

## Chapter 11 Motion

**Section 11.2 Speed and Velocity**

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**Calculating Average Speed****Content and Vocabulary Support****Speed**

**Speed** is a measure of how fast something is moving. It is calculated by dividing the distance an object moves by the amount of time it takes the object to move that distance. For example, a car that travels 50 kilometers in one hour has a speed of 50 km/h. In other words, speed is a ratio of distance to time.

Many objects do not move at a constant speed. For example, a car traveling at a speed of 50 km/h may slow down as it approaches a red light and then speed up again when the light turns green. The car's speed at any given moment in time is called its **instantaneous speed**.

**Average Speed**

Although an object may not have a constant speed, its motion over a given distance can be expressed as its average speed. **Average speed** is the total distance traveled, divided by the total time it takes to travel that distance. The equation for average speed is:

$$\text{Average speed} = \frac{\text{Total distance}}{\text{Total time}}, \text{ or } \bar{v} = \frac{d}{t}$$

For example, if a car travels 80 kilometers in the first hour of a two-hour trip and 100 kilometers in the second hour, its average speed for the total trip would be:

$$\bar{v} = \frac{(80 \text{ km} + 100 \text{ km})}{(1 \text{ h} + 1 \text{ h})} = \frac{180 \text{ km}}{2 \text{ h}} = 90 \text{ km/hr}$$

The equation for average speed can be rewritten to find either the total time or the total distance when the other two variables are known:

$$t = \frac{d}{\bar{v}} \text{ and } d = \bar{v} \times t$$

## Section 11.2 Speed and Velocity

### Solved Examples

**Example 1:** A winner of the Indianapolis 500 auto race completed the 806.5-kilometer race in 2.98 hours. What was the driver's average speed during the race?

*Given:* Total distance ( $d$ ) = 806.5 km

Total time ( $t$ ) = 2.98 h

*Unknown:* Average speed ( $\bar{v}$ )

*Equation:*  $\bar{v} = \frac{d}{t}$

*Solution:*  $\bar{v} = \frac{806.5 \text{ km}}{2.98 \text{ h}} = 270.6 \text{ km/h}$

**Example 2:** Different animal species show a tremendous range of variation in their speed of movement. The fastest land animal, the cheetah, can travel 100.0 km/h. In contrast, the slowest animal, a species of sea crab, has an average speed of just 5.7 km/y. How long would it take the sea crab to travel 100.0 km?

*Given:* Average speed ( $\bar{v}$ ) = 5.7 km/y

Total distance ( $d$ ) = 100 km

*Unknown:* Total time ( $t$ )

*Equation:*  $t = \frac{d}{\bar{v}}$

*Solution:*  $t = \frac{100 \text{ km}}{5.7 \text{ km/y}} = 17.5 \text{ y}$

**Example 3:** You usually see lightning before you hear thunder, because light travels faster than sound. Juan saw a flash of lightning and heard the thunder 6 seconds later. Sound travels at a speed of 340 m/s in air. How far away was Juan from the lightning?

*Given:* Average speed ( $\bar{v}$ ) = 340m/s

Total time ( $t$ ) = 6 s

*Unknown:* Total distance ( $d$ )

*Equation:*  $d = \bar{v} \times t$

*Solution:*  $d = (340 \text{ m/s}) \times (6 \text{ s}) = 2,040 \text{ m}$

**Practice Exercises**

- Exercise 1:** In a boat race, Dan drove his motorboat over the 1000-meter course from start to finish in 40 seconds. What was Dan's average speed during the race?
- Exercise 2:** It takes Serina 0.25 hour to drive to school. Her route is 16 km long. What is Serina's average speed on her drive to school?
- Exercise 3:** In a competition, an athlete threw a flying disk 139 meters through the air. While in flight, the disk traveled at an average speed of 13.0 m/s. How long did the disk remain in flight?
- Exercise 4:** If you shout into Grand Canyon, your voice travels at the speed of sound (340 m/s) to the bottom of the canyon and back, and you hear an echo. How deep is the Grand Canyon in a spot where you can hear your echo 5.2 seconds after you shout?
- Exercise 5:** Sound travels much faster in water than air. It takes 4.2 seconds for the sound of an explosion to travel underwater to a diver 6,006 m away. What is the speed of sound in water?