

Velocity

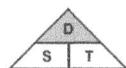
Work on a Separate Sheet of Paper.

Speed and velocity do not have the same meaning to scientists. Speed is a *scalar quantity*, which means it can be completely described by its magnitude (or size). The magnitude is given by a number and a unit. For example, an object's speed may be measured as 15 meters per second.

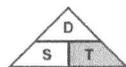
Velocity is a *vector quantity*. In order to measure a vector quantity, you must know both its magnitude and direction. The velocity of an object is determined by measuring both the *speed* and *direction* in which an object is traveling.

- If the speed of an object changes, then its velocity also changes.
- If the direction in which an object is traveling changes, then its velocity changes.
- A change in either speed, direction, or both causes a change in velocity.

You can use $v = d/t$ to solve velocity problems in the same manner that you changed the form of the equation to solve speed problems in Part A. The boldfaced v is used to represent velocity as a vector quantity. The variables d and t are used for distance and time. **The velocity of an object in motion is equal to the distance it travels per unit of time in a given direction.**



$$\text{Distance} = \text{Speed} \times \text{Time}$$



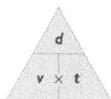
$$\text{Time} = \frac{\text{Distance}}{\text{Speed}}$$



$$\text{Speed} = \frac{\text{Distance}}{\text{Time}}$$

Example 1: What is the velocity of a car that travels 100.0 meters, northeast in 4.65 seconds?

Looking for Velocity of the car.	Solution $\text{velocity} = \frac{d}{t} = \frac{100.0 \text{ m}}{4.65 \text{ s}} = \frac{21.5 \text{ m}}{\text{s}}$ The velocity of the car is 21.5 meters per second, northeast.
Given Distance = 100.0 meters Time = 4.65 seconds	
Relationship $\text{velocity} = \frac{d}{t}$	



Example 2: A boat travels with a velocity equal to 14.0 meters per second, east in 5.15 seconds. What distance in meters does the boat travel?

Looking for Distance the boat travels.	Solution $\text{distance} = v \times t = \frac{14.0 \text{ m}}{\text{s}} \times 5.15 \text{ s} = 72.1 \text{ m}$ The boat travels 72.1 meters.
Given Velocity = 14.0 meters per second, east Time = 5.15 seconds	
Relationship $\text{distance} = v \times t$	

1. An airplane flies 525 kilometers north in 1.25 hours. What is the airplane's velocity?

Looking for	Solution
Given	
Relationship	

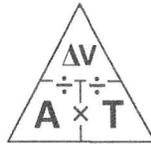
- A soccer player kicks a ball 6.5 meters. How much time is needed for the ball to travel this distance if its velocity is 22 meters per second, south?
- A cruise ship travels east across a river at 19.0 meters per minute. If the river is 4,250 meters wide, how long does it take for the ship to reach the other side?
- Joaquin mows the lawn at his grandmother's home during the summer months. Joaquin measured the distance across his grandmother's lawn as 11.5 meters.
 - If Joaquin mows one length across the lawn from east to west in 7.10 seconds, then what is the velocity of the lawnmower?
 - Once he reaches the edge of the lawn, Joaquin turns the lawnmower around. He mows in the opposite direction but maintains the same speed. What is the velocity of the lawnmower?
- A family drives 881 miles from Houston, Texas to Santa Fe, New Mexico for vacation. How long will it take the family to reach their destination if they travel at a velocity of 55.0 miles per hour, northwest?
- A shopping cart is pushed 15.6 meters west across a parking lot in 5.2 seconds. What is the velocity of the shopping cart?
- Katie and her best friend Liam play tennis every Saturday morning. When Katie serves the ball to Liam, it travels 9.5 meters south in 2.1 seconds.
 - What is the velocity of the tennis ball?
 - If the tennis ball travels at constant speed, what is its velocity when Liam returns Katie's serve?
- A driver realizes that she is traveling in the wrong direction on a one-way street. She has already driven 3.5 meters at a velocity of 16 meters per second, east before deciding to make a U-turn. How long did it take for the driver to realize her error?
- Juan's mother drives 12.5 miles southwest to her favorite shopping mall. What is the velocity of her automobile if she arrives at the mall in 7.25 minutes?
- A bus is traveling at 79.7 kilometers per hour east, how far does the bus travel 1.45 hours?
- A girl scout troop hiked 5.8 kilometers southeast in 1.5 hours. What was the troop's velocity?
- A volcanologist noted that a lahar rushed down a mountain at 32.2 kilometers per hour, south. How far did the mud flow in 17.5 minutes?

Acceleration Worksheet. Work on a separate sheet of paper.

Acceleration is the rate of change in the speed of an object. To determine the rate of acceleration, you use the formula below. The units for acceleration are meters per second per second or m/s^2 .

$$\text{Acceleration} = \frac{\text{Final speed} - \text{Beginning speed}}{\text{Time}}$$

$$a = \frac{v_2 - v_1}{t}$$

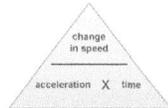


A positive value for acceleration shows speeding up, and negative value for acceleration shows slowing down. Slowing down is also called *deceleration*.

The acceleration formula can be rearranged to solve for other variables such as final speed (v_2) and time (t).

$$v_2 = v_1 + (a \times t)$$

$$t = \frac{v_2 - v_1}{a}$$



EXAMPLES

1. A skater increases her velocity from 2.0 m/s to 10.0 m/s in 3.0 seconds. What is the skater's acceleration?

Looking for Acceleration of the skater	Solution
Given Beginning speed = 2.0 m/s Final speed = 10.0 m/s Change in time = 3 seconds	Acceleration = $\frac{10.0 \text{ m/s} - 2.0 \text{ m/s}}{3 \text{ s}} = 2.7 \text{ m/s}^2$
Relationship $a = \frac{v_2 - v_1}{t}$	The acceleration of the skater is 2.7 meters per second per second.

2. A car accelerates at a rate of 3.0 m/s^2 . If its original speed is 8.0 m/s, how many seconds will it take the car to reach a final speed of 25.0 m/s?

Looking for The time to reach the final speed.	Solution
Given Beginning speed = 8.0 m/s; Final speed = 25.0 m/s Acceleration = 3.0 m/s^2	Time = $\frac{25.0 \text{ m/s} - 8.0 \text{ m/s}}{3.0 \text{ m/s}^2} = 5.7 \text{ s}$
Relationship $t = \frac{v_2 - v_1}{a}$	The time for the car to reach its final speed is 5.7 seconds.

- While traveling along a highway a driver slows from 24 m/s to 15 m/s in 12 seconds. What is the automobile's acceleration? (Remember that a negative value indicates a slowing down or deceleration.)
- A parachute on a racing dragster opens and changes the speed of the car from 85 m/s to 45 m/s in a period of 4.5 seconds. What is the acceleration of the dragster?
- The table below includes data for a ball rolling down a hill. Fill in the missing data values in the table and determine the acceleration of the rolling ball.

Time (seconds)	Speed (km/h)
0 (start)	0 (start)
2	3
	6
	9
8	
10	15

Acceleration = _____

- A car traveling at a speed of 30.0 m/s encounters an emergency and comes to a complete stop. How much time will it take for the car to stop if it decelerates at -4.0 m/s^2 ?
- If a car can go from 0 to 60 mi/hr in 8.0 seconds, what would be its final speed after 5.0 seconds if its starting speed were 50 mi/hr?
- A cart rolling down an incline for 5.0 seconds has an acceleration of 4.0 m/s^2 . If the cart has a beginning speed of 2.0 m/s, what is its final speed?
- A helicopter's speed increases from 25 m/s to 60 m/s in 5 seconds. What is the acceleration of this helicopter?
- As she climbs a hill, a cyclist slows down from 25 mi/hr to 6 mi/hr in 10 seconds. What is her deceleration?
- A motorcycle traveling at 25 m/s accelerates at a rate of 7.0 m/s^2 for 6.0 seconds. What is the final speed of the motorcycle?
- A car starting from rest accelerates at a rate of 8.0 m/s^2 . What is its final speed at the end of 4.0 seconds?
- After traveling for 6.0 seconds, a runner reaches a speed of 10 m/s. What is the runner's acceleration?
- A cyclist accelerates at a rate of 7.0 m/s^2 . How long will it take the cyclist to reach a speed of 18 m/s?
- A skateboarder traveling at 7.0 meters per second rolls to a stop at the top of a ramp in 3.0 seconds. What is the skateboarder's acceleration?