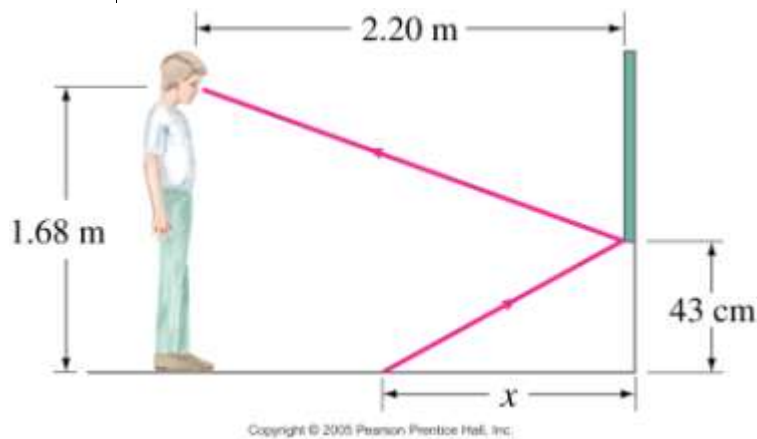


CHAPTER 23: Light: Geometric Optics

Problems

23–2 Reflection; Plane Mirrors

4. (II) A person whose eyes are 1.68 m above the floor stands 2.20 m in front of a vertical plane mirror whose bottom edge is 43 cm above the floor, Fig. 23–48. What is the horizontal distance x to the base of the wall supporting the mirror of the nearest point on the floor that can be seen reflected in the mirror?



23–3 Spherical Mirrors

9. (II) If you look at yourself in a shiny Christmas tree ball with a diameter of 9.0 cm when your face is 30.0 cm away from it, where is your image? Is it real or virtual? Is it upright or inverted?
12. (II) Some rearview mirrors produce images of cars behind you that are smaller than they would be if the mirror were flat. Are the mirrors concave or convex? What is a mirror's radius of curvature if cars 20.0 m away appear $0.33\times$ their normal size?
15. (II) (a) Where should an object be placed in front of a concave mirror so that it produces an image at the same location as the object? (b) Is the image real or virtual? (c) Is the image inverted or upright? (d) What is the magnification of the image?

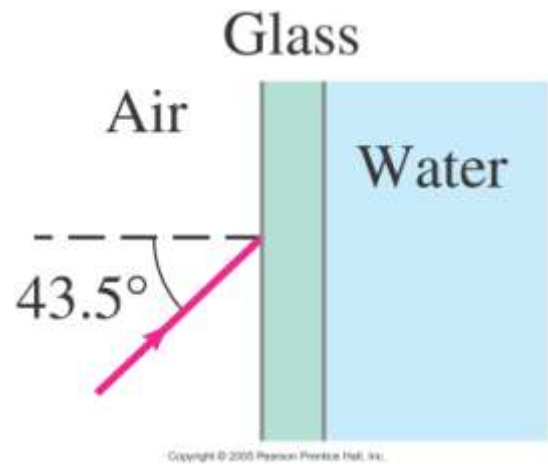
18. (II) Show, using a ray diagram, that the magnification m of a convex mirror is $m = -d_i/d_o$, just as for a concave mirror. [*Hint*: consider a ray from the top of the object that reflects at the center of the mirror.]

23–4 Index of Refraction

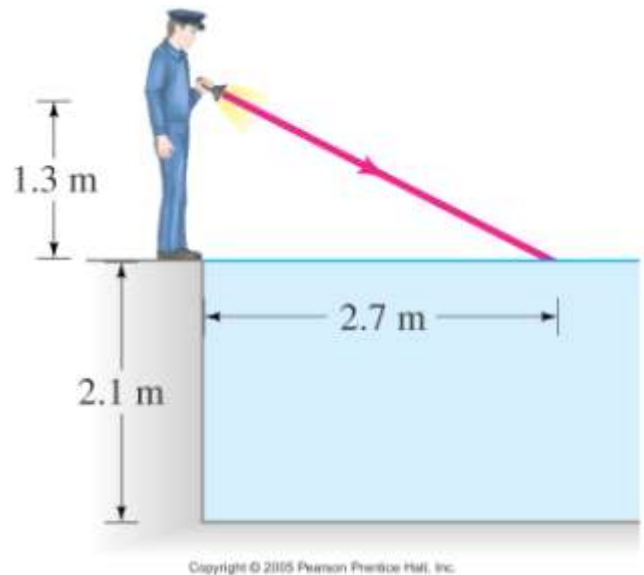
23. (I) What is the speed of light in (a) crown glass, (b) Lucite, and (c) ethyl alcohol?
25. (II) The speed of light in a certain substance is 89% of its value in water. What is the index of refraction of this substance?

23–5 Refraction: Snell's Law

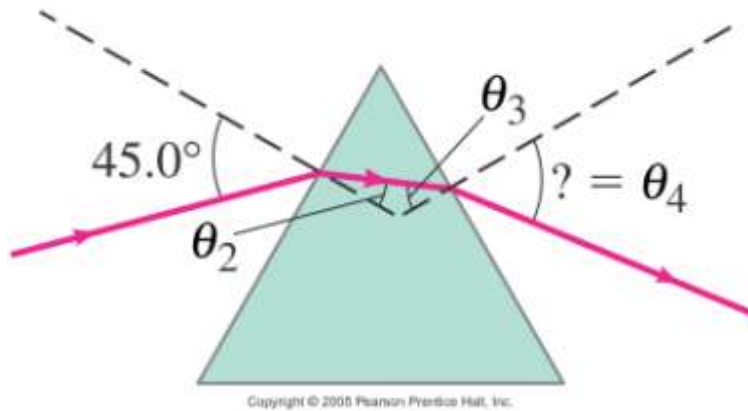
30. (II) An aquarium filled with water has flat glass sides whose index of refraction is 1.52. A beam of light from outside the aquarium strikes the glass at a 43.5° angle to the perpendicular (Fig. 23–49). What is the angle of this light ray when it enters (a) the glass, and then (b) the water? (c) What would be the refracted angle if the ray entered the water directly?



31. (II) In searching the bottom of a pool at night, a watchman shines a narrow beam of light from his flashlight, 1.3 m above the water level, onto the surface of the water at a point 2.7 m from the edge of the pool (Fig. 23–50). Where does the spot of light hit the bottom of the pool, measured from the wall beneath his foot, if the pool is 2.1 m deep?



32. (II) Light is incident on an equilateral glass prism at a 45.0° angle to one face, Fig. 23–51. Calculate the angle at which light emerges from the opposite face. Assume that $n = 1.58$.



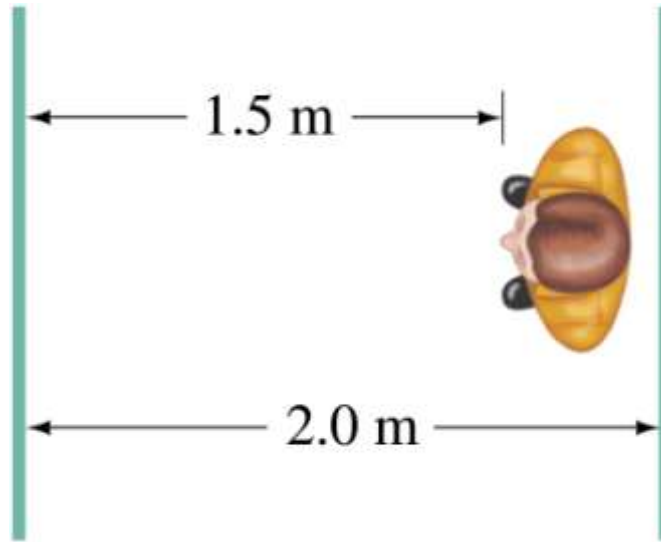
23–6 Total Internal Reflection

40. (III) Suppose a ray strikes the left face of the prism in Fig. 23–51 at 45.0° as shown, but is totally internally reflected at the opposite side. If the prism apex angle (at the top) is $\phi = 75.0^\circ$, what can you say about the index of refraction of the prism?

23–7 and 23–8 Thin Lenses

46. (I) (a) What is the power of a 20.5-cm-focal-length lens? (b) What is the focal length of a -6.25 -diopter lens? (c) Are these lenses converging or diverging?
49. (II) An 80-mm-focal-length lens is used to focus an image on the film of a camera. The maximum distance allowed between the lens and the film plane is 120 mm. (a) How far ahead of the film should the lens be if the object to be photographed is 10.0 m away? (b) 3.0 m away? (c) 1.0 m away? (d) What is the closest object this lens could photograph sharply?
53. (II) (a) How far from a 50.0-mm-focal-length lens must an object be placed if its image is to be magnified $2.00\times$ and be real? (b) What if the image is to be virtual and magnified $2.00\times$?

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?



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