Vectors & Scalars

Vectors & Scalars

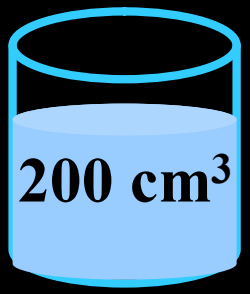
- **Scalars … have magnitude only**
- **Vectors ... have magnitude and direction**

Examples

Scalars	Vectors
Volume	Force
Time	Velocity
Energy	Acceleration

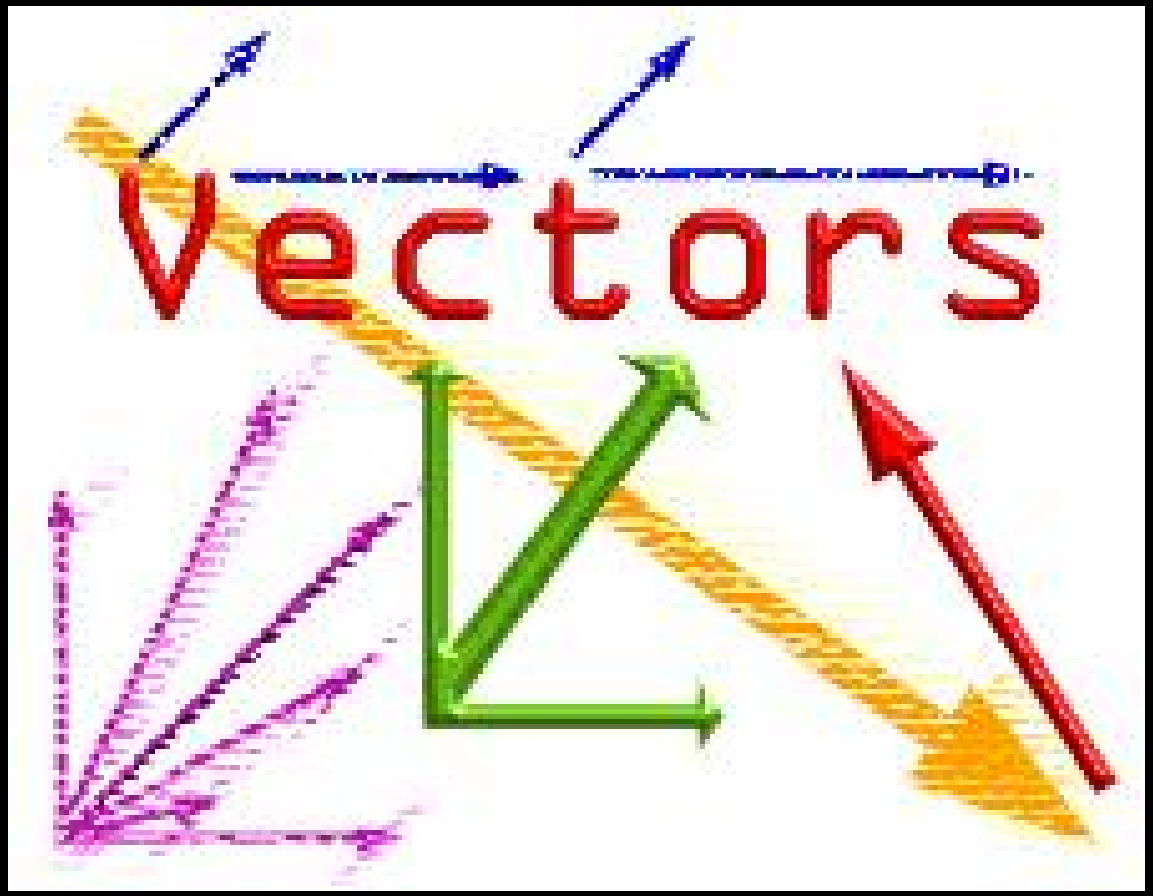
Scalars

Volume



Time **36 seconds**

Energy **250,000 J**


Vectors

Vectors

Displacement	**2 km north**
Velocity	**25 m s^{-1} north-west**
Acceleration	**9.8 m s^{-2} vertically down**

Which Are Vectors?
Which Are Scalars?

- Distance
- Displacement
- Speed
- Velocity
- Acceleration
- Momentum
- Force
- Density
- Pressure
- Power
- Temperature
- Electric Field Intensity
- Magnetic Flux Density
- Activity

Which Are Vectors?
Which Are Scalars?

- Distance
- Displacement
- Speed
- Velocity
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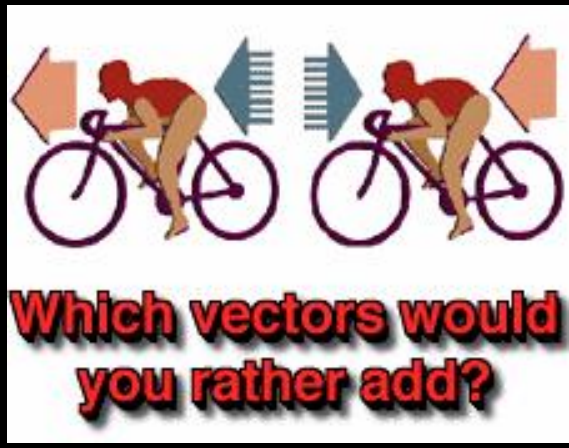
- Momentum
- Force
- Density
- Pressure
- Power
- Temperature
- Electric Field Intensity
- Magnetic Flux Density
- Activity

Adding



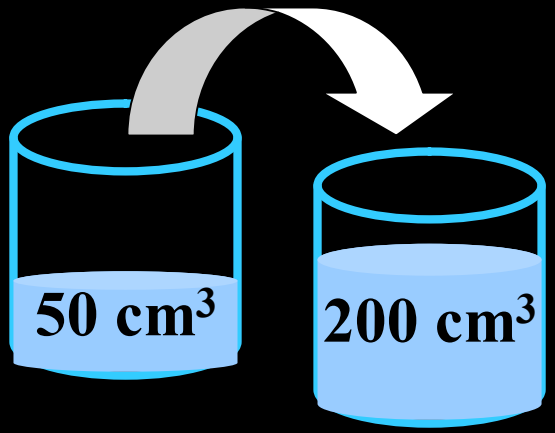
Scalars

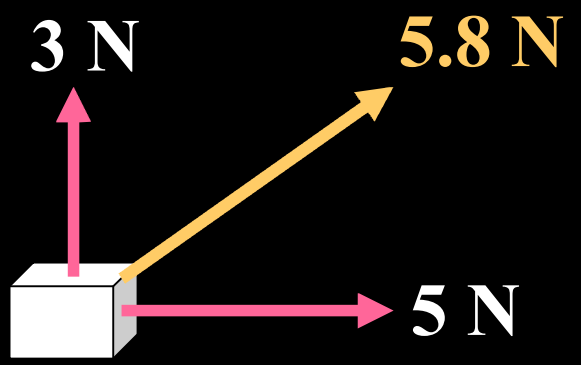
… Easy

Vectors

… more difficult

… due to direction





Summary …

Scalar = ??

Vector = ??

2 Examples of a Scalar = ??

2 Examples of a Vector = ??

3 Important Vectors

Displacement

Velocity

Acceleration

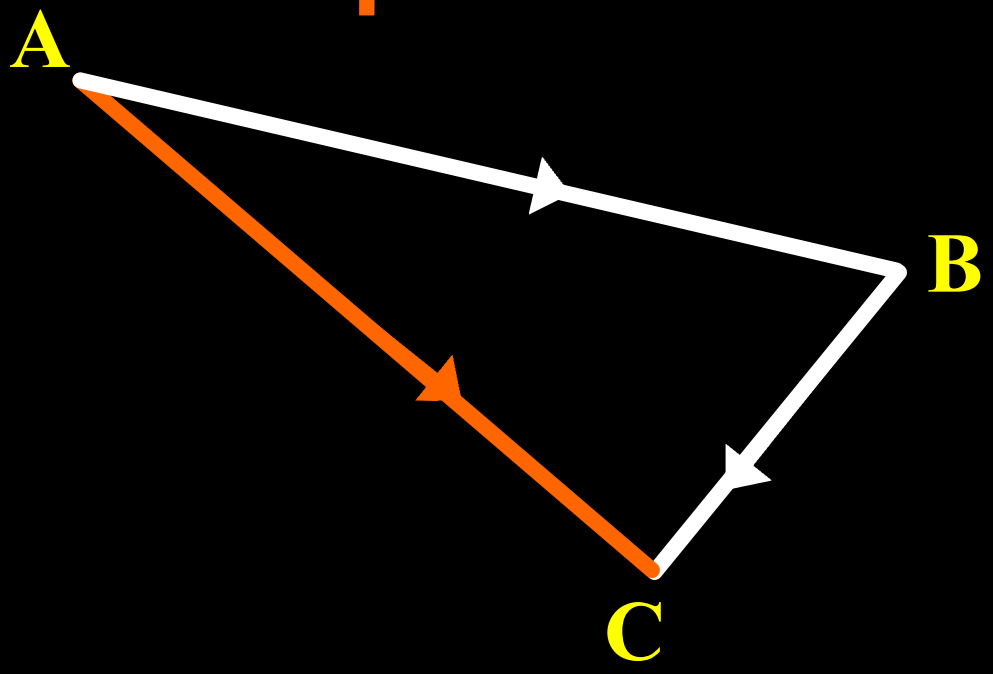
Displacement

Straight line distance and direction from one point to another

Symbol: *s*

Unit: metre (m)

Displacement



$A \rightarrow B \rightarrow C$

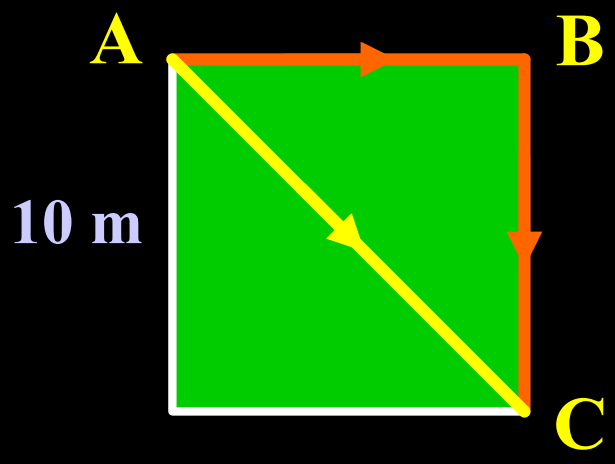
Distance = ??

Displacement = ??

Distance = AB + BC

Displacement = AC (magnitude & direction)

Grass & Path



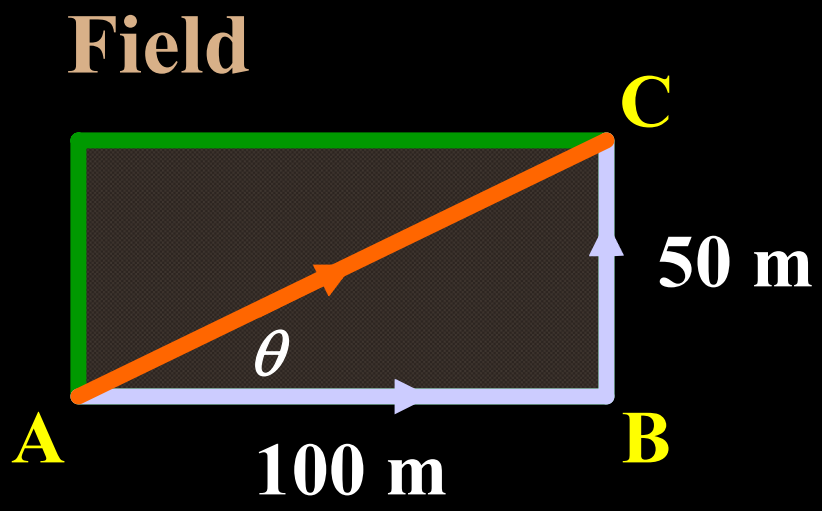
$A \rightarrow B \rightarrow C$

Distance = ??

Displacement = ??

Distance = 20 m

Displacement = $\sqrt{200}$ m, E45°S



$A \rightarrow B \rightarrow C$

Distance = ??

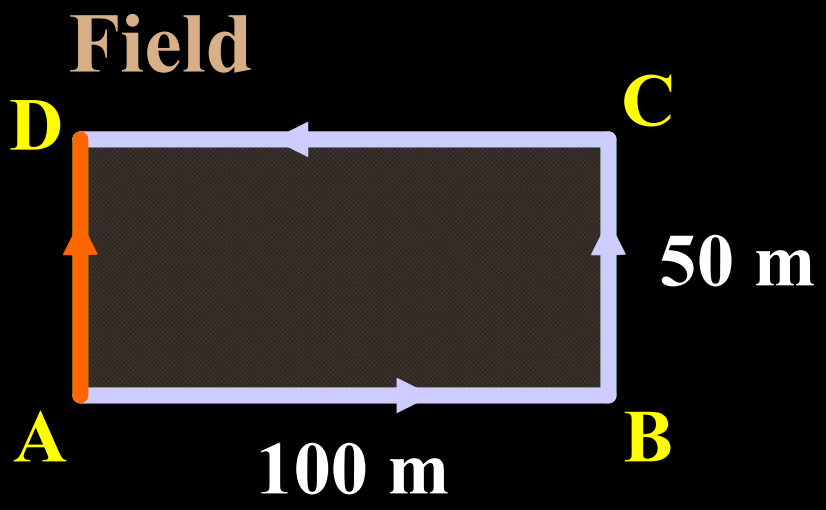
Displacement = ??

Distance = 150 m

$$Displacement = s = \sqrt{100^2 + 50^2} = 112\ m$$

$$\tan\theta = \frac{50}{100} = 0.50 \Rightarrow \theta = 26.6°$$

E 26.6° N



$A \rightarrow B \rightarrow C \rightarrow D$

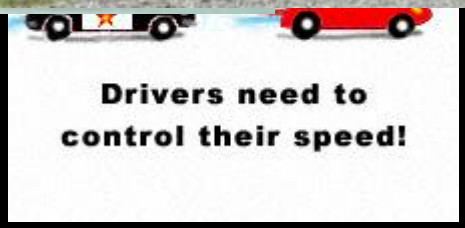
Distance = ??

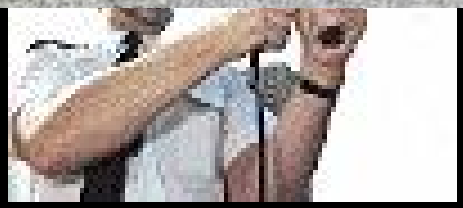
Displacement = ??

Distance = 250 m

Displacement = 50 m
North

SPEED



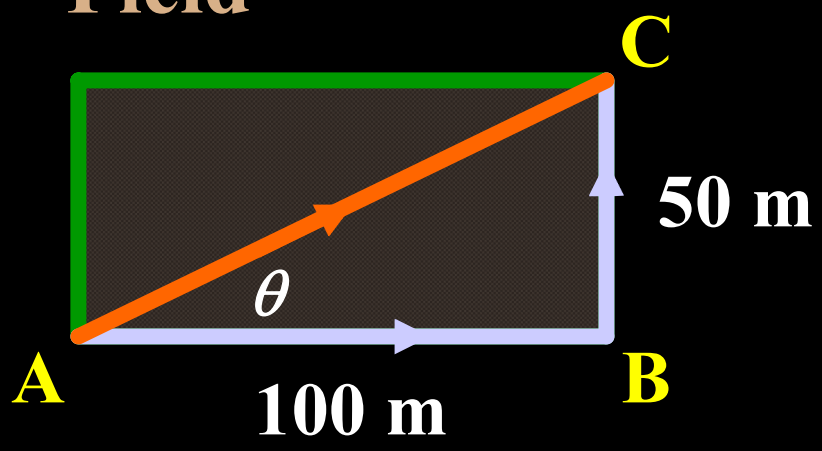


Velocity

- **Rate of change of displacement (w.r.t. time)**
- **Displacement in unit time**
- **Velocity = displacement ÷ time**

- **Symbols:** u / v
- **Units:** $m\ s^{-1}$

Field



It takes 2 minutes to go from A to B to C.

Speed = ??

Velocity = ??

Speed = distance ÷ time

= 150 ÷ 120 = 1.25 m s^{-1}

Velocity = displacement ÷ time

= 112 ÷ 120 = 0.93 m s^{-1}

E 26.6° N

Acceleration

- **Rate of change of velocity (w.r.t. time)**
- **Change in velocity in unit time**
- **Acceleration = (change in velocity) ÷ time**

- **Symbol: a**
- **Units: $m\ s^{-2}$**

The velocity of a car increases from 5 m s^{-1} N to 25 m s^{-1} N in 10 s.

Calculate the acceleration of the car.

a = (change in velocity) ÷ time

a = (25 - 5) ÷ 10

a = + 2.0 m s^{-2}

2.0 m s^{-2} N

Acceleration Due To Gravity

$g = 9.8 \text{ m s}^{-2}$

Velocity increases by 9.8 m s^{-1} every second

Equations Of Motion

$v = u + at$

$s = ut + \frac{1}{2}at^2$

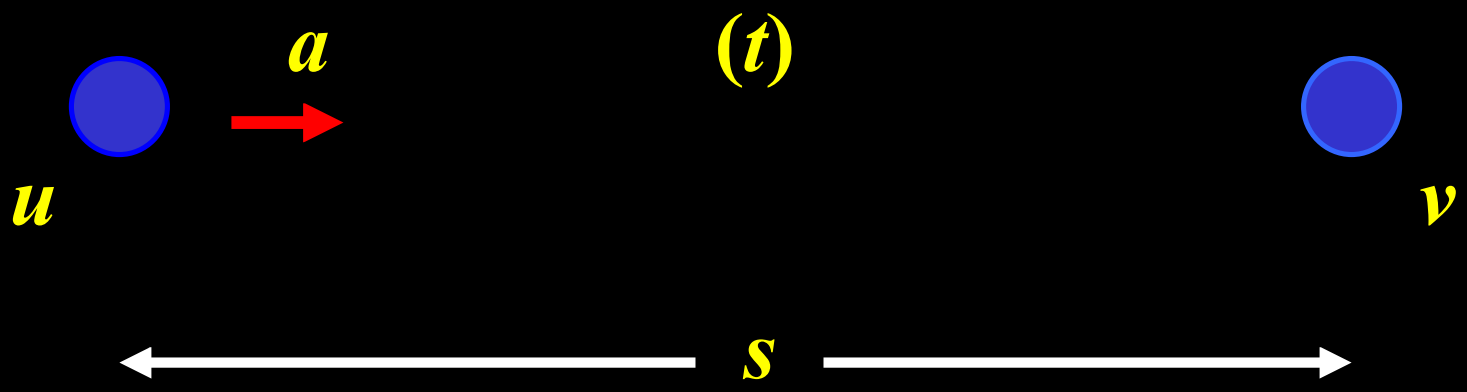
$v^2 = u^2 + 2as$

a = acceleration

u = initial velocity

v = final velocity

s = displacement t = time

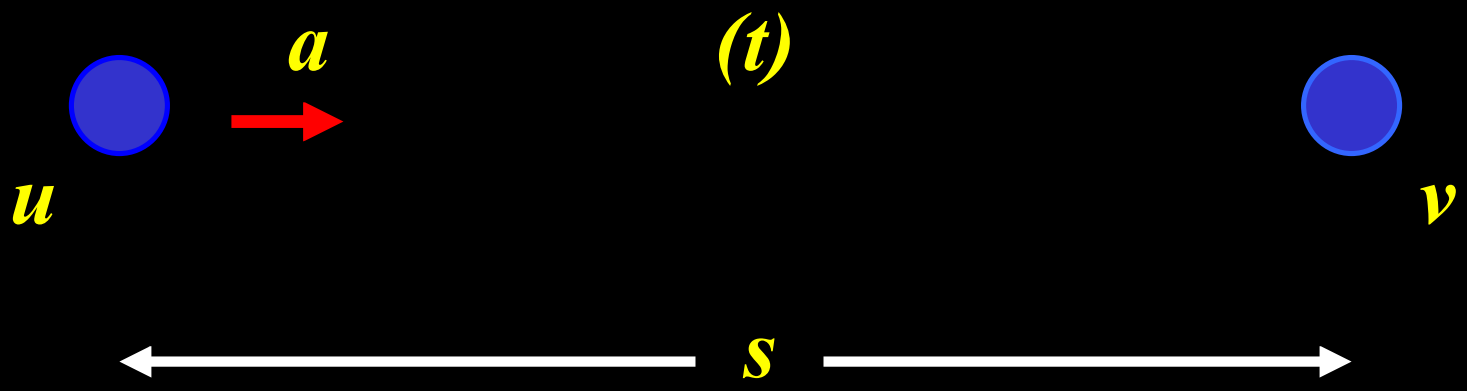


Deriving $v = u + at$

a = change in velocity ÷ time

$a = (v - u) \div t$

$v = u + at$



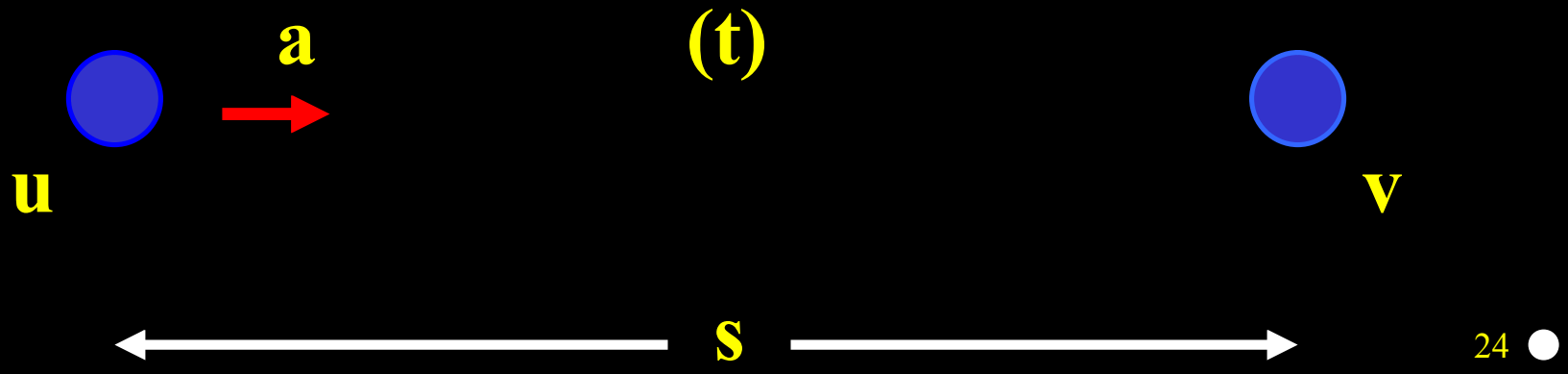
Deriving: $s = ut + \frac{1}{2}at^2$

s = (average velocity) x time

$s = \frac{1}{2}(u + v)\,t$ **[average velocity = $\frac{1}{2}(u + v)$]**

$s = \frac{1}{2}(u + u + at)\,t$

$s = ut + \frac{1}{2}at^2$



Deriving: $v^2 = u^2 + 2as$

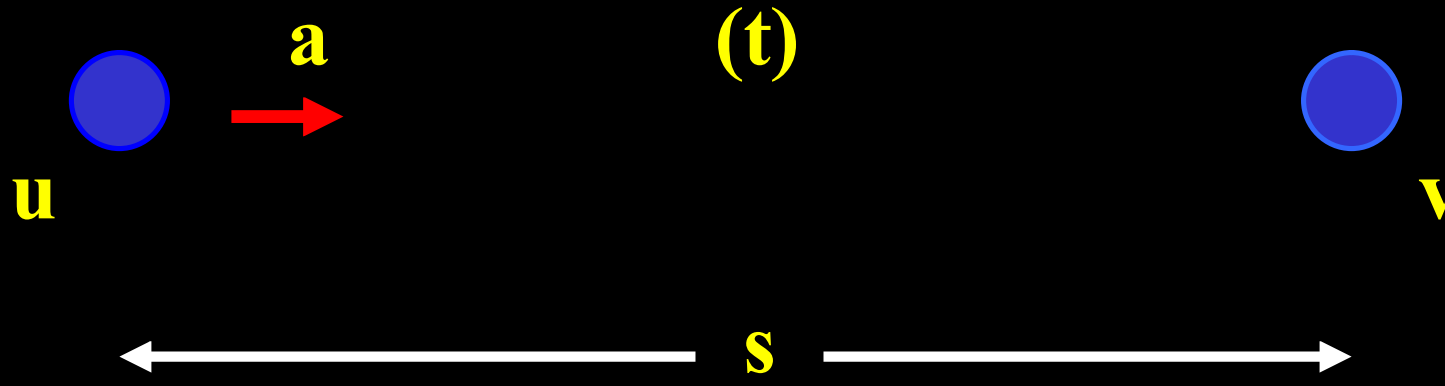
$v = u + at$

$v^2 = (u + at)^2$

$v^2 = u^2 + 2.u.at + a^2t^2$

$v^2 = u^2 + 2a(ut + \frac{1}{2}at^2)$

$v^2 = u^2 + 2as$



A car starts from rest and accelerates at 2.0 m s^{-2} east for 10 s.

Calculate, (i) the final velocity, (ii) the car's displacement.

East = + direction

$v = u + at$

$s = ut + \frac{1}{2}at^2$

$v^2 = u^2 + 2as$

(i) $v = u + at$

$\Rightarrow \quad v = 0 + (+2.0)(10) = 20 \text{ m s}^{-1}$

[20 m s^{-1}, E]

(ii) $s = ut + \frac{1}{2}at^2$

$\Rightarrow \quad s = 0 + \frac{1}{2}(+2.0)(10)^2 = +100 \text{ m}$

[100 m, E]

A car travelling at 25 m s^{-1} E slows to 10 m s^{-1} E over a distance of 100 m.
Calculate the acceleration of the car.

East = + direction

$$v^2 = u^2 + 2as$$

$$\Rightarrow \quad (+10)^2 = (+25)^2 + 2a(+100)$$

$$\Rightarrow \quad a = -2.6 \text{ m s}^{-2}$$

[2.6 m s^{-2}, W]

$v = u + at$
$s = ut + \frac{1}{2}at^2$
$v^2 = u^2 + 2as$

A stone is thrown vertically upwards from the ground with an initial velocity of 15 m s^{-1}. Calculate ...

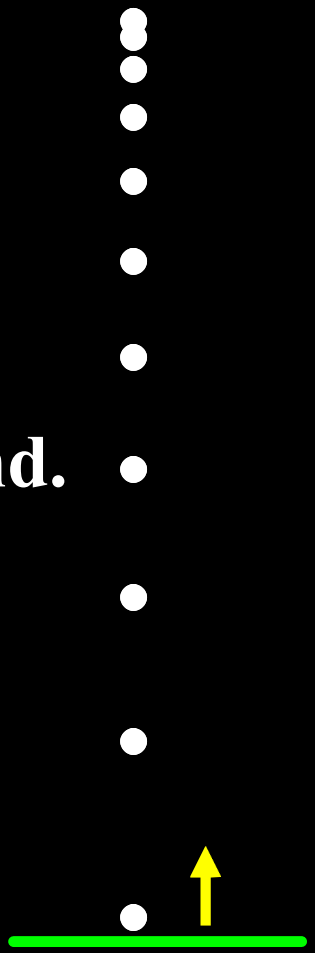
(i) the maximum height it reaches,

(ii) how long it takes to reach the highest point,

(iii) its height after 2.0 s,

(iv) its velocities when it is 5.0 m above the ground.

(Acceleration due to gravity = 9.8 m s^{-2}, vertically down)



A stone is thrown vertically upwards from the ground with an initial velocity of 15 m s^{-1}. Calculate ...

(i) the maximum height it reaches, (ii) how long it takes to reach the highest point, (iii) its height after 2.0 s, (iv) its velocities when it is 5.0 m above the ground. (Acceleration due to gravity = 9.8 m s^{-2}, vertically down)

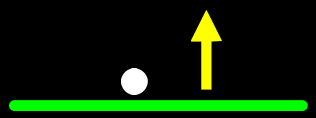
- **(i) Up = + direction** s **= ??**

  $u = +15$ m s^{-1}, $v = 0$, $a = -9.8$ m s^{-2}

  $v^2 = u^2 + 2as$ $\quad 0 = (15)^2 + 2(-9.8)s$

  $s = +11.5$ m

  [11.5 m above the ground]



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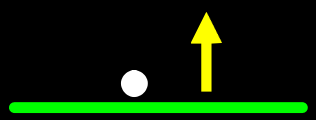
- (ii) Up = + direction t = ??

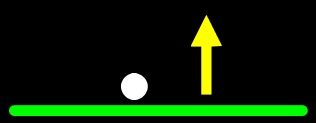
  u = + 15 m s^{-1}, v = 0, a = - 9.8 m s^{-2}

  $v = u + at$ $0 = (+15) + (-9.8)t$

  t = 1.5 s



A stone is thrown vertically upwards from the ground with an initial velocity of 15 m s^{-1}. Calculate (i) the maximum height it reaches, (ii) how long it takes to reach the highest point, (iii) its height after 2.0 s, (iv) its velocities when it is 5.0 m above the ground. (Acceleration due to gravity = 9.8 m s^{-2}, vertically down)



(iii) Up = + direction s = ??

u = + 15 m s^{-1}, t = 2.0 s, a = - 9.8 m s^{-2}

$s = ut + \frac{1}{2}at^2$

$s = (+15)(2.0) + \frac{1}{2}(-9.8)(2.0)^2$

s = +10.4 m

[10.4 m above ground]

A stone is thrown vertically upwards from the ground with an initial velocity of 15 m s^{-1}. Calculate (i) the maximum height it reaches, (ii) how long it takes to reach the highest point, (iii) its height after 2.0 s, (iv) its velocities when it is 5.0 m above the ground. (Acceleration due to gravity = 9.8 m s^{-2}, vertically down)

(iv) Up = + direction v = ??

u = + 15 m s^{-1}, s = +5.0 m, a = - 9.8 m s^{-2}

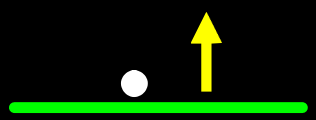
$v^2 = u^2 + 2as$

$v^2 = (+15)^2 + 2(-9.8)(5.0)^2$

$v^2 = 127$

$v = \pm 11.3$ m s^{-1}

11.3 m s^{-1} up & 11.3 m s^{-1} down



Summary ...

Definition		**Displacement**
Symbol	***for***	**Speed**
(Equation)		**Velocity**
Units		**Acceleration**

Equations of Motion = ??

Measuring Velocity & Acceleration

Powder Track Timer

Air Track Timer

Ticker Tape Timer

Powder Track Timer

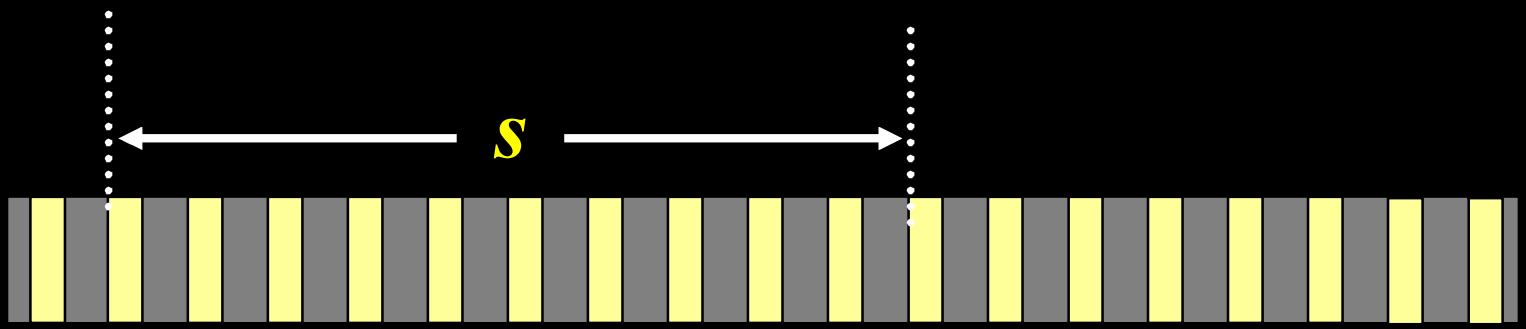
Trolley

Track

A.C. Power Supply

Sulphur Powder

PTT - Measuring Velocity

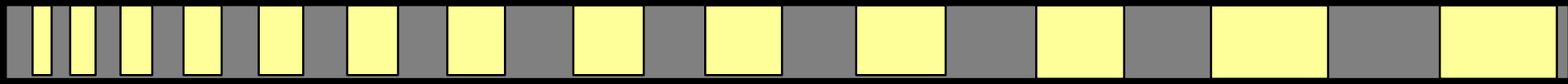


Velocity = spread of 10 patches ÷ (10 x 0.02)

or

velocity = average spread of patches ÷ 0.02

PTT - Measuring Acceleration



$v = u + at$

u = spread of 5 patches near the start ÷ (5 x 0.02)

v = spread of 5 patches near the end ÷ (5 x 0.02)

t = "n" x 0.02

PTT - Measuring Acceleration

or

$v^2 = u^2 + 2as$

u = spread of 5 patches near the start ÷ (5 x 0.02)

v = spread of 5 patches near the end ÷ (5 x 0.02)

s = distance from

middle of u patches to middle of v patches

PTT - Precautions

- **Wedge … to compensate for ??**
- ***u* and *v* well apart**
- **Repeat for other patches ...**
- **Velocity … use more than 10 patches**

Summary - Powder Track Timer

Parts (4) = ??

Why 0.02 s (1/50 s)?

Measuring Velocity

Pattern of patches ??

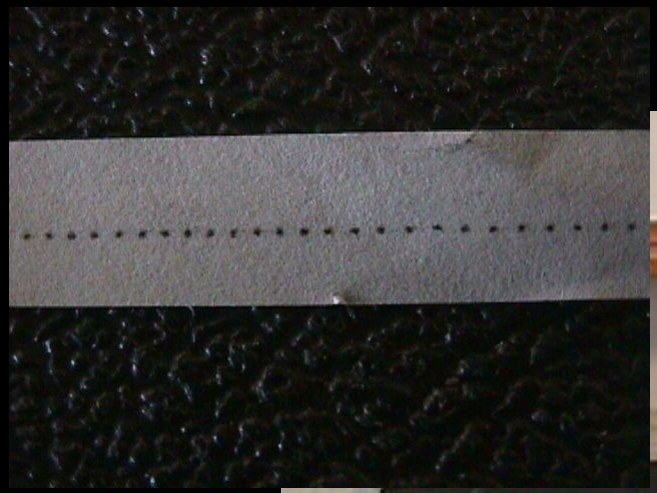
Equation = ??

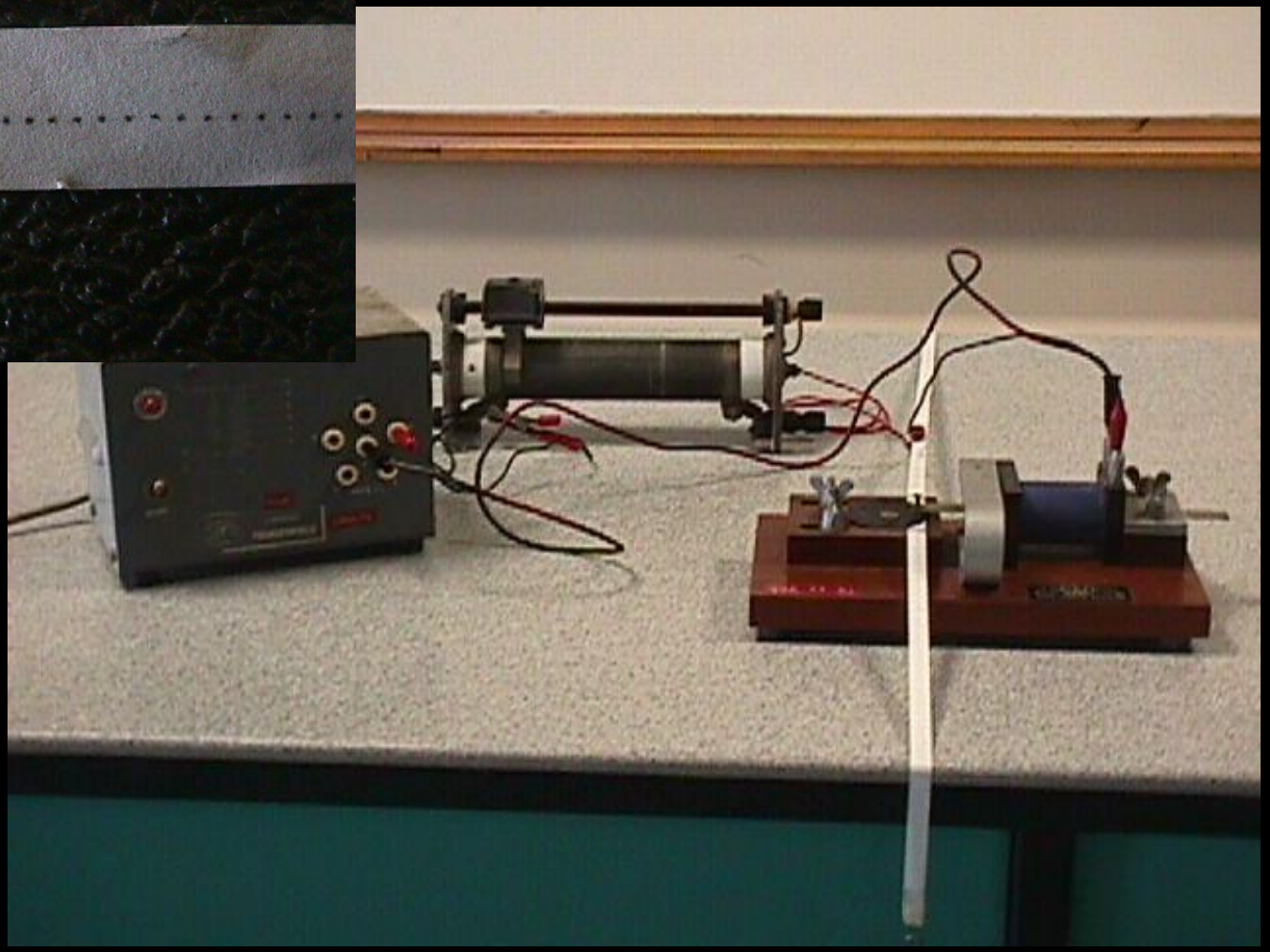
Measuring Acceleration

Pattern of patches ??

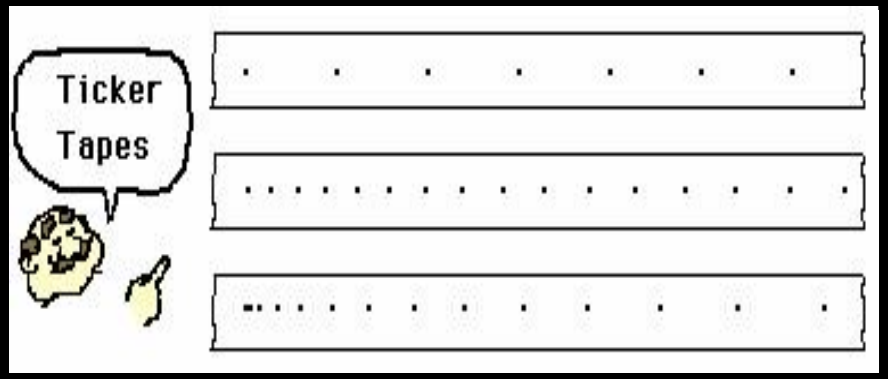
Equation = ??

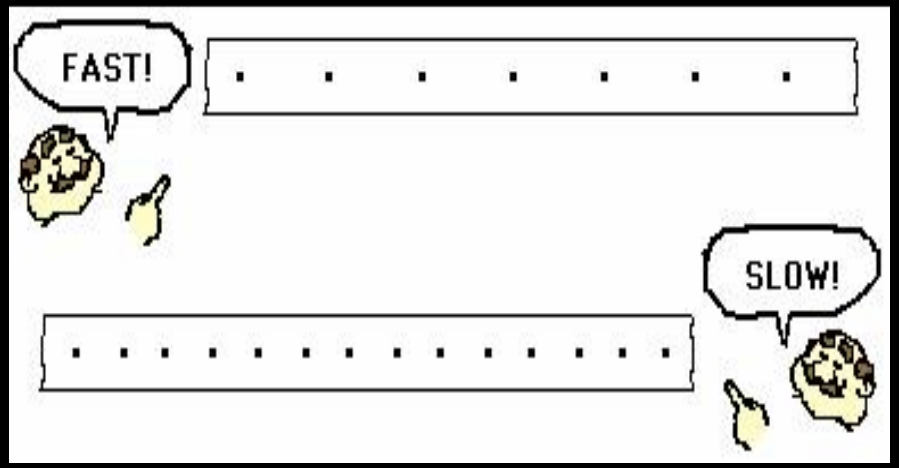
Ticker-Tape Timer

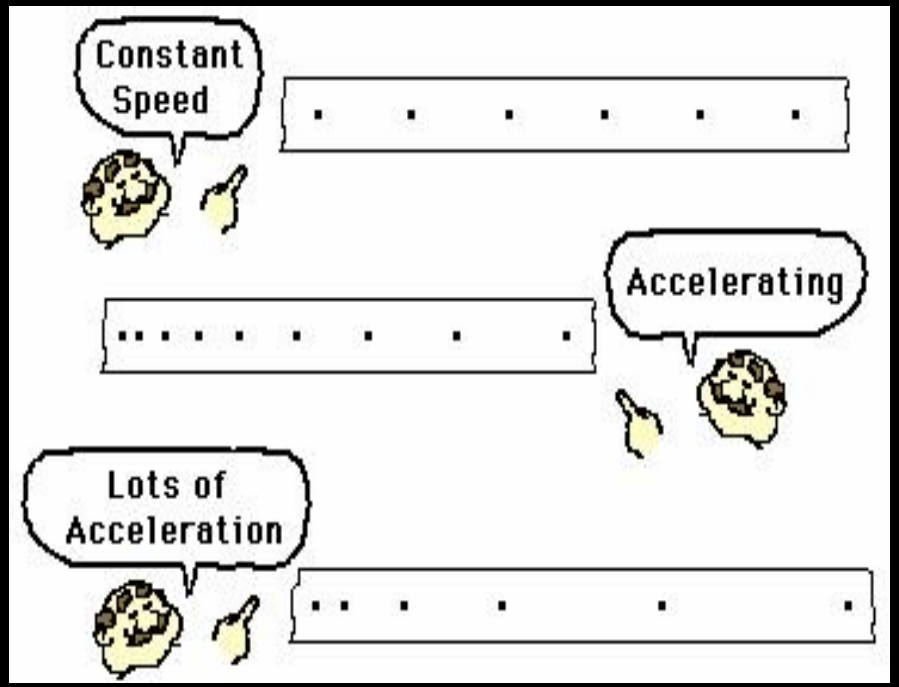




Ticker-Tape Timer

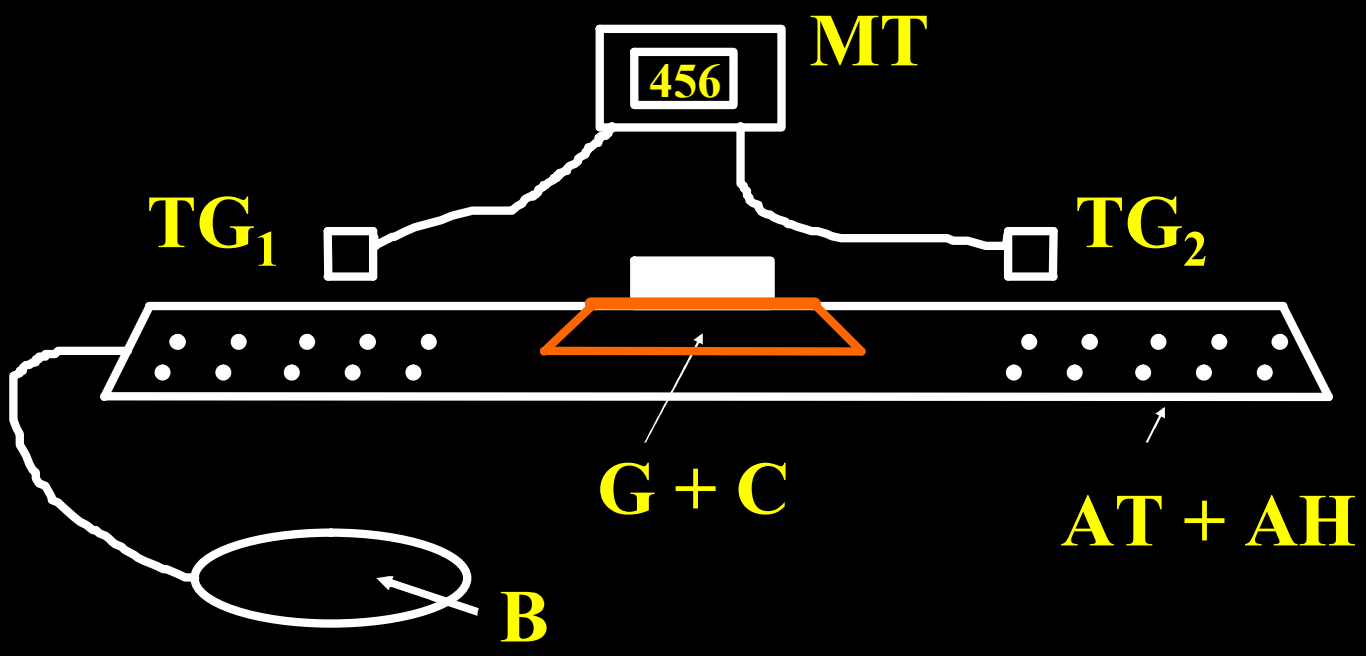






Air Track Timer

Air Track Timer



Air Track + Air Holes

Timing Gates

Blower

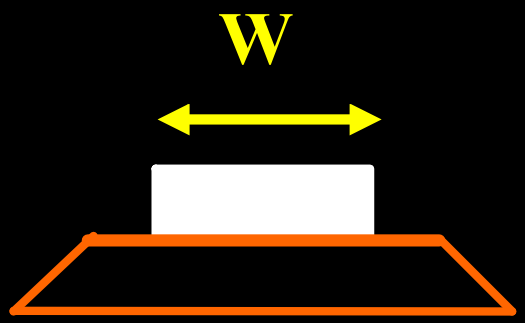
Glider + Card

Millisecond Timer

ATT - Measuring Velocity

Only one timing gate is needed.

Velocity = width of card (W) ÷ time



Precautions

- **Level track** **(How would you check it?)**
- **Strong enough air supply**

ATT - Measuring Acceleration

$v^2 = u^2 + 2as$

u = width of card ÷ time gate 1

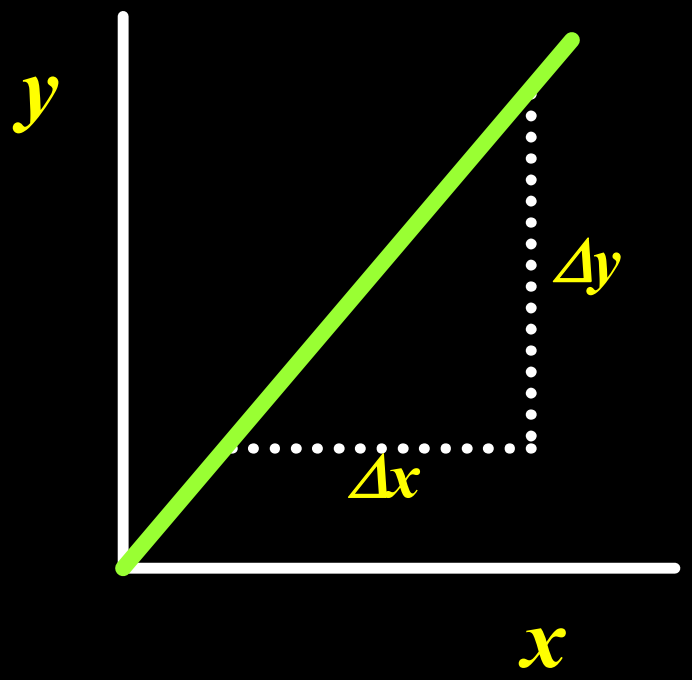
v = width of card ÷ time gate 2

s = distance from gate 1 to gate 2 (centres)

Precautions

- **s large**
- **strong enough air supply**
- **repeat other …**

Graphs



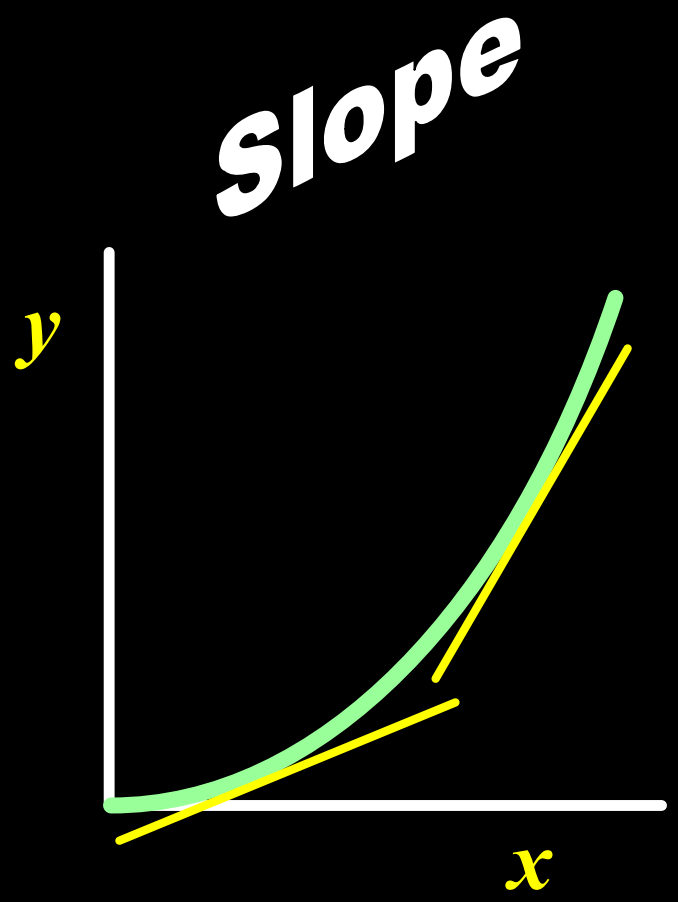
Slope

$$Slope = \frac{\Delta y}{\Delta x}$$

Δy = change in y

Δx = change in x

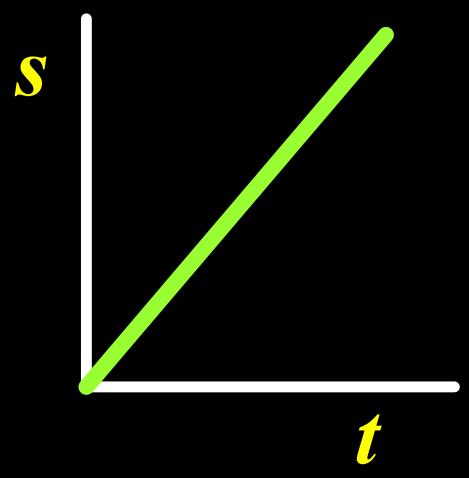
Graphs

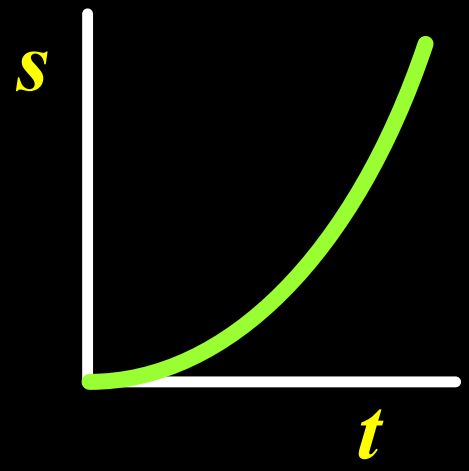


Slope ($\Delta y/\Delta x$)

increasing

Displacement - Time Graphs





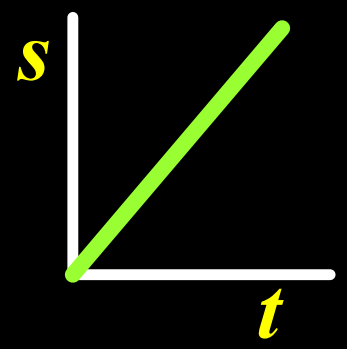
$$Slope = \frac{\Delta s}{\Delta t}$$

$$Slope = velocity\ (v)$$

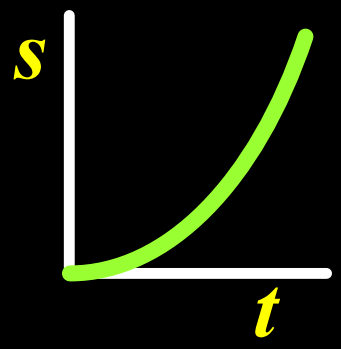
Velocity increasing

Displacement - Time Graphs

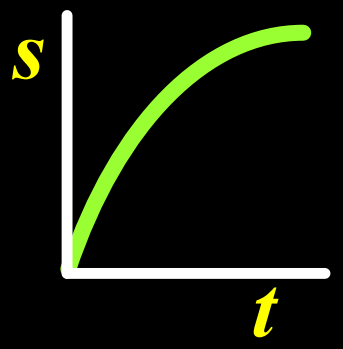
Is Velocity - incresing, decreasing or constant ??



Constant

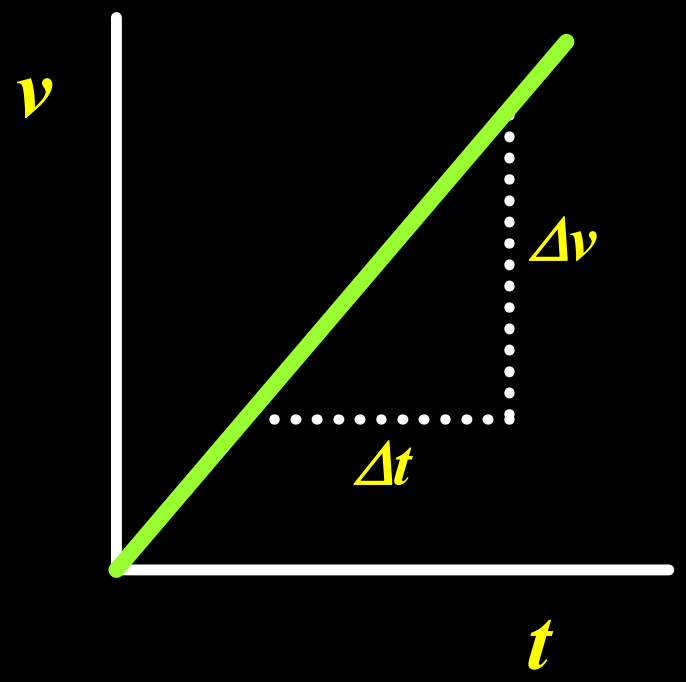


Increasing



Decreasing

Velocity - Time Graphs

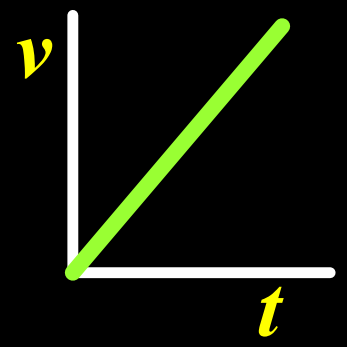


$$Slope = \frac{\Delta v}{\Delta t}$$

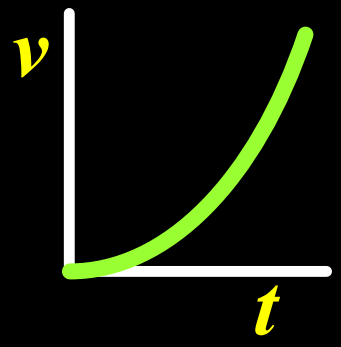
$$Slope = acceleration\ (a)$$

Velocity - Time Graphs

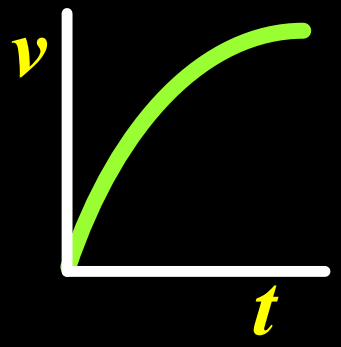
Acceleration is … (increasing - decreasing - constant ??)



Constant

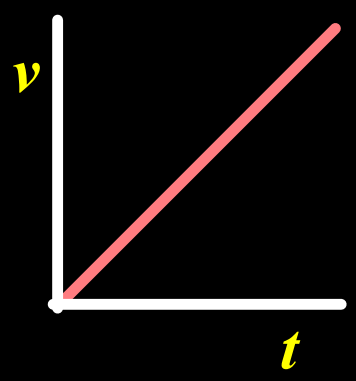


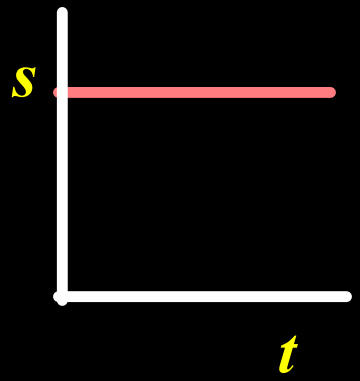
Increasing

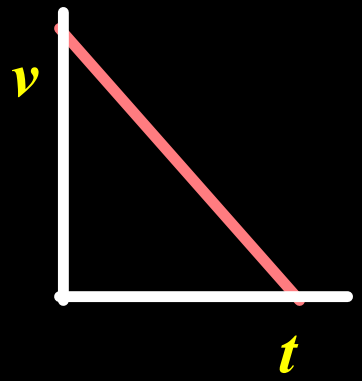


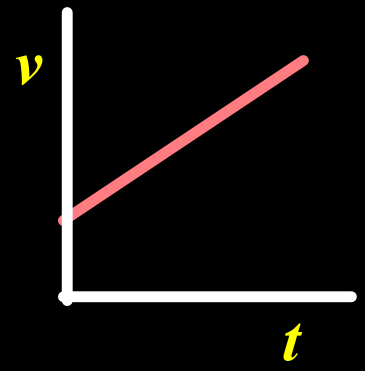
Decreasing

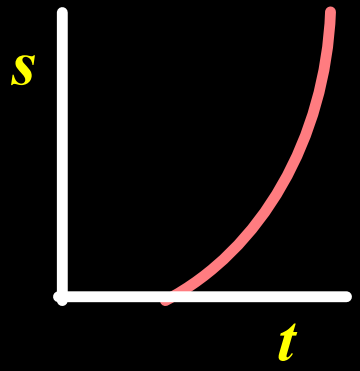
Describe these types of motion ...

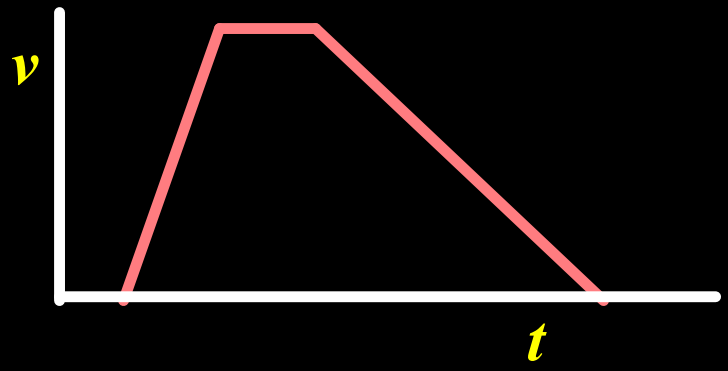












Describe these types of motion ...