





# Displacement

• The change in position of an object.

 $\Delta x = x - x_0$ where:  $\Delta x$  is the displacement x is the final position  $x_0$  is the initial position









#### Distance

- Displacement is described in terms of direction, distance is not.
- Distance is defined to be the magnitude or size of displacement between two positions.
- Note that the distance between two positions is not the same as the distance traveled between them. Distance traveled is the total length of the path traveled between two positions.



• Distance traveled = 9 km

### Vectors and Scalars

- A **vector** is any quantity with both *magnitude* and *direction*.
  - Displacement (100 km North)
  - Velocity (110 km/h West)
- A **scalar** is any quantity that has a *magnitude*, but no direction.
  - Temperature (20°C)
  - Mass (70 kg)

• A vector quantity is represented by an arrow over the variable.

 $\vec{v}$ 

• For one dimensional variables we normally do not use vector notation.

#### Direction

- To describe the direction of a vector quantity, you must designate a coordinate system within the reference frame.
- For one-dimensional motion, this is a simple coordinate system consisting of a one-dimensional coordinate line.
- For horizontal motion, motion to the right is usually considered positive (+), and motion to the left is considered negative (-).

- For vertical motion, motion up is usually positive and motion down is negative.
  - In some cases, it can be more convenient to switch the positive and negative directions.
    - If something is falling, you may want to make down the positive direction.



Note: It does not matter which direction is positive as long as the system is clear and consistent. Once you assign a positive direction and start solving a problem, you cannot change it.

## Velocity

• Average velocity is displacement (change in position) divided by the time of travel.

$$v_{avg} = \frac{\Delta x}{\Delta t} = \frac{x - x_0}{t - t_0}$$

Where:  $v_{avg}$  is the average velocity x is the displacement t is the time

- The average velocity of an object does not tell us anything about what happens to it between the start and end points.
- The motion needs to be divided into smaller intervals to get more detailed information.
- **Instantaneous velocity**, *v*, is the average velocity at a specific instant in time (or over an infinitesimally small time interval).

#### Speed

- Average speed is the distance traveled divided by elapsed time.
- **Instantaneous speed** is the magnitude of instantaneous velocity.









## Acceleration

• Average acceleration is the rate at which velocity changes.

$$a_{avg} = \frac{\Delta v}{\Delta t} = \frac{v - v_0}{t - t_0}$$

Where:  $a_{avg}$  is the average acceleration v is the velocity t is the time

- Acceleration is a vector in the same direction as the change in velocity.
- Since velocity is a vector, it can change either in magnitude or in direction.
- Acceleration is therefore a change in either speed or direction, or both.
- When an object's acceleration is in the same direction of its motion, the object will speed up.
- When an object's acceleration is opposite to the direction of its motion, the object will slow down.



## Example

 A car with a velocity of 10 m/s accelerates to a velocity of 20 m/s in 20 seconds then drives at a constant velocity for 20 seconds. The car then slows down to 5.0 m/s in 20 seconds. Calculate the average acceleration for the first and last 20 seconds of the trip.

• First 20 seconds  

$$a_{avg} = \frac{\Delta v}{\Delta t} = \frac{v - v_0}{t - t_0}$$

$$a_{avg} = \frac{20 - 10}{20} = 0.5 \text{ m/s}^2$$
• Last 20 seconds  

$$a_{avg} = \frac{\Delta v}{\Delta t} = \frac{v - v_0}{t - t_0}$$

$$a_{avg} = \frac{5 - 20}{20} = -0.75 \text{ m/s}^2$$



