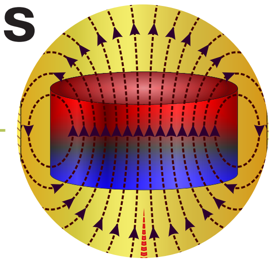
Investigating Interactions Between Electric and Magnetic Fields

A Carolina Essentials™ Activity



Overview

A foundational concept in physics is the relationship between electricity and magnetism. Common devices such as electric motors and generators apply the relationship between electric and magnetic fields. The forces producing the fields are so intertwined that we usually refer to the relationship as electromagnetism.

This activity offers a visual way for students to investigate the relationship between electrical conductors producing electric fields and magnetic fields. By taking time data for neodymium magnets falling through copper, aluminum, and PVC pipes, students identify variables contributing to the existence, strength, and interactions of electric and magnetic forces.

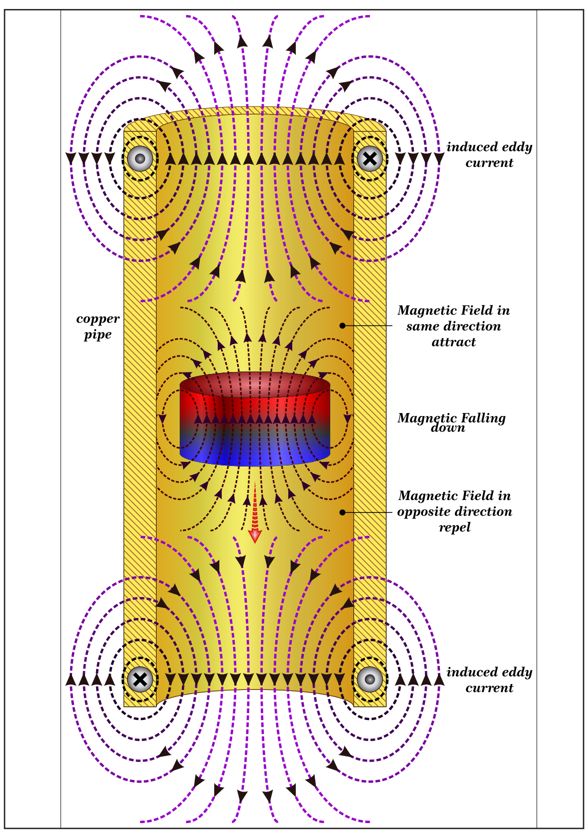
Physical Science, Physics
Grades: 6–8

Phenomenon

As a demonstration, set up identical lengths of these pipes: copper, aluminum foil tube, and PVC. Simultaneously drop a metal nut from the top of each pipe. The nuts should fall at the same velocity and hit the bottom at the same time. This demonstration helps students focus on the relationship between the magnetic field and the material from which the pipe is made.

Essential Question

How do electric and magnetic fields interact?



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TIME REQUIREMENTS

PREP	ACTIVITY
30 min	30–45 min

Teacher Prep: 30 min
Student Activity: 30–45 min

SAFETY REQUIREMENTS

No PPE is required for the activity.

MATERIALS (PER GROUP)

2–5 neodymium round magnets, $1/2 \times 1/4$ in

Stopwatch or smartphone timer

Copper pipe (same length as the aluminum foil tube × $1/2$ in outside diameter)

Aluminum foil tube (at least half a roll)

PVC pipe (same length as the aluminum foil tube × $1/2$ in outside diameter)

Support stand

Utility clamp

HELPFUL LINKS

Engineering an Electromagnetic Train

Making Audio Speakers from Household Materials

AM Crystal Radio Kit

REFERENCE KITS

Carolina® Introduction to Electromagnetism Kit

CAROLINA®
www.carolina.com

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Objectives

1. Conduct an investigation to gather data for a magnet interacting with 3 different materials.
2. Use data to explain the interaction of magnetic and electric fields.

Next Generation Science Standards* (NGSS)

MS-PS2-5. Conduct an investigation and evaluate the experimental design to provide evidence that fields exist between objects exerting forces on each other even though the objects are not in contact.

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Planning and Carrying Out Investigations • Conduct an investigation and evaluate the experimental design to produce data to serve as the basis for evidence that can meet the goals of the investigation.	**PS2.B: Types of Interactions** • When two objects interacting through a field change relative position, the energy stored in the field is changed.	**Cause and Effect** • Cause and effect relationships can be suggested and predicted for complex natural and human-designed systems by examining what is known about smaller scale mechanisms within the system.

Safety Procedures and Precautions

The neodymium magnets are strong. Keep your fingers and hands from between the magnet and other magnetically attractive bodies.

Teacher Preparation and Disposal

Purchase the pipe materials and precut the pipes into lengths that match the lengths of the aluminum foil tubes. Lightly sand the ends of the pipes to remove any burrs. Secure the pipes and aluminum foil tube with a clamp to a ring stand for more precise timing. The bottom edge of the pipes and tube should be 15 to 20 cm above the desk to facilitate timing).

Cushion the fall of the magnets with folded towels, paper towels, bubble wrap, or foam packing material placed directly under the pipes and tube. Neodymium magnets chip easily. All materials can be reused. You will need 3 nuts for the phenomenon demonstration (outside diameter of less than $^1/_2$ in).

Student Procedure

1. Place a pipe in the clamp attached to the support stand. The bottom edge of the pipe or tube should be 15 to 20 cm above the base of the support stand.
2. Add a cushion made from a folded towel, paper towels, bubble wrap, or foam packing material directly under the pipe or tube.
3. Place a magnet at the top edge of the pipe or tube.
4. Drop the magnet down the center of the tube.

Teacher Preparation and Tips

Set up the pipes and tube, secured in support stands, with cushions underneath to catch the nuts. Put some talcum powder on the cushion prior to releasing the nuts so there is a visual indicator of when the nut hits the cushion. Release a nut down the center of the pipes and tube at the same time. Have students write down their observations. You may need to repeat the procedure several times. All nuts should fall at the same rate with no force interactions.

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Student Procedure continued

5. Measure the time, in seconds, it takes for the magnet to fall the length of the tube.
6. Repeat the procedure for a total of 5 trials.
7. Experiment with additional numbers of magnets, recording the number of magnets used and the time in seconds.
8. Complete the same procedure for the other 2 pipes.
9. Your teacher may make a class data table to record all group data.

Teacher Preparation and Tips

To reduce time, you may want to set up stations. Set up one type of pipe per station and instruct students to rotate through them. If materials allow, students can also work in groups of 3.

Make certain that the pipes are measured correctly, using the aluminum foil tube as a standard.

You may want to set up a class data table to increase the number of trials. Ask students to average the data.

Data and Observations

Construct a data table for 5 trials on each of the 3 types of pipe material. ***Student data will vary slightly.***

Data and Observations

Time for 1 magnet to fall (s)

Trial	Alumninum	Copper	PVC
1			
2			
3			
4			
5			
Additional Magnets			

Average the total time for the magnet to fall over the 5 trials for each type of pipe. ***Answers will vary, but all groups should have similar data.***

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Analysis and Discussion

1. Which type of pipe or tube interacted most strongly with the magnet? What evidence supports your claim?

	Electrical conductivity (10.E6 Siemens/m)
Silver	62.1
Copper	58.7
Gold	44.2
Aluminum	36.9

   Copper slowed the magnet the most, so it produced the strongest electric field to interact with the magnetic field. See the electrical conductivity table above.

2. Which type of pipe or tube interacted the least with the magnet? What evidence supports your claim?

   The PVC pipe. It had no effect on the time it took the magnet to fall.

3. Explain which pipes or tube are most likely electrical conductors. What evidence supports your claim?

   Copper and aluminum are electrical conductors. Both pipes increased the time for the magnet to fall. See the conductivity table above.

4. Explain whether the number of magnets made a difference in the time.

   More magnets create a stronger magnetic field strengthening the opposing interacting forces, increasing the time it took the magnet to fall.

5. Using your data as evidence, explain the interaction between electric and magnetic forces.

   There are opposing forces, the magnetic and electric fields, interacting between the magnet and the copper and aluminum pipes, which increases the time it takes for the magnet to fall. This is Lenz's law.

6. Using the same materials, how could this experiment be modified to collect additional data to support the claim you made in item 4?

   Student answers will vary. Here are some suggestions:

   - ***Take some aluminum foil off the roll to investigate if the time changes.***
   - ***Use a ring magnet traveling on the outside of the pipe instead of the disk magnet traveling on the inside of the pipe.***
   - ***Lengthen the pipes.***

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TEACHER NOTES

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