ERIC LONG, SMITHSONIAN INSTITUTION

PART 2 Reflection and Refraction

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LESSON 14

Introducing Mirrors

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Why are the letters on the front of this ambulance written like this?

INTRODUCTION

Objects can be seen because they either emit or reflect light. You have investigated how objects reflect some colors and absorb others. Apart from color, do all objects reflect light in the same way? Think about this question the next time you are in a parking lot. Compare the surface of a recently washed and waxed car with the surface of one that is dirty. Here is a clue: What can you see in one but not in the other?

OBJECTIVES FOR THIS LESSON

Observe and discuss different types of reflection.

Investigate what you see in a flat (plane) mirror.

Make predictions about what you will see in a plane mirror.

Describe the features of an image formed in a plane mirror.

Getting Started

1. One member of your group should collect the plastic box of materials. Divide the materials between the pairs in your group.

2. Examine the white screen, mirror, and piece of half-silvered glass. Compare what they do to light that falls on them. Discuss your observations and ideas with your partner. Be prepared to share your observations with the class.

MATERIALS FOR LESSON 14

For you

- 1 copy of Student Sheet 14.2: Where Is the Image in the Mirror?
- 1 copy of Student Sheet 14.3: Predicting and Recognizing Mirror Images

For you and your lab partner

- 1 large mirror
- 1 white screen
- 1 piece of half-silvered glass
- 2 plastic stands
- 2 wooden blocks
- 1 metric ruler, 30 cm (12″)
- 1 adhesive dot

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A very smooth surface reflects light in such a way that an image is formed. Light from this town produces a reflection in the almost-smooth river that flows past it. The river is acting as a mirror. Would the reflection be visible if the water surface was very rough?

REFLECTING LIGHT

All surfaces, except those surfaces that are completely black, reflect light. How light behaves when it reflects off a surface depends on the smoothness of the surface. Rough surfaces reflect light, but you cannot see an image (a reflection) in rough surfaces. Clear images or reflections—like those seen in mirrors—can only be seen in very smooth surfaces that reflect light.

Rough surfaces can be designed to reflect large amounts of light. Both safety clothing and road signs are designed to reflect lots of light from car headlights, making the wearer or the sign more visible at night.

3M™ SCOTCHLITE™ REFLECTIVE MATERIAL. 3M AND SCOTCHLITE ARE TRADEMARKS OF 3M COMPANY

Be safe at night. Wear reflective clothing.

CORBIS/ROYALTY-FREE

How does your mirror image look and behave compared with your face?

Inquiry 14.1
Looking at Reflections

PROCEDURE

1. *Without looking in a mirror* describe to your partner how a mirror image (perhaps a mirror image of your face) differs from the object it reflects.

A. In your science notebook, record your description *before* proceeding to the next step.

2. Look at your face in the mirror. Try the following. (Here's a clue: Try not to think of the reflection as another person looking back at you—just record what you observe.)

A. Touch your left ear with your left hand.

On which side of the mirror is your left hand?

B. Touch your right ear with your right hand.

On which side of the mirror is your right hand?

C. Place your fingertip on the right-hand side of the mirror.

On which side of the mirror is the reflection of your finger?

Which way is your finger pointing?

3. Based on your observations, which of the following statements is correct?

A mirror image is reversed left to right.

A mirror image is reversed front to back (that is, the front of the image is facing back toward you).

Inquiry 14.2
Where Is the Image in the Mirror?

PROCEDURE

1. Spend a few minutes investigating what determines the size and position of your image in a plane (that is, flat) mirror. Discuss your observations and ideas with your partner.

2. Set up one of the wooden blocks and the half-silvered glass, as shown in Figure 14.1. The silvered side of the glass should face the observer.

3. Position your head as shown in Figure 14.1, so that you are looking at the block and toward the half-silvered glass with only one eye open. Record your responses to A–H on Student Sheet 14.2: Where Is the Image in the Mirror?

A. Describe what you observe when you look at the half-silvered glass.

4. Keep your head in this position and have your partner place the second block behind the glass. Guide your partner to move the second block around until it exactly matches the *image* of the first block in the half-silvered glass (see Figure 14.2).

B. How many positions of the second block (behind the half-silvered glass) exactly match the position of the image of the first block (the object in front of the glass)?

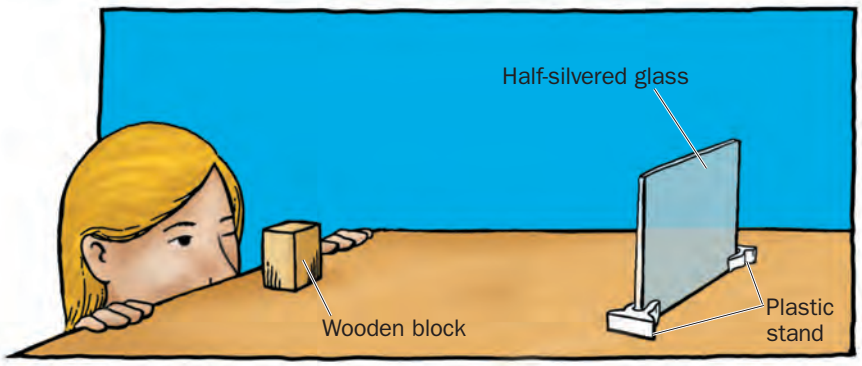

Figure 14.1 *Set up the half-silvered glass as shown. Place one of the blocks about 30 cm in front of the glass.*

SAFETY TIP

Have your partner separate the clips of each plastic stand, while you carefully insert the sides of the half-silvered glass.

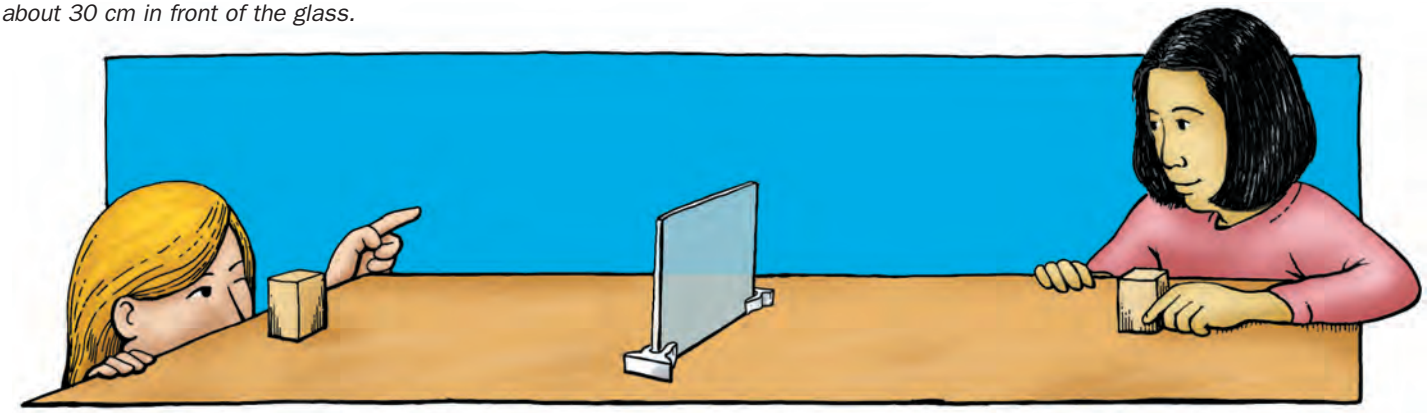

Figure 14.2 *With only one eye open, guide your partner to move the second block around until it exactly matches the image of the first block (the object).*

5. Measure the distance of both blocks from the silvered surface of the half-silvered glass.

C. Record your measurements.

6. Repeat this procedure with the first block positioned at different distances from the front of the half-silvered glass. (Decide how many measurements you should make.)

D. Design a data table and record all your measurements.

7. Compare your results with those of another pair of students.

E. From the data you have collected, what can you conclude about the position of an image in the half-silvered glass?

F. Do you think what you have observed with the block and half-silvered glass applies to the image formed by a plane mirror? Suggest how you could test your answer.

8. Look at the plane mirror. Discuss the following question with your partner, then record your answer:

G. When you look at an image in a plane mirror, does the image appear to be on or in the mirror's surface, behind the mirror, or in front of the mirror?

9. Use the instructions in this step and Steps 10–12 to test your ideas.

- Hold your hand at arm's length while you are facing a distant object.
- Focus your eyes on your hand.
- Now focus your eyes on the distant object.

Can you focus on both your hand and the distant object at the same time?

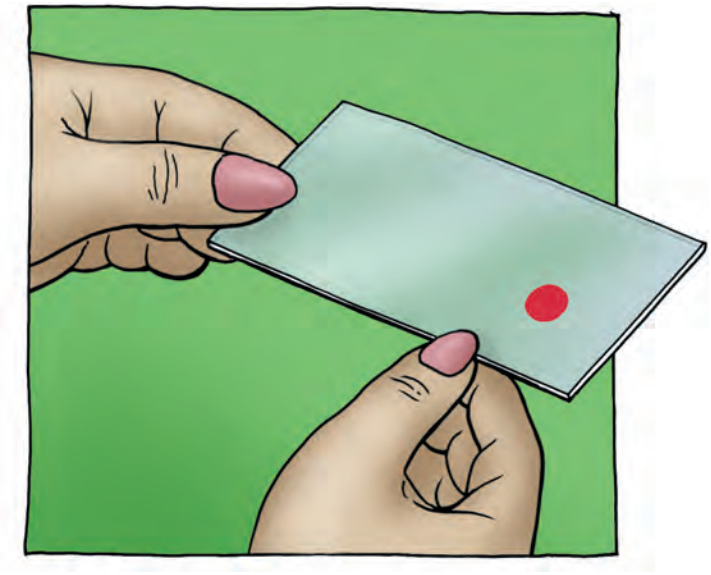

Figure 14.3 *Place an adhesive dot on the surface of the mirror about 3 cm in from the bottom right corner.*

10. Place an adhesive dot on the surface of the mirror about 3 cm in from the bottom right corner (see Figure 14.3).

11. Look at the image of your face in the mirror.

Can you focus on the dot and the image of your face at the same time?

12. Compare the observations you made about your hand and a distant object (in Step 9) with your observations of the image of your face in the mirror and the dot on the mirror.

H. Where do you think the *image* of your face is in relation to the surface of the mirror?

Inquiry 14.3
Predicting and Recognizing Mirror Images

PROCEDURE

1. In the previous inquiries, you discovered that the *image* produced in a plane mirror or piece of half-silvered glass is different from the *object* reflected in the mirror or half-silvered glass. Can you use this information to predict the appearance of a mirror image? Record your responses to A–C on Student Sheet 14.3: Predicting and Recognizing Mirror Images.

A. Look at the image of symbols within the set of squares shown in Figure 14.4. On the identical set of squares *on the student sheet,* draw the image—*without using a mirror*—as it would appear in a plane mirror placed along the line XY.

2. When you have completed your drawing, test it by placing the mirror on the line XY. Compare the image you drew with the one produced in the mirror. If you have made errors, figure out why you made them and then make corrections.

Figure 14.5 *Try writing your name while looking in the mirror. Why is it so difficult?*

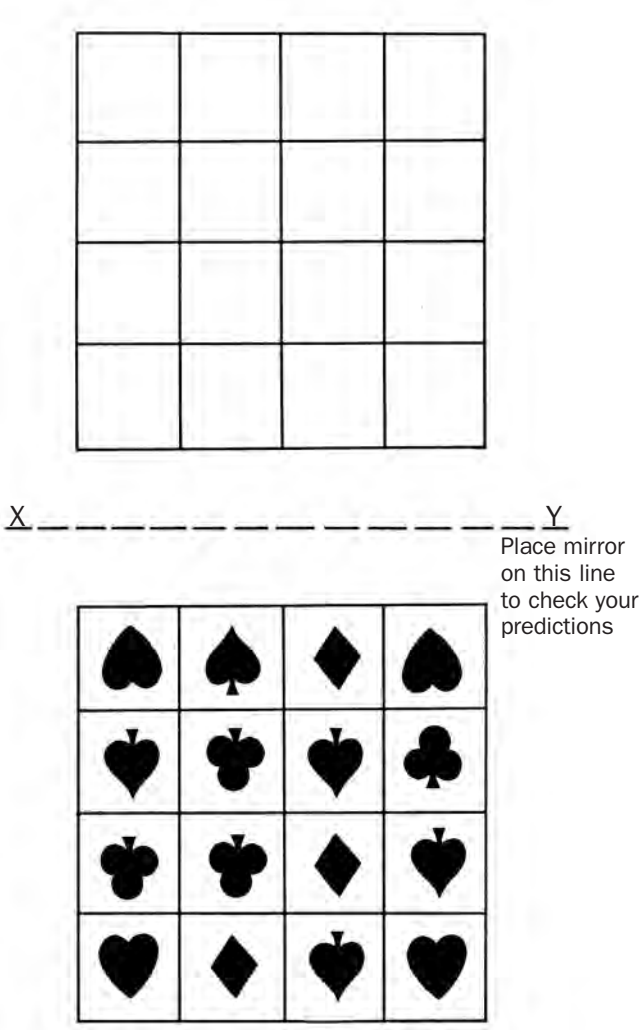

Figure 14.4 *On Student Sheet 14.3, draw the image—without using a mirror—as it would appear in a plane mirror placed along the line XY.*

3. Stand your mirror up along the line under B on the student sheet. Look in the mirror.

B. Try writing your name while looking in the mirror, as shown in Figure 14.5. Don't peek at the paper. Keep looking in the mirror; your teacher is watching you!

4. Recognizing mirror images can be difficult. Look at the two sets of photographs in Figure 14.6.

C. Which of these photographs are mirror images of each other—Set 1 or Set 2?

5. Use a mirror to check your answer to C.

REFLECTING ON WHAT YOU'VE DONE

Spend a few minutes discussing with your group what you have discovered about plane mirrors and the images formed in them.

A. Write a paragraph on Student Sheet 14.3 summarizing your findings. Be prepared to share your paragraph with the class.

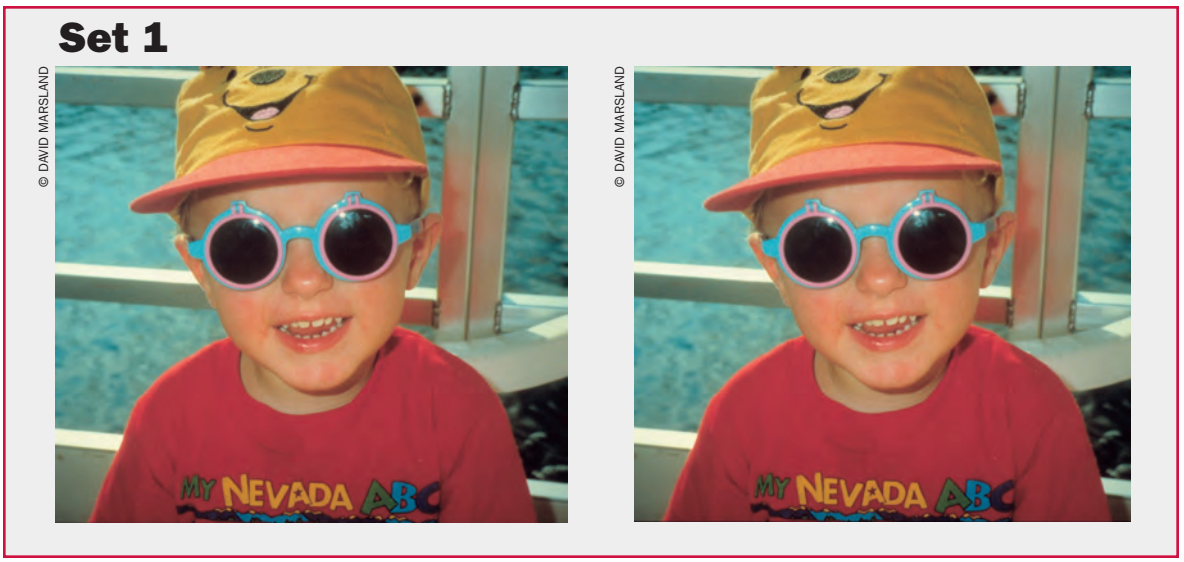

Figure 14.6 *Which of these two sets of photographs are mirror images of one another? How can you tell they are mirror images? Use a mirror to check your answer.*

MIRROR MAKERS

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Flat glass mirrors became popular in the 16th and 17th centuries. This drawing shows these mirrors being made by hand. The process was quite dangerous because it often involved the use of the poisonous metal mercury.

Imagine one of your prehistoric ancestors gazing at his or her face in a still pool. Without an understanding of the nature of light, this reflected image must have seemed magical. Perhaps this is why you often find mirrors in legends, fairy tales, and stories.

For most of human history, a still water surface may have been the only mirror available. The first manufactured mirrors were made probably from polished volcanic glass—the rock obsidian. Examples of these stone-age mirrors have been found in central Turkey. Like all mirror surfaces, these rock mirrors had to be very smooth. Bumps on a mirror's surface must be less than the wavelength of light being reflected. For visible light, this means bumps can be no bigger than 0.00005 centimeters (5.0×10^{-5} cm). Surfaces with bumps bigger than this reflect light, but you cannot see images in them. The volcanic glass mirrors found in Turkey were buried with their owners in graves more than eight thousand years old. Mirrors were valuable items, worth taking into a legendary afterlife.

UNIVERSITY OF PENNSYLVANIA MUSEUM

These hand mirrors were made sometime between 1539 B.C. and 1292 B.C. in Egypt. Hand mirrors like these made from polished metal were valuable possessions.

Once people learned how to use metal, they polished it to make mirrors. Early metal mirrors were made from copper, bronze, and silver and often were elaborately decorated.

The Romans used metal mirrors. They also tried making mirrors from glass. They put thin

layers of gold, copper, or silver onto the back of curved pieces of glass. Flat glass mirrors were not made in large numbers until the 16th century. The glassmakers of Venice perfected the technique for making flat mirrors. They backed these mirrors with a mixture of the metals tin and mercury. In the mid-1800s, this process of mixing tin and mercury—which is very poisonous—was replaced by a chemical process that backed mirrors with silver.

Today most mirrors are still made from glass backed with metal. Usually silver or aluminum is sprayed—or evaporated and condensed—onto the back of the glass. □

BINSWANGER MIRROR

In modern mirror-making, a shiny reflective surface is sprayed onto flat glass.

Mirrors in Myth

Mirrors and reflections play a big part in some stories, legends, and fairy tales. But when you understand how reflections are formed, mirrors become less mysterious. Do you know any stories in which mirrors play an important role?

PLATE WITH BORDER OF GROTESQUES ON AN ORANGE GROUND; IN THE CENTER, NARCISSUS GAZING AT HIS REFLECTION IN A FOUNTAIN, WIDENER COLLECTION, PHOTOGRAPH © 2002 BOARD OF TRUSTEES, NATIONAL GALLERY OF ART, WASHINGTON.

In Greek myth, Narcissus was so beautiful that he fell in love with his own reflection. His love affair with himself led to his untimely death by drowning.

ILLUSTRATION BY JOHN TENNIEL

A mirror was the door to a magic world in Lewis Carroll's Through the Looking Glass.