Displacement.

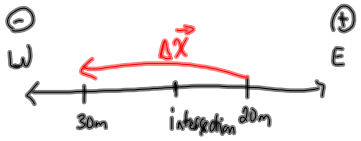
Example

A car starts from a position 20m east of an intersection and stops 30 m west of the intersections.

a) what distance does it travel?

b) what is its displacement?

a) $d = 50m$



b) $\Delta\vec{x} = \vec{x}_2 - \vec{x}_1$

$\Delta\vec{x} = -30m - 20m$

$\Delta\vec{x} = -50m$

$\Delta\vec{x} = 50m\,[W]$

Example

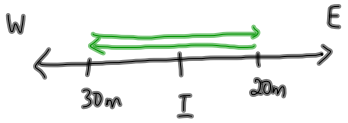
A car starts from a position 20m east of an intersection, travels to a position 30m west of the intersection, and then returns to its original position 20 m east of the intersection

a) what distance did the car travel?

b) what is the displacement?

a) $d = 100m$

b) $\Delta\vec{x} = 0$

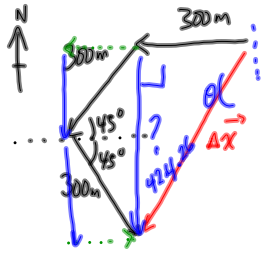


Example

A car travels 300m west, then 300m southwest, then 300m south east.

a) what distance does it travel? 900m

b) what is its displacement?



$c^2 = a^2 + b^2$

$c^2 = (300m)^2 + (300m)^2$

$c = 424.26\,m$

$c^2 = a^2 + b^2$

$c^2 = (300m)^2 + (424.26m)^2$

$c = 519.615\,m$

$\tan\theta = \frac{424.26}{300}$

$\theta = 54.7°$

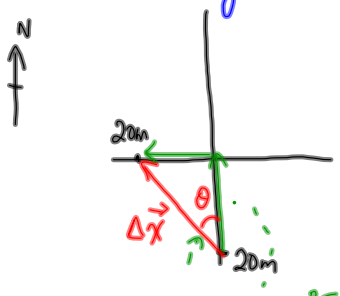
Speed and Velocity

Example

A car starts from a position 20m south of an intersection, travels north until it reaches the intersection, and then travels west to a position 20 m west of the intersection, in a time of 10s.

a) What is its average speed?

b) What is its average velocity?



$c^2 = a^2 + b^2$

$c^2 = (20m)^2 + (20m)^2$

$c = 28m$

a) $V_{ave} = \frac{d}{\Delta t}$

$V_{ave} = \frac{40m}{10s}$

$V_{ave} = 4 ms^{-1}$

b) $\vec{V}_{ave} = \frac{\Delta \vec{x}}{\Delta t}$

$\vec{V}_{ave} = \frac{28m\ [N45°W]}{10s}$

$\vec{V}_{ave} = 2.8 ms^{-1}\ [N45°W]$

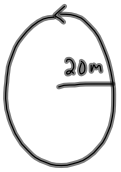
$315°T$

Example

A girl on a bicycle rides once around a circle of radius 20m, arriving at her starting position after 15.0s.

a) What is her average speed?

b) What is her average velocity?



$\Delta t = 15.0s$

a) $V_{ave} = \frac{d}{\Delta t}$

$V_{ave} = \frac{2\pi r}{\Delta t}$

$V_{ave} = \frac{2\pi (20m)}{15.0s}$

$V_{ave} = 8.4 ms^{-1}$

b) $\vec{V}_{ave} = 0$

Acceleration

Acceleration occurs if the speed and/or direction changes during a given time interval.

Examples

- a car moves off in a straight line from the traffic lights.
- a car slows down & stops at the lights
- a car travels at a constant speed around a circle.
- a car moves faster & faster around a circle
- a car slows down, stops, reverses and gets faster & faster going backwards.

Example

A car increases its velocity from $30\ ms^{-1}$ east ($\vec{V}_1$) to $40\ ms^{-1}$ east ($\vec{V}_2$) in 5.0s (Δt). What is its acceleration?

$\vec{V}_1 = 30 ms^{-1}$ east

$\vec{V}_2 = 40 ms^{-1}$ east

$\Delta t = 5.0s$

$a = ?$

$$\vec{a} = \frac{\Delta \vec{V}}{\Delta t}$$

$$\vec{a} = \frac{\vec{V}_2 - \vec{V}_1}{\Delta t}$$

these must be the same to subtract numerically

$$\vec{a} = \frac{40 ms^{-1}\ \text{east} - 30 ms^{-1}\ \text{east}}{5.0s}$$

$$\vec{a} = \frac{10 ms^{-1}\ \text{east}}{5.0s}$$

$$\vec{a} = 2.0\ ms^{-2}\ \text{east}$$

Example

A car decreases it velocity from $40 ms^{-1}$ east to $30 ms^{-1}$ east in 5.0s. What is its acceleration?

$\vec{V}_1 = 40 ms^{-1}$ east

$\vec{V}_2 = 30 ms^{-1}$ east

$\Delta t = 5.0s$

$\vec{a} = ?$

$$\vec{a} = \frac{\Delta \vec{v}}{\Delta t}$$

$$\vec{a} = \frac{30 ms^{-1} \text{ east} - 40 ms^{-1} \text{ east}}{5.0s}$$

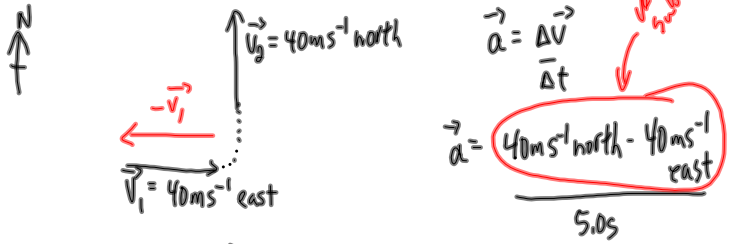
$$\vec{a} = \frac{-10 ms^{-1} \text{ east}}{5.0s}$$

$$\vec{a} = -2.0 ms^{-2} \text{ east}$$

or $2.0 ms^{-2}$ west.

Example

A car changes its velocity from $40 ms^{-1}$ east to $40 ms^{-1}$ north in 5.0s. What is its acceleration?



$$\vec{a} = \frac{\Delta \vec{v}}{\Delta t}$$

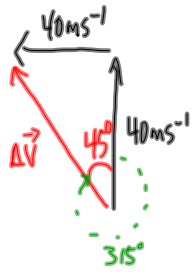
vector subtraction

$$\vec{a} = \frac{40 ms^{-1} \text{ north} - 40 ms^{-1} \text{ east}}{5.0s}$$

$$\Delta \vec{v} = \vec{V}_2 - \vec{V}_1$$

$$\Delta \vec{v} = \vec{V}_2 + (-\vec{V}_1)$$

$$\Delta \vec{v} = 40 ms^{-1} \text{ north} + 40 ms^{-1} \text{ west}$$



$$c^2 = a^2 + b^2$$

$$c^2 = (40 ms^{-1})^2 + (40 ms^{-1})^2$$

$$c \doteq 57 ms^{-1}$$

or 315°T

$$\therefore \Delta \vec{v} = 57 ms^{-1} \text{ [NW]}$$

$$\vec{a} = \frac{57 ms^{-1} \text{ [NW]}}{5.0s}$$

$$\vec{a} \doteq 11 ms^{-2} \text{ [NW]}$$