General Problems

58. Sam purchases +3.50-diopter eyeglasses which correct his faulty vision to put his near point at 25 cm. (Assume he wears the lenses 2.0 cm from his eyes.) (*a*) Calculate the focal length of Sam's glasses. (*b*) Calculate Sam's near point without glasses. (*c*) Pam, who has normal eyes with near point at 25 cm, puts on Sam's glasses. Calculate Pam's near point with Sam's glasses on.

59. As early morning passed toward midday, and the sunlight got more intense, a photographer noted that, if she kept her shutter speed constant, she had to change the f-number from $f/5.6$ to $f/22$. By what factor had the sunlight intensity increased during that time?

60. Show that for objects very far away (assume infinity), the magnification of a camera lens is proportional to its focal length.

61. For a camera equipped with a 50-mm-focal-length lens, what is the object distance if the image height equals the object height? How far is the object from the film?

62. A woman can see clearly with her right eye only when objects are between 45 cm and 155 cm away. Prescription bifocals should have what powers so that she can see distant objects clearly (upper part) and be able to read a book 25 cm away (lower part) with her right eye? Assume that the glasses will be 2.0 cm from the eye.

63. A child has a near point of 15 cm. What is the maximum magnification the child can obtain using an 8.0-cm-focal-length magnifier? What magnification can a normal eye obtain with the same lens? Which person sees more detail?

64. What is the magnifying power of a +4.0-D lens used as a magnifier? Assume a relaxed normal eye.

65. A physicist lost in the mountains tries to make a telescope using the lenses from his reading glasses. They have powers of +2.0 D and +4.5 D, respectively. (*a*) What maximum magnification telescope is possible? (*b*) Which lens should be used as the eyepiece?

66. A 50-year-old man uses +2.5-diopter lenses to read a newspaper 25 cm away. Ten years later, he must hold the paper 35 cm away to see clearly with the same lenses. What power lenses does he need now in order to hold the paper 25 cm away? (Distances are measured from the lens.)

67. Spy planes fly at extremely high altitudes (25 km) to avoid interception. Their cameras are reportedly able to discern features as small as 5 cm. What must be the minimum aperture of the camera lens to afford this resolution? (Use $\lambda = 550$ nm.)

68. When shooting pictures at very short distances, exposure times must be increased because of the increased distance of the lens from the film for a focused image. (*a*) Show that when the object is so close to the camera that the image height equals the object height, the exposure time must be four times longer (or 2 f-stops) than when the object is a long distance away (say, ∞), given the same illumination and f-stop. (*b*) Show that if d_o is at least four or five times the focal length f of the lens, the exposure time is increased by less than half an f-stop relative to the same object being a great distance away.

69. The objective lens and the eyepiece of a telescope are spaced 85 cm apart. If the eyepiece is +23 diopters, what is the total magnification of the telescope?

70. The Hubble Space Telescope, with an objective diameter of 2.4 m, is viewing the Moon. Estimate the minimum distance between two objects on the Moon that the Hubble can distinguish. Consider diffraction of light of wavelength 550 nm. Assume the Hubble is near the Earth.

71. Two converging lenses, one with $f = 4.0$ cm and the other with $f = 44$ cm, are made into a telescope. (*a*) What are the length and magnification? Which lens should be the eyepiece? (*b*) Assume these lenses are now combined to make a microscope; if the magnification needs to be 25×, how long would the microscope be?

72. An astronomical telescope has a magnification of 8.0. If the two lenses are 28 cm apart, determine the focal length of each lens.

73. You want to design a spy satellite to photograph license plate numbers. Assuming it is necessary to resolve points separated by 5 cm with 550-nm light, and that the satellite orbits at a height of 130 km, what minimum lens aperture (diameter) is required?

* 74. A Lucite planoconvex lens (Fig. 23–29a) has one flat surface and the other has $R = 18.4$ cm. This lens is used to view an object, located 66.0 cm away from the lens, which is a mixture of red and yellow. The index of refraction of the glass is 1.5106 for red light and 1.5226 for yellow light. What are the locations of the red and yellow images formed by the lens?

Answers to Exercises

A: 6.3 m.
B: $P = -4.0$ D.
C: 48 cm.
D: 2 m.