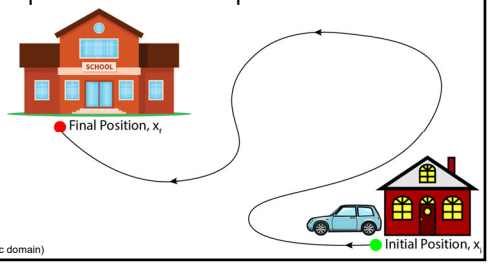
Motion in One Dimension

youtu.be/ZM8ECpBuQYE

Position

- Where an object is.
  - A car driving from home to school has an initial position and a final position.

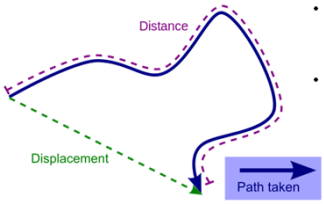


Images: Openclipart (public domain)

Distance & Displacement

Distance

- How far it is from point A to point B along the path traveled.

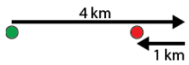


Displacement

- The change in position of an object.
  - Includes the direction
  - The total displacement of an object is the sum of the individual displacements.
  - Symbol: d

Example

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



What distance does he travel?

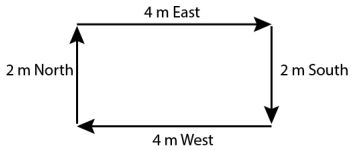
4 km + 1 km = **5 km**

What is his displacement?

$$d = d_1 + d_2$$
$$d = (4) + (-1)$$
$$d = \mathbf{3\ km\ East}$$

Example

- A boy walks 4 m East, 2 m South, 4 m West and finally 2 m North.



What distance does he travel?

12 m

What is his displacement?

0 m

Speed & Velocity

Speed

- How fast an object is moving.

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

Velocity

- How fast an object changes its position.
  - includes direction

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

$$\boxed{\bar{v} = \frac{\Delta d}{\Delta t}}$$

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 speed and velocity of the turtle.

Speed

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

$$= 2\ m/s$$

Velocity

$$\bar{v} = \frac{\Delta d}{\Delta t} = \frac{30 - 10\ m}{20\ s}$$

$$= 1\ m/s, \text{North}$$

Scalar & Vector

Scalar

- A quantity that has magnitude (how big or how much)
  - distance
    - 100 m
  - mass
    - 70 kg

Vector

- A quantity that has both magnitude and direction
  - displacement, d
    - 25 m South
  - velocity, v
    - 30 m/s, North

Uniform Motion

- The object is moving with a **constant** velocity in a straight line.
  - acceleration is equal to zero

Acceleration

- The change in velocity divided by time
  - Acceleration is a vector (includes direction)

$$average\ acceleration = \frac{change\ in\ velocity}{time}$$

$$\boxed{\bar{a} = \frac{\Delta v}{\Delta t}}$$

Example

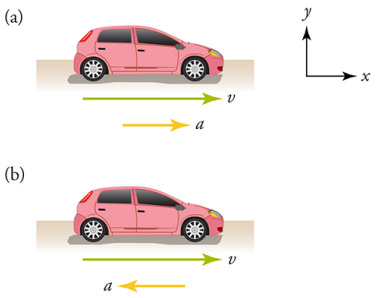
- A car starting from rest reaches a velocity of 20 m/s North in 5 s. What is the average acceleration of the car?

$$\bar{a} = \frac{\Delta v}{\Delta t} = \frac{20 - 0}{5} = 4 \text{ m/s}^2 \text{ North}$$

- Since velocity is speed plus direction, the velocity will change if the speed changes or the direction changes.
- Therefore, an object will accelerate if its speed changes or its direction changes.

- The direction of the acceleration depends on
  - what direction the object is moving
  - how the speed is changing
- The general principle for determining the direction of acceleration is
  - **If an object is slowing down, then its acceleration is in the opposite direction of its motion**

(a) Car is speeding up



(b) Car is slowing down

Examples

- Which direction is the acceleration?
  - A car is speeding up while traveling North
    - North
  - A truck going forwards is slowing down
    - Backwards
  - A car is slowing down while traveling East
    - West
  - A truck is speeding up while going backwards
    - backwards

Summary

- Distance
- Speed
  - $\frac{distance}{time}$
- Displacement
- Velocity
  - $\frac{displacement}{time}$
- Acceleration
  - $\frac{change\ in\ velocity}{time}$

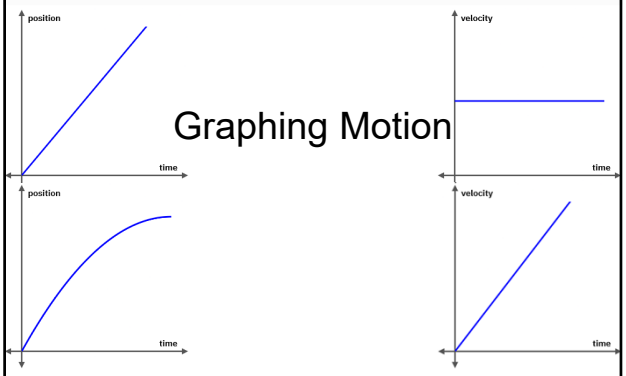
Unit Conversions

$$\frac{km}{h} \times \frac{1000}{3600} = \frac{m}{s}$$

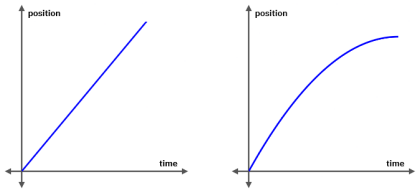
Example:

$$50\ \frac{km}{h} \times \frac{1000}{3600} = 13.9\ \frac{m}{s}$$

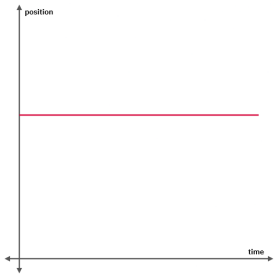
Graphing Motion



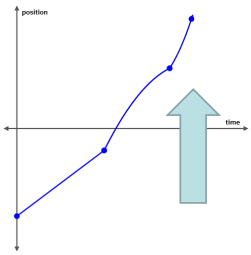
Position – Time Graphs

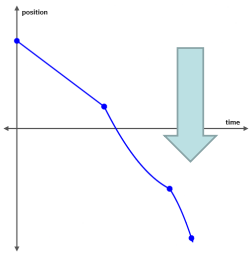


- If an object is stationary (at rest), the position does not change.
  - The graph is a flat line.

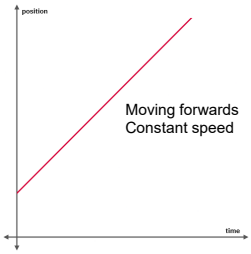


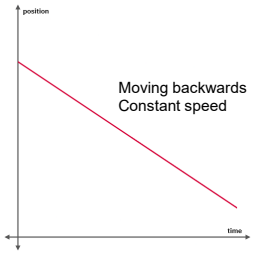
- Motion in the positive direction is shown by an increase in position with time
- Motion in the negative direction is shown by a decrease in position with time



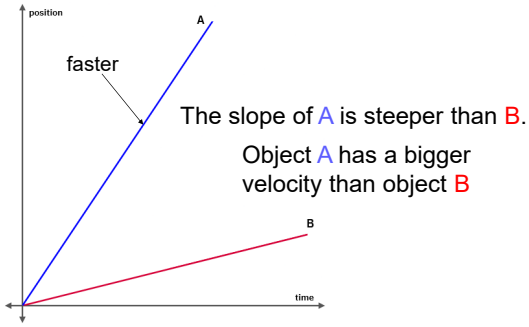


- A straight line (with a slope) represents constant speed.
  - Positive slope is forwards.
  - Negative slope is backwards.





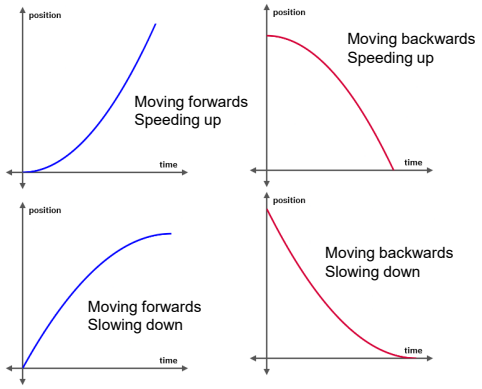
- The velocity is the slope of the line.
  - The steeper the slope, the bigger the velocity



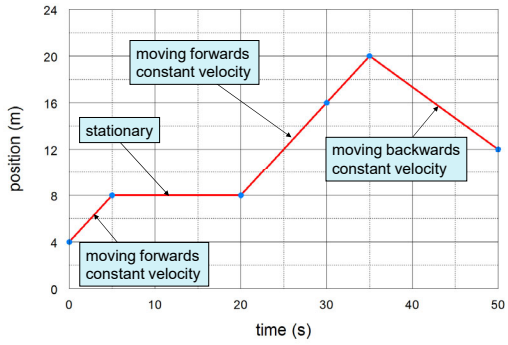
The slope of A is steeper than B.

Object A has a bigger velocity than object B

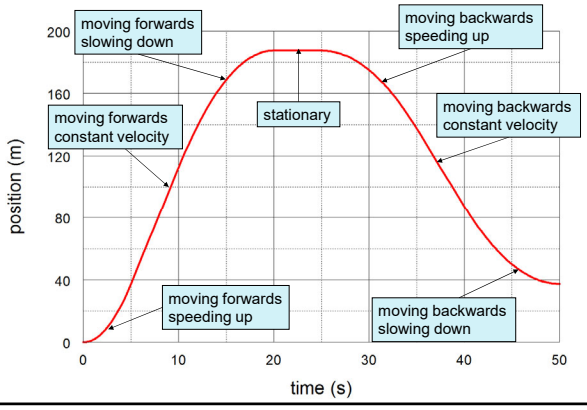
- Accelerated motion appears curved



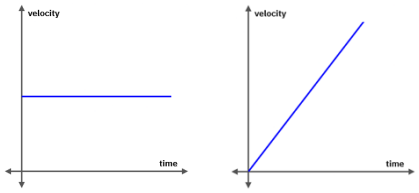
- Describe the motion



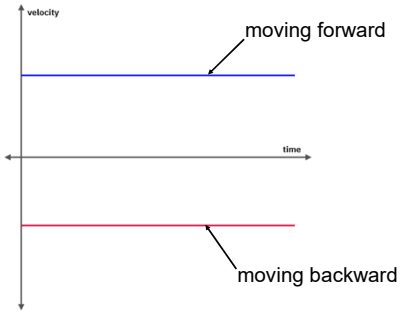
- Describe the motion



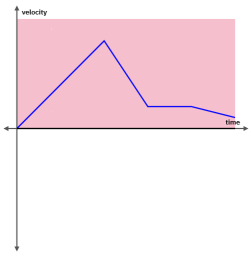
Velocity – Time Graphs



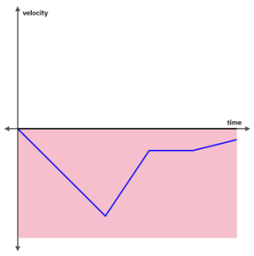
- Constant velocity is shown by a flat line.
  - Positive values are moving forward.
  - Negative values are moving backward.



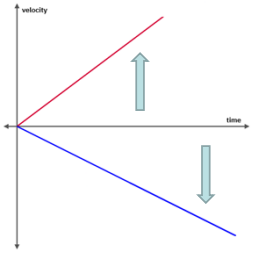
- Positive values represent motion in the positive direction (forward).

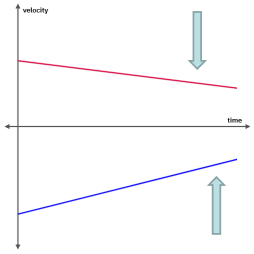


- Negative values represent motion in the negative direction (backward).

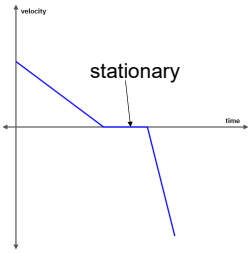


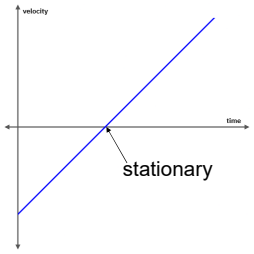
- Speeding up is shown as moving away from the time axis.
- Slowing down is shown as moving towards the time axis.





- The object is stationary when the velocity is equal to zero.





- Describe the motion