

Lesson 2 Speed, Velocity, and Acceleration

Grade Eight Science Content Standard. 1.d. Students know the velocity of an object must be described by specifying both the direction and the speed of the object. **Also covers:** 1.b, 1.c, 1.e.

● Before You Read

Have you ever run in a race? What kinds of things are measured in a race? Write your answers on the lines below. Then read the lesson to learn more about speed and velocity.

MAIN Idea

Speed, velocity, and acceleration describe how an object's position and motion change in time.

What You'll Learn

- speed as a rate of change
- why velocity is a vector
- when acceleration occurs

● Read to Learn

What is speed?

When you describe motion, you often want to know how fast something is moving. The faster something is moving, the less time it takes to travel a certain distance. The slower something is moving, the more time it takes to travel a certain distance. **Speed** is the rate of change of distance with time.

What is constant speed?

An object that moves at a **constant speed** travels the same distance each second. For example, if a train travels 100 km in one hour, then it will travel another 100 km in the next hour. So in two hours it will travel 200 km. In five hours it will travel 500 kilometers.

What is instantaneous speed?

Many things do not travel at constant speeds. Instead, they speed up or slow down. For example, a car driving along a city street slows down and stops at a stop sign. Then it starts moving again.

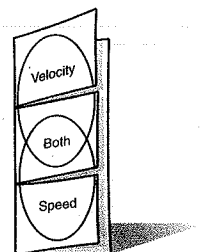
When the speed of an object isn't constant, it is helpful to know its instantaneous speed. The speed of an object at one instant in time is that object's **instantaneous** (ihn stuhn TAY nee us) **speed**.

Study Coach

Outline Create an outline of this lesson as you read. Be sure to include main ideas, underlined terms, and other important information.

FOLDABLES™

B Record Information Make a Venn-diagram Foldable and label the tabs as illustrated. Record what you learn about velocity and speed under the appropriate tabs. Explain how they are similar and different under the center tab.



✓ Reading Check

1. Determine What is a car's instantaneous speed when it is traveling at 65 km/h?

✓ Reading Check

2. Identify The average speed equation has what three variables?

When is instantaneous speed constant?

Now think about a car traveling on a highway at a constant speed of 80 km/h. What is the instantaneous speed of the car? When an object moves at a constant speed, its instantaneous speed is constant, too. So, the car's instantaneous speed is 80 km/h.

What is average speed?

The runners in a race line up at the starting line. When the starting gun is fired, the runners increase their speed until they cross the finish line. In a longer race, a runner might start quickly, slow down for a while to save energy, and then finish fast. During a race, a runner's instantaneous speed changes a lot.

How can you describe speed when it is changing? You can find an object's average speed. The **average speed** is the total distance traveled divided by the total time. You can find average speed using this equation:

$$\text{average speed (in m/s)} = \frac{\text{total distance (in m)}}{\text{total time (in s)}}$$

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

How can you find an unknown variable?

The average speed equation has three variables: average speed, distance, and time. If you know any two of the variables, you can use the equation to figure out the third, unknown variable.

Velocity

The **velocity** (vuh LAH suh tee) of an object is the speed of the object and the direction of its motion. The velocity of an object describes how fast that object is going and in what direction.

How is velocity a vector?

Imagine an airplane flying at a speed of 300 km/h and moving east. The airplane's velocity is 300 km/h east. Recall that a quantity, such as velocity, that has both size and direction is called a vector. The size of a velocity vector is the speed.

A velocity vector can be shown by an arrow that points in the direction of motion. The length of the arrow represents the speed. The length of the arrow increases as speed increases.

Acceleration

When an object changes its motion, it is accelerating. **Acceleration** (ak sel uh RAY shun) is the rate at which velocity changes with time. Just like velocity, acceleration is a vector. To specify an object's acceleration, both a size and direction must be given. ✓

Upon what does the direction of acceleration depend?

The velocity of an object changes when it speeds up or slows down. As a result, the object is accelerating. A runner, taking off at the beginning of a race or a car slowing down at an intersection are both accelerating. The direction of the acceleration depends on whether an object is speeding up or slowing down. If an object is speeding up, the direction of its acceleration is in the same direction that the object is moving. If an object is slowing down, the acceleration is in the opposite direction that the object is moving.

What happens to acceleration when the direction of motion of an object changes?

The velocity of an object can change even if its speed doesn't change. For example, the horses on a carousel normally move with constant speed. However, as the carousel turns, the direction of motion of the horses is constantly changing. As a result, the velocity of each horse is changing and the horses are accelerating. ✓

What have you learned?

Speed is the rate of change of position with time. You calculate average speed by dividing the distance traveled by the time taken to travel the distance.

In Lesson 1 you read that a vector is a quantity with both size and direction. In this lesson, you learned about two vector quantities—velocity and acceleration. Velocity is the speed and direction of an object's motion. Acceleration is the rate of change of velocity over time. Acceleration occurs when an object's speed or direction of motion changes.

✓ Reading Check

3. Define What is acceleration?

Academic Vocabulary
motion (MOH shun) (noun)
the process of changing place;
movement

✓ Reading Check

4. Explain How can the velocity of an object change if the object has a constant speed?
