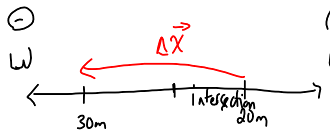
Displacement.

Example

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

a) what distance does it travel?

b) what is its displacement?



a) $d = 50\text{m}$

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

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

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

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

Example

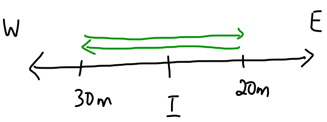
A car starts from a position 20m east of an intersection, travels to a position 30m west of the intersection, and then returns to its original position 20 m east of the intersection.

a) what distance did the car travel?

b) what is the displacement?

a) $d = 100\text{m}$

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

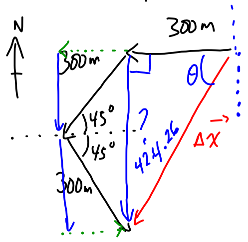


Example

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

a) what distance does it travel? 900m

b) what is its displacement?



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

$c^2 = (300\text{m})^2 + (300\text{m})^2$

$c = 424.26\text{ m}$

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

$c^2 = (300\text{m})^2 + (424.26\text{m})^2$

$c = 519.615\text{ m}$

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

$\theta = 54.7°$

The displacement is: $5.20 \times 10^2\text{ m}$ [W 54.7°S]

215°T

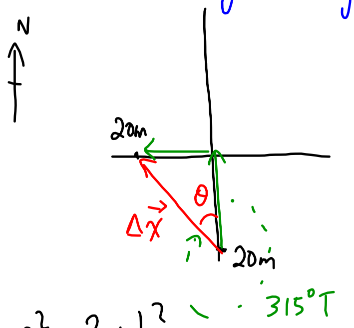
Speed and Velocity

Example

A car starts from a position 20 m 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 10 s.

a) What is its average speed?

b) What is its average velocity?



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

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

$c = 28\,m$

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

$v_{ave} = \frac{40\,m}{10\,s}$

$v_{ave} = 4\,ms^{-1}$

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

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

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

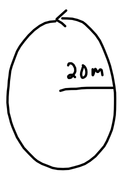
315°T

Example

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

a) What is her average speed?

b) What is her average velocity?



$\Delta t = 15.0\,s$

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

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

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

$v_{ave} = 8.4\,ms^{-1}$

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 5.0 s (Δt). What is its acceleration?

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

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

$\Delta t = 5.0\,s$

$\vec{a} = ?$

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

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

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

these must be the same to subtract numerically.

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

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

m/s/s

m/s^2

Example

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

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

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

$\Delta t = 5.0\ s$

$\vec{a} = ?$

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

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

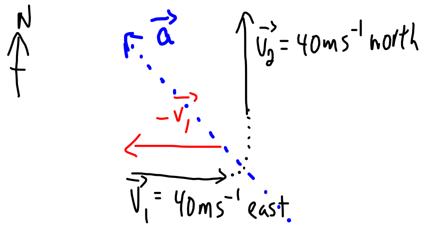
$$\vec{a} = \frac{-10\ ms^{-1}\ \text{east}}{5.0\ s}$$

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

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

Example

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



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

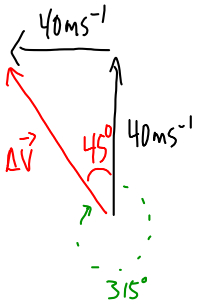
vector subtraction

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

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

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

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



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

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

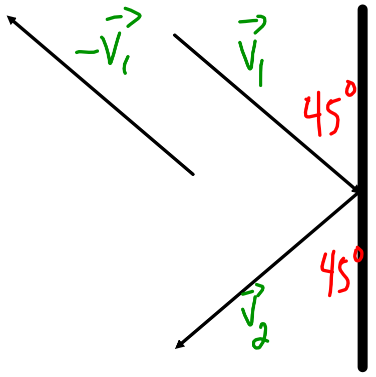
$c \doteq 57\ ms^{-1}$

$\therefore \Delta \vec{v} = 57\ ms^{-1}$ [NW] ← or 315°T

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

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

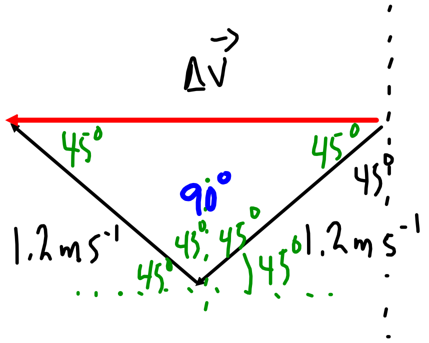
Example:
A billiard ball travelling at 1.2 m s^{-1} bounces off the edge of the table with no change in speed, with directions as shown below. The ball is in contact with the edge of the table for 5.0 x 10^{-3} s. What is the acceleration of the billiard ball?



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

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

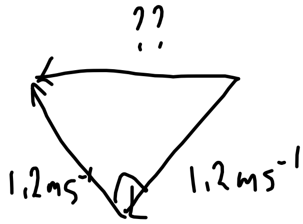
$$\vec{a} = \frac{\vec{v}_2 + (-\vec{v}_1)}{\Delta t}$$



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

$$c^2 = (1.2)^2 + (1.2)^2$$

$$c = 1.7 \text{ m s}^{-1}$$



$$\vec{a} = \frac{1.7 \text{ m s}^{-1}}{5.0 \times 10^{-3} \text{ s}}$$ [directly away from table edge]

$$\vec{a} \doteq 3.4 \times 10^{2} \text{ m s}^{-2}$$ [directly away from the table edge]