CONCEPT 1

Light changes direction and speed when it moves from one medium to another.

Activity

Visualizing Refraction

When light travels from one medium to another, both its speed and direction may change. To visualize this, consider this analogy. What happens if you are riding a bicycle and hit some soft mud? Fill in the blanks below to explain what happens. Compare your answers with others in the class.

The front wheels suddenly _____, but the back wheels keep travelling at the same _____. As a result, the bicycle _____.

You have already learned that light travels in a straight line through the same medium. You also know that when light travels from one medium to another, for example, from air to water, its path refracts (bends). What causes this refraction?

Refraction: Light Travels at Different Speeds and Changes Direction

Refraction occurs because light travels at different speeds in different media. For example, light travels at a different speed through air than it does through water. (Light, and all other types of electromagnetic radiation, only travel at the same speed—3.00×10^8 m/s—in a vacuum.) When light changes speed as it moves from one medium to another, the direction in which it travels also changes.

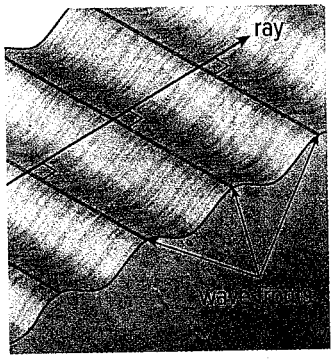

Figure 3.36 All the points on a wave front move together in the direction in which the wave itself is moving.

Describing Refraction Using the Wave Model and Ray Model of Light

It is helpful to use the wave model and ray model of light to visualize why the path of light changes direction when light changes speed. To see how these models fit together, look at **Figure 3.36**. Scientists often choose a specific part of a wave to follow and call it a *wave front*. As you can see in **Figure 3.36**, the crests of the waves are wave fronts. The ray (red arrow) shows the direction in which the waves are travelling. It is perpendicular to the wave fronts.

Try to visualize what happens when a wave front of light reaches the surface between two media. Imagine each wave front as a line of roller skaters holding hands. **Figure 3.37A** shows the movement of the skaters as they go from a paved surface to a gravel surface. As each skater reaches the gravel, he or she slows down. The slower skaters "pull" the line back and cause a bend in the line, representing the wave front. As a result, the direction in which the skaters move changes. This is what happens when a light wave moves from one medium to another: its speed and direction change (**Figure 3.37B**).

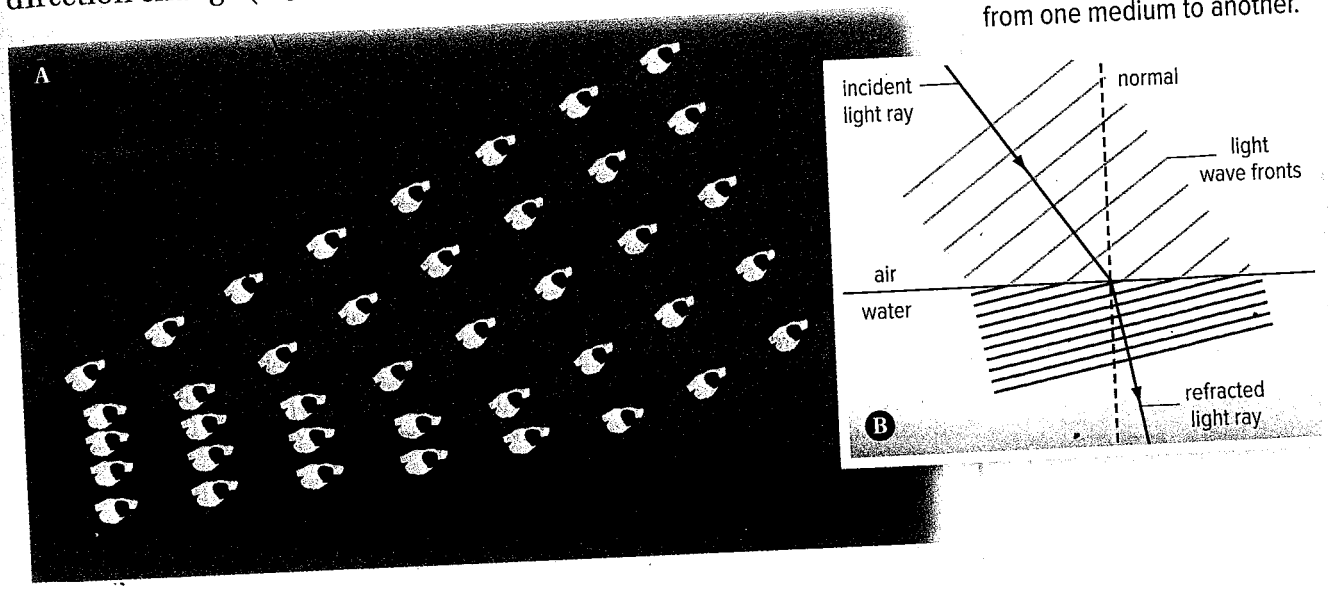

Figure 3.37 A When some of the skaters slow down, the direction of the line changes. The larger red arrow shows the direction in which the skaters are moving. B This visual shows how light waves behave in a similar way when they pass from one medium to another.

Did you notice that when the skaters and light waves slowed down, their direction turned toward the normal? When the speed of a wave slows down in the second medium, the direction of the wave is bent toward the normal. To predict if a wave will slow down or speed up when going from the first to the second medium, you need to know the density of the two media.

Light travels more slowly in a more dense medium than in a less dense medium. Therefore, the following statements are true.

- When light travels from a less dense to a more dense medium, the ray bends toward the normal.
- When light travels from a more dense medium to a less dense medium, the ray bends away from the normal.

Connect to Topic 2.2 on pages 114–115

Before you leave this page . . .

1. Come up with another analogy that you could use to visualize how refraction occurs.