# 2. Motion in One Dimension.

→ **motion** : It the position of particle changes with time then particle will called in motion

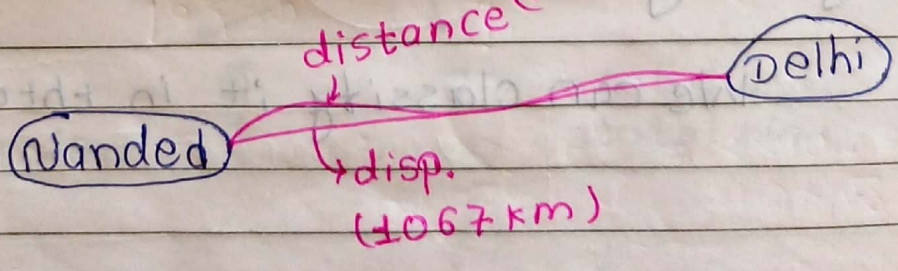
→ In given frame a body will be in motion at same time it may in rest in another frame.

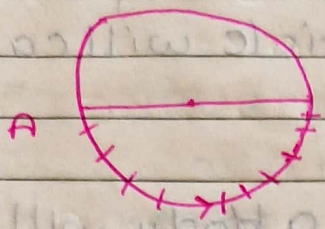
## *Distan and Displacement.

→ The total length of path traced by a particle is known as <u>distance</u> covered by him. where as lineae distance between intial and final point is known as <u>displacemed</u>.

→ Distance is a scalae. where as disp. is vectoe quantity.

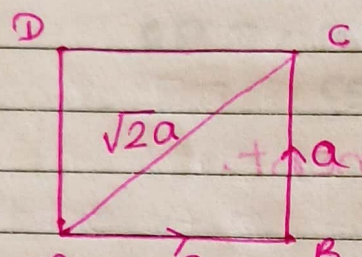
→ Unit of each metre (m) & dimension is $[M^{0}L^{0}T^{0}]$






distance = $\pi R$

disp. = $2R$.




distance = $2a$

disp. = $\sqrt{2}\,a$.

* The ratio of distance & disp. is greater than or equal to 1

$$\frac{\text{distance}}{\text{displacemet}} \geq 1$$

* Speed and velocity.

The distance covered in unit time by body is known as speed.

We can classify it in three catagory.

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Speed

general speed $\left(\frac{D}{t}\right)$ (t = moderate) | instantaneous speed $(\langle v \rangle)$ $t \to 0$ | Average speed. $\left(\frac{dx}{dt}\right)$ $t \uparrow$

→ These classification is based upon for time interval of motion.

**Speed:** Speed is a scalar quantity & its unit is metre/sec. & dimension is $[M^0LT^{-1}]$.

**Velocity:** Vector is vector quantity. The disp. of body in unit time is known as velocity of the particle. & its unit is metre/sec. & dimension $(M^0LT^{-1})$

On the bases of time interval we can classify it in three catagores as explained below.

Velocity

Given velocity $= \frac{\vec{D}}{t}$ | $\langle \vec{v} \rangle = \frac{\text{total dist.}}{\text{total time}}$ | Inst. vela $\frac{d\vec{x}}{dt}$

MTR

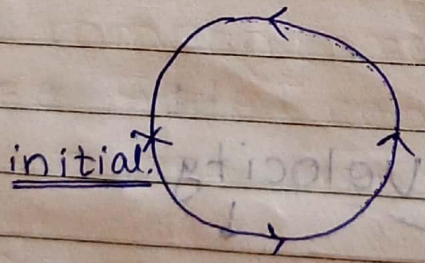
① If a car covers half distance with speed $v_1$ & remaining half with speed $v_2$. Then its average speed will be.

$$\text{Avg. speed} = \frac{2v_1v_2}{v_1+v_2}$$

② If a car moving with speed $v_1$ for half time & $v_2$ for remaining half time the Avg. speed will be.

$$\text{Avg. speed} = \frac{v_1+v_2}{2}$$

③ In a closed path the avg. velocity is zero. but the Avg. speed is non-zero because the disp. is zero but distance is non zero.




Disp. = 0

distance = $2\pi R$

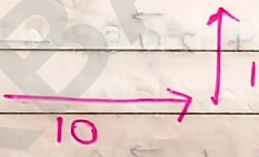
$$\text{Avg. speed} = \frac{2\pi R}{t}$$

★ Accn. : The rate of change of velocity for a given body is known as acceleration

→ It's a vector quantity & it's unit is $m/sec^2$ & dimension is $[M^0LT^{-2}]$.

→ Calculation of accn. in different case.

* If a car is moves toward east with 10m/s after 1sec. its velocity become $10\sqrt{3}$ m/s. towards north then find the accn. of car, its magnitude & its direct.




$$\frac{10\sqrt{3}j - 10i}{10}$$

$$a = \frac{10\sqrt{3}j - 10i}{10} = \sqrt{3}j - 1i. = 1.73 - 1$$

$$= 3 - 1 = 0.73 \text{ m/s}^2.$$

$$= 2 \text{ m/s.} \quad \& \quad N - W$$

N - W

# Newtones eqn of motion :

To describe the motion of a paeticle which is moving with constant velocity & accn. which aee known as eqn of newtones motion.

These eqn aee valid only foe constant accncelera tion. & they are respectively as undee.

① $\vec{v} = \vec{u} + \vec{a}t$ —— ① v-t relation.

② $\vec{s} = \vec{u}t + \frac{1}{2}\vec{a}t^2$ —— ② s.-t releati

③ $\vec{v}^2 = \vec{u}^2 + 2\vec{a}s$ —— ③ v/s releation.

④ $S_{nth} = \vec{u} + \frac{1}{2}\vec{a}(2n-1)$ —— ④

# A cae company maruti blames that its deiee model can attend velocity of 108 km/he. just in 6 sec. the find following.

① accn of a cae
② velocity atte 3 sec
③ Distance travelled by cae in 4 sec
④ velocity of a cae attee 100 m.
⑤ distance covered in 4th sec

① $108 \times \frac{5}{18}$

$= 30 \text{ m/s}.$

$v = u + at$

$30 = 0 + a(6)$

$a = 5 \text{ m/s}^2.$

② $v = 0 + 5 \times 3$

$v = 15 \text{ m/s}$

③ $s = \frac{5(16)}{2}$

$= 40\text{m}.$

④ $v^2 = 2(5)(50)$

$v^2 = 500$

$v = \sqrt{500}$

$v = 10\sqrt{5} \text{ m/s}$

⑤ $s = \frac{1}{2} g(2t-1)$

$= \frac{1}{2}(7) \times \frac{5}{2}$

$= \frac{35}{2}$

$s = 17.5\text{m}$

# It the velocity of an object decrease with time then the value of accn is -ve. which is also known as retardation.

In these case the eqn of motion are as under.

$$\bar{a} < 0.$$

$$v = u - at$$

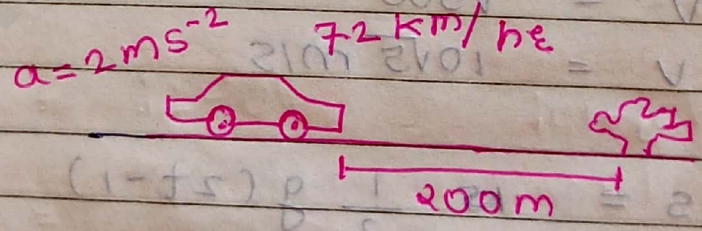
$$s = ut - \frac{1}{2}at^2$$

$$v^2 = u^2 - 2as$$

$$s = u - \frac{1}{2}a(2t-1)$$

# Stopping Distance:

MTR 3




$$\boxed{s = \frac{u^2}{2a}}$$

$$\frac{72}{72} \times \frac{5}{18} = 20 \text{ m/s}$$

$$= \frac{20 \times 20}{2 \times 2}$$

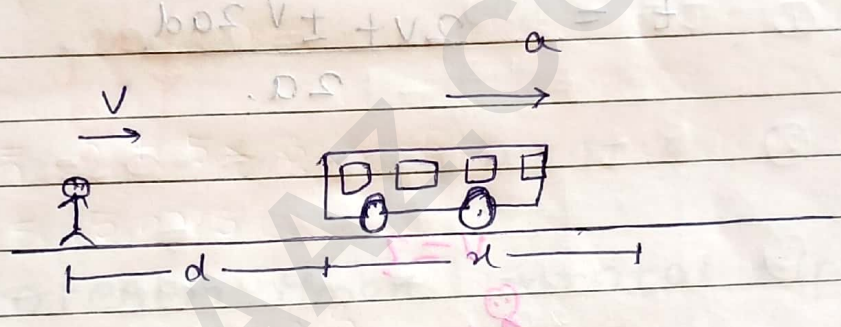
$$= 100 \text{ m}$$

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

$$= \frac{20}{2}$$

$$t = 10 \text{ sec.}$$

# Space-gap problems :




let the person catches the bus after time t in these time let the bus travel distance (s) then in the same time interval matheh man has to catch the bus

$$s = \frac{1}{2} a t^2$$

$$s + d = v \times t$$

$$\frac{1}{2} a t^2 + d = v \times t$$

$$a t^2 + 2d - 2vt = 0$$

$$at^2 - 2vt + 2d = 0$$

$$b^2 - 4ac = 4v^2 - 4a2d$$

$$= 4v^2 - 8ad.$$

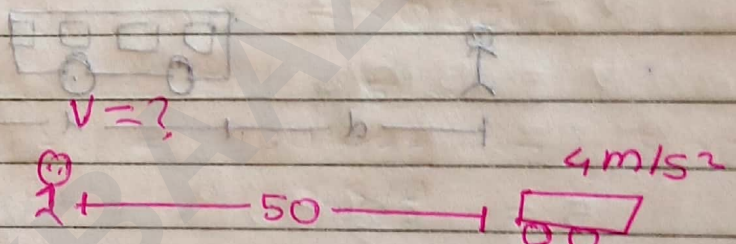
$$v = \frac{\sqrt{8ad}}{4}$$

MTR = 4

$$\boxed{v \geq \sqrt{2ad}.}$$

$$t = \frac{2v \pm \sqrt{2ad}}{2a.}$$

#

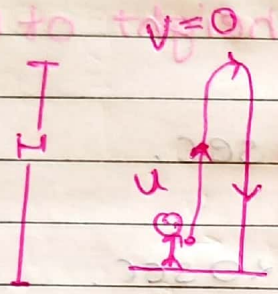



$$v = \sqrt{2 \times 4 \times 50}$$

$$= \sqrt{400} = 20 m/s.$$

# Motion under gravity

If a body is thrown vertically upward. then its eqⁿ of motion can be written as under:




★ Time to reach Hmax.

$$v = u + at$$

$$0 = u + at$$

$$\therefore t = \frac{u}{a}$$

★ Total time

$$t = \frac{2u}{g}$$

★ Hmax.

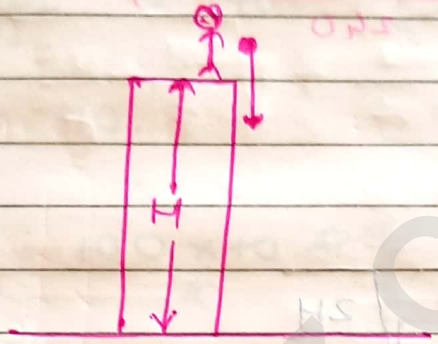
$$v^2 = u^2 + 2as$$

$$0 = u^2 + 2as$$

$$\therefore s = \frac{u^2}{2a}$$

MTR :5 If a body is thrown vertically upward then for any velocity the distance covered in last is always same & it is 5 mete

**Downward projection:** If a body is thrown from the top of tower with initial velocity u in downward direction then its eqⁿ of motion are as under.




① $v = u + gt$.

② $h = ut + \frac{1}{2}gt^2$

③ $v^2 = u^2 + 2gs$.

④ $H_{nth} = u + \frac{g}{2}(2n-1)$

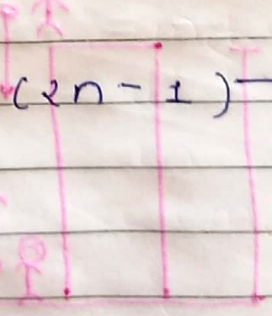
# If a body is dropped from height then its initial velocity is zero then the eqⁿ of motion.

$$v = gt \quad \text{—— ①}$$

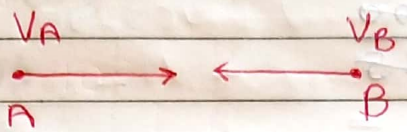
$$h = \frac{1}{2}gt^2 \quad \text{—— ②}$$

$$v^2 = 2gh \quad \text{—— ③}$$

$$h_n = \frac{g}{2}(2n-1) \quad \text{—— ④}$$



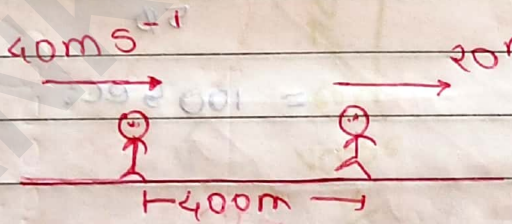
# When two particle A & B are provided and their velocity $v_A$ and $v_B$ are respectively. Hense the velocity of $v_A$ w.r.t. B is given by following expression.



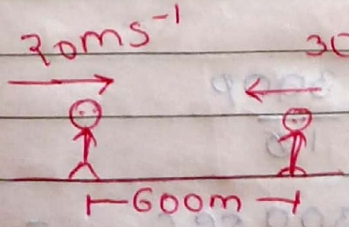

$$\vec{V}_{A/B} = \vec{V}_A + \vec{V}_B$$


$$\vec{V}_{A/B} = V_A - V_B$$

(1)




$$T. = \frac{400}{40-20} = \frac{400}{20} = 20.\text{sec}$$

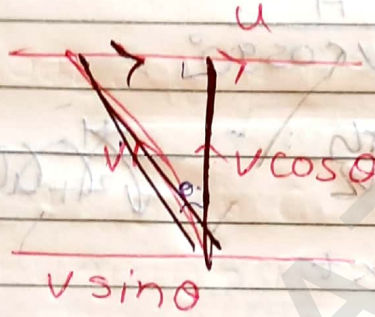



$$T = \frac{600}{50} = 12\text{sec}.$$

# River Concept

★ For shortest distance

Let a river is flowing with velocity v & a body who can swim with velocity v, in a water who wants to cross a river, we can cross it in two ways.



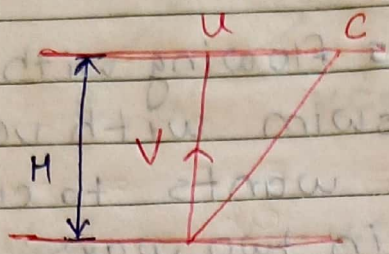

$v \sin\theta = u$

$\therefore \sin\theta = \frac{u}{v}$

$$\text{Time} = \frac{H}{v\cos\theta} = \frac{H}{v\cos\theta}$$

$$= \frac{H.}{\sqrt{v^2 - u^2}.}$$

* for shortest time.




$\theta = 90°$

$$t = \frac{H}{v\cos 90°}$$

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

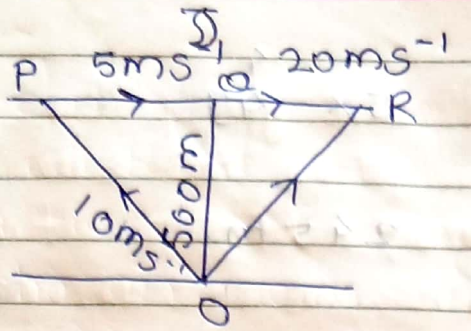
$$x = u \times t$$

$$= u \times \frac{H}{v}$$

$$= \frac{u \times H}{v}$$

# There is village named and river is flowing through it two children. kitchup & chotta manu can swimm in still water with speed 10ms$^{-1}$ kitchup obtained for shortest path where as manu. obtained for minimum time if there is a mango tree in opposite side then find the time taken by them reach the mango tree: hense tell who will eat the 1st mango, if chatta manu can run 20ms$^{-1}$ for the

Ans:




$$\text{Time} = \frac{H}{\sqrt{v^2 - u^2}}$$

$$= \frac{500}{\sqrt{100 - 25}}$$

$$= \frac{500}{\sqrt{75}}$$

$$= \frac{100}{5\sqrt{3}}$$

$$= \frac{100}{1.73}$$

$$= 57.80s^{-}$$

$$\text{Time} = \frac{H}{\sqrt{v^2 + u^2}}$$

$$= \frac{500}{\sqrt{100 + 25}}$$

$$= \frac{500}{\sqrt{125}} = \frac{100}{5\sqrt{5}}$$

$$= 49.$$

distance = $5 \times 49$

$= 245\ m.$

Time. $= \frac{245}{20} = 12.2$

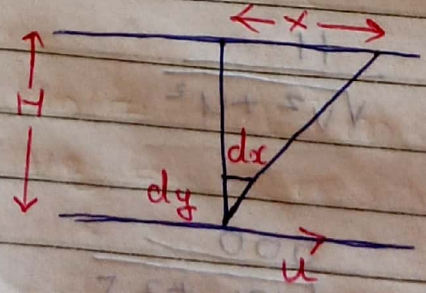
$= 12.2\ sec.$

Time for kitchup $= 57.80\ sec.$

Time for many $= 48 + 12.2 = 60.2$

∴ The kitchup will reach 1st & eat mango.

★ If there is a variation in a river flow and we want to calculate time of crossing then for these pupose we will use the integration method as explained the below:



Ans:

$$\boxed{t = \frac{H}{u}}$$

$v \propto y$

given.

$v = ky.$

$dx = v.dt.$

$$\int_0^x dx = \int_0^H ky \frac{dy}{u}$$

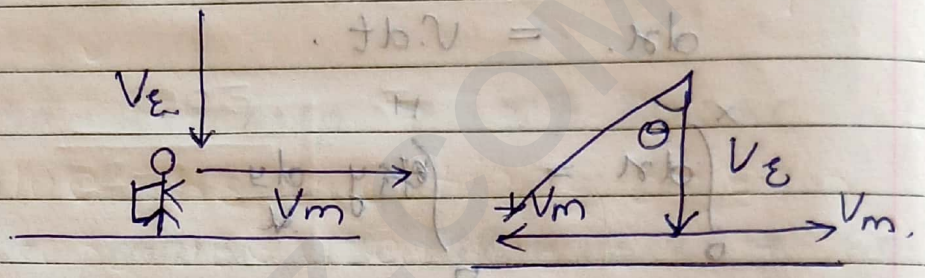
$$x = \frac{k}{u} \int_0^H y.dy$$

$$x = \frac{k}{u} \frac{y^2}{2}$$

$$\boxed{x = \frac{kH^2}{2u}}$$

Q One day little jony was going to his school suddenly the rain start with velocity $10ms^{-1}$ then find the apperant speed of rain hense its direction as experianced by jony. $V_m = 10\sqrt{3}\ ms^{-1}$

Ans.




$$\vec{V}_{\varepsilon/m} = \vec{V}_\varepsilon - \vec{V}_m$$

$$\vec{V}_{\varepsilon/m} = \vec{V}_\varepsilon + (-\vec{V}_m)$$

① Apperant speed $= V_{\varepsilon/m} = \sqrt{V_\varepsilon^2 + V_m^2}$

② Direction $= \boxed{\tan\theta = \frac{V_m}{V_\varepsilon}}$

Q. Ans:

$V_m = 10\sqrt{3}\ ms^{-1}$

$V_\varepsilon = 10\ ms^{-1}$

$|V_{\varepsilon/m}| = \sqrt{100\times3+100}$

$= \sqrt{400}$

$|V_{\varepsilon/m}| = 20ms^{-1}$

$$\tan\theta = \frac{V_m}{V_E} = \frac{10\sqrt{3}}{10} =$$

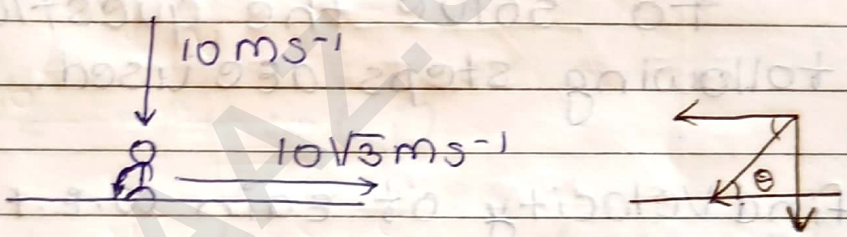
$$\tan\theta = \sqrt{3}$$

$$\theta = \tan^{-1}\sqrt{3}$$

$$\theta = 60°.$$

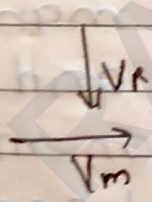
# For a given case find the apperant speed of rain (i) $V_{Elm}$ (ii) Direction of dit' umbrella to protect.

Ans:




$\vec{V}_{Elm} = \vec{V}_r - \vec{V}_m$ $\quad |V_{Elm}| = \sqrt{100 + 100 \times 3}$

$= 20 ms^{-1}$



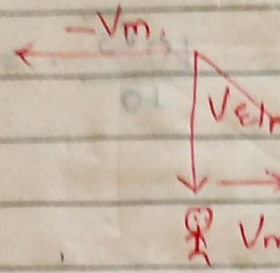

$\tan\theta = \frac{V_E}{V_m} = \frac{10}{10\sqrt{3}}$

$$\tan\theta = \frac{1}{\sqrt{3}}$$

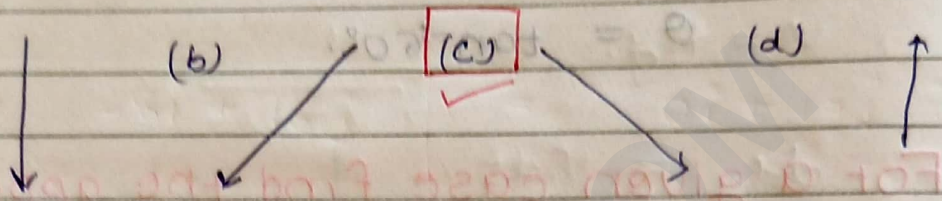
$$\theta = 30°$$

∴ he had to take umbrella at 30° with horizontally.

Q2.




Ans: (a) (b) (c) (d)



# To solve the questions of rain following steps are used.

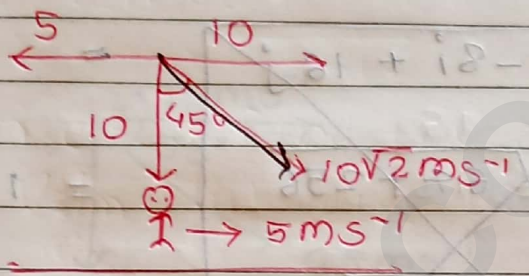
1. Find velocity of rain w.r.t. man. its magnitude will represent the speed of rain & angle will be $\theta = \tan^{-1} \frac{V_m}{V_{e,m}}$

2. On increasing the speed of man apparent speed will increase and the rian will bend towards the man. more the speed man more will be the bending of rain

3. If a running man feels that rain is falling vertically downward. then the actual direction of the ~~man~~ rain will be from the back side.

④ It we want to solve the question of rain in sec we must stop the man & its velocity to rain in opposite direction these way we can calculate apperate speed & direction.

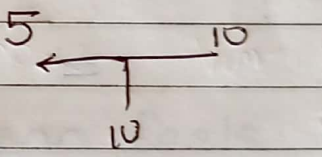
Q1



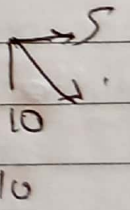

Ans: $V_{e/m} = 5i + 10(-j)$

$(V_{e/m}) = \sqrt{25+100} = \sqrt{125} = 5\sqrt{5}$

$\tan\theta = \frac{5}{10}$

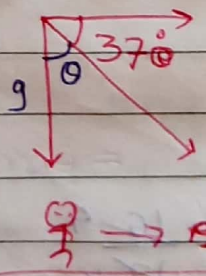



$\theta = \tan^{-1}\frac{1}{2}$,




Q2

$15 \times \cos 37° = 12$




Ans:

$V_{e/m} = 3i + (9)(-j)$

$= \sqrt{81+9}$

$= \sqrt{90}$

$= 3\sqrt{10}$

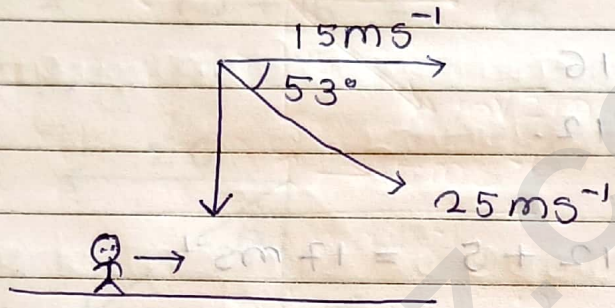
$\tan\theta = \frac{3}{9}$ $\frac{1}{3}$

$\tan\theta = \frac{1}{3}$

$\theta = \tan^{-1}\frac{1}{3}$

# If a boy standing on a road and rain is falling As shown in fig. Then find the speed of man so rain appears to him falling vertically Downwards?

Ans:




∴ The boy will be move 15 ms⁻¹ to appear rain vertically.

MTR → When ever a person feels that rain is falling vertically downward then the velocity of rain must be equal to horizontal compoent of rain.

→ The solve any question of rain & man use the following steps

(i) stops the man & Give it velocity to rain in opposite direction.

(ii) Find these releative velocity in vector form & calculate the speed

(iii) By the trigonametic write tanθ & get the angle.

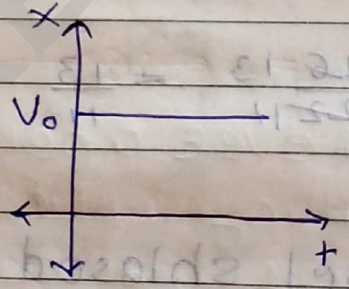
# Term Analysis

1. If the position of particle is represented with time on the graph then this is known as position time curve

2. The resultant from graph are obtained velocity.

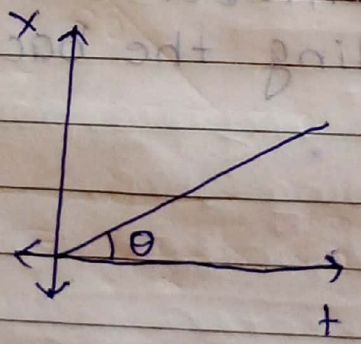
3. The slope of tangent drawn at any point represent velocity at that point

① x - t graph




$V_0 = 0$
(Rest)

②

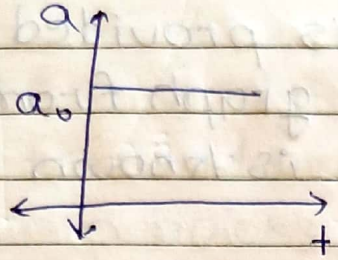



V = constant.

a = 0

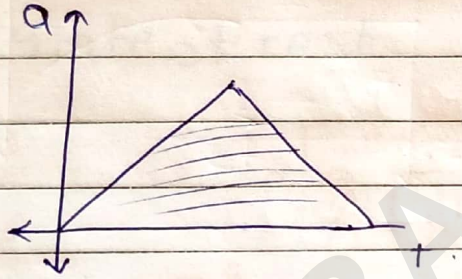
③ A-T curve.

ⓐ




accn = Constant.

ⓑ



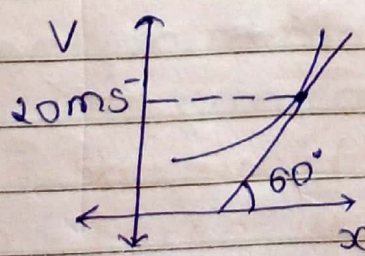

Area = change in velocity.

ⓒ

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

$$\text{accn} = \frac{v \cdot dv}{dx}$$

ⓓ




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

$$= 20 \times \tan 60^\circ$$

$$= 20 \times \sqrt{3}$$

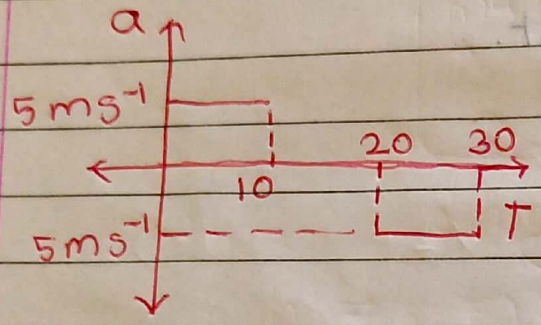
$$= 20\sqrt{3}\ ms^{-2}$$

Change in velocity.

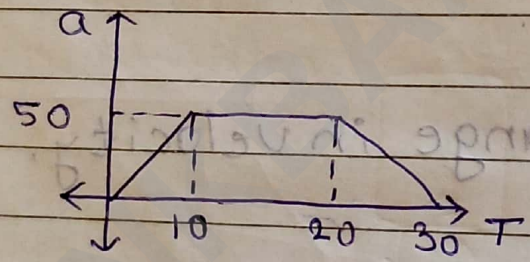
## # Mutual plotting

If any graph is provided & we want to plot another graph from it then these process is known as mutual plotting.

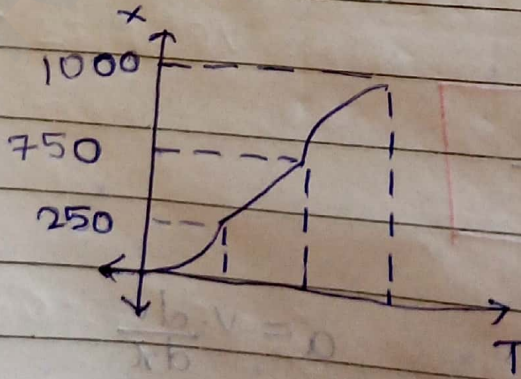
Q.




⇒ v-t.

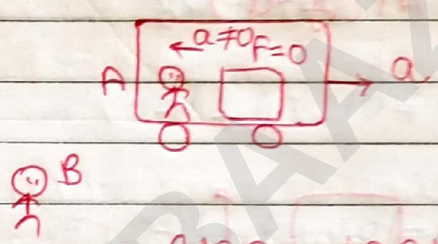



x-t.



# Inertia & non-inertial frame and psudo-force

If a body is on a moving car & the car starts suddenly then the block inside it move in backward direction. If we consider two observers A and B then the motion of the block can be explained by A on the bases of law of inertia because he will say that car is in motion & block will continue in state of rest.

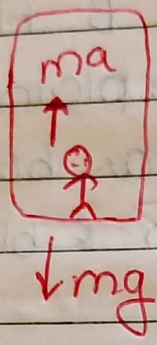



Non-inertial frame for A
inertial frame for B

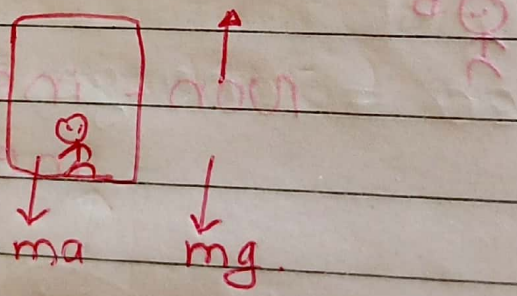
B is surpise because there is no direct force on block but accn. is non-zero which can not be prove by newton 2nd law. F=ma. So to make the newtons law correct we have develope the concept of psudoforce. means we will assume that a force will act opposite to the ~~of~~ direction of motion of the body.

So we can conclude that "The body is inside the accelerated frame will feel the psudo-force which is opposite to the direction on the force of the body."

So when we are moving up in a lift the psudo force act on downward so effective way weight increase. hense lift is moving down then psudo force will act upwards. will decrease as explain below.




$W = m(g-a)$

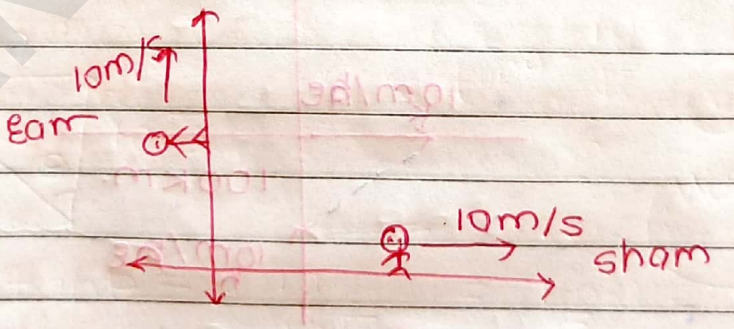



$W = m(g+a)$

## ★ Minimum Distance between two ship, cyclist.

There is a question of shortest distance between ship & cyclist then to solve such question following 4 steps are used they are as under:

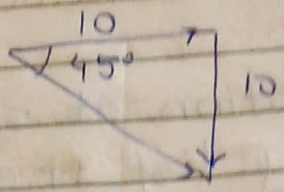
① Stop one of them hense gives its velocity to another one.
② Find the releative velocity hense draw its direction.
③ Draw a ⊥ on the these line from the body stop. the lenght of these ⊥ will represent minimum distance.
④ Then time taken to come these location will be $t = \frac{d'}{(V_{releative})}$




$\vec{V}_{s/r} = V_{sh.} - V_{ram}$

$= 10i - 10j$

$|V_{s/g}| = 10\sqrt{2}$ m/s.



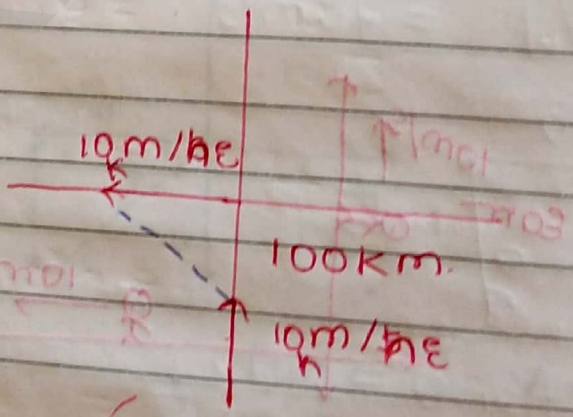

$\theta = 45°$.

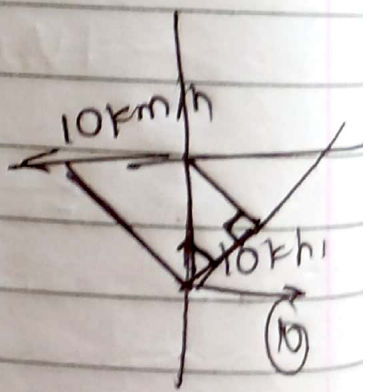
S/E.

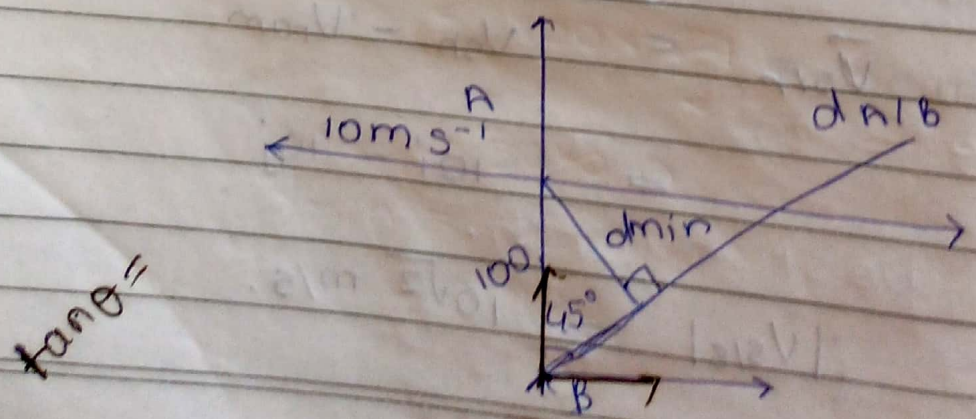
# A ship is going towards west with a velocity of 10m/s the another ship B is moving towards north, with velocity of 10m/s if the ship B is 100km of south from the south A then find the following.

① The minimum distance b/w ship A & ship B

② Time taken to come to these location



$d_{min} = 100 \sin 45°$

$dist. = \frac{100}{\sqrt{2}}$

$= 50\sqrt{2}$ km.

$d' = d\cos 45°$

$= 100 \times \frac{1}{\sqrt{2}}$

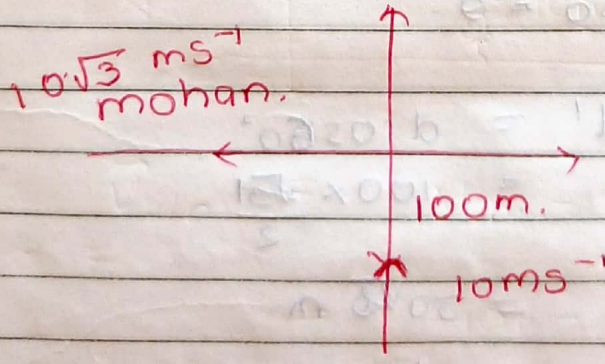
$= 50\sqrt{2}$ km

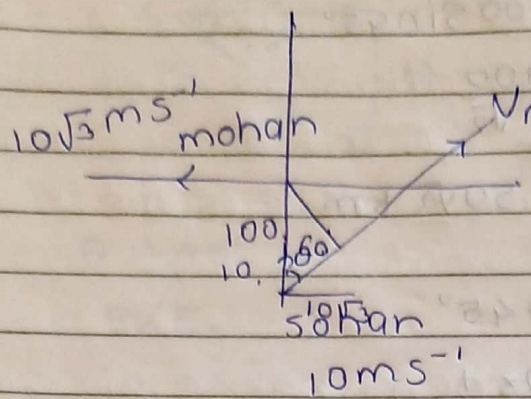
$t = \frac{d'}{|V_{rel}|}$

$= \frac{50\sqrt{2}}{10\sqrt{2}}$

$t = 5$ hr

* If two cyclist mohan & sohan are moving along -x & y direction resp. as shown in Figure, then find the minimum distance between them.






$$V_{m/s} = V_{mohan} - V_{sohan}$$

$$= 10\sqrt{3}(-i) - 10j$$

$$= 10\sqrt{3}(-i) + 10(-j)$$

$$= 20\,ms^{-1}$$

$$\tan\theta = \frac{10}{10\sqrt{3}}$$

$$= \frac{1}{\sqrt{3}}$$

$$30^\circ = \theta.$$

$$d' = d\cos 60^\circ$$

$$= 100 \times \frac{1}{2}$$

$$= 50\ m.$$

$$d_{min} = d\sin 30^\circ$$

$$= \frac{100}{2}$$

$$= 50\ m.$$