44. ***REASONING AND SOLUTION***

a. Using the thin-lens equation, we obtain

$$\frac{1}{d_\mathrm{i}} = \frac{1}{f} - \frac{1}{d_\mathrm{o}} = \frac{1}{-32\text{ cm}} - \frac{1}{+19\text{ cm}} \qquad \text{or} \qquad d_\mathrm{i} = \boxed{-12\text{ cm}}$$

b. Using the magnification equation, we find

$$m = -\frac{d_\mathrm{i}}{d_\mathrm{o}} = -\frac{-12\text{ cm}}{19\text{ cm}} = \boxed{+0.63}$$

c. The image is $\boxed{\text{virtual}}$ since d_i is negative.

d. The image is $\boxed{\text{upright}}$ since m is +.

e. The image is $\boxed{\text{reduced}}$ in size since $m < 1$.

---

45. **SSM** ***REASONING AND SOLUTION*** Equation 26.6 gives the thin-lens equation which relates the object and image distances d_o and d_i, respectively, to the focal length f of the lens: $(1/d_o)+(1/d_i)=(1/f)$.

The optical arrangement is similar to that in Figure 26.26. The problem statement gives values for the focal length ($f = 50.0$ mm) and the maximum lens-to-film distance ($d_i = 275$ mm). Therefore, the maximum distance that the object can be located in front of the lens is

$$\frac{1}{d_o}=\frac{1}{f}-\frac{1}{d_i}=\frac{1}{50.0\text{ mm}}-\frac{1}{275\text{ mm}} \quad \text{or} \quad \boxed{d_o = 61.1\text{ mm}}$$

---

46. ***REASONING*** Since the object distance and the focal length of the lens are given, the thin-lens equation (Equation 26.6) can be used to find the image distance. The height of the image can be determined by using the magnification equation (Equation 26.7).

SOLUTION
a. The object distance d_o, the image distance d_i, and the focal length f of the lens are related by the thin-lens equation:

$$\frac{1}{d_o} + \frac{1}{d_i} = \frac{1}{f} \tag{26.6}$$

Solving for the image distance gives

$$\frac{1}{d_i} = \frac{1}{f} - \frac{1}{d_o} = \frac{1}{12.0 \text{ cm}} - \frac{1}{8.00 \text{ cm}} \quad \text{or} \quad d_i = \boxed{-24 \text{ cm}}$$

b. The image height h_i (the height of the magnified print) is related to the object height h_o, the image distance d_i, and the object distance d_o by the magnification equation:

$$h_i = -h_o\left(\frac{d_i}{d_o}\right) = -(2.00 \text{ mm})\left(\frac{-24 \text{ cm}}{8.00 \text{ cm}}\right) = \boxed{6.0 \text{ mm}} \tag{26.7}$$

---

50. ***REASONING AND SOLUTION*** The image distance for the first case is

$$\frac{1}{d_\text{i}}=\frac{1}{f}-\frac{1}{d_\text{o}}=\frac{1}{200.0\text{ mm}}-\frac{1}{3.5\times10^3\text{ mm}} \qquad \text{or} \qquad d_\text{i}=212\text{ mm}$$

and, similarly, for the second case it is d_i = 201 mm. Thus, the lens must be capable of moving through a distance of 212 mm – 201 mm = 11 mm or $\boxed{0.011\text{ m}}$.

---

67. ***REASONING*** We will apply the thin-lens equation to solve this problem. In doing so, we must be careful to take into account the fact that the lenses of the glasses are worn at a distance of 2.2 or 3.3 cm from her eyes.

SOLUTION

a. The object distance is 25.0 cm – 2.2 cm, since it is measured relative to the lenses, which are worn 2.2 cm from the eyes. As discussed in the text, the lenses form a virtual image located at the near point. The image distance must be negative for a virtual image, but the value is not –67.0 cm, because the glasses are worn 2.2 cm from the eyes. Instead, the image distance is –67.0 cm + 2.2 cm. Using the thin-lens equation, we can find the focal length as follows:

$$\frac{1}{f} = \frac{1}{d_o} + \frac{1}{d_i} = \frac{1}{25.0\text{ cm} - 2.2\text{ cm}} + \frac{1}{-67.0\text{ cm} + 2.2\text{ cm}} \qquad \text{or} \qquad f = \boxed{35.2\text{ cm}}$$

b. Similarly, we find

$$\frac{1}{f} = \frac{1}{d_o} + \frac{1}{d_i} = \frac{1}{25.0\text{ cm} - 3.3\text{ cm}} + \frac{1}{-67.0\text{ cm} + 3.3\text{ cm}} \qquad \text{or} \qquad f = \boxed{32.9\text{ cm}}$$

69. **SSM** ***REASONING*** The far point is 5.0 m from the right eye, and 6.5 m from the left eye. For an object infinitely far away ($d_o = \infty$), the image distances for the corrective lenses are then –5.0 m for the right eye and –6.5 m for the left eye, the negative sign indicating that the images are virtual images formed to the left of the lenses. The thin-lens equation [Equation 26.6: $(1/d_o) + (1/d_i) = (1/f)$] can be used to find the focal length. Then, Equation 26.8 can be used to find the refractive power for the lens for each eye.

SOLUTION Since the object distance d_o is essentially infinite, $1/d_o = 1/\infty = 0$, and the thin-lens equation becomes $1/d_i = 1/f$, or $d_i = f$. Therefore, for the right eye, $f = -5.0\text{ m}$, and the refractive power is (see Equation 26.8)

[Right eye]
$$\begin{array}{c}\text{Refractive power}\\ \text{(in diopters)}\end{array} = \frac{1}{f} = \frac{1}{(-5.0\text{ m})} = \boxed{-0.20\text{ diopters}}$$

Similarly, for the left eye, $f = -6.5\text{ m}$, and the refractive power is

[Left eye]
$$\begin{array}{c}\text{Refractive power}\\ \text{(in diopters)}\end{array} = \frac{1}{f} = \frac{1}{(-6.5\text{ m})} = \boxed{-0.15\text{ diopters}}$$

70. ***REASONING*** The closest she can read the magazine is when the image formed by the contact lens is at the near point of her eye, or $d_i = -138$ cm. The image distance is negative because the image is a virtual image (see Section 26.10). Since the focal length is also known, the object distance can be found from the thin-lens equation.

SOLUTION The object distance d_o is related to the focal length f and the image distance d_i by the thin-lens equation:

$$\frac{1}{d_o} = \frac{1}{f} - \frac{1}{d_i} = \frac{1}{35.1 \text{ cm}} - \frac{1}{-138 \text{ cm}} \quad \text{or} \quad d_o = \boxed{28.0 \text{ cm}} \qquad (26.6)$$

---

76. ***REASONING*** The angular magnification M of a magnifying glass is given by

$$M \approx \left(\frac{1}{f} - \frac{1}{d_\text{i}} \right) N \qquad (26.10)$$

where f is the focal length of the lens, d_i is the image distance, and N is the near point of the eye. The focal length and the image distance are related to the object distance d_o by the thin-lens equation:

$$\frac{1}{f} - \frac{1}{d_\text{i}} = \frac{1}{d_\text{o}} \qquad (26.6)$$

These two relations will allow us to determine the angular magnification.

S***OLUTION*** Substituting Equation 26.6 into Equation 26.10 yields

$$M \approx \left(\frac{1}{f} - \frac{1}{d_\text{i}} \right) N = \frac{N}{d_\text{o}} = \frac{72\ \text{cm}}{4.0\ \text{cm}} = \boxed{18}$$

---

79. ***REASONING*** The angular magnification M of a magnifying glass is given by Equation 26.10 as

$$M = \frac{\theta'}{\theta} \approx \left(\frac{1}{f} - \frac{1}{d_i} \right) N$$

where θ' = 0.0380 rad is the angular size of the final image produced by the magnifying glass, θ = 0.0150 rad is the reference angular size of the object seen at the near point without the magnifying glass, and N is the near point of the eye. The largest possible angular magnification occurs when the image is at the near point of the eye, or $d_i = -N$, where the minus sign denotes that the image lies on the left side of the lens (the same side as the object). This equation can be solved to find the focal length of the magnifying glass.

SOLUTION Letting $d_i = -N$, and solving Equation 26.10 for the focal length f gives

$$f = \frac{N}{\dfrac{\theta'}{\theta} - 1} = \frac{21.0\text{ cm}}{\dfrac{0.0380\text{ rad}}{0.0150\text{ rad}} - 1} = \boxed{13.7\text{ cm}}$$

---

89. ***REASONING*** Knowing the angles subtended at the unaided eye and with the telescope will allow us to determine the angular magnification of the telescope. Then, since the angular magnification is related to the focal lengths of the eyepiece and the objective, we will use the known focal length of the eyepiece to determine the focal length of the objective.

SOLUTION From Equation 26.12, we have

$$M = \frac{\theta'}{\theta} = -\frac{f_o}{f_e}$$

where θ is the angle subtended by the unaided eye and θ' is the angle subtended when the telescope is used. We note that θ' is negative, since the telescope produces an inverted image. Thus, using Equation 26.12, we find

$$f_o = -\frac{f_e \theta'}{\theta} = -\frac{(0.032 \text{ m})(-2.8\times10^{-3} \text{ rad})}{8.0\times10^{-5} \text{ rad}} = \boxed{1.1 \text{ m}}$$