

Magnetic Fields

OBJECTIVES

Students make iron filing patterns to visualize the invisible field lines in a magnetic field. They also compare the pattern made by a single magnet to the pattern made by two magnets placed near each other.

The students

- ▶ observe the pattern made by iron filings on a sheet of paper placed over a magnet
- ▶ infer that the pattern is made by the invisible field lines in the field surrounding a magnet
- ▶ compare the pattern made by a single magnet to the pattern made by two magnets placed near each other

SCHEDULE

About 45 minutes

VOCABULARY

field lines
magnetic field

MATERIALS

For each student

- 1 Activity Sheet 4, Parts A and B
- 1 safety goggles*

For each team of two

- 1 cup, plastic
- 1 magnet, rod
- 1 magnet, small
- 1 sht paper, white

For the class

- 1 cont iron filings
- 1 roll tape, transparent*

*provided by the teacher

PREPARATION

- 1 Make a copy of Activity Sheet 4, Parts A and B, for each student.
- 2 For each team of two students, place about one-half teaspoon of iron filings into a plastic cup.
- 3 Each team of two students will need one small magnet, one rod magnet, a plastic cup containing iron filings, a sheet of paper, and two pieces of tape.

BACKGROUND INFORMATION

The area around a magnet where the force of the magnet acts or is felt is called the **magnetic field**. Although this magnetic field is invisible, if iron filings are sprinkled on a sheet of paper covering the magnet, the filings will arrange in a pattern of lines—called **field lines**—that reveal the presence of the magnetic field. The presence of the magnetic field explains why a magnet's force can be felt at a distance from the magnet itself.

The field lines (sometimes called *lines of force*) are more concentrated at the ends (poles) of the magnet and extend from the magnet in three dimensions. The strength of the magnetic force decreases as the distance from the magnet increases.

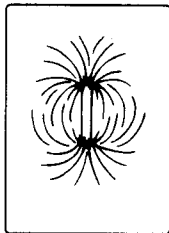
▼ Activity Sheet 4, Part A

Magnetic Fields

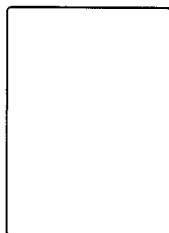
For each magnet, make three sketches of the patterns made by the iron filings. Compare your sketches with those of other students. Put an X in the box that shows the most common pattern.

Small Magnet

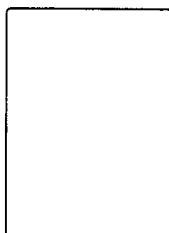
Picture 1



Picture 2



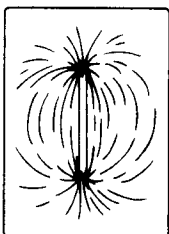
Picture 3



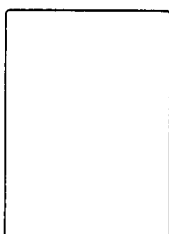
Drawings will vary. The pattern that students identify as "most common" should resemble the sketches shown here.

Rod Magnet

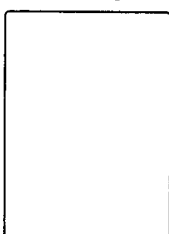
Picture 1



Picture 2



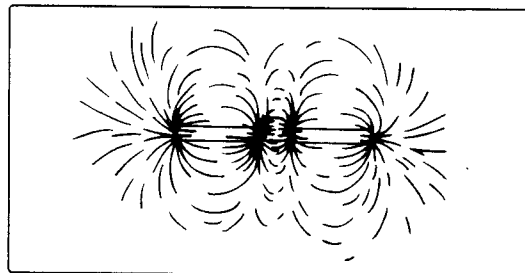
Picture 3



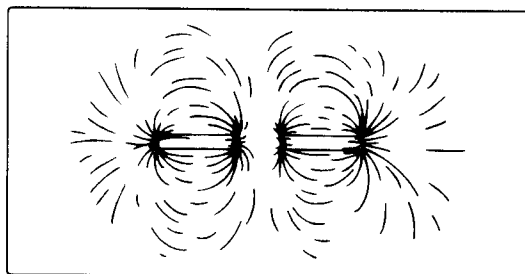
▼ Activity Sheet 4, Part B

Magnetic Fields

1. Sketch the pattern made by two magnets.



2. Turn one magnet around, tape it down again, and sprinkle the filings. Sketch the pattern you see.



Depending on which arrangement of magnets the student started with, the sketches may be switched.

Guiding the Activity

1 Divide the class into teams of two and distribute one small magnet, one rod magnet, a cup containing iron filings, a sheet of paper, and two pieces of tape to each team. Distribute **Activity Sheet 4, Parts A and B**, and a pair of safety goggles to each student.

2 Tell the students to tape the small magnet to the top of one of their desks and to place a sheet of paper over the magnet. Ask the students to sprinkle the iron filings onto the paper over the magnet.

3 Tell the students to sketch on Activity Sheet 4, Part A, the pattern made by the iron filings and the small magnet (see Figure 5-1). Ask the students to repeat the process two more times and to sketch what they see each time.

Additional Information

Safety Note: Have students wear safety goggles when working with loose iron filings. After completing the activity, use a magnet to clear the work area of iron filings before using it for another purpose. Have students wash their hands if they handle any filings.

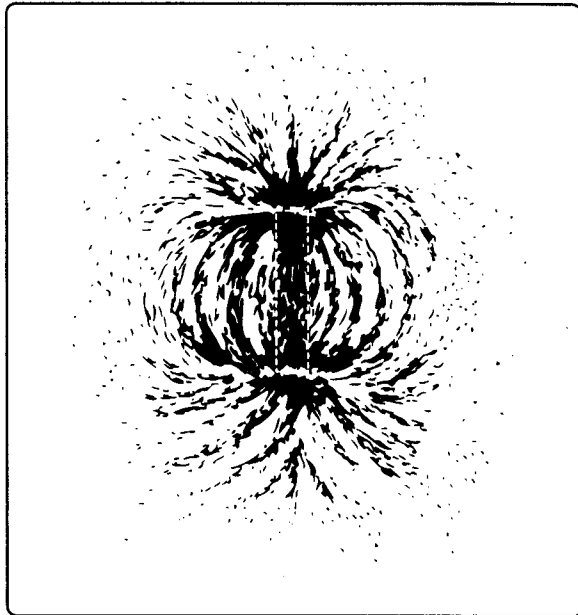
Students may need to try this several times to get a distinct pattern. Let them repeat the process. The filings can be returned to the cup by picking up the two sides of the sheet of paper and pouring the filings back into the cup.

As students work, remind them to notice whether any patterns are observed repeatedly.

Note: Tell the students that all of the iron filings will be collected at the end of the activity.

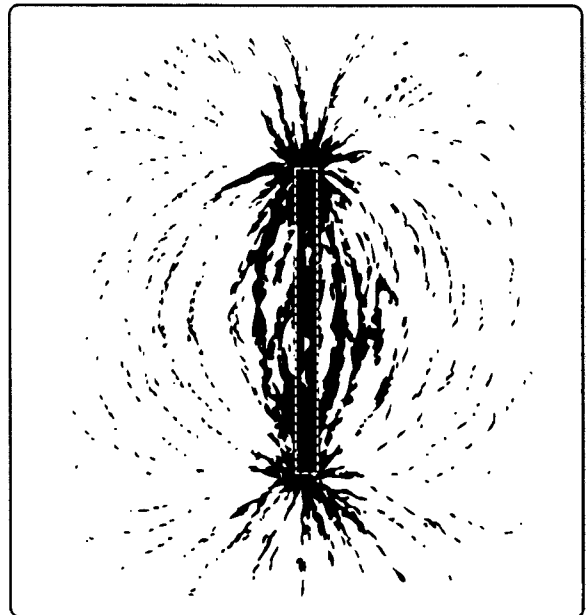
* Avoid attracting the iron filings directly to the magnets. This complicates clean-up!

Guiding the Activity



▲ Figure 5-1. Iron filing pattern of the small magnet.

Additional Information



▲ Figure 5-2. Iron filing pattern of the rod magnet.

- 4** After students have finished making patterns and recording them, invite teams to compare their sketches with those of other teams. Have several students come to the board to sketch the most typical patterns made by the iron filings.

Write the term *field lines* on the board. Explain that what they have sketched is a picture of the invisible **field lines** that surround the magnet and show where its magnetic force can be felt.

Next, write *magnetic field* on the board, and make sure students can define **magnetic field** as the area around a magnet where the magnet's field lines can be detected. Tell the students that as the tiny iron filings respond to the pull of the magnet, they line up around the magnet, outlining the magnetic field.

- 5** Repeat steps 2 and 3, this time with the rod magnet (see Figure 5-2).

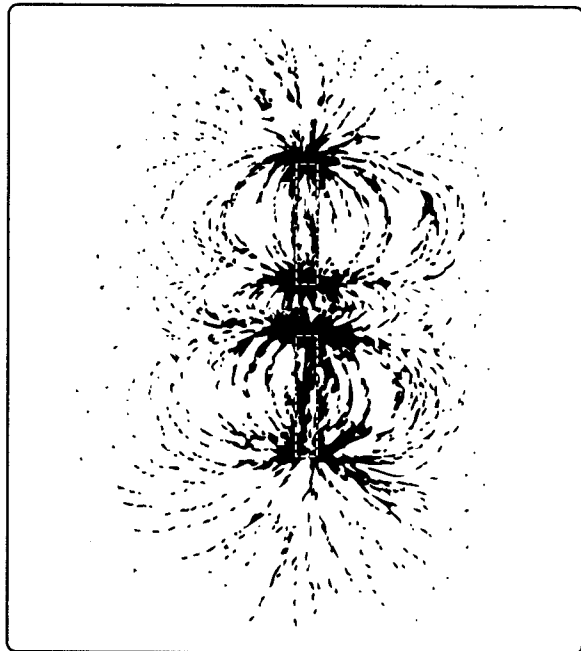
Again, invite teams to compare their sketches with those of other teams. Have several students come to the board to sketch the most typical patterns made by the iron filings.

Guiding the Activity

- 6 Now encourage the students to explore the pattern made by a combination of magnets. Ask, **What do you think the pattern would look like if two magnets were placed next to each other (end to end) without touching?**

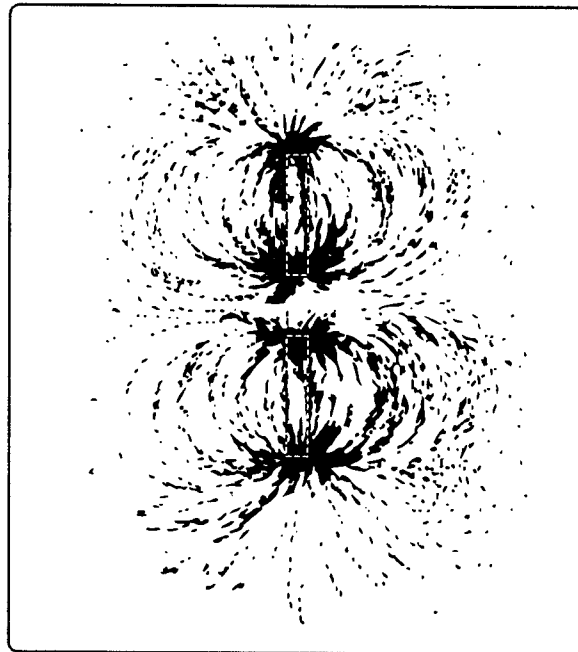
~~Tell teams to exchange magnets so that each team has two magnets of the same kind.~~

- 7 Teams should position the two magnets end to end, about 1.5 cm (1/2 in.) apart, and tape them to the desk top. Tell students to cover the two magnets with a sheet of paper and sprinkle the iron filings as before (see Figure 5-3). Have the students sketch the pattern that results at the top of Activity Sheet 4, Part B.



Additional Information

use same magnets - both rod
or both small.



▲ Figure 5-3. Iron filing patterns with opposite poles together (left) and like poles together (right).

- 8 Now tell teams to remove the paper and iron filings, turn one of the magnets 180° (facing in the opposite direction), and tape it down again. Tell them to cover the magnets again with paper, sprinkle the iron filings, and notice how the pattern has changed. Tell them to sketch this pattern at the bottom of Activity Sheet 4, Part B.

Guiding the Activity

9

Ask, How do the patterns confirm what you already know about the strength of different parts of the magnet?

Ask, Is the magnetic field flat or does it surround the magnet in all directions?

Tell students that they can observe that the magnetic field extends in all directions. Place a large magnet flat on a desk.

Sprinkle some iron filings on a sheet of paper

covering the magnet as before.

They will observe the iron filings "standing" up and arcing out from the center.

Additional Information

The concentration of filings is greater at the ends of the magnet. In the last activity students discovered that the ends of a magnet picked up more paper clips than the middle of the magnet.

Students probably know that the magnetic force acts in all directions. However, they may not realize that the field lines extend in three dimensions.

Note that field lines will not appear because the poles are on the large flat surfaces.

REINFORCEMENT

Ask students to trace the outline of a magnet in the center of a piece of paper. Then ask them to make an iron filing pattern by placing the piece of paper so that the magnet outline is positioned over the magnet taped to the desk. Now ask them to use another magnet and a paper clip to test the strength of that magnet at the ends and in the middle. Ask them to compare the strength of the different parts of the magnet with the iron filing pattern.

SCIENCE JOURNALS

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

CLEANUP

The iron filings should be poured back into their container and returned, along with the cups and magnets, to the kit.

Investigating Magnetic Poles

OBJECTIVES

Students observe the pulling and pushing power (attraction and repulsion) of magnets. They are also introduced to the Law of Magnetic Attraction.

The students

- ▶ observe that the interaction between two magnets results in attraction or repulsion
- ▶ learn that the ends of magnets are referred to as poles
- ▶ are introduced to the Law of Magnetic Attraction

SCHEDULE

About 30 minutes

VOCABULARY

- attract
- Law of Magnetic Attraction
- poles
- repel



MATERIALS

For each student

- 1 Activity Sheet 5

For each team of two

- 1 cart, plastic
- 1 dot
- 1 magnet, large
- 1 magnet, rod

Ready & Waiting!

PREPARATION

Done

- 1 Make a copy of Activity Sheet 5 for each student.
- 2 Assemble the plastic carts by inserting the two metal axles into the holes in each cart and attaching the four wheels to the axles.
- 3 Each team of two students will need a plastic cart, a rod magnet, a large magnet, and a dot.
- 4 Arrange for each team of two students to work on a flat surface at least as big as (or bigger than) a desk top. Uncarpeted hallways are excellent work sites for this activity.

BACKGROUND INFORMATION

Students have observed how magnets respond when they are placed near a magnetic material such as iron or steel.

In this activity students observe the interaction between a large magnet and a rod magnet. The **poles** of the large magnet are located at its flat sides, or faces. Because this magnet is positioned in the cart randomly by the students, and because the dot is placed on the rod magnet arbitrarily, the initial investigation by the students will yield mixed results. About half the carts will be **attracted** to, or pulled toward, the rod magnet and half will be **repelled**, or pushed away. From this experiment students learn that two magnets interact differently with each other, depending on how they are positioned.



▼ Activity Sheet 5

Investigating Magnetic Poles

1. What is the Law of Magnetic Attraction?

Like poles repel. Unlike poles attract.

Circle the correct answer based on your observations.

2. When the dotted end of the rod magnet was brought close to the magnet in the cart, the cart was **pulled/pushed**.
3. This means that the two magnets **repelled/attracted** each other.
4. Think about the Law of Magnetic Attraction. The poles of the magnets were **like/unlike**.
5. When the undotted end of the rod magnet was brought close to the magnet in the cart, the cart was **pulled/pushed**.
6. This means that the two magnets **repelled/attracted** each other.
7. Think about the Law of Magnetic Attraction. The poles of the magnets were **like/unlike**.

Answers will vary, depending on the orientation of the magnets.

The answers **pulled, attracted, and unlike** will be correct for one end of the magnet. The answers **pushed, repelled, and like** will be correct for the other end of the magnet.

Guiding the Activity

- 1 Divide the class into teams of two and distribute an assembled cart, a large magnet, a rod magnet, and a dot to each team.

- 2 Give the students 2–3 minutes to investigate the materials. Then explain that they should put the large magnet in the slot at one end of the cart and take their materials to the work site you have selected for them.

Tell the students not to remove the magnet once it has been inserted into the cart.

- 3 Have one team member put a colored dot on one end of the rod magnet. Have the other team member hold the dotted end of the rod magnet at least 30 cm (about 1 ft) from the end of the cart that contains the large magnet, then slowly inch the rod magnet toward the cart until there is a reaction (see Figure 6-1). Ask, **What happened when the cart and rod magnet got close to each other?**

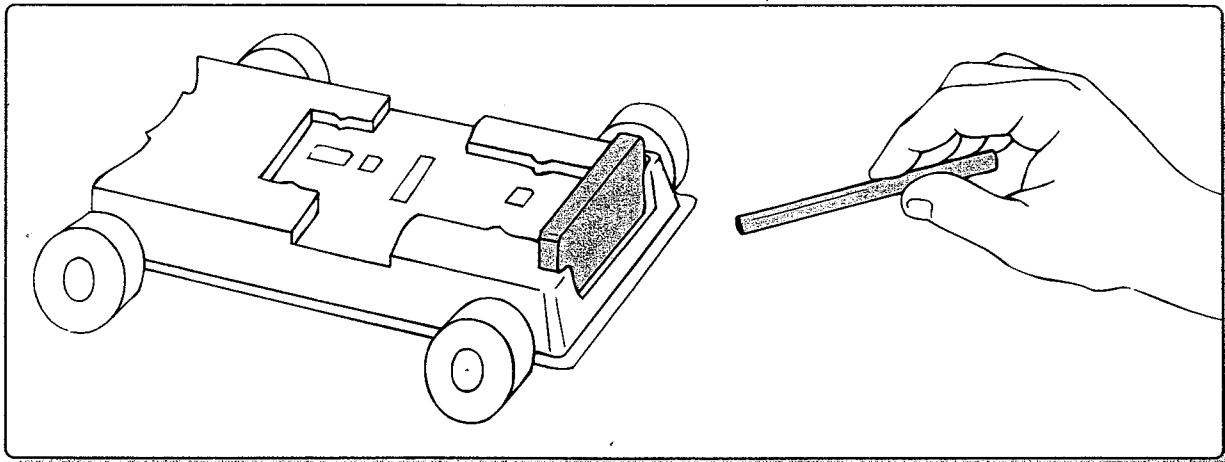
Additional Information

Because the materials are new to the students, they will need time to explore them before they can be expected to settle into their work. This time spent will arouse interest in the investigation of magnets and will ultimately lead to a clearer understanding of the concepts.

Some carts will move toward (be attracted to) the rod magnet while others will move away from (be repelled by) the rod magnet.

Guiding the Activity

Additional Information



▲ Figure 6-1. Slowly inch the rod magnet toward the cart until there is a reaction.

4 Write *Moved Toward* and *Moved Away* on the board. Ask, **How many carts moved toward the rod magnet? How many moved away from the rod magnet?** Record the number of carts under each heading.

In most classes, about half the teams will observe attraction and half will observe repulsion.

5 Encourage students to repeat the activity two or three times. As they work, verify that all teams are using the same materials and that all teams are conducting the investigation in the same way, that is, they are keeping the dotted end of the rod magnet facing the magnet on the cart. Ask, **How can you explain the fact that we all used the same materials and did the same thing, but we all did not get the same results?**

After repeating the activity several times, the students should become aware that there is another factor involved that is causing different teams to get different results.

6 If students are not clear about what they have seen, encourage discussion by using the two ends of the rod magnet to push and pull the cart around a flat surface, such as a desk or the floor in the classroom or hallway. Ask, **What must you do to pull the cart? What must you do to push the cart?**

Holding the rod magnet one way will pull the cart. Turning it the other way will push the cart.

7 Now have the students turn their rod magnet around so that the opposite (undotted) end of the rod magnet is pointing toward the cart. Tell them to slowly move the undotted end of the rod magnet toward the cart. After students observe a reaction, ask, **What happened?**

Most students will be surprised to find that their cart moves in the opposite direction. In other words, if the dotted end of the magnet pulled the cart, the undotted end will push the cart, and vice versa.

Guiding the Activity

8 Write *attract* and *repel* on the board and explain that scientists use these words to describe the actions of a magnet. Tell the students that both ends of a magnet will always **attract**—or pull—magnetic materials, but that the end of one magnet does not always attract the end of another magnet. When the ends of two magnets do not attract each other, they **repel**—or push each other away.

9 Write *poles* on the board. Tell students that the ends of magnets are called **poles**. The poles are where the magnetic field is strongest. Every magnet has two poles that are equal in strength.

10 Write *Law of Magnetic Attraction* on the board and tell the students that the **Law of Magnetic Attraction** states the following: Like poles repel; unlike poles attract.

11 Distribute a copy of **Activity Sheet 5** to each student. Tell students to answer question 1 by writing the Law of Magnetic Attraction at the top of their sheets. Have them answer questions 2–7 according to what they observed during their experiments.

Additional Information

If possible, give the students more time to investigate the attraction and repulsion of the magnets. Encourage them to use the words attract and repel to describe what they see.

Science and Math

▶ Have students measure the “pulling” and “pushing” forces of the large magnet and the rod magnet as follows: Lay a ruler horizontally on the desk, and put the large magnet at the left end of the ruler with one end touching the ruler. Slowly push the rod magnet along the ruler from right to left toward the large magnet. Note when the “push” or “pull” between the magnets is first felt, and record that distance. Turn the rod magnet around, repeat the test, and record that distance. Then turn the large magnet around, repeat the test, and record the distance. Finally, turn the rod magnet around again, repeat the test, and record the distance. Have students compare the four distances that they recorded. Are the two “push” distances the same? Are the two “pull” distances the same? Are the “push” distances the same as the “pull” distances? (All distances should be roughly the same.)

REINFORCEMENT

If students do not understand the concept of magnetic attraction and repulsion, give them additional time to work with two of the same type of magnets. Students can use either the rod, large, or small magnets to investigate how, by changing the orientation of one of the magnets, the magnets will either repel or attract each other.