'KINEMATICS'

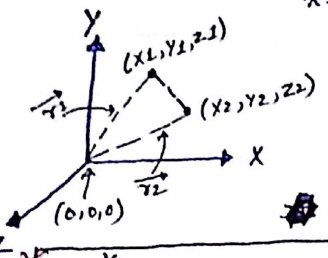
|I| → Distance & Displacement →

DISTANCE

* Actual length of path.
* Scalar
* Depend on path
* always ↑ w.r.t time.
* Always ⊕ve.
* In close path not equal to zero.

Displacement

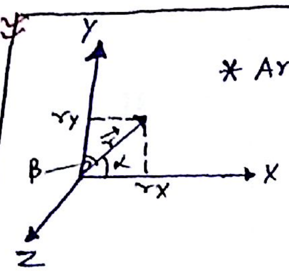
* Shortest dist. b/w Initial & Final point.



* Disp vector

$$\vec{r_1} + \vec{r} = \vec{r_2}$$
$$\vec{r} = \vec{r_2} - \vec{r_1}$$

$$\vec{r} = (x_2 - x_1)\hat{i} + (y_2 - y_1)\hat{j} + (z_2 - z_1)\hat{k}$$
$$|\vec{r}| = \sqrt{(x_2-x_1)^2 + (y_2-y_1)^2 + (z_2-z_1)^2}$$

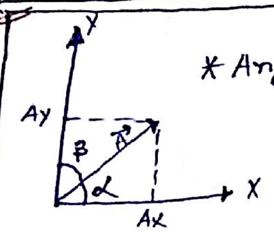


* Angle from 'x' axis

$$\cos\alpha = \frac{r_x}{|\vec{r}|} \Rightarrow \alpha = \cos^{-1}\left(\frac{r_x}{\sqrt{r_x^2 + r_y^2 + r_z^2}}\right)$$

* Angle from y-axis

$$\cos\beta = \frac{r_y}{|\vec{r}|} = \beta = \cos^{-1}\left(\frac{r_y}{\sqrt{r_x^2 + r_y^2 + r_z^2}}\right)$$



* Angle from 'x' axis

$$\tan\alpha = \frac{A_y}{A_x} = \alpha = \tan^{-1}\left(\frac{A_y}{A_x}\right)$$

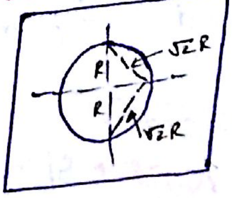
* Angle from 'y' axis

$$\tan\beta = \frac{A_x}{A_y} = \beta = \tan^{-1}\left(\frac{A_x}{A_y}\right)$$

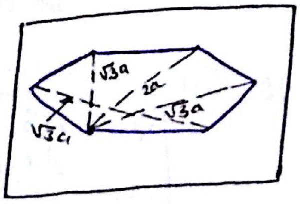
NOTE → * It is vector quantity & depend on Final & Initial position. (Independent from path)

* When particle goes away from Initial point its value ↑ & move towards Initial its value ↓. [Int Mag (↑) or (↓) w.r.t Time].
* Distance ≥ Displacement.
* If particle move in a Rectilinear path in same direction distance is equal to displacement & when direction change distance is always greater than displacement.
* In close path disp. of moving particle is zero.

*** # A particle move in circular path radius 'R'. than for calculation of distance & Displacement of particle.

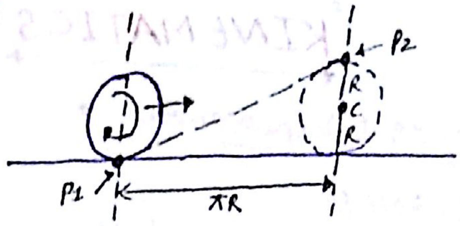


	Distance	Displacement
|1| → $\frac{1}{4}$th	$\frac{\pi}{2}R$	$\sqrt{2}R$
|2| → $\frac{1}{2}$	πR	$2R$
|3| → $\frac{3}{4}$	$\frac{3\pi}{2}R$	$\sqrt{2}R$
|4| → 1	$2\pi R$	0
|5| → In a 'θ' angular disp.	θR	$2R\sin(\theta/2)$



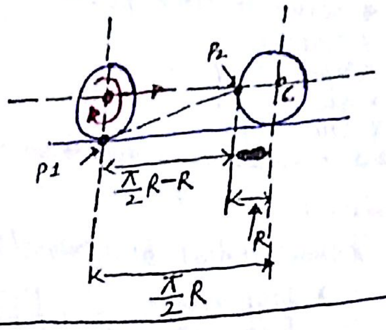
|i|→

$$P_1P_2 = \sqrt{(\pi R)^2 + (2R)^2} = R\sqrt{\pi^2 + 4}$$



|ii|→

$$P_1P_2 = \sqrt{\left(\frac{\pi}{2}R - R\right)^2 + R^2} = R\sqrt{\left(\frac{\pi}{2} - 1\right) + 1}$$



In circle

In 'θ' Angular displacement

$\boxed{\text{Disp} = 2R\sin\theta/2}$

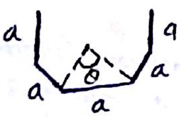
$\boxed{\text{Distance} = \theta R}$

*Average velocity in circle $= \dfrac{v\sin(\theta/2)}{\theta/2}$

Change in velocity $= 2v\sin\theta/2$

$$f_{average} = \frac{mv^2}{R}\,\frac{\sin(\theta/2)}{\theta/2}$$

Polygon of side 'n'



*Average velocity

$$\frac{v\sin(m\theta/2)}{m\sin\theta/2}$$

*Then After side 'm'

$\boxed{\text{Distance} = ma}$

$$\text{Displacement} = \frac{a\sin(m\theta/2)}{\sin(\theta/2)}$$

|2|→ Speed & velocity

$$\text{Speed} = \frac{\text{Distance}}{\text{Time}}$$

↳ scalar

$$\text{velocity} = \frac{\text{Displacement}}{\text{Time}}$$

↳ vector.

NOTE→ Speed of moving particle is always ⊕ve but velocity may be ⊕ve, or, ⊖ve.

Instantantinaus speed/velo

$\boxed{v = \dfrac{\Delta S}{\Delta t}}$

$\boxed{V_t = \lim_{\Delta t \to 0} \left|\dfrac{ds}{dt}\right|}$ ⟹ slope of 's-t' curve.

$\boxed{\vec{V_t} = \lim_{\Delta t \to 0} \dfrac{d\vec{s}}{dt}}$

Average speed/velocity

$$\vec{V}_{Avg} = \text{Avg. velo} = \frac{\text{Total disp.}}{\text{time}} = \frac{\vec{S}_1 + \vec{S}_2 + \cdots \vec{S}_N}{t_1 + t_2 + \cdots t_N}$$

$$\vec{V}_{avg} = \frac{\text{Total distance}}{\text{time}} = \frac{|\vec{S}_1| + |\vec{S}_2| + \cdots |\vec{S}_N|}{t_1 + t_2 + \cdots + t_N}$$

NOTE → If particle move in a rectilinear path in same direction Avg. speed is equal to Avg. velo. & When direction change Avg. speed is always greater than Avg. velocity.

Special case

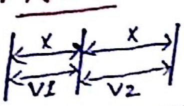
Case-I → Particle covered $x_1, x_2, x_3 \cdots x_N$ with speed $v_1, v_2, v_3 \cdots v_N$. Then Avg. speed of particle.

$$\boxed{V_{Avg} = \frac{x_1 + x_2 + \cdots x_N}{\frac{x_1}{v_1} + \frac{x_2}{v_2} + \cdots \frac{x_N}{v_N}}}$$

$x_1 = x_2 = \cdots x_N = x$

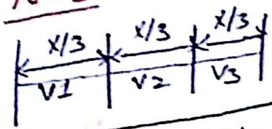
$$\boxed{V_{Avg} = \frac{N}{\frac{1}{v_1} + \frac{1}{v_2} + \cdots \frac{1}{v_N}}}$$

|a| → N = 2



$$\boxed{V_{Avg} = \frac{2v_1 v_2}{v_1 + v_2}} \text{ (H.M)}$$

|b| → N = 3



$$\boxed{V_{Avg} = \frac{3v_1 v_2 v_3}{v_1 v_2 + v_2 v_3 + v_3 v_1}}$$

Case-II → Particle move with speed $v_1, v_2, v_3 \cdots v_N$ for time interval $t_1, t_2, t_3 \cdots t_N$ than Avg. speed of particle.

$$V_{avg} = \frac{x_1 + x_2 + \cdots x_N}{t_1 + t_2 + \cdots t_N}$$

$$\boxed{V_{Avg} = \frac{v_1 t_1 + v_2 t_2 + \cdots v_N t_N}{t_1 + t_2 + \cdots t_N}}$$

$t_1 = t_2 = \cdots = t_N = t$

$$V_{Avg} = \frac{v_1 + v_2 + \cdots v_N}{N}$$

|a| → N = 2

$$\boxed{V_{Avg} = \frac{v_1 + v_2}{2}}$$

|b| → N = 3

$$\boxed{V_{Avg} = \frac{v_1 + v_2 + v_3}{3}}$$

|3| → Acceleration (a/A)

$$\boxed{a = \frac{\Delta \vec{V}}{\Delta t}}$$

* vector
* may be ⊕ve, ⊖ve or, zero. It depend on direction of
* velocity of particle ↑ or, ↓. velocity & Accl^n.

\# ⊖ve ⟵⟶ ⊕ve

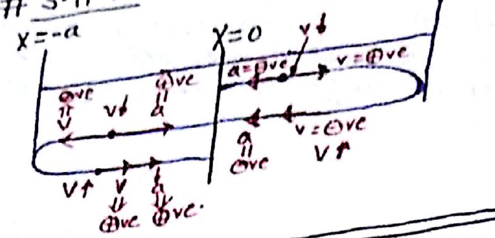
|a| → $(m) \xrightarrow{a} \xrightarrow{} v$ (V↑)

|b| → $\overset{a}{\longleftarrow} (m) \longrightarrow v$ (V↓)

|c| → $a \; v \longleftarrow (m)$ (V↑)

|d| → $v \longleftarrow (m) \longrightarrow a$ (V↓)

\# S·H·M

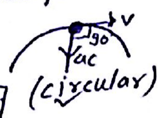


\# Path of particle depend on Angle b/w velocity & Acceleration.

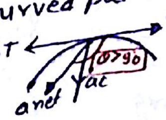
|i| → $\theta = 0$ (Parallel)
$\theta = 180°$ (Antiparallel)] straight line

|ii| → $\theta \neq 0°, 180° \Rightarrow$ curved path ⇒ V ⇒ same.

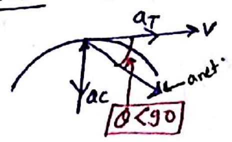
|a| → $\theta = 90°$ $\boxed{V = const}$ (circular)



|b| → $\theta > 90° \Rightarrow$ curved path. (V↓) $\boxed{|\vec{V}| = ↓}$



|c| → $\theta < 90° \Rightarrow$ path curved ($\vec{V}$↑) $\boxed{\vec{V} = ↑}$



$$\vec{V} = \frac{d\vec{s}}{dt} \qquad \vec{a} = \frac{d\vec{v}}{dt} = \frac{d^2\vec{s}}{dt^2}$$

$$a = \frac{dv}{dt} \quad = \int dv = \int a\,dt$$

$$v = \frac{ds}{dt} \quad = \int ds = \int v\,dt$$

$$\boxed{a = v\frac{dv}{dx}}$$

\# Time velocity & space average velocity

$$\text{Time average} = \langle v_t \rangle = \frac{\int_0^t f(x)\,dt}{\int_0^t dt}$$

$$\text{Space Average velo.} \; \langle v_x \rangle = \frac{\int f(x)\,dx}{\int dx}$$

Graphical section

Disp. time curve

Slope of disp. time curve gives velo. of particle.

$$\text{Slope} = \frac{dy}{dx} = \frac{ds}{dt} = \frac{y_2 - y_1}{x_2 - x_1} = \frac{D_2 - D_1}{T_2 - T_1} = \text{velocity} = \tan\theta \Rightarrow$$ angle from ⊕ve x-axis.

velocity time curve

slope of velocity time curve respresent accl^n of particle.

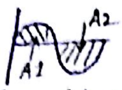
$$\text{Slope} = \frac{dy}{dx} = \frac{dv}{dt} = \frac{y_2 - y_1}{x_2 - x_1} = \frac{V_2 - V_1}{T_2 - T_1} = \text{accleration} = \tan\theta$$

Ⓐ

→ Area inclosed b/w velocity time curve & the time axis Represent disp. of particle.

$$\boxed{\text{Area} = \text{Integration} = \int y\,dx = \int v\,dt = ds = \text{displacement}}$$

[* Disp. = some of Area of V-t Graph with proper sign.
* Disp = Some of Area of V-t Graph with proper sign.
* Distance ⇒ some of Area of V-t Graph with +ve sign.



$$\boxed{\begin{aligned} * \text{Disp.} &= A_1 - A_2 \\ * \text{Dist.} &= A_1 + A_2 \end{aligned}}$$

* Acceleration - time Graph
→ Acceleration time-Graph represent Jerk of particle.

$$\boxed{\text{slope} = \frac{dy}{dx} = \frac{da}{dt} = \frac{a_2 - a_1}{t_2 - t_1} = \tan\theta = \text{Jerk}}$$

* Area enclosed b/w acceleration - time curve & time axis Represent.
change in velocity of particle of particle.

$$\boxed{\text{Area} = I = \int y\,dx = \int a\,dt = dv = V_f - V_i}$$

Imp
* If a particle start from with const. Acceln 'α' & comes in Rest with constant retardation 'β' then Relation →

$$\boxed{\frac{d_1}{d_2} = \frac{t_1}{t_2} = \frac{\beta}{\alpha}}$$

* Avg Acceln

$$\boxed{\vec{A}_{avg} = \frac{\Delta\vec{V}}{\Delta t} = \frac{\vec{V}_f - \vec{V}_i}{t_f - t_i}}$$

NOTE → ** Direction of Instantinous Acceleration in the the direction of force. but Avg. Acceleration in the direction of change in velocity.

Problem based on differentiation & Intigration

case-I $\boxed{X = f(t)}$

$$\boxed{\begin{aligned} V &= \frac{dx}{dt} = \frac{d}{dt}[f(t)] \\ a &= \frac{dv}{dt} = \frac{d^2x}{dt^2} = \frac{d^2}{dt^2}[f(t)] \end{aligned}}$$

case-II $a = f(t)$

$$a = \frac{dv}{dt}$$

$$\boxed{dv = \int a\,dt}$$

$$V = \frac{ds}{dt} \qquad \boxed{ds = \int v\,dt}$$

caseIII → |a| → $V = f(x)$

$$\boxed{a = v\frac{dv}{dx} = f(x)\frac{d}{dx}[f(x)]}$$

|b| → $V = f(x) = \frac{dx}{dt}$

$$\boxed{\int dt = \int \frac{dx}{f(x)}}$$

|c| → $f = f(x)$

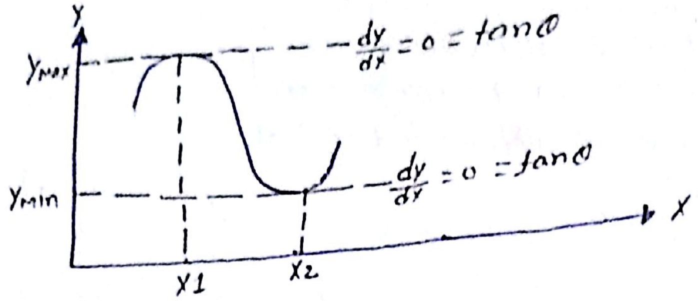
$$v\frac{dv}{dx} = f(x)$$

$$\boxed{\int v\,dv = \int f(x)\,dx}$$

**

$$\boxed{\boxed{X = f(t)} \underset{\int v\,dt}{\overset{dx/dt}{\rightleftarrows}} \boxed{V = f(t)} \underset{\int a\,dt}{\overset{dv/dt}{\rightleftarrows}} \boxed{a = f(t)}}$$

Maxima - minima concept



Step-I

$\boxed{\frac{dy}{dx} = 0} \Rightarrow x = x_1, x_2, x_3 \ldots$

Step-II

* $\frac{d}{dt}\left(\frac{dy}{dx}\right) = \frac{d^2y}{dx^2}$ → $x = x_1 \Rightarrow \frac{d^2y}{dy^2} \Rightarrow$ ⊖ve $\Rightarrow$ Max at x_1.
→ $x = x_2 \Rightarrow \frac{d^2y}{dx^2} \Rightarrow$ ⊕ve $\Rightarrow$ Min at x_2.

Step-III

* (y_{max}) at $x_1 \Rightarrow f(x_1)$
* (y_{min}) at $x_2 \Rightarrow f(x_2)$

|4| → Equation of Motion

Ist $\vec{v} = \vec{u} + \vec{a}t$

2nd $\vec{S} = \vec{u}t + \frac{1}{2}\vec{a}t^2$

3rd $\vec{v}^2 = \vec{u}^2 + 2\vec{a}\cdot\vec{s}$

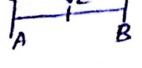
4th $S_{nth} = u + \frac{1}{2}a(2n-1)$
(Dist. & Disp. in nth sec.)

NOTE → Equation of motion use only When particle move With const. acceleration.

$$\boxed{\begin{aligned}\vec{S} &= \vec{V}_{avg} \times t \\ \vec{V}_{aver} &= \frac{\vec{S}}{t}\end{aligned}}$$

Standard NOTE →
* If particle start from Rest with constant acceleration then Ratio of distance covered in conseCtive same time Interval Will be 1 : 3 : 5 : 7 : 9 - - - (T, 2T, 3T)
* If constant Retardation applied on object & final velocity become zero than Ratio of distance covered in a consecutive Same time interval will be 9 : 7 : 5 : 3 : 1 (T, 2T, 3T)
* If particle start from Rest with constant acceleration then ratio of time taken for same consicutive distance is (Mans S, 2S, 3S...) is $1 : \sqrt{2}-\sqrt{1} : \sqrt{3}-\sqrt{2} : \sqrt{4}-\sqrt{3}$ - - -
* If two velocity at poin 'A' & 'B' are given then velocity at centre of point 'A' & 'B' are

$$\boxed{V_c = \sqrt{\frac{u^2 + v^2}{2}}}$$



⑥

* If a bus is at a distance of 'x' meter fr... velocity of the person to catch ... move with const acceln, then velocity of the person from/bus.

$$\boxed{V \geq \sqrt{2ax}}$$

* A vehicle travel half of distance 'l' with v_1 & the other half with speed v_2, then Average speed.

$$\boxed{V_{avg} = \frac{2v_1v_2}{v_1+v_2}}$$

* If a particle is Accelerated for time 't_1' with acceleration a_1 & for a time 't_2' with acceleration a_2. then Average acceln.

$$\boxed{a_{avg} = \frac{a_1t_1 + a_2t_2}{t_1+t_2}}$$

MOTION UNDER GRAVITY

Case-I → Particle projected vertically upward from the Ground

* Time taken from bottom to top $= \boxed{\frac{u}{g}}$
* Time of flight ($T_{up} + T_{down}$)

$$\boxed{T = \frac{2u}{g}}$$

* $H_{max} = \frac{u^2}{2g}$ [* Dist $= 2H_{max} = \frac{u^2}{g}$; * Disp $= 0$]

* velo at time 't'
  * $t = 0 \Rightarrow v = u$
  * $t = \frac{u}{g} \Rightarrow v = 0$
  * $t = \frac{2u}{g} \Rightarrow v = -u$

* position at time 't'

$$\boxed{h = ut - \frac{1}{2}gt^2}$$

* Friction $= 0 \Rightarrow t_{up} = t_{down}$
  $T = 2t_{up} = \frac{2u}{g}$
* Friction $\neq 0$
  $\boxed{t_{up} < t_{down}}$
  * $t_{up} = \frac{u}{g+a}$
  * $t_{down} = \frac{u}{g-a}$

Standard NOTE →

* If air friction is not consider then, time of ascending is equal to time of descending.
* Equation of motion in motion under gravity is only valid/use when gravitation acceln is const. It is possible when 'h' is less-less than 'R' ($h \ll R$).
* In last second of Ascending & First second of descending distance covered by particle is 5m & It is independent from max Height & projection velocity.
* Velocity of particle in last second of Ascending & After first second of descending is 9.8 m/sec. It is also independent from max height & projection velocity.
* At same level speed of particle same due to direction velocity is changed.
* If Air drag is consider than time of descending is more than time of Ascending.
* Particle crosses same height at two time in journey.
* Its same height speed of particle is same when it goes upward & downward.
* Distance covered by particle in last 't' sec. of Ascending & Ist 't' sec. of descending is same ($\frac{1}{2}gt^2$).

Case-II → Vertical projection from Height.

* $\boxed{H_{max} = H + \frac{u^2}{2g}}$
* Velocity at botom

$$\boxed{V_b = \sqrt{u^2 + 2gH}}$$

* Time of flight

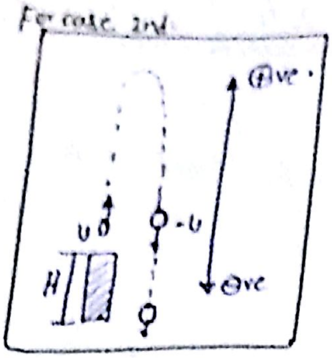
$$\boxed{T = \frac{u}{g} + \sqrt{\frac{u^2}{g^2} + \frac{2H}{g}}}$$

* velo at time 't'

$$\boxed{v = u - gt}$$

* Position At time 't'

Disp. from Height (Bulding) $\boxed{h = ut - \frac{1}{2}gt^2}$



Downward direction

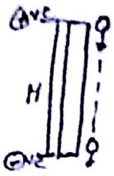
* velocity at bottom

$V_b = \sqrt{u^2 + 2gh}$

* Time of Height

$T = \frac{-u}{g} + \sqrt{\frac{u^2}{g^2} + \frac{2H}{g}}$

Case-III → Drop from Height



* velocity at bottom $\boxed{V_b = \sqrt{2gh}}$
* Time of flight $\boxed{T = \sqrt{\frac{2H}{g}}}$
* velocity at time 't' $\boxed{V = -gt}$
* Position at time 't' or, vertical disp at time 't' $\boxed{h = \frac{1}{2}gt^2}$

NOTE → * From same height different particle is projected with same speed in different direction than speed of particle at bottom point independent from projection direction. ($V = \sqrt{u^2+2gH}$)

* If particle drop from height $s = ut + 1/2\, at^2$; $-h = (0) + 1/2\, (-g)t^2$. Ratio of dist. traveled in consecutive same time interval is 1 : 3 : 5 : 7 . . . .

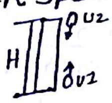
* If particle drop from height than Ratio of time taken by particle ~~ioas~~ to cover equal distance.

$t_1 : t_2 : t_3 = 1 : \sqrt{2} - \sqrt{1} : \sqrt{3} - \sqrt{2} : \sqrt{4} - \sqrt{3}$.

STANDARD RESULT

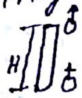
*→ When a particle is Released from height with velocity U_2 & anothe particle is projected with speed U_1. They will meet at time.

$$\boxed{t = \frac{H}{U_1 + U_2}}$$



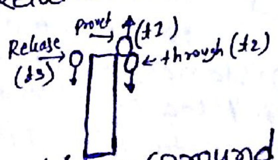
*→ When a particle is projected upward some height & anothe particle projected from Ground than they will meet at time 't'

$$\boxed{t = \frac{H}{U_1 - U_2}}$$



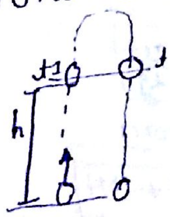
*→ When a particle projected vertically upward from height 'h' with speed 'u' & When an another particle is thrown vertically downward with same speed at same instant & at same Instant another 3rd particle is Released from height then Relation of Time taken by particle to Reach the Ground is.

$$\boxed{t_3 = \sqrt{t_1 t_2}}$$

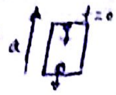


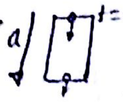
*→ Particle projected vertically upward from Ground time taken the same height Resp. t_1 & t_2.

* $h = \frac{1}{2} g t_1 t_2$
* $u = \frac{g}{2}(t_1 + t_2)$
* $v = \frac{g}{2}(t_2 - t_1)$
* $H_{max} = \frac{g}{8}(t_1 + t_2)^2$

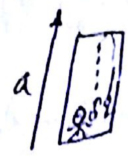


* → Drop in lift

|a| →  $\boxed{t = \sqrt{\frac{2H}{g+a}}}$

|b| →  $\boxed{t = \sqrt{\frac{2H}{g-a}}}$

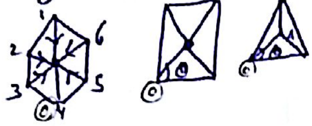
|c| → V=c or V=0  $\boxed{t = \sqrt{\frac{2H}{g}}}$



$t_{up} = \frac{2u}{g+a}$

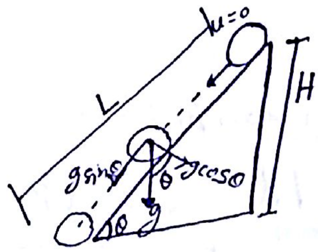
$t_{down} = \frac{2u}{g-a}$

* If some particle is ⊕nt in square, triangle, rectangular Hexagonal corner & Ist move towards 2nd, 2nd move towards third like that then they will meet at centre of system like that

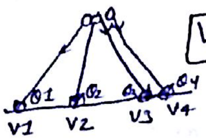


$\boxed{t = \frac{OA}{v\cos\theta}}$

Case IV → Motion along the Inclined plane



* Velocity at Ground $= \sqrt{2gH} \propto \theta^{\circ}$
* Time taken to Reach the Ground $t = \frac{1}{\sin\theta}\sqrt{\frac{2H}{g}}$
* If drop from same height



$\boxed{V_1 = V_2 = V_3 = V_4}$

$\boxed{T_{min}\ \theta = 90^{\circ}}$

$\boxed{T_{30} > T_{45} > T_{60} > T_{90}}$

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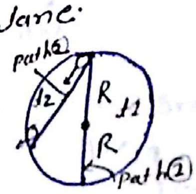
NOTE → * In a translational motion along the incline plane velocity at bottom is independent from angle of Inclination & size & shape of object.

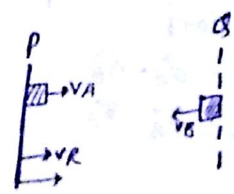
* It depend ~~condy~~ at height.
* Time taken by particle is depend on angle of inclination & Height but also Independent from size & shape of object.

A particle of mass 'M' move along the path 1 & 2 in Vt. plane.



* Time taken to cross the chord $= \boxed{2\sqrt{R/g}}$
* velo of particle at opposite chord $= \boxed{2v\cos\theta\sqrt{Rg}}$
* Ratio of $\boxed{t_1 : t_2 = 1:1}$

River crossing problem



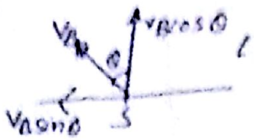
* upstream condition

$\boxed{t = \frac{PQ}{V_B - V_R}}$

* For downstream condition

$\boxed{t = \frac{PQ}{V_B + V_R}}$

* For min distance condition



$\boxed{V_B\sin\theta = V_R}$ → For min Distance

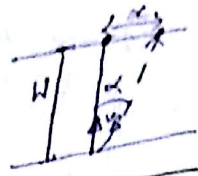
$\boxed{\theta = \sin^{-1}\frac{V_R}{V_B}}$

Angle from River flow = $\boxed{90 + \sin^{-1}\frac{V_R}{V_B}}$

Time to cover min distance $\boxed{t = \frac{\omega}{\sqrt{V_B^2 - V_R^2}}}$

* Minimum time Approch

* To cross river minimum time boat or swimer move ⊥ to the direction of River Flow



Drift $= x = V_R t_{min}$

$= \boxed{V_R\left(\frac{W}{V_B}\right)}$

$\boxed{t_{min} = \frac{W}{V_B}}$

$\boxed{\alpha = \tan^{-1}\frac{V_B}{V_R}}$

Rain Man problem

$V_{rg} = -y\hat{j}$

$\boxed{V_{rm} = -y\hat{j} - x\hat{i}}$

$\boxed{|V_{rm}| = \sqrt{x^2+y^2}}$

$\boxed{\tan\theta = x/y}$

To solve the prob. of Rain

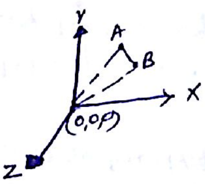
$\vec{V}_{rm} = \vec{V}_{rg} - \vec{V}_{mg}.$

* Ist stop the observer & then make him moving.
* Then go on drawing the Rain on him as ray & try to make a trangle. Then find out unknown from trangle.

Relative velocity

* position of 'A' w.r.t 'B'

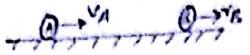
$\vec{X}_{AB} = \vec{X}_A - \vec{X}_B$



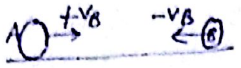
* Relative velocity
  - of 'A' w.r.t 'B' ⇒ $\vec{V}_{AB} = \vec{V}_A - \vec{V}_B$
  - of 'B' w.r.t 'A' ⇒ $\vec{V}_{BA} = \vec{V}_B - \vec{V}_A$

$\boxed{\vec{V}_{AB} = -\vec{V}_{BA}}$

* Relative Acceleration
  * $\vec{a}_{AB} = \vec{a}_A - \vec{a}_B$
  * $\vec{a}_{BA} = \vec{a}_B - \vec{a}_A$

|a| → 

$$\left.\begin{aligned} V_{AB} &= V_A - V_B \\ V_{BA} &= V_B - V_A \end{aligned}\right] V_{min}$$

|b| → 

$$\left.\begin{aligned} V_{AB} &= V_A - (-V_B) = V_A + V_B \\ V_{BA} &= -V_B - V_A = -(V_A + V_B) \end{aligned}\right] V_{max}$$

NOTE → * If two particle in same direction w.r.t common frame of Reference, relative velocity is Min & When move in opposite direction relative velocity is max.

* If particle move in moving frame of Reference than Relative velocity w.r.t Ground in same direction is Max & opposite direction is Min.