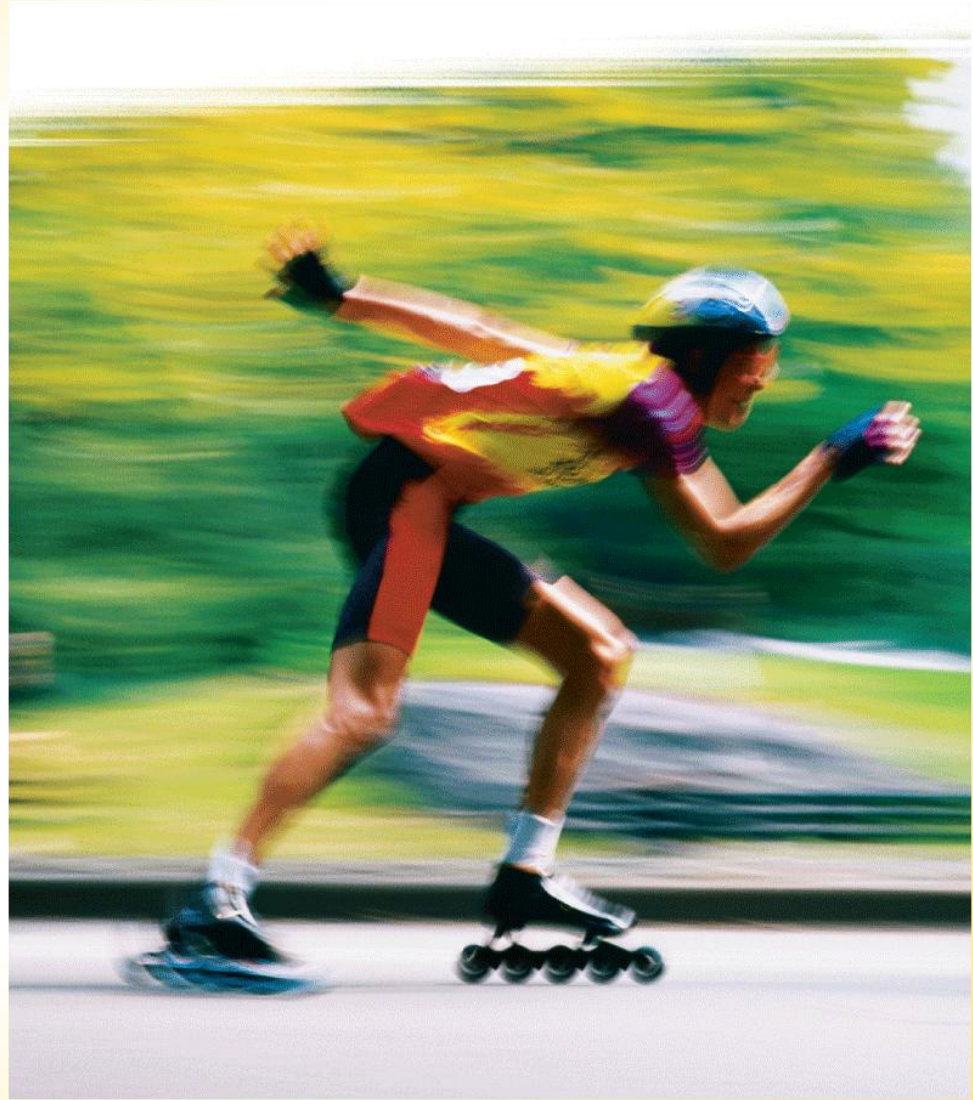The speed of an in-line skater is usually described in meters per second. The speed of a car is usually described in kilometers per hour.

Speed

How are instantaneous speed and average speed different?

Average speed is computed for the entire duration of a trip, and instantaneous speed is measured at a particular instant.

Speed

Speed is the ratio of the distance an object moves to the amount of time the object moves.

The SI unit of speed is meters per second (m/s).

Two ways to express the speed of an object are average speed and instantaneous speed.

Speed

Average Speed

Sometimes it is useful to know how fast something moves for an entire trip, even though its speed may change during the trip.

Average speed, is the total distance traveled, *d,* divided by the time, *t,* it takes to travel that distance.

Average Speed

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

Speed

Math Skills

Calculating Average Speed

While traveling on vacation, you measure the times and distances traveled. You travel 35 kilometers in 0.4 hour, followed by 53 kilometers in 0.6 hour. What is your average speed?

Speed

Math Skills

1 **Read and Understand**

What information are you given?

Speed

Math Skills

❶ Read and Understand

What information are you given?

Total Distance *(d)* **= 35 km + 53 km = 88 km**

Total Time *(t)* **= 0.4 h + 0.6 h = 1.0 h**

Speed

Math Skills

2 **Plan and Solve**

What unknown are you trying to calculate?

What formula contains the given quantities and the unknown?

Replace each variable with its known value.

Speed

Math Skills

2 Plan and Solve

What unknown are you trying to calculate?

$$\text{Average Speed } (\bar{v}) = ?$$

What formula contains the given quantities and the unknown?

$$\bar{v} = \frac{d}{t}$$

Replace each variable with its known value.

$$\bar{v} = \frac{88 \text{ km}}{1 \text{ h}} = 88 \text{ km/h}$$

Speed

Math Skills

3 **Look Back and Check**

Is your answer reasonable?

Speed

Math Skills

3 **Look Back and Check**

Is your answer reasonable?

Yes, 88 km/h is a typical highway speed.

Speed

Math Practice

1. A person jogs 4.0 kilometers in 32 minutes, then 2.0 kilometers in 22 minutes, and finally 1.0 kilometer in 16 minutes. What is the jogger's average speed in kilometers per minute?

Speed

Math Practice

1. A person jogs 4.0 kilometers in 32 minutes, then 2.0 kilometers in 22 minutes, and finally 1.0 kilometer in 16 minutes. What is the jogger's average speed in kilometers per minute?

Answer: $\bar{v}$ = (4.0 km + 2.0 km + 1.0 km)/ (32 min + 22 min + 16 min) = (7.0 km)/(70 min) = 0.10 km/min

Speed

Math Practice

2. A train travels 190 kilometers in 3.0 hours, and then 120 kilometers in 2.0 hours. What is its average speed?

Speed

2. A train travels 190 kilometers in 3.0 hours, and then 120 kilometers in 2.0 hours. What is its average speed?

Answer: $\bar{v} = (190 \text{ km} + 120 \text{ km})/(3.0 \text{ h} + 2.0 \text{ h}) = (310 \text{ km})/(5.0 \text{ h}) = 62 \text{ km/h}$
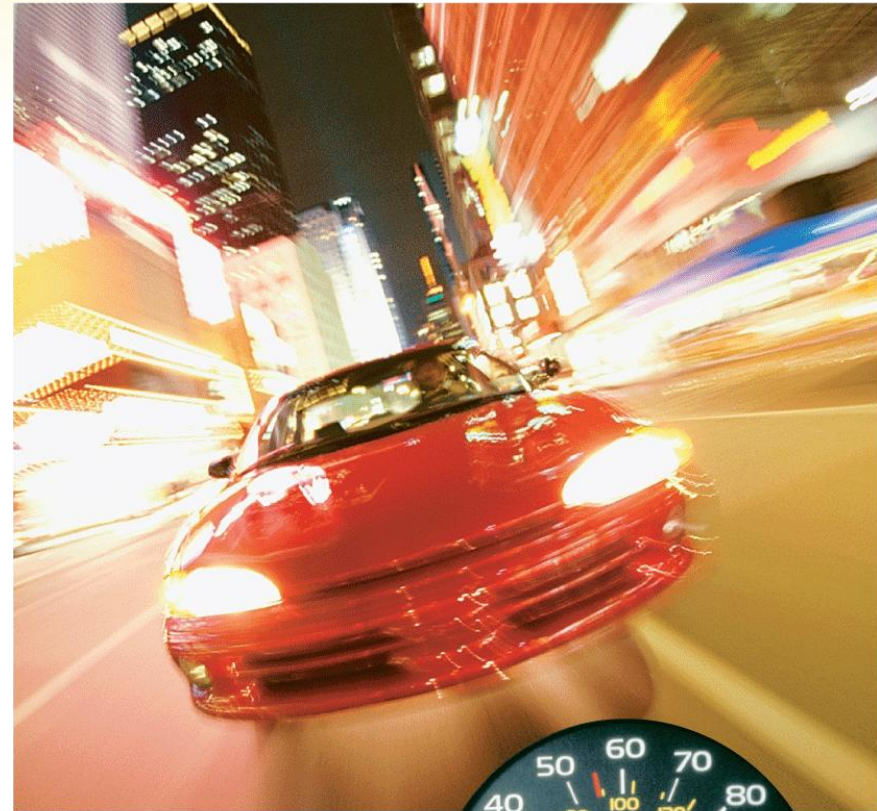
Speed

Instantaneous Speed

Sometimes you need to know how fast you are going at a particular moment.

Instantaneous speed, *v,* is the rate at which an object is moving at a given moment in time.

Speed

The speedometer in a car measures the car's instantaneous speed.

Note the scale markings are given both in km/h and miles per hour, mph.

Graphing Motion

How can you find the speed from a distance-time graph?

The slope of a line on a distance-time graph is speed.
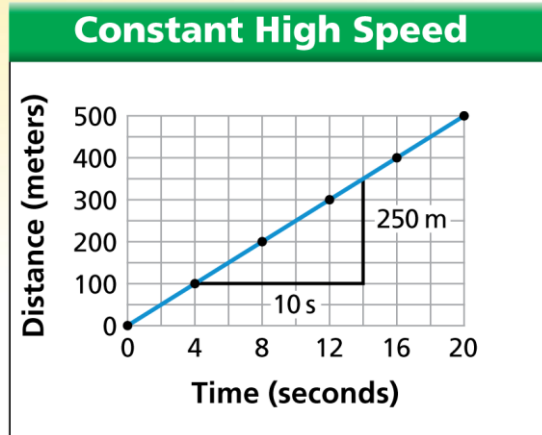
Graphing Motion

A distance-time graph is a good way to describe motion.

Slope is the change in the vertical axis value divided by the change in the horizontal axis value.
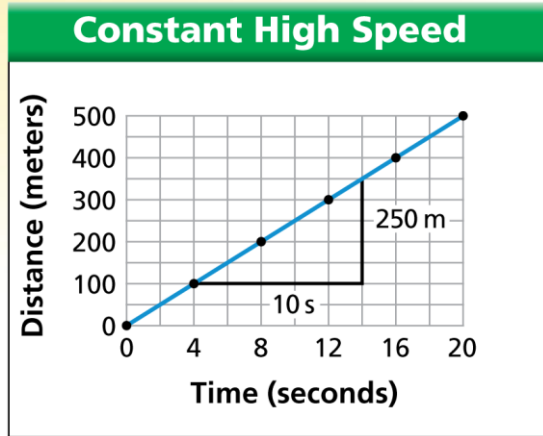
A steeper slope on a distance-time graph indicates a higher speed.
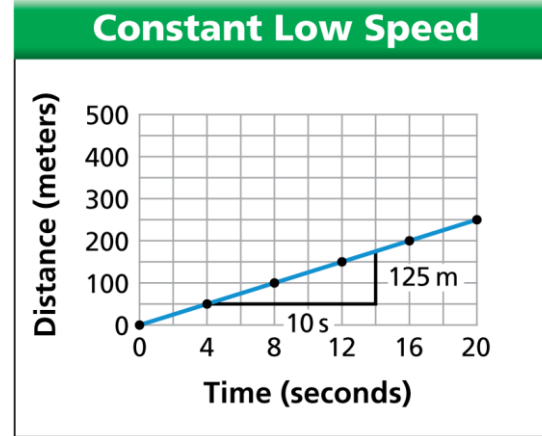
Graphing Motion

A

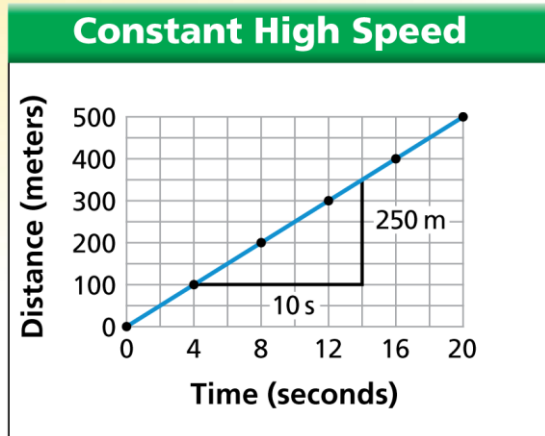Constant High Speed

Distance (meters) vs Time (seconds)

250 m

10 s

Graphing Motion

A

Constant High Speed

Distance (meters) vs. Time (seconds)

250 m
10 s

B

Constant Low Speed

Distance (meters) vs. Time (seconds)

125 m
10 s

Graphing Motion

A — Constant High Speed
B — Constant Low Speed
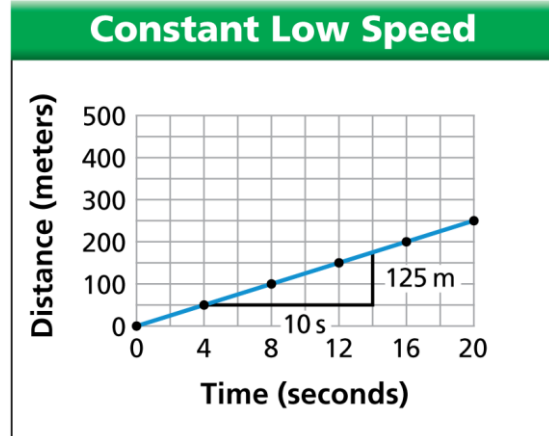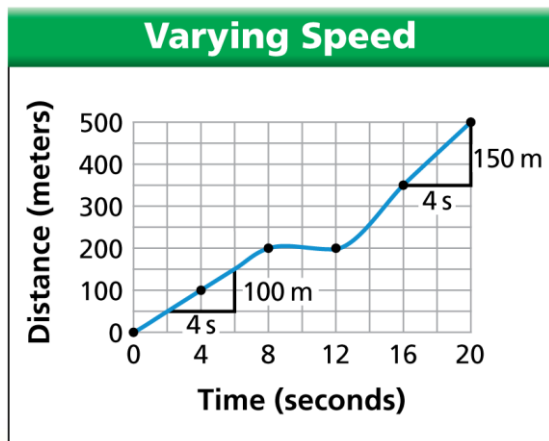C — Varying Speed

Velocity

How are speed and velocity different?

Velocity is a description of both speed and direction of motion. Velocity is a vector.

Velocity

Sometimes knowing only the speed of an object isn't enough. You also need to know the direction of the object's motion.

Together, the speed and direction in which an object is moving are called **velocity.**

Velocity

A cheetah's speed may be as fast as 90 km/h. To describe the cheetah's velocity, you must also know the direction in which it is moving.

Velocity

Vectors can be used to show changes in motion.

- Vectors of varying lengths, each vector corresponding to the velocity at a particular instant, can represent motion.

- A longer vector represents a faster speed, and a shorter one a slower speed.

- Vectors point in different directions to represent direction at any moment.

Velocity

As the sailboat's direction changes, its velocity also changes, even if its speed stays the same.

Combining Velocities

How do velocities add?

Two or more velocities add by vector addition.
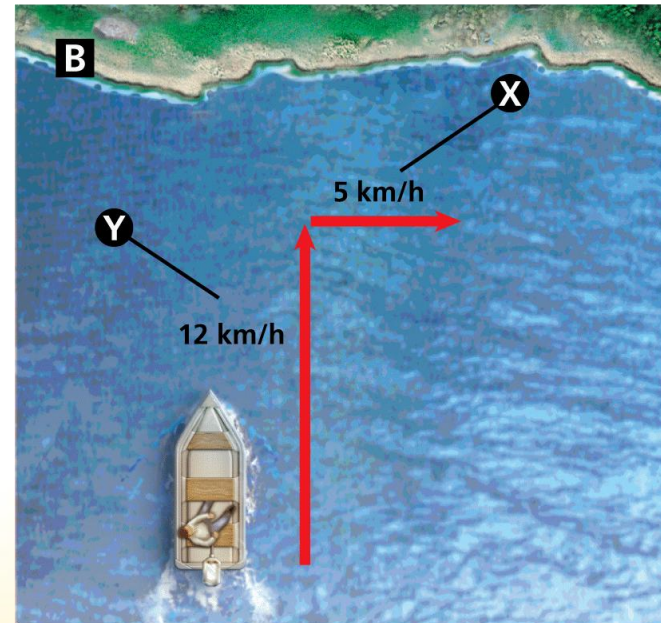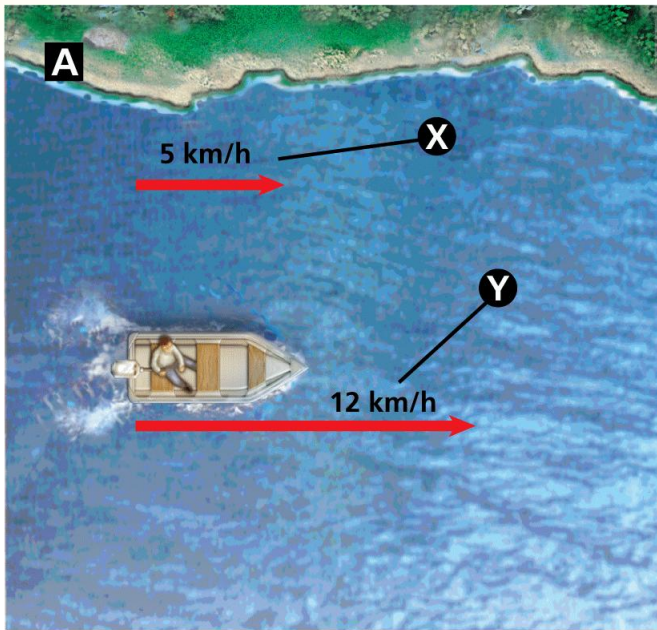
Combining Velocities

Sometimes the motion of an object involves more than one velocity.

If a boat is moving on a flowing river, the velocity of the river relative to the riverbank and the velocity of the boat relative to the river combine.

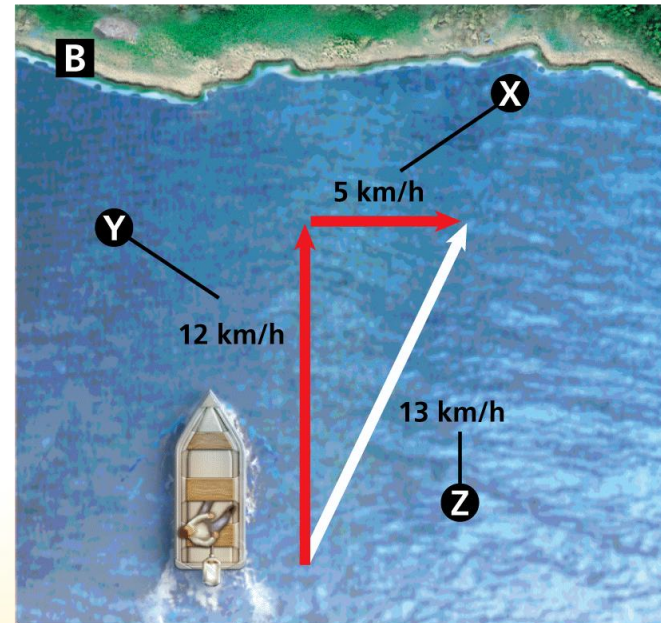They yield the velocity of the boat relative to the riverbank.

Combining Velocities

The velocity of the boat relative to the riverbank is a combination of the relative velocities of the boat and the river.

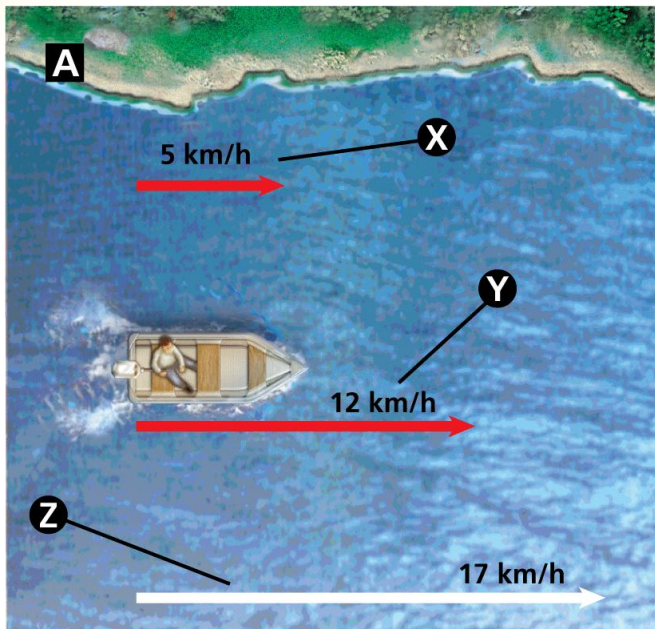# Combining Velocities

The velocity of the boat relative to the riverbank is a combination of the relative velocities of the boat and the river.

Assessment Questions

1. A woman jogs 10 kilometers in one hour, stops at a restaurant for one hour, and then walks 10 kilometers in two hours. What is her average speed for the outing?

    a. 0.2 km/h

    b. 4 km/h

    c. 5 km/h

    d. 10 km/h

Assessment Questions

1. A woman jogs 10 kilometers in one hour, stops at a restaurant for one hour, and then walks 10 kilometers in two hours. What is her average speed for the outing?

    a. 0.2 km/h

    b. 4 km/h

    c. 5 km/h

    d. 10 km/h

    ANS: C

Assessment Questions

2. Lisa plotted time on the *x*-axis of a line graph and distance on the *y*-axis. What does the slope of her graph represent?

   a. total distance traveled
   b. velocity
   c. speed
   d. displacement

Assessment Questions

2. Lisa plotted time on the *x*-axis of a line graph and distance on the *y*-axis. What does the slope of her graph represent?

   a. total distance traveled
   b. velocity
   c. speed
   d. displacement

   ANS: C

Assessment Questions

3. Lisa plotted time in seconds on the *x*-axis of a line graph and distance in centimeters on the *y*-axis. Her plot showed a straight line from (0,0) to (10, 20). What is the speed?

   a. 0.5 cm/s

   b. 2 cm/s

   c. 10 cm/s

   d. 20 cm/s

Assessment Questions

3. Lisa plotted time in seconds on the *x*-axis of a line graph and distance in centimeters on the *y*-axis. Her plot showed a straight line from (0,0) to (10, 20). What is the speed?

   a. 0.5 cm/s

   b. 2 cm/s

   c. 10 cm/s

   d. 20 cm/s

   ANS: B

Assessment Questions

4. Two velocities of an object are combined by using

   a. division of the larger velocity by the smaller velocity.

   b. addition of the two speeds.

   c. vector addition.

   d. numeric addition.

Assessment Questions

4. Two velocities of an object are combined by using

   a. division of the larger velocity by the smaller velocity.

   b. addition of the two speeds.

   c. vector addition.

   d. numeric addition.

    ANS: C

Assessment Questions

5. A kayak is moving across a stream that is flowing downstream at a velocity of 4 km/h. The kayak's velocity is 3 km/h. What is the magnitude of the kayak's velocity relative to the river bank?

a. 1.3 km/h

b. 5 km/h

c. 7 km/h

d. 12 km/h

Assessment Questions

5. A kayak is moving across a stream that is flowing downstream at a velocity of 4 km/h. The kayak's velocity is 3 km/h. What is the magnitude of the kayak's velocity relative to the river bank?

    a. 1.3 km/h

    b. 5 km/h

    c. 7 km/h

    d. 12 km/h

    ANS: B

Assessment Questions

1. The SI unit for speed of an airplane is miles per hour.

   True
   False

Assessment Questions

1. The SI unit for speed of an airplane is miles per hour.

    True
    False

    ANS: F, kilometers per hour