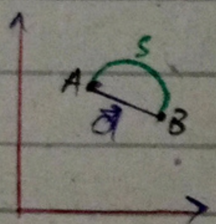
Physics

Unit #1 MOTION & FORCE

→ Rest and motion are relative ⇒ observer dependa

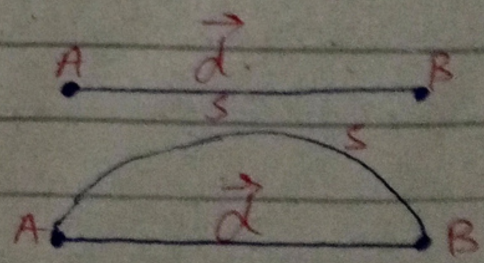
→ Motion of earth with respect to sun is 30K

Distance (s)	Displacement ($\vec{d}$)
→ Actual path length	→ Shortest distance b/w 2 po from initial to final.
→ Scalar Quantity	→ Vector Quantity (i-f)
→ meter (m)	→ meter (m)
→ [L]	→ [L]
→ It is always positive.	→ It may positive or nega tive or also zero
→ May not have unique value.	→ Always has unique value.



→ $s = \vec{d}$ for straight path

→ $s > \vec{d}$ for curved path

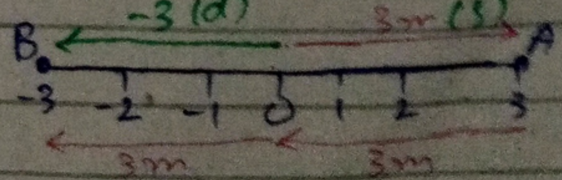


* $s \geq \vec{d} \Rightarrow \frac{s}{\vec{d}} \geq 1 \Rightarrow \vec{d} \leq s \Rightarrow \frac{\vec{d}}{s} \leq 1$

MCQ:

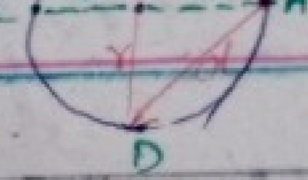
$O \to A \to B$

$s = ?$, $d = ?$



$s = 3 + 3 + 3 = 9m$ (distance is always +ive)

$\vec{d} = -3$ (can be +ive, -ive and zero)



Circle:

Circumference or length of Circle = $2\pi r$

if $A \rightarrow A$:
then, $S = ?$ $d = ?$
$S = 2\pi r$, $d = 0$

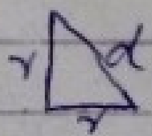
Ratio of s to $\vec{d}$: $\frac{s}{d} = \frac{2\pi r}{0} = \infty$

Ratio of $\vec{d}$ to s = $\frac{\vec{d}}{s} = \frac{0}{2\pi r} = 0$

if $A \rightarrow C$ (Semi circle)
then, $S = ?$ $d = ?$
$S = \pi r$, $\vec{d} = 2r$

$\frac{s}{d} = \frac{\pi r}{2r} \Rightarrow \frac{s}{d} = \frac{\pi}{2}$

if $A \rightarrow B$ (Quarter) ($1/4$th)
then, $S = ?$ $d = ?$
$S = \frac{2\pi r}{4} \Rightarrow S = \frac{\pi r}{2}$



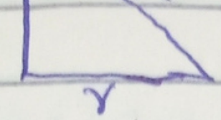
$H^2 = P^2 + B^2$
$d^2 = r^2 + r^2$
$d = \sqrt{2r^2} \Rightarrow d = \sqrt{2}r$

if $A \rightarrow D$ ($3/4$th)

$S = \frac{3\pi r}{2} \Rightarrow 3\left(\frac{\pi r}{2}\right)$

$d = \sqrt{2}r$

MCQ: If body covers 1 complete round in circle in 20s, what will be $\vec{d}$ after 50s?
$\Rightarrow$ It will be equal to semicircle $(2r) \Rightarrow 40s = 0$, $10s = 2r$



$H^2 = B^2 + P^2$

$d^2 = r^2 + r^2$

$d = \sqrt{2r^2}$

$d = \sqrt{2}\,r$

ii) $A \rightarrow D$ $\left(\frac{3}{4}\text{th}\right)$

$S = 3\frac{(\pi r)}{2} = \frac{3\pi r}{2}$

$d = \sqrt{2}\,r$

if body covers 1 complete round in circ in 20s, what will be displacement after 50s.

→ It will be equal to semicircle (2r). 40s =
10s =

Speed: (v)

→ rate of change of distance

→ $v = \frac{\Delta s}{\Delta t}$

→ Scalar Quantity

→ Alway positive and moving body has always speed.

→ m/s

speed $\neq 0$

speed = velocity → in straight path

speed > velocity → in curved path

Velocity: ($\vec{v}$)

→ rate of change of displacement.

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

→ Vector Quantity

→ maybe positive, negative or zero.

→ m/s

$Kmh^{-1} \longrightarrow ms^{-1}$

$18\ Kmh^{-1} \times \frac{5}{18} = 5\ m/s$

$36\ Kmh^{-1} \times 5/18 = 10\ m/s$

$72\ Kmh^{-1} \times 5/18 = 20\ m/s$

$144\ Kmh^{-1} \times 5/18 = 40\ m/s$

MCQ:

If thed $\vec{d}$ is 15m t is 10s what is $\langle v \rangle$?

a: 12.5 c 2.5

(b): 1.5 : 3

MCQ:

Arshad is driving down Seven street He drives 150m in 18s. Assume he doesn't speed up and down.

$v = \frac{s}{t} = \frac{150}{18} = \frac{30}{3} = 8.33\ m/s$

a: 0.38m/s (b): 8.33m/s c: 126m/s d: 158.33

Relative Velocity: Two bodies moving relative to each other.

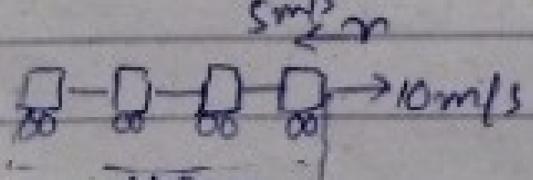
$V_{rel} = \sqrt{v_1^2 + v_2^2 - 2v_1v_2\cos\theta}$

$\rightrightarrows$ 0° $v_{rel} = \sqrt{(v_1 - v_2)^2} \Rightarrow v_{rel} = v_1 - v_2$

$\rightarrow \leftarrow$ 180° $v_{rel} = \sqrt{(v_1 + v_2)^2} \Rightarrow v_{rel} = v_1 + v_2$

$\downarrow \rightarrow$ 90° $v_{rel} = \sqrt{v_1^2 + v_2^2}$

MCQ:



$V_{rel} = 5 + 10 = 15\ m/s$

$t = \frac{s}{v_{rel}} = \frac{150}{15} = 10s$

Acceleration:

→ Rate of change of velocity

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

$a = ?$ → speed change / → Direction change / → Both

→ vector

→ Direction is along change in velocity → not in the direction of velocity

* If $v\uparrow$, angle b/w $\vec{a}$ & $\Delta\vec{v} = 0^\circ$

* If $v\downarrow$, angle b/w $\vec{a}$ & $\Delta\vec{v} = 180^\circ$

$$\vec{a} = \frac{\Delta \vec{v}}{\Delta t} = \frac{\vec{v_f} - \vec{v_i}}{\Delta t}$$

Types:

→ Uniform/Constant: Equal change in $\vec{v}$ in equal time.

→ Non-Uniform/Variable: Unequal change in $\vec{v}$ in equal time.

→ Instanteneous: $a_{ins} = \lim_{\Delta t \to 0} \frac{\Delta V}{\Delta t}$

→ Average: $\langle a \rangle = \frac{tot.\ \Delta V}{tot.\ \Delta t}$

Note: $V_{ins} = V_{av}$ → body is moving with uniform $\vec{v}$.

$a_{ins} = a_{av}$ → uniform acceleration.

→ Retardation/Dacceleration: Decrease in velocity per unit time.

also $\boxed{a = -ve}$

MCQ:

$v_i = 60\,m/s$, $v_f = 40\,m/$, $t = 2s$

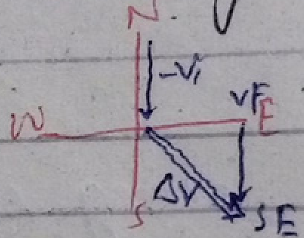
$a = ?$

$a = \frac{v_f - v_i}{t} = \underline{40-60} = \underline{-20} = -10\,ms^{-2}$

If a body is moving towards North with 5m/s and take a turn towards east and moving with same velocity for the next 5s.

a: 0   b: $5\sqrt{2}$

c: $1/\sqrt{2}$ d: None of these



$\Delta V = V_f - V_i$ $\quad \Delta V = \sqrt{5^2+5^2} = \Delta V = 5\sqrt{2}$ $\quad t = 10s$

$\Delta a = \frac{5\sqrt{2}}{t} = \frac{5\sqrt{2}}{10} = \frac{\sqrt{2}}{2} = \frac{\sqrt{2}\times\sqrt{2}}{2\times\sqrt{2}} = \frac{2}{2\times\sqrt{2}} = \frac{\cancel{2}}{\cancel{2}\times\sqrt{2}}$

$\Delta a = 1/\sqrt{2}$

Velocity Time Graph:

slope = Gradient = $\tan\theta = \frac{P}{B} = \frac{y\text{-axis}}{x\text{-axis}} = \frac{v}{t} = \vec{a}$

Area = (y)(x)

= vt

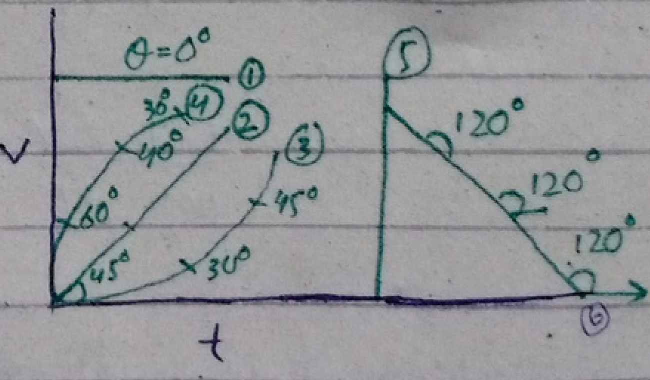
= s

slope = a

slope = $\tan\theta$

slope↑ ∝ θ↑

slope↓ ∝ θ↓



(1): slope = 0, a = 0, v = constant/uniform

(2): slope = constant, a = constant, v↑ uniformly

(3): slope = ↑, a = ↑, v = variable

(4): slope = ↓, a = ↓, v = variable

(5): slope = ∞, a = ∞ (which is not possible in classic physics

(6): slope = −constant, a = −constant

	0	30	45	60	90
Sinθ	0	1/2	$\frac{1}{\sqrt{2}}$	$\sqrt{3}/2$	1
Cosθ	1	$\sqrt{3}/2$	$\frac{1}{\sqrt{2}}$	1/2	0
Tanθ	0	$\frac{1}{\sqrt{3}}$	1	$\sqrt{3}$	∞

$\tan 90^\circ = \infty$

$\tan 91^\circ = -ive$

* Speed time graph is always positive, b/c speed can't be negative.

MCQ:

If the velocity of body changes by the equal ~~time~~ amount ~~by~~ in equal time

uniform velocity

MCQ

WOF v-t graph represent constant $\vec{a}$?

a: line 1 | (b) Line 2
c: line 3 | d: Line 4

MCQ:

If the slope of v-t graph is not constant at diff points the body is moving with.

a: uniform $\vec{v}$ | b: averge $\vec{a}$
(c) increasing $\vec{a}$ | d: contant $\vec{a}$

MCQ:

slop of S-t graph will always b

(a) +ive | b -ive

same

MCQ: Slope of $\vec{v}$–t graph represents:

a: $\vec{a}$ b: v

c: S d: $\vec{d}$

MCQ:

What is the slope of ~~straight line~~ straight line S–t graph.

a: velocity b: acceleration $\vec{v} = v$ in straight line

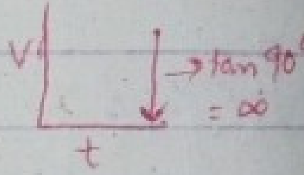
c: displacement

MCQ:

The v–t graph slope is parallel to y-axis.

a: maximum b: infinity

c: zero



Equation Of Motion:

1: $v_f = v_i + at$ :: Independent of displacement

2: $S = v_i t + \frac{1}{2} a t^2$ :: Independent of final velocity

3: $2aS = v_f^2 - v_i^2$ :: Independent of time

Limitation:

Applicable only for:

1: Straight line motion

2: Acceleration must be constant/uniform

3: Neglect air resistance.

$a = ms^{-1}s^{-1}$

$g = 9.8 m/s/s \cong 10 m/s/s$

Case 1: Free fall

$v_i = 0$, $a = g = +10$

$$v_f = gt \;,\quad S = \frac{1}{2}gt^2 \;,\quad v_f = \sqrt{2gS}$$

$$v_f = 10t \qquad S = 5t^2$$

t	v_f	S	v_f
0	0	0	0
1	10	5	10
2	20	20	20
3	30	45	30
4	40	80	40
5	50	125	50
6	60		60
7	70		70
8	80		80
9	90		90
10	100		100

5m, 15m, 25m

- Distance covered in 1^{st} sec = 5m
- " " 2^{nd} sec = 15m
- " " 3^{rd} s = 25m
- " " 3 sec = 45m

MCQ:
The ratio of distance of free falling body of 1^{st} 3 seconds:

$\frac{5}{5} : \frac{15}{5} : \frac{25}{5}$

$\boxed{1 : 3 : 5}$

Case 2: Upward case

g is always downward while it is +ive or -ive

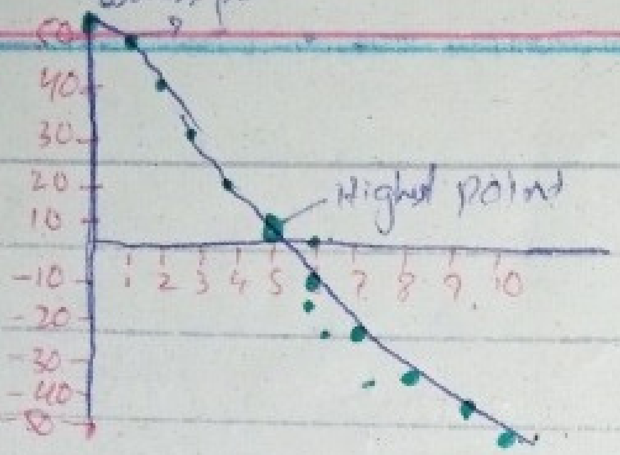
$v_i \neq 0 ,\; v_f = 0$

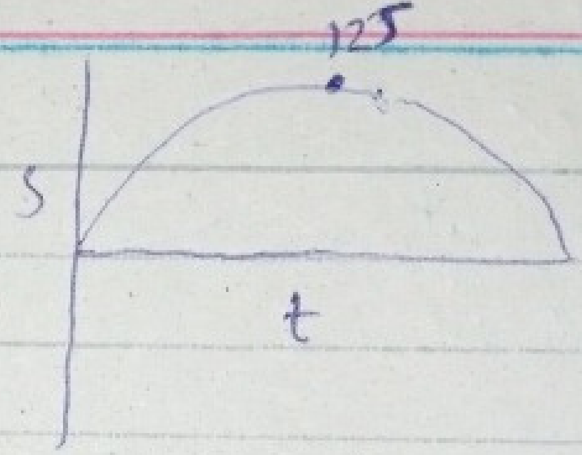
$a = -g = -10$ Let $v_i = 50\,m/s$

$$v_f = v_i - gt \;,\quad S = v_i t - \frac{1}{2}gt^2$$

$$v_f = 50 - 10t \qquad S = 50t - 5t^2$$

t	v_f	S
0	50	0
1	40	45
2	30	80
3	20	105
4	10	





Newton's Laws:

Limitations:

→ only for bodies moving slowly.
* car, train, airplane.

1: Ist Law:

- → It define force.
- → $v = 0$
- → $v = \text{constant}$
- → $\Delta v = 0$
- → $a = \frac{\Delta v}{\Delta t} = 0$
- → $F_{net} = ma = 0$
- → Equilibrium
- → Law of inertia

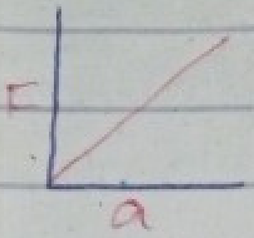
2: 2nd Law:

→ It measures force
→ $F = Kma$
→ $K = 1$, In SI
→ $F = ma$
$N = kg\,m/s^2$

If $m = constant$

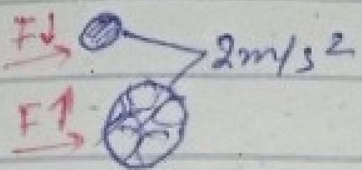
$F \propto a$

$$\boxed{\frac{F_1}{F_2} = \frac{a_1}{a_2}}$$



• If $a = constant$

$F \propto m$



If $F = constant$

↑$a \propto \frac{1}{m}$↓

$5N \rightarrow$ ● a↑

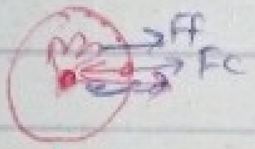
$5N \rightarrow$ ⬤ a↓

3^{rd} Law:

→ Forces always exist in pair

→ $F_c = F_f$ → centrifugal

→ Walk, swimming



S: Action and reaction act on two different bodies.

$$|\vec{F}_{Action}| = |\vec{F}_{reaction}|$$

Momentum:

→ The quantity of motion.

→ Product of mass & and velocity

→ $\vec{P} = m\vec{v}$

→ Direction of $\vec{v}$

→ $Ns = kgm/s$

$$P = mV$$

If ~~P∝v~~ $m = constant$

$P \propto v$

If $v = constant$

$P \propto m$

$P = constant$

$v \propto \frac{1}{...}$

$$F = m\frac{(v_f - v_i)}{\Delta t}$$

$$F = \frac{mv_f - mv_i}{\Delta t}$$

$$F = \frac{P_f - P_i}{\Delta t}$$

$$F = \frac{\Delta P}{\Delta t}$$

↳ rate of change of momentum → (F)

MCQ:

$P = 25\,Ns$, $\Delta t = 0.005\,s$, $F = ?$

MC

$$F = \frac{25}{0.005} \Rightarrow \frac{25}{\frac{0.005}{1000}} \Rightarrow \frac{\overset{5}{\cancel{25}} \times 1000}{\cancel{5}_1} \Rightarrow \boxed{5000\,N}$$

Law Of Conservation Of Momentum:

$P = \text{constant}$

$\Delta P = 0 \Rightarrow \boxed{F_{net} = 0} \rightarrow$ Newton 1^{st} law

$P_f - P_i = 0$

$\boxed{P_f = P_i}$

* In an isolated system net force is equal to zero.

Example: <u>Bullet-gun:</u>

$P_i = P_G + P_b$

$P_f = P_G + P_b$ $\therefore P_f = P_i$

$0 = MV + mv$

$MV = -mv$

$$\boxed{V = \frac{-mv}{M}}$$

$$\boxed{mV = Mv}$$

Impulse:

"When a very large force acts on body for very short interval of time called impulse force."

$\vec{I} = \vec{J} = \vec{F}_{av} \times \Delta t$

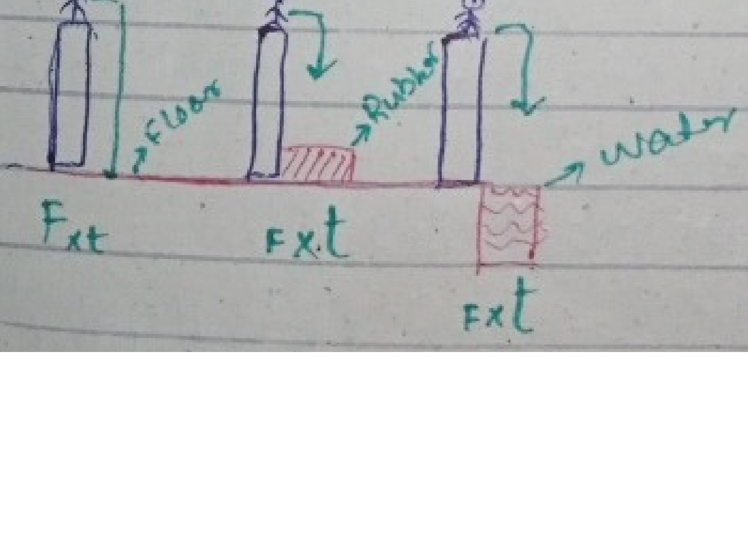
$\therefore \Delta P = F \times \Delta t$

$\boxed{\vec{J} = \Delta P}$ → Change in momentum of body.

* If J = const

impulsive force ← $F \propto \frac{1}{t}$ $\boxed{F \times t = F \times t = constant}$

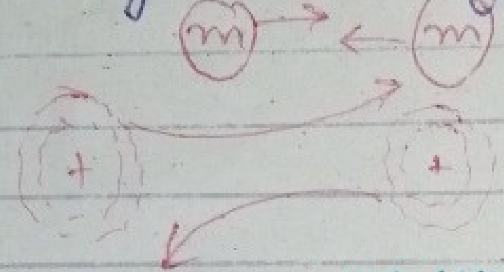
t → impact time



Collision:

When two or more bodies interact each other by means of force.

|S|N| |N|S|



Types:

① Elastic Collision: → no sound, → no heat → Ideal case

K.E = P = T.E ⇒ conserve

$(K.E)_i = (K.E)_f$

$P_i = P_f$

$(T.E)_i = (T.E)_f$

→ If moving track collides with bycycle it will not effect the K.E of truck, so this will be elastic collisio

② Inelastic Collision: → sound, → heat

K.E ≠ conserve

P = T.E = conserve

<u>Note</u>: For every type of collision T.E and momentum always rema conserve → b/c both are from conservation laws.

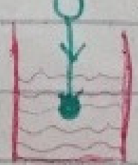
③: Pefectly elastic:

↳ K.E = 100% conserve

↳ K.E of ideal gas particles

* Perfectly Inelastic:

K.E = 100% loss



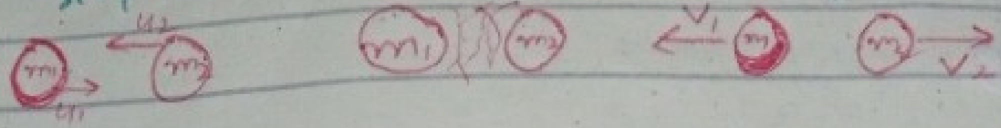
If pebble drops in water tub it will not bounce up it means K.E = 100% loss

Elastic Collision in 1 Dimension

→ When two
→ Hard
→ Non-Rotating
→ Smooth
→ bodies collide and moving along same line

before and after collision.

step 1: step 2: step 3:



$u_1, u_2 \rightarrow$ Before collision

$v_1, v_2 \rightarrow$ After Collision

$$u_1 - u_2 = v_2 - v_1$$

$$u_1 - u_2 = -(v_1 - v_2)$$

Relative velocity of approaching = Relative velocity of separation

Newton's Law Of Restitution (e)
OR
Cofficient of Restitution: (e)

→ Ratio of relative velocity of separation to approach.

$$e = \frac{v_2 - v_1}{u_1 - u_2}$$

Perfectly elastic: $\boxed{e=1}$

Perfectly inelastic: $\boxed{e=0}$

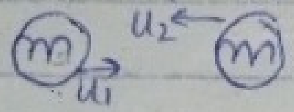
→ After Collision Velocity:

$$v_1 = \frac{m_1 - m_2}{m_1 + m_2} u_1 + \frac{2m_2}{m_1 + m_2} u_2$$

$$v_2 = \frac{2m_1}{m_1 + m_2} u_1 + \frac{m_2 - m_1}{m_1 + m_2} u_2$$

Case 1:

$m_1 = m_2 = m$



$v_1 = ?$

$v_2 = ?$

- $v_1 = 0 + \frac{\cancel{2m}}{\cancel{2m}} u_2$

$\boxed{v_1 = u_2}$

- $v_2 = \frac{\cancel{2m}}{\cancel{2m}} u_1 + 0$

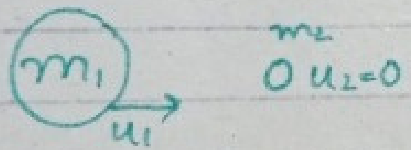
$\boxed{v_2 = u_1}$

→ Velocities are interchanged

Case 2:

$m_1 >>>>>> m_2$

$m_2 \approx 0, \; u_2 = 0$



- $v_1 = \frac{\cancel{m}-0}{\cancel{m}-0} u_1 + 0$

$\boxed{v_1 = u_1}$

- $v_2 = \frac{2\cancel{m_1}}{\cancel{m_1}+0} u_1 + 0$

$\boxed{v_2 = 2u_1}$

Case 3:

$m_1 <<< m_2,$

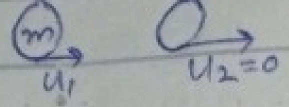
$m_1 \approx 0, \; u_2 = 0$

- $v_1 = -u_1$
- $v_2 = 0$

} After prove

Case 4:

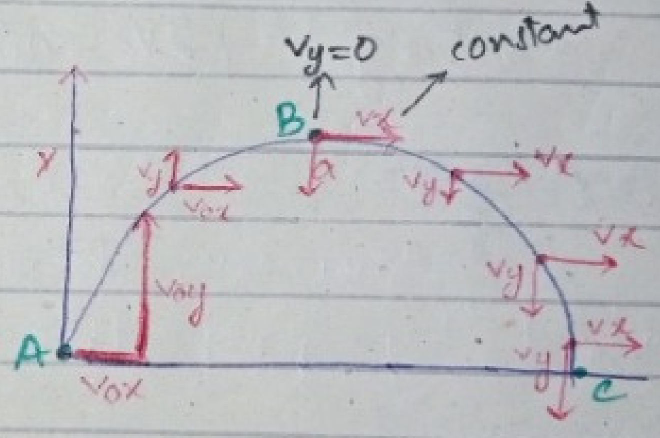
$m_1 = m_2$, $u_2 = 0$



- $v_1 = 0$
- $v_2 = u_1$

Projectile Motion:

→ 2D motion
→ constant acceleration
→ $a = g$ ⇒ free fall
→ Neglect air friction.
→ v_x = constant
→ $\Delta v_x = 0$
→ $a_x = \frac{\Delta v_x}{\Delta t} = 0$
→ $F_x = 0$
→ $v_y \neq$ constant
→ $a_y = -g$
→ $F_y \neq 0$



→ parabola
→ $v \neq 0$ throughout
→ at B angle b/w $\vec{a}$ & $\vec{v}$ → 90°
→ V_{max} at A & C
→ V_{min} at B
→ $v \neq 0$ at B
→ K.E max at A & C
→ P_{max} at A & C
→ K.E min at B
→ P_{min} at B
→ K.E ≠ 0

→ K.E can't be completely transfer into P.E.

→ $\vec{a}$ always downward during ascending or descending

Velocities:

x axis: $v_{ix} = v_{ox} = v_o \cos\theta$

$v_{fx} = v_{ox} = v_o \cos\theta$

y axis: $v_{iy} = v_{oy} = v_o \sin\theta$

$v_{fy} = v_{ofy} = v_o \sin\theta - gt$

$$v_f = \sqrt{v_{fx}^2 + v_{fy}^2}$$

$$= \sqrt{(v_o\cos\theta)^2 + (v_o\sin\theta - gt)^2}$$

$$= \sqrt{v_o^2\cos^2\theta + v_o^2\sin^2\theta + g^2t^2 - 2v_o\sin\theta gt}$$

$$= \sqrt{v_o^2(\cos^2\theta + \sin^2\theta) + g^2t^2 - 2v_o\sin\theta gt}$$

$$= \sqrt{v_o^2 + g^2t^2 - 2v_o\sin\theta gt}$$

Range:

Maximum horizontal distance covered by projectile.

$$R = \frac{v_o^2 \sin 2\theta}{g}$$

For max range:

$\theta = 45°$

$$R_{max} = \frac{v_o^2}{g}$$

$R = R_{max} \times \sin 2\theta$

$\boxed{R_{max} = 4H}$

At which angle range is half of its max R.

a: 15° b: 30° c: 45°

$R = R_{max} \times \sin 2(15°)$

$= R_{max} \times \sin 30°$ $\because \sin 30° = 1/2$

$$\boxed{R = \frac{R_{max}}{2}}$$

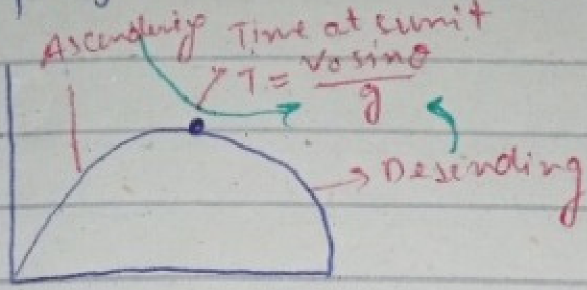
$\therefore$ if $R = R_{max} \times \sin 2(30°)$

$= R_{max} \times \sin 60°$ $\because \sin 60 = \sqrt{3}/2$

$$R = \frac{\sqrt{3}}{2} R_{max}$$

Time:

Maximum time for a projectile from point of projection to landing point.



Tim

$$T = \frac{2v_0 \sin\theta}{\cancel{2}g}$$

90°

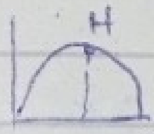
θ

∴ The more will be θ till 90° the more time it will take.

$T \propto v_0$

$T \propto \theta$

Height:



Max verticle distance

$$H = \frac{v_0^2 \sin^2\theta}{2g}$$

$H \propto v_0^2$

$H \propto \sin^2\theta$

Shortcuts:

$R_{max} = 4H$

or

$\boxed{R \tan\theta = 4H}$

$R_{max} = 80m$, $H = ?$

$$H = \frac{R_{max}}{4} = \frac{80}{4} = 20m$$

$$\tan\theta = \frac{4H}{R}$$

$$\theta = \tan^{-1}\left(\frac{4H}{R}\right)$$

$H = R$

$\theta = \tan^{-1}(4) = 76^\circ$

Time & Height.

$$gT^2 = 8H$$

$$\boxed{H = \frac{gT^2}{8}}$$

$$T^2 = \frac{8H}{g}$$

$$T = \sqrt{\frac{8H}{g}}$$

Time and Range:

$$H = \frac{R_{max}}{4}$$

$$gT^2 = 8(H)$$

$$gT^2 = \overset{2}{\cancel{8}} \frac{R_{max}}{\cancel{4}_1}$$

$$gT^2 = 2R_{max}.$$

$R_{max} = 200\,m$

$t = ?$

$$\sqrt{T^2} = \sqrt{\frac{2R_m}{g}}$$

$$T = \sqrt{\frac{2 \times 200}{10}}$$

$$T = \sqrt{40} = 6.3$$