EXAMPLE 25–5 **Farsighted eye.** Sue is farsighted with a near point of 100 cm. Reading glasses must have what lens power so that she can read a newspaper at a distance of 25 cm? Assume the lens is very close to the eye.

APPROACH When the object is placed 25 cm from the lens, we want the image to be 100 cm away on the *same* side of the lens (so the eye can focus it), and so the image is virtual, Fig. 25–12, and $d_i = -100$ cm will be negative. We use the thin lens equation (Eq. 23–8) to determine the needed focal length. Optometrists' prescriptions specify the power ($P = 1/f$, Eq. 23–7) given in diopters ($1\text{ D} = 1\text{ m}^{-1}$).

SOLUTION Given that $d_o = 25$ cm and $d_i = -100$ cm, the thin lens equation gives

$$\frac{1}{f} = \frac{1}{d_o} + \frac{1}{d_i} = \frac{1}{25\text{ cm}} + \frac{1}{-100\text{ cm}} = \frac{4-1}{100\text{ cm}} = \frac{1}{33\text{ cm}}.$$

So $f = 33\text{ cm} = 0.33$ m. The power P of the lens is $P = 1/f = +3.0$ D. The plus sign indicates that it is a converging lens.

NOTE We chose the image position to be where the eye can actually focus. The lens needs to put the image there, given the desired placement of the object (newspaper).

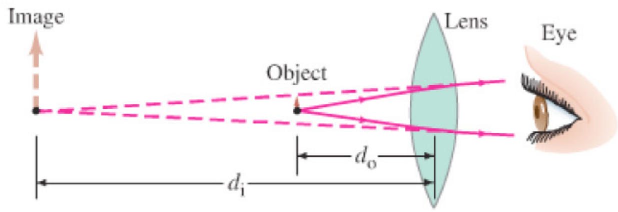


FIGURE 25–12 Lens of reading glasses (Example 25–5).

EXAMPLE 25–6 **Nearsighted eye.** A nearsighted eye has near and far points of 12 cm and 17 cm, respectively. (*a*) What lens power is needed for this person to see distant objects clearly, and (*b*) what then will be the near point? Assume that the lens is 2.0 cm from the eye (typical for eyeglasses).

APPROACH For a distant object ($d_o = \infty$), the lens must put the image at the far point of the eye as shown in Fig. 25–13a, 17 cm in front of the eye. We can use the thin lens equation to find the focal length of the lens, and from this its lens power. The new near point (as shown in Fig. 25–13b) can be calculated for the lens by again using the thin lens equation.

SOLUTION (*a*) For an object at infinity ($d_o = \infty$), the image must be in front of the lens 17 cm from the eye or $(17\text{ cm} - 2\text{ cm}) = 15$ cm from the lens; hence $d_i = -15$ cm. We use the thin lens equation to solve for the focal length of the needed lens:

$$\frac{1}{f} = \frac{1}{d_o} + \frac{1}{d_i} = \frac{1}{\infty} + \frac{1}{-15\text{ cm}} = -\frac{1}{15\text{ cm}}.$$

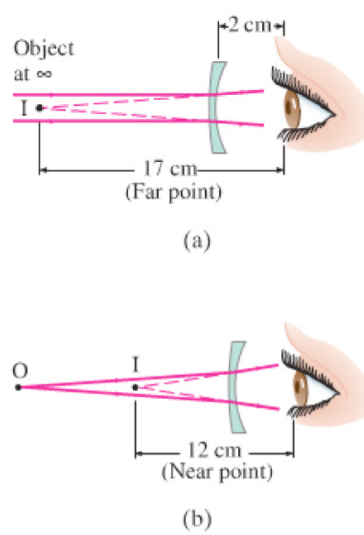
So $f = -15\text{ cm} = -0.15$ m or $P = 1/f = -6.7$ D. The minus sign indicates that it must be a diverging lens for the myopic eye.

(*b*) The near point when glasses are worn is where an object is placed (d_o) so that the lens forms an image at the "near point of the naked eye," namely 12 cm from the eye. That image point is $(12\text{ cm} - 2\text{ cm}) = 10$ cm in front of the lens, so $d_i = -0.10$ m and the thin lens equation gives

$$\frac{1}{d_o} = \frac{1}{f} - \frac{1}{d_i} = -\frac{1}{0.15\text{ m}} + \frac{1}{0.10\text{ m}} = \frac{-2+3}{0.30\text{ m}} = \frac{1}{0.30\text{ m}}.$$

So $d_o = 30$ cm, which means the near point when the person is wearing glasses is 30 cm in front of the lens, or 32 cm from the eye.

FIGURE 25–13 Example 25–6.



Contact lenses

Suppose contact lenses are used to correct the eye in Example 25–6. Since contacts are placed directly on the cornea, we would not subtract out the 2.0 cm for the image distances. That is, for distant objects $d_i = f = -17$ cm, so $P = 1/f = -5.9$ D. The new near point would be 41 cm. Thus we see that a