

Chapter 25

Optical Instruments

Quick Quizzes

1. (c). The corrective lens for a farsighted eye is a converging lens, while that for a nearsighted eye is a diverging lens. Since a converging lens is required to form a real image of the Sun on the paper to start a fire, the campers should use the glasses of the farsighted person.
2. (a). We would like to reduce the minimum angular separation for two objects below the angle subtended by the two stars in the binary system. We can do that by reducing the wavelength of the light—this in essence makes the aperture larger, relative to the light wavelength, increasing the resolving power. Thus, we would choose a blue filter.

Answers to Conceptual Questions

2. The objective lens of the microscope must form a real image just inside the focal point of the eyepiece lens. In order for this to occur, the object must be located just outside the focal point of the objective lens. Since the focal length of the objective lens is typically quite short (~ 1 cm), this means that the microscope can focus properly only on objects close to the end of the barrel and will be unable to focus on objects across the room.
4. For a lens to operate as a simple magnifier, the object should be located just inside the focal point of the lens. If the power of the lens is $+20.0$ diopters, its focal length is

$$f = (1.00 \text{ m})/\mathcal{P} = (1.00 \text{ m})/+20.0 = 0.0500 \text{ m} = 5.00 \text{ cm}$$
 The object should be placed slightly less than 5.00 cm in front of the lens.
6. The aperture of a camera is a close approximation to the iris of the eye. The retina of the eye corresponds to the film of the camera, and a close approximation to the cornea of the eye is the lens of the camera.
8. You want a real image formed at the location of the paper. To form such an image, the object distance must be greater than the focal length of the lens.
10. Under low ambient light conditions, a photoflash unit is used to insure that light entering the camera lens will deliver sufficient energy for a proper exposure to each area of the film. Thus, the most important criterion is the additional energy per unit area (product of intensity and the duration of the flash, assuming this duration is less than the shutter speed) provided by the flash unit.
12. The angular magnification produced by a simple magnifier is $m = (25 \text{ cm})/f$. Note that this is proportional to the optical power of a lens, $\mathcal{P} = 1/f$, where the focal length f is expressed in meters. Thus, if the power of the lens is doubled, the angular magnification will also double.

Answers to Even Numbered Problems

2. 31 mm
4. 1.09 mm
6. (b) $\approx 1/100$ s
8. 2.2 mm farther from the film
10. For the right eye, $\mathcal{P} = -1.18$ diopters; for the left eye, $\mathcal{P} = -0.820$ diopters.
12. (a) 33.3 cm (b) +3.00 diopters
14. (a) +50.8 diopters to +60.0 diopters
(b) -0.800 diopters; diverging
16. (a) -0.67 diopters (b) +0.67 diopters
18. (a) $m = +2.0$ (b) $m = +1.0$
20. (a) 4.17 cm in front of the lens (b) $m = +6.00$
22. (a) 0.400 cm (b) 1.25 cm (c) $M = -1000$
24. $0.806 \mu\text{m}$
26. 1.6×10^2 mi
28. (a) $m = 7.50$ (b) 0.944 m
30. (a) virtual image (b) $q_2 \rightarrow \infty$ (c) $f_o = 15.0$ cm, $f_e = -5.00$ cm
32. 0.77 m (≈ 30 inches)
34. 1.00 mrad
36. (a) 2.29×10^{-4} rad (b) 43.6 m
38. 38 cm
40. (a) 3.6×10^3 lines (b) 1.8×10^3 lines
42. 1.31×10^3 fringe shifts
44. $39.6 \mu\text{m}$