

## Velocity

Polar bears are extremely good swimmers and can travel as long as 10 hours without resting. If a polar bear is swimming with an average speed of 2.6 m/s, how far will it have traveled after 10.0 hours?

### 1. List the given and unknown values.

*Given:* speed,  $v = 2.6$  m/s  
time,  $t = 10.0$  h =  $10.0$  h  $\times$  3600 s/h =  $3.6 \times 10^4$  s

*Unknown:* distance,  $d = ?$  m

### 2. Rearrange the speed equation to solve for distance.

$$\text{speed} = \frac{\text{distance}}{\text{time}} \quad v = \frac{d}{t}$$

$$d = vt$$

### 3. Substitute speed and time values into the equation, and solve.

$$d = \frac{2.6 \text{ m}}{\text{s}} \times (3.6 \times 10^4 \text{ s})$$

$$d = 9.4 \times 10^4 \text{ m} = 94 \text{ km}$$

## Practice

- Suppose the polar bear were running on land instead of swimming. If the polar bear runs at a speed of about 8.3 m/s, how far will it travel in 10.0 hours?
- Like the polar bear, the walrus is a fine swimmer, though it does not have the same endurance. For short periods of time, a walrus can swim with an average speed of 9.7 m/s. How far would a walrus swim at this speed in 3.4 minutes?
- The maximum posted speed limit on the U.S. Interstate Highway System may be found in rural areas of several western states. This maximum speed is 75 mi/h, or 121 km/h. What is the distance, in kilometers, traveled by a car moving continuously at this speed for 3 hours and 20 minutes?
- For normal situations, the minimum speed limit throughout the U.S. Interstate Highway System is 45 mi/h, or 72 km/h. How far, in kilometers, will a car travel if it is moving continuously at this speed for 3 hours and 20 minutes?

**Sample Problem**

A baseball is pitched with a speed of 35.0 m/s. How long does it take the ball to travel 18.4 m from the pitcher's mound to home plate?

**1. List the given and unknown values.**

*Given:* speed,  $v = 35.0$  m/s  
 distance,  $d = 18.4$  m

*Unknown:* time,  $t = ?$  s

**2. Rearrange the speed equation to solve for time.**

$$\text{speed} = \frac{\text{distance}}{\text{time}} \qquad v = \frac{d}{t}$$

$$tv = d \qquad \frac{tv}{v} = \frac{d}{v}$$

**3. Substitute distance and speed values into the equation, and solve.**

$$t = \frac{18.4 \text{ m}}{35.0 \text{ m/s}}$$

$$t = 0.526 \text{ s}$$

**Practice**

5. The various types of tree sloths share the honor of being the slowest-moving mammals. An average tree sloth moves with a speed of 0.743 m/s. How long does it take a sloth moving at this speed to travel 22.30 m?
6. The longest stretch of straight railroad tracks lies across the desolate Nullarbor Plain, between the Australian cities of Adelaide and Perth. The tracks extend a distance of 478 km without a curve. How long would it take a train moving at a constant speed of 97 km/h to travel this length of track?
7. The fastest supersonic passenger jet is the Concorde. How long would it take the Concorde to travel the 6265 km between New York City and London, England, assuming that the jet travels at its maximum speed of  $2.150 \times 10^3$  km/h during the entire trip?
8. The longest distance in a field and track event is the 10 km run. The record holder for the women's 10 km run is Wang Junxia of China. Assuming that Wang Junxia ran a distance of 10.00 km with an average speed of 5.644 m/s, what was her time?

**Sample Problem**

Florence Griffith-Joyner set the women's world record for running 200.0 m in 1988. At the 1988 Summer Olympics in Seoul, South Korea, she completed the distance in 21.34 s. What was Florence Griffith-Joyner's average speed?

**1. List the given and unknown values.**

*Given:* distance,  $d = 200.0$  m

time,  $t = 21.34$  s

*Unknown:* speed,  $v = ?$  m/s

**2. Write out the equation for speed.**

$$\text{speed} = \frac{\text{distance}}{\text{time}} \quad v = \frac{d}{t}$$

**3. Substitute distance and time values into the speed equation, and solve.**

$$v = \frac{d}{t} = \frac{200.0 \text{ m}}{21.34 \text{ s}}$$

$$v = 9.372 \text{ m/s}$$

**Practice**

9. The cheetah, the fastest of land animals, can run a distance of 274 m in 8.65 s at its top speed. What is the cheetah's top speed?
10. In 1985, Matt Biondi set a record for the men's 100 m freestyle event in swimming. It took him 49.17 s to swim the 50.0 m length of the pool and swim back. Assume that half of Biondi's record time was spent traveling the length of the pool. What was his speed?
11. The fastest crossing of the Atlantic Ocean by an ocean liner was made on July 7, 1952. The ship, the *S.S. United States*, traveled 4727 km east by northeast in 3 days, 10 hours, and 40 minutes. Assume that the ship had traveled the same speed, but directly east. What would the velocity of the *S.S. United States* be in kilometers per hour?
12. The bird that migrates the farthest is the Arctic tern. Each year, the Arctic tern travels 32 000 km between the Arctic Ocean and the continent of Antarctica. Most of the migration takes place within two four-month periods each year. Assume an Arctic tern completes the second half of its annual migration distance in 122 days. Also assume that during this time the tern flies directly north. If the tern flies the same distance each day, what is its velocity in kilometers per day?

**Mixed Review**

13. The typical snail doesn't cover very much ground even when it is moving at its maximum speed, which is  $5.0 \times 10^{-2}$  m/h. How far will a snail travel if it moves at its top speed for 45 minutes?

14. Motion pictures typically are filmed and shown at a speed of 24 frames per second, where a frame is a single photographic image in the film. In the field of high-speed photography, a motion-picture camera that is able to move the film at  $2.4 \times 10^5$  frames per second is used. When the film is reshowed at 24 frames per second, the filmed object is seen to move very slowly. This technique is used to analyze the motion of objects, like bullets, that move too quickly to be observed by the human eye. If a frame of 16 mm film is 0.75 cm in length, how fast does the film move through the high-speed camera when the film is being exposed?
15. In 1926, Gertrude Ederle of the United States became the first woman to swim across the English Channel. She also set what was at that time the world record for the crossing, with an average speed of 0.725 m/s. Assuming that the distance Ederle swam was 37.9 km (the shortest distance between England and France), how long did it take her to swim the Channel?
16. Bonnie Blair set the world record for women's speed skating in 1995, with an average speed of 12.9 m/s. How far would Blair have traveled at this speed in a time of 5.00 minutes?
17. Although they seem to remain unchanged, many mountains undergo steady growth. If erosion and weathering are ignored, some mountains, like the San Gabriels in southern California, grow as much as 1.0 cm within a year. If a year is considered to be exactly 365 days, what is the speed at which the San Gabriel Mountains grow in kilometers per hour?
18. The Trans-Siberian Railroad is the longest single railroad in the world. Starting in Moscow, the tracks stretch 9354 km across the Siberian frontier to Vladivostok, at the edge of the Pacific Ocean. If you were to leave Moscow and travel on the railroad with an average speed of 90.0 km/h, how long would it take for you to reach Vladivostok?
19. The largest sheep and cattle ranches in the world are in Australia. The areas of some of these ranches are about equal to the area of Connecticut, so the fences needed to protect the livestock from dingos and other predators are extensive. The world's longest "dingo-proof" fence is 5530 km long. Suppose you were to travel around this fence in a jeep with an average speed of 45 km/h. How long would it take you to return to your starting point?
20. Stars do not appear to move because of their tremendous distances from us. In fact, stars move at fairly high speeds. Consider the relatively close star Sirius, which is moving away from our solar system with a speed of about 17.8 km/s. How far will this star travel in 2590 years, the time it takes for Sirius to move  $1^\circ$  across the sky?