STUDENT WORKSHEET

FUNDAMENTAL FORCES OF NATURE (CERN)

Investigating Electromagnetism

INTRODUCTION

In the *Searching* series video clip you just watched as a class, Dr. Alan Lightman talks to scientists performing particle physics research at CERN, where they use some of the largest, most sophisticated technology in existence to probe the smallest, most fundamental structures of our universe. Today you will use common household objects to explore the effects of one of those forces: electromagnetism.

OBJECTIVE

In this lesson, you will perform three short activities demonstrating electromagnetic force, recording your findings in sketches and observational statements. After the lab, you'll reflect on your experimental process and explore the value of science with no practical application.

ACTIVITY 1: MAGNETIC FIELD LINES

MATERIALS

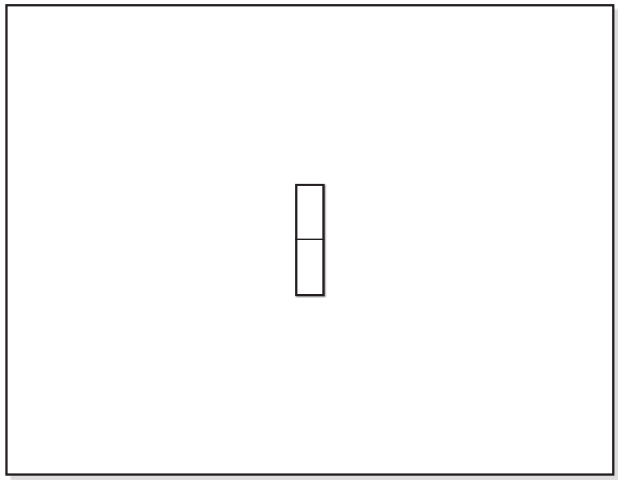
- Clear plastic sheet protector
- Iron filings
- Sheet of plain white paper
- Tape
- 2 bar magnets
- Directional compass

PROCEDURE

1. Place the white paper on a work surface and lay one bar magnet flat on top of it, oriented vertically.
2. Sprinkle iron filings into the sheet protector and tape the top shut.
3. Lay the sheet protector on top of the magnet and gently shake the sheet protector to distribute the iron filings then tap the sides until the filings align in a pattern.
4. Record your observations.
   a. Sketch the pattern you see in the "Observe and Record" section below.
   b. Being careful not to touch the magnet, move the compass around the magnet, over the lines created by the iron filings. Determine which side of the magnet the compass points toward and label it North on your sketch. Label the other side South.
5. Experiment with different orientations. Turn the magnet on its side or stand it up on one end. Be sure to keep the sheet protector flat above the magnet.

OBSERVE AND RECORD

One Bar Magnet



1. Describe the pattern the iron filings make around the magnet. These patterns are called **field lines**. Where do these field lines appear to be the strongest?

2. Why do you think the iron filings created patterns around the magnet?

Two Bar Magnets

Before you experiment, make a prediction about the orientation of the field lines for each scenario below. Sketch your predictions, then set up each scenario pictured and sketch the field lines you are able to observe from the iron filings.

	SCENARIO 1	SCENARIO 2
Prediction	N / S N / S	N / S S / N
Observation	N / S N / S	N / S S / N

3. **Compare and contrast your prediction sketches to your observation sketches for each scenario. How well did you predict the pattern produced by the field lines?**

4. **Compare and contrast the patterns produced by Scenario 1 to the patterns produced by Scenario 2. How are they the same? How are they different? Why?**

ACTIVITY 2: STATIC ELECTRICITY

MATERIALS

- Latex balloon
- Tissue paper (cut into a few small pieces)

PROCEDURE

1. Inflate and tie off the balloon, then rub it on your head for about 30 seconds.
2. Hold the balloon high over the pieces of tissue paper and slowly lower it towards them. Record your observations in the Observe and Record section below.

OBSERVE AND RECORD

1. Describe what happened as you lowered the charged balloon over the tissue paper.

2. What do you think happened when you rubbed the balloon on your head? Compare and contrast the way the balloon attracted objects with the magnet in the first activity. How might they be related?

ACTIVITY 3: ELECTROMAGNETIC INDUCTION

MATERIALS

- PVC pipe (1-1.5" diameter, 1 foot length)
- Insulated copper wire
- Galvanometer
- Pencil
- Bar magnet

PROCEDURE

1. Strip the insulation from about 2 centimeters off one end of the wire.
2. Leaving a tail of about a foot, start wrapping the wire around the PVC pipe. Continue wrapping the wire in tight coils around the PVC pipe until you have around 100 coils.
3. Leaving another tail of about a foot, clip the end of the wire and remove the insulation from about 2 centimeters off this end of the wire.
4. Connect each end of the wire to the galvanometer, one end to the positive and the other to the negative.
5. Watching the galvanometer needle, pick up a pen or pencil and drop it through the pipe. Insert the pencil into the pipe quickly then pull it back out quickly. Record your observations below (Question 1).
6. Watching the galvanometer needle, drop the magnet through the pipe. Insert the bar magnet into the pipe quickly then pull it back out quickly. Watch the galvanometer needle. Record your observations below (Question 2).
7. Flip the magnet over and perform step 4 again. Watch the galvanometer needle. Record your observations below (Question 3).

OBSERVE AND RECORD

1. Describe what happened as you moved the pencil into and out of the pipe. Did the galvanometer needle move?

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2. Describe what happened as you moved the magnet into and out of the pipe. Did the galvanometer needle move? Which way?

3. Describe what happened when you flipped the magnet over. Compared to your last trial, what was different about the way the needle moved on the galvanometer? What was similar?

4. Why do you think the magnet was able to move the needle on the galvanometer but the pencil was not?

5. **Why do you think the behavior of the needle changed when you flipped the magnet?**

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CONCLUDE AND REFLECT

Using the questions below to guide your thoughts, reflect upon your experience during this lab. Jot down any thoughts in the space below and prepare to share your thoughts in a group discussion.

1. **What have you learned about electromagnetic fields from these activities?**

2. **How is electricity connected to magnetism?**

3. **Electromagnetic forces, in the form of radio waves, are passing through our bodies all the time. Can you feel them?**

4. **Why do you think physicists are interested in finding the fundamental forces of nature?**

5. **These huge machines, like CERN, designed to understand the fundamental forces and particles of nature, cost billions of dollars, yet have few – if any – practical applications. Do you think our society can justify spending so much money on such machines?**

6. **What do you think is the motivation of the scientists who work at CERN?**