22.2 Reflection

1. **MC** A ray (a) is perpendicular to the direction of energy flow, (b) is always parallel to other rays, (c) is perpendicular to a series of wave fronts, (d) illustrates the wave nature of light. (c)

2. **MC** The angle of incidence is the angle between (a) the incident ray and the reflecting surface, (b) the incident ray and the normal to the surface, (c) the incident ray and the reflected ray, (d) the reflected ray and the normal to the surface. (b)

3. **MC** For both specular (regular) and diffuse (irregular) reflections, (a) the angle of incidence equals the angle of reflection, (b) the incident and reflected rays are on opposite sides of the normal, (c) the incident ray, the reflected ray, and the local normal lie in the same plane, (d) all of the preceding. (d)

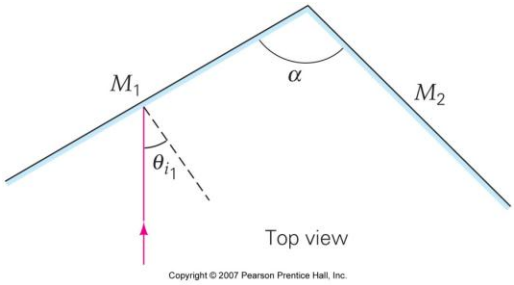
4. **CQ** Under what circumstances will the angle of reflection be smaller than the angle of incidence? never, they are always equal

7. ● The angle of incidence of a light ray on a mirrored surface is 35°. What is the angle between the incident and reflected rays? 70°

8. ● A beam of light is incident on a plane mirror at an angle of 32° relative to the normal. What is the angle between the reflected rays and the surface of the mirror? 58°

10. **IE** ●● Two upright plane mirrors touch along one edge, where their planes make an angle of α. A beam of light is directed onto one of the mirrors at an angle of incidence $\beta < \alpha$ and is reflected onto the other mirror. (a) Will the angle of reflection of the beam from the second mirror be (1) α, (2) β, (3) $\alpha + \beta$, or (4) $\alpha - \beta$? (b) If $\alpha = 60°$ and $\beta = 40°$, what will be the angle of reflection of the beam from the second mirror? (a) (4) $\alpha - \beta$ (b) 20°

14. ●●● Two plane mirrors, M_1 and M_2, are placed together as illustrated in >Fig. 22.23. (a) If the angle α between the mirrors is 70° and the angle of incidence, θ_{i_1}, of a light ray incident on M_1 is 35°, what is the angle of reflection, θ_{r_2}, from M_2? (b) If $\alpha = 115°$ and $\theta_{i_1} = 60°$, what is θ_{r_2}? (a) 35° (b) 55°



22.4 Total Internal Reflection and Fiber Optics

16. **MC** Light refracted at the boundary of two different media (a) is bent toward the normal when $n_1 > n_2$, (b) is bent away from the normal when $n_1 > n_2$, (c) is bent away from the normal when $n_1 < n_2$, (d) has the same angle of refraction as the angle of incidence. (b)

17. **MC** The index of refraction (a) is always greater than or equal to 1, (b) is inversely proportional to the speed of light in a medium, (c) is inversely proportional to the wavelength of light in the medium, (d) all of the preceding. (d)

18. **MC** Which of the following must be satisfied for total internal reflection to occur: (a) $n_1 > n_2$, (b) $n_2 > n_1$, (c) $\theta_1 > \theta_c$, or (d) $\theta_1 < \theta_c$. (a) and (c)

19. **CQ** Explain the fundamental physical reason for refraction. light speed depends on medium

20. **CQ** As light travels from one medium to another, does its wavelength change? Its frequency? Its speed? yes, no, yes

24. ● The speed of light in the core of the crystalline lens in a human eye is 2.13×10^8 m/s. What is the index of refraction of the core? 1.41

30. ● The critical angle for a certain type of glass in air is 41.8°. What is the index of refraction of the glass? 1.50

31. ●● A beam of light in air is incident on the surface of a slab of fused quartz. Part of the beam is transmitted into the quartz at an angle of refraction of 30° relative to a normal to the surface, and part is reflected. What is the angle of reflection? 47°

33. ●● Monochromatic blue light that has a frequency of 6.5×10^{14} Hz enters a piece of flint glass. What are the frequency and wavelength of the light in the glass? 6.5×10^{14} Hz; 2.8×10^{-7} m

38. ●● A person lying at poolside looks over the edge of the pool and sees a bottle cap on the bottom directly below, where the depth is 3.2 m. How far below the water surface does the bottle cap appear to be? (Hint - See

Exercise 37b.) 2.4 m

43. ●● A submerged diver shines a light toward the surface of a body of water at angles of incidence of 40° and 50°. Can a person on the shore see a beam of light emerging from the surface in either case? Justify your answer mathematically. seen for 40° but not for 50°; see Solutions

48. ●● A crown-glass plate 2.5 cm thick is placed over a newspaper. How far beneath the top surface of the plate would the print appear to be if you were looking almost vertically downward through the plate? (See Exercise 37b.) 1.6 cm

49. ●● A beam of light traveling in water strikes a surface of a transparent material at an angle of incidence of 45°. If the angle of refraction in the material is 35°, what is the index of refraction of the transparent material? 1.64

53. ●●● An outdoor circular fish pond has a diameter of 4.00 m and a uniform full depth of 1.50 m. A fish halfway down in the pond and 0.50 m from the near side can just see the full height of a 1.80-m-tall person. How far away from the edge of the pond is the person? 2.0 m

22.5 Dispersion

56. **MC** Dispersion can occur only if the light is (a) monochromatic, (b) polychromatic, (c) white light, (d) both b and c. (d)

57. **MC** Dispersion can occur only during (a) reflection, (b) refraction, (c) total internal reflection, (d) all of the preceding. (b)

58. **MC** Dispersion is caused by (a) the difference in the speed of light in different media, (b) the difference in the speed of light for different wavelengths of light in a given medium, (c) the difference in the angle of incidence for different wavelengths of light in a given medium, (d) the difference in the indices of refraction of light in different media. (b)

59. **CQ** Why is dispersion more prominent when using a triangular prism rather than a square block? two refractions and two dispersions in a prism

64. **IE** ●● The index of refraction of crown glass is 1.515 for red light and 1.523 for blue light. (a) If light is incident on crown glass from air, which color, red or blue, will be refracted more? Explain? (b) Find the angle separating rays of the two colors in a piece of crown glass if their angle of incidence is 37°. (a) blue (b) 0.131°

65. ●● A beam of light with red and blue components of wavelengths 670 nm and 425 nm, respectively, strikes a slab of fused quartz at an incident angle of 30°. On refraction, the different components are separated by an angle of 0.00131 rad. If the index of refraction of the red light is 1.4925, what is the index of refraction of the blue light? 1.498

66. ●● White light passes through a piece of crown glass and strikes an interface with air at an angle of 41.15°. Assume the indices of refraction of crown glass are the same as given in Exercise 64. Which color(s) of light will be refracted out into the air? only red

71. **IE** The critical angle for a glass–air interface is 41.11° for red light and 41.04° for blue light. (a) During the time the blue light travels 1.000 m, the red light will travel (1) more than (2) less than, (3) exactly 1.000 m. Explain. (b) Calculate the difference in distance traveled by the two colors. (a) (1) more than (b) 1.3 mm