Section 2

Reflection and Mirrors

Reading Preview

Key Concepts

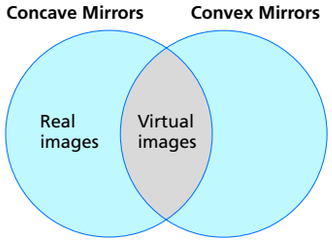
- What are the kinds of reflection?
- What types of images are produced by plane, concave, and convex mirrors?

Key Terms

- ray • regular reflection
- diffuse reflection
- plane mirror • image
- virtual image
- concave mirror • optical axis
- focal point • real image
- convex mirror

Target Reading Skill

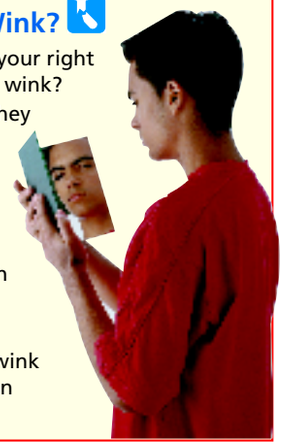
Comparing and Contrasting
As you read, compare and contrast concave and convex mirrors in a Venn diagram like the one below. Write the similarities in the space where the circles overlap and the differences on the left and right sides.



Lab zone Discover Activity

How Does Your Reflection Wink?

1. Look at your face in a mirror. Wink your right eye. Which eye does your reflection wink?
2. Tape two mirrors together so that they open and close like a book. Open them so they form a 90-degree angle with each other. **CAUTION:** *Be careful of any sharp edges.*
3. Looking into both mirrors at once, wink at your reflection again. Which eye does your reflection wink now?



Think It Over
Observing How does your reflection wink at you? How does the second reflection compare with the first reflection?

You laugh as you and a friend move toward the curved mirror. First your reflections look tall and skinny. Then they become short and wide. At one point, your reflections disappear even though you are still in front of the mirror. Imagine what it would be like if this happened every time you tried to comb your hair in front of a mirror!

Funhouse mirror ▶

Lab zone Discover Activity

Skills Focus Observing L1

Materials 2 plane mirrors, tape

Time 10 minutes

Tips Use hand mirrors or cosmetic mirrors. Tape any sharp edges and caution students not to touch them.

Expected Outcome When the student looks into one mirror and winks the right eye, the left eye of the reflection winks. When the student looks into two mirrors at right angles and winks the right eye, the right eye of the reflection winks.

Think It Over The reflection winks the opposite eye. The second reflection is a reflection of the first image, so it winks the same eye as the student.

Section 2

Reflection and Mirrors

Objectives

After this lesson, students will be able to
O.4.2.1 Identify the kinds of reflection.
O.4.2.2 Describe the types of images produced by plane, concave, and convex mirrors.

Target Reading Skill

Comparing and Contrasting Explain that comparing and contrasting information shows how ideas, facts, and events are similar and different. The results of the comparison can have importance.

Answers

Sample Venn diagram:
Concave Mirror
Real images
Enlarged images
Curves inward
Convex Mirror
Curves outward
Similarities
Virtual images
Reduced images

All in One Teaching Resources

- Transparency O42

Preteach

Build Background Knowledge L2

Focusing on Reflection

Ask: **How do the mirrors on the inside and outside of vehicles help drivers?** *(Sample answer: Allow drivers to see what is behind them)* Explain that mirrors work by reflecting light. Tell students that in this section they will learn more about reflection of light and about other types of mirrors.

Instruct

Reflection of Light Rays

Teach Key Concepts L2

Types of Reflection

Focus Tell students there are two types of reflection: regular and diffuse.

Teach Make a Venn diagram on the board comparing and contrasting regular and diffuse reflection. *(Both involve the reflection of light rays from a surface, and in both the rays obey the law of reflection. However, regular reflection occurs with a smooth surface and creates a sharp image, whereas diffuse reflection occurs with a bumpy surface and creates a fuzzy image or no image at all.)*

Apply Ask: **Why do we see most objects by diffuse reflection?** *(Sample answer: Because most objects have relatively rough surfaces that reflect parallel rays at different angles)* **learning modality: visual**

Use Visuals: Figure 7 L2

Comparing Angles of Incidence and Reflection

Focus Remind students that the angle of incidence and the angle of reflection of light are always equal.

Teach For the diagram of regular reflection, have students identify the angles of incidence and the angles of reflection. Ask: **Why are there several different angles of reflected light rays shown in the diagram on the left and just one angle in the diagram on the right?** *(In the left diagram, the surface is rough, so light rays strike the surface at different angles, so rays are reflected at different angles. In the right diagram, the surface is smooth, so all light rays strike the surface at the same angle and are reflected at the same angle.)*

Apply Ask: **What determines whether the reflection from the surface of the water is regular or diffuse?** *(Whether the water is smooth or choppy)* **learning modality: logical/mathematical**

Independent Practice L2

All in One Teaching Resources

- Guided Reading and Study Worksheet: *Reflection and Mirrors*
- Transparency O43

Student Edition on Audio CD

Lab zone Skills Activity

Observing

In a dark room, hold a flashlight next to a table. **CAUTION:** *Do not look directly into the flashlight.* Point its beam straight up so no light shines on the tabletop. Then hold a metal can upright 5 cm above the flashlight. Tilt the can so its flat bottom reflects light onto the table. Try this again using a white paper cup. How does the light reflected by the can compare with the light reflected by the cup?

Reflection of Light Rays

The reflection you see in a mirror depends on how the surface reflects light. To show how light reflects, you can represent light waves as straight lines called **rays.** Recall from Chapter 1 that light rays obey the law of reflection—the angle of reflection equals the angle of incidence.

Figure 7 shows two kinds of reflection. In the choppy water, you do not see a clear reflection of the person in the boat. But in the smooth water, you see a sharp reflection. **The two ways in which a surface can reflect light are regular reflection and diffuse reflection.**

Regular Reflection When parallel rays of light hit a smooth surface, **regular reflection** occurs. All of the light rays are reflected at the same angle because of the smooth surface. So, you see a sharp reflection.

Diffuse Reflection When parallel rays of light hit a bumpy or uneven surface, **diffuse reflection** occurs. Each light ray obeys the law of reflection but hits the surface at a different angle because the surface is uneven. Therefore, each ray reflects at a different angle, and you don't see a clear reflection.

Reading Checkpoint **What kind of surface results in diffuse reflection?**

FIGURE 7
Diffuse and Regular Reflection
The type of reflection that occurs at a surface depends on whether the surface is rough or smooth.

Lab zone Skills Activity

Skills Focus Observing L2

Materials flashlight, metal can, white paper cup

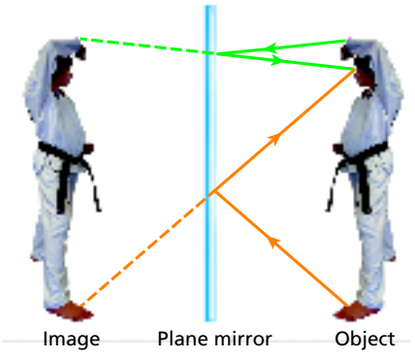
Time 10 minutes

Tips Make sure students keep the light and reflective material in the same positions when they compare the can and the cup. You may want to do this activity as a demonstration.

Expected Outcome The reflection from the can is a brighter, narrower beam or spot of light. The reflection from the paper cup is weak and diffuse.

Extend Ask: **Why is the light reflected by the cup not as bright as the light reflected by the can?** *(The surface of the cup is not as smooth as the surface of the can, so it scatters light.)* **learning modality: kinesthetic**

FIGURE 8
Image in a Plane Mirror
A plane mirror forms a virtual image. The reflected light rays appear to come from behind the mirror, where the image forms.
Observing *Is the raised hand in the image a left hand or a right hand?*



Plane Mirrors

Did you look into a mirror this morning to comb your hair or brush your teeth? If you did, you probably used a plane mirror. A **plane mirror** is a flat sheet of glass that has a smooth, silver-colored coating on one side. Often the coating is on the back of the mirror to protect it from damage. When light strikes a mirror, the coating reflects the light. Because the coating is smooth, regular reflection occurs and a clear image forms. An **image** is a copy of an object formed by reflected or refracted rays of light.

What Kind of Image Forms The image you see in a plane mirror is a **virtual image**—an upright image that forms where light seems to come from. "Virtual" describes something that does not really exist. Your image appears to be behind the mirror, but you can't reach behind the mirror and touch it.

A plane mirror produces a virtual image that is upright and the same size as the object. But the image is not quite the same as the object. The left and right of the image are reversed. For example, when you look in a mirror, your right hand appears to be a left hand in the image.

How Images Form Figure 8 shows how a plane mirror forms an image. Some light rays from the karate student strike the mirror and reflect toward his eye. Even though the rays are reflected, the student's brain treats them as if they had come from behind the mirror. The dashed lines show where the light rays appear to come from. Because the light appears to come from behind the mirror, this is where the student's image appears to be located.

Reading Checkpoint **Where does an image in a plane mirror appear to be located?**

Plane Mirrors

Teach Key Concepts L2

Plane Mirrors and Virtual Images

Focus Familiarize students with plane mirrors and virtual images.

Teach Define plane mirrors, and say they are the mirrors students use everyday when they brush their teeth or comb their hair. Define virtual images as the images that form in plane mirrors. Ask: **When you see your virtual image in a plane mirror, how is it similar to the real you?** *(Sample answer: The image has the same details and color, is the same size, and is upright.)* **How is your virtual image different?** *(Some students may correctly say the left and right of the image are reversed.)*

Apply Ask: **Why does a virtual image appear to be located behind a plane mirror?** *(The reflected light appears to come from the image, making the image appear to be as far behind the mirror as the object is in front of the mirror.)* **learning modality: verbal**

All in One Teaching Resources

- Transparency O44

Monitor Progress L2

Drawing Have students draw a diagram showing how a plane mirror forms a virtual image.

Students can keep their drawings in their portfolios. Portfolio

Answers

Figure 8 The raised hand in the image is a left hand (left and right are reversed).

Reading Checkpoint A bumpy or uneven surface results in diffuse reflection.

Reading Checkpoint An image in a plane mirror appears to be located behind the mirror.

Differentiated Instruction

Special Needs L1

Observing Virtual Images Help students understand how an object's virtual image differs from the object. Have pairs of students play a game in one student pretends to be the object and the other student pretends to be the image. Tell them to face each other and move their arms and legs in unison to show how the image reverses left and right relative to the object. **learning modality: kinesthetic**

Gifted and Talented L3

Diagramming Virtual Images Challenge students to draw a diagram including an object, plane mirror, image, and light rays to show why a virtual image reverses left and right. Give them an opportunity to explain their diagrams to the class. **learning modality: visual**

Concave Mirrors

Teach Key Concepts L2

Introducing Concave Mirrors

Focus Describe how a concave mirror is curved like the inside of a bowl.

Teach Use Figure 9 or a similar sketch on an overhead projector to show students how light is reflected from a concave surface. Point to the angles of incidence and angles of reflection of the rays in Figure 9 or your sketch. Then, ask: **Why are parallel rays no longer parallel after they are reflected by the concave surface of the mirror?** *(Because the rays strike the curved surface at different angles, causing them to be reflected at different angles as well.)*

Apply Ask: **When rays parallel to the optical axis strike a concave mirror, where do all the reflected rays meet?** *(At the focal point)* **learning modality: visual**

Lab zone Teacher Demo L1

Modeling Reflection From a Concave Mirror

Materials large round bowl, modeling clay, water-filled squirt toy, paper towels

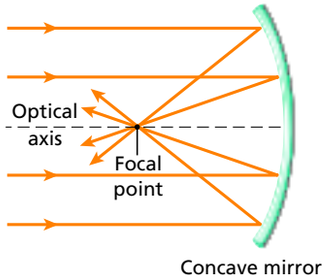
Time 10 minutes

Focus Tell students you will use the bowl to represent a concave mirror and a stream of water from the toy to represent a ray of light.

Teach Use modeling clay to hold the bowl vertically (on its side) on a table top. As students observe, spray a horizontal stream of water directly at the center of the bottom of the bowl. Ask: **What happens to the stream of water?** *(It bounces off the bottom of the bowl toward the center.)* Then, spray streams of water toward other locations inside the bowl. Ask: **What keeps happening to the streams of water?** *(As long as the spray is parallel to the bowl's "optical axis," the water bounces back toward the center of the bow, but in front of the bowl.)*

Apply Ask: **What happens to light rays when they strike the concave surface of a mirror?** *(Sample answer: They bounce back toward the mirror's focal point.)* **learning modality: visual**

FIGURE 9
Focal Point of a Concave Mirror
A concave mirror reflects rays of light parallel to the optical axis back through the focal point.



Concave Mirrors

A mirror with a surface that curves inward like the inside of a bowl is a **concave mirror.** Figure 9 shows how a concave mirror can reflect parallel rays of light so that they meet at a point. Notice that the rays of light shown are parallel to the optical axis. The **optical axis** is an imaginary line that divides a mirror in half, much like the Equator that divides Earth into northern and southern halves. The point at which rays parallel to the optical axis meet is called the **focal point.** The location of the focal point depends on the shape of the mirror. The more curved the mirror is, the closer the focal point is to the mirror.

Representing How Images Form Ray diagrams are used to show where a focused image forms in a concave mirror. A ray diagram shows rays of light coming from points on the object. Two rays coming from one point on the object meet or appear to meet at the corresponding point on the image. Figure 10 shows how a ray diagram is drawn.

FIGURE 10
Drawing a Ray Diagram

Ray diagrams show where an image forms and the size of the image. The steps below show how to draw a ray diagram.

1. Draw a red ray from a point on the object (point **A**) to the mirror. Make this ray parallel to the optical axis. Then draw the reflected ray, which passes through the focal point.
2. Draw the green ray from the same point on the object to the mirror. Draw this ray as if it comes from the focal point. Then draw the reflected ray, which is parallel to the optical axis.
3. Draw dashed lines behind the mirror to show where the reflected rays appear to come from. The corresponding point on the image is located where the dashed lines cross.

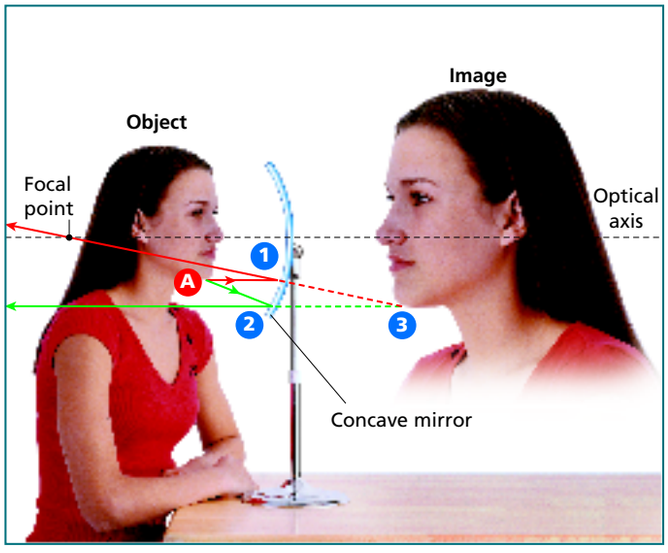
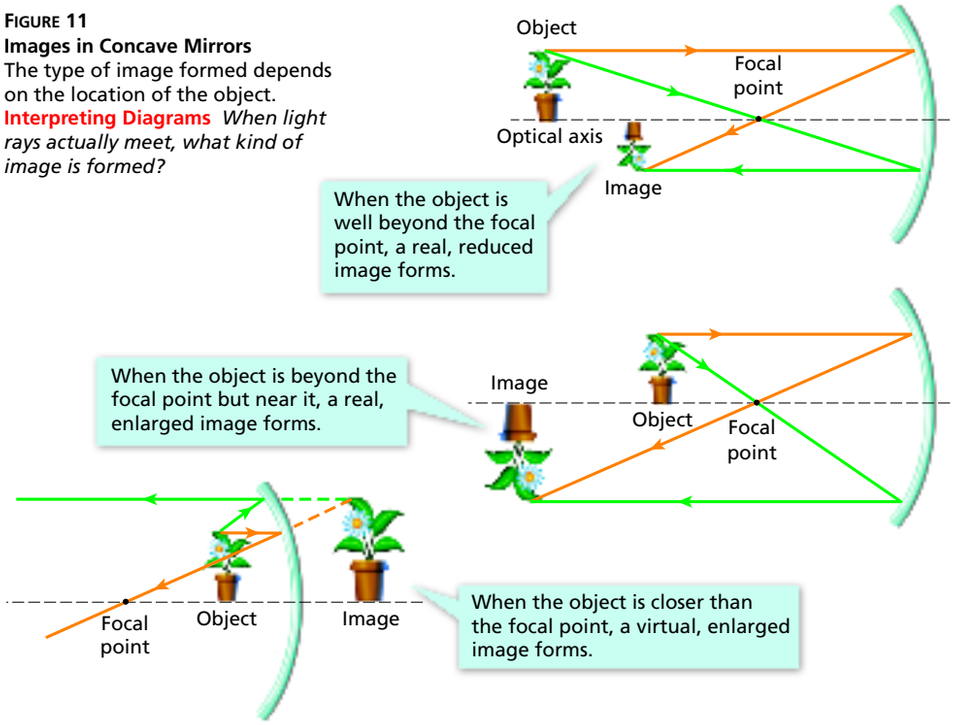


FIGURE 11
Images in Concave Mirrors
The type of image formed depends on the location of the object.
Interpreting Diagrams *When light rays actually meet, what kind of image is formed?*



Determining the Type of Image The type of image that is formed by a concave mirror depends on the location of the object. **Concave mirrors can form either virtual images or real images.** If the object is farther away from the mirror than the focal point, the reflected rays form a real image as shown in Figure 11. A **real image** forms when rays actually meet. Real images are upside down. A real image may be larger or smaller than the object.

If the object is between the mirror and the focal point, the reflected rays form a virtual image. The image appears to be behind the mirror and is upright. Virtual images formed by a concave mirror are always larger than the object. Concave mirrors produce the magnified images you see in a makeup mirror.

If an object is placed at the focal point, no image forms. But if a light source is placed at the focal point, the mirror can project parallel rays of light. A car headlight, for example, has a light bulb at the focal point of a concave mirror. Light hits the mirror, forming a beam of light that shines on the road ahead.

Reading Checkpoint **What is a real image?**

Go Online **active art**
For: Mirrors activity
Visit: PHSchool.com
Web Code: cgp-5042

Lab zone **Build Inquiry** L2

Finding the Focal Point of a Concave Mirror

Materials concave mirror, white paper, flashlight

Time 15 minutes

Focus Challenge small groups of students to produce real images of the flashlight bulb on the paper to determine where the focal point of a mirror is.

Teach Have students look at the positions of the objects, mirrors, and images in Figure 11 to determine where to place the flashlight, mirror, and paper. Suggest that one student hold the mirror, another the white paper, and a third the flashlight.

Apply Ask: **Where is the focal point?** *(The location of the flashlight beyond which the image becomes inverted and real)* **learning modality: kinesthetic**

All in One **Teaching Resources**
- Transparency O45

Go Online **active art**
For: Mirror activity
Visit: PHSchool.com
Web Code: cgp-5042
Students can interact with ray diagrams of mirrors online.

Differentiated Instruction

Less Proficient Readers L1
Comparing and Contrasting Images
Pair less proficient readers with more proficient readers. Have each pair make a table comparing and contrasting the real and virtual images produced by a concave mirror. Tables should compare and contrast how the images form and how they appear. **learning modality: visual**

Gifted and Talented L3
Diagramming Reflected Rays
Challenge students to draw diagrams showing how the shiny concave surface behind the bulb of a flashlight reflects light. *(Diagrams should show rays of light from the bulb, which is placed at the focal point, striking the concave surface at different angles and being reflected in rays parallel to the optical axis.)* **learning modality: logical/mathematical**

Monitor Progress L2

Writing Have students explain the difference between a real and a virtual image.

Answers
Figure 11 A real image forms.
Reading Checkpoint An upside-down image that forms when rays of light actually meet

Convex Mirrors

Teach Key Concepts L2

Reflection From Convex Mirrors

Focus Call students' attention to Figure 12.

Teach Ask: **Why does a convex mirror never produce a real image?** *(Because rays reflected from any point on the object never meet)*

Apply Ask: **What are examples of convex mirrors you use?** *(Sample answer: Rearview mirrors of vehicles)* **learning modality: visual**

All in One Teaching Resources

- Transparency O46

Monitor Progress L2

Answers

Figure 12 The rays spread out as they move away from the mirror.

Reading Checkpoint Passenger-side mirrors in cars

Assess

Reviewing Key Concepts

1. a. Regular and diffuse **b.** In both, the angle of reflection equals the angle of incidence. In regular reflection, parallel rays strike and are reflected from a smooth surface at the same angle; in diffuse reflection, parallel rays strike and are reflected from a bumpy surface at different angles. **c.** The shiny spoon produces a regular reflection and the tarnished spoon a diffuse reflection.

2. a. Copy of an object formed by reflected or refracted rays of light **b.** All three types form virtual images. Concave mirrors also form real images. **c.** In both types, the size of the image depends on the distance of the object from the mirror. A concave mirror produces images that are real or virtual, reduced or enlarged, and upright or upside-down. A convex mirror produces only upright, reduced, virtual images.

Reteach L1

Describe a real and a virtual image, and have students identify which types of mirrors can produce each image.

Performance Assessment L2

Ask students to draw diagrams showing how concave and convex mirrors form virtual images.

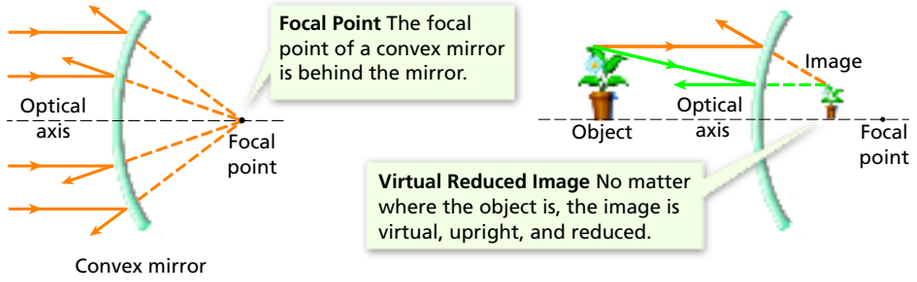


FIGURE 12
Convex Mirrors
Light rays parallel to the optical axis reflect as if they came from the focal point behind the mirror. The image formed by a convex mirror is always virtual.
Making Generalizations *Describe the directions of the parallel rays reflected by a convex mirror.*

Convex Mirrors

A mirror with a surface that curves outward is called a **convex mirror.** Figure 12 shows how convex mirrors reflect parallel rays of light. The rays spread out but appear to come from a focal point behind the mirror. The focal point of a convex mirror is the point from which the rays appear to come. **Because the rays never meet, images formed by convex mirrors are always virtual and smaller than the object.**

Perhaps you have seen this warning on a car mirror: "Objects in mirror are closer than they appear." Convex mirrors are used in cars as passenger-side mirrors. The advantage of a convex mirror is that it allows you to see a larger area than you can with a plane mirror. The disadvantage is that the image is reduced in size, so it appears to be farther away than it actually is.

Reading Checkpoint **Where are convex mirrors typically used?**

Section 2 Assessment

Target Reading Skill

Comparing and Contrasting Use your Venn diagram about mirrors to help you answer Question 2 below.

Reviewing Key Concepts

1. a. Reviewing What are two kinds of reflection?
b. Explaining Explain how both kinds of reflection obey the law of reflection.
c. Inferring Why is an image clear in a shiny spoon but fuzzy in a tarnished spoon?

2. a. Defining What is an image?
b. Classifying Which mirrors can form real images? Which can form virtual images?
c. Comparing and Contrasting How are images in concave mirrors like images in convex mirrors? How are they different?

Writing in Science

Dialogue At a funhouse mirror, your younger brother notices he can make his image disappear as he walks toward the mirror. He asks you to explain, but your answer leads to more questions. Write the dialogue that might take place between you and your brother.

All in One Teaching Resources

- Section Summary: *Reflection and Mirrors*
- Review and Reinforcement: *Reflection and Mirrors*
- Enrich: *Reflection and Mirrors*

Writing in Science

Writing Mode Dialogue

Scoring Rubric

4 Exceeds criteria
3 Meets criteria
2 Includes a dialogue but makes errors and/or does not provide enough detail
1 Includes no dialogue and/or fails to explain reflection from a concave mirror