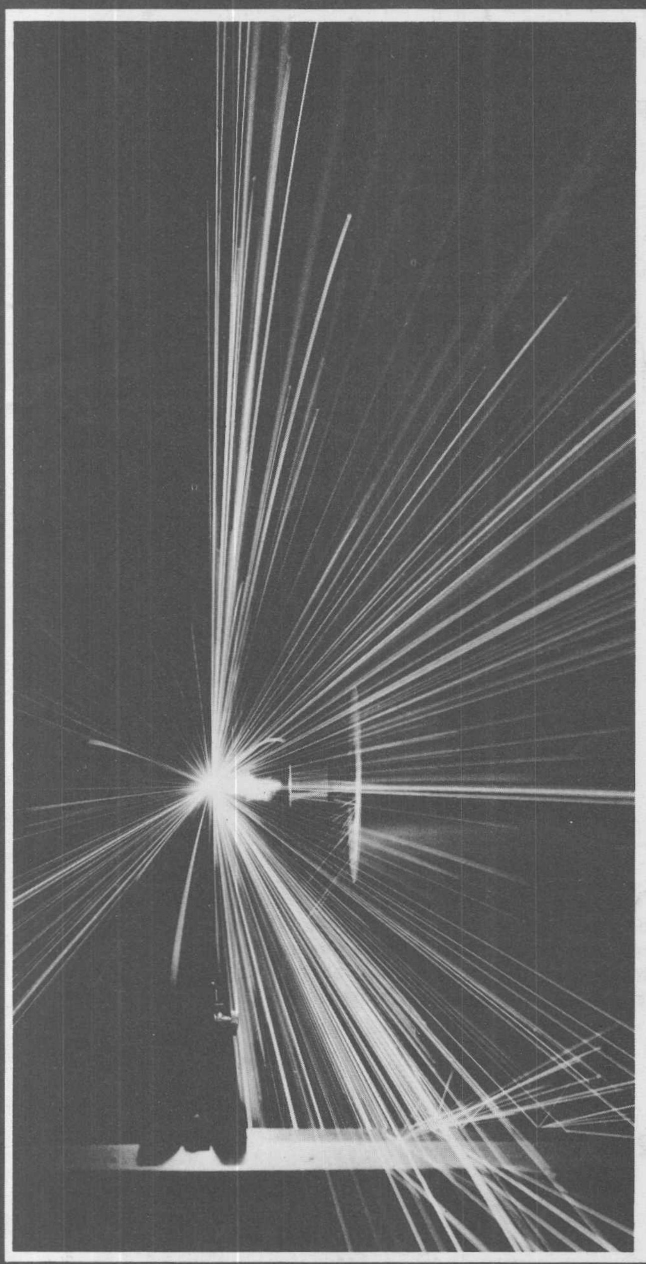
BEHAVIOR OF LIGHT AND SOUND



Have you ever walked into a completely darkened room and then turned on the lights? Before the lights were turned on you could see nothing in the room. However, when the lights came on, the chairs, the tables, the rug and everything in the room became visible. Therefore, we can say that only when there is **light** can we "see" things.

Actually, what we are really seeing is only the light coming from the objects we are looking at. When you look at a distant star on a clear night you do not actually see the star itself. You see only the *light* that left that star many, many years ago. The star itself may no longer exist.

What is light? Many scientists have struggled all their lives trying to find the answer. Their efforts have led to the formation of a simple theory that explains much about the nature and behavior of light, and which has enabled man to invent amazing new ways of producing light, such as the **laser beam,** which you see on this page.

Before you can try to understand the theory you must first observe the behavior of light. In many ways, light behaves very simply. It can be made to bounce back from a surface like a rubber ball. It can be made to turn around corners like an automobile, even though it travels about ten million times faster than any racing car. It can even travel through outer space. In fact, all of the heat and light on this earth come through outer space from the sun and other stars.

The behavior of sound, although similar in some ways to the behavior of light, is completely different in other ways. Sound is similar to light in that it can be made to bounce off a surface to produce echoes. Like light it can travel through solids, liquids and gases. Both light and sound are considered some form of wave motion, but the two kinds of waves travel differently.

Sound, as well as light, increases the enjoyment of life. It provides us with the means of listening to beautiful music of a symphony orchestra, or to the songs of birds. Sound can locate submerged submarines and underground oil. Certain kinds of sounds are used by dentists to clean teeth, and by doctors to relieve pain. Sound is being used to sterilize food and even to weld metals. In the following activities, you will discover some simple properties of light and sound.

Unit Opening Photograph

This spectacular light display occurred when a ruby laser beam drilled a hole through a sheet of extremely hard tantalum metal. The intensive burst of the beam pierced the tantalum in less than 1000th of a second. Do you think you would have heard a drilling sound as the optical drill pierced the metal? (Courtesy of Hughes Aircraft Company.)

Lab-Inquiry Texts
PHYSICAL SCIENCE

TITLES

Methods of Science
Measurement
Using Line Graphs
Properties of Matter
Force and Motion
Work, Energy and Simple Machines
Magnetism and Electricity
Behavior of Light and Sound

By Sanford M. Eisler and Murray Stock

CAMBRIDGE BOOK COMPANY
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problem 8-1

To determine the path of a ray of light.

MATERIALS

3 3 × 5 Index cards	Battery holder
3 Thumbtacks	Wire
3 Wooden blocks (soft pine)	Switch
	Lamp and socket
Battery	Meter stick

PROCEDURE

1. Take three regular 3×5 cards and find their exact center by drawing two diagonal lines. The center of the card is at the point where the diagonals cross.

With a thumbtack punch a small hole in the card at its center (Fig. 8-1). At the *exact middle* of the top edge of each card make a pencil mark (Fig. 8-1). Using thumbtacks, tack each card to a wooden block so that the base of the card is flush with the table top (Fig. 8-1).

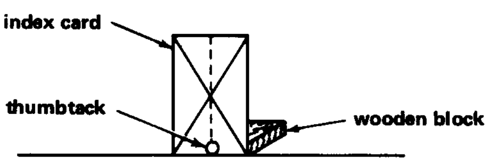


Figure 8-1

2. Connect a battery, switch and lamp so that they form an electric circuit (Fig. 8-2).

Place book(s) under the lamp so that the bulb's center is at the exact height of the holes in the index cards. Line up the three index cards about 20 cm apart so that the lighted lamp can be seen through all of the small holes in the cards (Fig. 8-3).

The path of light through the holes in the cards is called a **ray** or **beam** of light.

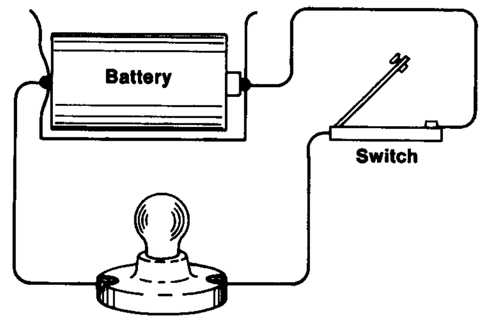


Figure 8-2

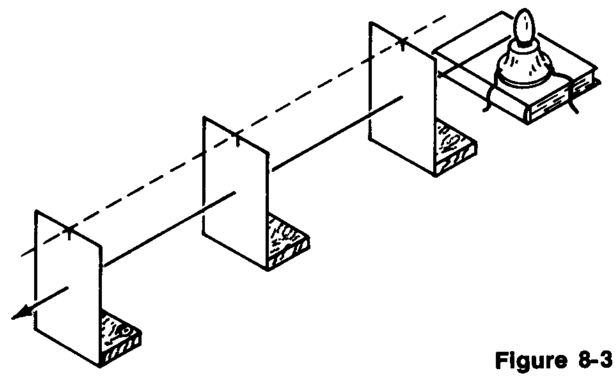


Figure 8-3

While the cards are still lined up, place a meter stick along the pencil marks on the top of the cards.

a. What kind of line is formed by the points on the top of the card?

____

b. What kind of line is formed by the ray of light?

____

4. Move any one of the cards just a fraction of a centimeter to one side or the other.

Are you able to see the light through the holes in the card? Explain.

5. Allow the lamp to remain in its position on the book but move the three cards to another part of the table. Line them up again so that you can see the lamp through the holes.

What is passing through the holes in the cards?

6. Move the cards again to still another part of the table. Line them up so you can still see the lamp through the holes.

a. Is there any direction that you can place the three cards in a *straight* line, so that a ray will *not* pass through the holes?

b. In how many different directions are rays of light being sent out by the light? Explain.

BEYOND THE CLASSROOM

Make a drawing that explains why we cannot see around a corner of a building.

problem 8-2

To construct a study box with which to observe the behavior of light.

MATERIALS

Shoebox and cover
Spray can of black paint
Single-edged razor blade
Clear plastic wrap
Masking tape

PROCEDURE

1. Remove the cover of an ordinary shoebox. The teacher will spray the inside of the box with quick-drying black paint. While the paint is drying, cut a large rectangle from the cover of the box. Use a single-edged razor blade. (Be careful not to cut yourself!) Allow about a 2-cm border around the cover (Fig. 8-4a).
2. Cut a piece of clear plastic wrap a little larger than the hole cut in the top of the shoebox. Fasten the plastic smoothly over the hole with pieces of masking tape.
3. After the paint in the shoebox has dried, cut a hole about 4 cm wide and 7 cm high in one of the ends of the shoebox (Fig. 8-4b).
4. Draw a straight line down the center of a playing card. On this line, about 2 cm from the top of the card, punch a clean hole about 5 mm in diameter. Use the point of a sharpened pencil to punch the hole. Punch another hole on the line about 6 cm below the first hole. Clean away any fuzzy edges.
5. Fasten the card over the hole in the end of the box with masking tape. Place the cover on the shoebox. You now have a light study box with which to do different activities involving the behavior of light (Fig. 8-5).

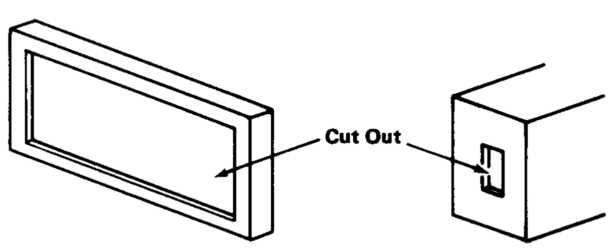


Figure 8-4a **Figure 8-4b**

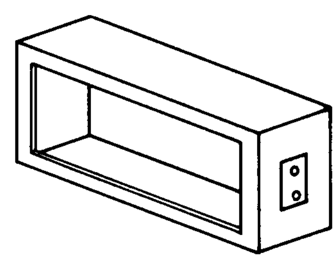


Figure 8-5

reference sheet 8-1

Each of us has used a mirror at one time or another. Most mirrors are made of a flat piece of clear glass covered on the back with a very thin layer of silver. It is this layer of silver that *reflects* or sends back most of the light that hits the mirror.

Reflection of light is very similar to the action of a bouncing ball. If you bounce a rubber ball straight down on a smooth floor, it will bounce back, straight up (Fig. 8-6a).

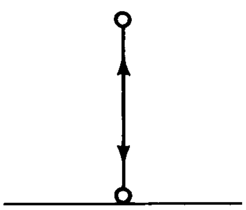


Figure 8-6a

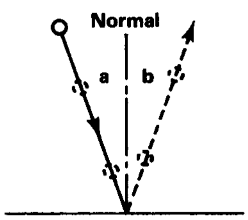


Figure 8-6b

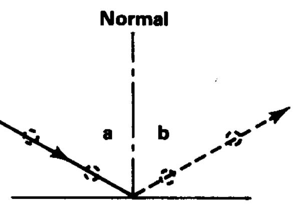


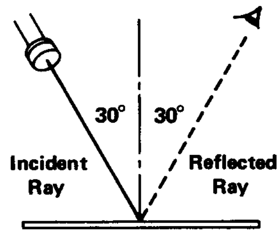
Figure 8-6c

However, if the ball is thrown to the floor at an angle it will bounce away at the same angle (Figs. 8-6 b, c). Locate the angle *a* in Figs. 8-6 b, c. This angle is called the **angle of incidence** (in′-sid-ence). Angle *b* is called the **angle of reflection.**

Notice that angles *a* and *b* are *not* measured from the floor. These angles are measured between the path of the bouncing ball and a vertical line called the **normal.** Also notice that in both Figs. 8-6 b and 8-6 c, angle *a* equals angle *b.*

Light rays act just like a bouncing ball when they strike a mirror. If a light ray strikes a mirror at an angle of 30° from the normal, the reflected ray leaves the mirror at an angle of 30° from the normal (Fig. 8-7).

Figure 8-7



The light ray striking the mirror is called the **incident** ray and the ray leaving the mirror is called the **reflected ray.**

problem 8-3

To make visible the path of a ray of light.

MATERIALS
Flashlight
Cardboard
Light study box
Metal cap
Touch paper (or a piece of rope)
Match

PROCEDURE

1. Cover part of the face of a flashlight with a strip of cardboard. Allow about 1 cm opening above and below the cardboard (Fig. 8-8a). (When you have finished this investigation, keep the covered flashlight for use in Problem 8-4.)

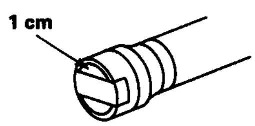


Figure 8-8a

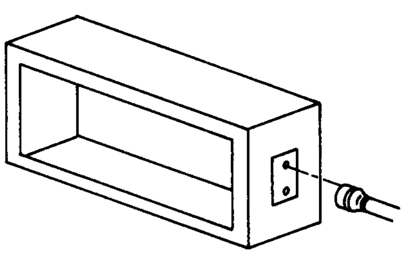


Figure 8-8b

2. Darken the room as much as possible *(the darker the better)*. Shine the light from the upper half of the flashlight into the light study box through the upper hole in the card (Fig. 8-8 b). Look into the box.

Can you see any of the rays of light from the flashlight *inside* the box?

____

3. Place a small metal cap in one corner of the light study box. Crumple a piece of touch paper and place it in the cap. Ignite the paper with a match. As the paper begins to burn, *quickly* place the cover on the box to keep the smoke inside. Darken the room. Shine the flashlight into the box as in Procedure 2. Look into the box.

a. What effect does putting smoke in the box have on the light *inside* the box?

____

____

b. Can you explain why smoke is necessary to see the ray of light from the flashlight inside the box?

____

____

____

BEYOND THE CLASSROOM

Late in the evening completely darken a room at home. Then shine a bright ray from a flashlight across the room. Can you see the path of rays of light from the flashlight? Shake a rag full of dust into the room. Now what do you see? Why?

problem 8-4

To show the relationship between incident and reflected rays of light.

MATERIALS

Mirror
Light study box
Covered flashlight
Touch paper (or a piece of rope)
Match

PROCEDURE

1. Place a small mirror in the approximate center of the bottom of the light study box (Fig. 8-9). Study Reference Sheet 8-1.

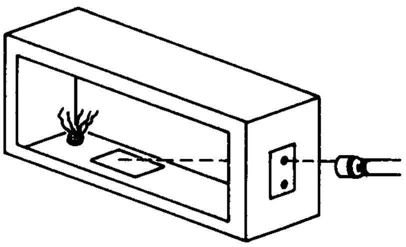


Figure 8-9

2. Darken the room. Ignite some touch paper and again fill the box with smoke. Shine the light from the upper half of the flashlight through the upper hole in the card.

Adjust the position of the flashlight so that the light ray coming through the hole strikes the center of the mirror (Fig. 8-9).

3. On the diagram shown in Fig. 8-10, draw the positions of the light rays as they appear in the box. Draw the ray at the approximate angle it strikes or hits the mirror, and the angle it leaves the mirror.

Mirror

Figure 8-10

4. Label the incident ray and reflected ray on your drawing. Also label the angle of incidence and the angle of reflection.

How does the size of angle of incidence compare to the size of the angle of reflection?

____

____

5. Shine the light from the *bottom* half of the flashlight onto the center of the mirror through the *lower* hole of the card. Notice the angles of incidence and reflection this time. Draw these new angles on the drawing in Procedure 3 (Fig. 8-10).

a. How does the size of the angle of incidence compare to the angle of reflection in this case?

____

____

b. Which angle of incidence is larger — the one you made in Procedure 3 or the one you made in this procedure?

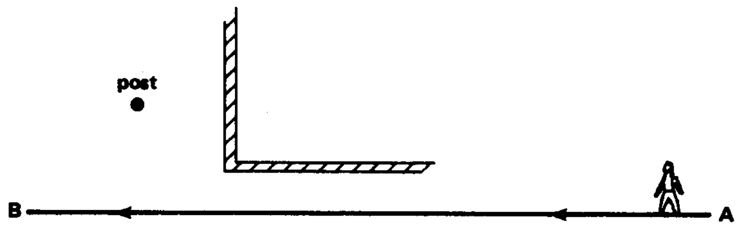
____

____

6. Complete Worksheet 8-1.

worksheet 8-1

1. Imagine that in the diagram below a man is walking along a path from A to B. Mark the point on this path where he will first be able to see the post.

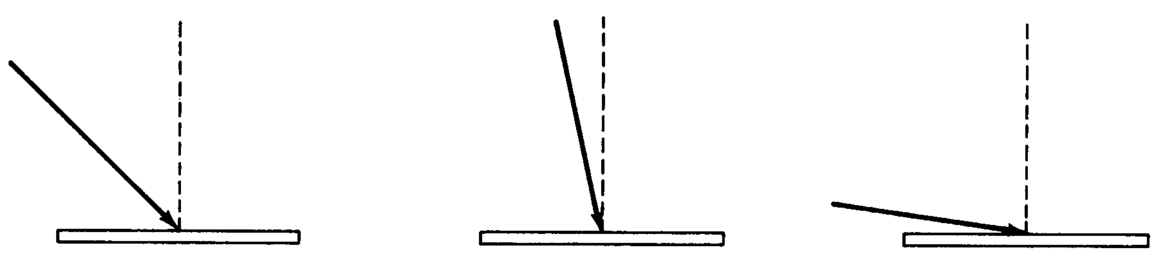


2. What is a shadow?

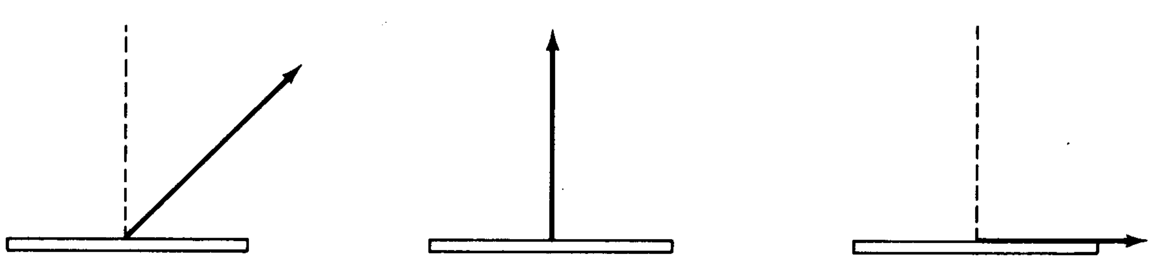
____

____

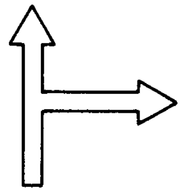
3. On the diagrams below, draw the path of the reflected light ray from each mirror.



4. On the diagrams below, draw the path of the incident light ray hitting each mirror.



5. In the space next to the diagram below, draw the object as it would appear if seen in a mirror.

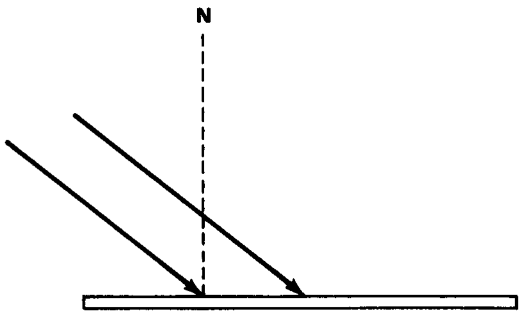


6. How would the following letters appear if they were seen in a mirror?

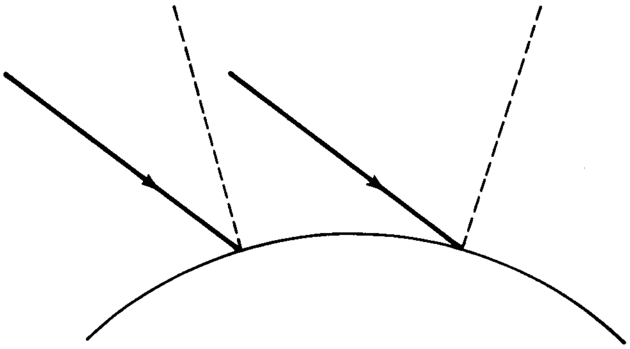
WTSEVLMNABCX

7. Write a word with at least four letters that would appear the same in a mirror image.

8. Two parallel rays strike a *flat* mirror at the same angle of incidence. Draw the reflected rays.



9. Two parallel rays strike a *curved* mirror surface. Draw the reflected rays. How do the reflected rays differ from those in Problem 8?



problem 8-5

To find the positions of mirror images and to observe relative distances between objects and their images.

MATERIALS

Corrugated cardboard
Notebook paper
Scissors
Mirror
Wooden block
Rubber band
4 Straight pins (with different colored heads)

PROCEDURE

1. Cut a piece of corrugated cardboard a little larger than a sheet of notebook paper. Place the sheet of notebook paper on this cardboard. Stand a mirror in an upright position near the center of the paper. Use a block of wood and a thin rubber band to hold the mirror in an upright position (Fig. 8-11a). Draw a line on the paper along the *base* of the mirror.

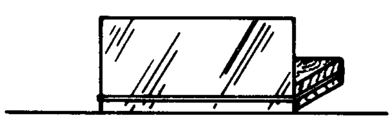


Figure 8-11a

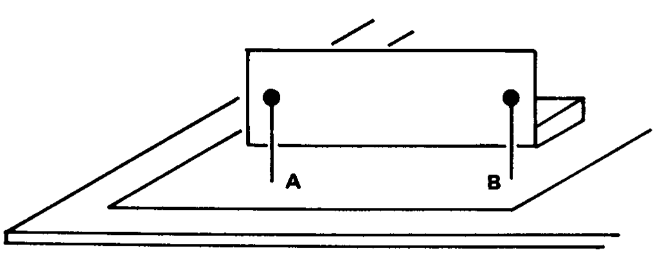


Figure 8-11b

2. Stick two pins, *A* and *B*, into the paper placing them about 10 cm apart and about 5 cm in front of the mirror. Use different colored pin heads. Mark the position of the pins on the paper with the letters *A* and *B* (Fig. 8-11b).

3. Position yourself off to one side of pin *B* and with your eyes at the level of the bottom of the mirror, look at pin *B* and into the mirror at the same time (Fig. 8-12 a). Line up pin *B* with the *image* of pin *A* that you see in the mirror. This can be done by placing a third pin *C* right next to the mirror where the line between pin *B* and image *A* crosses the base line of the mirror (Fig. 8-12 b).

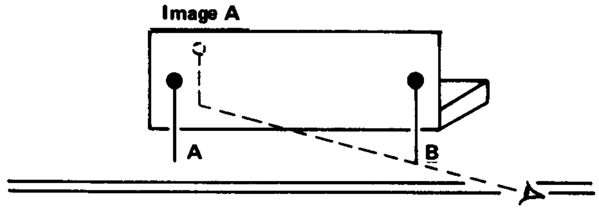


Figure 8-12a

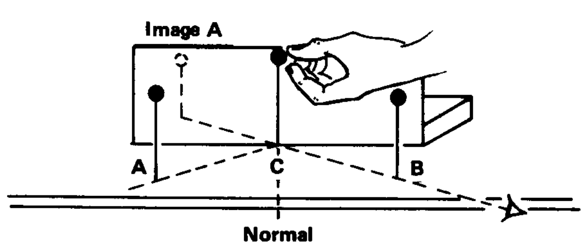


Figure 8-12b

a. As you look into the mirror and see the *image* of pin *A* what are you really seeing? (*Hint:* A mirror reflects light.)

____

____

b. As you look into the mirror where does pin *A seem* to be with reference to the mirror?

____

____

Draw lines from pin *B* to pin *C* and from pin *A* to pin *C*. Draw the *normal* from pin *C* at right angles from the mirror line (Fig. 8-12 b).

c. What is the angle called that is formed by the line from *A* to *C* and the normal?

____

____

d. What is the angle formed by the line from *B* to *C* and the normal?

____

e. Are these angles equal or unequal? Explain your answer.

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____

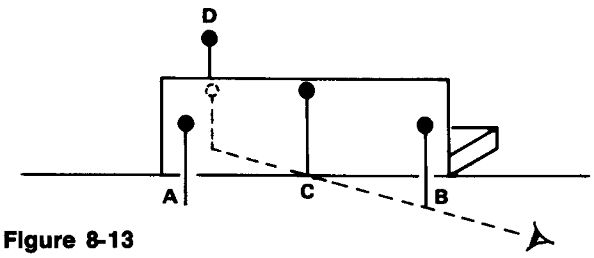


Figure 8-13

4. Place a fourth pin, *D, behind* the mirror where the image of *A seems* to be (Fig. 8-13). Pin *D* represents the *mirror image* of pin *A*. Remove the mirror and block of wood. Draw a straight line from pin *A* to pin *D*.

a. How far is pin *D* from the mirror line?

____

b. How far is pin *A* from the mirror line?

____

If you located the position of pin *D* accurately, the above distances should be equal. Also, the line from pin *A* to pin *D* would be at right angles to the mirror line. Place your diagrams in your notebook.

BEYOND THE CLASSROOM

1. Write your name on a sheet of paper and hold it in front of the mirror. How does the mirror image appear to you?

2. Look into the mirror. Move it closer, then farther from your face. How does the distance of the mirror image change as you move the mirror?

3. Do you see yourself in the mirror *exactly* as others see you? Explain.

problem 8-6

To determine how light is refracted.

MATERIALS

Small square bottle	Touch paper
Milk (or chalk dust)	Bottle cap
Stirrer	Matches
Light study box	Flashlight

PROCEDURE

1. Fill the square bottle about three-quarters full of water. Put *no more* than a drop or two of milk into the water. (If no milk is available, sprinkle in a pinch of chalk dust and stir.)
2. Place the bottle inside the light study box (See Fig. 8-14). Put touch paper on bottle cap into box. Ignite paper and when it smokes cover the box. Darken the room.
3. Shine a beam of light from the flashlight through the upper hole in the end. Adjust the flashlight so that the beam of light strikes the side of the bottle just below the water level (Fig. 8-14). *Observe the path of the beam very carefully.*
   a. What happens to the path of the beam as it passes from air into water and into air again? Is it a straight line path?

   ____

   ____

   b. On the diagram below, draw the path of the beam of light as it passes from air through water and back into air (Fig. 8-14).

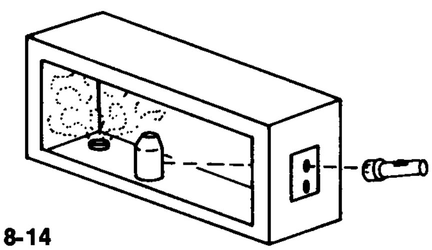


Figure 8-14

4. Study Reference Sheet 8-2.

BEYOND THE CLASSROOM

Place a coin in the bottom of shallow teacup. Hold the cup so that the coin is *just out of sight* over the edge of the cup (Fig. 8-15).

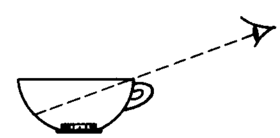


Figure 8-15

As you watch the cup, have someone slowly fill the cup with water. Can you give an explanation of what you see?

reference sheet 8-2

When you turn on the light in a room do you realize that it actually takes time for the light beam to leave the bulb and reach your eye? It takes a very short time, to be sure, but it still takes *some* time.

Scientists have been able to measure the speed of light very accurately. They have discovered that light travels very, very fast. Through air light travels about 186 thousand miles per second. That is faster than anything else in this world ever travels. But, scientists have discovered that light really slows down quite a bit as it passes through glass or water, or other transparent materials that are denser than air.

It is as if a speeding automobile that is moving on a smooth, dry pavement suddenly comes to a section of soft or muddy dirt road, which causes the driver to slow down. When the pavement is again dry and smooth and the car can move ahead easily, the driver would probably speed up again.

Now suppose that only the *right front wheel* of the speeding car was slowed down by some mud, but the other wheels were still on dry pavement. Would the car continue to move straight ahead, swerve to the left or swerve to the right?

If you said that the car would swerve to the right you would be correct. The car would turn to the right since the right wheel would move slower than the left. This, of course, would cause the car to turn to the right. A beam of light acts the same way.

Suppose a beam of light, moving very fast through the air, suddenly strikes the edge of a piece of glass at an angle (Fig. 8-16). Just as the one wheel on the car hits the mud first, and so slows up and swerves, Part *A* of the beam hits the glass before Part *B* does. This causes the ray of light to bend to the left as it passes from the air into the glass.

As the beam leaves the glass and enters the air again, part *D leaves first* and speeds up. The part of the beam still in the glass *C* is still moving more slowly. This causes the beam to bend to the *right* this time as the light leaves the glass. (Why doesn't the beam bend as it passes through the glass in Fig. 8-17?)

The bending of light as it passes from one material to another of different density is called **refraction** (re-frac′-shun). Light is said to **refract** when it is bent.

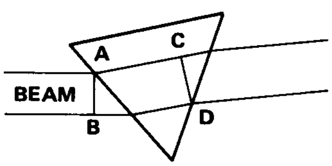


Figure 8-16

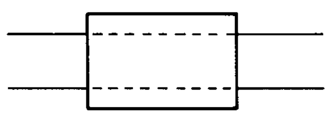


Figure 8-17

problem 8-7

To determine the path of a ray of light as it is refracted by glass.

MATERIALS
Corrugated cardboard
Rectangular plate glass
4 Large head pins (different colors)
Triangular plate glass

PROCEDURE

1. Place a sheet of clean white paper over a piece of corrugated cardboard. Place a rectangular piece of plate glass in the center of the paper. Carefully draw the outline of the glass on the sheet of paper with a sharp pencil.

2. Stick two pins, *A* and *B*, into the paper. Place the pins about 5 cm apart so that they form a line of about 60° with the back edge of the glass (Fig. 8-18a).

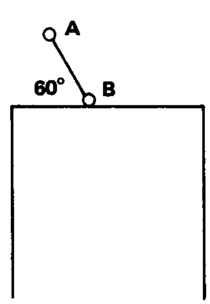


Figure 8-18a

3. With your eye at the level of the table look at pins *A* and *B* through the edge of the glass (Fig. 8-18 b).

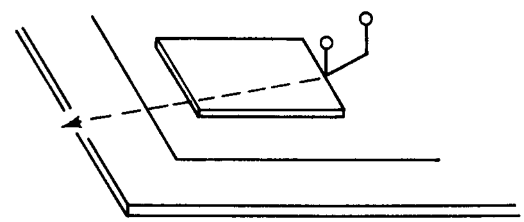


Figure 8-18b

Place two more pins, *C* and *D*, so that all four pins *seem* to line up in a straight line as you look through the edge of the glass. Again, it should appear as if you see only one pin (Fig. 8-18 c).

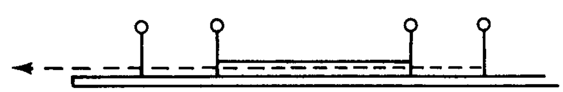


Figure 8-18c

4. Remove the glass and draw connecting lines from pins *A* to *B*, *B* to *C*, and *C* to *D*. (This line represents the actual path of light from pin *A* as it passes through the glass to your eyes.) The line *A, B* on your drawing is the path of the *incident* ray. The line *C, D* is the path of the *refracted* ray. Write these names in the correct place along the lines in your drawing. Try to place a ruler along both the incident ray and the refracted ray at the same time.

Do the lines lie on a straight line? Explain your answer.

5. At points *B* and *C* on your drawing, draw two dotted lines at *right angles* to the edges of the glass plate (Fig. 8-19). These lines are called **normals.** Any line drawn at right angles to a surface is the normal to the surface. Write "normal" on each of these lines.

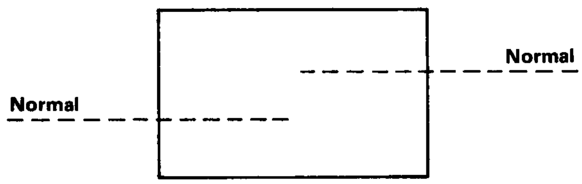


Figure 8-19

6. Examine your drawing carefully.

a. How does light bend as it passes from air into glass — toward or away from the normal?

b. How does light bend as it passes from glass into air?

7. Repeat Procedures 2, 3 and 4, but use a triangular piece of glass instead of the rectangular piece. Arrange the glass on your paper and draw a line around it (Fig. 8-20).

Place pins *C* and *D* so that again all the pins seem to lie in a straight line as you look through the edge of the glass plate. Remove the glass and draw lines connecting the positions of all the pins. Draw the normals at points *B* and *C*.

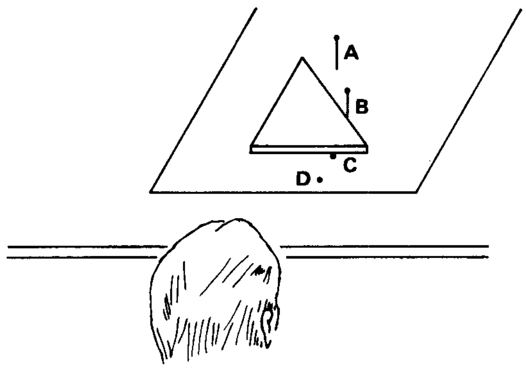


Figure 8-20

a. How does light bend as it passes from air into glass — toward or away from the normal?

b. How does light bend as it passes from glass into air?

c. Compare the above answers with those in Procedure 6. Write a general rule about how light bends when it passes from air into glass. From glass into air.

8. Repeat Procedures 2, 3 and 4 using the rectangular glass, but this time place pins *A* and *B* so they form a line at *right angles,* or lie on the normal edge of the glass (Fig. 8-21).

a. Describe the line connecting the four pins. How does it differ from the line drawn in Procedure 4?

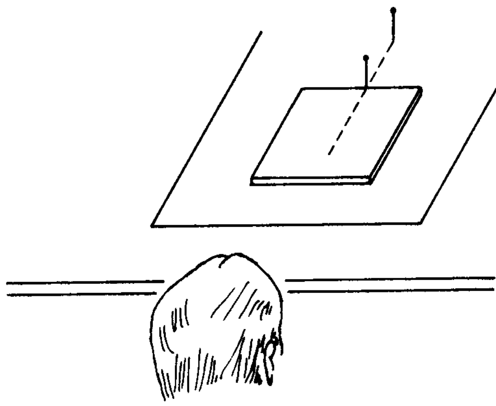


Figure 8-21

b. Using the explanation in Reference Sheet 8–2, explain the reason for the difference.

9. Place your drawing into your notebook. Complete Practice Sheet 8-1.

BEYOND THE CLASSROOM

Stand as far back as possible from a window in a room and look out of the window. Move your head from left to right and notice the ripples in what you are looking at. Can you explain why you see the ripples?

reference sheet 8-3

The human eye is a wonderful instrument. It permits you to "see" objects. As was mentioned before, you see only the light rays coming *from* an object.

In the drawing of the arrow only the rays leaving the head and base of the arrow are shown (Fig. 8-22). Actually, light rays are leaving *every point* on that arrow and traveling in straight lines in all directions.

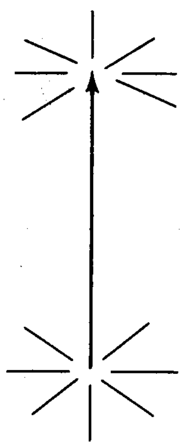


Figure 8-22

Trace the path of just *two* of the rays from the head of the arrow and *two* rays from the base. Trace these rays through two triangular glass plates onto a screen (Fig. 8-23).

Notice that the two rays from the head *A* are refracted by the glass and meet on the screen. The two rays from the base *B* also are refracted. *When two or more*

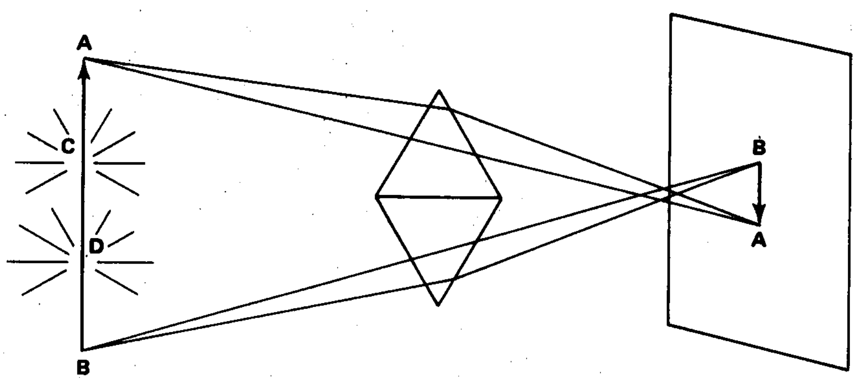


Figure 8-23

rays leave a common point they can be refracted, so that when they again meet they can form the image of the point on a screen. In this case the rays are forming images of the head and base of the arrow on the screen.

If the two triangular glass plates were properly shaped, all the other points C, D, etc. on the arrow would also form images on the screen. You would then see the image of the *entire* arrow since all the points would form images.

Lenses are used to **focus** the image of an object on a screen or film. This means that the lens refracts or bends the rays of light so that the many rays leaving a point on an object come back together again and meet on a screen or film to form an image of the object (Fig. 8-24). In the investigations in this unit, you will use a double convex lens to form an image.

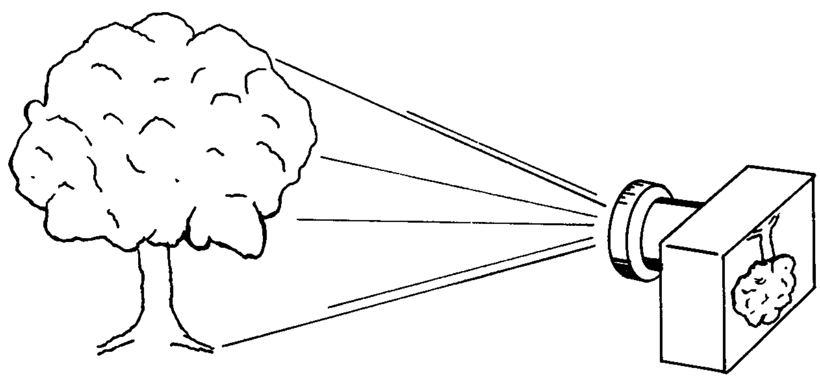


Figure 8-24

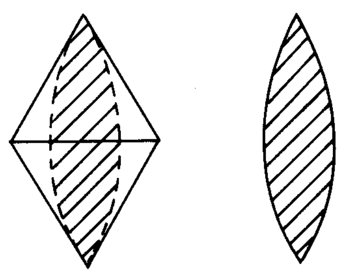
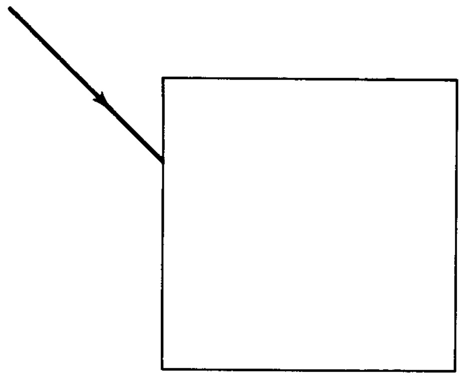


Figure 8-25

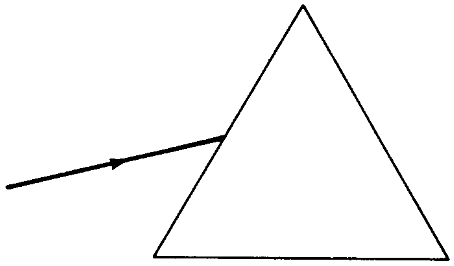
One of the best lenses for forming images is the **convex lens.** This type of lens is found in most cameras. It is also the type of lens that is found in the eyes of human beings. A convex lens is similar to the shape of the two triangular plates but the sides have been rounded off (Fig. 8-25).

practice sheet 8-1

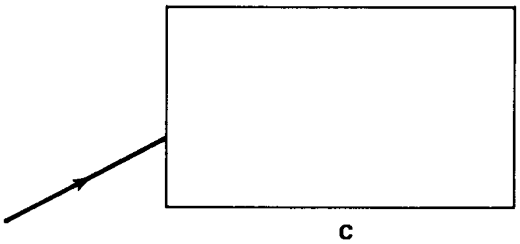
Trace the paths the rays of light would take through the following shapes of glass and back out into the air.



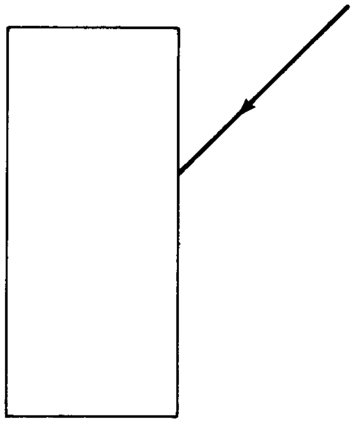
A



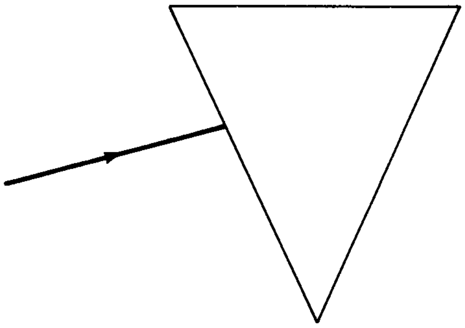
B



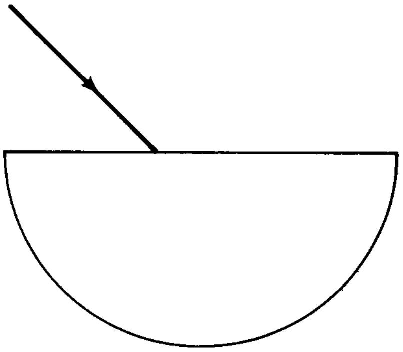
C



D



E



F

problem 8-8

To measure the magnifying power of a convex lens.

MATERIALS

Flashlight	Lens holder
Aluminum foil	Screenholder
Razor blade	White cardboard
Masking tape	Double convex lens
Meter stick	Meter stick supports

PROCEDURE

1. Study Reference Sheet 8-3.
2. Prepare a piece of aluminum foil slightly larger than the front of the flashlight. With a razor blade, cut a thin, arrow-shaped opening about 3 cm in length in the foil. With scotch or masking tape, tape the foil over the front of the flashlight so that the arrow is in the center of the lens (Fig. 8-26a).

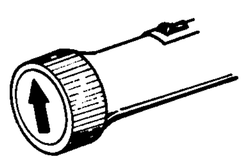


Figure 8-26a

3. Set up the meter stick as an optical bench (See Fig. 8-26 b). Place the meter stick in the two stick supports. Place a screen holder near one end. Put a piece of white cardboard, or stiff white paper, 15 cm square into the holder. Clip a lens into a lens holder and place it about 20 cm from the cardboard screen.
4. Darken the room. With the flashlight about 1.5 meters from the lens, direct a beam through the lens onto the card (Fig. 8-26b). Slowly slide

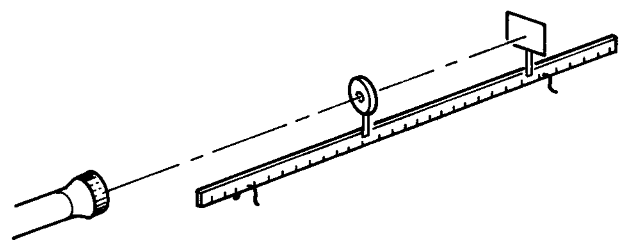


Figure 8-26b

the lens onto the card (Fig. 8-26b). Slowly slide the lens back and forth until a *sharp image* of the arrow is formed on the card. You are **focusing** (fo′-cuss-ing) the image onto the screen.

a. Compare the *position* of the head of the arrow on the flashlight with its image.

b. Compare the *size* of the arrow with its image.

While you hold the flashlight in position, ask a friend to remove the lens and holder from the optical bench.

c. What happened to the image? Why?

d. In what part of the human body would you find a lens? What is its purpose?

e. Suggest a reason why a camera needs a lens.

5. Turn to Practice Sheet 8-2. Place the double convex lens on the graph paper.

a. Do the squares on the paper look any different through the lens?

With one eye closed, look through the lens and *slowly* raise it from the paper.

b. What happens to the size of the squares as the lens is raised?

6. Raise the lens from the paper until the lines are as sharp and clear as possible. Count the number of horizontal lines seen in the lens and compare it to the number of horizontal lines actually on that spot of paper (Fig. 8-27).

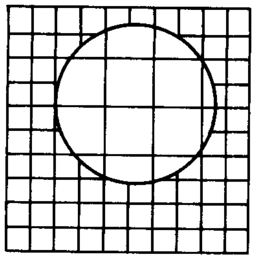


Figure 8-27

a. How many times larger are the spaces between the horizontal lines as seen through the lens, as compared to the actual space between horizontal lines on the paper?

A convex lens can be used to magnify or make an object appear larger. The number of times it enlarges the object is its **magnifying power.**

b. What is the magnifying power of your lens?

BEYOND THE CLASSROOM

Remove the back of any camera as if you were loading it with film. *Before you do so, be sure there is no film left in the camera!* Set the exposure on "time." Hold a piece of wax paper over the back of the camera and press the button that opens the shutter to take the picture. Point the camera at a window or a bright light. What is the position of the image formed on the wax paper?

PRACTICE SHEET 8-2

problem 8-9

To investigate how illumination is affected by distance from the light source.

MATERIALS

Paper
Single-edged razor blade
Meter stick
Supports
2 Screen holders
Paper clips
Battery
Battery holder
Lamp
Lamp socket
Switch
Wire

PROCEDURE

1. Again turn to Practice Sheet 8-2. Cut a piece of graph paper about 6 cm wide and 10 cm long. With a single-edged razor blade carefully cut from the middle of the third layer of boxes exactly one square. Be sure there are no fuzzy edges left around the hole in the paper (Fig. 8-28).

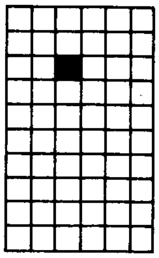


Figure 8-28

2. Set up an optical bench by placing a meter stick in the two metal supports. Place a screen holder on the meter stick so that the tip of the marker is exactly on the 5 cm mark. Slip the paper with the hole in it into the marker so that the paper stands upright (Fig. 8-29).

3. Cut the remaining part of the graph paper into a piece about 10 cm wide and 16 cm long.

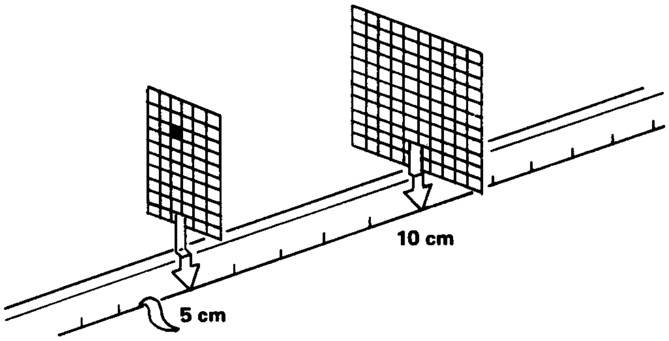


Figure 8-29

Clip or staple this to a piece of cardboard or stiff paper. Place this second piece of graph paper in another screen holder. Set this marker so that its tip is exactly at the 10 cm mark.

4. Connect a battery, lamp and switch to form an electric circuit (See Fig. 8-2). Place the lamp so that its center is directly over the 0 cm end of the meter stick. The center of the lamp should also be at the same level as the hole in the graph paper. Use books to position the lamp (Fig. 8-30).

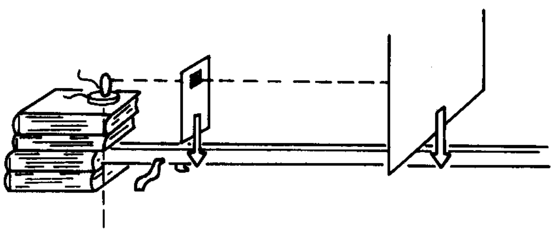


Figure 8-30

5. Darken the room. Close the switch to complete the circuit. Light rays from the lamp should pass through the hole in the smaller sheet and illuminate a certain number of squares near the center of the larger sheet.

6. Count the number of squares illuminated on the larger sheet or screen. You may move the sheet in its holder to make it easier to count the number of squares. DO NOT MOVE THE MARKER. Record the number of squares, position of screen and distance of screen from hole in Table 8-1.

TABLE 8-1

Position of Hole	Position of Screen	Distance of Screen from Hole	Number of Squares Illuminated
5 cm	10/5 cm	10/5 cm	
5 cm	15/10 cm	15/10 cm	
5 cm	cm	cm	
5 cm	cm	cm	
5 cm	cm	cm	
5 cm	cm	cm	
5 cm	cm	cm	

Show, by completing the drawing below, why the illuminated area is a *square* instead of some other shape. Continue the rays from the lamp through the hole to the screen.

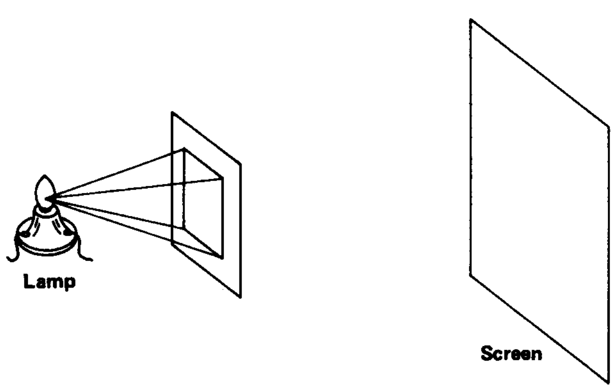


Figure 8-31

7. Move the marker holding the larger sheet so that its tip is at the 15 cm mark on the meter stick. Count the number of squares illuminated in this position. Record the number of squares and distances in Table 8-1.

Is there as much light falling on, or illuminating *each square* of the graph paper in Procedure 7 as there was in Procedure 6? Explain.

8. Continue to move the marker holding the illuminated screen sheet 5 cm farther each time. Count the number of squares illuminated in each position. Record the data in Table 8-1. Continue to do this until you are unable to count the number of squares clearly.

Did the amount of light coming through the hole change as you moved the screen sheet farther and farther away from the bulb? What did change?

9. Examine the data in the column *Number of Squares Illuminated* in Table 8-1.

a. In what way do the number of illuminated squares on the screen increase with every 5 cm increase in the distance?

b. How many squares would be illuminated if the sheet were at the 50 cm mark on the meter stick?

10. Complete Worksheet 8-2.

BEYOND THE CLASSROOM

1. Investigate the difference between the terms "Intensity of Light" and "Illumination."

2. At home after dark lay a sheet of black paper or cloth on a table. Darken the room as much as possible and then shine a flashlight directly down on the black paper or cloth. How well can you see the objects in the room?

Replace the black cloth with a white sheet of paper and repeat. How well can you see the objects in the room now? Explain the change.

worksheet 8-2

1. Is light slowed down or speeded up as it passes from

   a. air to water? ____________________

   b. air to glass? ____________________

   c. glass to air? ____________________

   d. water to glass? ____________________

2. Why does a pencil or a spoon appear to be bent or broken when it is placed in a glass of water?

____

____

3. Why do stars seem to twinkle or flicker when viewed on a hot summer night?

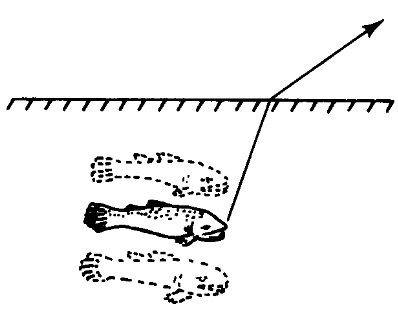
____

____

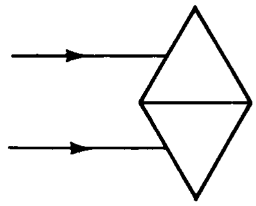
4. If you looked into a pond and saw a fish as shown below, would the fish actually be below, or above, the spot where it seemed to be? Explain.

____

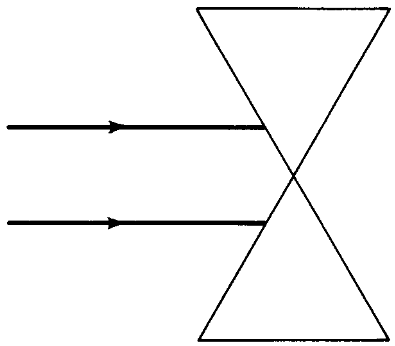
____



5. Two parallel rays strike a piece of glass made up of two glass triangles, as shown below. Trace the path of the rays through the glass.



6. Two parallel rays strike a piece of glass with the triangles arranged as in the drawing below. Trace the path of the rays through the glass.



7. How do the paths of the rays differ in Problems 5 and 6?

____

____

8. What are convex lenses usually used for?

____

____

9. Many people wear eyeglasses. If the human eye has a lens in it, why must some people wear glasses?

____

____

10. Name as many instruments as you can think of in which there are lenses.

____

____

reference sheet 8-4

Close your eyes and sit quietly for a few moments. Listen to the sounds around you. They may come from different sources such as an automobile horn, someone talking, or the chirping of a bird. But they all have one thing in common. Whatever the source that is producing the sound, it is **vibrating** (vy-brate-ing). To vibrate is to move back and forth very rapidly.

Sound is considered to be a form of energy — kinetic energy. Kinetic energy is the energy of a moving object. Every sound can be traced to something that is vibrating. Sound energy like other forms of energy can be transferred. For a person to hear sound, it must be carried or transmitted by some material or **medium** from the vibrating object to the ear. This medium may be either a gas, liquid or solid. The most common medium that carries sound to the ear is air. Sound can, however, be transmitted through water, wood, steel or any other form of matter that can be made to vibrate.

In the classroom, as you listen to the teacher, you may assume that you hear the sound of his voice the instant he speaks. Actually this is not true. Sound travels at definite speeds depending on the medium transmitting the sound. It also depends on temperature and other factors.

Have you noticed that during a thunderstorm you often hear the thunder many seconds after you see the lightning? This is because in air, the speed of sound is only *1100 feet per second,* while the speed of light is over *186,000 miles per second.* Therefore you see the flash of lightning before you hear the clap of thunder.

Like light, sound has certain characteristics. In the problems that follow you will learn some of these characteristics, such as how sound is produced and transmitted.

problem 8-10

To determine various methods by which sounds are produced.

MATERIALS

Pegboard platform	Pencil
2 Support rods	Paper soda straw
Wide rubber band	*Styrofoam* ball or small wad of paper
Two 3 × 5 index cards	Thread
Test tube	Masking tape
Tuning fork	
1-hole rubber stopper	

PROCEDURE

1. Study Reference Sheet 8-4.

2. Stretch a wide rubber band between two support rods attached to the pegboard (Fig. 8-32). Stretch the rubber band as far as possible without breaking it. Pull only the top strand of the rubber band with your finger and then release it. Notice that sound is produced.

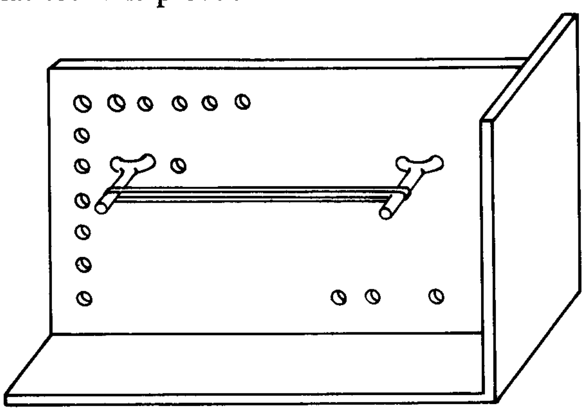


Figure 8-32

What is happening to the rubber band as it is producing the sound?

____

____

4. Place the edges of two slightly curved index cards between your lips (Fig. 8-33). Blow hard enough to produce a sound.

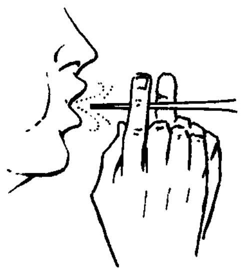


Figure 8-33

What is happening to the cards as they produce sound?

____

____

5. Strike one prong of a tuning fork with a hammer made of a rubber stopper attached to the sharpened end of a pencil (Fig. 8-34).

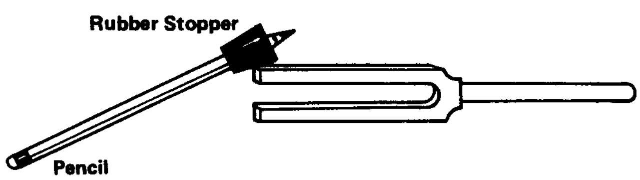


Figure 8-34

Observe the prongs closely. Are they clear or blurred as the fork is producing a sound? Explain.

6. Suspend a *styrofoam* ball or a small wad of paper from the end of a length of thread. Attach the ball of paper to the thread with a piece of masking tape. Strike the tuning fork with the rubber hammer and let the fork touch the suspended ball.

Describe what happens.

7. Place the open end of a test tube against your lower lip and blow as hard as you can.

What do you think is producing the sound you hear?

8. Pinch one end of a paper soda straw until it is almost flat. Close your lips *gently* around the end of the straw and blow air through it.

What do you think is producing the sound in this case?

problem 8-11

To investigate various characteristics of sound.

MATERIALS

Six metal washers	Pencil
Tuning fork	Metric ruler
Wooden block	Wide rubber band
One-hole rubber stopper	

PROCEDURE

1. Arrange five metal washers in a straight line so that each one is touching the others. Place four fingers of your left hand firmly on four of the washers (Fig. 8-35). Place another washer about 6 cm from the end of the line of washers. With the forefinger of your right hand flip the washer sharply against the row of washers (Fig. 8-35).

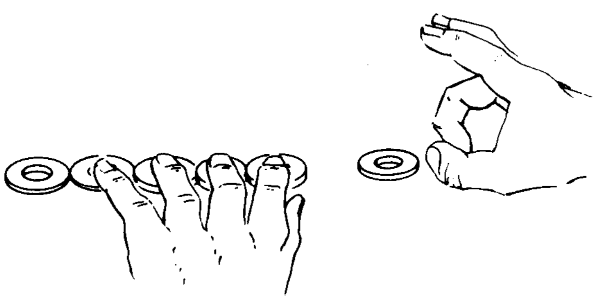


Figure 8-35

a. Describe what happens.

b. If you think of the stationary washers as representing particles and the flipped washer as sound, explain how sound energy passes through matter.

2. Place one end of a block of wood against your ear. Strike a tuning fork with a rubber hammer. Touch the other end of the block with the handle of the tuning fork (Fig. 8-36).

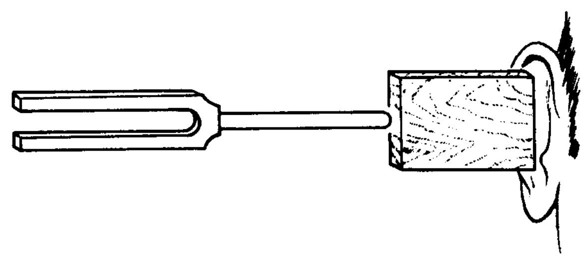


Figure 8-36

a. What happened to the sound when you touched the block with the tuning fork?

b. Explain why sound travels better through a solid than through a gas.

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