

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?

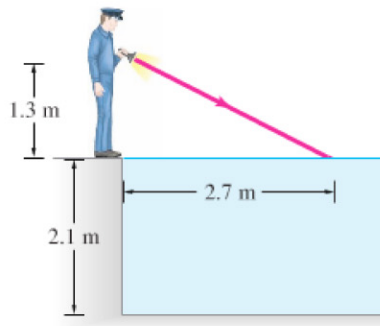


FIGURE 23–50 Problem 31.

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 $n = 1.58$.

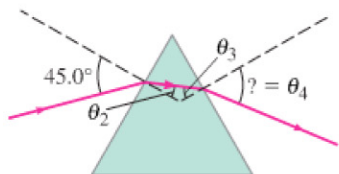


FIGURE 23–51 Problems 32 and 40.

33. (II) A beam of light in air strikes a slab of glass ($n = 1.52$) and is partially reflected and partially refracted. Find the angle of incidence if the angle of reflection is twice the angle of refraction.
34. (III) Prove in general that for a light beam incident on a uniform layer of transparent material, as in Fig. 23–22, the direction of the emerging beam is parallel to the incident beam, independent of the incident angle θ . Assume air on both sides of the glass.
35. (III) A light ray is incident on a flat piece of glass with index of refraction n as in Fig. 23–22. Show that if the incident angle θ is small, the emerging ray is displaced a distance $d = t\theta(n - 1)/n$ from the incident ray, where t is the thickness of the glass and θ is in radians. [Hint: for small θ , $\sin \theta \approx \tan \theta \approx \theta$ in radians.]

23–6 Total Internal Reflection

36. (I) What is the critical angle for the interface between water and Lucite? To be totally internally reflected, the light must start in which material?

37. (I) The critical angle for a certain liquid–air surface is 47.7° . What is the index of refraction of the liquid?
38. (II) A beam of light is emitted in a pool of water from a depth of 62.0 cm. Where must it strike the air–water interface, relative to the spot directly above it, in order that the light does *not* exit the water?
39. (II) A beam of light is emitted 8.0 cm beneath the surface of a liquid and strikes the surface 7.0 cm from the point directly above the source. If total internal reflection occurs, what can you say about the index of refraction of the liquid?
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?

41. (III) A beam of light enters the end of an optic fiber as shown in Fig. 23–52. Show that we can guarantee total internal reflection at the side surface of the material (at point a), if the index of refraction is greater than about 1.42. In other words, regardless of the angle α , the light beam reflects back into the material at point a.

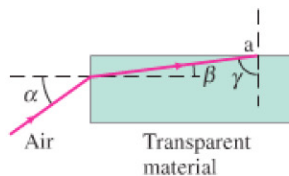


FIGURE 23–52 Problem 41.

42. (III) (a) What is the minimum index of refraction for a glass or plastic prism to be used in binoculars (Fig. 23–26) so that total internal reflection occurs at 45° ? (b) Will binoculars work if its prisms (assume $n = 1.50$) are immersed in water? (c) What minimum n is needed if the prisms are immersed in water?

23–7 and 23–8 Thin Lenses

43. (I) A sharp image is located 78.0 mm behind a 65.0-mm-focal-length converging lens. Find the object distance (a) using a ray diagram, (b) by calculation.
44. (I) Sunlight is observed to focus at a point 18.5 cm behind a lens. (a) What kind of lens is it? (b) What is its power in diopters?
45. (I) A certain lens focuses light from an object 2.75 m away as an image 48.3 cm on the other side of the lens. What type of lens is it and what is its focal length? Is the image real or virtual?
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?
47. (II) A stamp collector uses a converging lens with focal length 24 cm to view a stamp 18 cm in front of the lens. (a) Where is the image located? (b) What is the magnification?