chapter 12

Light

section 1 The Behavior of Light

What You'll Learn

- how light waves interact with matter
- regular and diffuse reflection
- index of refraction
- why prisms bend light

Before You Read

Rainbows can appear when the Sun is shining during a rain shower. What do you think causes rainbows in the sky?

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Read to Learn

Light and Matter

Imagine looking around a dark room. Your eyes slowly get used to the darkness. You begin to see things that look familiar. The objects look different than they do with the light on. Everything is a shade of gray or even black. When you turn on the light, the objects are colorful again. What you see depends on the amount of light in the room. It also depends on the color of the objects in the room. For you to see an object, it must reflect light to your eyes.

Study Coach

Create a Quiz After you read each paragraph, write a question that you think your teacher might ask on a quiz. When you finish reading the section, try to answer all of your quiz questions.

What are opaque, transparent, and translucent objects?

Objects can absorb light, reflect light, or transmit light. Transmitting light means that light can pass through the object. Whether light is absorbed, reflected, or transmitted depends on what the object is made of. Think of a coffee mug. Most likely, you can't see through it. This is because no light passes through it. It only absorbs or reflects light. A material that only absorbs or reflects light is **opaque** (oh PAYK).

Reading Check

1. **Determine** Which of the following materials is opaque?

   a. plastic food wrap

   b. poster board

   c. waxed paper

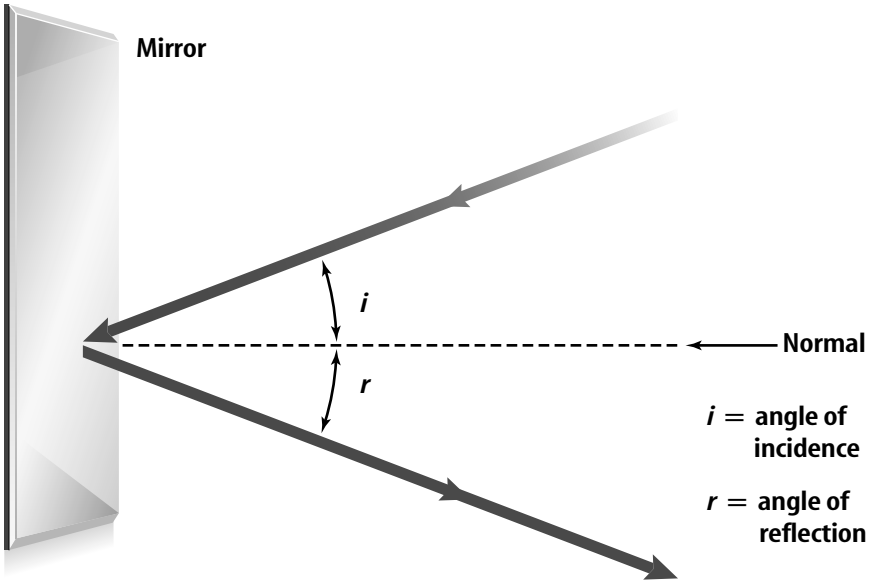
   d. window glass

Have you ever seen a drinking glass made of dark-colored glass? You can see light through the glass, but you can't really see what's behind it. **Translucent** (trans-LEW-sunt) materials allow some light to pass through. You can't see clearly through translucent materials.

Matter that is clear, such as glass or water, is transparent. **Transparent** materials allow almost all the light to pass through. You can see clearly through transparent materials.

Reflection of Light

Did you look in a mirror this morning before you left for school? When you saw your reflection, you actually saw light that reflected off of your body. The light then reflected off of the mirror and traveled to your eye. Reflection happens when light waves bounce off objects.



What is the law of reflection?

Have you ever shone a flashlight at a mirror in a dark room? The beam of light does not always shine straight back at you. Depending on how you hold the flashlight, the beam might hit the ceiling or the floor. When light is reflected, it follows the law of reflection. According to the law of reflection, the angle at which a light wave strikes a surface is the same as the angle at which it is reflected. The figure above shows the law of reflection. Light follows this law when it is reflected from any surface, whether it is a mirror or a piece of paper.

How is regular reflection different from diffuse reflection?

You can see your reflection in a window. But you cannot see your reflection in a brick wall. Why not? How well you can see your reflection depends on the smoothness of the surfaces. A glass window has a very smooth surface and a brick wall has a very rough surface. Smooth surfaces like the glass window usually reflect light in an even pattern. They produce sharp images. Reflection of light waves from a smooth surface is called regular reflection. Rough or uneven surfaces like the brick wall reflect light in many directions. Reflection of light from a rough surface is called diffuse reflection.

Applying Math

2. Observe Suppose the light from the flashlight hits the mirror at a 60° angle. What will be the angle of the reflected beam of light?

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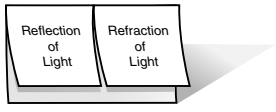
FOLDABLES™

A Find Main Ideas Make a Foldable like the one shown to write down the main ideas in this section about reflection of light and refraction of light.



Think it Over

3. **Explain** Car side mirrors do not work when they are covered with frost. What does frost do to the surface of a mirror to cause a diffuse reflection?

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How smooth must a surface be for regular reflection?

Some surfaces seem smooth, but they still cause diffuse reflection. For example, the surface of a metal pot might look smooth. But if you looked at it under a microscope, you would see that it is not smooth. The rough surface causes diffuse reflection.

Refraction of Light

Have you ever seen a spoon sitting in a glass of water, like the one in the figure? If you look at the glass from the side, the spoon looks bent or broken. What you see is caused by the refraction, or bending, of light.

The speed of light depends on the substance it travels through. Light travels at different speeds in air, glass, and water. Refraction is caused by a change in the speed of a light ray. When light passes from one substance to another, it is refracted if it is traveling at an angle.

Picture This

4. **Identify** How do you know that light waves are being refracted when they pass from the air to the water in the glass?

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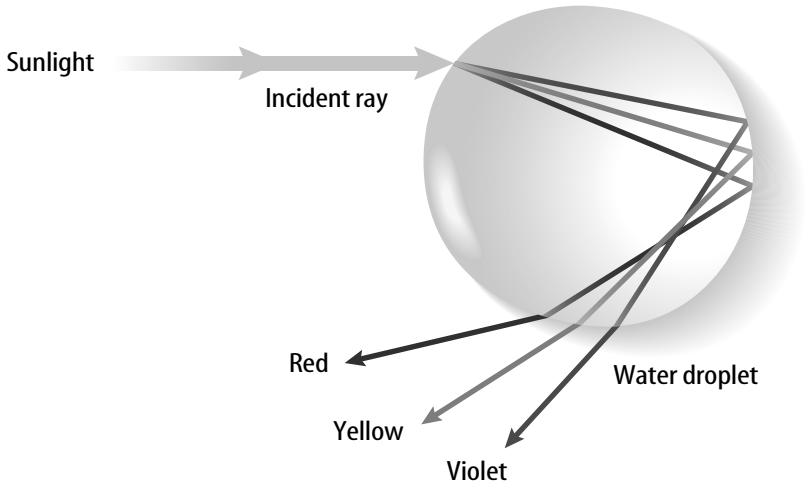
What is the index of refraction?

The amount that light rays bend when they are refracted depends on the speed that light travels in each material. The greater the difference in speeds, the more the light will be bent. Every material has an index of refraction. The **index of refraction** is a property of a material that indicates how much light slows down when it travels in the material.

The greater the index of refraction, the more light slows down in the material. For example, glass has a greater index of refraction than air. This means light moves more slowly in glass than in air. Glass lenses in eyeglasses, microscopes, and cameras use refraction to focus light.

What are prisms?

A prism is a triangular piece of glass that refracts sunlight into colorful patterns. How does bending light create colors? White light, such as sunlight, is composed of several wavelengths of energy which are detected by the eye as colors. The longest wavelength we call red, and the shortest we call violet. As light enters the glass prism, it slows down and changes its direction (bends). As it leaves the prism it bends a second time as it enters air. The prism's shape and the glass medium separates white light into its various colors which we see in a rainbow pattern.



How do rainbows form?

The refracted light from a prism should remind you of a rainbow. Like prisms, raindrops also can refract light. Look at the figure above. Sunlight enters water droplets in the atmosphere. The droplets separate the light into individual colors, depending on wavelength.

Humans can usually see only seven colors in a rainbow or in the refracted light of a prism. The colors are red, orange, yellow, green, blue, indigo, and violet, in order from longest wavelength to shortest wavelength.

What causes mirages?

Have you ever been riding in a car on a hot, sunny day? When you looked ahead, you may have seen what looked like a pool of water on the road. As you got closer, the pool of water seemed to disappear. What you saw was a mirage. A **mirage** is an image of a faraway object. The image is made when light is refracted through air layers of different densities.

Mirages result when the air at ground level is much warmer or much cooler than the air above ground level. As the temperature of air changes, the density of air changes also. These changes in density cause light waves to refract as they pass through air layers with different temperatures.

Picture This

5. **Observe** Circle the two areas in the figure that show where sunlight is refracted by the water droplet.

Reading Check

6. **Explain** What happens to light waves as they pass through air layers with different temperatures?

After You Read

Mini Glossary

index of refraction: a property of a material that indicates how much light slows down when it travels in the material

mirage: an image of a far away object that is made when light is refracted through air layers of different densities

opaque: a material that absorbs or reflects all light

translucent: a material that allows some light to pass through it

transparent: a material that allows almost all the light that strikes it to pass through it

1. Review the terms and their definitions in the Mini Glossary. Why do bathroom windows often have translucent glass?

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_____

2. Complete the graphic organizer to organize the information you learned in this section about the behavior of light.

Reflection

- Happens when light waves _____ off objects.
- The angle at which light strikes a surface and the angle at which it is reflected are the _____.

Regular reflection

- _____ surfaces
- _____ images

Diffuse reflection

- _____ surfaces
- _____ light

Refraction

- The _____ of light.
- A property of a material that indicates how much light slows down when traveling in the material is the _____.

Prisms

- _____ light
- _____ wavelengths

Rainbows

- formed by light refracting in _____

Mirages

- formed when light is refracted through _____

End of Section