NEET | IIT - JEE
FOUNDATIONS

NEET

PHYSICS NOTES

Motion in a straight line

MOTION IN A STRAIGHT LINE

It deals with the motion of an object which changes it's position with time along a straight line.

Kinematics:

The study of the motion of objects without considering the cause of motion is called kinematics.

Rest and Motion:

* **Rest:** If the position of a body does not change with time with respect to the surrounding then it is said to be at rest.

* **Motion:** If the position of a body changes with time with respect to the surrounding then it is said to be in Motion.

Example:

A person standing in a moving bus is at rest with respect to bus and he is in motion with respect to an observer on the ground.

* **Does motion and rest are relative?**

* **Distance:** The actual path covered by a moving particle in a given interval of time.

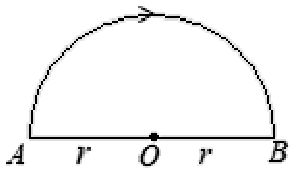
* **Displacement:** The shortest perpendicular distance between initial and final points is called displacement.

$\boxed{\text{Distance} \geq \text{Displacement}}$

* Distance and Displacements both are having same units and dimensional formulas.

S.I unit $= m$; D.F $= L^1$

* Distance is a scalar quantity; Displacement is a vector quantity.

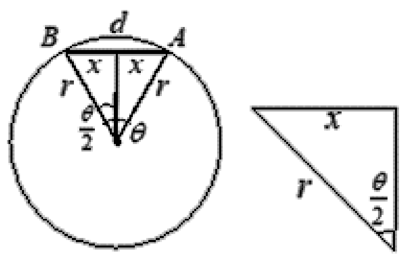


In semicircle
Distance $= \pi r$
Displacement $= 2r$

If an object turns through an angle θ along a circular path of radius r from point A to point B, then

Distance $d = r\theta$

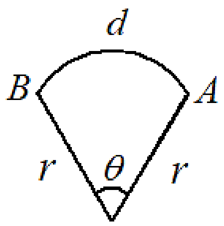
Displacement $2x = 2r \sin\dfrac{\theta}{2}$



$$\sin\left(\frac{\theta}{2}\right) = \frac{x}{r}$$

$$x = r\sin\left(\frac{\theta}{2}\right)$$

Displacement $2x = 2r\sin\left(\frac{\theta}{2}\right)$



$\sin\theta = \frac{\text{length of arc}}{\text{radius}}$

$\sin\theta = \frac{AB}{OB} = \frac{d}{r}$

For smaller angles $\sin\theta \cong \theta$

$\theta = \frac{d}{r} \Rightarrow d = r\theta$

Displacement $2x = 2r\sin\left(\frac{\theta}{2}\right)$

Speed: The rate of change of distances of a moving object is called Speed.

Speed is a scalar

S.I unit $= ms^{-1}$

D.F $= L^1T^{-1}$

Speed $= \frac{\text{distance}}{\text{time}} \Rightarrow v = \frac{s}{t}$

Velocity: The rate of change of displacement of a moving body is called Velocity.

It is a vector.

S.I unit $= ms^{-1}$

D.F $= L^1T^{-1}$

Velocity $= \frac{\text{displacement}}{\text{time}}$

$\vec{v} = \frac{\vec{s}}{t}$

Average speed: The ratio of total distance travelled by the moving object to time taken.

$v_{\text{avg}} = \frac{\text{Total distance travelled}}{\text{Total time taken}}$

$v_{\text{avg}} = \frac{ds}{dt}$

Average velocity: The ratio of total displacement to total time taken by a moving object.

$\vec{v}_{\text{avg}} = \frac{\text{total displacement}}{\text{total time}} = \frac{d\vec{s}}{dt}$

Instant speed: The speed at a particular instant of time.

Instantaneous speed $= \underset{\Delta t \to 0}{\text{lt}} \frac{\Delta s}{\Delta t} = \frac{ds}{dt}$

Instantaneous velocity: The velocity at a particular instant of time.

$$\text{Instantaneous velocity} = \underset{\Delta t \to 0}{\text{lt}} \frac{\Delta \vec{s}}{\Delta t} = \frac{d\vec{s}}{dt}$$

Uniform motion: If an object moving along a straight line covers equal distances in equals intervals of time is knows as uniform motion.

Acceleration:

The rate of change of velocity. of a moving body is called acceleration.

Let $v_1,\ v_2$ be the velocities of a particle at instance $t_1,\ t_2$ respectively then

$$\text{Acceleration} = \frac{\text{change in velocity}}{\text{time}} = \frac{v_2 - v_1}{t_2 - t_1}$$

$$a = \frac{v-u}{t} \text{ (or) } \frac{dv}{dt}$$

S.I unit of $a = ms^{-2}$

D.F for $a = LT^{-2}$

Instantaneous acceleration:

The acceleration at a particular instant of time.

$$\text{Instantaneous acceleration} = \underset{\Delta t \to 0}{\text{Lt}} \frac{\Delta v}{\Delta t} = \frac{dv}{dt}$$

Deceleration [retardation or negative acceleration]:

The velocity of a moving object decreases is called deceleration.

Uniform acceleration:

The velocity either increases or decreases at the same rate throughout the motion.

kinematical equations of motion

1. $v = u + at$
2. $v^2 - u^2 = 2as$
3. $s = ut + \frac{1}{2}at^2$
4. $s_n = u + a\left[n - \frac{1}{2}\right]$

$s_n =$ distance travelled in n^{th} second

5. Displacement = (Average velocity) time

$$s = v_{\text{avg}}\ T = \left(\frac{v+u}{2}\right)T$$

where

$u =$ initial velocity

$v =$ final velocity

$s =$ distance or displacement

$a =$ acceleration

$t =$ time

6. $x_i =$ initial position

$x_f =$ final position then

displacement $s = x_f - x_i$

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

$$x_f - x_i = ut + \frac{1}{2}at^2$$

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

General method:

$$\text{Acceleration} = \frac{\text{change in velocity}}{\text{time}}$$

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

$$at = v - u$$

$$v = u + at$$

$$v_{\text{avg}} = \frac{s}{t}$$

$$v_{\text{avg}} = \frac{v+u}{2}$$

$$\frac{s}{t} = \frac{v+u}{2}$$

$$\frac{s}{t} = \frac{u+at+u}{2}$$

$$\frac{s}{t} = \frac{2u+at}{2}$$

$$\frac{s}{t} = \frac{2u}{2} + \frac{at}{2}$$

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

$$v = u + at$$

$$v - u = at \rightarrow \text{(a)}$$

$$\frac{s}{t} = \frac{v+u}{2}$$

$$v + u = \frac{2s}{t} \rightarrow \text{(b)}$$

$\text{a} \times \text{b}$:

$$(v+u)(v-u)=\frac{2s}{t}\times at$$

$$v^2-u^2=2as \rightarrow (3)$$

<u>Acceleration due to gravity g :</u>

The uniform acceleration of a freely falling body towards the centre of the earth due to earth's gravitational force. It is represented by g.

Its value is constant for all bodies at a given place.

$g=9.8ms^{-2} \rightarrow$ SI

$g=980cm^{-2} \rightarrow$ C.G.S.

$\rightarrow$ When a body is falls freely velocity is increases.

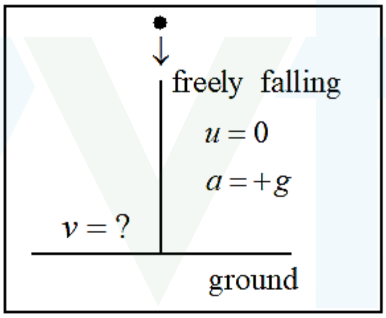
g is +ve sign.

$\rightarrow$ When a body is projected vertically upwards velocity is decreases.

g is -ve sign.

$\rightarrow$ The acceleration due to gravity at the centre of the earth is zero

Equations of motion for a freely falling body:



1. $v=u+at$

$v=0+gt$

$v=gt$

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

$v^2-0=2(g)s$

$v^2=2gs$

$v=\sqrt{2gs}$

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

$s=(0)t+\frac{1}{2}gt^2$

$s=\frac{1}{2}gt^2$

$2s=gt^2$

$t=\sqrt{\frac{2s}{g}}$

If $s=h$

Then $t=\sqrt{\frac{2h}{g}}$

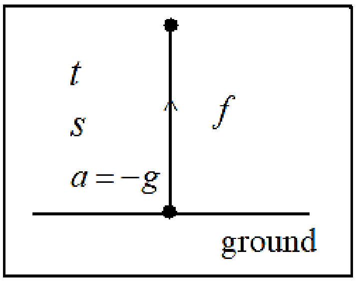
4. $s_n = u + a\left[n - \frac{1}{2}\right]$

$s_n = 0 + g\left[n - \frac{1}{2}\right]$

$s_n = g\left[n - \frac{1}{2}\right]$

Equation of motion for vertically projected body upwards:

1. $v = u + at$



$v = u - gt$

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

$v^2 - u^2 = 2(-g)s$

$v^2 - u^2 = -2gs$

$v^2 = u^2 - 2gs$

$v = \sqrt{u^2 - 2gs}$

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

4. $s_n = u + a\left[n - \frac{1}{2}\right]$

$s_n = u - g\left[n - \frac{1}{2}\right]$

Motion parameters of a body projected vertically upwards:

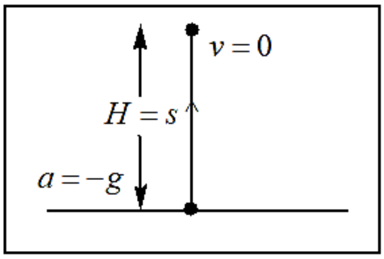
Maximum Height:

For a body projected vertically upwards the maximum vertical displacement with which its final velocity becomes zero called maximum height.

Proof:-

Consider a body is projected vertically upwards with an initial velocity is 'u'?

$\rightarrow$ from $v^2 - u^2 = 2as$



$0^2 - u^2 = 2(-g)H$

$-u^2 = -2gH$

$u^2 = 2gH$

$H = \frac{u^2}{2g}$

Time of ascent:

The time taken by a vertically projected body to reach its maximum height is called Time of ascent.

Proof:-

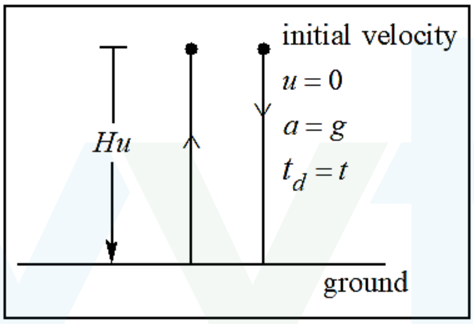
$$\begin{array}{ll} t = t_a & v = u + at \\ v = 0 & 0 = u + (-g)t_a \\ u = u & 0 = u - gt_a \\ a = -g & gt_a = u \\ & t_a = \dfrac{u}{g} \end{array}$$

Time of descent:

For a body projected upwards, the time taken from maximum height to reach the ground [point of projection] is called time of descent.

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

$$H = (0)t + \frac{1}{2}(g)t^2$$



$$H = \frac{gt^2}{2}$$

$$\frac{u^2}{2g} = \frac{gt^2}{2}$$

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

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

$$t_d = \frac{u}{g}$$

Time of flight:

For a body projected vertically upwards sum of time of descent and the time of ascent is called time of flight.

$$t_f = t_a + t_d = \frac{u}{g} + \frac{u}{g}$$

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

Velocity of the body on reaching the point of projection $\left[v_{\text{striking}}\right]$

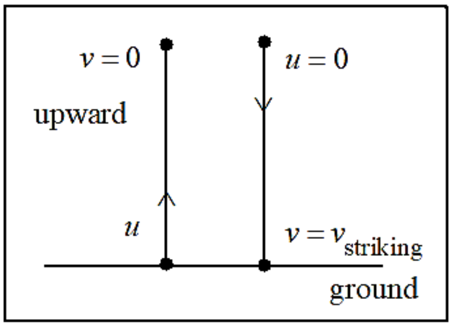
Consider a body is projected vertically upwards with an initial velocity u. The body reaches the point of projection once again after a time of flight (t_f)

We know that

$v = u + at$

$v = v, a = -g$

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



$v_{\text{striking}} = u - g\left[t_f\right]$

$v_{\text{striking}} = u - \frac{2ug}{g} = u - 2u$

$v_{\text{striking}} = -u \to (1)$

upwards

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

$0^2 - u^2 = 2(-g)H$

$-u^2 = -2gh$

$u^2 = 2gh$

$u = \sqrt{2gh} \to (2)$

From eqn. (1) and (2)

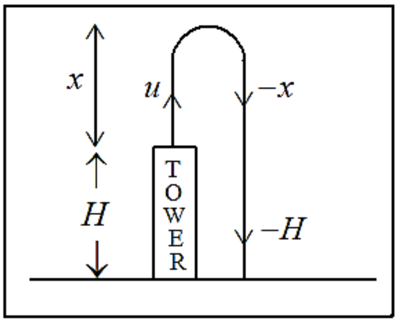
$v_{\text{striking}} = -u = -\sqrt{2gH}$

The body reaches the point of projection with the same speed of projection but in opposite direction.

Vertical projection of an object from a tower

[Equation for height of the tower]

Body is projected upwards



Total displacement $s = x - x - H = -H$

Time $= t$

Initial velocity $= u$

$a = -g$

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

$-H = ut + \frac{1}{2}(-g)t^2$

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

$H = -ut + \frac{1}{2}gt^2$

$\frac{1}{2}gt^2 - ut - H = 0$

$ax^2 + bx + c = 0$

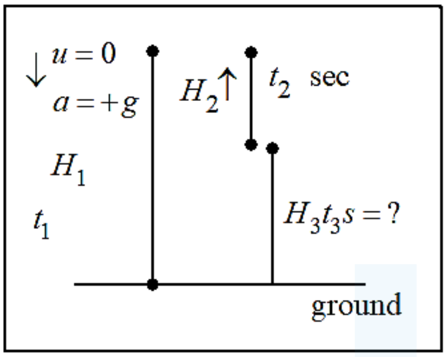
quadratic expression

$$t = \frac{u \pm \sqrt{u^2 + 2gH}}{g}$$

$$x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$$

Consider a tower of height. Let a body is projected upwards vertically with initial velocity u from the top of tower as shown in the above picture.

$\rightarrow$ A body dropped freely from a multistored building can reach the ground in t_1 sec. It is stopped in its path after t_2 sec. and again dropped freely from the point. Find the further time taken by it to reach the ground.



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

$$H_1 = (0)t_1 + \frac{1}{2}gt_1^2$$

$$H_1 = \frac{1}{2}gt_1^2$$

$$H_2 = \frac{1}{2}gt_2^2$$

$$H_3 = \frac{1}{2}gt_3^2$$

From the figure

$$H_1 = H_2 + H_3$$

$$\frac{1}{2}gt_1^2 = \frac{1}{2}gt_2^2 + \frac{1}{2}gt_3^2$$

$$t_1^2 = t_2^2 + t_3^2$$

$$t_3^2 = t_1^2 - t_2^2$$

$$t_3 = \sqrt{t_1^2 - t_2^2}$$

$\rightarrow$ Body I is released from top of tower at the same time is projected vertically upwards as shown in the figure.

Let the two meet after a time t seconds

$t_1 = t_2 = t$ sec $= ?$

Body I	Body II
$u = 0, a = +g$	$s = ut + \frac{1}{2}at^2$
$s = ut + \frac{1}{2}at^2$	$s_2 = ut + \frac{1}{2}(-g)t^2$
$s_1 = (0)t + \frac{1}{2}gt^2$	$s_1 = ut - \frac{1}{2}gt^2$
$s_1 = \frac{1}{2}gt^2$	

We know that

$$h = s_1 + s_2 = \frac{1}{2}gt^2 + ut - \frac{1}{2}gt^2$$

$$h = ut$$

$$t = \frac{h}{u}$$

→ At what time their velocity are equal for body I freely falling $u = 0, a = +g, t = t$

$$v = u + at$$

$$v = 0 + gt$$

$$v_1 = gt$$

For body II

$$u = u \quad a = -g$$

$$t = t \quad v = v_2$$

From $v = u + at$

$$v_2 = u - gt$$

Given $v_1 = v_2$

$$gt = u - gt$$

$$gt + gt = u$$

$$2gt = u$$

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

→ Find their ratio of distance covered their velocities are equal at $t = \frac{u}{2g}$

$$s_1 = \frac{1}{2}gt^2 = \frac{g}{2}\left[\frac{u}{2g}\right]^2 = \frac{g}{2}\left[\frac{u^2}{4g^2}\right] = \frac{u^2}{8g}$$

$$s_2 = ut - \frac{1}{2}gt^2 = u \cdot \left[\frac{u}{2g}\right] - \frac{u^2}{8g} = \frac{u^2}{2g} - \frac{u^2}{8g}$$

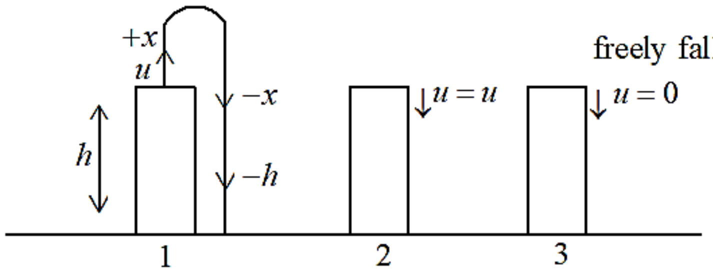
$$s_2 = \frac{4u^2 - u^2}{8g} = \frac{3u^2}{8g}$$

$$\frac{s_1}{s_2} = \frac{\frac{u^2}{8g}}{\frac{3u^2}{8g}} = \frac{1}{3}$$

$$s_1 : s_2 = 1 : 3$$

→ Three bodies are projected from towers of same height as shown. 1^{st} one is projected vertically upwards with velocity u the 2^{nd} one is thrown down vertically with the same velocity and the 3^{rd} one is dropped as freely falling body.

If t_1, t_2, t_3 are the times taken by them to reach the ground, then



For 1^{st} body, $h = -ut_1 + \frac{1}{2}gt_1^2 \rightarrow (1)$

vertically upwards

2^{nd} body, $h = ut_2 + \frac{1}{2}gt_2^2 \rightarrow (2)$

3^{rd} body, $h = \frac{1}{2}gt_3^2 \rightarrow (3)$

eq. $(1)\times t_2 \rightarrow \quad ht_2 = -ut_1t_2 + \frac{1}{2}gt_1^2t_2$

eq. $(2)\times t_1 \rightarrow \quad ht_1 = ut_2t_1 + \frac{1}{2}gt_2^2t_1$

$$h(t_2+t_1) = \frac{g}{2}\left[t_1t_2 + \frac{gt_1t_2}{2}[t_1+t_2]\right]$$

$h = \frac{gt_1t_2}{2} \rightarrow (4)$

From eqns. (3) and (4)

$\frac{1}{2}gt_3^2 = \frac{gt_1t_2}{2}$

$t_3^2 = t_1t_2$

$t_3 = \sqrt{t_1t_2}$

$\rightarrow$ eq. (1) = eq. (2)

$-ut_1 + \frac{1}{2}gt_1^2 = ut_2 + \frac{1}{2}gt_2^2$

$\frac{1}{2}g\left[t_1^2 - t_2^2\right] = ut_2 + ut_1$

$\frac{g}{2}\left[t_1^2 - t_2^2\right] = u\left[t_1 + t_2\right]$

$\frac{g}{2}[t_2 - t_1][t_2 + t_1] = u[t_1 + t_2]$

Velocity of projection $u = \frac{g}{2}(t_2 - t_1) \rightarrow$ eq. (6)

Time difference b/w first two bodies to reach the ground, $\Delta t = \frac{2u}{g}$

From eq. (6)

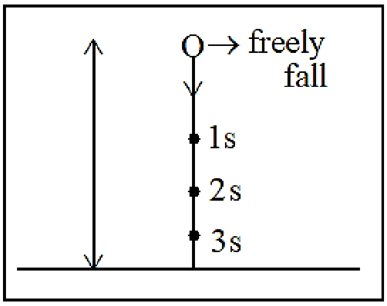
$$2u = g(t_2 - t_1)$$

$$\frac{2u}{g} = t_2 - t_1 = \Delta t$$

For a freely falling body the ratio of distances travelled in 1 second, 2 seconds, 3 seconds is

In case of freely falling

$u = 0, a = g, t = t$



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

$$s = (0)t + \frac{1}{2}gt^2$$

$$s = \frac{1}{2}gt^2$$

$$s \propto t^2$$

If $t = 1$ sec then $s_1 = \frac{1}{2}g(1)^2 = \frac{g}{2}[1]$

If $t = 2$ sec then $s_2 = \frac{1}{2}g(2)^2 = \frac{g}{2}[4]$

If $t = 3$ sec then $s_3 = \frac{1}{2}g(3)^2 = \frac{g}{2}[9]$

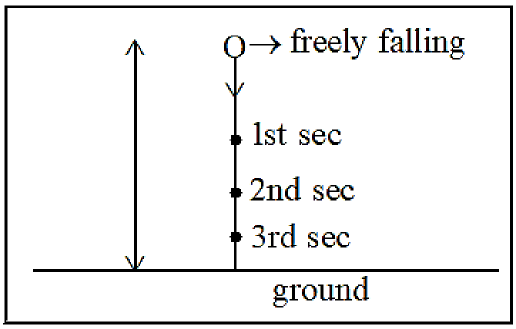
If $t = 4$ sec then $s_4 = \frac{1}{2}g(4)^2 = \frac{g}{2}[16]$

$$\therefore s_1 : s_2 : s_3 : s_4 : \ldots = 1 : 4 : 9 : 16 : \ldots$$

For a freely falling body the ratio of distances travelled in $1^{st}, 2^{nd}, 3^{rd}$ sec...... is

In case of freely falling

$u = 0,\ a = g,\ t = t$



From $s_n = u + a\left[1 - \frac{n}{2}\right]$

$$s_n = 0 + g\left[n - \frac{1}{2}\right]$$

$$s_n = \frac{g}{2}[2n - 1]$$

$$s_n \propto (2n - 1)$$

If $n = 1^{st}$ sec then $s_1 = \frac{g}{2}[2 - 1] = \frac{g}{2}$

If $t = 2^{nd}$ sec then $s_2 = \frac{g}{2}[4 - 1] = \frac{3g}{2}$

If $t = 3^{\text{rd}}$ sec then $s_3 = \frac{g}{2}[6-1] = \frac{5g}{2}$

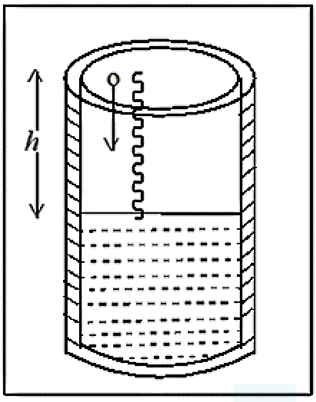
If $t = 4^{\text{th}}$ sec then $s_4 = \frac{g}{2}[8-1] = \frac{7g}{2}$

If $t = 5^{\text{th}}$ sec then $s_5 = \frac{g}{2}[10-1] = \frac{9g}{2}$

$s_1 : s_2 : s_3 : s_4 : s_5 : \ldots\ldots = 1:3:5:7:9:\ldots\ldots$

A stone is dropped into a well of depth 'h' then the sound of splash is heard after a time t is

Free falling



$u = 0, a = +g, s = h$

$$s = ut_1 + \frac{1}{2}at_1^2$$

$$h = (0)t_1 + \frac{1}{2}gt_1^2$$

$$\frac{gt_1^2}{2} = h$$

$$t_1 = \sqrt{\frac{2h}{9}}$$

time taken by the body to touches the water.

Time taken by the sound to travel a distance of h,

$$\text{Velocity} = \frac{\text{displacement}}{\text{time}}$$

$$v_{\text{sound}} = \frac{h}{t^2}$$

$$t_2 = \frac{h}{v_{\text{sound}}}$$

Time to hear splash of sound is

$$t = t_1 + t_2 = \sqrt{\frac{2h}{9}} + \frac{h}{v_{\text{sound}}}$$

If a particle starts from rest and moves with uniform acceleration a such that it travels a distances S_m and S_n in m^{th} and n^{th} seconds then

$$s_n = u + a\left[n - \frac{1}{2}\right]$$

$$s_m = u + a\left[n - \frac{1}{2}\right]$$

Rest $u = 0$

$$s_n = 0 + a\left[n - \frac{1}{2}\right]$$

$$s_n = a\left(\frac{2n-1}{2}\right)$$

$$s_m = a\left[\frac{2m-1}{2}\right]$$

$$s_n - s_m = \frac{a}{2}[2n - 1 - 2m + 1]$$

$$s_n - s_m = \frac{a}{2}[2n - 2m]$$

$$s_n - s_m = a[n - m]$$

$$\boxed{a = \frac{s_n - s_m}{n - m}}$$

If a particle starts from rest and moves with uniform acceleration 'a'

If s is the distance travelled in n seconds

$t = n$ sec

rest $u = 0$

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

$$s = 0(n) + \frac{1}{2}an^2$$

$$s = \frac{an^2}{2} \rightarrow (1)$$

If s_n is the distance travelled in n^{th} second

$$s_n = u + a\left[\frac{2n-1}{2}\right]$$

$$s_n = 0 + a\left(\frac{2n-1}{2}\right)$$

$$s_n = \frac{a}{2}(2n-1) - 2$$

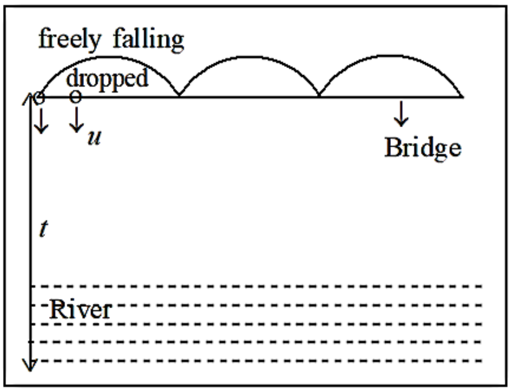
$$\frac{s_n}{s} = \frac{\frac{a}{2}(2n-1)}{\frac{a}{2}\left(n^2\right)}$$

$$\frac{s_n}{s} = \frac{2n-1}{n^2}$$

$\rightarrow$ A stone is dropped into a river from the bridge and after a time x sec another stone is projected down into the river from the same point with a velocity 'u'

If both stones reaches the water simultaneously then

1^{st} stone freely falling



$u = 0$

$a = +g$

$t_1 = t$ second

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

$$s_1 = (0)t + \frac{1}{2}gt^2$$

$$s_1 = \frac{1}{2}gt^2$$

2^{nd} stone thrown downwards

$u = u$

$a = +g$

$t_2 = t - x$

$$s_2 = u(t-x) + \frac{1}{2}g(t-x)^2$$

Motion Curves:-

Graphical analysis is a convenient method of studying the motion of a particle. It can be effectively applied to analyse the motion of situation of a particle. For graphical representation we required two coordinate axes.

One is independent variable along x-axis and the dependent variable along y-axis

Ex:- With time as on of the variable it usually taken along x-axis (since it is independent) and the other variable is along y-axis.

In many problems either slope or area both has to be determined to explained or understand the motion of a particle.

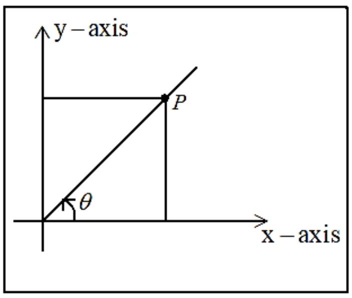
Slope of a straight line is determined by two methods

In the first method:

The St. line whose slope has to be determined is extended the angle made by the line with x-axis is noted the tangent to that angle gives slope of the straight line.

If 'θ' is the angle made by extended tine with x-axis as shown in the figure.

$\text{Slope}(m) = \tan\theta$

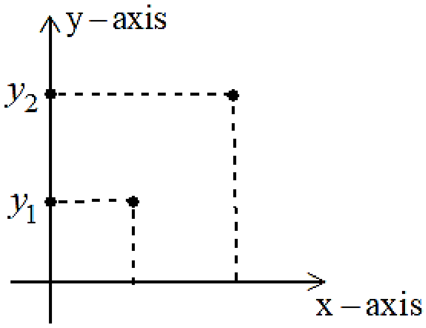


2nd method:

Any two points on the line $\perp$ lers are drawn on to both x and y axes. Their respective coordinates (foot of $\perp$ lers) are noted. The ratio of difference of y-coordinates to x-coordinates gives the slope of this straight line.

Let A and B are two points on the St. line

The slope of St. line $m = \dfrac{y_2 - y_1}{x_2 - x_1}$



Position - time graph's [*x-t* graph]:

Graphs are drawn with time along x axis and position [displacement w.r.t origin] along y axis

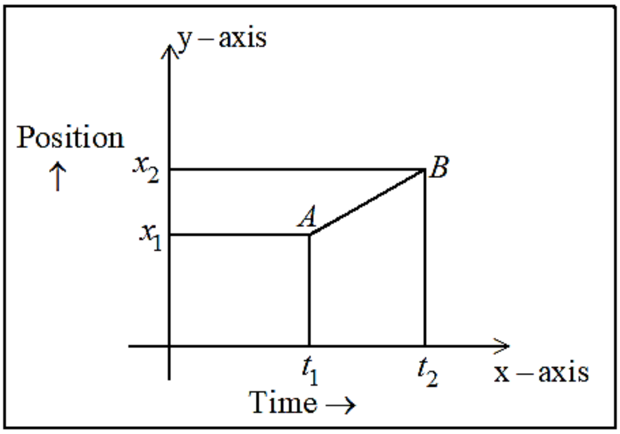
1. Slope of the tangent at any point gives instantaneous velocity.

Slope $m = \tan\theta = \dfrac{PA}{OA}$

$= \dfrac{x}{t}$

= velocity

2. The slope of the chord b/w two points gives average velocity.



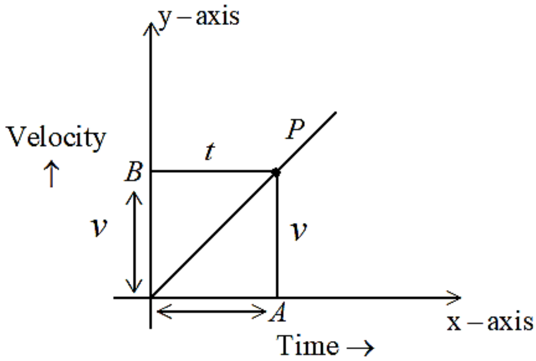
Slope $(m) = \dfrac{y_2 - y_1}{x_2 - x_1} = \dfrac{x_2 - x_1}{t_2 - t_1}$

= average velocity

Velocity time graphs [*v-t* graph]

Graphs are drawn with time along x axis and velocity along y axis.

1. Slope of the tangent at any point gives instantaneous acceleration.

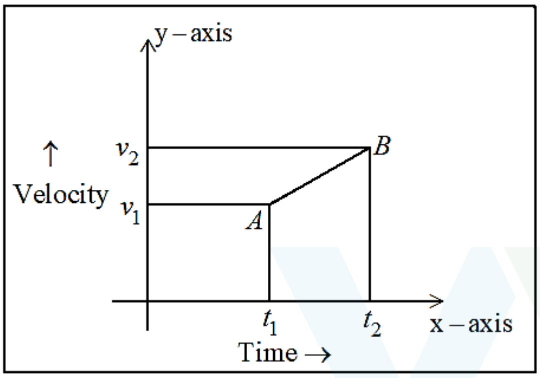


Slope $m = \text{Tan}\,\theta = \frac{PA}{OA}$

$= \frac{v}{t}$

= Instantaneous acceleration

2. The slope of the chord b/w two points gives average acceleration.

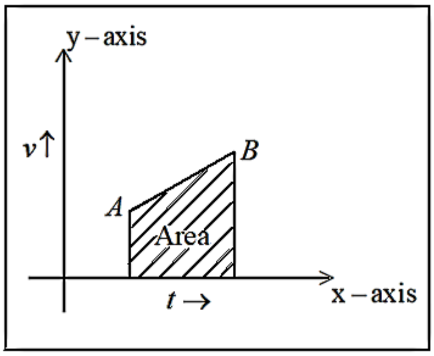


Slope $(m) = \frac{y_2 - y_1}{x_2 - x_1} = \frac{v_2 - v_1}{t_2 - t_1}$

= Average acceleration

3. The area under cover velocity-time graph gives displacement

Displacement (s) = Area of $v - t$ graph



Graphical method:-

Kinematical eqs. of motion of a body with uniform acceleration.

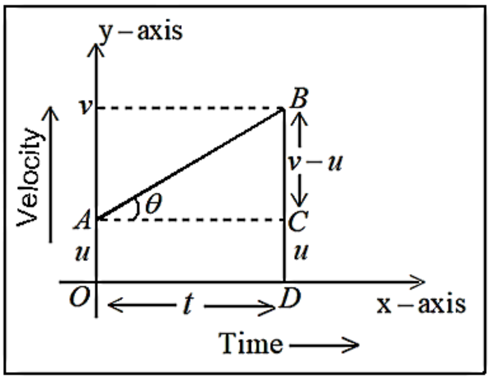
consider a particle moving with initial velocity u and uniform acceleration a.

Suppose v be the velocity after time t seconds

Let 's' be the displacement travelled in that time

The velocity time graph is a straight line with positive slope.

The graph is given by the line AB as shown in the figure.



To show that $v = u + at$:

Slope of the tangent from $v - t$ graph gives acceleration.

$$\text{Tan}\,\theta = \frac{BC}{AC} = \frac{v-u}{t} = a \Rightarrow at = v - u$$

$$\boxed{v = u + at}$$

To prove that $s = ut + \frac{1}{2}at^2$ **:**

From the diagram

Displacement = Area under $v - t$ graph

$s =$ Area of rectangle $OACD +$ Area of le ABC

$$s = (OD)(OA) + \frac{1}{2}AC \times BC$$

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

$$s = ut + \frac{1}{2}t(at)\left[\because a = \frac{v-u}{t}\right]$$

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

If $s = x$ and $u = v_0$ then

$$x = v_0 t + \frac{1}{2}at^2$$

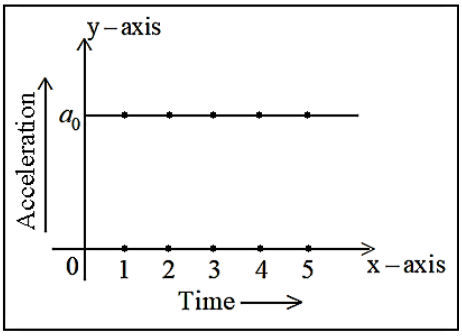
Acceleration-time graphs ($a - t$ graphs):

Graphs are drawn with time along x-axis and acceleration along y-axis.

Significances:

→ The slope of the tangent at any point gives Instantaneous Jerk.

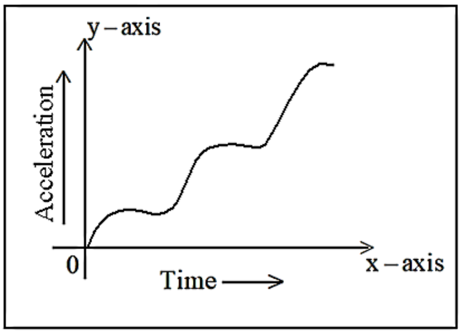
→The area under covered $a - t$ graph gives changes in velocity $(v - u)$



$\rightarrow$Particle moves with constant acceleration (a_0)

$\rightarrow$The graph is a straight line parallel to x-axis

y-intercept = acceleration = a_0



<u>Relative motion in one dimension:</u>

Relative velocity: Velocity of one moving body with respect to other moving body is called relative velocity.

Let two objects A and B are moving uniformly with arrearage velocities v_A and v_B in one dimension says along x-axis having the positions $x_A(0)$ and $x_B(0)$ at $t = 0$ sec.

After $t = t$ sec

The position of A is $x_A(t) = x_A(0) + v_A t$

The position of B is $x_B(t) = x_B(0) + v_B t$

$x_{BA}(t) = x_B(t) - x_A(t)$

$= x_B(0) - x_A(0) + (v_B - v_A)t$

$x_{BA}(t) = x_{BA}(0) + v_{BA} t$

$\therefore \overrightarrow{v_{BA}} = \overrightarrow{v_B} - \overrightarrow{v_A}$

Similarly, $\overrightarrow{v_{AB}} = \overrightarrow{v_A} - \overrightarrow{v_B}$

Avg velocity $v = \dfrac{x_2 - x_1}{t_2 - t_1}$

$$v = \frac{x(t) - x(0)}{t - 0}$$

$$vt = x(t) - x(0)$$

$$x(t) = x(0) + vt$$

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