Magnetism

Magnets and Magnetic Fields

Before You Read

What do you think? Read the two statements below and decide whether you agree or disagree with them. Place an A in the Before column if you agree with the statement or a D if you disagree. After you've read this lesson, reread the statements to see if you have changed your mind.

Before	Statement	After
	1. All metal objects are attracted to a magnet.	
	2. Two magnets can attract or repel each other.	

Key Concepts

- What types of forces do magnets apply to other magnets?
- Why are some materials magnetic?
- Why are some magnets temporary while others are permanent?

Read to Learn

Magnets

Did you use a computer or a hair dryer today? Did you listen to a stereo system? It might surprise you to know that these devices contain magnets. Magnets also are used to produce the electric energy that makes these familiar devices work. *A* **magnet** *is any object that attracts the metal iron.*

People use magnets in many ways. These different uses call for magnets of many shapes and sizes. You might be familiar with bar magnets and horseshoe magnets. Some of the magnets holding papers on your refrigerator might be disc-shaped or flat and flexible. However, all magnets have certain things in common, regardless of their shape and size.

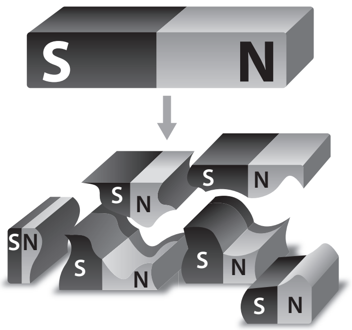
Mark the Text

Identify the Main Ideas Write notes to summarize the main ideas next to each paragraph. On a separate piece of paper, organize these notes into two columns. Place each main idea in the left column. List the details to support it in the right column. Use your table to review the lesson.

Magnetic Poles

You might have noticed that the ends of some magnets are different colors or labeled *N* and *S*. These colors and labels identify the magnet's magnetic poles. *A* **magnetic pole** *is a place on a magnet where the force it applies is strongest.* All magnets have two magnetic poles—a north pole and a south pole. As shown in the figure, if a magnet is broken into pieces, each piece will have a north pole and a south pole.

Magnet



Visual Check

1. State What is the same for each of the magnet pieces?

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The Forces Between Magnetic Poles

A force exists between the poles of any two magnets. If similar poles of two magnets, such as north and north or south and south, are brought near each other, the magnets repel. They push away from each other. If the north pole of one magnet is brought near the south pole of another magnet, the two magnets attract, or pull together. Similar magnetic poles repel and opposite magnetic poles attract.

A force of attraction or repulsion between the poles of two magnets is a **magnetic force.** A magnetic force becomes stronger as magnets move closer together and becomes weaker as the magnets move farther apart.

Key Concept Check
2. Describe What types of forces do magnets apply to other magnets?

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Magnetic Fields

Recall that charged objects repel or attract each other even when they are not touching. Similarly, magnets can repel or attract each other even when they are not touching. An invisible magnetic field surrounds all magnets. It is this magnetic field that applies forces on other magnets.

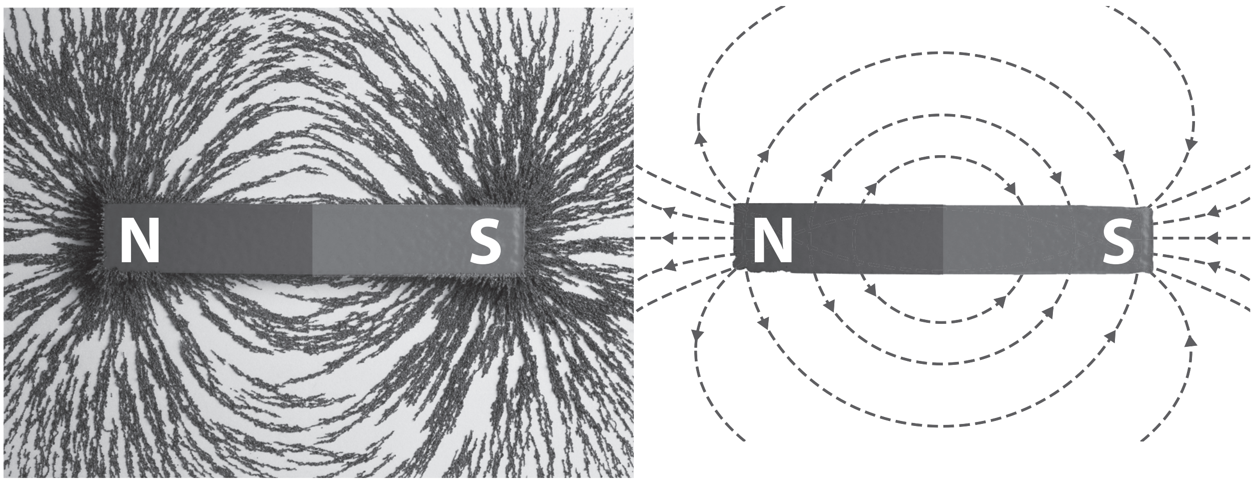
Magnetic Field Lines

On the left in the figure below, iron filings have been sprinkled around a bar magnet. The iron filings form a pattern of curved lines that show the magnet's magnetic field.

A magnet's magnetic field can be represented by lines, called magnetic field lines. Magnetic field lines have a direction that is shown on the right in the figure below. The lines are closest together at the magnet's poles. This is where the magnetic force is strongest. Where the field lines are farther apart, the field and the force are weaker.

Visual Check
3. Draw arrows showing the direction of the magnetic field lines on the left side of the figure.

Magnetic Field



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Combining Magnetic Fields

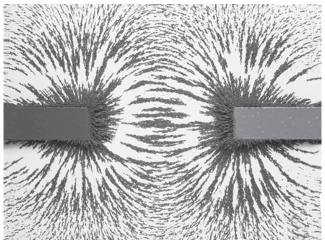
What happens to the magnetic fields around two bar magnets that are brought together? The two fields combine and form one new magnetic field.

The pattern of the new magnetic field lines depends on whether two like poles or two unlike poles are near each other. This is shown in the figure below.

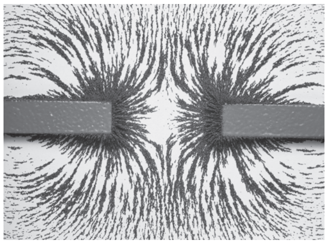
Magnetic Attraction and Repulsion

Attraction

When opposite poles of two magnets are near each other, the resulting magnetic field applies a force of attraction.



Repulsion



When like poles of two magnets are near each other, the resulting magnetic field applies a force of repulsion.

Earth's Magnetic Field

A magnetic field surrounds Earth similar to the way a magnetic field surrounds a bar magnet. Earth has a magnetic field due to molten iron and nickel in its outer core. Like all magnets, Earth has a magnetic north pole and a magnetic south pole.

Compasses

Have you ever wondered why a compass needle points toward north? The needle of a compass is a small magnet. Like other magnets, a compass needle has a north pole and a south pole. Earth's magnetic field exerts a force on the needle, causing it to rotate.

If a compass needle is within any magnetic field, including Earth's, it will line up with the magnet's field lines. A compass needle does not point directly toward the poles of a magnet. Instead, the needle aligns with the field lines and points in the direction of the field lines.

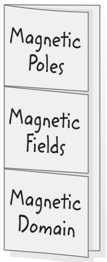
Earth's magnetic poles and geographic poles are not in the same spot. Therefore, you cannot find your way to the geographic poles with only a compass.

Visual Check

4. Identify Circle the diagram that shows magnetic fields forming lines to connect the two poles.

FOLDABLES®

Make a three-tab book to organize your notes about magnetic forces.



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Auroras

Earth's magnetic field protects Earth from charged particles from the Sun. These particles can damage living organisms if they reach the surface of Earth. Earth's magnetic field deflects most of these particles.

Sometimes, large numbers of these particles coming from the Sun travel along Earth's magnetic field lines and concentrate near the magnetic poles. There, the particles collide with atoms of gases in the atmosphere. This causes the atmosphere to glow. The light forms shimmering sheets of color known as auroras. ✓

Reading Check

5. Define What is an aurora?

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Magnetic Materials

You have read that magnets attract each other when their unlike poles come close together. However, magnets also attract objects such as nails, which are not magnets. *Any material that is strongly attracted to a magnet is a* **magnetic material.** Magnetic materials often contain ferromagnetic (fer oh mag NEH tik) elements. **Ferromagnetic elements** *are elements, including iron, nickel, and cobalt, that have an especially strong attraction to magnets.* ✓

Reading Check

6. Name What are magnetic materials made of?

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It is important to understand that while not all materials are magnetic, a magnetic field does surround every atom that makes up all materials. The field is created by the atom's constantly moving electrons. The interactions of these individual fields determines whether a material is magnetic.

Next, you will read about why magnetic materials make good magnets while most elements do not. You will learn about how groups of atoms can act together and form a magnet. ✓

Reading Check

7. Explain Why is nickel a magnetic material?

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Magnetic Domains

If all atoms act like tiny magnets, why do magnets not attract most materials, such as glass and plastic? The answer is that in most materials, the magnetic fields of the atoms point in different directions. As the fields around the atoms combine, they cancel each other. Thus, most types of matter are nonmagnetic materials and are not attracted to magnets.

In a magnetic material, atoms form groups called magnetic domains. *A* **magnetic domain** *is a region in a magnetic material in which the magnetic fields of the atoms all point in the same direction.* The magnetic fields of the atoms in a domain combine, forming a single field around the domain. As a result, each domain is a tiny magnet with a north pole and a south pole.

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When Domains Don't Line Up

Some objects made of magnetic materials are not magnets. This is because the magnetic fields of their domains point in random directions. Similar to the atoms of a nonmagnetic material, the random magnetic fields of the domains cancel each other. Therefore, even though the individual domains are magnets, the entire object has no effective magnetic field.

SCIENCE USE V. COMMON USE
domain
Science Use any small region of uniform magnetism in a ferromagnetic material
Common Use complete and absolute ownership of land

When Domains Line Up

How do a bar magnet and a steel nail that is not a magnet differ? Both are magnetic materials. Both have atoms grouped into magnetic domains.

However, for an object to be a magnet, its magnetic domains must align. When the domains align, their magnetic fields combine, forming a single magnetic field around the entire material. This causes the object to become a magnet.

Key Concept Check
8. Explain Why are some materials magnetic?

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How Magnets Attract Magnetic Materials

Imagine a nail coming close to one of the poles of a bar magnet. Remember, even though the nail itself is not a magnet, each magnetic domain in the nail is a small magnet.

The magnetic field around the bar magnet applies a force to each of the nail's magnetic domains. This force causes the domains in the nail to align along the bar magnet's magnetic field lines. As the poles of the domains of the nail point in the same direction, the nail becomes a magnet. Now the nail can attract other magnetic materials, such as paperclips.

Temporary Magnets

In the example of the nail and the bar magnet, the nail became a temporary magnet. *A magnet that quickly loses its magnetic field after being removed from a magnetic field is a* **temporary magnet.**

The nail was a magnet only when it was close to the bar magnet. There, the magnetic field of the bar magnet was strong enough to cause the nail's magnetic domains to line up. However, when the nail was moved away from the bar magnet, the poles of the domains in the nail returned to pointing in different directions. The nail was no longer a magnet and no longer attracted other magnetic materials.

Reading Check
9. Assess Why did the nail lose its magnetic field when it was moved away from the bar magnet?

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Permanent Magnets

A magnet that remains a magnet after being removed from another magnetic field is a **permanent magnet.** In a permanent magnet, the magnetic domains remain lined up.

Some magnetic materials can be made into permanent magnets by placing them in a very strong magnetic field. This causes the magnetic domains to align and stay aligned. The material then remains a magnet after it is removed from the field.

Key Concept Check

10. Distinguish Why are some magnets temporary while others are permanent?

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After You Read

Mini Glossary

ferromagnetic (fer oh mag NEH tik) element: elements that have an especially strong attraction to magnets, including iron, nickel, and cobalt

magnet: any object that attracts the metal iron

magnetic domain: a region in a magnetic material in which the magnetic fields of the atoms all point in the same direction

magnetic force: force of attraction or repulsion between the poles of two magnets

magnetic material: any material that is strongly attracted to a magnet

magnetic pole: the place on a magnet where the force it applies is strongest

permanent magnet: a magnet that remains a magnet after being removed from another magnetic field

temporary magnet: a magnet that quickly loses its magnetic field after being removed from a magnetic field

1. Review the terms and their definitions in the Mini Glossary. Write a sentence that explains what causes a magnetic force to get stronger.

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2. Circle *like* or *unlike* and *attract* or *repel* next to each pair of bar magnets.

like unlike
attract repel

like unlike
attract repel

like unlike
attract repel

3. Describe the process by which a magnetic material could be made into a permanent magnet.

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What do you think NOW?

Reread the statements at the beginning of the lesson. Fill in the After column with an A if you agree with the statement or a D if you disagree. Did you change your mind?

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END OF LESSON

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