Kinematics

The study of motion - how objects move

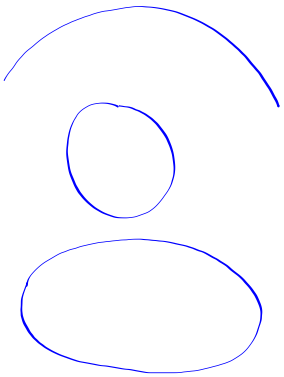
Trajectories - The path an object takes

Motion: 2 types i) Rectilinear
ii) Non-Rectilinear

Rectilinear - Motion in a straight line
Ex. Walking, Running, Jump up & down, Falling objects

Uniform → constant velocity
Non-uniform → velocity changes
↓
acceleration present
↙ ↘
Constant a non-uniform a

Non-Rectilinear
1.) Curvilinear - Parabolic
- Circular
- Elliptical



2.) Random

Motion in a Straight Line

Scalar vs Vector

Magnitude

i) Speed - 80km/hr

ii) Distance

iii) Time

iv.) Mass

v.) Temperature

Magnitude & Direction

i) Velocity 80km/hr N

80km/hr [45°]

80km/hr [N26W]

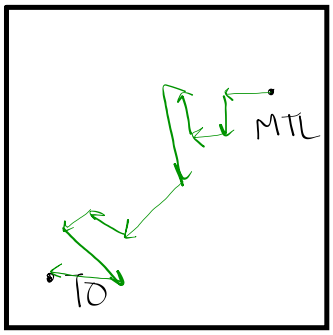
ii) Displacement

iii) Acceleration

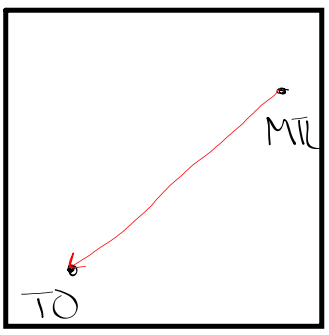
iv) Force

Distance vs Displacement

Ex. MTL to TO = 600km

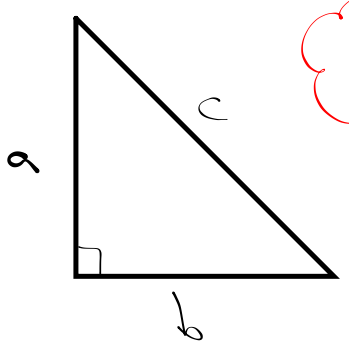


MTL to TO = 500 km SW



Recall:

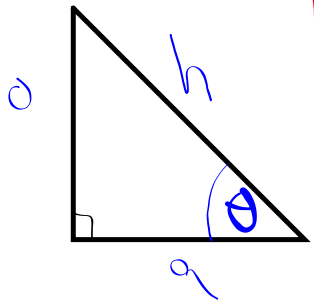
Pythagorean's Theorem



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

$$c=\sqrt{a^2+b^2}$$

Trigonometry



$$\sin\theta=\frac{o}{h} \quad \text{SOH}$$

$$\cos\theta=\frac{a}{h} \quad \text{CAH}$$

$$\tan\theta=\frac{o}{a} \quad \text{TOA}$$

Ex. A car travels 20km E then 50 km N.

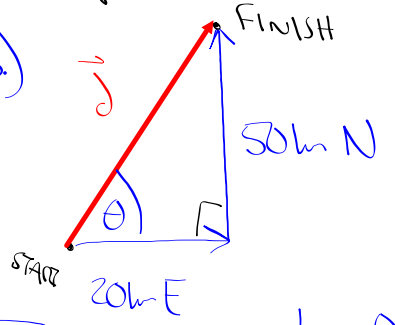
A.) What is the distance travelled?

B.) What is the displacement?

A.) $d = 20 + 50$

$d = 70\text{km}$

B.)



$\vec{d} = \sqrt{20^2 + 50^2}$

$\vec{d} = \sqrt{2900}$

$\vec{d} = 53.9\text{km}$

$\tan\theta = \frac{o}{a}$

$\tan\theta = \frac{50}{20}$

$\tan\theta = 2.5$

$\theta = \tan^{-1}(2.5)$

$\theta = 68.2°$

$\vec{d} = 53.9\text{km}\ [E\ 68.2°\ N]$

Speed vs Velocity

scalar

vector

speed = distance / time

$$v = \frac{d}{t}$$

velocity = displacement / time

$$\vec{v} = \frac{\vec{d}}{t}$$

Units: km/hr or m/s

Note: 1 km = 1000 m

÷1000

×1000

1 hr = 60 min = 3600 s

÷3600

÷60 ÷60

×60 ×60

×3600

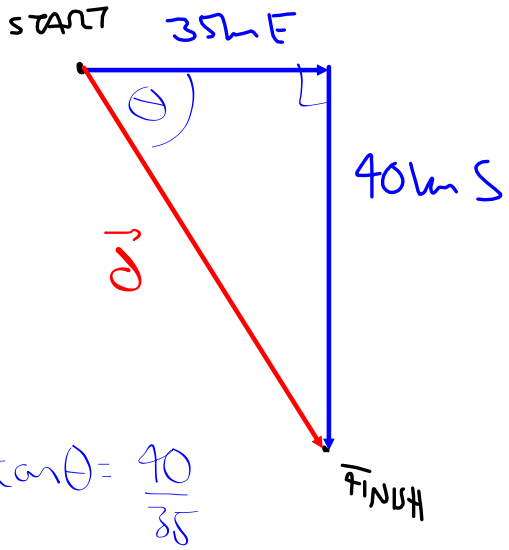
Ex. Rick goes for a 75 min drive to find Morty. He travels 35km E then 40km S.

A) Distance?

B) Displacement?

C) Speed?

D) Velocity?



A.) $d = 35 + 40$

$d = 75\text{km}$

B.) $\vec{d} = \sqrt{35^2 + 40^2}$ $\tan\theta = \frac{40}{35}$

$\vec{d} = 53.2\text{km}$ $\theta = 48.8°$

$\vec{d} = 53.2\text{km}\,[E\,48.8°\,S]$

C.) $t = 75\text{ min} \div 60$

$t = 1.25\text{hr}$

$v = \frac{d}{t} = \frac{75\text{km}}{1.25\text{hr}}$

$v = 60\text{km/hr}$

D.) $\vec{v} = \frac{\vec{d}}{t} = \frac{53.2\text{km}\,[E\,48.8°\,S]}{1.25\text{hr}}$

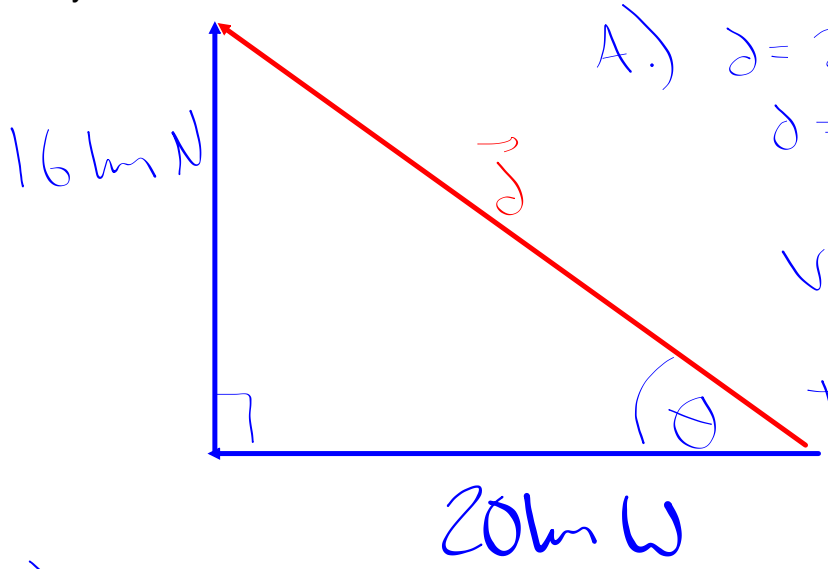
$\vec{v} = 42.6\text{km/hr}\,[E\,48.8°\,S]$

Ex. Captain Marvel is going for a walk. First she travels 20km W and then climbs a mountain 16km straight up. She completes this task in 30 min and is recruited into the Avengers.

$t = 0.5\ hr$

A) Speed? (Answer in km/hr)

B) Velocity?



A.) $d = 20 + 16$

$d = 36km$

$v = \frac{d}{t} = \frac{36km}{0.5hr}$

$v = 72km/hr$

B.) $\vec{d} = \sqrt{20^2 + 16^2}$ $\quad \tan\theta = \frac{16}{20}$

$\vec{d} = 25.6km$ $\quad \theta = 38.7°$

$\vec{d} = 25.6km\ [W\ 38.7°\ N]$

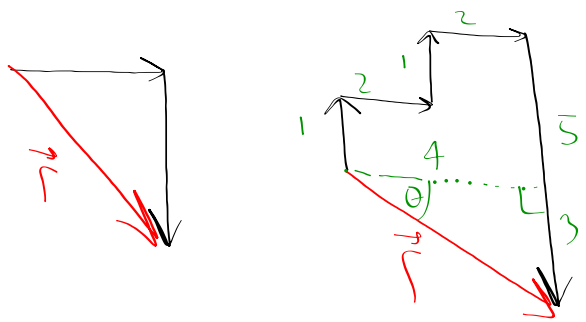
$\vec{v} = \frac{\vec{d}}{t} = \frac{25.6km\ [W\ 38.7°\ N]}{0.5hr}$

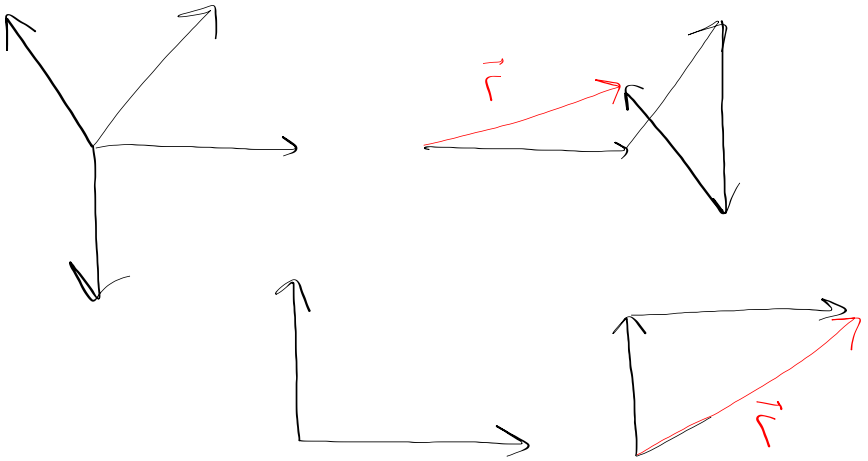
$\vec{v} = 51.2km/hr\ [W\ 38.7°\ N]$

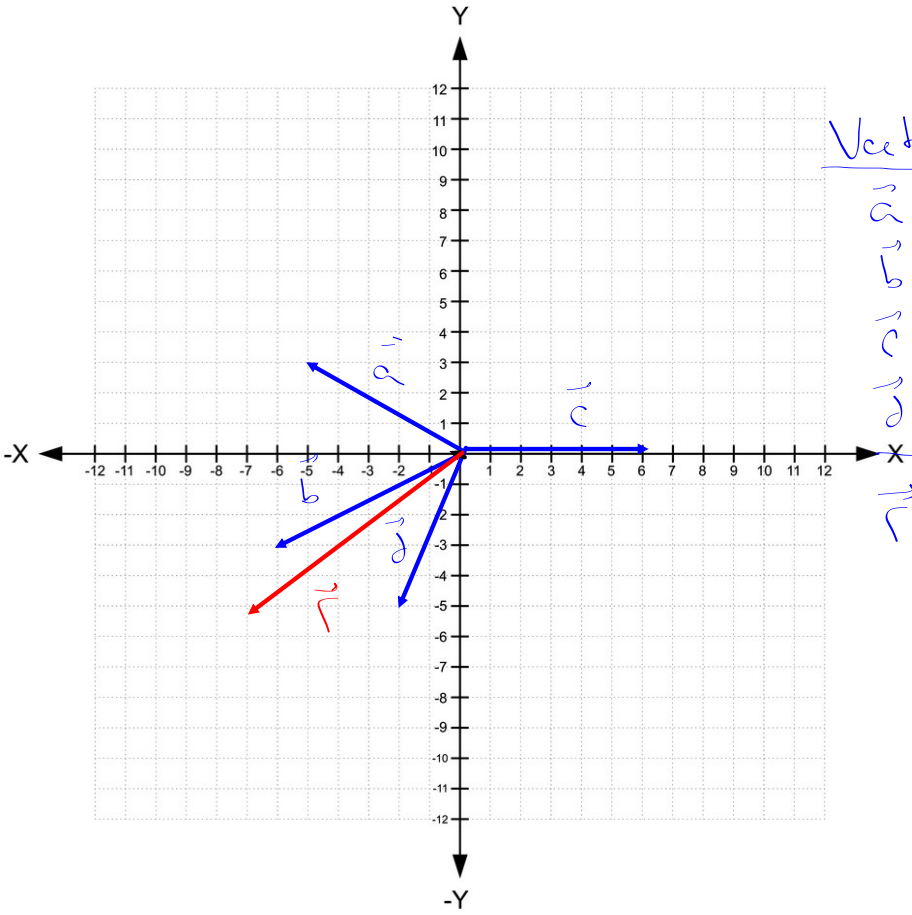
Note: In general

Distance ≥ Displacement

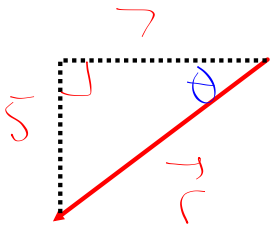
Drawing Vectors







Vector	x	y
$\vec{a}$	-5	3
$\vec{b}$	-6	-3
$\vec{c}$	6	0
$\vec{d}$	-2	-5
$\vec{r}$	-7	-5



$\vec{r} = \sqrt{7^2+5^2}$

$\vec{r} = 8.6 \text{ units}$

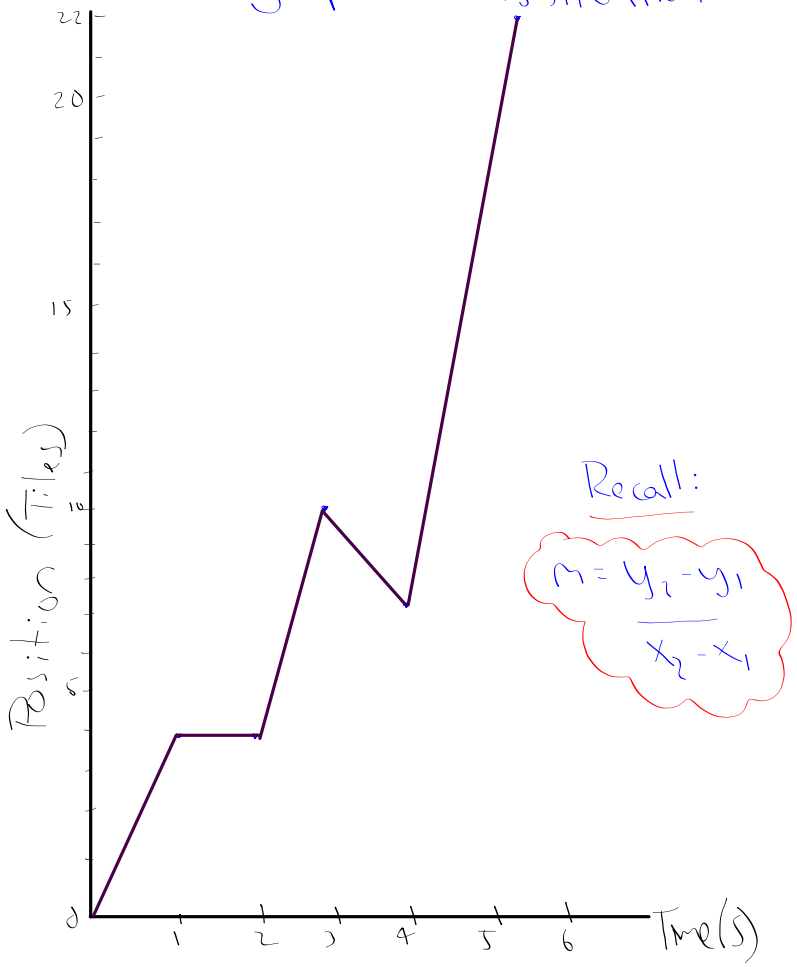
$\theta = \tan^{-1}\left(\frac{5}{7}\right)$

$\theta = W\,35.5^\circ S$

$\vec{r} = 8.6 \text{ units}[W\,35.5^\circ S]$

Position Tiles	seconds Time
4	1.0
0	2.0
6	3.0
-3	4.0
15	5.0

Task 1: Create a Position vs Time graph of this situation



Recall:

$$m = \frac{y_2 - y_1}{x_2 - x_1}$$

$t = 0\text{-}1s$ $m = \frac{4-0}{1-0}$ $m = 4$ tiles/s

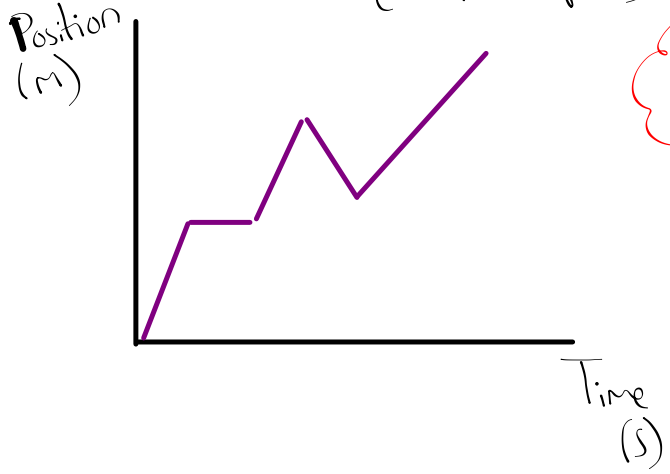
$t = 1\text{-}2s$ $m = \frac{4-4}{2-1}$ $m = 0$ tiles/s

$t = 2\text{-}3s$ $m = \frac{10-4}{3-2}$ $m = 6$ tiles/s

$t = 3\text{-}4s$ $m = \frac{7-10}{4-3}$ $m = -3$ tiles/s

$t = 4\text{-}5s$ $m = \frac{22-7}{5-4}$ $m = 15$ tiles/s

Position-Time Graphs (P-T Graphs)



Slope = Velocity

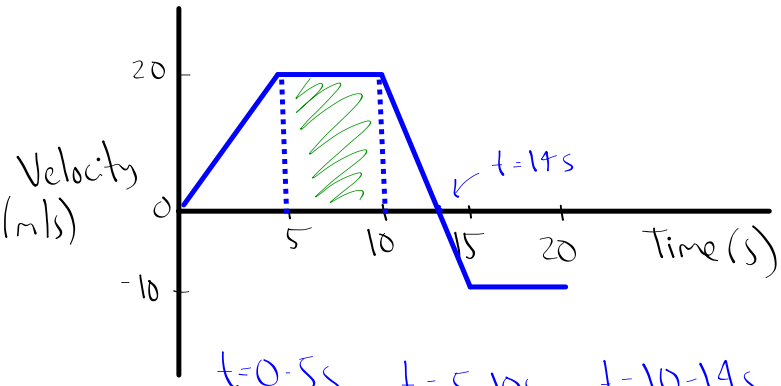
$m = \frac{y_2 - y_1}{x_2 - x_1} \rightarrow \frac{\vec{d}}{t} = \vec{v}$

Pos$^+$ slope = moving forward

Neg slope = moving backwards

Zero slope = Stopped moving

Velocity-Time Graph (V-T Graph)



Acceleration = $\frac{\text{Velocity}}{\text{Time}}$ = slope!

$\frac{m}{s} \div s$

$\frac{m}{s} \times \frac{1}{s}$

$\frac{m}{s^2}$ ← Units for acceleration

t = 0-5 s	t = 5-10 s	t = 10-14 s
$m = \frac{20-0}{5-0}$	$m = \frac{20-20}{10-5}$	$m = \frac{0-20}{14-10}$
$m = 4\ m/s^2$	$m = 0\ m/s^2$	$m = -5\ m/s^2$
Speeding up	Constant speed!	slowing down

Area Under the Curve = Displacement