SECTION 3

Optical Phenomena

SECTION OBJECTIVES

- Predict whether light will be refracted or undergo total internal reflection.
- Recognize atmospheric conditions that cause refraction.
- Explain dispersion and phenomena such as rainbows in terms of the relationship between the index of refraction and the wavelength.

TOTAL INTERNAL REFLECTION

An interesting effect called **total internal reflection** can occur when light moves along a path from a medium with a *higher* index of refraction to one with a *lower* index of refraction. Consider light rays traveling from water into air, as shown in **Figure 10(a).** Four possible directions of the rays are shown in the figure.

At some particular angle of incidence, called the **critical angle,** the refracted ray moves parallel to the boundary, making the angle of refraction equal to 90°, as shown in **Figure 10(b).** For angles of incidence greater than the critical angle, the ray is entirely reflected at the boundary, as shown in **Figure 10.** This ray is reflected at the boundary as though it had struck a perfectly reflecting surface. Its path and the path of all rays like it can be predicted by the law of reflection; that is, the angle of incidence equals the angle of reflection.

In optical equipment, prisms are arranged so that light entering the prism is totally internally reflected off the back surface of the prism. Prisms are used in place of silvered or aluminized mirrors because they reflect light more efficiently and are more scratch resistant.

Snell's law can be used to find the critical angle. As mentioned above, when the angle of incidence, θ_i, equals the critical angle, θ_c, then the angle of refraction, θ_r, equals 90°. Substituting these values into Snell's law gives the following relation.

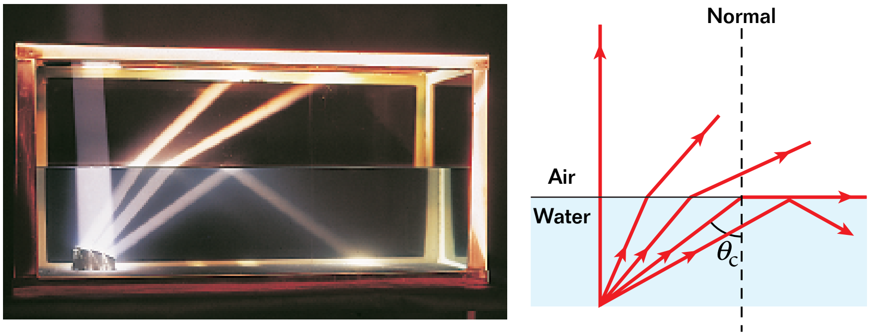
$$n_i \sin \theta_c = n_r \sin 90°$$

total internal reflection

the complete reflection that takes place within a substance when the angle of incidence of light striking the surface boundary is greater than the critical angle

critical angle

the angle of incidence at which the refracted light makes an angle of 90° with the normal



(a) (b)

Figure 10

(a) This photo demonstrates several different paths of light radiated from the bottom of an aquarium. **(b)** At the critical angle, θ_c, a light ray will travel parallel to the boundary. Any rays with an angle of incidence greater than θ_c will be totally internally reflected at the boundary.