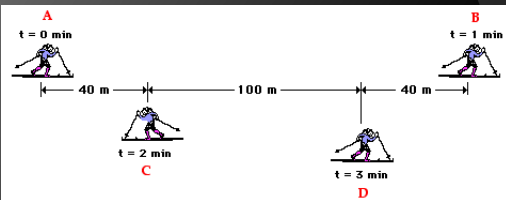


Warm UP: Determine distance traveled and displacement by the skier.



II. SPEED AND VELOCITY

Just as distance and displacement have distinctly different meanings (despite their similarities), so do speed and velocity.

Speed is a **scalar quantity** which refers to "how fast an object is moving."



An object with no movement at all has a zero speed.



Velocity is a **vector quantity** which refers to "the rate at which an object changes its position"

Imagine a person moving rapidly - one step forward and one step back - always returning to the original starting position. While this might result in a frenzy of activity, it would result in a zero velocity. Because the person always returns to the original position, the motion would never result in a change in position. Since velocity is defined as the rate at which the position changes, this motion results in zero velocity.



Velocity is a vector quantity. As such, velocity is *direction aware*.



When evaluating the velocity of an object, one must keep track of direction. It would not be enough to say that an object has a velocity of 55 mi/hr. One must include direction information in order to fully describe the velocity of the object. For instance, you must describe an object's velocity as being 55 mi/hr, **east**. This is one of the essential differences between speed and velocity.

Speed is a scalar quantity and does not *keep track of direction*; velocity is a vector quantity and is *direction aware*.



Calculating Average Speed and Average Velocity

The average speed during the course of a motion is often computed using the following formula:

$$\text{Average Speed} = \frac{\text{Distance Traveled}}{\text{Time of Travel}}$$

While on vacation, my parents traveled a total distance of 440 miles. Her trip took 8 hours. What was her average speed?

To compute her average speed, we simply divide the distance of travel by the time of travel.

$$s = \frac{d}{t} = \frac{440 \text{ mi}}{8 \text{ hr}} = 55 \text{ mi/hr}$$



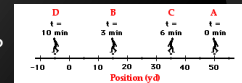
Practice: A cyclist races 100 meters in 50 seconds. What is his speed?

Meanwhile, the average velocity is often computed using the equation

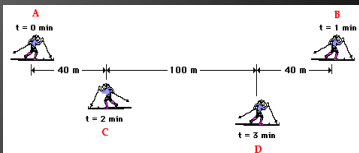
$$\text{Average Velocity} = \frac{\Delta \text{position}}{\text{time}} = \frac{\text{displacement}}{\text{time}}$$

A football coach paces back and forth along the sidelines. The diagram below shows several of coach's positions at various times. At each marked position, the coach makes a "U-turn" and moves in the opposite direction. In other words, the coach moves from position A to B to C to D.

What is the coach's average speed and average velocity?



The diagram below shows the position of a cross-country skier at various times. At each of the indicated times, the skier turns around and reverses the direction of travel. In other words, the skier moves from A to B to C to D.



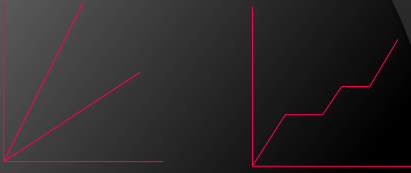
The skier has an average speed of $(420 \text{ m}) / (3 \text{ min}) = 140 \text{ m/min}$ and an average velocity of $(140 \text{ m, right}) / (3 \text{ min}) = 46.7 \text{ m/min, right}$

Use the diagram to determine the average speed and the average velocity of the skier during these three minutes. When finished, click the button to view the answer.



Instantaneous Speed - the speed at any given instant in time.

Moving objects don't always travel with erratic and changing speeds. Occasionally, an object will move at a steady rate with a constant speed. is, the object will cover the same distance every regular interval of time. For instance, a cross-country runner might be running with a constant speed of 6 m/s in a straight line for several minutes. If her speed is constant, then the distance traveled every second is the same. The runner would cover a distance of 6 meters every second



The steepness of the line indicates how fast an object is moving

Steeper line = greater speed

Horizontal line = not moving

Check your understanding.



What is the displacement of the BHS cross-country team if they begin at the school, run 10 miles and finish back at the school?

A marathon runner completes a 40 km race as follows:

First 10 km in 1 hour

Second 10 km in 1.6 hour

Third 10 km in 1.2 hour

Fourth 10 km in 2.4 hour.

Calculate the average speed of the marathon runner.