

23.1 Plane Mirrors

1. MC A plane mirror (a) has a greater image distance than object distance; (b) produces a virtual, upright, unmagnified image; (c) changes the vertical orientation of an object; (d) reverses an object's top and bottom. (b)
2. MC A plane mirror (a) produces both real and virtual images, (b) always produces a virtual image, (c) always produces a real image, (d) forms images by diffuse reflection. (b)
3. MC The lateral magnification of a plane mirror is (a) greater than 1, (b) less than 1, (c) equal to +1, (d) equal to -1. (c)
4. CQ What is the focal length of a plane mirror? Why? *infinite, because it cannot focus light to a point*
9. ● A person stands 2.0 m away from the reflecting surface of a plane mirror. (a) What is the distance between the person and his or her image? (b) What are the image characteristics? (a) 4.0 m (b) upright, virtual, and same size
12. ●● If you hold a 900-cm² square plane mirror 45 cm from your eyes and can just see the full length of an 8.5-m flagpole behind you, how far are you from the pole? [*Hint: A diagram is helpful.*] 12 m
13. ●● A small dog sits 1.5 m in front of a plane mirror. (a) Where is the dog's image in relation to the mirror? (b) If the dog jumps at the mirror at a speed of 0.50 m/s, how fast does the dog approach its image? (a) 1.5 m behind the mirror (b) 1.0 m/s
16. ●● A woman 1.7 m tall stands 3.0 m in front of a plane mirror. (a) What is the minimum height the mirror must be to allow the woman to view her complete image from head to foot? Assume that her eyes are 10 cm below the top of her head. (b) What would be the required minimum height of the mirror if she were to stand 5.0 m away? (a) 0.85 m (b) 0.85 m

23.2 Spherical Mirrors

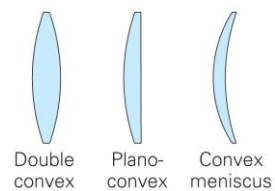
19. MC Which of the following statements concerning spherical mirrors is correct? (a) A converging mirror alone can produce an inverted virtual image. (b) A diverging mirror alone can produce an inverted virtual image. (c) A diverging mirror can produce an inverted real image. (d) A converging mirror can produce an inverted real image. (d)
20. MC The image produced by a convex mirror is always (a) virtual and upright, (b) real and upright, (c) virtual and inverted, (d) real and inverted. (a)
21. MC A shaving/makeup mirror is used to form an image that is larger than the object, so it is a (a) concave, (b) convex, (c) plane mirror. (a) concave
22. CQ (a) What is the purpose of using a dual mirror on a car or truck, such as the one shown in ▶ Fig. 23.25? (b) Some rearview mirrors on the passenger side of automobiles have the warning "OBJECTS IN MIRROR ARE CLOSER THAN THEY APPEAR." Explain why. (c) Could a TV satellite dish be considered a converging mirror? Explain. *see Solutions*
28. ● An object 3.0 cm tall is placed 20 cm from the front of a concave mirror with a radius of curvature of 30 cm. Where is the image formed, and how tall is it? $d_i = 60 \text{ cm}$; $h_i = 9.0 \text{ cm}$
29. ● If the object in Exercise 28 is moved to a position 10 cm from the front of the mirror, what will be the characteristics of the image? $d_i = -30 \text{ cm}$; $h_i = 9.0 \text{ cm}$; *image is virtual, upright, and magnified*
30. ● A candle with a flame 1.5 cm tall is placed 5.0 cm from the front of a concave mirror. A virtual image is produced that is 10 cm from the vertex of the mirror. (a) Find the focal length and radius of curvature of the mirror. (b) How tall is the image of the flame? (a) $f = 10 \text{ cm}$, $R = 20 \text{ cm}$ (b) 3.0 cm
45. ●● A 15-cm-long pencil is placed with its eraser on the optic axis of a concave mirror and its point directed upward at a distance of 20 cm in front of the mirror. The radius of curvature of the mirror is 30 cm. Use (a) a ray diagram and (b) the mirror equation to locate the image and determine the image characteristics. (a) *see Solutions* (b) $d_i = 60 \text{ cm}$, $M = -3.0$, *real and inverted*
50. ●●● A section of a sphere is mirrored on both sides. If the magnification of an object is +1.8 when the section is used as a concave mirror, what is the magnification of an object at the same distance in front of the convex side? 0.69
53. ●●● Two students in a physics laboratory each have a concave mirror with the same radius of curvature, 40 cm. Each student places an object in front of her mirror. The image in both mirrors is three times the size of the object. However, when the students compare notes, they find that the object distances are not the same. Is this possible? If so, what are the object distances? *yes: 13 cm; 27 cm*

23.3 Lenses

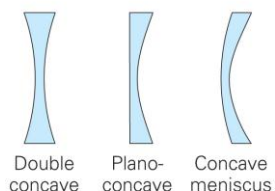
54. **MC** The image produced by a diverging lens is always (a) virtual and magnified, (b) real and magnified, (c) virtual and reduced, (d) real and reduced. (c)
55. **MC** A converging lens (a) must have at least one convex surface, (b) cannot produce a virtual and reduced image, (c) is thicker at its center than at the periphery, (d) all of the preceding. (d)
56. **MC** If an object is placed at the focal point of a converging lens, the image is (a) at zero, (b) also at the focal point, (c) at a distance equal to twice the focal length, (d) at infinity. (d)
57. **CQ** Explain why a fish in a spherical fish bowl, viewed from the side, appears larger than it really is. [see Solutions](#)
58. **CQ** Can a converging lens ever form a virtual image of a real object? If yes, under what conditions? [yes, \$d_o < f\$](#)
59. **CQ** How can you quickly determine the focal length of a converging lens? Will the same method work for a diverging lens? [locate the image of a distant object; no](#)
60. **CQ** If you want to use a converging lens to design a simple overhead projector so as to project the magnified image of some small writing onto a screen on a wall, how far should you place the object in front of the lens? [\$2f > d_o > f\$](#)
67. ●● A biconvex lens has a focal length of 0.12 m. Where on the lens axis should an object be placed in order to get (a) a real, enlarged image with a magnification of 2.0 and (b) a virtual, enlarged image with a magnification of 2.0? (a) 18 cm (b) 6.0 cm
77. ●● (a) If a book is held 30 cm from an eyeglass lens with a focal length of -45 cm, where is the image of the print formed? (b) If an eyeglass lens with a focal length of $+57$ cm is used, where is the image formed? (a) -18 cm (b) -63 cm
82. ●●● Two converging lenses L_1 and L_2 have focal lengths of 30 cm and 20 cm, respectively. The lenses are placed 60 cm apart along the same axis, and an object is placed 50 cm from L_1 on the side opposite L_2 . Where is the image formed relative to L_2 , and what are its characteristics? 8.6 cm; real, inverted, $M_{\text{total}} = -0.86$

23.5 Lens Aberrations

85. **MC** The power of a lens is expressed in units of (a) watts, (b) diopters, (c) meters, (d) both b and c. (b)
86. **MC** A lens aberration that is caused by dispersion is called (a) spherical aberration, (b) chromatic aberration, (c) refractive aberration, (d) none of the preceding. (b)
87. **MC** The focal length of a rectangular glass block is (a) zero, (b) infinity, (c) not defined. (b)
88. **CQ** Determine the signs of R_1 and R_2 for each lens shown in >Fig. 23.14. $+, +; +, \infty; +, -; -, -; \infty, -; +, -$.
95. ●● A plastic plano-concave lens has a radius of curvature of 50 cm for its concave surface. If the index of refraction of the plastic is 1.35, what is the power of the lens? -0.70 D
103. An object is 15 cm from a converging lens whose focal length is 10 cm. On the opposite side of that lens, at a distance of 60 cm, is a converging lens with a focal length of 20 cm. Where is the final image formed, and what are its characteristics? 60 cm to right of second lens; real, upright, $M_{\text{total}} = 4.0$



Converging lenses



Diverging lenses

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