General Problems

72. Two plane mirrors face each other 2.0 m apart as in Fig. 23–53. You stand 1.5 m away from one of these mirrors and look into it. You will see multiple images of yourself. (*a*) How far away from you are the first three images in the mirror in front of you? (*b*) Are these first three images facing toward you or away from you?

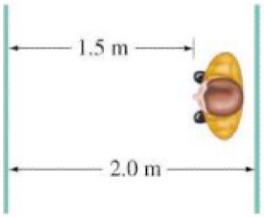

FIGURE 23–53 Problem 72.

73. We wish to determine the depth of a swimming pool filled with water. We measure the width ($x = 5.50$ m) and then note that the bottom edge of the pool is just visible at an angle of 14.0° above the horizontal as shown in Fig. 23–54. Calculate the depth of the pool.

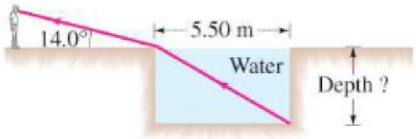

FIGURE 23–54 Problem 73.

74. The critical angle of a certain piece of plastic in air is $\theta_C = 37.3°$. What is the critical angle of the same plastic if it is immersed in water?

75. (*a*) A plane mirror can be considered a limiting case of a spherical mirror. Specify what this limit is. (*b*) Determine an equation that relates the image and object distances in this limit of a plane mirror. (*c*) Determine the magnification of a plane mirror in this same limit. (*d*) Are your results in parts (*b*) and (*c*) consistent with the discussion of Section 23–2 on plane mirrors?

76. Stand up two plane mirrors so they form a 90° angle as in Fig. 23–55. When you look into this double mirror, you see yourself as others see you, instead of reversed as in a single mirror. Make a careful ray diagram to show how this occurs.

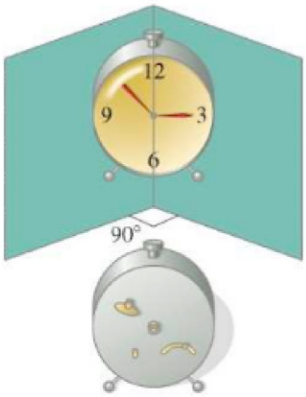

FIGURE 23–55 Problem 76.

77. Show analytically that a diverging lens can never form a real image of a real object. Can you describe a situation in which a diverging lens can form a real image?

78. Each student in a physics lab is assigned to find the location where a bright object may be placed in order that a concave mirror with radius of curvature $r = 40$ cm will produce an image three times the size of the object. Two students complete the assignment at different times using identical equipment, but when they compare notes later, they discover that their answers for the object distance are not the same. Explain why they do not necessarily need to repeat the lab, and justify your response with a calculation.

79. If the apex angle of a prism is $\phi = 72°$ (see Fig. 23–56), what is the minimum incident angle for a ray if it is to emerge from the opposite side (i.e., not be totally internally reflected), given $n = 1.50$?

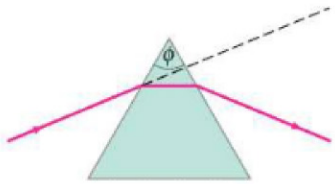

FIGURE 23–56 Problem 79.

80. The end faces of a cylindrical glass rod ($n = 1.54$) are perpendicular to the sides. Show that a light ray entering an end face at any angle will be totally internally reflected inside the rod when the ray strikes the sides. Assume the rod is in air. What if it were in water?

*** 81.** A lighted candle is placed 33 cm in front of a converging lens of focal length $f_1 = 15$ cm, which in turn is 55 cm in front of another converging lens of focal length $f_2 = 12$ cm (see Fig. 23–57). (*a*) Draw a ray diagram and estimate the location and the relative size of the final image. (*b*) Calculate the position and relative size of the final image.

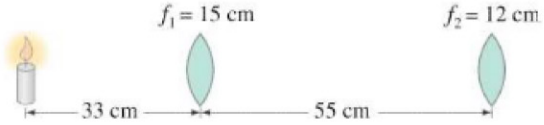

FIGURE 23–57 Problem 81.

82. A bright object is placed on one side of a converging lens of focal length f, and a white screen for viewing the image is on the opposite side. The distance $d_T = d_i + d_o$ between the object and the screen is kept fixed, but the lens can be moved. (*a*) Show that if $d_T > 4f$, there will be two positions where the lens can be placed and a sharp image will be produced on the screen. (*b*) If $d_T < 4f$, show that there will be no lens position where a sharp image is formed. (*c*) Determine a formula for the distance between the two lens positions in part (*a*), and the ratio of the image sizes.