheets of white paper, and card-board.

Procedure:

1. Place a sheet of paper on the lab table, place a bar-magnet on it, trace the outlines of the magnet, and identify the poles (N and S) of the magnet.
2. Draw a dot somewhere near the magnet and place the center of a compass over the dot.
3. Draw a dot at the location of the arrow head (or tail) of the compass needle.
4. Move the compass center to this new dot, and again draw a dot at the location of the compass needle head (or tail).
5. Repeat steps 4-5 until the line meets the magnet or paper’s edge.
6. Remove the compass from the paper and draw a line connecting the dots with arrows indicating the direction of the magnetic field, N to S.
7. Pick another spot near the magnet and repeat the process (steps 2-6).



1. Repeat the above procedures for a horse-shoe magnet.
2. **Electromagnetic Induction**

**Purpose:** Investigate the electromotive force (emf) induced in a solenoid by a moving magnet.

**Apparatus:** PC w/interface (Pasco 850), voltage sensor, solenoid (# of turns =540), magnets (bar and horse-shoe), and soft-box (to catch the magnet).

**Theory:**

When a magnet is passed through a coil there is a changing magnetic flux through the coil which induces an electromotive force, emf. According to Faraday's law of induction the induced emf, *ξ* is given by; where *B*┴ is the magnetic field perpendicular to the area *A* and *N* is the number of turns in the coil.



In this activity, a plot of the emf *versus* time is made and the area under the curve represents the magnetic flux.  
  
  
Pasco Capstone display menu descriptions:



1. Maximize graph (Scale axes to show all active data)
2. Automatically scale axes during data collection.
3. Select visible runs.
4. Select ranges of data.
5. Statistics.
6. Display area under active data
7. Curve fitting.
8. Show coordinates tool.
9. Determining slope.
10. Annotation.
11. Add new Y-axis.
12. Add new plot area.
13. Remove data.

**Procedure:**

1. Setting up the Interface:   
a. Make sure that the power for the interface is turned on.  
b. Connect the voltage sensor to analog input A.  
c. Plug in the red and black leads from the voltage sensor to the solenoid and place the solenoid vertically on the lab table.  
d. Open **PASCO Capstone** software from the desktop.   
e. Click **File** (top-left corner), click **Open Experiment**, click the drop-down menu for **Files of type**, and choose **DataStudio 1.9 files**, open **P30\_Induction.ds** from desktop, and OK **USB 850 interface.**f. Click **Data Summary** on the left, click **Voltage (V)**, click on the **gear symbol** on the right, under Numerical Format change the fixed decimals to 3. Click **Data Summary** again to close it.  
g. In the Voltage Graph display (bottom-middle) increase the sample rate to 200 Hz.  
2. Place one side of the horse-shoe magnet inside the solenoid.

3. Click **Record** and remove the horse-shoe magnet.

4. If nothing is displayed; stop the data collection, place the other side of the horse-shoe magnet and try Procedure (3) again.

5. Maximize the graph display.

6. Measure the peak value of the induced voltage using the **Show Coordinates Tool** and the magnetic flux (area under the V vs. t graph) using the **Display area under active data tool**.

7. Repeat procedures 4-6, for removing the magnet quicker, and complete the data table for the horse-shoe magnet.

8. Place the soft-box on the floor close to the edge of the table and hold the solenoid vertically above it.

9. Click **Record** and drop the bar magnet, N-pole down, through the solenoid.

10. The data collection will stop automatically. You should see two peaks.

11. Magnetic flux is obtained by finding the area under the V vs. t graph.

12. After completing the data tables, and answering the questions, close Pasco Capstone, and write a conclusion.

DATA: a. Horse-shoe magnet

|  |  |  |
| --- | --- | --- |
|  | Slow removal | Quick removal |
| Peak value of the induced emf |  |  |
| Magnetic flux (Area under the V vs. t graph) |  |  |

Q1. Why the magnitude of the peak value of the induced emf is higher for the quick removal?

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Q2. Is the magnitude of the magnetic flux equal for the two peaks? Explain why.

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Q3. Calculate the average magnetic field strength, B for the horse-shoe magnet by assuming the following properties for the solenoid: number of turns in the solenoid is 540 and the diameter is 4 cm. (Magnetic Flux = N∙B∙A)

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b. Bar magnet:

|  |  |  |
| --- | --- | --- |
|  | First Peak | Second Peak |
| Peak value of the induced emf |  |  |
| Magnetic flux (Area under the V vs. t graph) |  |  |

Q1. Is the magnitude of the magnetic flux equal for the two peaks? Explain why.

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Q2. Why the magnitude of the peak value of the induced emf is higher for the second peak?  
  
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Q3. Describe how the display will change if the S-pole is down when the bar magnet is dropped.

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Q4. Click Start again and drop the bar magnet, this time S-pole down, through the solenoid. Describe and explain what you see. Does this support your prediction in Q3?  
  
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Conclusion: