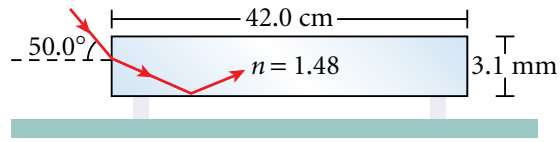
60. A flashlight on the bottom of a 4.00 m deep swimming pool sends a ray upward and at an angle so that the ray strikes the surface of the water 2.00 m from the point directly above the flashlight. What angle (in air) does the emerging ray make with the water's surface? (Hint: To determine the angle of incidence, consider the right triangle formed by the light ray, the pool bottom, and the imaginary line straight down from where the ray strikes the surface of the water.)

61. A submarine is 325 m horizontally out from the shore and 115 m beneath the surface of the water. A laser beam is sent from the submarine so that it strikes the surface of the water at a point 205 m from the shore. If the beam strikes the top of a building standing directly at the water's edge, find the height of the building. (Hint: To determine the angle of incidence, consider the right triangle formed by the light beam, the horizontal line drawn at the depth of the submarine, and the imaginary line straight down from where the beam strikes the surface of the water.)

62. A laser beam traveling in air strikes the midpoint of one end of a slab of material, as shown in the figure (in the next column). The index of refraction of the slab is 1.48. Determine the number of internal reflections of the laser beam before it finally emerges from the opposite end of the slab.



63. A nature photographer is using a camera that has a lens with a focal length of 4.80 cm. The photographer is taking pictures of ancient trees in a forest and wants the lens to be focused on a very old tree that is 10.0 m away.

a. How far must the lens be from the film in order for the resulting picture to be clearly focused?

b. How much would the lens have to be moved to take a picture of another tree that is only 1.75 m away?

64. The distance from the front to the back of your eye is approximately 1.90 cm. If you can see a clear image of a book when it is 35.0 cm from your eye, what is the focal length of the lens/cornea system?

65. Suppose you look out the window and see your friend, who is standing 15.0 m away. To what focal length must your eye muscles adjust the lens of your eye so that you may see your friend clearly? Remember that the distance from the front to the back of your eye is about 1.90 cm.

Graphing Calculator Practice

Snell's Law

What happens to a light ray that passes from air into a medium whose index of refraction differs from that of air? Snell's law, as you learned earlier in this chapter, describes the relationship between the angle of refraction and the index of refraction.

$$n_i \sin \theta_i = n_r \sin \theta_r$$

In this equation, n_i is the index of refraction of the medium of the incident light ray, and θ_i is the angle of incidence; n_r is the index of refraction of the medium of the refracted light, and θ_r is the angle of refraction.

In this graphing calculator activity, you will enter the angle of incidence and will view a graph of the index of refraction versus the angle of refraction. You can use this graph to better understand the relationship between the index of refraction and the angle of refraction.

Visit go.hrw.com and enter the keyword **HF6REFX** to find this graphing calculator activity. Refer to **Appendix B** for instructions on downloading the program for this activity.