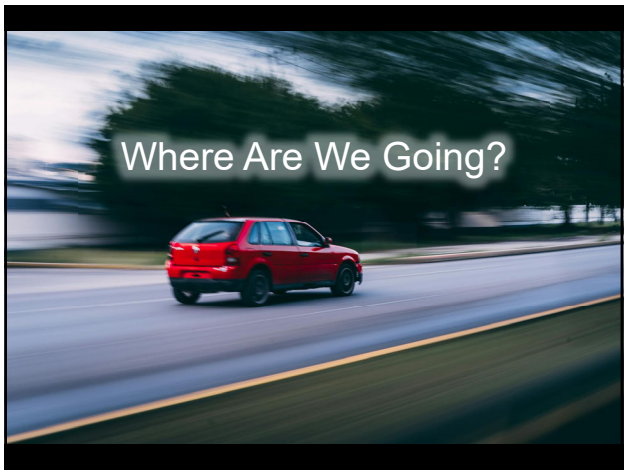


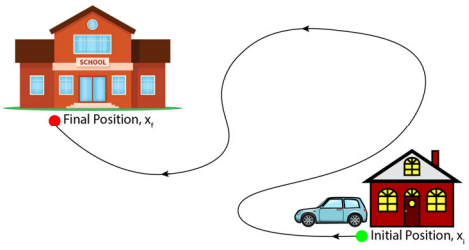
Scalar or Vector

- There are some measurements that are just a value. For example, the weight of something is just a number (and units).
- Quantities that only have a magnitude (number) are called **scalar** quantities.
  - length, temperature, weight, speed

- Sometimes it is important to know the direction of a quantity. For example, if you are driving somewhere, it might be necessary to know both the speed and the direction.
- Quantities have a magnitude (number) and a direction are called **vector** quantities.
  - displacement, velocity, acceleration, force.

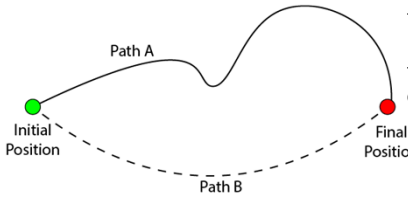
Position

- The position of an object is where it is at a particular time.
  - A car driving from home to school has an initial position and a final position.



Distance

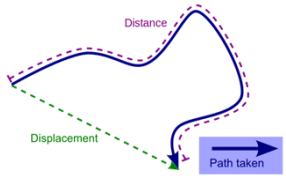
- The distance an object moves is the length of the path between its initial position and its final position. The distance depends on the path taken.



The distance of Path A is greater than the distance of Path B.

Displacement

- The net change in position of an object is its displacement.
  - The length of the straight line between the initial and final positions.
  - Displacement includes direction.



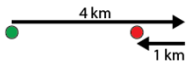
Direction

- The direction of motion can be stated as forwards, backwards, up, down, left, or right.
- We can also state the direction of motion as north, south, east, or west.

- Mathematically we describe motion in the positive or negative direction.
  - Forward motion is positive.
  - Backwards motion is negative.
  - Motion to the right, north, east, or up is usually positive.
  - Motion to the left, south, west, or down is usually negative.

Example

A boy walks 4 km East then turns around and walks 1 km West.



What distance does he travel?

4 km + 1 km = **5 km**

What is his displacement?

$$displacement = (4) + (-1)$$
$$displacement = \mathbf{3\ km\ East}$$

Example

A girl walks 1 km North and then turns around and walks 1 km South.

What distance does she travel?

1 km + 1 km = **2 km**

What is her displacement?

$$displacement = (1) + (-1)$$
$$displacement = \mathbf{0}$$

Speed

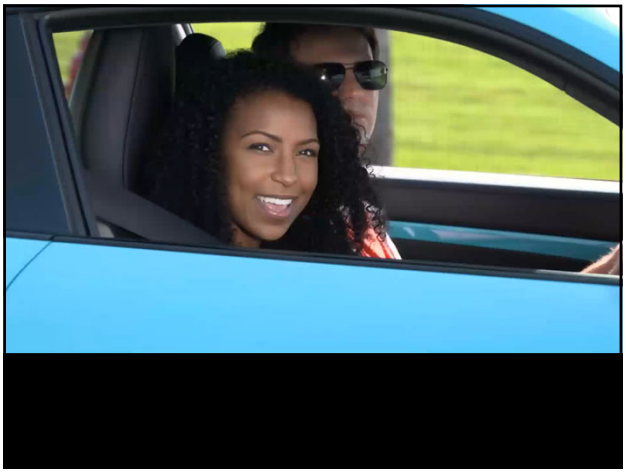
- The speed of an object is how fast it is going.
  - The distance traveled in an amount of time.

$$average\ speed = \frac{distance}{time}$$

Velocity

- The speed of an object and the direction it is moving.
  - The displacement of an object over an amount of time.

$$average\ velocity = \frac{displacement}{time}$$



Example

- A turtle leaves his house and moves 30 m North followed by 10 m South. The trip takes 20 s to complete. Calculate the average speed and average velocity of the turtle.

$$average\ speed = \frac{distance}{time}$$

$$= \frac{30 + 10\ m}{20\ s}$$

$$= \mathbf{2\ m/s}$$

$$average\ velocity = \frac{displacement}{time}$$

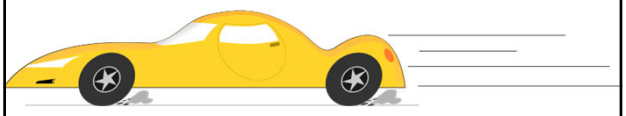
$$= \frac{30 - 10\ m}{20\ s}$$

$$= \mathbf{1\ m/s\ North}$$

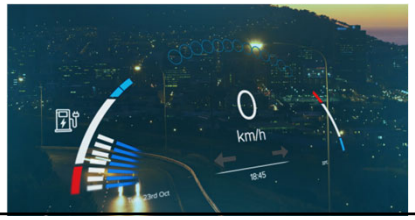
Acceleration

- Acceleration is the change in velocity divided by time.

$$acceleration = \frac{final\ velocity\ - initial\ velocity}{time}$$

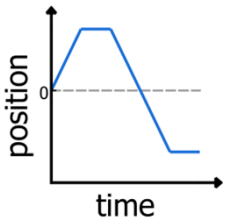


- Acceleration is a vector, so it includes direction.
  - Since velocity is a vector, a change in velocity could mean a change in speed or direction.
  - Therefore, an object will accelerate if the speed changes or the direction changes.

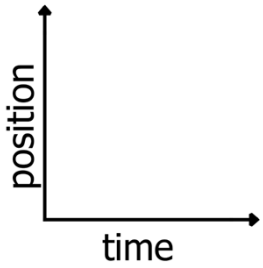


Position-time Graphs

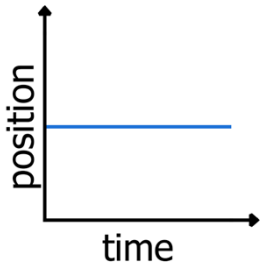
- A position-time graph is a useful tool for visualizing the position of an object with respect to time.



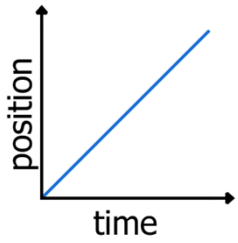
- We plot the position of an object from a reference point (origin) on the vertical axis at a time on the horizontal axis.



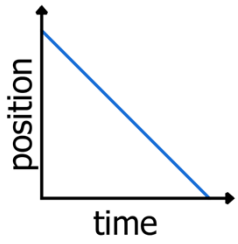
- If an object is stationary, the position does not change over time.



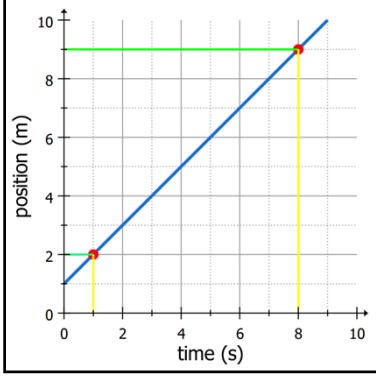
- If an object is moving at a constant speed in the positive direction, the position of the object increases at a constant rate. This appears as a straight line with a positive slope.



- If an object is moving at a constant speed in the negative direction, the position of the object decreases at a constant rate. This appears as a straight line with a negative slope.



- We can determine the speed by calculating the slope of the line.



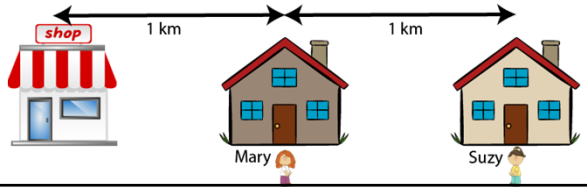
$$slope = \frac{rise}{run}$$

$$= \frac{(9-2)}{(8-1)} = \frac{7}{7} = 1$$

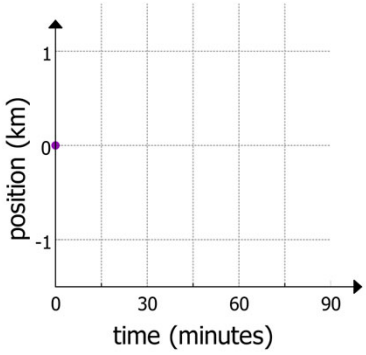
$$speed = 1\ \mathrm{m/s}$$

Example

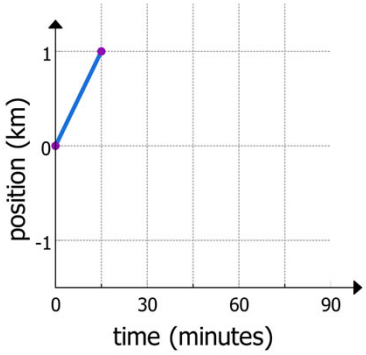
Mary walks 1 km East to her friend Suzy's house. The trip takes 15 minutes. Mary and Suzy stay at the house for 10 minutes. The girls walk West to the store that is 2 km away. They arrive at the store 25 minutes later. The girls are in the store for 20 minutes. It takes them 15 minutes to walk back to Mary's house.



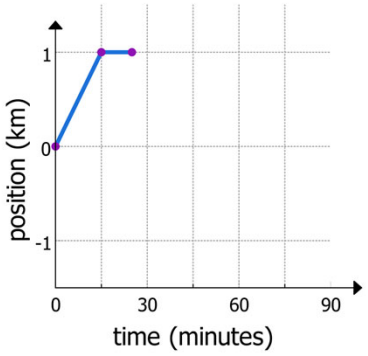
We will use Mary's house as the origin (position 0 on the graph).



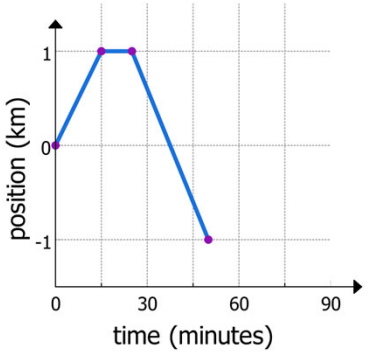
Mary walks 1 km East (positive) to her friend Suzy's house. The trip takes 15 minutes.



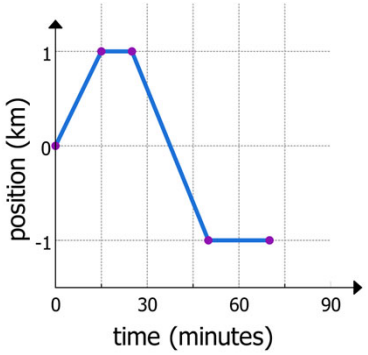
Mary and Suzy stay at the house for 10 minutes.



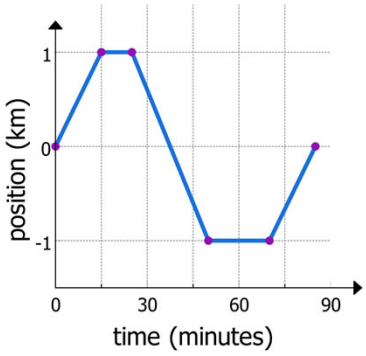
The girls walk West (negative) to the store that is 2 km away. They arrive at the store 25 minutes later.



The girls are in the store for 20 minutes.

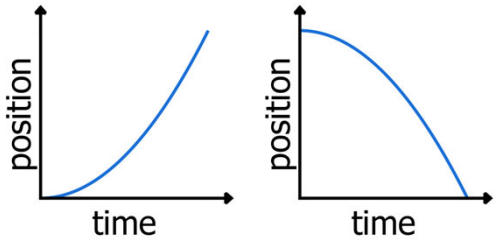


It takes them 15 minutes to walk back to Mary's house (1 km East or positive).

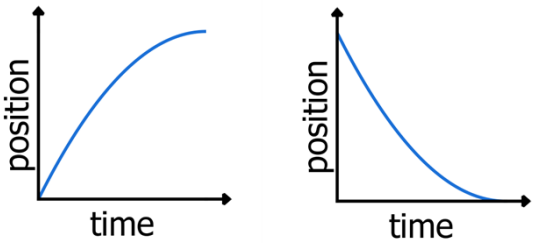


Graphing Accelerated Motion

- If an object is speeding up, the position of the object is changing at a faster rate.



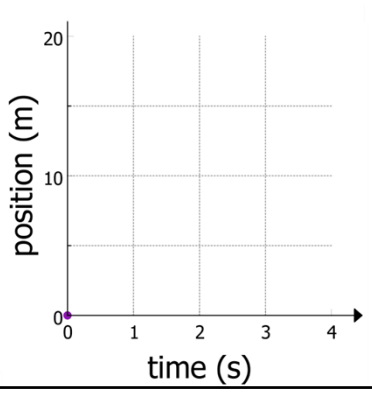
- If the object is slowing down, the position of the object is changing at a slower rate.



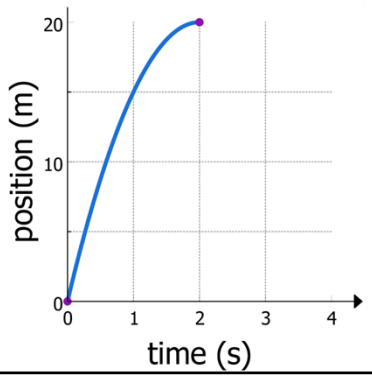
Example

A ball is shot straight up in the air from the ground. It takes the ball 2 seconds to reach its highest point of 20 m. As the ball goes up, it slows down. The ball speeds up as it falls taking 2 seconds to return.

The ground will be the origin.



It takes the ball 2 seconds to reach its highest point of 20 m. As the ball goes up, it slows down.



The ball speeds up as it falls taking 2 seconds to return.