ACTIVITY 4

How Strong Is the Force?

OBJECTIVES

Students investigate the strength of different magnets and then the strength at different places on each magnet. They also investigate the relationship between distance and magnetic force.

The students

- guess the strength of different magnets
- measure the strength at different places on each magnet
- discover that magnetic force increases as the distance between a magnetic object and a magnet decreases

SCHEDULE

About 45 minutes

MATERIALS

For each student

1	Activity Sheet 3, Parts A and B

For each team of two

2	dots
1	magnet, rod
1	magnet, small
25	paper clips

PREPARATION

1. Make a copy of Activity Sheet 3, Parts A and B, for each student.
2. Each group of two students will need a rod magnet, a small magnet, two dots, and twenty-five paper clips.

BACKGROUND INFORMATION

The strength of a magnet can be measured by how many paper clips it can pick up. This same method can be used to compare the relative strength of two or more magnets as well as the relative strength of different parts of the same magnet.

During this activity, students explore two laws of magnetic attraction: (1) The force of a magnet is strongest at its ends. (2) Magnetic force increases as the distance between a magnetic object and the magnet decreases.

▼ **Activity Sheet 3, Part A**

How Strong Is the Force?

Magnet	Guess	Number of paper clips lifted			
		Trial 1	Trial 2	Trial 3	Average
rod magnet, dotted end		Answers will vary.			
rod magnet, undotted end					
small magnet, dotted end					
small magnet, undotted end					

1. Which end (dotted or undotted) of the rod magnet is stronger?
   same
2. Which end (dotted or undotted) of the small magnet is stronger?
   same
3. Which magnet is stronger? the rod magnet

▼ **Activity Sheet 3, Part B**

How Strong Is the Force?

Magnet	Guess	Number of paper clips lifted			
		Trial 1	Trial 2	Trial 3	Average
rod magnet, middle		Answers will vary.			
small magnet, middle					

4. Did the ends or the middle hold more paper clips?
   the ends

Guiding the Activity

Additional Information

1 Begin a discussion by reminding students of the tests they conducted in Activities 2 and 3 to determine which objects the magnet did and did not attract, and which objects did and did not block the magnetic force. Then hold up a rod magnet and a small magnet and ask, **How strong do you think these magnets are?**

Answers will vary.

2 Ask, **Is there a way to measure the strength of our magnets?**

Suggest that the students use their magnets to pick up several paper clips and to see how many clips their magnets can lift.

Students may suggest several methods. Acknowledge all student responses and, if possible, test one of the students' methods in addition to the paper clip method described below.

Guiding the Activity

Additional Information

3 Divide the students into teams of two. Distribute copies of **Activity Sheet 3, Parts A and B,** to each student**.** Distribute a rod magnet, a small magnet, and two dots to each team. Ask students to put a colored dot on one end of each magnet. Then ask students to guess how many paper clips they think each end of each magnet can lift.

Have them record their guesses in the chart on Part A of their activity sheets.

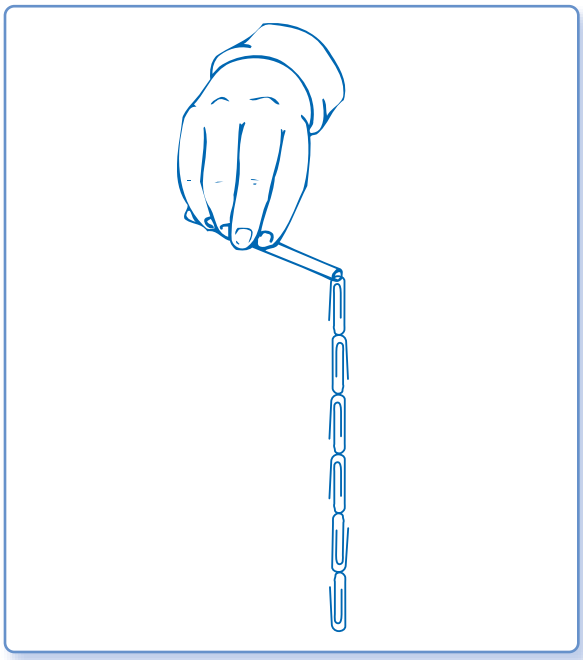
4 Distribute twenty-five paper clips to each team. Have them pick up one by one, end to end, as many paper clips as possible by the dotted end of the rod magnet. Have them repeat this step three times and record their results on Activity Sheet 3, Part A.

Help students to average their results by adding the number of paper clips picked up in each trial and dividing by the number of trials (three).

Tell the students to repeat the procedure using the undotted end of the rod magnet. Remind them to record their results.

After students have recorded the results for the rod magnet, ask them to repeat the procedure with the small magnet.

Check to make sure that students are not "linking" the paper clips but rather allowing magnetism to hold the clips end to end, as shown in Figure 4-1.



▲ ***Figure 4-1.*** *Lifting paper clips.*

5 When students have calculated the average number of paper clips held by each end of each magnet, ask, **Which magnet is stronger? How do you know?**

Ask, **Are both ends of each magnet equally strong?**

Students should say that the rod magnet is stronger because it can lift more paper clips.

Yes. In addition, those students who have been playing with their magnets may have already discovered that the ends of a magnet are stronger than the middle. Others, however, may be unsure or unaware of this.

Guiding the Activity

	Additional Information
6 Encourage the students to think of methods for testing the strength of the middle of a magnet. Use the methods they think of in addition to finding out how many paper clips the magnet can hold at its middle. Ask, **How many paper clips do you think each magnet can hold at the middle?** Have students write their predictions on Activity Sheet 3, Part B.	
7 After students have made their predictions, tell them to begin picking up paper clips using the middle of each magnet. Remind them to write down their results, to repeat the procedure three times, and to find the average number of paper clips held at the middle of each magnet.	
8 Ask, **How did the number of paper clips held at the ends of the magnet compare with the number of clips held at the middle?**	*Students will discover that either end of a magnet will hold more paper clips than the middle of that same magnet.*
9 Now have one member in each team place a paper clip in the palm of one hand and hold the small magnet between the thumb and index finger of the other hand. Have him or her slowly move the magnet toward the paper clip until the clip begins to react to the magnet. Have the second team member perform the same procedure. Then ask, **What happens to the magnetic force as the distance between the magnet and the paper clip decreases?**	*The magnetic force felt by the paper clip increases as the distance decreases.*
10 Begin a discussion by asking, **What can you hypothesize about magnets based on the results of these activities?**	*(1) Magnetic force is strongest at the ends of a magnet. (2) Magnetic force increases as the distance between a magnetic object and the magnet decreases.*

Reinforcement

Ask, **Which part of which magnet do you think would enable you to pick up a paper clip from farthest away?** Students should be able to apply what they have discovered in this activity—that the rod magnet is stronger than the small magnet, and that the ends of a magnet are stronger than its middle.

Assessment Opportunity

This Reinforcement also may be used as an ongoing assessment of students' understanding of science concepts and skills.

Science Journals

Have students place their completed activity sheets in their science journals.

Cleanup

Students will enjoy using their magnets to gather up the loose paper clips. Tell them to return the clips to the boxes. Remove the dots from the magnets and return all materials to the kit.

Science at Home

Have students examine various magnets found in the home. Are they all the same strength? Compare the magnets holding the refrigerator door closed with the magnets used to hold notes or photographs to the front of the refrigerator door. Ask students to test how far they have to shut the refrigerator door before it closes automatically. How close must a magnet be held to the refrigerator door before it is attracted to the door?

Connections

Science Extension

Provide magnets of different shapes—horseshoe magnets, U magnets, square or round magnets with the poles on the flat sides, and so forth. Have students test these magnets as described on the activity sheet. Do these magnets have stronger and weaker areas? If so, where on each magnet are those areas located?

Have students test a horseshoe magnet to find out how many iron nails can be picked up with each end of the magnet separately and how many can be picked up with both ends together. Make sure that the nails are long enough to extend across both ends of the magnet. Students will discover that more nails can be picked up with both ends together than with either end separately.

To demonstrate the greater strength of a horseshoe magnet, have students extend their arms straight out from their sides and imagine that they are a bar magnet. Tell them to try to lift a chair with one extended hand (representing one end of the magnet). Then tell them to extend their arms straight out in front of them with their hands about 0.5 m (18 in.) apart to represent a horseshoe magnet, and again try to lift the chair. Which "magnet" lifted the chair more easily?

Science and Math

Encourage students to use a dictionary or encyclopedia to find out the difference between the mean (the average), the median (the middle number in a series of numbers arranged from highest to lowest), and the mode (the most frequent number in a series). Use the data from their investigations with the magnet and paper clips to demonstrate the difference between the mean, the median, and the mode.

Science and Language Arts

Ask each student to choose one magnet that he or she identified in Science at Home in this activity or in an earlier activity and to write one or two paragraphs describing how the magnet is used. Encourage students to examine the magnet closely and to include details in their description—for example, the shape of the magnet, whether its side or an end is in contact with metal, what type of anchoring device is used, and so forth. Have students share their descriptions in class, and encourage other students to ask questions about any details that may have been omitted.

Science and Social Studies

Explain that scientists measure force, including magnetic force, in units called *newtons*. Suggest that students use an encyclopedia to find out how the newton got its name.

Science, Technology, and Society

A magnetometer is an instrument used to measure the strength of a magnetic field. Magnetometers of various types are used in medicine to detect brain abnormalities, in industries such as the manufacture of superconductors, and by field geologists to detect oil or mineral deposits. Magnetometers also help geologists learn more about rock formations below the Earth's surface. Encourage students to find out more about how magnetometers work and who uses them.