chapter 13

Mirrors and Lenses

section 1 Mirrors

What You'll Learn

- how three kinds of mirrors work
- the difference between real and virtual images
- uses of plane, concave, and convex mirrors

Before You Read

Turn off the lights and try to read this page. Turn the lights back on and try again. On the lines below, explain why you think it is easier to read a printed page with the lights on.

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_____

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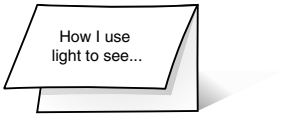
Mark the Text

Locate Information Many headings in this section are questions. Underline the answers to these questions.

FOLDABLES™

A Find Main Ideas Make a Foldable like the one shown below to write down main ideas about light and vision.



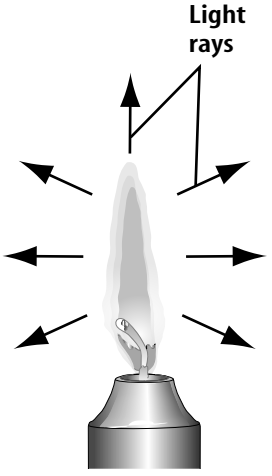
Read to Learn

How do you use light to see?

Light comes from sources like lightbulbs, candles, and the Sun. When light reflects, or bounces, off of an object and travels to your eye, you see the object. For example, light from the lightbulbs in your classroom reflects off this book. The light travels from the book to your eyes. As a result, you see the words on the page. The more light there is to reflect off of objects, the easier it is to see them. When there is no light to reflect off objects, you cannot see anything. This is why it is hard to read a book in the dark.

What is a light ray?

First, think about light as waves. A light source like the Sun or a lightbulb sends out waves of light in all directions. Now, think about light as being many straight lines of light coming out from a source. Each line is called a light ray. Light rays refract and reflect just like light waves. The figure shows how a candle puts out rays of light in all directions. You can change the direction of light rays by reflecting them off a shiny object, like a mirror.



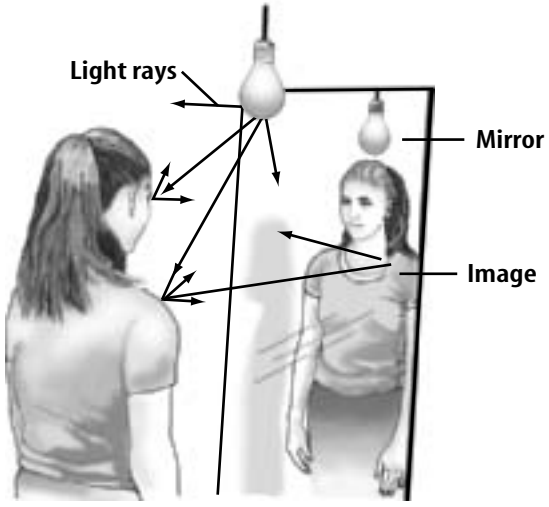
Seeing Reflections with Plane Mirrors

Imagine a lake with trees growing along the shore. If you look at the surface of the water, you will see an image of the trees. An image is the picture you see when light reflects off of a smooth surface. You might see an image in a store window or a shiny car hood.

A very common place to see an image is in a flat, smooth mirror called a **plane mirror**. This is the kind of mirror you see in most bathrooms and dressing rooms.

How does a plane mirror work?

Suppose you stand in front of a mirror and turn on a light as shown below. The light bulb puts out rays of light. Some of the light rays hit you. Then the rays reflect off of you in all directions. Some of these rays hit the mirror. The mirror reflects these rays in all directions. Some of the reflected light rays hit your eyes. You see your image in the mirror. If there are no light rays to reflect, there is no image for you to see.



What does an image in a plane mirror look like?

Your image in a plane mirror appears right side up. Your head is at the top of the image and your feet are at the bottom. But the image that faces you in the mirror is reversed, or opposite. Your left side appears on the right side of the image. Your right side appears on the left side of the image. Suppose you stand 1 m in front of a plane mirror. Your image will look like it is standing 1 m behind the mirror. To you, your image appears to be 2 m away.

Reading Check

1. **Define** What is a plane mirror?

_____

_____

Picture This

2. **Infer** What will happen to the image in a plane mirror if the lights are turned out? Why?

_____

_____

_____

Picture This

3. **Apply** Look at the figure. Which action would make the image look like it is farther behind the mirror?

   a. Turn out the lights.

   b. Turn on more lights.

   c. Move closer to the mirror.

   d. Move away from the mirror.

Reading Check

4. **Describe** What is a virtual image?

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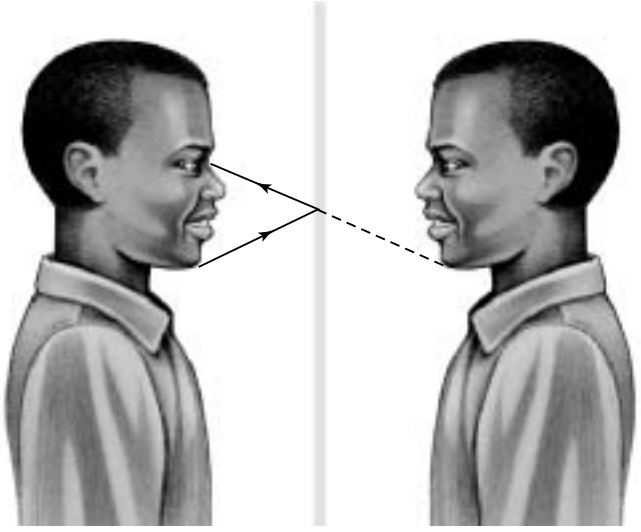
What is a virtual image?

The figure below shows why an image in a plane mirror looks like it is behind the mirror.



Suppose you see your reflection in a plane mirror. The arrows show light rays from you hitting a mirror. The arrows show these light rays reflecting off of the mirror. When these reflected rays hit your eyes, you see your image in the mirror.

What Your Brain Sees Your brain interprets light rays as if they travel in a straight line. It does not understand that the light rays changed direction when they reflected off of the mirror. Imagine extending the reflected light rays back behind the mirror. The dashed lines in the figure show that the rays would meet at one point. Your brain thinks that the light rays are coming from this point. That is why the image of the person looks like it is behind the mirror.

However, no light really is coming from behind the mirror. The image you see is called a virtual image. A **virtual image** is an image that is not real, even though it looks real. No light rays actually meet to create the image. The virtual image always appears to be as far behind the mirror as the object is in front of it.

Concave Mirrors

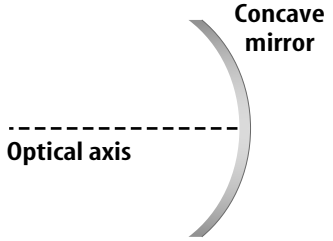
A plane mirror is flat. It produces a right side up, virtual image. However, not all mirrors are flat. Some mirrors have curved surfaces. Mirrors with curved surfaces form different kinds of images. One kind of mirror with a curved surface is a concave mirror.

What is a concave mirror?

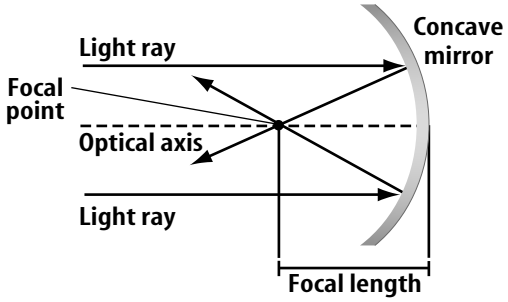
A **concave mirror** has a surface that curves in. The edges of a concave mirror are closer to you than the center of the mirror. Many shaving mirrors and makeup mirrors are concave. Have you ever looked at your image inside the bowl of a shiny spoon? The inside of the bowl of the spoon is a concave mirror, too.

How does a concave mirror work?

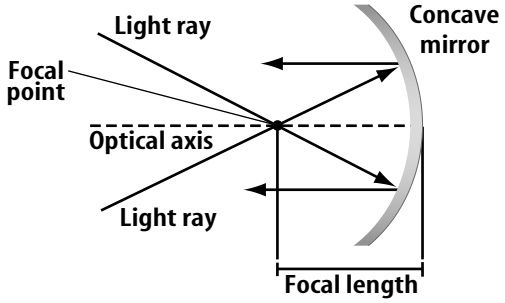
Every concave mirror has an optical axis. The **optical axis** is an imaginary line perpendicular to the surface of the mirror. It also passes through the center of the mirror. The figure below shows a side view of a concave mirror and the location of its optical axis.



Parallel Light Rays Some light rays travel parallel to the optical axis on their way to a concave mirror. These rays reflect off the mirror. As the figure below shows, the reflected rays all cross each other at the same point. This point is called the **focal point**. The distance from the center of the mirror to the focal point is called the **focal length**.



Intersecting Light Rays As shown below, some light rays travel through the focal point on their way to a concave mirror. The mirror reflects these rays parallel to the optical axis.



Picture This

5. Draw Connect the top and bottom of the concave mirror with a line. Is this line parallel or perpendicular to the optical axis?

_____

Reading Check

6. Identify What is the focal point of a concave mirror?

_____

_____

_____

Picture This

7. Identify In the last two figures, use a highlighter to trace the light rays and the paths of their reflection.

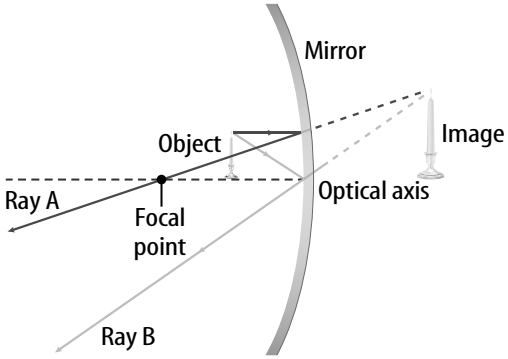
What does an image in a concave mirror look like?

The image of an object in a concave mirror does not always look the same. It depends on how close the object is to the mirror.

Suppose you put a candle less than one focal length from the mirror. Look at the first figure. Like an image in a plane mirror, the image of the candle in the concave mirror is a virtual image. The image is right side up. But, the image is larger than the candle. Have you ever seen a concave shaving mirror or makeup mirror? When you stand less than one focal length away, the image of your face looks larger.

Picture This

8. Infer What will happen to the image if the candle is moved closer to the mirror?

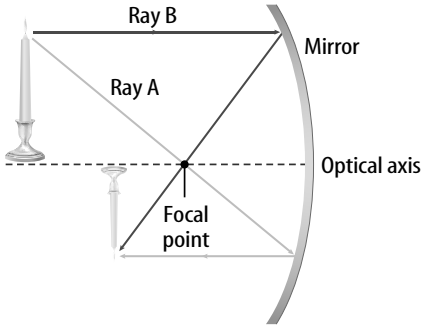


What are real images?

What happens when the distance from the candle to the mirror is between one and two focal lengths? This time the mirror will produce a real image. A **real image** is formed when rays of light converge to form the image. Rays of light really pass through the location of the image. The image is larger than the candle. And, the image is upside down.

How do mirrors decrease size?

If the distance between the candle and the mirror is more than two focal lengths, you get another kind of image. Look at the figure below. The mirror produces a real image. The image is also upside down. However, the image is smaller than the candle.

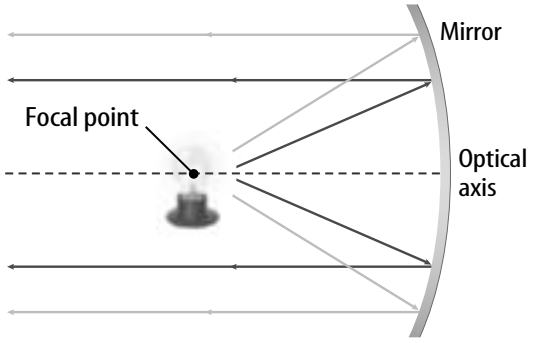


Picture This

9. Highlight the part of the figure that shows why the mirror does not produce an image.

How are light beams created?

What happens if you put an object right at the focal point? Look at the next figure. All the rays of light start at the focal point. The mirror reflects them parallel to the optical axis. The rays never cross, even if you extend them backward. So, the mirror does not produce an image. You see all those parallel light rays as a bright beam of light. This is how flashlights, spotlights, lighthouses, and headlights create light beams.



Convex Mirrors

Concave mirrors are only one kind of curved mirror. Another kind of mirror with a curved surface is a convex mirror. Convex mirrors have some special uses in everyday life.

What is a convex mirror?

Have you seen a side-view mirror on a car that says "Objects in mirror are closer than they appear?" A **convex mirror** has a surface that curves out, like the back of a spoon. The center of a convex mirror is closer to you than the edges of the mirror. The security mirrors in banks and stores are convex mirrors. Some rear-view mirrors and side-view mirrors in cars are convex, too.

Picture This

10. Determine where 2 focal lengths are and place a mark at that point on the optical axis.

Reading Check

11. Define What is a convex mirror?

Think it Over

12. Infer Why might a store-owner use convex mirrors, instead of plane or concave mirrors, to watch the store?

Picture This

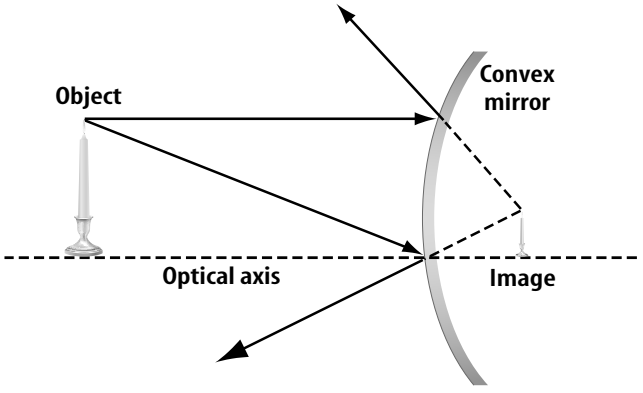
13. Compare and Contrast How are the images in a plane mirror and a convex mirror alike? How are they different?

How does a convex mirror work?

When a convex mirror reflects light rays, it spreads the light rays apart from each other. Because of this, a convex mirror can show you the image of a large area. This is called a wide field of view. For example, the wide field of view of the convex mirrors in cars lets drivers see more of the traffic around them.

What does an image in a convex mirror look like?

So why do side-view mirrors say that the objects "are closer than they appear?" The light rays that reflect off of a convex mirror do not cross each other. Like a plane mirror, a convex mirror produces a virtual image. The image of an object in a convex mirror is right side up. But, the image is smaller than the object. If an image appears smaller, then we think it is farther away.



The table below summarizes the images formed by plane, concave, and convex mirrors.

Images Formed by Mirrors

Mirror Shape	Position of Object	Virtual/Real	Image Created Upright/Upside Down	Size
Plane		virtual	upright	same as object
Concave	Object more than two focal lengths from mirror	real	upside down	smaller than object
	Object between one and two focal lengths	real	upside down	larger than object
	Object at focal point	none	none	none
	Object within focal length	virtual	upright	larger than object
Convex		virtual	upright	smaller than object

After You Read

Mini Glossary

concave mirror: a mirror with a curved surface so that the edges are closer to you than the center of the mirror is

convex mirror: a mirror with a curved surface so that the center is closer to you than the edges of the mirror are

focal length: the distance from the center of a concave mirror to the mirror's focal point

focal point: if light rays parallel to the optical axis hit a concave mirror, the reflected rays cross at this point

optical axis: an imaginary line perpendicular to the center of a concave mirror

plane mirror: a flat, smooth mirror

real image: an image formed when rays of light converge to form the image

virtual image: an image that looks real, but no light rays actually pass through it

1. Review the terms and their definitions in the Mini Glossary. Write a sentence that uses the terms *concave mirror*, *optical axis*, and *focal point*.

2. Complete the chart below to organize the information from this section.

Kind of Mirror	Position of Object	Is image right side up or upside down?	Is image larger, smaller or the same size as the object?
Plane			
Concave	object more than two focal lengths from mirror		
Concave	object between one and two focal lengths		
Concave	object at focal point		
Concave	object within one focal length		
Convex			

3. Mark the Text How did underlining the answers to questions asked in this section's headings help you learn about mirrors and images?

End of Section