SUVAT Equations:

The SUVAT equations are the equation of 'UNIFORM' motion; in other words, they are valid when the ACCELERATION IS CONSTANT.

S - Displacement (metres)
u - Initial velocity (ms^{-1})
V - Final velocity (ms^{-1})
A - Acceleration (ms^{-2})
T - time (s)

Note: 4 out of the 5 variables are VECTOR QUANTITIES (having both magnitude & direction). This means we use positive & negative to define left or right; up or down.

The Equations:

$$V = u + at$$

$$S = \left(\frac{V+u}{2}\right).t$$

$$V^2 = u^2 + 2as$$

$$S = ut + \tfrac{1}{2}at^2$$ (← note: only t is squared)

Using SUVAT:

Problem: A car, from rest, accelerates at $4ms^{-2}$ for 6 seconds. What is it's final velocity & what distance does it cover?

Note: From rest means $u = 0ms^{-1}$

① First of all, extract the information you know.

$S = ?$

$U = 0ms^{-1}$

$V = ?$

$A = 4ms^{-2}$

$T = 6$ seconds

② Choose an equation which only has one unknown variable.

e.g. $V = u + at$

$V = 0 + 4 \times 6$

$V = \underline{24ms^{-1}}$

or

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

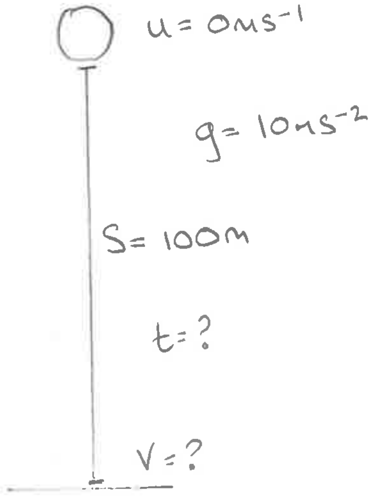
$S = (0.6) + \frac{1}{2}.4.(6)^2$

$S = \underline{\underline{72m}}$

Falling Objects & Projectile Motion

If an object is dropped (no vertical velocity on release) it will accelerate due to the gravitational field acting on it at $g = 10\,ms^{-2}$.

This means the acceleration is constant (assuming we ignore air resistance) so we can use the SUVAT equations.



The time it takes for the ball to fall to the ground can be determined by:

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

Initial vertical velocity = 0 (→ ut)

As it is falling $a = g = 10\,ms^{-2}$

$$\therefore \quad S = \frac{1}{2}gt^2$$

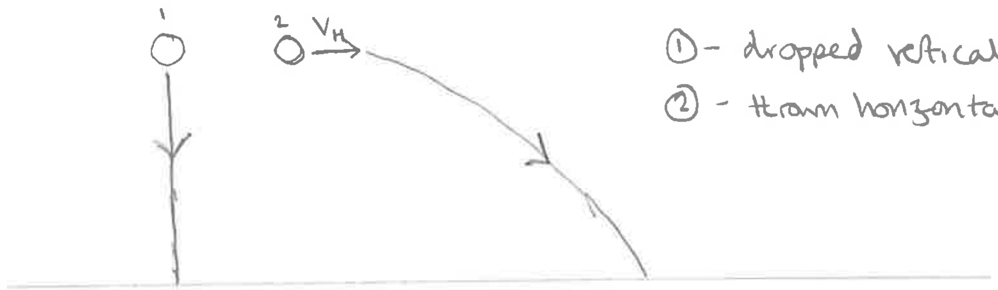
$$100 = \frac{1}{2} \cdot 10 \cdot t^2$$

$$\therefore \quad t = \sqrt{20} = \underline{\underline{4.47 \text{ seconds}}}.$$

Horizontal Projectiles

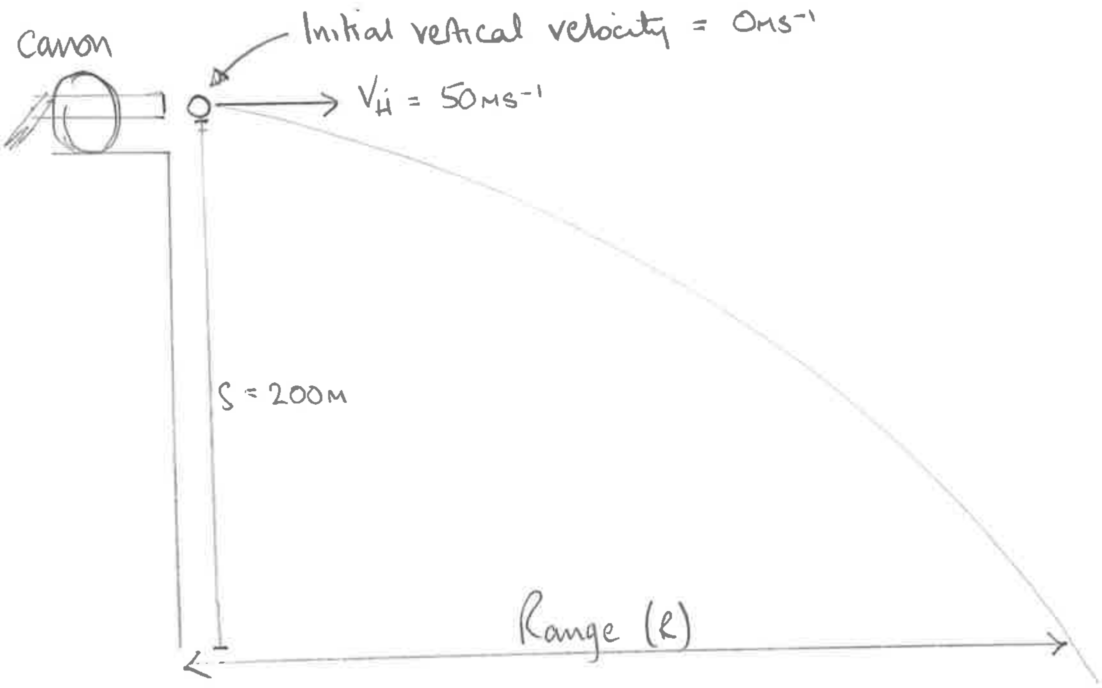
When dealing with horizontal projectiles, we treat the HORIZONTAL and VERTICAL COMPONENTS seperately.

The key point is that: the time of flight is the same time as an object dropped vertically.



① - dropped vertically
② - thrown horizontally
} both hit ground at same time.

To determine the range of the object it is simply how long it is falling for multiplied by the horizontal speed.



The time of flight, t, is the time it would take an object to fall vertically through S (200m) ∴ :

$$S = \frac{1}{2} g t^2$$

$$200 = \frac{1}{2} . 10 . t^2$$

$$\underline{t = 6.32 \text{ Seconds}}$$

As it is falling each seconds it is moving forward horizontally a distance of 50m ∴ the Range :

$$\text{Range} = \text{Horizontal Velocity} \times \text{Time of Flight}$$

$$R = V_H \times t$$

$$R = 50ms^{-1} \times 6.32s$$

$$\underline{R = 316m}$$

Can we determine the velocity and direction at a point in the flight path of the projectile eg. after 3 Seconds?

Yes, firstly calculate the vertical velocity at 3 Seconds.

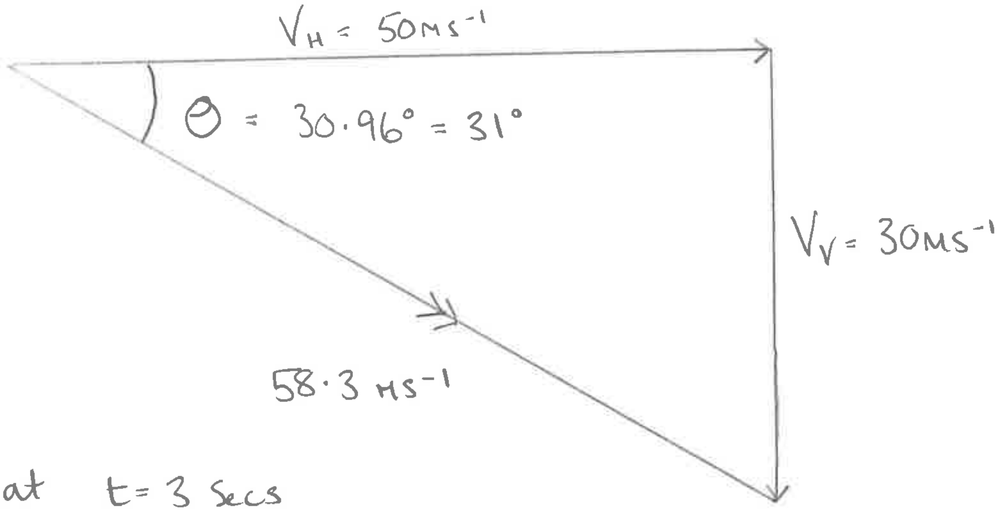
$$V = u + at$$

$$V = u + 10 \times 3$$

$$\underline{V_v = 30ms^{-1}}$$ - the vertical velocity

Therefore at 3 seconds, the vertical velocity is $30ms^{-1}$ downwards
horizontal velocity is $50ms^{-1}$ (in x axis).

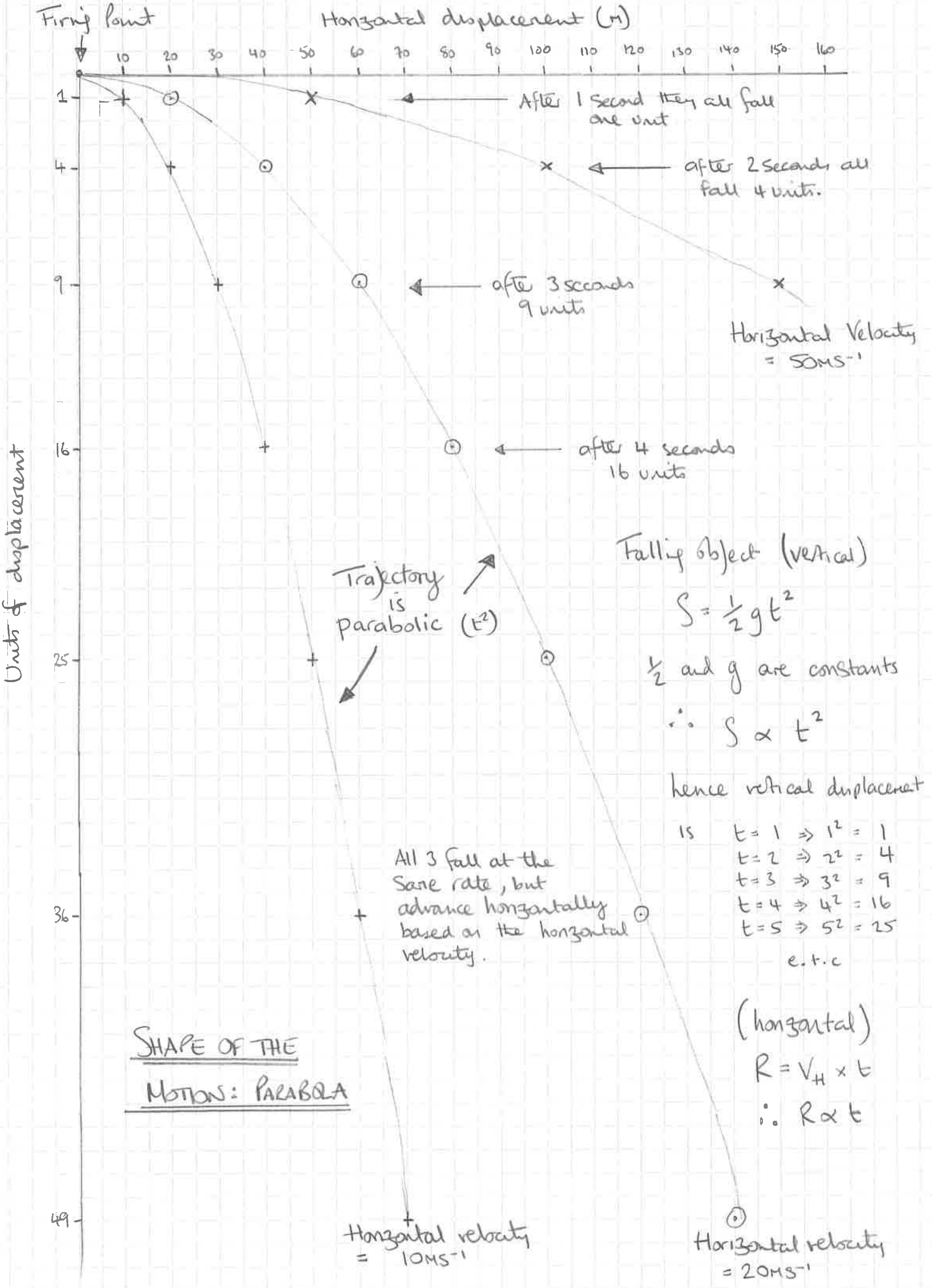
By scale drawing : Scale 2cm = $10ms^{-1}$



Therefore at t = 3 secs

Velocity of projectile is $58.3ms^{-1}$ at an angle of 31° below the horizontal.

SHAPE OF THE MOTION: PARABOLA



Falling object (vertical)

$$S = \frac{1}{2} g t^2$$

$\frac{1}{2}$ and g are constants

$$\therefore S \propto t^2$$

hence vertical displacement is

$t = 1 \Rightarrow 1^2 = 1$
$t = 2 \Rightarrow 2^2 = 4$
$t = 3 \Rightarrow 3^2 = 9$
$t = 4 \Rightarrow 4^2 = 16$
$t = 5 \Rightarrow 5^2 = 25$

e.t.c

(horizontal)

$$R = V_H \times t$$

$$\therefore R \propto t$$