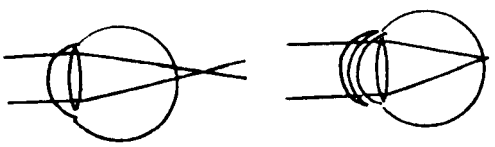
14-2 Eyeglasses

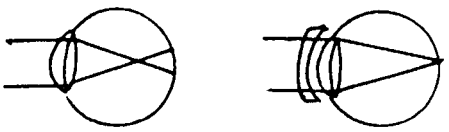
When the eye is unable to focus incoming light directly on the retina (a layer of tissue in the back of the eye that is sensitive to light), eyeglasses or contact lenses are usually prescribed.

If the lens, or cornea, is curved so that light would focus behind the retina, the result is a condition called **farsightedness**, where only objects at a distance can be seen clearly. To correct this problem, glasses for a farsighted person have lenses that are thicker in the middle and thinner near the edges (converging lenses).



Uncorrected Corrected

If the lens, or cornea, is curved so that light would focus in front of the retina, the result is a condition called **nearsightedness**, where only objects close up can be seen clearly. To correct this problem, glasses for a nearsighted person have lenses that are thinner in the middle and thicker near the edges (diverging lenses).



Uncorrected Corrected

The power of a pair of prescription glasses is the reciprocal of the focal length, if the focal length is measured in meters.

$$\textbf{Power} = \frac{\mathbf{1}}{\textbf{focal length}} \quad \text{or} \quad P = \frac{1}{f}$$

The SI unit for the power of eyeglasses is the **diopter**, which equals the **reciprocal of a meter ($\mathbf{m^{-1}}$)**.

For all the following exercises, assume that the preferred far point of the eye is infinity, ∞, and the preferred near point is 25 cm. To find the power of the lenses in a pair of glasses, take the difference between the reciprocal of how far the eye can see without glasses and how far it can see with glasses.

$$\text{power} = \frac{1}{f_{\text{glasses}}} = \frac{1}{d_{o(\text{glasses})}} - \frac{1}{d_{o(\text{no glasses})}}$$

If you wear glasses or contact lenses, ask your doctor about the power of your prescription. You may find that it can be different for each eye!

Solved Examples

Example 5: Craig is nearsighted, so he must wear glasses to see objects that are far away. If his glasses have a focal length of 0.5 m, what is their power in diopters?

Solution: The focal length must be written as a negative number because a nearsighted person will always wear glasses with diverging lenses. A diverging lens has a negative focal length.

Given: $f_{\text{glasses}} = -0.5 \text{ m}$ *Unknown:* $P = ?$
Original equation: $P = \dfrac{1}{f}$

Solve: $P = \dfrac{1}{f} = \dfrac{1}{-0.5 \text{ m}} = \mathbf{-2 \text{ diopters}}$

Example 6: In the previous exercise, if Craig can see to infinity with his glasses on, what is the maximum distance he can see clearly with the glasses off?

Given: $f_{\text{glasses}} = -0.5 \text{ m}$, $d_{\text{o(glasses)}} = \infty$ *Unknown:* $d_{\text{o(no glasses)}} = ?$
Original equation: $\dfrac{1}{f_{\text{glasses}}} = \dfrac{1}{d_{o\text{(glasses)}}} - \dfrac{1}{d_{o\text{(no glasses)}}}$

Solve: $\dfrac{1}{d_{o\text{(no glasses)}}} = \dfrac{1}{d_{o\text{(glasses)}}} - \dfrac{1}{f_{\text{glasses}}} = \dfrac{1}{\infty} - \dfrac{1}{-0.5 \text{ m}} = 0 - (-2) = 2 \text{ diopters}$

$$d_{\text{o(no glasses)}} = \frac{1}{2 \text{ diopters}} = \mathbf{0.5 \text{ m}}$$

The farthest Craig can see clearly without glasses is 0.5 m.

Example 7: Dorcas must hold the phone book 0.5 m from her eyes in order to find the eye doctor's phone number. a) If Dorcas would like to read the phone book at a more comfortable distance of 0.25 m, what power glasses does she need?
b) What type of lenses would these glasses contain?

a. *Given:* $d_{\text{o(no glasses)}} = 0.5 \text{ m}$, $d_{\text{o(glasses)}} = 0.25 \text{ m}$ *Unknown:* $P = ?$
Original equation: $\dfrac{1}{f_{\text{glasses}}} = \dfrac{1}{d_{o\text{(glasses)}}} - \dfrac{1}{d_{o\text{(no glasses)}}}$

Solve: $\dfrac{1}{f_{\text{glasses}}} = \dfrac{1}{d_{o\text{(glasses)}}} - \dfrac{1}{d_{o\text{(no glasses)}}} = \dfrac{1}{0.25 \text{ m}} - \dfrac{1}{0.5 \text{ m}} = 4 - 2 = \mathbf{2 \text{ diopters}}$

b. Because the power of the glasses in this example is a positive number, the lenses must be converging lenses. This is supported by the fact that farsightedness must be corrected with converging lenses.

Practice Exercises

Exercise 8: Beth is farsighted, so she must wear glasses to see objects close by. If her glasses have a focal length of 0.30 m, what is their power in diopters?

Answer: _____

Exercise 9: Herman is able to read the newspaper at a distance of 0.75 m, but no closer. a) Is he farsighted or nearsighted? b) What power lens should he use to allow him to read the paper at 0.25 m? c) What type of lens does he need?

Answer: **a.** _____

Answer: **b.** _____

Answer: **c.** _____

Exercise 10: At the beach, Maria can see Sandy, a surfer, clearly only when he is standing closer than 2.0 m. a) What power prescription sunglasses would Maria need in order to see Sandy when he is out on the ocean riding a wave? b) What type of lenses will her glasses contain?

Answer: **a.** _____

Answer: **b.** _____

Exercise 11: Matt is driving his "18-wheeler" while wearing his new pair of glasses whose focal length is -0.40 m. If the glasses allow Matt to see clearly at an infinite distance for normal driving, how far could Matt see clearly before he bought the glasses?

Answer: _____

Exercise 12: Moshe has gone to Bermuda for spring vacation and when he is on the beach realizes that he has picked up his father's pair of prescription sunglasses by mistake. The glasses have a power of $+3.0$ diopters. a) What type of eye problem does Moshe's father have, and how do you know? b) What is the closest that Moshe's father can see clearly without his glasses? c) Will these glasses produce an image in front of, or behind, the image formed by Moshe's normal eye?

Answer: **a.** _____

Answer: **b.** _____

Answer: **c.** _____

9. b) 2.7 diopters
11. 0.40 m