section 2

Reflection and Mirrors

The Law of Reflection

You've probably noticed your image on the surface of a pool or lake. If the surface of the water was smooth, you could see your face clearly. If the surface of the water was wavy, however, your face might have seemed distorted. The image you saw was the result of light reflecting from the surface and traveling to your eyes. How the light was reflected determined the sharpness of the image you saw.

When a light ray strikes a surface and is reflected, as in **Figure 8,** the reflected ray obeys the law of reflection. Imagine a line that is drawn perpendicular to the surface where the light ray strikes. This line is called the normal to the surface. The incoming ray and the normal form an angle called the angle of incidence. The reflected light ray forms an angle with the normal called the angle of reflection. According to the **law of reflection,** the angle of incidence is equal to the angle of reflection. This is true for any surface, no matter what material it is made of.

Reflection from Surfaces

Why can you see your reflection in some surfaces and not others? Why does a piece of shiny metal make a good mirror, but a piece of paper does not? The answers have to do with the smoothness of each surface.

as you read

What You'll Learn

- **Explain** how light is reflected from rough and smooth surfaces.
- **Determine** how mirrors form an image.
- **Describe** how concave and convex mirrors form an image.

Why It's Important

Mirrors can change the direction of light waves and enable you to see images, such as your own face.

Review Vocabulary

normal: a line drawn perpendicular to a surface or line

New Vocabulary

- law of reflection
- focal point
- focal length

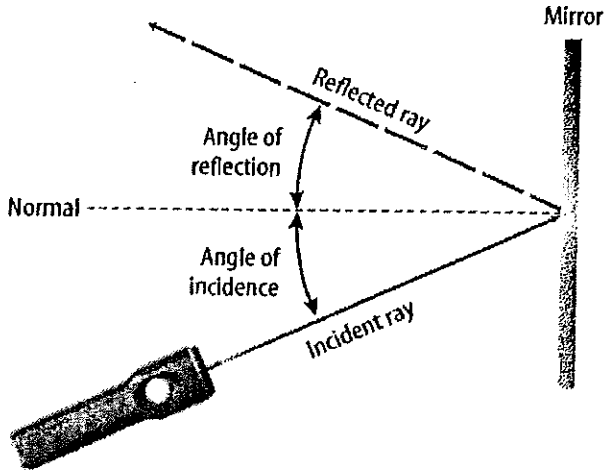
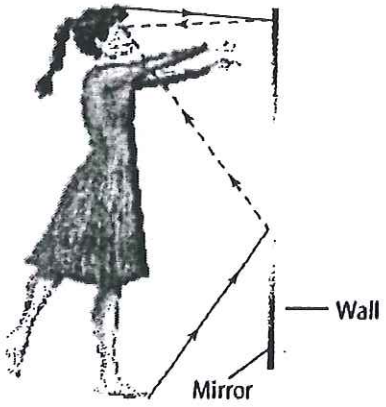
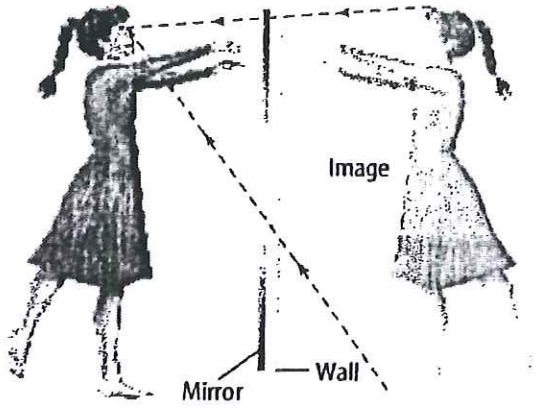


Figure 8 A light ray strikes a surface and is reflected. The angle of incidence is always equal to the angle of reflection. This is the law of reflection.



A Light rays that bounce off a person strike the mirror. Some these light rays are reflected into the person's eye.



B The light rays that are shown entering the person's eye seem to be coming from a person behind the mirror.

Figure 11 A plane mirror forms an image by changing the direction of light rays.
Describe *how you and your image in a plane mirror are different.*

Reflection by Plane Mirrors Did you glance in the mirror before leaving for school this morning? If you did, you probably looked at your reflection in a plane mirror. A plane mirror is a mirror with a flat reflecting surface. In a plane mirror, your image looks much the same as it would in a photograph. However, you and your image are facing in opposite directions. This causes your left side and your right side to switch places on your mirror image. Also, your image seems to be coming from behind the mirror. How does a plane mirror form an image?

Reading Check *What is a plane mirror?*

Figure 11 shows a person looking into a plane mirror. Light waves from the Sun or another source of light strike each part of the person. These light rays bounce off the person according to the law of reflection, and some of them strike the mirror. The rays that strike the mirror also are reflected according to the law of reflection. **Figure 11A** shows the path traveled by a few of the rays that have been reflected off the person and reflected back to the person's eye by the mirror.

The Image in a Plane Mirror Why does the image you see in a plane mirror seem to be behind the mirror? This is a result of how your brain processes the light rays that enter your eyes. Although the light rays bounced off the mirror's surface, your brain interprets them as having followed the path shown by the dashed lines in **Figure 11B.** In other words, your brain always assumes that light rays travel in straight lines without changing direction. This makes the reflected light rays look as if they are coming from behind the mirror, even though no source of light is there. The image also seems to be the same distance behind the mirror as the person is in front of the mirror.

Light Waves and Photons When an object like a marble or a basketball bounces off a surface, it obeys the law of reflection. Because light also obeys the law of reflection, people once thought that light must be a stream of particles. Today, experiments have shown that light can behave as though it were both a wave and a stream of energy bundles called photons. Read an article about photons and write a description in your Science Journal.

Science Online

Topic: Concave Mirrors

Visit ips.msscience.com for Web links to information about the concave mirrors used in telescopes.

Activity Make a chart showing the five largest telescope mirrors and where they are located.

Concave and Convex Mirrors

Some mirrors are not flat. A concave mirror has a surface that is curved inward, like the bowl of a spoon. Unlike plane mirrors, concave mirrors cause light rays to come together, or converge. A convex mirror, on the other hand, has a surface that curves outward, like the back of a spoon. Convex mirrors cause light waves to spread out, or diverge. These two types of mirrors form images that are different from the images that are formed by plane mirrors. Examples of a concave and a convex mirror are shown in **Figure 12.**

Reading Check *What's the difference between a concave and convex mirror?*

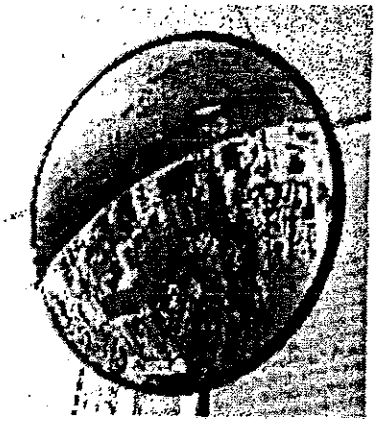
Concave Mirrors The way in which a concave mirror forms an image is shown in **Figure 13.** A straight line drawn perpendicular to the center of a concave or convex mirror is called the optical axis. Light rays that travel parallel to the optical axis and strike the mirror are reflected so that they pass through a single point on the optical axis called the **focal point.** The distance along the optical axis from the center of the mirror to the focal point is called the **focal length.**

The image formed by a concave mirror depends on the position of the object relative to its focal point. If the object is farther from the mirror than the focal point, the image appears to be upside down, or inverted. The size of the image decreases as the object is moved farther away from the mirror. If the object is closer to the mirror than one focal length, the image is upright and gets smaller as the object moves closer to the mirror.

A concave mirror can produce a focused beam of light if a source of light is placed at the mirror's focal point, as shown in **Figure 13.** Flashlights and automobile headlights use concave mirrors to produce directed beams of light.

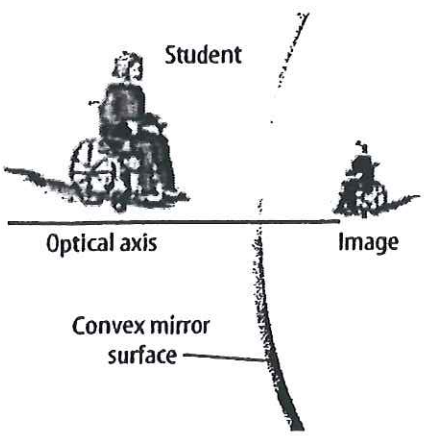
Figure 12 Convex and concave mirrors have curved surfaces.

A concave mirror has a surface that's curved inward.

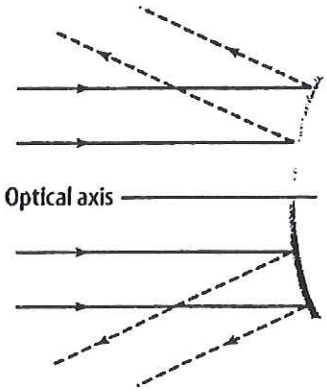


A convex mirror has a surface that's curved outward.

Figure 14 A convex mirror is a mirror that curves outward.



A convex mirror causes light rays that are traveling parallel to the optical axis to spread apart after they are reflected.



No matter how far an object is from a convex mirror, the image is always upright and smaller than the object.

Convex Mirrors A convex mirror has a reflecting surface that curves outward and causes light rays to spread apart, or diverge, as shown in **Figure 14.** Like the image formed by plane mirror, the image formed by a convex mirror seems to be behind the mirror. **Figure 14** shows that the image always is upright and smaller than the object.

Convex mirrors often are used as security mirrors in stores and as outside rearview mirrors on cars and other vehicles. You can see a larger area reflected in a convex mirror than in other mirrors.

section 2 review

Summary

Reflection and Plane Mirrors

- The law of reflection states that the angle of incidence equals the angle of reflection.
- A regular reflection is produced by a smooth surface, such as a mirror. A rough surface forms a diffuse reflection.
- Scattering occurs when light rays traveling in one direction are made to travel in many directions.
- A plane mirror forms a image that is reversed left to right and seems to be behind the mirror.

Concave and Convex Mirrors

- Concave mirrors curve inward and make light rays converge.
- Images formed by a concave mirror can be either upright or inverted and can vary from larger to smaller than the object.
- Convex mirrors curve outward and make light rays diverge.
- Images formed by a convex mirror are always upright and smaller than the object.

Self Check

1. Describe the image formed by a concave mirror when an object is less than one focal length from the mirror.
2. Explain why concave mirrors are used in flashlights and automobile headlights.
3. Describe If an object is more than one focal length from a concave mirror, how does the image formed by the mirror change as the object moves farther from the mirror?
4. Determine which light rays striking a concave mirror are reflected so that they pass through the focal point.
5. Think Critically After you wash and wax a car, you can see your reflection in the car's surface. Before you washed and waxed the car, no reflection could be seen. Explain.

Applying Skills

6. Use a Spreadsheet Make a table using a spreadsheet comparing the images formed by plane, concave, and convex mirrors. Include in your table how the images depend on the distance of the object from the mirror.