VELOCITY

Where an object started and where it stopped does not completely describe the motion of the object. For example, the ground that you're standing on may move 8.0 cm to the left. This motion could take several years and be a sign of the normal slow movement of Earth's tectonic plates. If this motion takes place in just a second, however, you may be experiencing an earthquake or a landslide. Knowing the speed is important when evaluating motion.

Average velocity is displacement divided by the time interval

Consider the car in **Figure 4.** The car is moving along a highway in a straight line (the x-axis). Suppose that the positions of the car are x_i at time t_i and x_f at time t_f. In the time interval $\Delta t = t_f - t_i$, the displacement of the car is $\Delta x = x_f - x_i$. The **average velocity,** v_{avg}, is defined as the displacement divided by the time interval during which the displacement occurred. In SI, the unit of velocity is meters per second, abbreviated as m/s.

Figure 4
The average velocity of this car tells you how fast and in which direction it is moving.

average velocity

the total displacement divided by the time interval during which the displacement occurred

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AVERAGE VELOCITY

$$v_{avg} = \frac{\Delta x}{\Delta t} = \frac{x_f - x_i}{t_f - t_i}$$

$$\text{average velocity} = \frac{\text{change in position}}{\text{change in time}} = \frac{\text{displacement}}{\text{time interval}}$$

The average velocity of an object can be positive or negative, depending on the sign of the displacement. (The time interval is always positive.) As an example, consider a car trip to a friend's house 370 km to the west (the negative direction) along a straight highway. If you left your house at 10 A.M. and arrived at your friend's house at 3 P.M., your average velocity would be as follows:

$$v_{avg} = \frac{\Delta x}{\Delta t} = \frac{-370 \text{ km}}{5.0 \text{ h}} = -74 \text{ km/h} = 74 \text{ km/h west}$$

This value is an average. You probably did not travel exactly 74 km/h at every moment. You may have stopped to buy gas or have lunch. At other times, you may have traveled more slowly as a result of heavy traffic. To make up for such delays, when you were traveling slower than 74 km/h, there must also have been other times when you traveled faster than 74 km/h.

The average velocity is equal to the constant velocity needed to cover the given displacement in a given time interval. In the example above, if you left your house and maintained a velocity of 74 km/h to the west at every moment, it would take you 5.0 h to travel 370 km.

> **TIP** *Average velocity is not always equal to the average of the initial and final velocities. For instance, if you drive first at 40 km/h west and later at 60 km/h west, your average velocity is not necessarily 50 km/h west.*
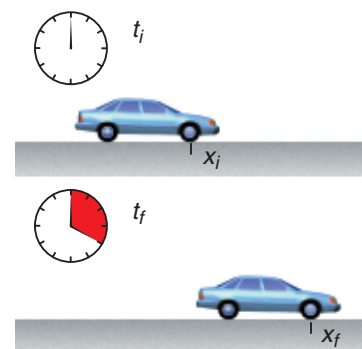
Did you know?

The branch of physics concerned with motion and forces is called *mechanics*. The subset of mechanics that describes motion without regard to its causes is called *kinematics*.