* **40.** (I) A 620× microscope uses a 0.40-cm-focal-length objective lens. If the tube length is 17.5 cm, what is the focal length of the eyepiece? Assume a normal eye and that the final image is at infinity.

* **41.** (I) A 17-cm-long microscope has an eyepiece with a focal length of 2.5 cm and an objective with a focal length of 0.28 cm. What is the approximate magnification?

* **42.** (II) A microscope has a 12.0× eyepiece and a 59.0× objective lens 20.0 cm apart. Calculate (*a*) the total magnification, (*b*) the focal length of each lens, and (*c*) where the object must be for a normal relaxed eye to see it in focus.

* **43.** (II) A microscope has a 1.8-cm-focal-length eyepiece and a 0.80-cm objective lens. Assuming a relaxed normal eye, calculate (*a*) the position of the object if the distance between the lenses is 16.0 cm, and (*b*) the total magnification.

* **44.** (II) Repeat Problem 43 assuming that the final image is located 25 cm from the eyepiece (near point of a normal eye).

* **45.** (III) The eyepiece of a compound microscope has a focal length of 2.70 cm, and the objective lens has $f = 0.740$ cm. If an object is placed 0.790 cm from the objective lens, calculate (*a*) the distance between the lenses when the microscope is adjusted for a relaxed eye, and (*b*) the total magnification.

* 25–6 Aberrations

* **46.** (II) An achromatic lens is made of two very thin lenses, placed in contact, that have focal lengths of $f_1 = -28$ cm and $f_2 = +23$ cm. (*a*) Is the combination converging or diverging? (*b*) What is the net focal length?

* **47.** (III) Let's examine spherical aberration in a particular situation. A planoconvex lens of index of refraction 1.50 and radius of curvature $R = 12.0$ cm is shown in Fig. 25–48. Consider an incoming ray parallel to the principal axis and a height h above it as shown. Determine the distance d, from the flat face of the lens, to where this ray crosses the principal axis if (*a*) $h = 1.0$ cm, and (*b*) $h = 6.0$ cm. (*c*) How far apart are these "focal points"? (*d*) What is the radius of the "circle of least confusion" produced by the $h = 6.0$-cm ray at the "focal point" for $h = 1.0$ cm?

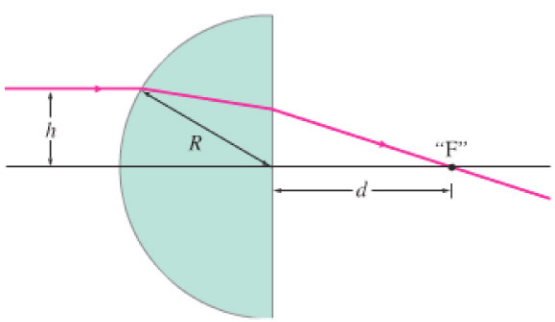

FIGURE 25–48 Problem 47.

25–7 to 25–9 Resolution

48. (I) What is the angular resolution limit (degrees) set by diffraction for the 100-in. (254-cm mirror diameter) Mt. Wilson telescope ($\lambda = 550$ nm)?

49. (II) Suppose that you wish to construct a telescope that can resolve features 7.0 km across on the Moon, 384,000 km away. You have a 2.0-m-focal-length objective lens whose diameter is 11.0 cm. What focal-length eyepiece is needed if your eye can resolve objects 0.10 mm apart at a distance of 25 cm? What is the resolution limit (radians) set by the size of the objective lens (that is, by diffraction)? Use $\lambda = 550$ nm.

50. (II) The normal lens on a 35-mm camera has a focal length of 50.0 mm. Its aperture diameter varies from a maximum of 25 mm ($f/2$) to a minimum of 3.0 mm ($f/16$). Determine the resolution limit set by diffraction for $f/2$ and $f/16$. Specify as the number of lines per millimeter resolved on the film. Take $\lambda = 550$ nm.

51. (II) Two stars 15 light-years away are barely resolved by a 55-cm (mirror diameter) telescope. How far apart are the stars? Assume $\lambda = 550$ nm and that the resolution is limited by diffraction.

52. (II) (*a*) How far away can a human eye distinguish two car headlights 2.0 m apart? Consider only diffraction effects and assume an eye pupil diameter of 5.0 mm and a wavelength of 550 nm. (*b*) What is the minimum angular separation an eye could resolve when viewing two stars, considering only diffraction effects? In reality, it is about 1′ of arc. Why is it not equal to your answer in (*b*)?

53. (II) The Earth and Moon are separated by about 400×10^6 m. When Mars is 8×10^{10} m from Earth, could a person standing on Mars resolve the Earth and its Moon as two separate objects without a telescope? Assume a pupil diameter of 5 mm and $\lambda = 550$ nm.

* 25–11 X-rays

* **54.** (II) X-rays of wavelength 0.133 nm fall on a crystal whose atoms, lying in planes, are spaced 0.280 nm apart. At what angle ϕ (relative to the surface, Fig. 25–37) must the X-rays be directed if the first diffraction maximum is to be observed?

* **55.** (II) X-rays of wavelength 0.0973 nm are directed at an unknown crystal. The second diffraction maximum is recorded when the X-rays are directed at an angle of 23.4° relative to the crystal surface. What is the spacing between crystal planes?

* **56.** (II) First-order Bragg diffraction is observed at 25.2° related to the crystal surface, with spacing between atoms of 0.24 nm. (*a*) At what angle will second order be observed? (*b*) What is the wavelength of the X-rays?

* 25–12 Computed Tomography

* **57.** (II) (*a*) Suppose for a conventional X-ray image that the X-ray beam consists of parallel rays. What would be the magnification of the image? (*b*) Suppose, instead, the X-rays come from a point source (as in Fig. 25–41) that is 15 cm in front of a human body 25 cm thick, and the film is pressed against the person's back. Determine and discuss the range of magnifications that results.