Throughout the guide, teaching tips are in red.

Activity Description & Estimated Class Time

This activity requires three 50-minute blocks. In the first block, pairs of students explore magnetic attraction and repulsion. In the second block, they determine whether different test items are attracted to a magnet. In the third block, they work with a floating paper clip setup and iron filings to develop the idea of a magnetic field.

Objectives

Students will demonstrate knowledge and understanding of the following ideas and content:

- Magnets have poles and can attract or repel each other
- Magnets attract things made of iron
- Magnets have a field that extends in space from the magnet and that can make things move without contact

Students demonstrate this knowledge and understanding by using the properties of magnets to solve challenges.

Correlations to North Carolina Science Standards

4.P.1.1 *Explain how magnets interact with all things made of iron and with other magnets to produce motion without touching them.*

Brief Science Background

A magnet is a piece of iron that can attract other things made of iron. Both magnets and objects that they can attract are called "magnetic." Magnets can cause magnetic objects to move without touching them.

When two magnets are near each other, a force between them can either push them apart or pull them together. This is because magnets have two ends that may look alike, but are different with regard to magnetism. These ends are called poles. They are the places where a magnet exerts its strongest forces. One pole is called north and the other is called south.

When like poles of two magnets are near each other, the magnets push each other away, or repel. When opposite poles are near each other, the magnets pull together, or attract.

A magnet can cause magnetic things in the space around it to move. This space is called the magnetic field. The magnetic field is stronger closer to the magnet and weaker farther away. A magnet's field can extend through non-magnetic materials such as glass or paper. For example, a magnet held under a plate can move a paper clip lying on the plate.

Part 1 — Magnets and Magnets (50 minutes)

Materials

Materials for groups of 2 students

- 2 bar magnets
- 2 donut magnets
- 1 science notebook per student (supplied by teacher)

Procedure

Activity – 40 minutes

1. Give each pair of students two bar magnets. Ask them to experiment with the magnets and notice what happens. Call the groups back together and have them report their findings.

At this point, it is important that students engage with materials and concepts, ask questions, and share what they notice. This is not a time to explain what they are seeing. Avoid teaching content at this time, even during discussions.

2. Use the class discussion of how the magnets behaved to introduce the terms **attract** and **repel**. Challenge the students to find and draw different arrangements in which the magnets attract or repel. Ask students to put the magnets aside and answer the following prompt in their science notebooks.

   Notebook Prompt. *Write some rules for magnets attracting and repelling each other.*

3. In groups of four, ask students to share their rules for attracting and repelling, and then decide on one rule for the group to present to the class.

This is not a time to correct any misconceptions or for direct teaching. Let students know that the rules for attracting and repelling will be reviewed later.

Students should now understand that the ends of two magnets with the same letter repel each other, and the ends of two magnets with different letters attract each other.

4. Collect the bar magnets and inform students that they will now get a pair of a different type of magnet. Say that you would like them to use these new magnets to test their rules for the way magnets attract and repel. Pass out two donut magnets to each pair of students.
5. Have students share their findings.
6. Give out the bar magnets again. Ask the students to find arrangements, using any of their four magnets, in which the magnets seem to attract and repel with the most strength.
7. Hold a class discussion in which students describe the arrangements they came up with.

Part 1 (cont.)

Students will find that, unlike bar magnets, donut magnets attract and repel each other on the top and bottom surfaces (the flat surfaces when the magnets are held like a coin in the palm of a hand). The poles of donut magnets are these top and bottom surfaces. Students should also notice that the poles of both types of magnet are the "strongest" parts, where they feel the most attraction and repulsion.

Wrap-Up – 10 minutes

1. Ask the students how they could label a donut magnet with an N and an S.

Students should be able to say that they could use one of their bar magnets to find out which side of the donut magnet is attracted to it and which side is repelled by it.

2. Challenge students to determine N and S for their donut magnets and then test them with another group's donut magnet. (Both groups should have determined the two sides of their magnets before testing.)

3. Explain that the ends of the magnets are called poles, with the N and S standing for north and south. A general rule for all magnets is that the same poles repel each other but opposite poles attract. (The general rule that opposites attract is true in some other systems that students will explore in the future, such as in chemistry and electricity.)

Part 2 — Magnets and Materials (50 minutes)

Materials

Materials for groups of 2 students

- 2 bar magnets
- 1 bag of test objects (see step 3 in procedure below)
- Black Line Master (BLM) 1 prediction table
- 1 science notebook per student (supplied by teacher)

Preparation

Print one prediction table for each group.

Procedure

Exploration – 10 minutes

Give each students a bar magnet. Ask everyone to find objects in the room that the magnets stick to, and objects that the magnets do not stick to. After a few minutes of exploring, ask students to report their findings.

Activity – 30 minutes

1. Collect the magnets and pass out the bags of test objects and copies of the prediction table. **Be sure students do not have magnets and test objects at the same time.** Ask students to place each test object in a box in the left column of the prediction table. In the center column, ask them to record their predictions about whether that item will interact with the magnet.

2. After students have recorded their predictions, they may get a magnet from the teacher, conduct their tests, and record the results in the right hand column of the prediction table.

3. Ask students to share any of their predictions that were incorrect. Each bag contains:

— a paper clip	— steel
— a rock	— rubber
— magnetite	— plastic
— brass	— cardboard
— aluminum	— a pipe cleaner

Students will be able to identify many, but not all, of the materials the objects are made of. At this time, do not identify objects they identify incorrectly or do not know.

Wrap-Up – 10 minutes

Put these sentence fragments on the board. Ask students to complete them based on their findings:

1. *Magnets can attract…*

2. *Magnets do not attract…*

Part 2 (cont.)

Answer Key

1. Students should say that magnets can attract one of the metal squares, one of the nails, the pipe cleaner and one of the rocks.

2. Students should say that magnets do not attract any of the other objects.

   Start a discussion by asking if the objects that were attracted to the magnets have anything in common. Allow students time to think and share their ideas.

   Students will probably respond that magnets stick to some kinds of metal. Depending on how much they know about rocks, some might wonder if the rock that was attracted to the magnet contained "the right kind of metal."

   Tell students that magnets and things that can be attracted by magnets are made of iron and are called "magnetic". Things that are not attracted to a magnet are called "non-magnetic". Non-magnetic objects either do not contain any iron at all or they contain only very small amounts of it. Take time to name and describe materials found in the test bag:

   - Magnetite is a mineral made of iron and oxygen and it acts as a magnet.
   - Steel is an alloy (blend) of iron and a very small amount of carbon, and sometimes even smaller amounts of other metallic elements such as chromium or tungsten. Because steel generally consists of more that 95% iron, it is magnetic. Many familiar objects are made of steel, such as paper clips and binder clips, scissor blades, screwdrivers, most car bodies, and refrigerator doors. (Stainless steel, however, which kitchen sinks and eating utensils are commonly made of, is not magnetic. Stainless steel is iron that has other metals added to it to prevent rust, and these additives disrupt the iron's internal structure so it is no longer magnetic. There are no stainless steel objects in the students' test bags, and this information is included only in case they test objects at home, ask their parents what they are made of, and then come to school asking why a magnet won't stick to the kitchen sink.)
   - Brass is an alloy of copper and zinc, which are both pure metals different than iron. Many electrical wires and some plumbing pipes are made of copper. Batteries often contain zinc.
   - Aluminum is another pure metal different from iron. It is what soda cans and foil food wrap are made of.

3. Ask, based on this information, what is true of all the items that were magnetic? Students should be able to respond that they all must contain iron. They should also be able to state that the non-magnetic objects do not contain iron.

Part 2 (cont.)

Guided Practice (25 Minutes)

Guided Practices are similar to typical tests, but require students to reveal their thinking about content. They serve as a practice before a test and should not be graded. They are intended to expose misconceptions *before* an assessment and to provide opportunities for discussion, re-teaching, and for students to justify answers. They are best given as individual assignments without manipulatives used in the activity. In that context, project BLM 2: Infomercial. Ask students to work individually, then share answers in a class discussion.

A clever 4th grade student invented an amazing new tool consisting of a very strong magnet attached to a stick. Her television infomercial claimed that it had dozens of uses including:

- picking up empty soda cans for recycling
- collecting steel nuts, bolts, and nails from the floor of a hardware store
- finding the copper electrical wires within a house's walls
- picking up old steel pieces of barbed wire in pastures so cows won't eat them
- finding gold rings that were lost at the beach

1. Write a paragraph about which of her claims you don't agree with and include the reasons you think they are not true.
2. Help this student sell her invention by listing some other uses for her amazing new tool.

Suggested answers:

1. Her magnet will not be able to pick up soda cans because they are made of aluminum, which does not contain iron and therefore is not magnetic. Likewise, copper wires and gold rings do not contain iron and will not be attracted to her magnet either.
2. She could use her invention for picking up spilled boxes of paper clips, picking up steel nails at construction sites, and removing steel cans from the aluminum can bin at recycling centers.

Part 3 — Floating Paper Clip (50 minutes)

Materials

Materials for the whole class

- available to project: BLM 2, BLM 3 (suspended paperclip setup, bar magnet & field viewer, magnet & field, donut magnet field), BLM 4

Materials for groups of 2 students

- 2 donut magnets
- a 6-inch piece of string
- a paperclip
- a 4-inch piece of tape
- BLM 1 prediction table
- magnetic field viewer
- 2 bar magnets
- 1 science notebook per student (supplied by teacher)
- magnetic test items

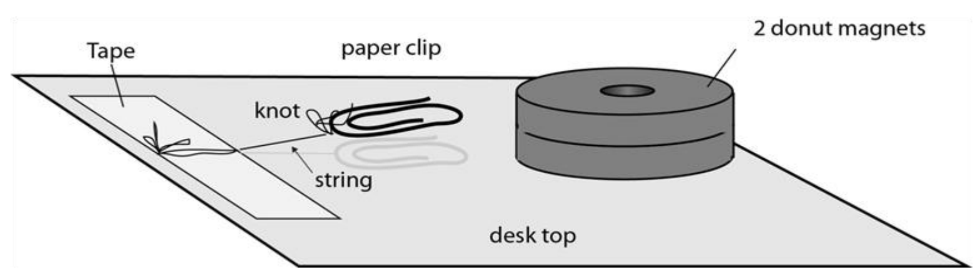
Preparation

1. Cut string to make one 6-inch length per group.
2. Print one BLM 1 prediction table for each group.

Procedure

Project BLM 2 Suspended Paper Clip Setup and make a setup of your own to show students how to set up a floating, paper clip. Show them that the paper clip falls when the magnets are moved away. The length of string between the tape and paper clip should be about an inch.

As pairs of students successfully set up their floating paper clips, ask them to move the two donut magnets to the place where the paper clip remains in the air but the magnets are as far away as possible (a little farther away, and the paper clip falls).



Suspended Paper Clip Setup

1. Ask students to use BLM 1, prediction table, to predict which test objects placed between the magnets and the paper clip will block the magnet's pull and make the paper clip fall. They can place test items in the item column.
2. Students can start testing only after they have filled in their predictions on the table. After that, they can test and fill in the results column of the table.
3. Ask students to share their results with the class.

Part 3 (cont.)

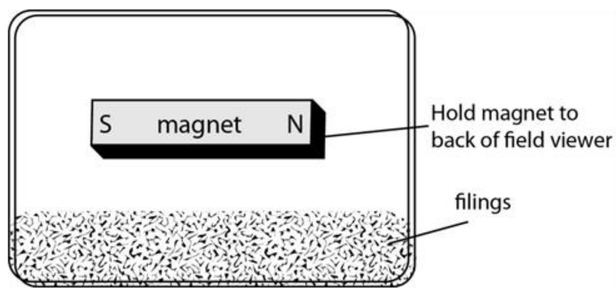
Wrap-Up

1. Give out the magnetic field viewers and bar magnets. Leave the field viewers in their plastic bags. Ask students to describe what they see when they place the bar magnet next to the plastic container.

2. Students may discuss this briefly, since they can't see what is causing the pushing or pulling.

   It might help to remind them that we can't see gravity working, but we still know that it is a force that causes a ball thrown in the air to fall back down.

3. Show students how to hold a magnet against the back of the plastic container (the field viewer), as shown in BLM 2. Show how to move the container level to the ground so that all of the filings move to the magnet, then tip the container so that some of the filings move away from the magnet. Last, holding the container level and lightly tap on its top.

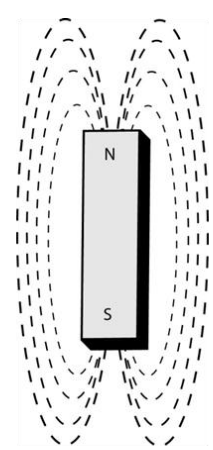


Bar Magnet and Magnetic Field Viewer

   Ask students for their observations.

   Students should see clusters of filings at the poles of the magnet, and other filings that are lined up between the poles on both sides of the magnet.

4. Explain that there are magnetic force lines that go between the north and the south poles of the magnets, and the iron filings have been attracted to these lines of force. Also, the space where a magnet can act is called a magnetic field. Project the Magnet and Field Lines diagram on BLM 2 and point out similarities between the arrangement of iron filings around their magnets and the diagram.

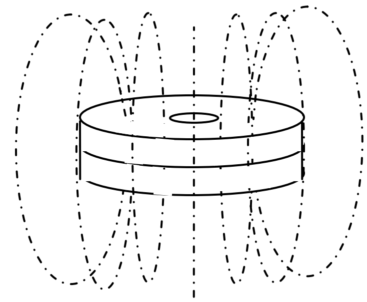


Magnet and Field Lines

5. Explain that the attractive and repulsive forces of a magnet act along the magnetic field lines. Remind students that they observed the effects of this force field extending out from their magnets all the way to their floating paper clips. They also observed that the force could travel through non-magnetic objects, such as the cardboard and plastic, but was disturbed by the objects made of magnetic materials, such as the paper clip.

Part 3 (cont.)

6. Ask students to think about the poles of a donut magnet and to predict what they think field viewer will look like when placed over a donut magnet. Pass out the donut magnets and then ask for their observations. Let the class discuss their predictions and observations.



Donut Magnet Field Lines

Iron filings align vertically around the top of the donut except for an open space over the donut hole. Students might describe them as “standing up” on top of the magnet. This is because the strong field of a donut magnet acts vertically, as students discovered in Part 1. There aren’t filings above the hole because the magnetic force is much stronger immediately above the actual magnet material, so the filings are pulled there instead of over the hole.

Guided Practice

Project BLM 4 “Magnet Challenges” and reveal the challenges one at a time. Ask students to try ideas on their own first, then discuss them with table-mates. Let the whole class discuss the proposed solutions.

1. Using a pencil and donut magnets, how could you suspend a magnet in mid-air (levitate it) without touching it? Make a drawing that shows your idea and explain how it works.
2. Your class just got a new box of 30 bar magnets. Only one of the magnets has the north and south poles marked on it. Your teacher asks you to mark all of the other magnets. How will you do this?
3. Your class got another box of bar magnets. All of the magnets are unmarked. You soon realize that in the box there are also bars of iron that are not magnets, but they look exactly like the magnets. How can you separate the pieces of iron that are not magnets from the actual magnets?
4. How can you remove a paper clip from a glass of water without putting anything else in the water or pouring any of it out?
5. Sam claimed that he found a way to use scissors to cut the magnetic force of donut magnets. Sarah told him there was no way he could use scissors to cut a magnetic force, just like you can’t use scissors to cut gravity. To prove he could do it, Sam set up a suspended paper clip using two donut magnets, like you did in class. Then he took a pair of scissors and “cut” the air between the paper clip and the magnets. As the scissor blades came together, the paper clip instantly fell to the desk. “See? I did it,” he said. Did Sam cut the magnetic force, or was Sarah right? Explain the reason for your answer.

Part 3 (cont.)

Suggested Answers

1. Putting a pencil vertically through the holes of 2 magnets will keep them in line and in place so that, when arranged with like poles facing each other, the 2 magnets will repel. If the bottom magnet is held in place, the other magnet will float above it on the pencil.

2. Use the north end of the marked magnet and move it near one end of another magnet. If that end of the unmarked magnet is pulled toward the north end of the marked magnet, label that end S and its other end N. If the end of the unmarked magnet is pushed away from the N end of the marked magnet, label that end N and its other end S. Then do the same thing for all the other magnets in the box.

3. First find two bars that are magnets by testing several bars. Test them by putting their ends near each other, and making sure to test both ends. You can tell they are magnets if you put two ends together and feel the repelling force. If only one of them is a magnet you will feel the attractive force but you won't be able to feel a repelling force. Once you've found two magnets, you can use one of them to test all the other bars in the box, again looking for the repelling force.

4. Hold a magnet to the side of the glass closest to the paper clip to attract it, and then drag the paper clip up the side of the glass to the top.

5. The blades of the scissors must have been made of steel, which is mostly iron, so it interfered with the magnet's field so the magnetic force couldn't hold the paper clip up in the air. Sarah is right. (In fact, as soon as Sam removed the scissors from the gap, the paper clip would have floated in the air again.)

BLM 1 Prediction Table

Name ______________________________

	prediction	result
ITEM	Y or N?	Y or N?

	prediction	result
ITEM	Y or N?	Y or N?

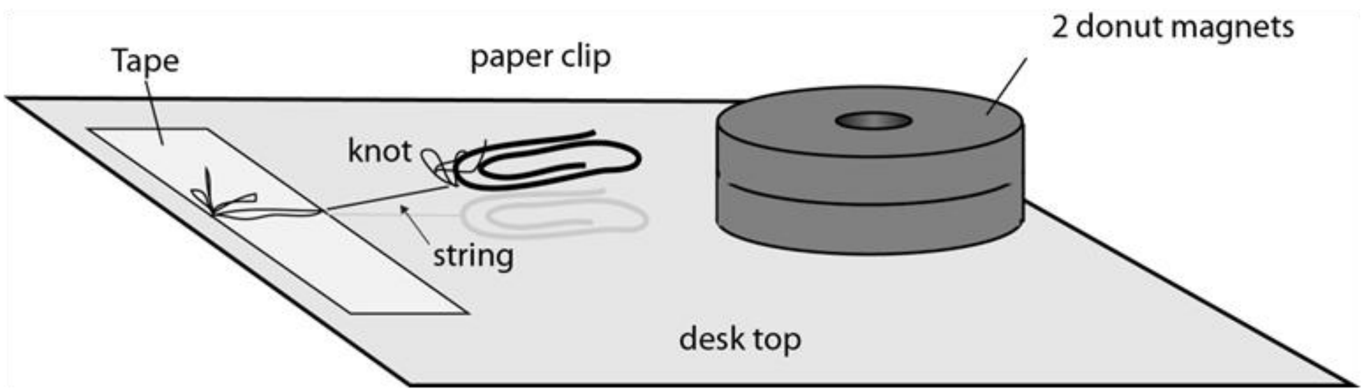
BLM 2: Informercial

A clever 4th grade student invented an amazing new tool consisting of a very strong magnet attached to a stick. Her television infomercial claimed that it had dozens of uses including:

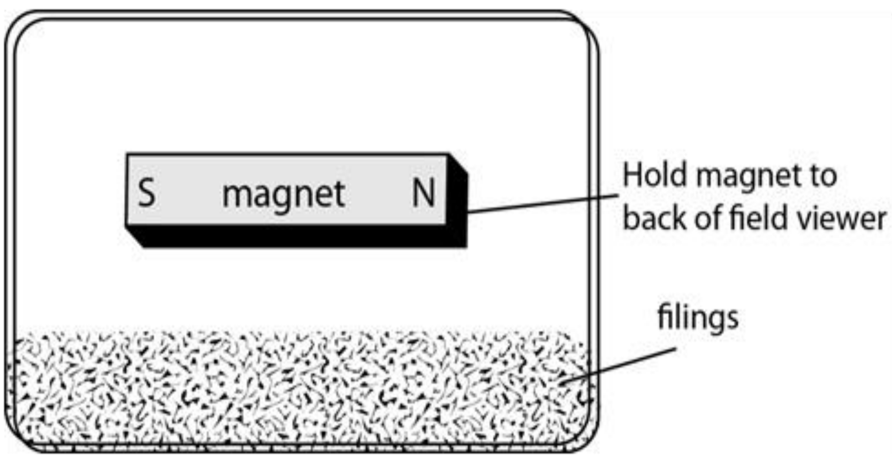
- picking up empty soda cans for recycling
- collecting steel nuts, bolts, and nails from the floor of a hardware store
- finding the copper electrical wires within a house's walls
- picking up old steel pieces of barbed wire in pastures so cows won't eat them
- finding gold rings that were lost at the beach

1. Write a paragraph about which of her claims you don't agree with and include the reasons you think they are not true.
2. Help this student sell her invention by listing some other uses for her amazing new tool.

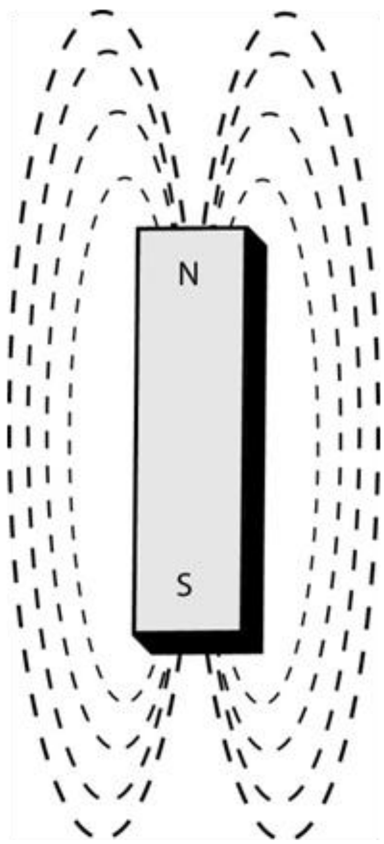
BLM 3



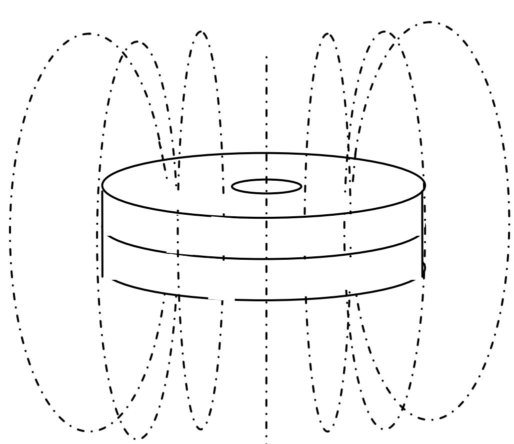
Suspended Paper Clip Setup



Bar Magnet and Magnetic Field Viewer



Magnet and Field Lines



Donut Magnet Field Lines

BLM 4 Magnet Challenges

1. Using a pencil and donut magnets, how could you suspend a magnet in mid-air (levitate it) without touching it? Make a drawing that shows your idea and explain how it works.
2. Your class just got a new box of 30 bar magnets. Only one of the magnets has the north and south poles marked on it. Your teacher asks you to mark all of the other magnets. How will you do this?
3. Your class got another box of bar magnets. All of the magnets are unmarked. You soon realize that in the box there are also bars of iron that are not magnets, but they look exactly like the magnets. How can you separate the pieces of iron that are not magnets from the actual magnets?
4. How can you remove a paper clip from a glass of water without putting anything else in the water or pouring any of it out?
5. Sam claimed that he found a way to use scissors to cut the magnetic force of donut magnets. Sarah told him there was no way he could use scissors to cut a magnetic force, just like you can't use scissors to cut gravity. To prove he could do it, Sam set up a suspended paper clip using two donut magnets, like you did in class. Then he took a pair of scissors and "cut" the air between the paper clip and the magnets. As the scissor blades came together, the paper clip instantly fell to the desk. "See? I did it," he said. Did Sam cut the magnetic force, or was Sarah right? Explain the reason for your answer.

Appendix

Common Student Preconceptions About This Topic

Studies of children's ideas about magnetism find that many children see magnetism as a kind of gravity. Many also think that air is necessary for a magnet to work. Although many students know that two magnets can be made to repel, few have an idea of poles, and those that are aware of poles believe them to be only at the ends of the magnets. Further, students often have minimal understanding of the role of magnets in common objects such as motors, loudspeakers, and headphones.

Detailed Background Information

A piece of iron can be made to attract other things made of iron. If it can do this, it is called a magnet. When two magnets are near each other, a force between them can either push them apart or pull them together. This is because magnets have two ends that may look alike, but are different with regard to magnetism. These ends are called poles, and we refer to one as north and the other as south.

A magnet exerts its strongest force at its poles. When like poles of two magnets, for example, the two north ends, are near each other, the magnets will push each other away, or repel each other. When the opposite poles, that is, the north pole of one magnet and the south pole of another, are near each other, the two magnets are pulled together. In other words, they attract each other.

Extending outward from the poles is a space where a magnet can make iron objects move without actually touching them. This volume of space is called a magnetic field. The field is strongest close to the magnet and weaker farther away. The stronger the field, the stronger the force exerted. The size and strength of the magnetic field generally depends on the size of the magnet. For example, the magnets in plastic letters of the alphabet that small children play with are barely strong enough to stick to a refrigerator door, but the magnets used to separate steel cans from aluminum ones in a recycling plant can be hundreds of times bigger.

A remarkable feature of the magnetic field is that it can penetrate non-magnetic objects as if they were not there – but only if the non-magnetic object is thinner than the width of the magnetic field. You can easily see evidence of the penetrating ability of magnetic forces by scattering several paper clips on a piece of cardboard, and then rearranging them with a magnet held under the cardboard. However, trying the same thing with paper clips scattered on a closed book or a thick magazine is unlikely to produce movement of the paper clips caused by the magnet below.

Students may wonder if there is any relationship between the north and south poles of magnets and the North and South Poles of the Earth. There is. Much of the Earth's interior consists of iron, and all that iron makes it seem as if a giant bar magnet runs through the center of the Earth. Imagine that this giant bar magnet is the bar magnet shown in Diagram 3. The spherical Earth would be wrapped in three dimensions around this giant magnet, and the giant magnet's

Appendix (cont.)

north and south poles would be located at the Earth's North and South poles, respectively.

Keeping in mind that the magnetic force of any magnet is strongest at its poles, imagine that all the magnets in classrooms all over the Earth could magically float in the air. Every such floating magnet would have its south pole attracted to the Earth's North Pole, and its north pole attracted to the Earth's South Pole (since opposites attract). This means that if all the magnets on Earth could float in the air, they would look like the dashed lines in Diagram 3, except in 3-D.

A magnet lying on a table won't move to line up with the Earth's magnetic field because friction prevents it from moving freely. A compass, though, contains a small, lightweight magnet shaped like a pointer, which floats in water or oil, so there is very little friction present. Thus, the pointed end of a compass magnet will always be aimed toward the North Pole. (Always, that is, unless the compass is close to another magnet. A compass can also be thrown off if it is close to large magnetic objects or sources of electrical energy.)

Although the south end of an imaginary floating magnet would point to the North Pole, we actually call the end of a magnet that points north the "north" pole. This is short for its full name, the "north-seeking pole", meaning the pole that is attracted to the Earth's North Pole.