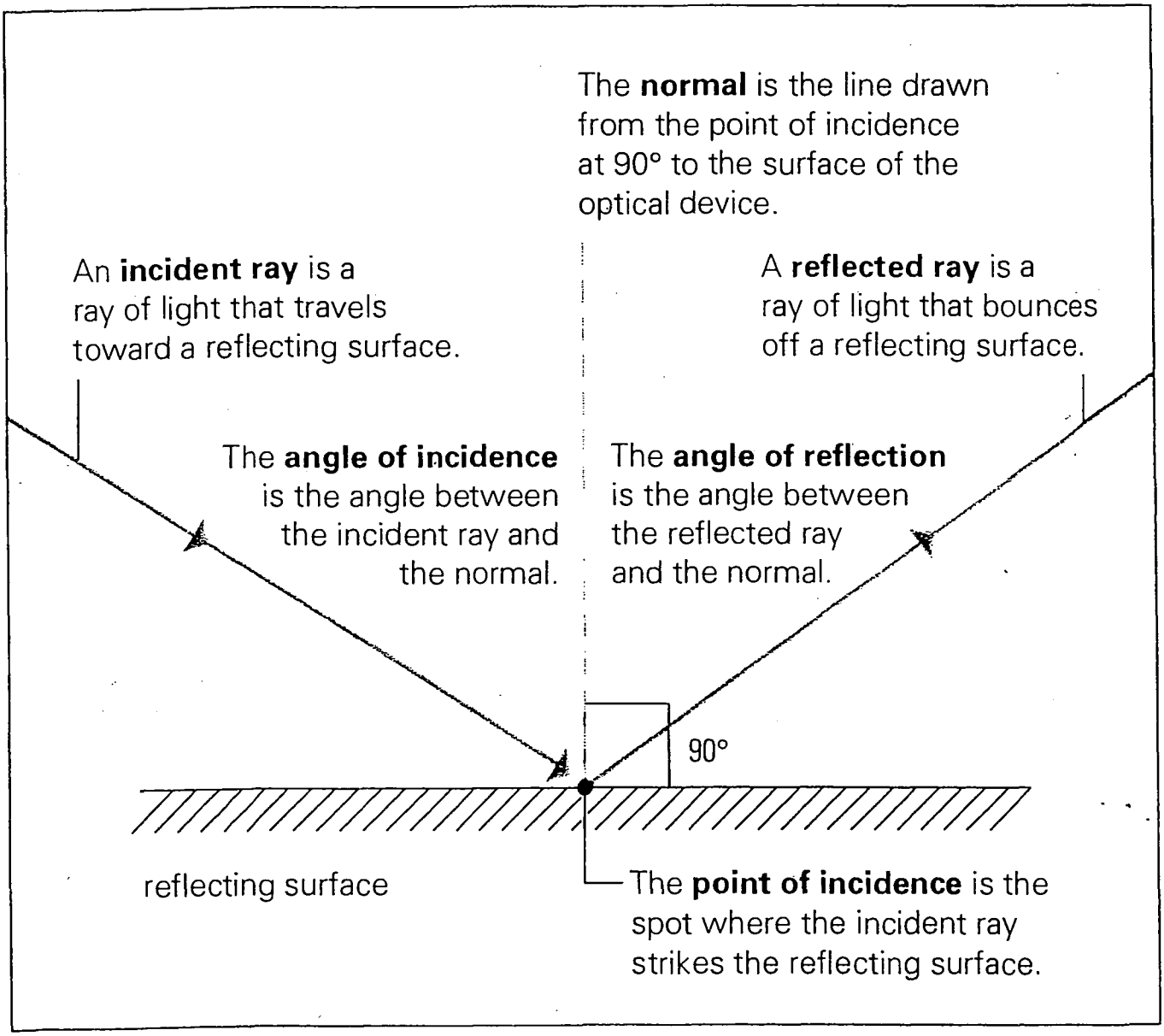
The Laws of Reflection

- *The First Law of Reflection*: The incident beam (ray), the normal and the reflected beam are all on the same plane (all occur on the same flat surface).

- *The Second Law of Reflection*: The angle of incidence is equal to the angle of reflection.

5.5 Terms Related to the Reflection of Light



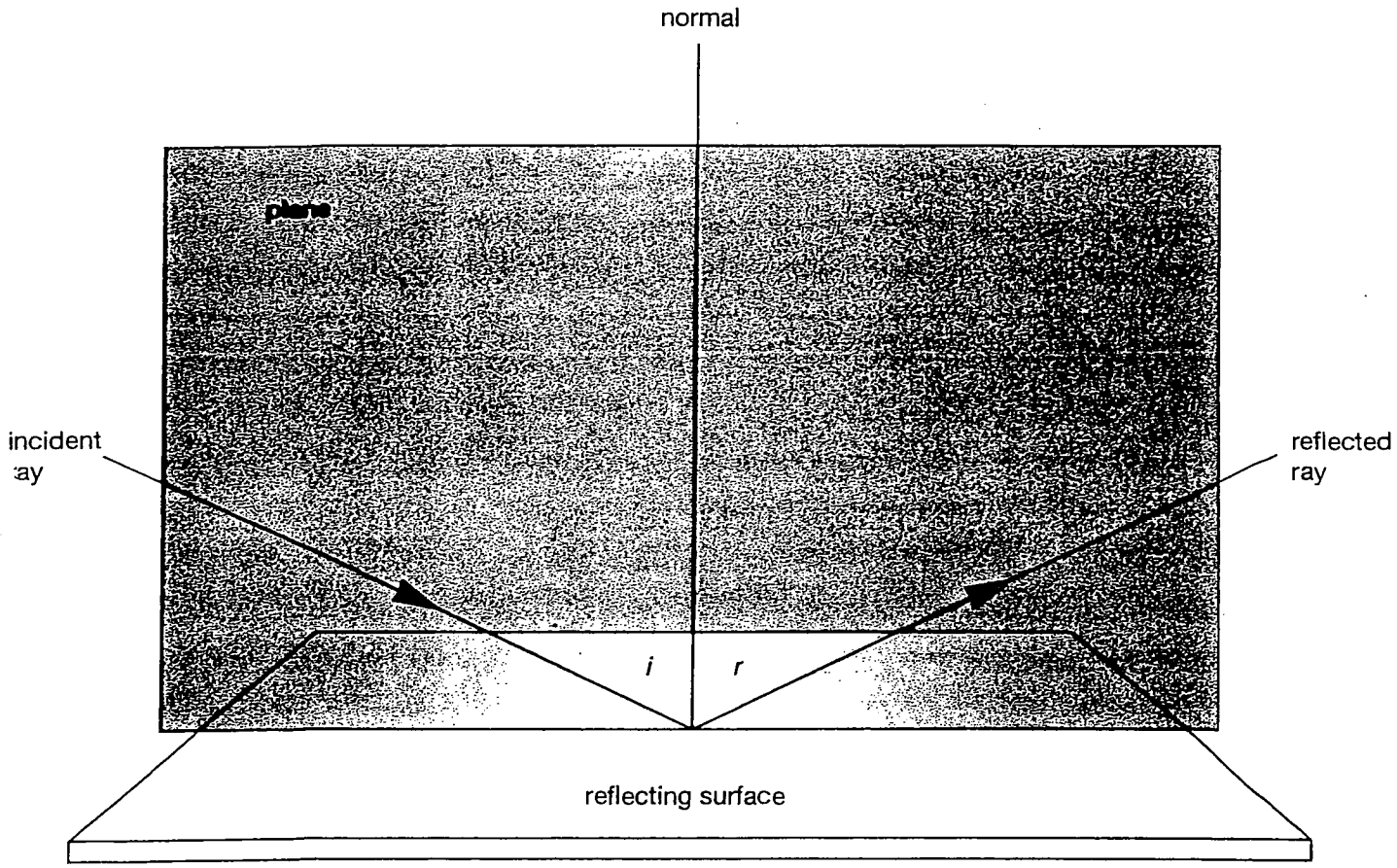


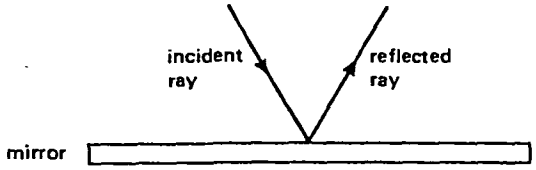
Figure 7.15 The two laws of reflection: 1. The angle of reflection, *r*, is always equal to the angle of incidence, *i*. 2. The incident ray, the normal, and the reflected ray are always in the same plane.

LESSON 11 | What is reflection?

How does a ball bounce back to you after you throw it against a wall? It depends upon how you throw it. If you throw the ball straight on, it will bounce back straight on. If you throw it at an angle, it will bounce back at an angle.

Light, you know, can bounce. "Bounced" light is reflected light. We can predict how reflected light will behave. Just follow the explanation.

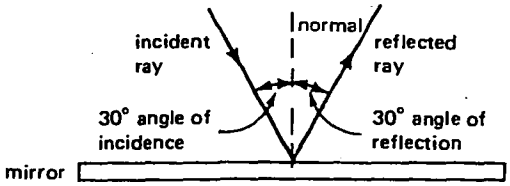
A single beam of light is called a light **ray.** Light is made up of many, many light rays. But let us look at one light ray.



This is a single light ray. It is hitting a flat mirror at an angle. Then it is bouncing off. It is reflecting.

The ray that hits the mirror is called the **incident** [IN si dent] **ray.**

The ray that bounces off the mirror is called the **reflected ray.**



Now let's draw a line that makes a right angle (90 degrees) where the incident ray hits the mirror. This line is called the **normal.**

- The angle between the incident ray and the normal is called the **angle of incidence.**
- The angle between the reflected ray and the normal is called the **angle of reflection.**

The **Law of Reflection** states that "the angle of incidence is equal to the angle of reflection."

In the example on this page, the angle of incidence is 30 degrees. The angle of reflection, then, is also 30 degrees.

REFLECTING RAYS

Two reflecting rays are shown in Figures A and B. Identify the parts shown by number. Choose from the following:

incident ray
reflected ray
normal
angle of incidence
angle of reflection

Write your answers next to the correct numbers.

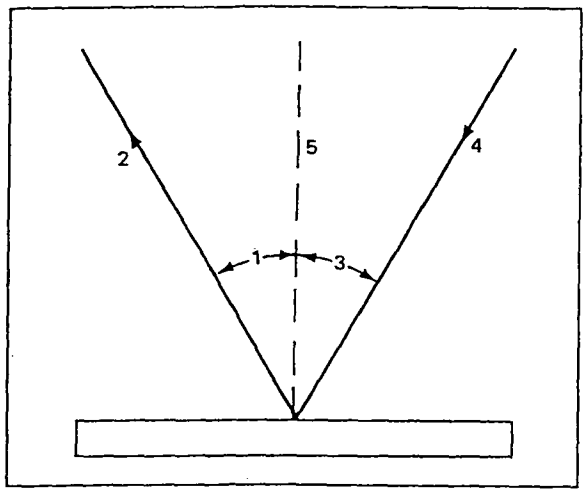


Figure A

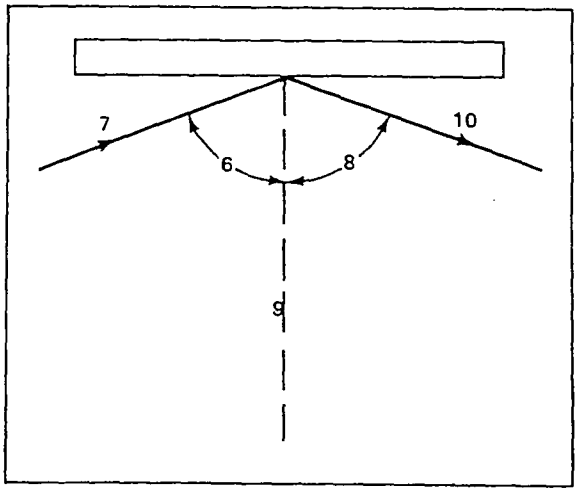


Figure B

1. _____
2. _____
3. _____
4. _____
5. _____

6. _____
7. _____
8. _____
9. _____
10. _____

11. State the Law of Reflection. _____

_____

12. Which of the angles above are equal? (Use numbers.)

    a) In Figure A, _____ and _____ are equal.

    b) In Figure B, _____ and _____ are equal.

Something Extra

If you have a protractor, measure the angles in Figures A and B. What degrees do the angles measure? Figure A _____

Figure B _____

KINDS OF REFLECTIONS

There are two kinds of reflections: regular and diffuse [di FYOOS]. What are the differences? Find out for yourself. It's easy! Figures C and D show the two kinds of reflection. They also show light rays all coming from a single source.

Study each figure. Then answer the questions that go with each.

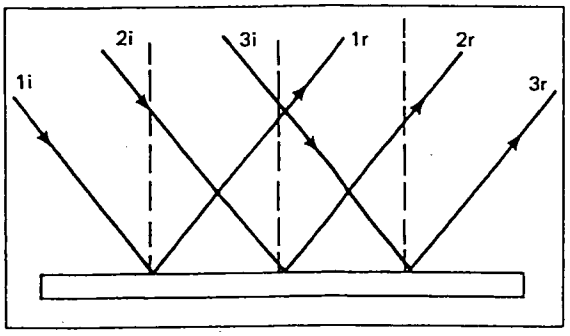


Figure C *Regular reflection*

1. Figure C shows _____ (regular, diffuse) reflection.
2. A surface that gives a regular reflection is _____ (even, uneven).

3. Every ray has its own normal. In regular reflection, the normals _____ (do, do not) face in the same direction.

4. In a regular reflection . . .
   a) every angle of incidence _____ (is, is not) the same.
   b) every angle of reflection _____ (is, is not) the same.

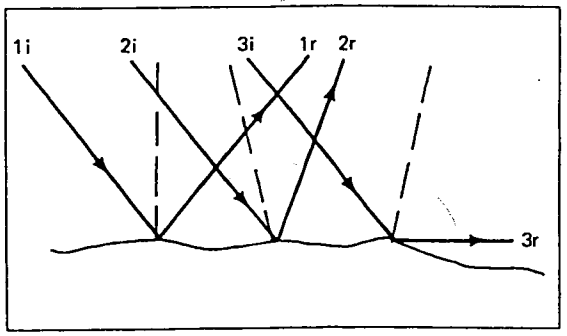


Figure D *Diffuse reflection*

5. Figure D shows a _____ (regular, diffuse) reflection.
6. A surface that gives a diffuse reflection is _____ (even, uneven).

7. In a diffuse reflection, the normals _____ (do, do not) face in the same direction.
8. In a diffuse reflection . . .
   a) every angle of incidence _____ (is, is not) the same. (Careful, remember where the angle of incidence is!)
   b) every angle of reflection _____ (is, is not) the same.

What do you think?

9. Which kind of reflection do you think a mirror gives, regular or diffuse?

   _____

10. Hold your book up and look at this page.

    a) Does the page reflect like a mirror? _____

    b) This shows that paper gives a _____ (regular, diffuse) reflection.

11. Run your hand over this page. To your sense of touch, paper is _____ (rough, smooth).

12. To light, the surface of the paper is _____ (even, uneven).

FILL IN THE BLANK

Complete each statement using a term or terms from the list below. Write your answers in the spaces provided. Some words may be used more than once.

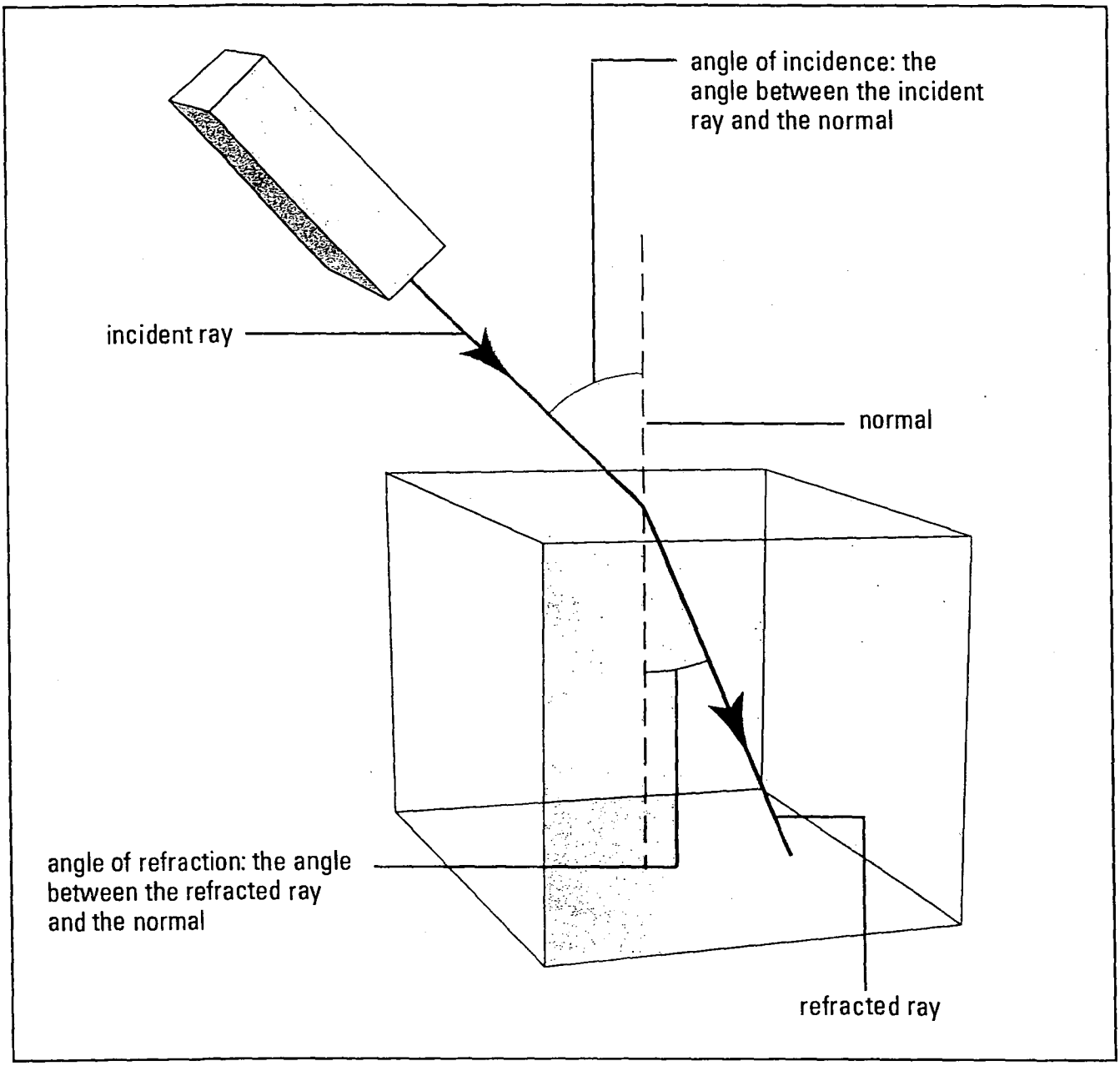
incident	diffuse	angle of incidence
equal	angle of reflection	ray
normal	reflected	regular

1. A single line of light energy is called a _____.
2. A ray that strikes a surface is called an _____ ray.
3. A "bounced" ray is called a _____ ray.
4. A line that makes a 90° angle to a surface is called a _____.
5. The angle between an incident ray and its normal is called the _____.
6. The angle between a reflected ray and its normal is called the _____.
7. An angle of incidence is _____ to its angle of reflection.
8. There are two kinds of reflections. They are _____ and _____.
9. A perfectly even surface gives a _____ reflection.
10. An uneven surface gives a _____ reflection.

Refraction

Refraction is the bending of light as it travels from one material into another.

5.10 Terms Related to the Refraction of Light



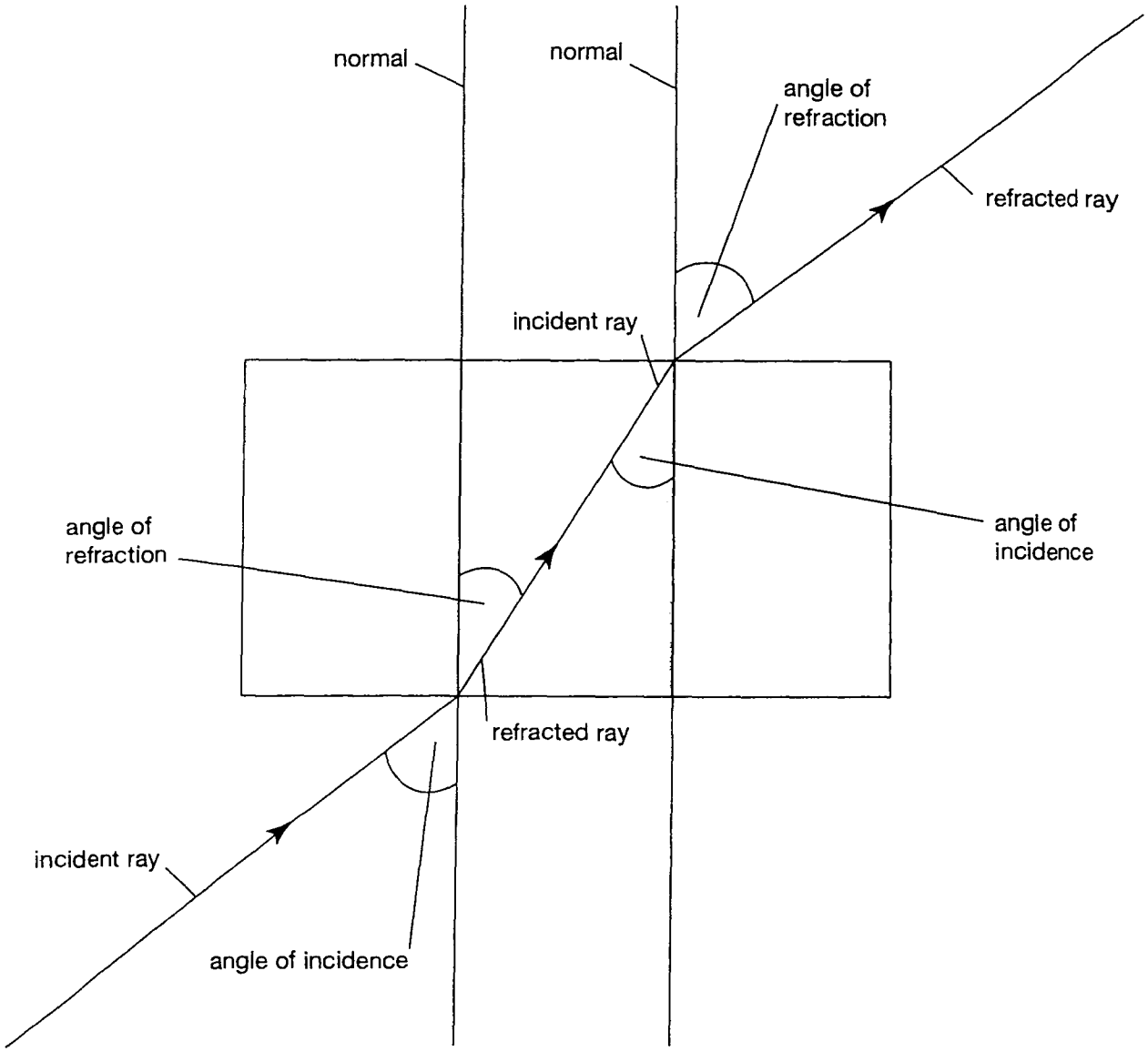


Figure 7.23 Light is refracted as it passes through one medium into a denser medium.

LESSON 12 | What is refraction?

Light travels in straight lines. But light rays can also "bend." They can change direction.

You have seen that light changes direction when it is reflected. Light also changes direction when it passes at an angle from one medium into another medium. This bending is called **refraction** [ree FRAK shun].

Refraction causes us to see objects at positions different from their actual positions. You may have experienced refraction. Did you ever reach into a fish tank to pick up a rock? Was the rock exactly where you thought it was?

How can refraction be explained?

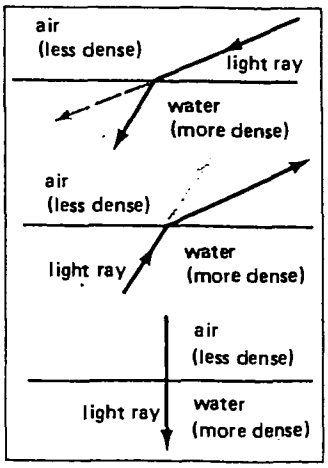
Light travels at different speeds through different mediums. Light travels at about 300,000 kilometers (186,000 miles) per second in air. But light slows down in other substances. In water, for example, light slows down to about 225,000 kilometers (140,000 miles) per second.

The speed at which light travels through a medium depends upon the **density** of that medium. Density has to do with how closely packed the molecules of a substance are. The more closely packed the molecules are, the more dense the substance is.

Different substances have different densities. For example, water is more dense than air.

The following are the Laws of Refraction. They explain how light "bends."

- Light that moves at an angle from a less dense medium to a more dense medium bends towards the normal.
- Light that moves at an angle from a more dense medium to a less dense medium bends away from the normal.
- Light that moves straight on from one medium to another does not bend. It is not refracted.



UNDERSTANDING REFRACTION

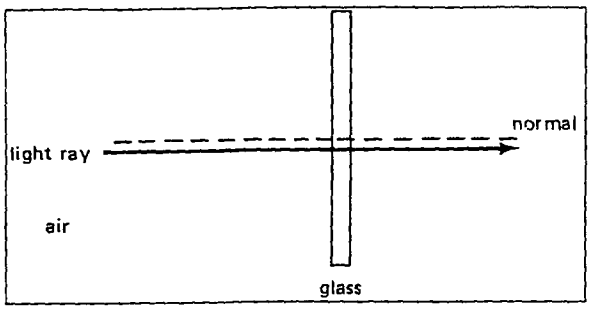


Figure A

1. From your own experience, you know that glass is _____ (more, less) dense than air.
2. The light is hitting the glass _____ (at an angle, straight on).

3. The light _____ (is, is not) bending. It _____ (is, is not) being refracted.
4. Why isn't the light being refracted? _____
5. Write the part of the Law of Refraction that explains why this is happening.

_____

Look at Figures B through G. In each, light is being refracted. The dotted line in color is the normal. Is the light being refracted towards the normal or away from the normal?

Complete the sentence under each figure.

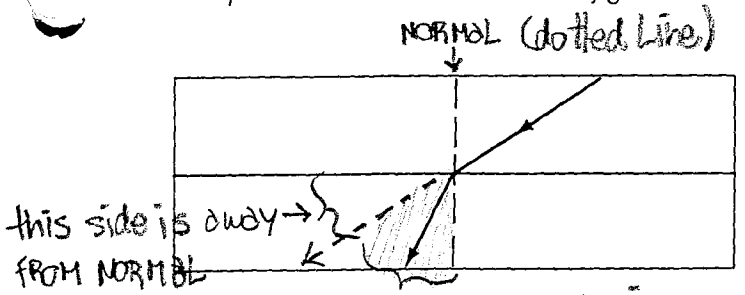


Figure B

6. Light is being refracted _____ (towards, away from) the normal.

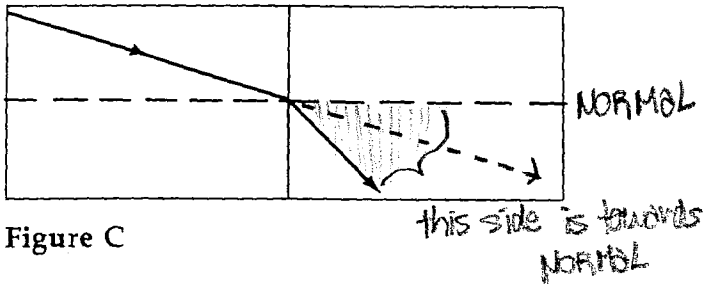


Figure C

7. Light is being refracted _____ (towards, away from) the normal.

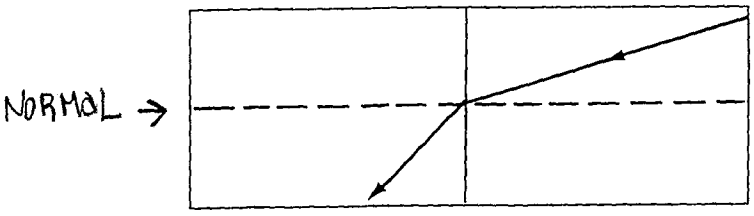


Figure D

8. Light is being _____

_____

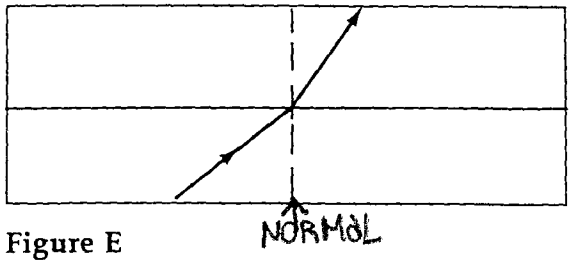


Figure E

9. Light _____

_____

Now, answer with complete sentences.

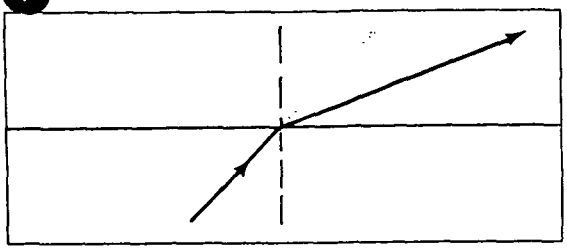


Figure F

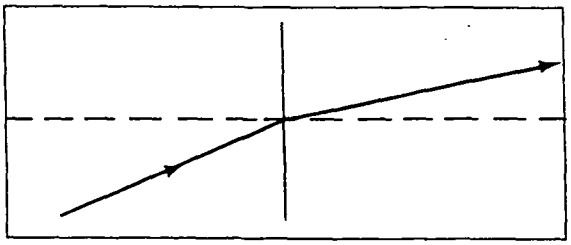


Figure G

10. _____

_____

11. _____

_____

MORE ABOUT REFRACTION

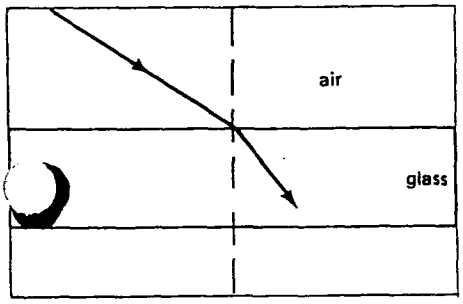


Figure H

Look at Figures H and I. Answer the questions with each.

1. a) In Figure H, light is passing from _____ (air to glass, glass to air).

   b) Glass is _____ (more, less) dense than air.

2. The light is hitting the glass _____ (at an angle, straight on).

3. The light _____ (is, is not) bending. It _____ (is, is not) being refracted.

4. The light is being refracted _____ (towards, away from) the normal.

5. Write the part of the Law of Refraction that explains why this is happening.

_____

_____

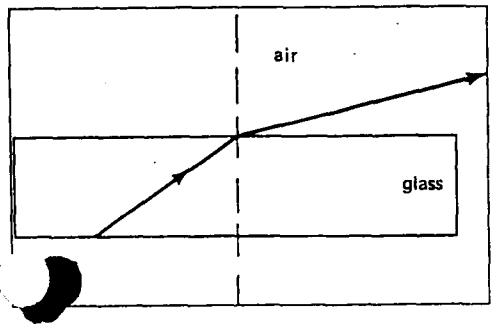


Figure I

6. a) In Figure I, light is passing from _____ (air to glass, glass to air).

   b) Air is _____ (more, less) dense than glass.

7. The light is hitting the air _____ (at an angle, straight on).

8. The light _____ bending. It _____ being refracted.
(is, is not) (is, is not)

9. The light is being refracted _____ the normal.
(towards, away from)

10. Write the part of the Law of Refraction that explains why this is happening.

_____

_____

REFRACTION AND CHANGE OF POSITION

Study Figure J. Answer the questions.

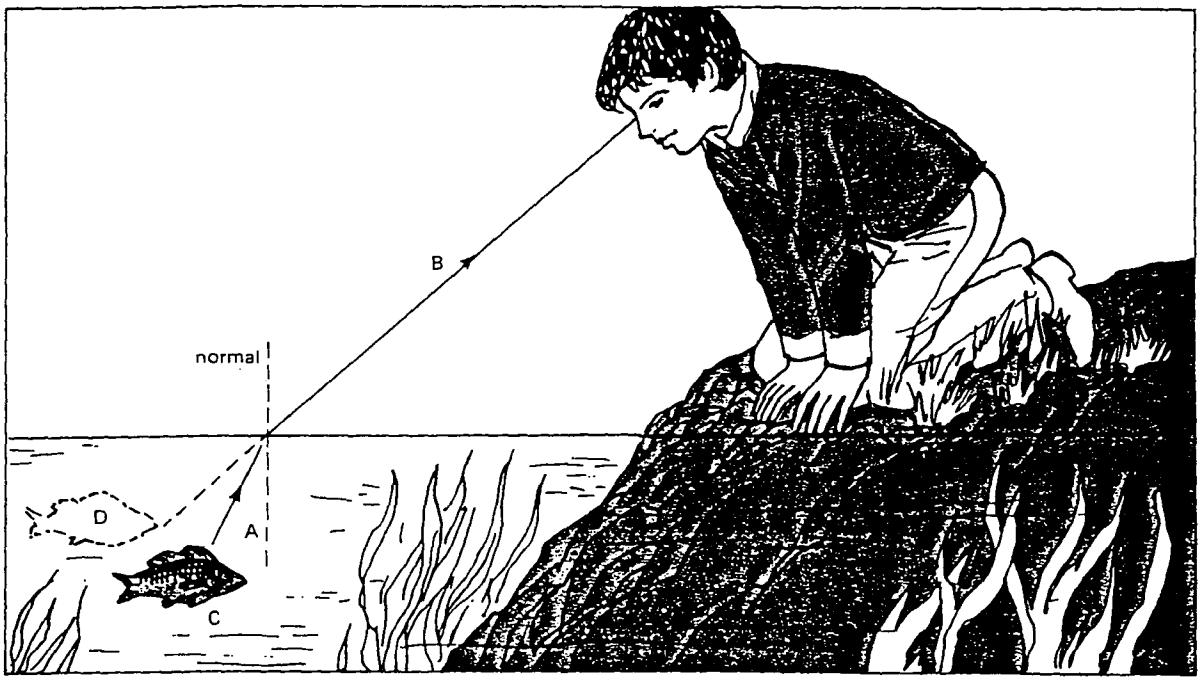


Figure J *The fish is actually at C. But to the boy, the fish appears to be at D.*

1. The boy sees the fish because light is traveling _____
(from the boy's eyes to the fish,)

_____ .
(from the fish to the boy's eyes)

2. The fish is _____ .
(giving off its own light, reflecting light)

3. The light is moving from _____ .
(water to air, air to water)

4. The light from the fish is being refracted _____ the normal.
(towards, away from)

5. The boy sees the fish in line with the refracted light. The refracted light is _____ (A, B).

6. Refraction _____ (does, does not) seem to change the position of an object.

FILL IN THE BLANK

Complete each statement using a term or terms from the list below. Write your answers in the spaces provided. Some words may be used more than once.

is not	refraction	more slowly
away from	more	air
at an angle	toward	less

1. The bending of light as it passes from one medium to another is called _____.

2. Refraction takes place when light strikes a surface _____ to the normal.

3. Light that strikes a surface in the same direction as the normal _____ refracted.

4. Light travels at about 300,000 kilometers per second in _____.

5. Glass and water are _____ dense than air.

6. Light travels _____ in glass or water than it does in air.

7. Light that moves at an angle from a less dense medium to a more dense medium is refracted _____ the normal.

8. Light that moves at an angle from a more dense medium to a less dense medium is refracted _____ the normal.

9. The light ray in Figure K is being refracted _____ the normal.

10. A is _____ dense than B.

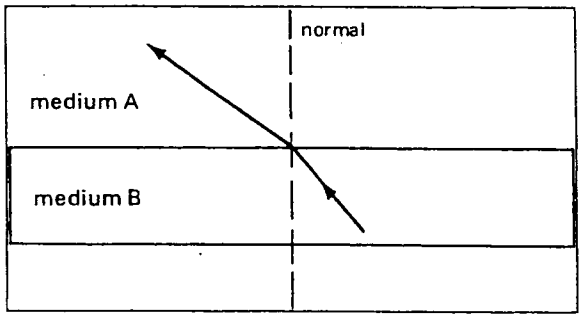


Figure K