KINEMATICS 1D

Abhilash Sharma

B.Tech - NIT Calicut

- Experience - 8+ years
- 700+ selections in JEE Advanced
- 6000+ selections in JEE Mains

BounceBack

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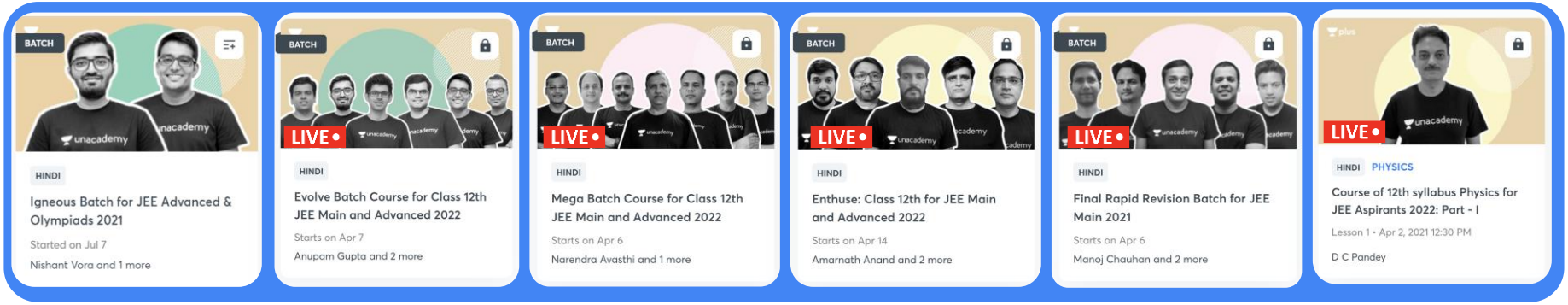

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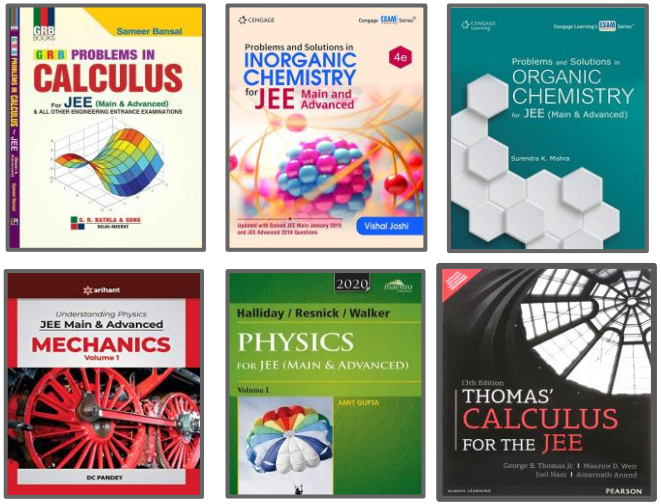

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for IIT JEE Main and Advanced 2024

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Batch highlights:

- Curated by India's Top Educators
- Coverage of Class 11 JEE syllabus
- Enhance conceptual understanding of JEE Main & JEE Advanced subjects
- Systematically designed courses
- Strengthen JEE problem-solving ability

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Nishant Vora
Mathematics Maestro

Ajit Lulla
Physics Maestro

Abhilash Sharma
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Sakshi Vora
Chemistry Maestro

Megha Khandelwal
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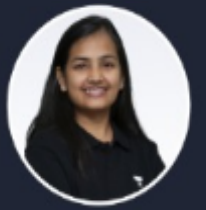

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- Systematic course flow of subjects and related topics
- Strengthening the problem-solving ability of JEE level problems

For more details, contact **8585858585**

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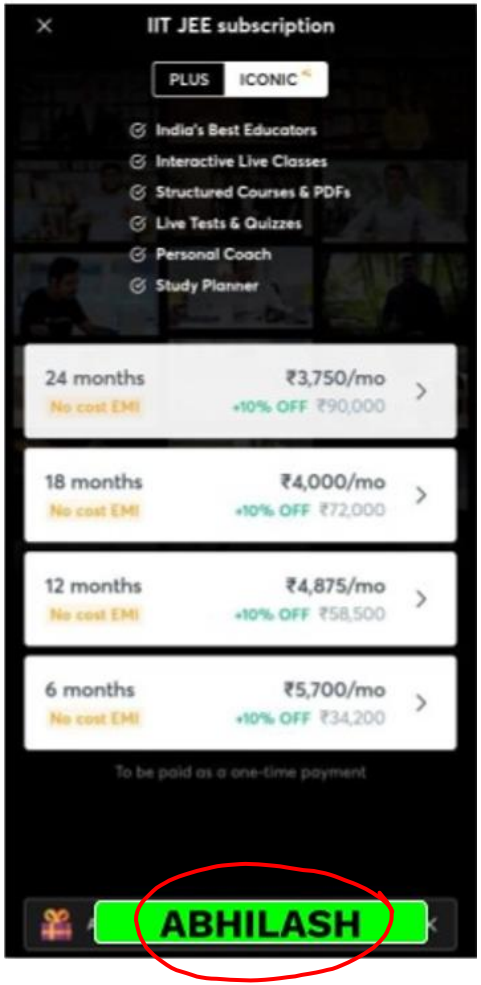
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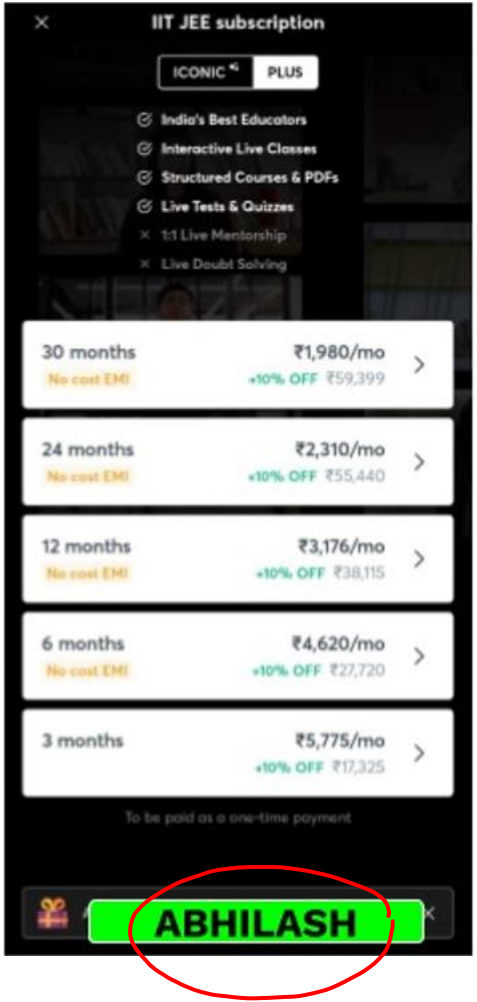
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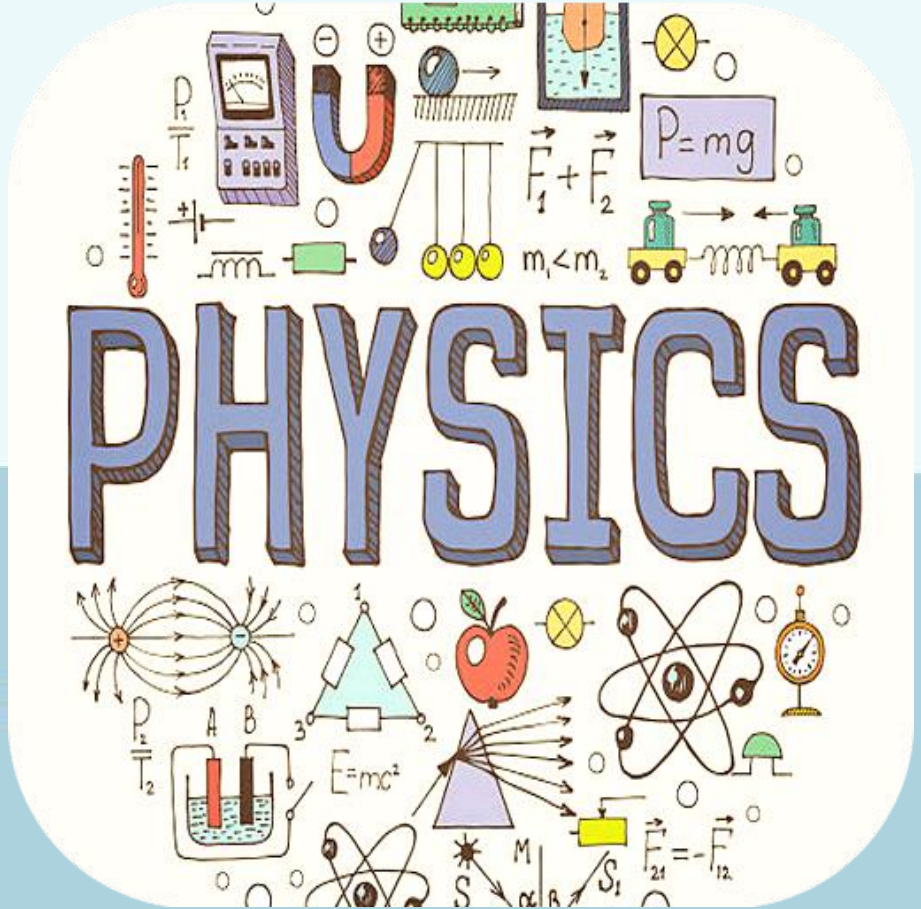


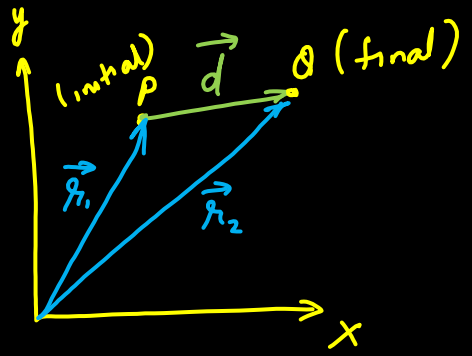
Kinematics 1D

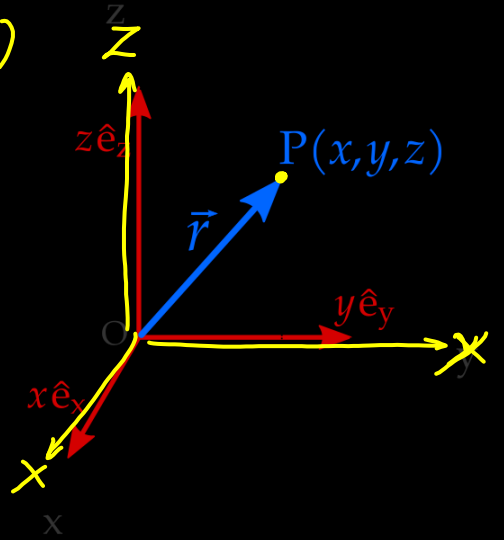
Position Vector $(\vec{r})$

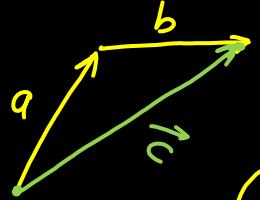
displacement $= \vec{d}$

$\vec{r}_1 + \vec{d} = \vec{r}_2$

$\boxed{\vec{d} = \vec{r}_2 - \vec{r}_1}$







$\vec{c} = \vec{a} + \vec{b}$

Three vectors P, Q and R are shown in the figure. Let S be any point on the vector R. The distance between the points P and S is b|R|. The general

$\vec{OP} + \vec{PS} = \vec{OS}$

$\vec{P} + (b|\vec{R}|)\hat{R} = \vec{S}$

$\vec{P} + b|\vec{R}|\left(\frac{\vec{R}}{|\vec{R}|}\right) = \vec{S}$

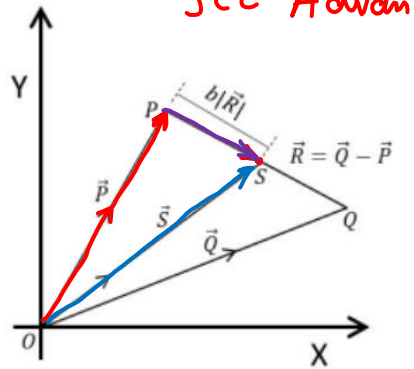
$\vec{P} + b\vec{R} = \vec{S}$

$\vec{P} + b(\vec{Q} - \vec{P}) = \vec{S}$

$\vec{P}(1-b) + b\vec{Q} = \vec{S}$

Three vectors $\vec{P}$, $\vec{Q}$ and $\vec{R}$ are shown in the figure. Let S be any point on the vector $\vec{R}$. The distance between the points P and S is $b|\vec{R}|$. The general relation among vectors $\vec{P}$, $\vec{Q}$ and $\vec{S}$ is

JEE Advanced [2017]



[A] $\vec{S} = (1-b)\vec{P} + b\vec{Q}$

[B] $\vec{S} = (b-1)\vec{P} + b\vec{Q}$

[C] $\vec{S} = (1-b^2)\vec{P} + b\vec{Q}$

[D] $\vec{S} = (1-b)\vec{P} + b^2\vec{Q}$

Average Velocity/Speed

In 1D Motion

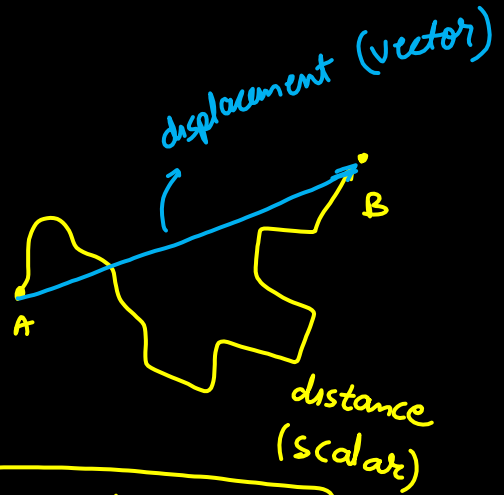
distance = |displacement|

Speed = |velocity|

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

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

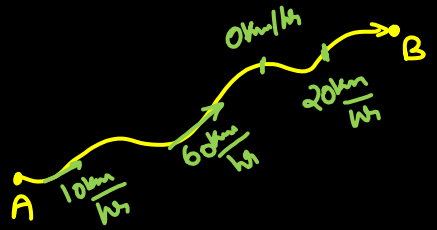
$$d = vt$$



$$\text{Speed} = \frac{\text{distance}}{\text{time}}$$

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

Average Velocity/Speed



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

$$\text{Average Velocity} = \frac{\text{Total Displacement}}{\text{Total Time}}$$

T20 3 of 3 (IND wins 2-1)	25 Sept
Australia	186/7 (20)
India	187/4 (19.5)

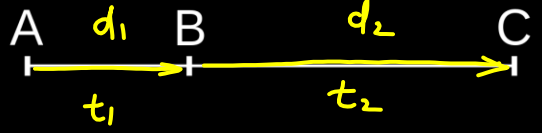
(Aus) Average Run Rate ⇒ No of Runs scored per over

$$= \frac{\text{Total Run}}{\text{Total over}} = \frac{186}{20} = 93$$

Average Velocity/Speed

Case 1

$$V_{avg} = \frac{d_1 + d_2}{t_1 + t_2}$$

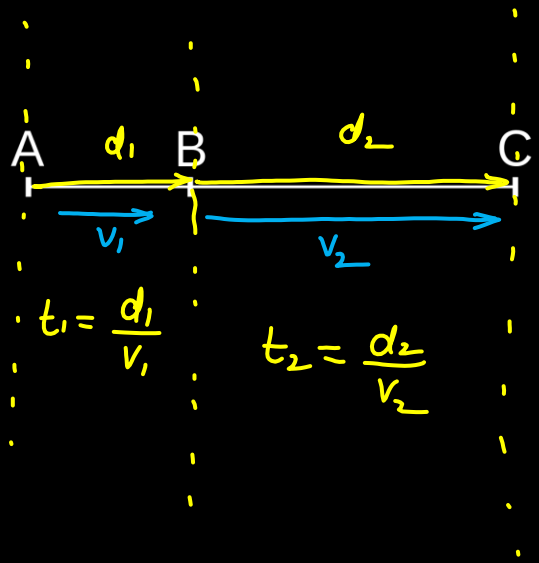


Average Velocity/Speed

Case 2

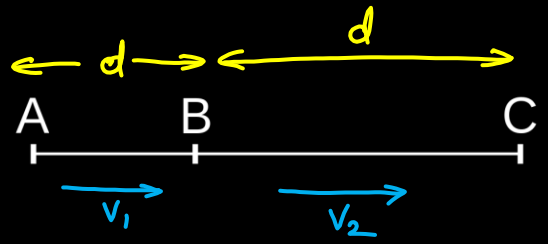
$$V_{avg} = \frac{d_1 + d_2}{t_1 + t_2}$$

$$\boxed{V_{avg} = \frac{d_1 + d_2}{\left(\frac{d_1}{v_1} + \frac{d_2}{v_2}\right)}}$$



Average Velocity/Speed

* **Special Case** $d_1 = d_2 = d$



$$v_{avg} = \frac{d + d}{\frac{d}{v_1} + \frac{d}{v_2}} = \frac{2d}{d\left(\frac{1}{v_1} + \frac{1}{v_2}\right)}$$

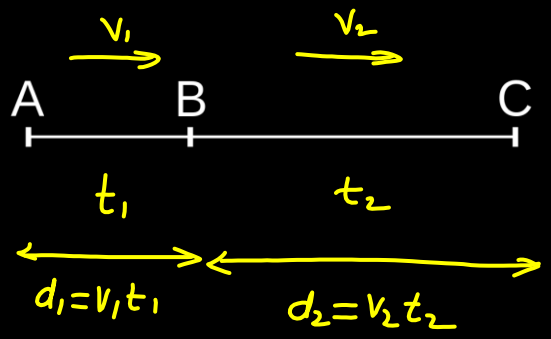
$$\boxed{v_{avg} = \frac{2 v_1 v_2}{v_1 + v_2}} \; *$$

Average Velocity/Speed

Case 3

$v = d/t$

$d = vt$

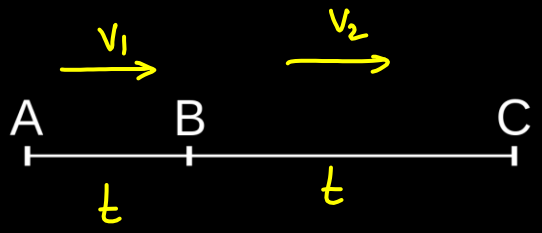


$$V_{avg} = \frac{d_1 + d_2}{t_1 + t_2}$$

$$\boxed{V_{avg} = \frac{v_1 t_1 + v_2 t_2}{t_1 + t_2}}$$

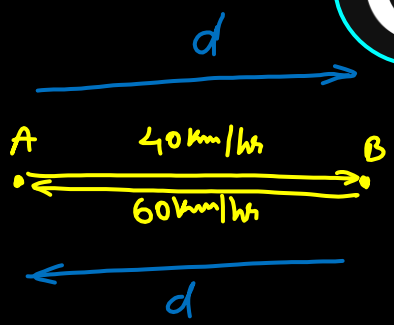
Average Velocity/Speed

* **Special Case** $t_1 = t_2 = t$



$$V_{avg} = \frac{v_1 t + v_2 t}{t + t} = \frac{t(v_1 + v_2)}{2t}$$

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



A car travels from A to B with a uniform speed of 40 km/hr and returns from B to A with a uniform speed of 60 km/hr. Its average speed is

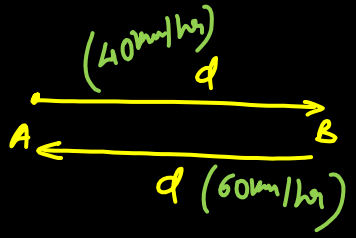
A. 50 km/hr
B. 24 km/hr
C. 48 km/hr
D. 52 km/hr

* $d_1 = d_2$ $\quad V_{avg} = \frac{2 v_1 v_2}{v_1 + v_2}$

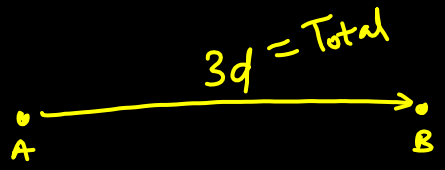
$$V_{avg} = \frac{2(40)(60)}{40+60}$$

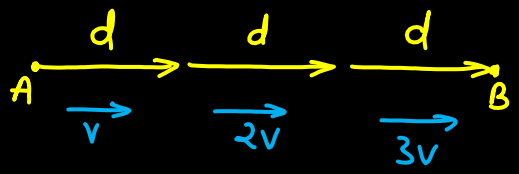
$$= 48 \text{ km/hr}$$

Alternate method



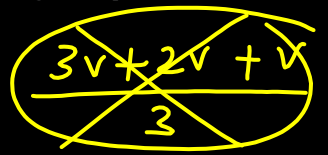
$$V_{avg.} = \frac{d + d}{\left(\frac{d}{40} + \frac{d}{60}\right)} = 48 \frac{km}{hr}$$





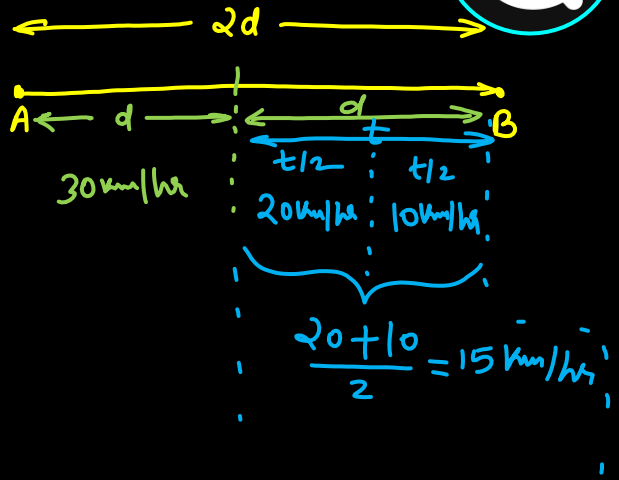
A body has speed V, 2V and 3V in first 1/3 of distance S second 1/3 s and third 1/3 of S respectively. Its average speed will be

A. V
B. 2V
C. 18/11 V
D. 11/18 V



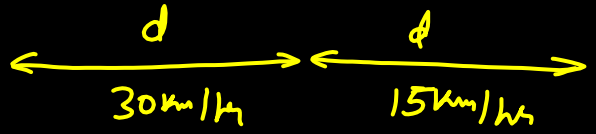
$$V_{avg} = \frac{3d}{\left(\frac{d}{v} + \frac{d}{2v} + \frac{d}{3v}\right)} = \frac{3}{\left(\frac{6+3+2}{6v}\right)} = \frac{18v}{11}$$

Good Question



A man traversed half the distance with a speed of 30 km/hr. The remaining distance was covered with velocity 20 km/hr for half time, and with 10 km/hr for the other half of the time. Find the average speed of the man for the entire motion.

A. 10 km/hr
B. 30 km/hr
C. 20 km/hr ✓
D. 15 km/hr



$$V_{avg} = \frac{2V_1V_2}{V_1+V_2} = \frac{2\times30\times15}{30+15} = \frac{60\times15}{45_3} = 20\ \frac{km}{hr}$$

Instantaneous Velocity

Velocity of the particle at an instant is called instantaneous velocity.

very very small

$$V_{inst} = \frac{dx}{dt}$$

$V = b\sqrt{x} \Rightarrow \sqrt{x} = \frac{V}{b}$

Unacademy Atoms

A particle is moving with a speed v= b√x along positive x axis. Calculate the speed of the particle at time t= τ

[JEE Main 2019]

A. $b^2\tau/4$
B. $b^2\tau/2$ ✓
C. $b^2\tau$
D. $b^2\tau/\sqrt{2}$

$$V = b\sqrt{x}$$

$$\frac{dx}{dt} = b\sqrt{x}$$

$$\int_0^x \frac{dx}{\sqrt{x}} = b\int_0^t dt$$

$$\left(\frac{x^{-1/2+1}}{-1/2+1}\right)_0^x = bt$$

$$2\sqrt{x} = bt$$

$$2\left(\frac{V}{b}\right) = bt$$

$$V = \frac{b^2 t}{2}$$

$$V = \frac{b^2 \tau}{2}$$

A particle is moving along x-axis. Its X-coordinate varies with time as, $x=2t^2+4t-6$ Here, x is in metres and t in seconds. Find the average velocity between the time interval t = 0 to t = 2 s.

(A) 4 m/s
(B) 8 m/s
(C) 12 m/s
(D) 16 m/s

$x = 2t^2 + 4t - 6$

$V = \frac{dx}{dt} = 4t + 4$ ⇒ Instan

$V_{avg} = \frac{\text{Total displacement}}{\text{Total Time}}$

$= \frac{x_2 - x_1}{t_2 - t_1} = \frac{10 - (-6)}{2} = 8 \text{ m/s}$

$t = 0$ | $t = 2$

$x_1 = -6 \text{ m}$ | $x_2 = 2(2)^2 + 4 \times 2 - 6$

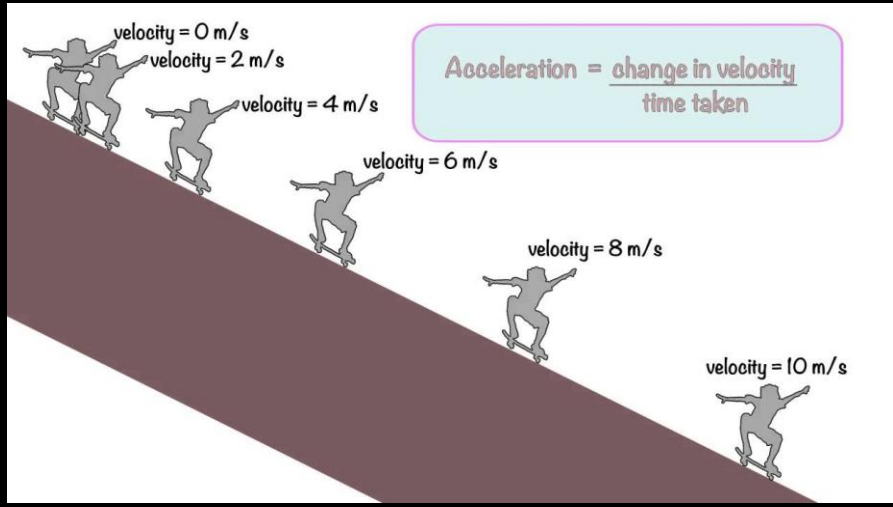
$x_2 = 10 \text{ m}$

Acceleration (m/s^2 OR km/hr^2)

Lamborghini $\Rightarrow$ 0 km/hr $\Rightarrow$ 200 km/hr in $t = 3$ sec - 5 sec.

Normal Car $\Rightarrow$ 0 km/hr $\Rightarrow$ 100 km/hr in $t = 30$-40 sec

$$a_1 = \frac{200 \text{ km/hr}}{(5/3600) \text{ hr}} \qquad a_1 = \frac{100 \text{ km/hr}}{(40/3600) \text{ hr}}$$



$$a_{avg} = \frac{\Delta V}{\Delta t} = \frac{V_2 - V_1}{t_2 - t_1}$$

A particle is moving in x-y plane. Its x and y coordinates are $x=2t^2$ and $y=t^3$ here x and y are in metres and t in seconds. Find average acceleration between a time interval from t = 0 to t s = 2 .

A. 2i + 3j m/s²

B. 6i + 4j m/s²

C. 3i + 2j m/s²

D. 4i + 6j m/s² ✓

$x = 2t^2$

$V_x = \frac{dx}{dt} = 4t$

$V_x = 4t$

$t = 0 \quad V_x = 0$

$t = 2 \quad V_x = 8\ m/s$

$\Rightarrow a_x = \frac{8-0}{2-0}\ \frac{m}{s^2}$

$a_x = 4\ m/s^2$

$y = t^3$

$V_y = \frac{dy}{dt} = 3t^2$

y

$V_y = 3t^2$

$t = 0$ $\quad$ $t = 2$

$V_y = 0$ $\quad$ $V_y = 12\ m/s$

$a_y = \frac{12-0}{2-0} = 6\ m/s$

Instantaneous Acceleration

$$a_{inst.} = \frac{dv}{dt}$$

* Another Important Formula

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

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

Instantaneous Acceleration

$$a = \frac{dv}{dt} = \frac{d}{dt}\left(\frac{dx}{dt}\right) = \frac{d^2x}{dt^2} \left(\text{Double Derivative}\right)$$

$$x = 5t^3 - 3t^2 + 2$$

$\frac{dx}{dt}$

$$v = 15t^2 - 6t$$

$\frac{d^2x}{dt^2}$

$$a = 30t - 6$$

$x(t) = at + bt^2 - ct^3$

$v = a + 2bt - 3ct^2$

$a = 0 + 2b - 6ct$

$a = 0$

$2b - 6ct = 0$

$t = \frac{2b}{6c} = \frac{b}{3c}$

The position of a particle as a function of time t, is given by $x(t) = at + bt^2 - ct^3$

Where a, b and c are constants. When the particle attains zero acceleration, then its velocity will be

(a) $a + \frac{b^2}{4c}$

(b) $a + \frac{b^2}{3c}$

(c) $a + \frac{b^2}{c}$

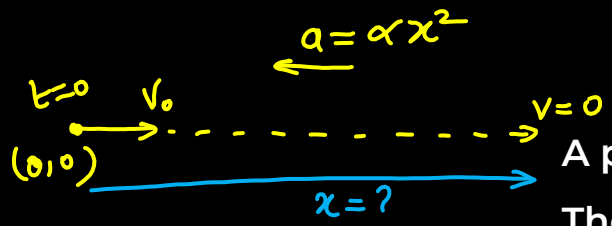
(d) $a + \frac{b^2}{2c}$

[JEE Main 2019]

$$v = a + 2b\left(\frac{b}{3c}\right) - 3c\left(\frac{b}{3c}\right)^2$$

$$= a + \frac{2b^2}{3c} - \frac{b^2}{3c}$$

$$\boxed{v = a + \frac{b^2}{3c}}$$



A particle is projected with velocity V_0 along x-axis. The declaration on the particle is proportional to the square of the distance from the origin i.e, $a = \alpha x^2$. The distance at which the particle stops is

$$a = -\alpha x^2 \quad \text{(deceleration)}$$

$$V\frac{dV}{dx} = -\alpha x^2$$

$$\int_{V_0}^{0} V\,dV = -\alpha \int_{0}^{x} x^2 \cdot dx$$

$$\frac{V^2}{2}\Big|_{V_0}^{0} = -\alpha \frac{x^3}{3}\Big|_{0}^{x}$$

(a) $\sqrt{\frac{3v_0}{2\alpha}}$

(b) $\left(\frac{3v_o}{2\alpha}\right)^{\frac{1}{3}}$

(c) $\sqrt{\frac{3v_0^2}{2\alpha}}$

(d) $\left(\frac{3v_0^2}{2\alpha}\right)^{\frac{1}{3}}$

$$0 - \frac{V_0^2}{2} = -\frac{\alpha x^3}{3} - 0$$

$$\frac{V_0^2}{2} = \frac{\alpha x^3}{3}$$

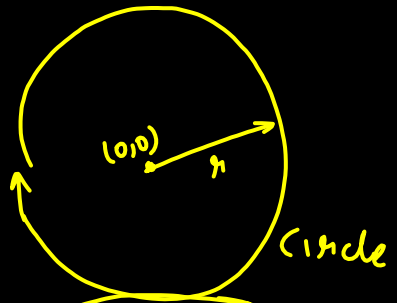
$$x^3 = \frac{3V_0^2}{2\alpha}$$

$$\boxed{x = \left(\frac{3V_0^2}{2\alpha}\right)^{1/3}}$$

Trajectory

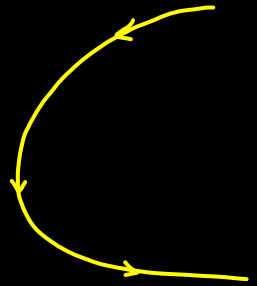
Eqn should be independent of time

Path traced by a moving particle



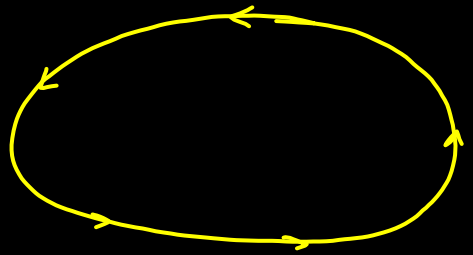
Circle

$x^2+y^2=r^2$



Parabola

$y^2=4ax$



Ellipse

$\frac{x^2}{a^2}+\frac{y^2}{b^2}=1$

A particle is moving in x-y plane. Its x and y coordinates are $x=2t$ and $y=4t^2$ here x and y are in metres and t in seconds. Find the trajectory of the particle

A. $y=4x^2$

B. $y=x^2$ ✓

C. $x=4y^2$

D. $x=y^2$

$x = 2t$

$t = \frac{x}{2}$

$y = 4t^2$

$y = 4\left(\frac{x}{2}\right)^2$

$y = x^2$

A particle is moving in x-y plane. Its x and y coordinates are X= 3Sin(2πt) & Y=2Cos(2πt). Here, x and y are in metres and t in seconds. The trajectory of the particle is

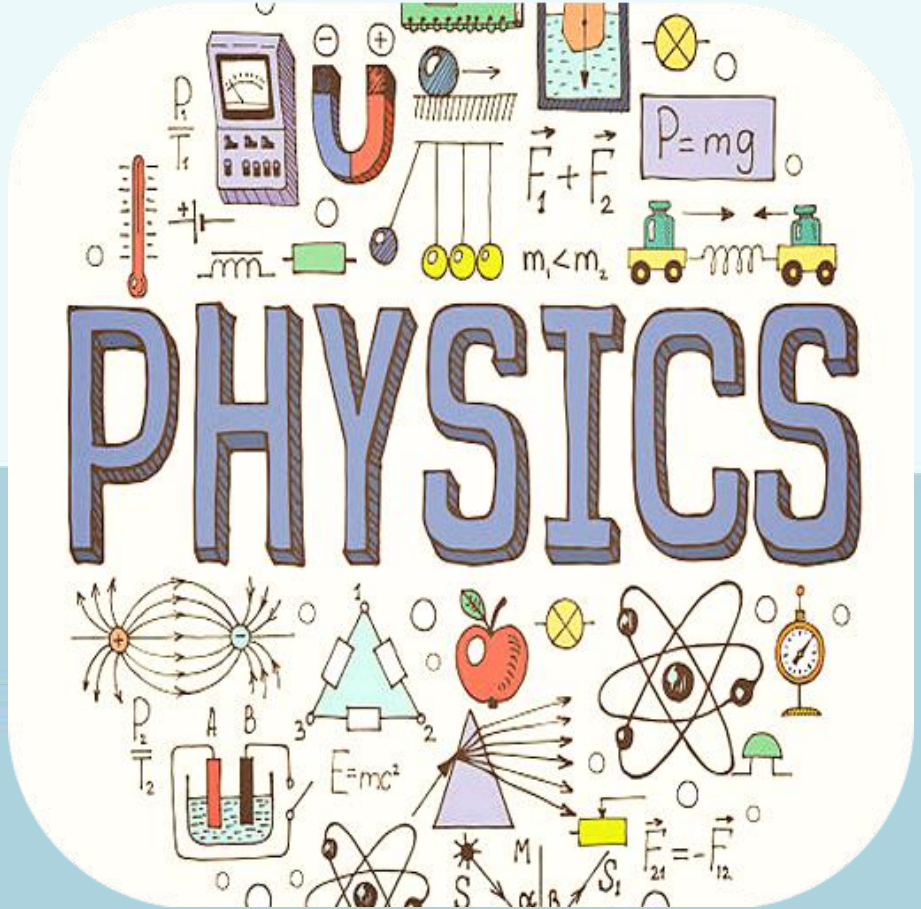
A. Circle
B. Parabola
C. Ellipse
D. Hyperbola

[JEE Main 2019]

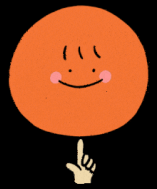
$\frac{x}{3} = \sin(2\pi t)$

$\frac{y}{2} = \cos(2\pi t)$

$\left(\frac{x}{3}\right)^2 + \left(\frac{y}{2}\right)^2 = 1$



Equations of Motion



Types of Motion

Non Accelerated Motion ($a = 0$)*	Uniformly Accelerated Motion ($a = const$)	Non Uniformly Accelerated Motion ($a \neq const$)
$v = const$ $V = d/t$ *	Equations of motion	Calculus

Equations of Motion

(a = const)

$u, a \Rightarrow$ In all 3 Eqⁿ

1st Eq $v = u + at$ → (s)

2nd Eq $s = ut + \frac{1}{2}at^2$ → (v)

3rd Eq $v^2 = u^2 + 2as$ → (t)

1) Take a sign convention (Free to choose)

2) Substitute with sign

A particle starts with a speed of 20m/s along +X axis with a uniform acceleration of 2 m/s2 along -X axis. Find the distance covered by the particle in 20 seconds

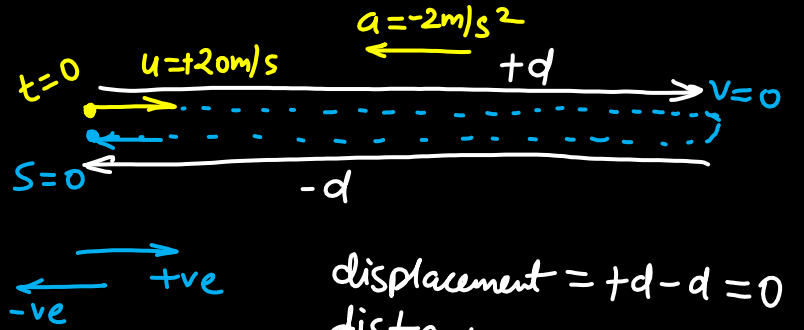
A. 0 m
B. 400 m
C. 100 m
D. 200 m

$t = 20$ sec

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

$s = (20)(20) + \frac{1}{2}(-2)(20)^2$

$s = 0$ ⇒ displacement



displacement = +d − d = 0

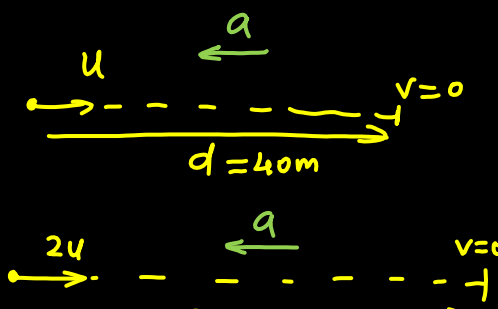
distance = 2d

$u = 20\,m/s$, $v = 0$, $s = d$, $a = -2\,m/s^2$

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

$0 = (20)^2 + 2(-2)d$

$$d = \frac{400}{4} = 100\,m$$



An automobile, travelling at 40 km/h, can be stopped at a distance of 40 m by applying brakes. If the same automobile is travelling at 80 km/h, the minimum stopping distance, in metres, is (assume constant retardation)

(JEE Main 2018)

2022

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

$0^2 = u^2 + 2a(d)$

$\frac{-u^2}{2a} = d$

$0^2 = (2u)^2 + 2a(x)$

$-\frac{4u^2}{2a} = x$

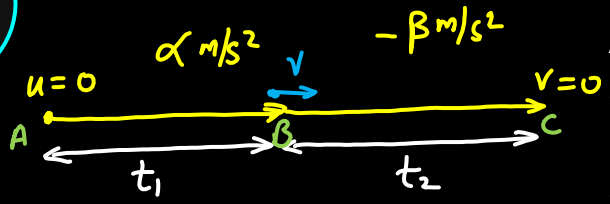
$4(d) = x$

A. 80 m

B. 120 m

C. 160 m ✓

D. 200 m



A car accelerates from rest at a constant rate α for some time after which it decelerates at a constant rate β to come to rest. If the total time elapsed is t seconds, the total distance travelled is.

[JEE Main 2021]

$t = t_1 + t_2$

AB

$v = u + at$

$v = 0 + \alpha t_1$

$t_1 = \frac{v}{\alpha}$

BC

$v = u + at$

$0 = (v) + (-\beta)t_2$

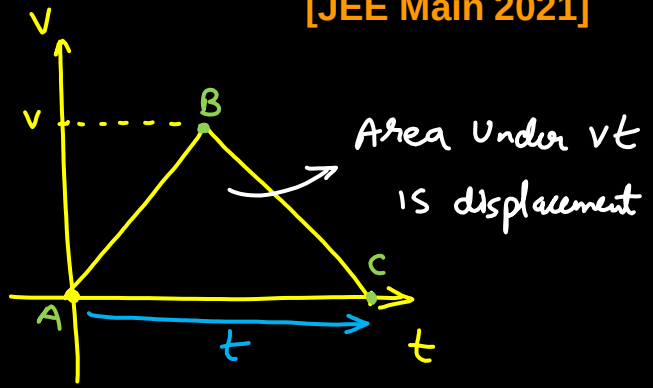
$t_2 = \frac{v}{\beta}$

A. $\frac{4\alpha\beta}{(\alpha+\beta)}t^2$

B. $\frac{2\alpha\beta}{(\alpha+\beta)}t^2$

C. $\frac{\alpha\beta}{2(\alpha+\beta)}t^2$ ✓

D. $\frac{\alpha\beta}{4(\alpha+\beta)}t^2$



$$t = t_1 + t_2 = \frac{v}{\alpha} + \frac{v}{\beta}$$

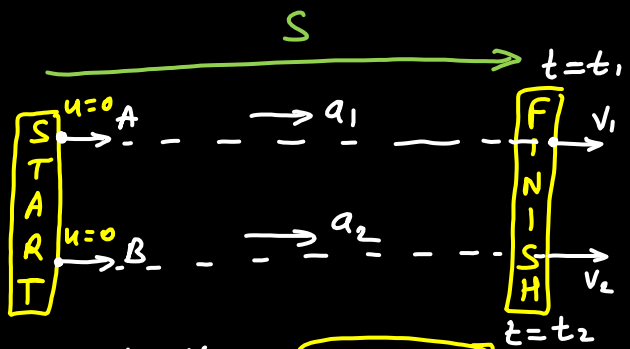
$$t = \left(\frac{\alpha+\beta}{\alpha\beta}\right) v$$

$$\boxed{v = \frac{\alpha\beta t}{\alpha+\beta}}$$

Distance = Area of Δ

$$= \frac{1}{2} \times v \times t$$

$$\boxed{d = \frac{\alpha\beta t^2}{2(\alpha+\beta)}}$$



$v_1 > v_2 \Rightarrow v_1 - v_2 = v$

$t_1 < t_2 \Rightarrow t_2 - t_1 = t$

Car A

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

$s = 0 + \frac{1}{2}a_1 t_1^2$

$t_1 = \sqrt{\frac{2s}{a_1}}$

Car B

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

$s = 0 + \frac{1}{2}a_2 t_2^2$

$t_2 = \sqrt{\frac{2s}{a_2}}$

In a car race on straight road, car A takes a time a time t less than car B at the finish and passes finishing point with a speed 'v' more than of car B. Both the cars start from rest and travel with constant acceleration a_1 and a_2 respectively . Then 'v' is equal to:

(a) $\frac{2a_1 a_2}{a_1 + a_2} t$

(b) $\sqrt{2a_1 a_2}\, t$

(c) $\sqrt{a_1 a_2}\, t$

(d) $\frac{a_1 + a_2}{2} t$

[JEE Main 2019]

Car A

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

$v_1^2 = 0 + 2a_1 s$

$\boxed{v_1 = \sqrt{2a_1 s}}$

Car B

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

$v_2^2 = 0 + 2a_2 s$

$\boxed{v_2 = \sqrt{2a_2 s}}$

$t_2 - t_1 = t$

$\sqrt{\frac{2s}{a_2}} - \sqrt{\frac{2s}{a_1}} = t$

$\frac{\sqrt{2a_1 s} - \sqrt{2a_2 s}}{\sqrt{a_1 a_2}} = t$

$\sqrt{2a_1 s} - \sqrt{2a_2 s} = \sqrt{a_1 a_2}\, t$

$v_1 - v_2 = \sqrt{a_1 a_2}\, t$

$\boxed{v = \sqrt{a_1 a_2}\, t}$

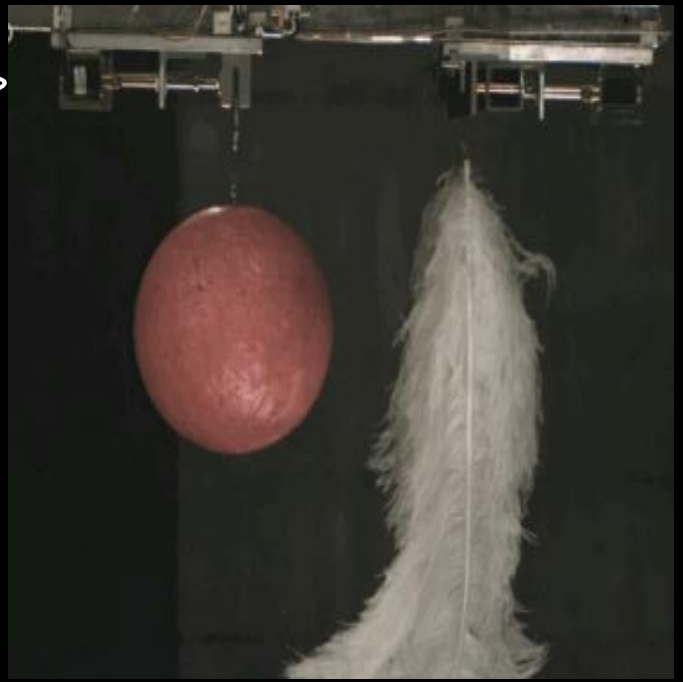
Freely Falling Objects

$F = ma$

$a = F/m$

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

Vaccum Chamber ⟹



$m_1 > m_2$

m_1 $\quad$ m_2

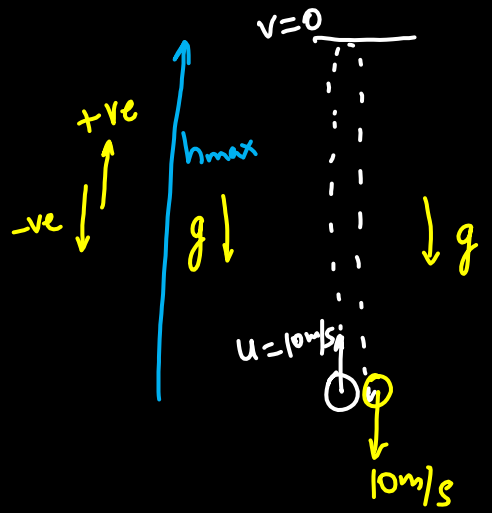
$F_1 = m_1 g$ $\quad$ $F_2 = m_2 g$

$F_1 > F_2$

$a_1 = \frac{F_1}{m_1}$ $\quad$ $a_2 = \frac{F_2}{m_2}$

$a_1 = \frac{m_1 g}{m_1}$ $\quad$ $a_2 = \frac{m_2 g}{m_2}$

$a_1 = g$ $\quad$ $a_2 = g$



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

$$0 = (10)^2 + 2(-10)h_{max}$$

$$h_{max} = 5\,m$$

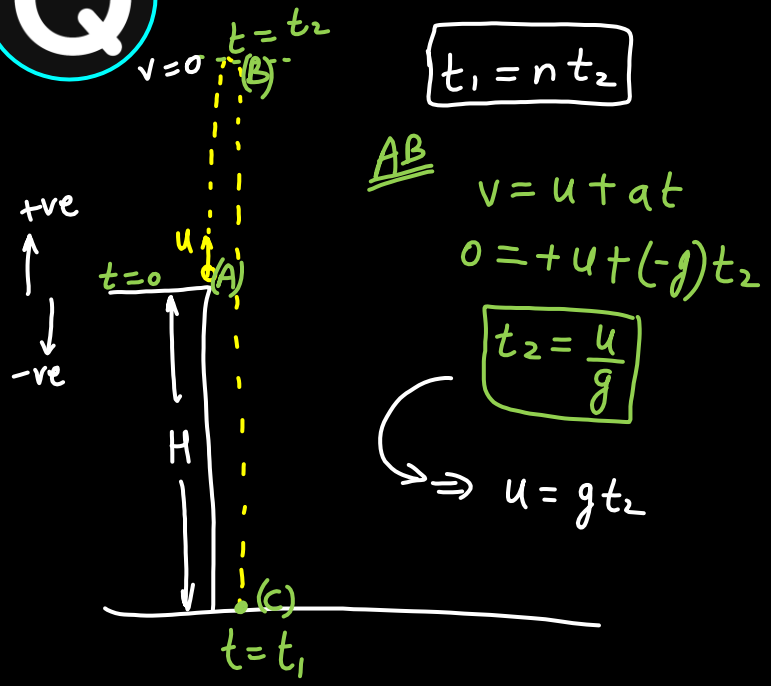
A ball is thrown vertically upwards with a speed of 10 m/s. The maximum height attained by the ball is

A. 5 m

B. 10 m

C. 15 m

D. 20 m



$t_1 = n t_2$

AB

$v = u + at$

$0 = +u + (-g)t_2$

$t_2 = \frac{u}{g}$

$\Rightarrow u = g t_2$

From a tower of height H, a particle is thrown vertically upwards with a speed u. The time taken by the particle, to hit the ground, is n times that taken by it to reach the highest point of its path. The relation between H, u and n is:

[Main 2014]

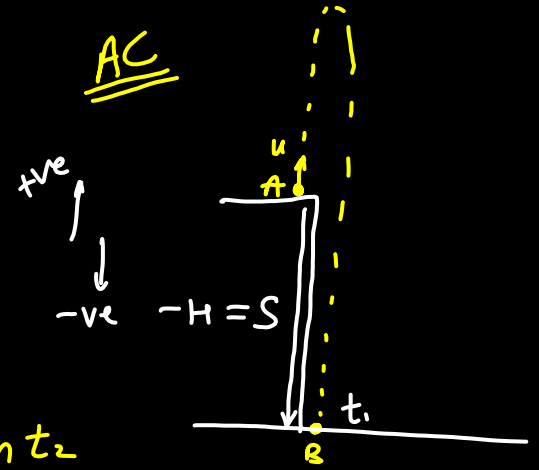
A. $2gH = n^2u^2$

B. $gH = (n - 2)^2u^2d$

C. $2gH = nu^2 (n - 2)$ ✓

D. $gH = (n - 2)u^2$

AC



$t_1 = n t_2$

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

$$\pm\sqrt{u^2+2gH} = nu - u$$

$$u^2+2gH = (n-1)^2u^2 \Rightarrow 2gH = (n-1)^2u^2 - u^2$$

$$\boxed{2gH = (n-2)nu^2}$$

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

$$-H = ut_1 + \frac{1}{2}(-g)t_1^2$$

$$H = -ut_1 + \frac{g}{2}t_1^2$$

$$gt_1^2 - 2ut_1 - 2H = 0$$

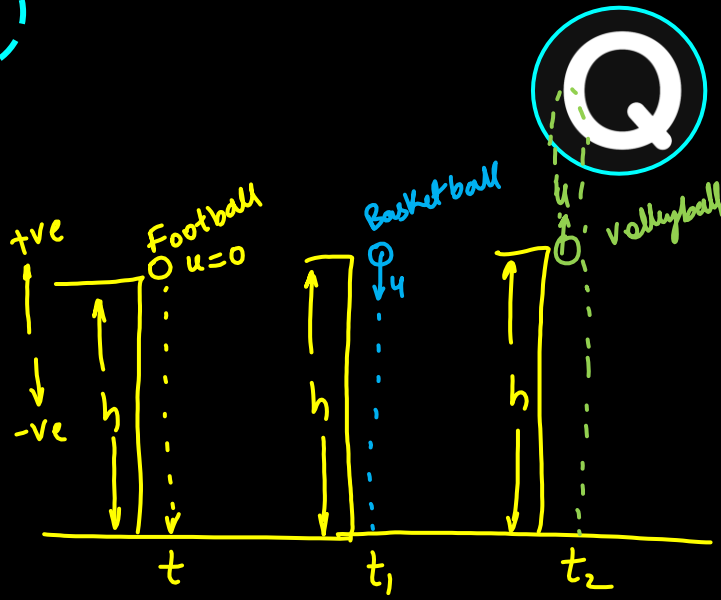
$$t_1 = \frac{2u \pm \sqrt{4u^2+8gH}}{2g} = \frac{u \pm \sqrt{u^2+2gh}}{g}$$

HW

A ball is dropped from the top of a tower. The time taken to travel the first half of the height is t1 and for the second half of the height is t2. The ratio of t2/t1 is

[JEE Main 2022]

A. 1
B. √2-1
C. √2+1
D. 1/2



A stone dropped from a building of height h and it reaches after t seconds on earth. From the same building if two stones are thrown (one upwards and other downwards) with the same velocity u and they reach the earth surface after t_1 and t_2 seconds respectively, then

(a) $t = t_1 - t_2$

(b) $t = \frac{t_1 + t_2}{2}$

(c) $t = \sqrt{t_1 t_2}$

(d) $t = t_1^2 t_2^2$

[JEE Main 2022]

F//

$-h = \frac{1}{2}(-g)t^2$

$h = \frac{gt^2}{2}$ → (1)

B//

$-h = -ut_1 + \frac{1}{2}(-g)t_1^2$

$h = ut_1 + \frac{1}{2}gt_1^2$ → (2)

V

$$-h = ut_2 + \frac{1}{2}(-g)t_2^2$$

$$\boxed{h = -ut_2 + \frac{1}{2}gt_2^2} \rightarrow (3)$$

Equate (2) & (3)

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

$$u(t_1 + t_2) = \frac{g}{2}(t_2^2 - t_1^2)$$

$$\boxed{u = \frac{g}{2}(t_2 - t_1)} \rightarrow (4)$$

Equate (1) & (2)

$$\frac{gt^2}{2} = ut_1 + \frac{g}{2}t_1^2$$

$$\frac{gt^2}{2} = \left[\frac{g}{2}(t_2 - t_1)\right]t_1 + \frac{g}{2}t_1^2 \quad \{\text{Using (4)}\}$$

$$t^2 = t_2t_1 - t_1^2 + t_1^2$$

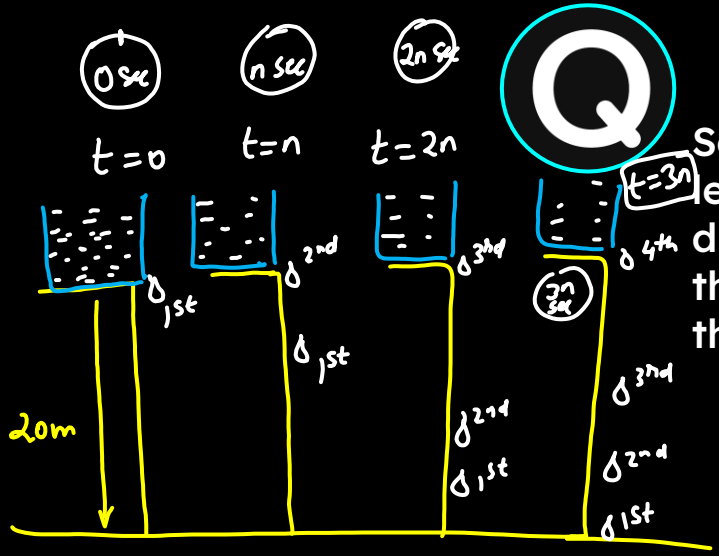
$$t^2 = t_1t_2$$

$$\boxed{t = \sqrt{t_1t_2}} \ *$$

Very Good Advanced Level

Some milk drops fall at regular interval from a leakage is vessel 20 m above the ground. The first drop strikes the ground when fourth drop is leaving the leakage. Find the height of second drop from the ground

A. 15 m
B. 20/9 m
C. 80/9 m
D. 100/9 m ✓



$3n = 2$

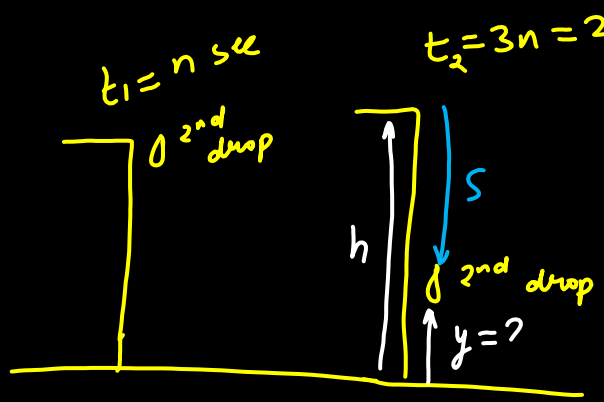
$n = 2/3$ sec

Time taken by first drop

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

$-20 = 0 + \frac{1}{2}(-10)t^2$

$t = 2$ sec



Time elapsed $= t_2 - t_1$

$= 2 - n$

$= 2 - 2/3$

$\Delta t = \frac{4}{3}$ sec

$y = |h| - |s|$

$= 20 - \frac{80}{g}$

$y = \frac{100}{g}$ m

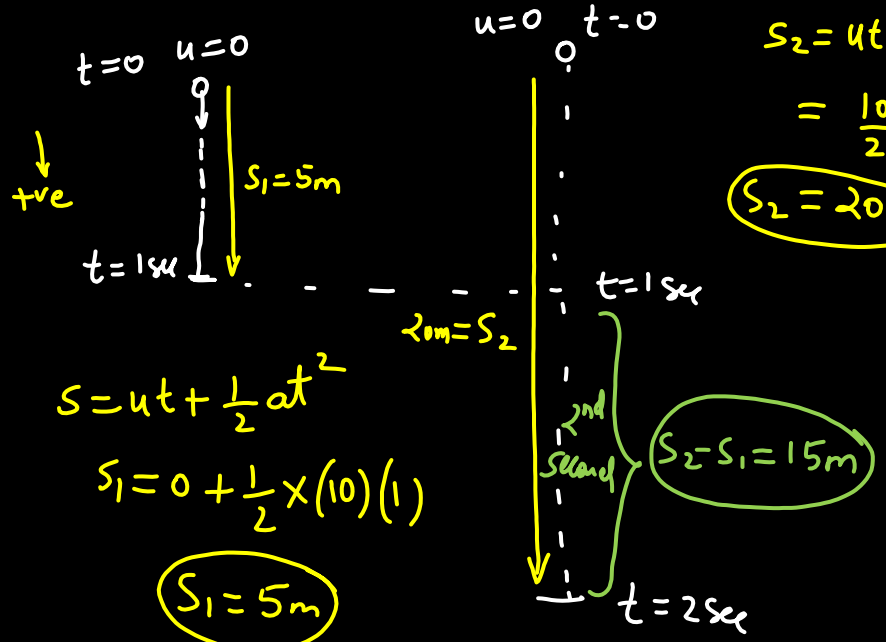
$s = ut + \frac{1}{2}at^2$

$s = (0) + \frac{1}{2}(-10)\left(\frac{4}{3}\right)^2$

$s = -\frac{80}{g}$ m

Displacement in n_{th} Second

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



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

$$s_1 = 0 + \frac{1}{2} \times (10)(1)$$

$$s_1 = 5m$$

$$s_2 = ut + \frac{1}{2}at^2$$

$$= \frac{10}{2}(2)^2$$

$$s_2 = 20m$$

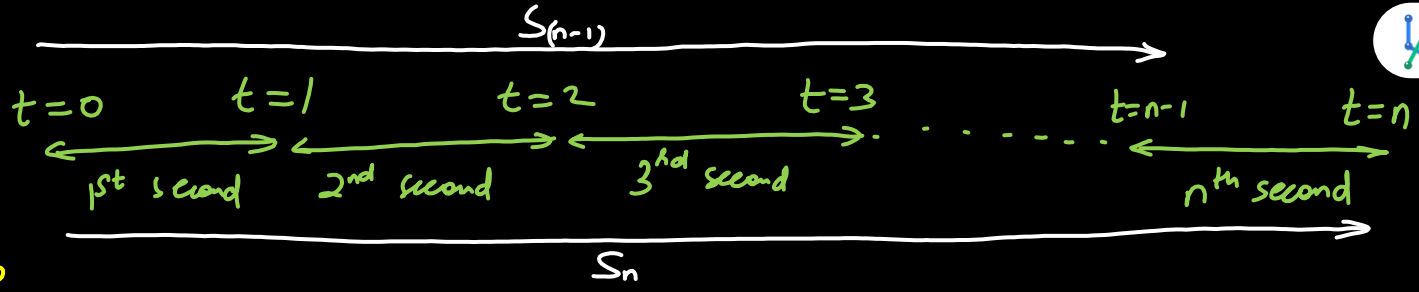
$s_3 = 45m$

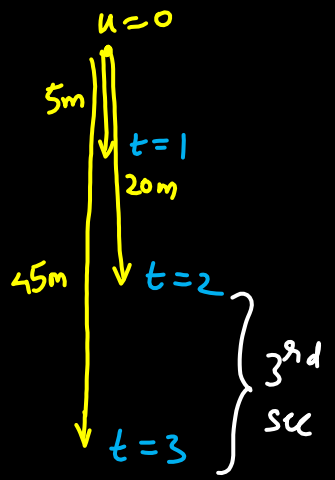
$s_4 = 80m$

20^{th} century 1901 - 2000

21^{st} century 2000 - 2100

22^{nd} " 2100 - 2200





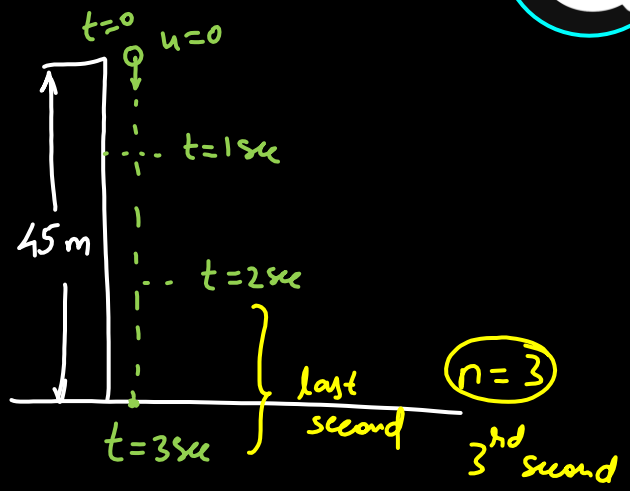
Displacement in 3^{rd} sec $= 45 - 20$

$= 25m$

$$d_n = S_n - S_{(n-1)}$$

$$d_n = \left\{un + \frac{1}{2}an^2\right\} - \left\{u(n-1) + \frac{1}{2}a(n-1)^2\right\}$$

$$\boxed{d_n = u + \frac{a}{2}(2n-1)}$$



An Object is dropped from the height of 45 m. Find the distance covered by the object in the last second of the motion.

A. 5 m
B. 15 m
C. 20 m
D. 25 m

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

$45 = 0 + \frac{10}{2}t^2$

$t = 3\text{sec}$

$d_n = u + \frac{a}{2}(2n-1)$

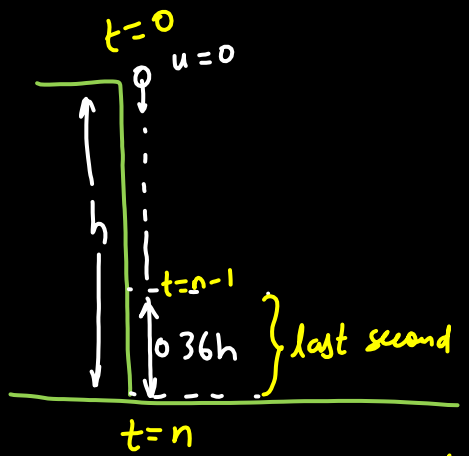
$= 0 + \frac{10}{2}(2\times3-1)$

$d_n = 25\text{m}$

HW

A body falls freely from the top of a tower. It covers 36% of the total height in the last second before striking the ground level the height of the tower is

A. 5o m
B. 75 m
C. 100 m
D. 125 m



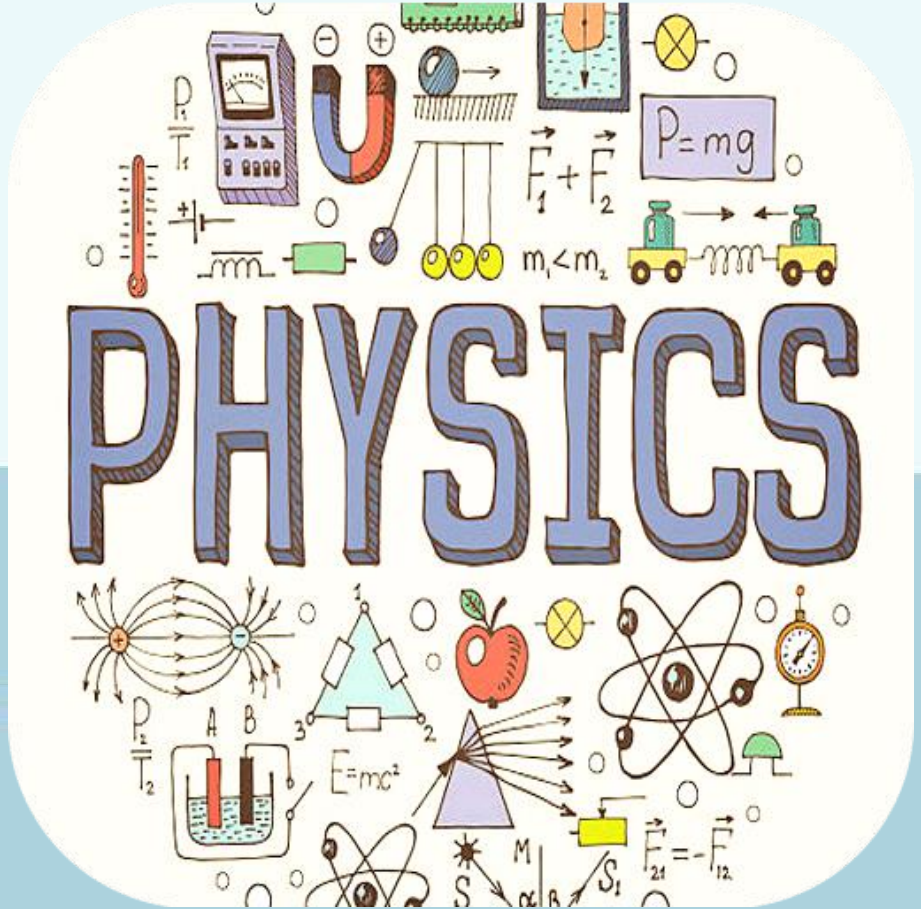
$$s = ut + \frac{1}{2}at^2$$

$$h = 0 + \frac{10}{2}n^2$$

$$h = 5n^2 \longrightarrow (2)$$

$$d_n = u + \frac{a}{2}(2n-1)$$

$$0.36h = 0 + \frac{10}{2}(2n-1) \longrightarrow (1)$$



Graphs

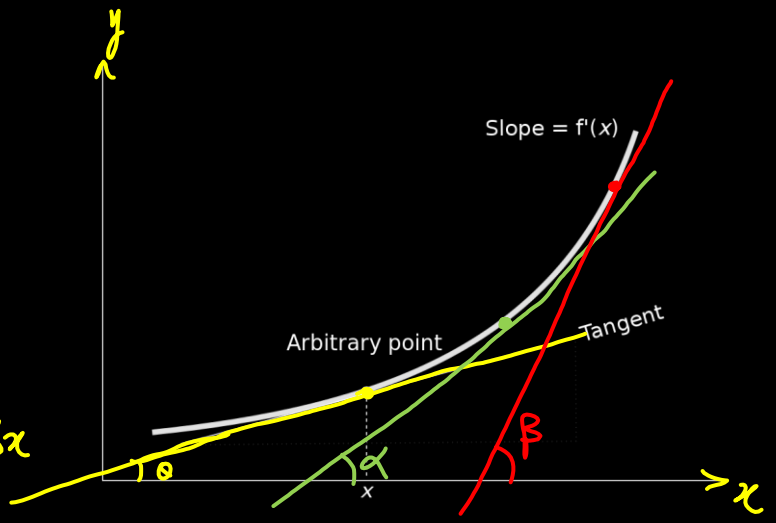
Graphs

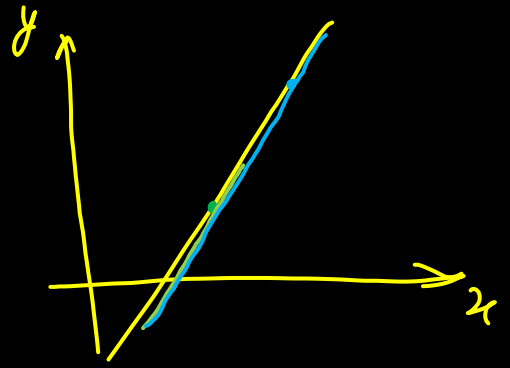
Slope of tangent $= \frac{dy}{dx}$

$\tan\theta = \frac{dy}{dx}$

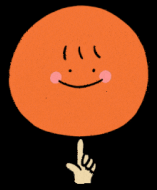
1) Curve $\Rightarrow$ $\frac{dy}{dx} \neq$ const | $y = 4x^2$ | $\frac{dy}{dx} = 8x$

2) Straight Line $\Rightarrow$ $\frac{dy}{dx} =$ const | $y = 2x + 3$ | $\frac{dy}{dx} = 2$



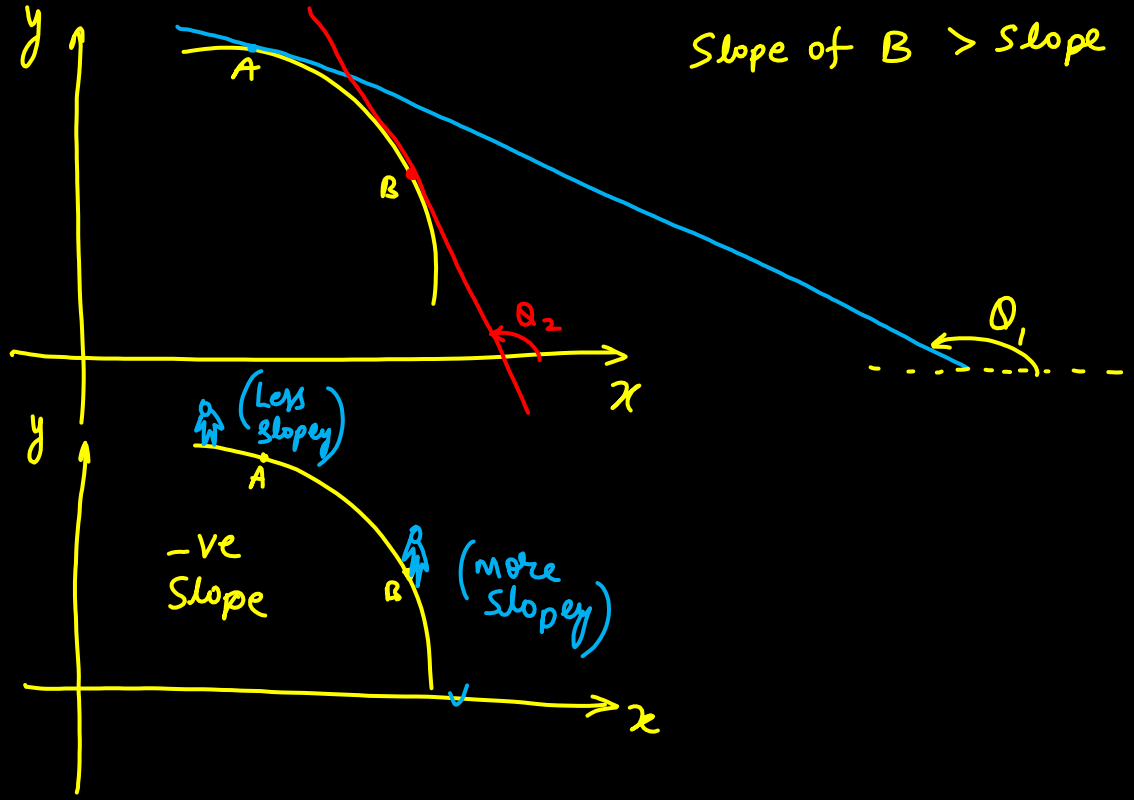


Slope Shortcut

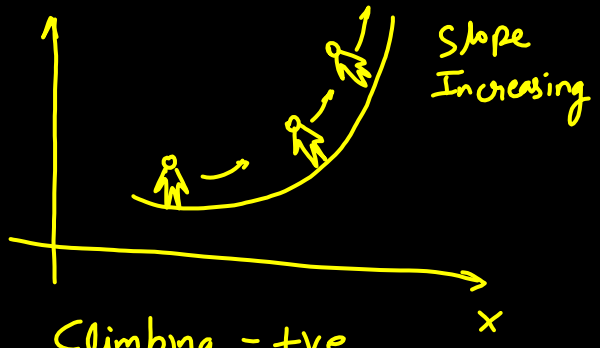


$\theta_1 > \theta_2$

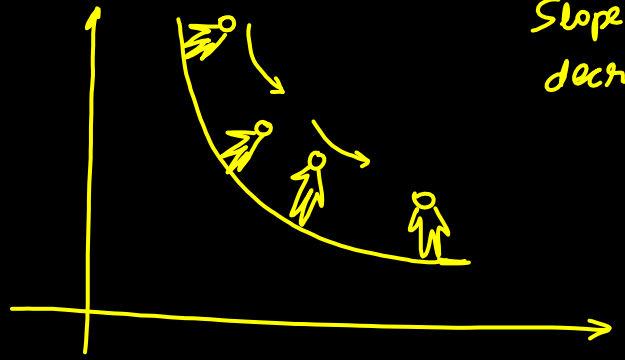
Slope of B > slope of A



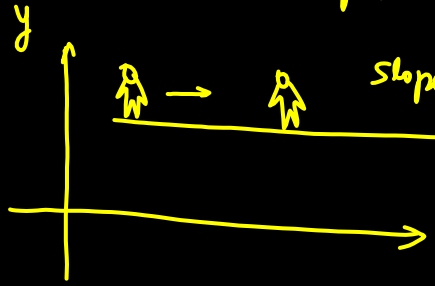
Slope Shortcut

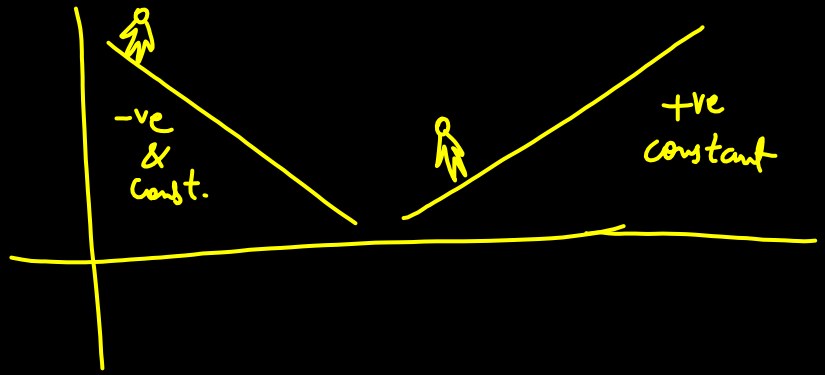


Climbing = +ve Slope



Sliding down = -ve slope





Displacement Time Graph

Slope = $\frac{dx}{dt}$ = velocity

Math

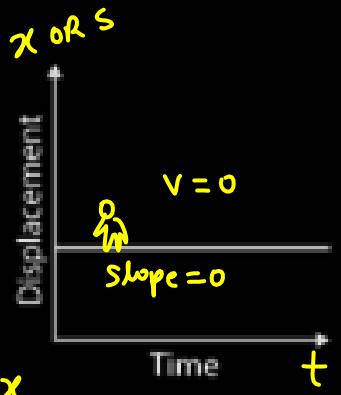
$-3 > -10$

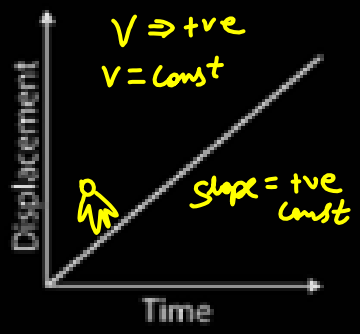
Physics

$-3\ m/s < -10\ m/s$ ✗

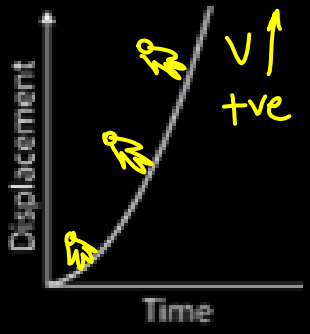
-ve

$-100\ km/hr$ $\quad -10\ km/hr$

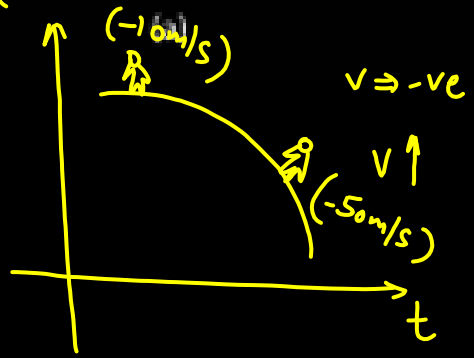




(b)



(c)



Velocity Time Graph

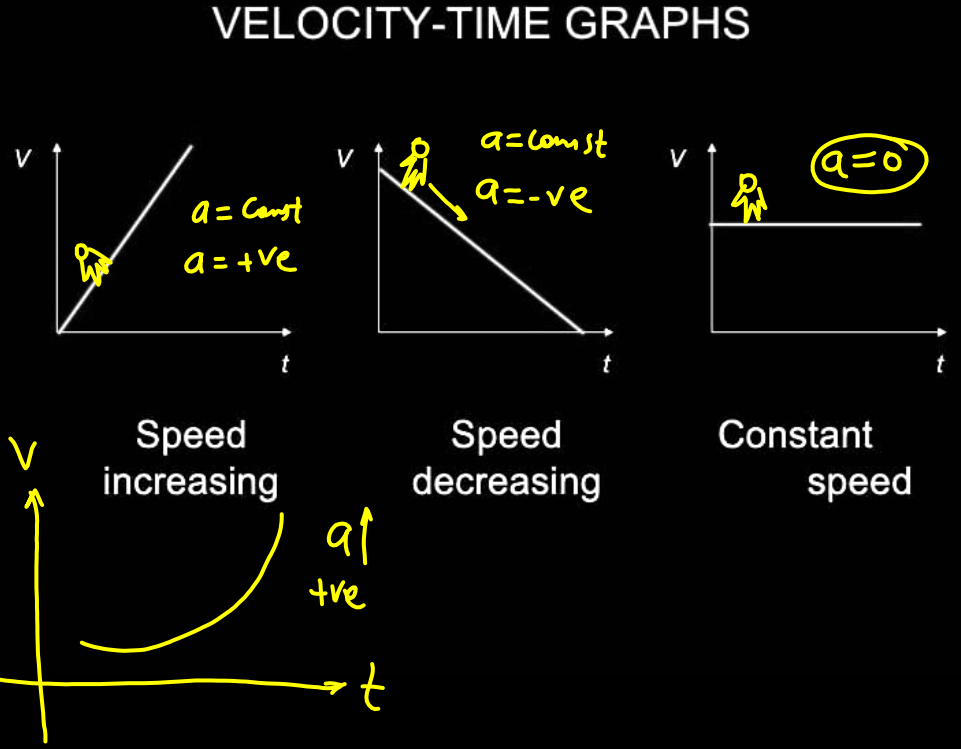
$$\text{Slope} = \frac{dv}{dt} = a$$

v-t graph ⇒ curve ⇒ $a \neq$ const

v-t graph ⇒ st line ⇒ a = const

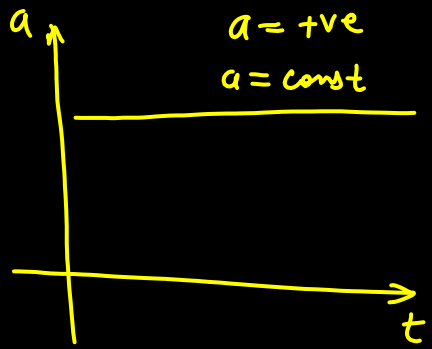
⇒ For Freely Falling object (a = g)

v-t graph is always st line



Acceleration Time Graph

$$\text{Slope} = \frac{da}{dt}$$

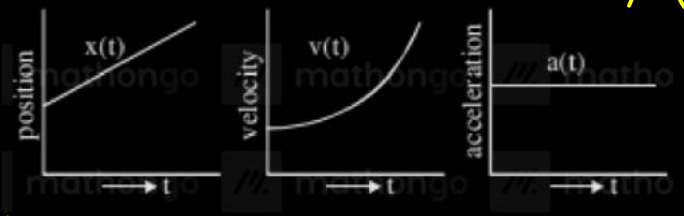


$a = \text{const}$

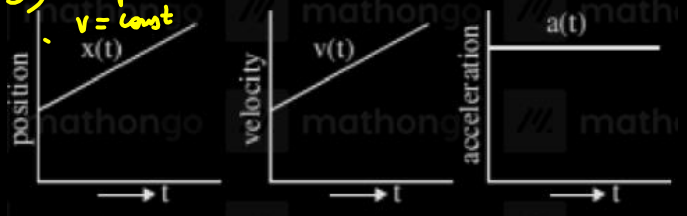
The position, velocity and acceleration of a particle moving with constant acceleration can be represented by

[JEE Main 2021]

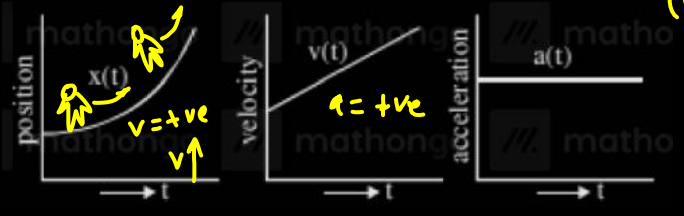
(a)



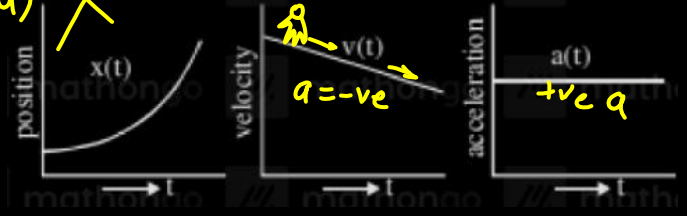
(b) Slope = const, v = const



(c)



(d)

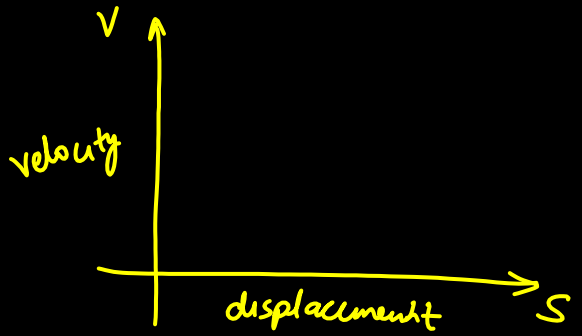


Velocity Displacement Graph

$$\text{Slope} = \frac{dv}{ds} = \frac{a}{v}$$

$$a = v\frac{dv}{ds}$$

$$\frac{dv}{ds} = \frac{a}{v}$$



The velocity - displacement graph of a particle is shown in the figure. The acceleration displacement graph of the particle is represented by:

[JEE Main 2021]

$\text{Slope} = \frac{a}{v} = -\frac{V_0}{x_0}$

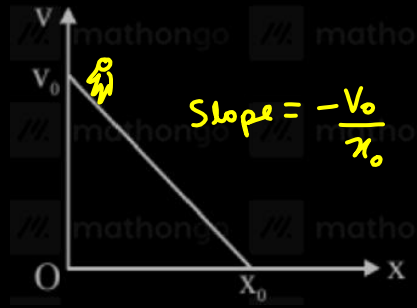
$y = mx + c$

$v = -\frac{V_0}{x_0}x + V_0$

diff

$\frac{dv}{dt} = \left(-\frac{V_0}{x_0}\right)\frac{dx}{dt} + 0$

$a = -\frac{V_0}{x_0}v$

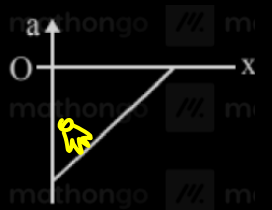


Figure

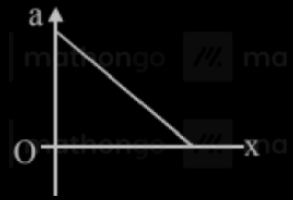
$a = -\frac{V_0}{x_0}\left(-\frac{V_0}{x_0}x + V_0\right) = +\frac{V_0^2}{x_0^2}x - \frac{V_0^2}{x_0}$

A

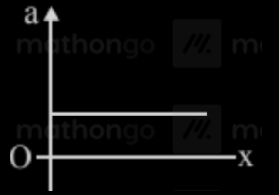
B



C

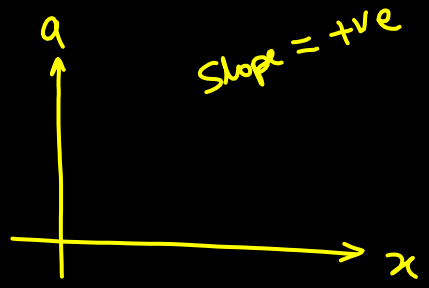


D



$$a = \left(+\frac{v_0^2}{x_0^2}\right)x - \left(\frac{v_0^2}{x_0}\right)$$

$$y = mx + c$$



Unacademy Atoms

Q

a(-ve) ⟵

⟶ v(+ve)

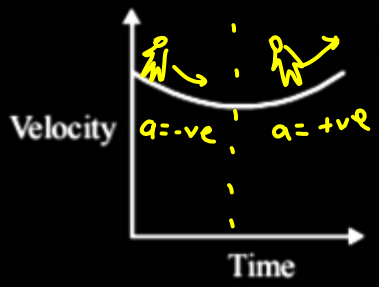
a = Const
a = -ve
v = +ve
⇒ v ↓

↑ Slope = $\frac{a}{v} = \frac{-a}{v\downarrow}$

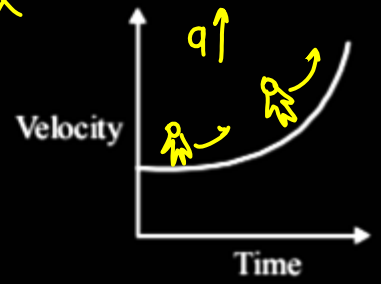
Which graph corresponds to an object moving with a constant negative acceleration and a positive velocity ?

[JEE Main 2017]

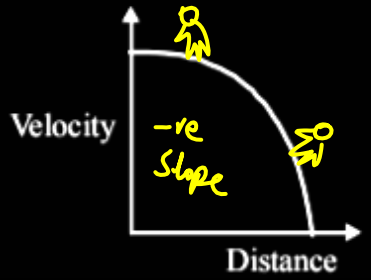
(a) ✗



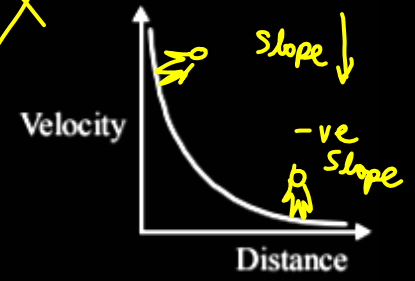
(b) ✗

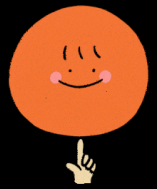


(c) ✓



(d) ✗

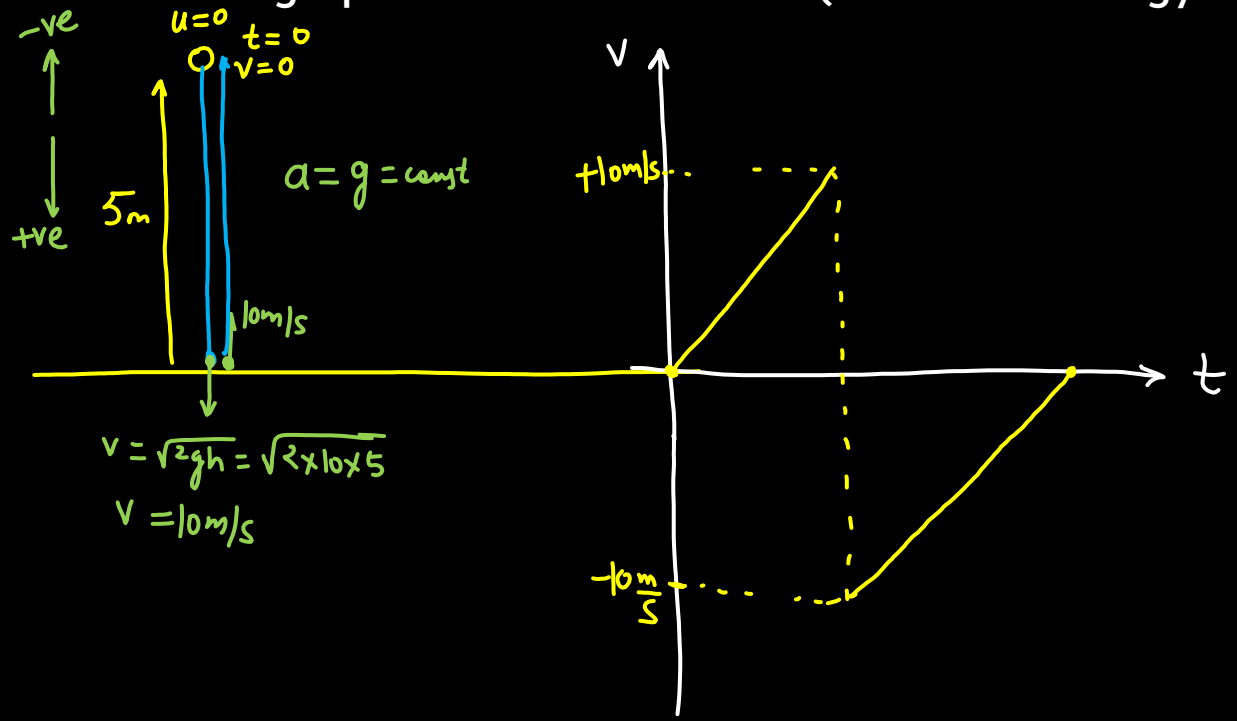


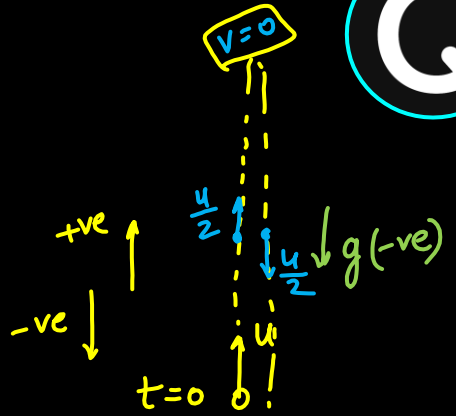


How to Draw the Graph ?

- Identify the situation at t=0
- Choose the sign convention
- Identify if it will be straight line or curve

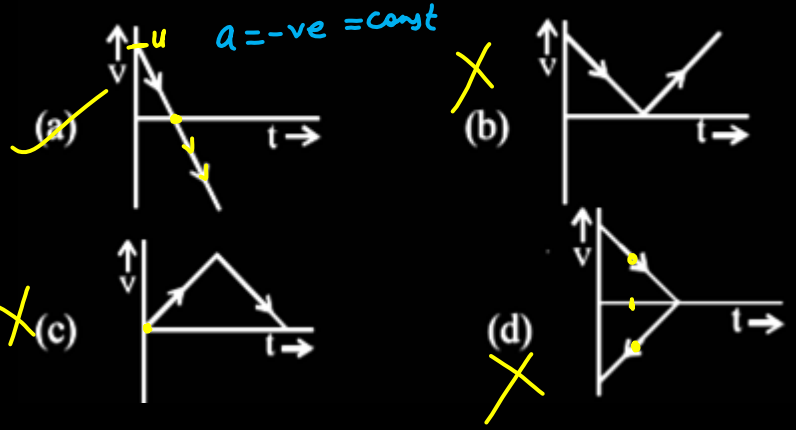
A ball is dropped from a height of 5m. It hits the ground and bounces back. Plot the velocity time graph for its entire motion. (Assume no energy loss)





A body is thrown vertically upwards. Which one of the following graphs correctly represent velocity vs time

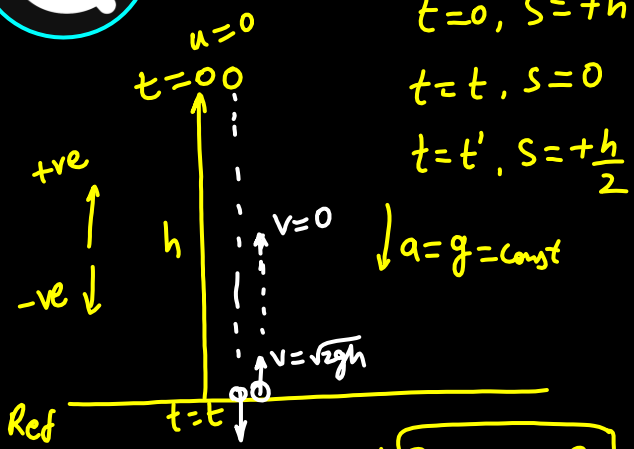
[JEE Main 2017]

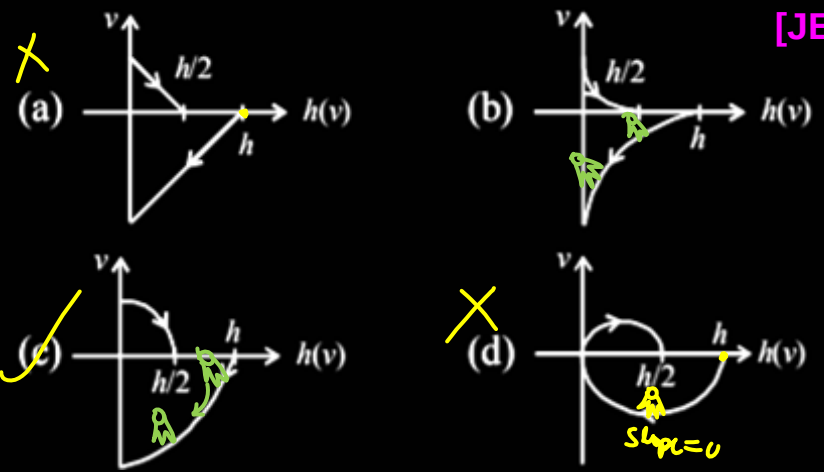


Best Question of PYQ

A tennis ball is released from a height h and after freely falling on a wooden floor it rebounds and reaches height h/2. The velocity versus height of the ball during it motion may be represented graphically by :
(graph are drawn schematically and on not to scale)

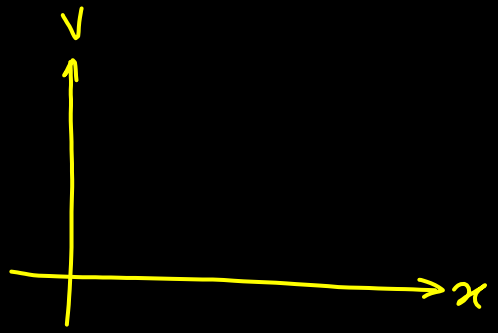
[JEE Main 2020]

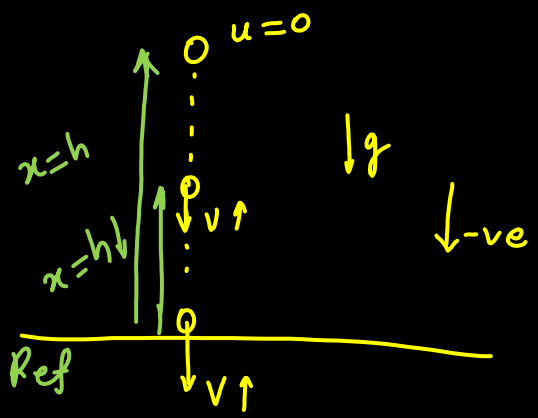




$$\text{Slope} = \frac{-a}{-v}$$

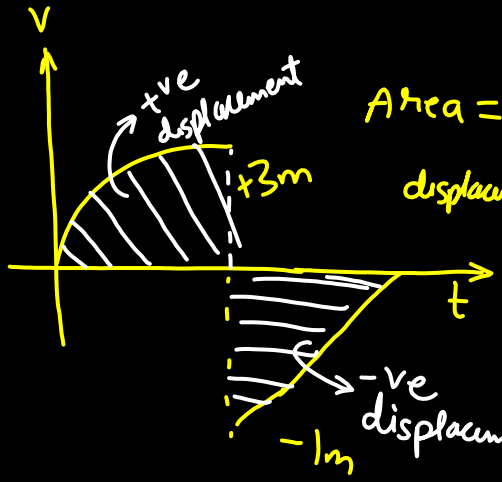
$$\downarrow \text{Slope} = \frac{a\,(\text{const})}{v\uparrow}$$





Area Under the Curve

$$\text{Area} = \int y\,dx$$



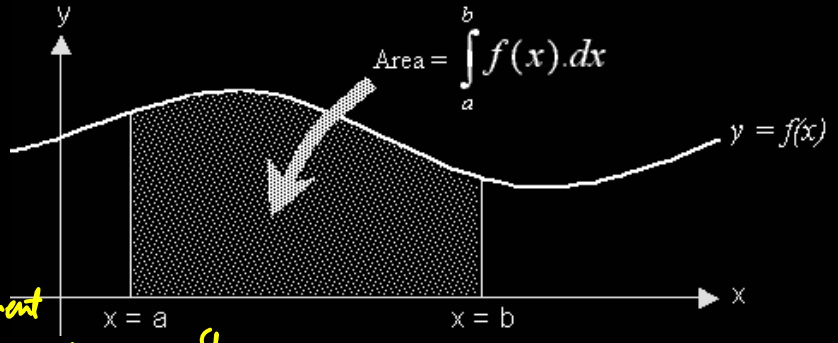
$$\text{Area} = \int v\,dt = \text{displacement}$$

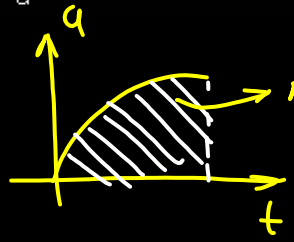
displacement $= +3 - 1$

$= 2\,m$

distance $= +3 + 1$

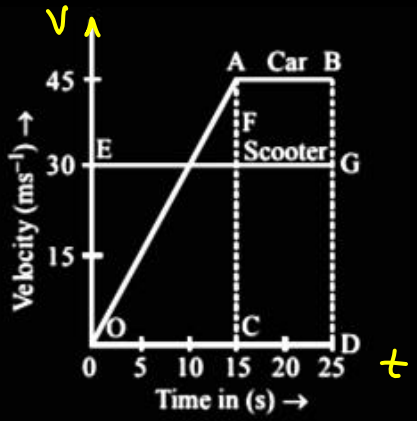
$= 4m$



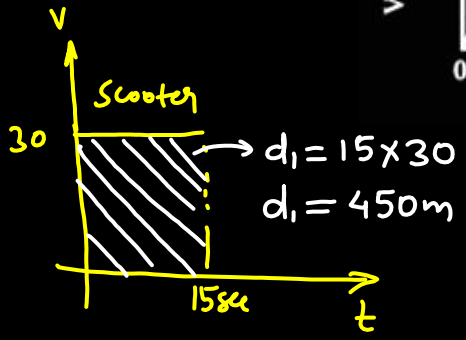


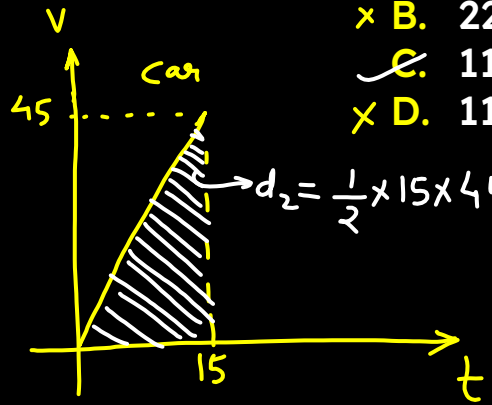
Area $= \int a\,dt$

$=$ velocity



The velocity time graphs of a car and a scooter are shown in the figure (i) the difference between the distance travelled by the car and the scooter in 15 s and (ii) the time at which the car will catch up with the scooter are, respectively





- ✗ A. 337.5 m and 25s
- ✗ B. 225.5 m and 10 s
- C. 112.5m and 22.5s
- ✗ D. 11.2.5 m and 15s

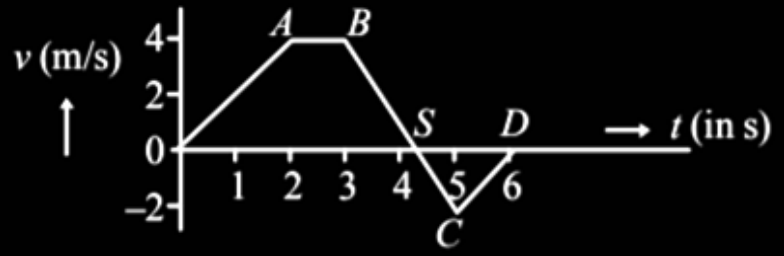
(i) $d_1 - d_2 = 450 - 337.5$

$= 112.5\,m$

HW

The velocity (v) and time (t) graph of a body in a straight line motion is shown in the figure. The points S is at 4.333 seconds. The total distance covered by the body in 6 s is :

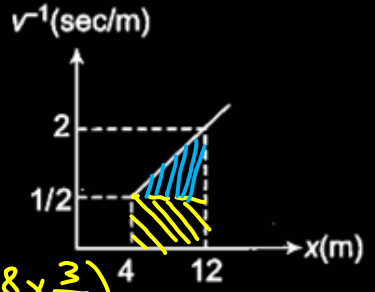
A. 37/3 m
B. 12 m
C. 11 m
D. 49 / 4 m



[JEE Main 2021]

Graph of (1/v) vs. x for a particle under motion is as shown where v is velocity and x is position. The time taken by particle to move from x = 4m to x = 12 m is

A. 16/3 sec
B. 10 sec ✓
C. 8 sec
D. 12 sec



$$\text{Area} = \int y \cdot dx$$

$$= \int v^{-1}\, dx$$

$$= \int \frac{dx}{v}$$

$$= \int \frac{dx}{(dx/dt)} = \int dt = t$$

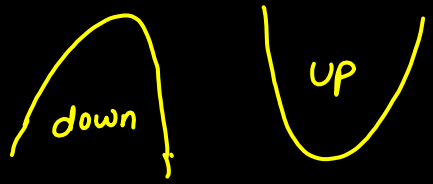
$$\text{Area} = t = \left(8 \times \frac{1}{2}\right) + \left(\frac{1}{2} \times 8 \times \frac{3}{2}\right)$$

$$= 4 + 6$$

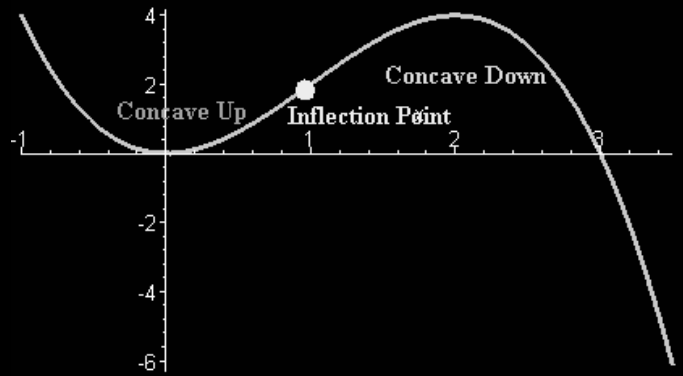
$$t = 10 \text{ sec.}$$

Concavity

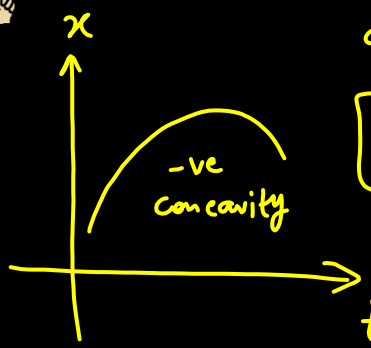
⇒ Orientation of Graph



$$\text{Concavity} = \frac{d^2y}{dx^2}$$



Concavity

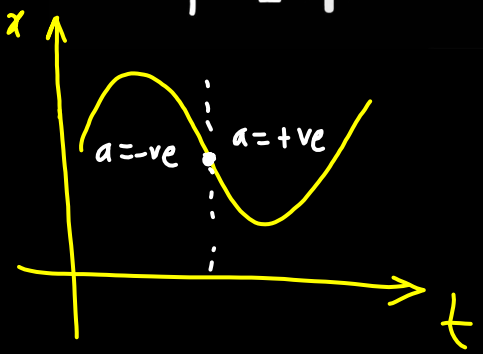


$a = \frac{dv}{dt}$

$a = \frac{d^2x}{dt^2}$

$\Rightarrow$ a = - ve for all the time

Acceleration is the Concavity of x-t graph



Concavity

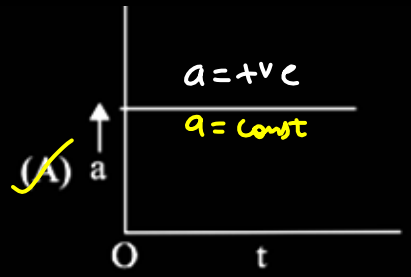
Up

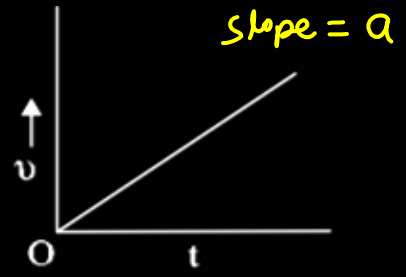
f'' = +

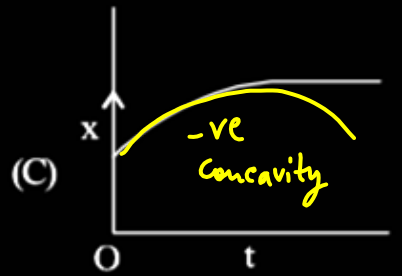
Down

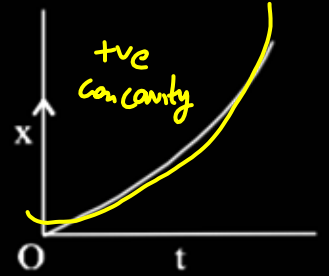
f'' = -

A particle starts from origin rest and moves with a uniform acceleration along the positive x - axis. Identify all figures that correctly represents the motion qualitatively (a = acceleration, v = velocity, x = displacement, t= time)



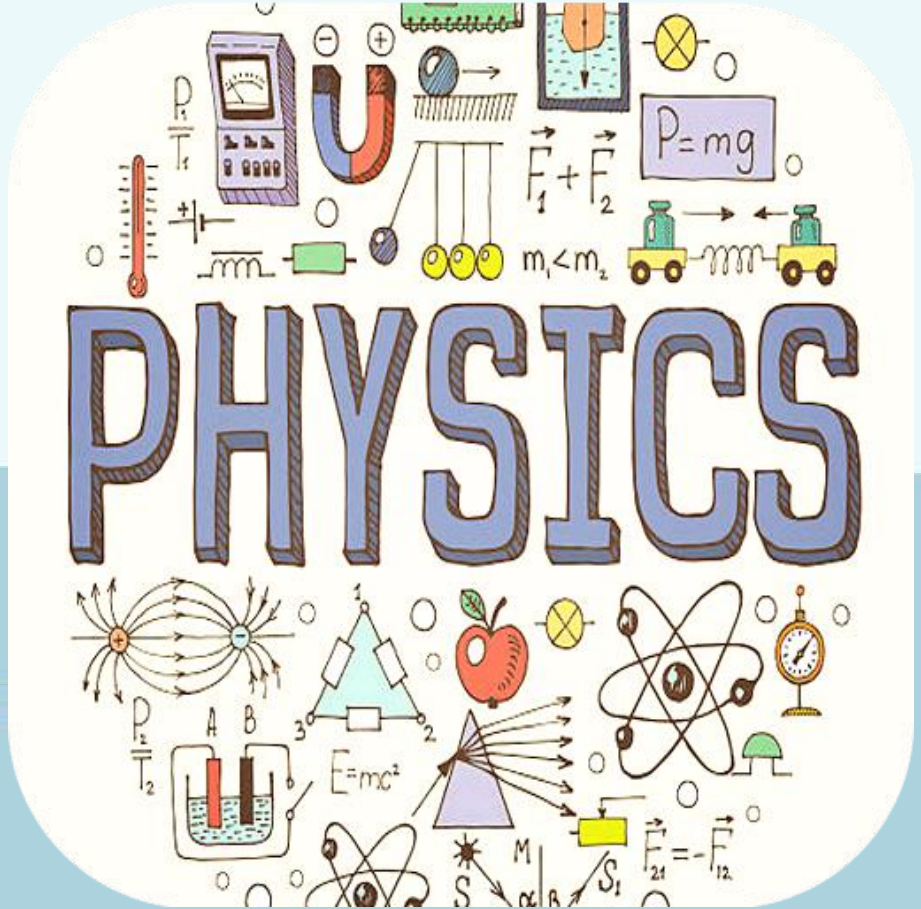






(a) (B), (C)
(b) (A)
(c) (A), (B), (C)
(d) (A), (B), (D)

Comment on the motion of the particle based on following graph

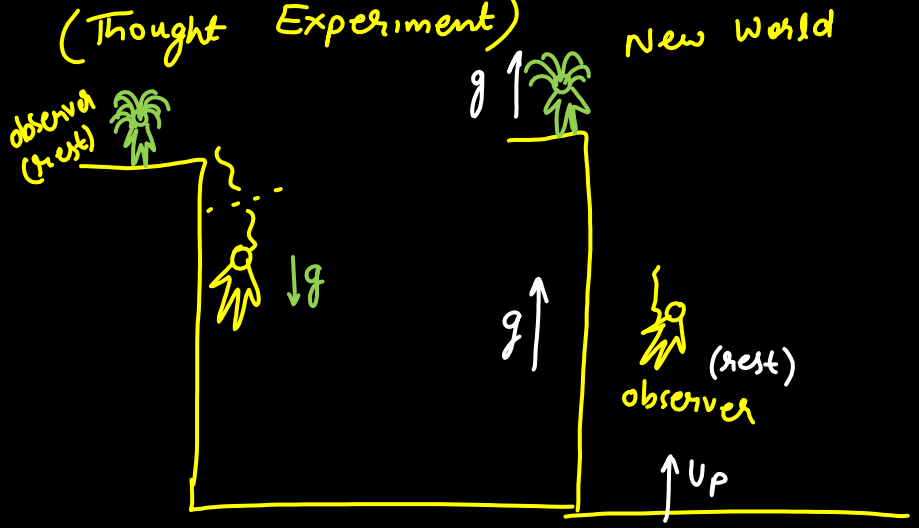


Relative Motion in 1D

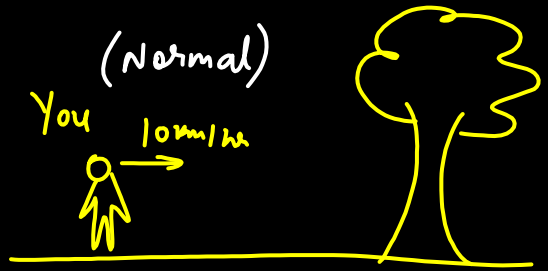
Unacademy Atoms

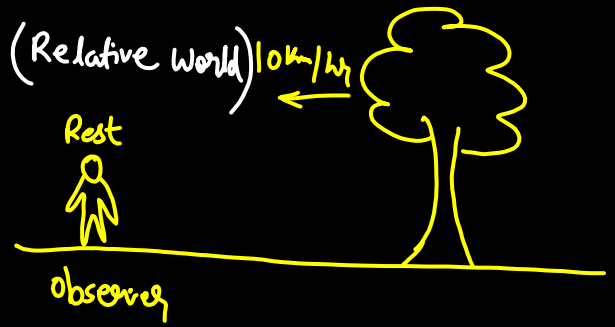
Relative Velocity

(Thought Experiment)

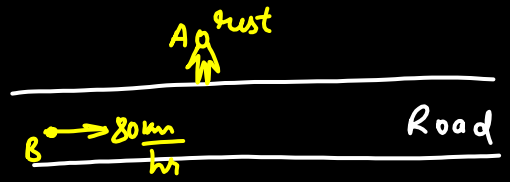


Observer is always at rest

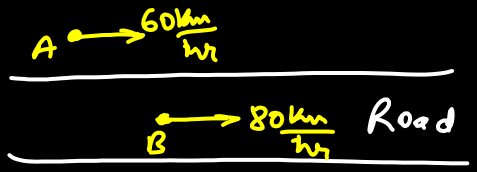




Relative Velocity



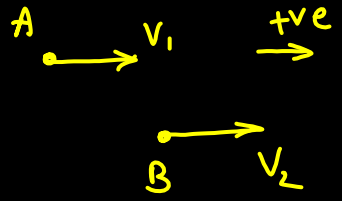
$V_{BA} = 80 \text{ km/hr}$



$V_{BA} = 20 \text{ km/hr} = 80 - 60$

$$\vec{V}_{BA} = \vec{V}_{BG} - \vec{V}_{AG}$$

$$\vec{V}_{AB} = \vec{V}_{AG} - \vec{V}_{BG}$$

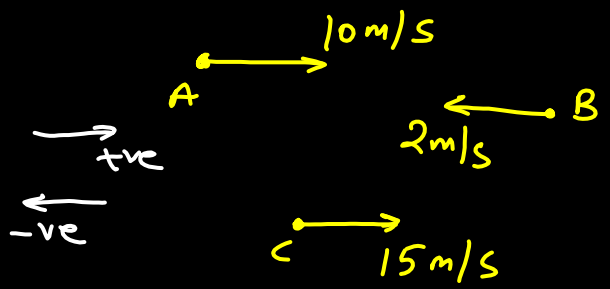


$V_{BA} = V_B - V_A = (+V_2) - (+V_1)$

$$V_{BA} = V_2 - V_1$$

$V_{BA} = V_B - V_A = (-V_2) - (+V_1)$

$$V_{BA} = -(V_1 + V_2)$$

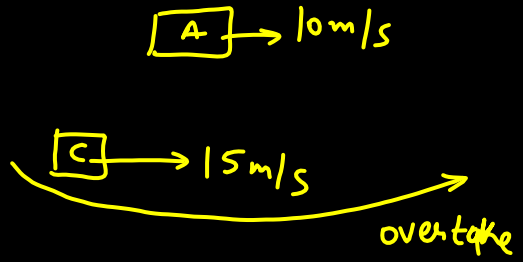


(i) $V_{AB} = V_A - V_B = (+10) - (-2)$

$V_{AB} = +12\ m/s$

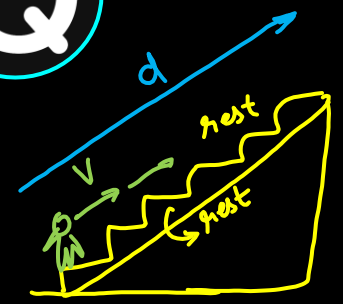
(ii) $V_{BC} = V_B - V_C = (-2) - (+15)$

$V_{BC} = -17\ m/s$



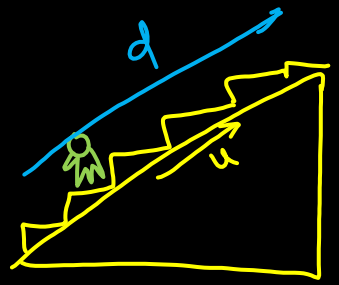
(iii) $V_{AC} = V_A - V_C = (+10) - (+15)$

$V_{AC} = -5\ m/s$



$t_1 = \frac{d}{v} = 60\,\text{sec}$

$\Rightarrow v = \frac{d}{60}$



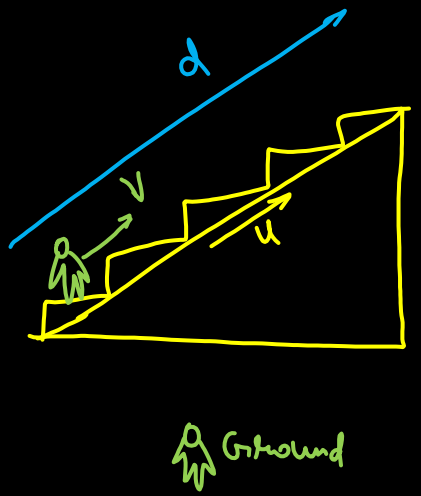
$t_2 = \frac{d}{u} = 40\,\text{sec}$

$u = \frac{d}{40}$

A person climbs up a stalled escalator in 60 s. If standing on the same but escalator running with constant velocity he takes 40 s. How much time is taken by the person to walk up the moving escalator ?

[JEE Main 2014]

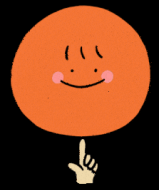
A. 37s
B. 27s
C. 24s ✓
D. 45s

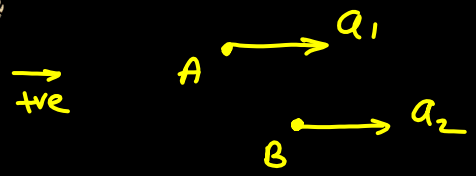


$$t_3 = \frac{d}{v+u} = \frac{d}{\frac{d}{60}+\frac{d}{40}} = \frac{1}{\frac{40+60}{40\times60}}$$

$$= \frac{2400}{100} = 24 \text{ sec}$$

Relative Acceleration



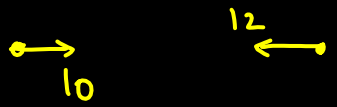


$$\vec{a}_{AB} = \vec{a}_A - \vec{a}_B$$

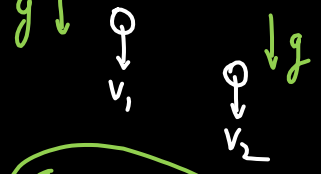
$$\vec{a}_{AB} = -\vec{a}_{BA}$$

$a_{AB} = a_1 - a_2$

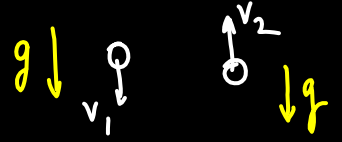
$a_{BA} = a_2 - a_1$



Free Fall



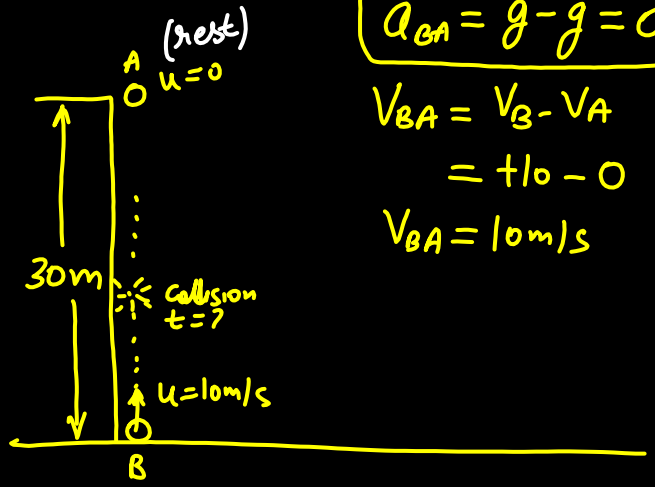
$a_{relative} = 0$



$a_{relative} = g - g = 0$

A stone is dropped from a tower of height 30 m. Simultaneously another stone is thrown vertically upwards with a speed of 10 m/s. The time after which the two stones collide is

(a) 1 sec
(b) 2 sec
(c) 3 sec ✓
(d) 4 sec



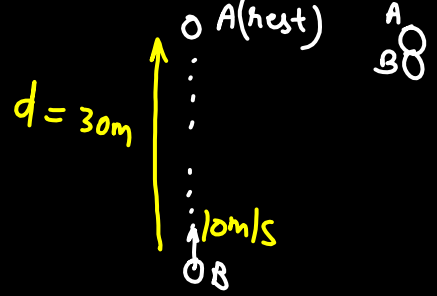
$a_{BA} = g - g = 0$

$V_{BA} = V_B - V_A$

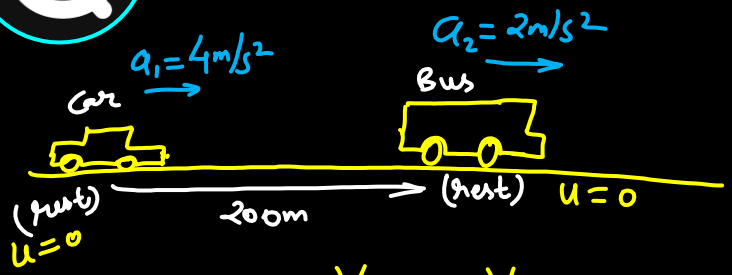
$= +10 - 0$

$V_{BA} = 10\,m/s$

Relative Frame



$t = \frac{d}{V} = \frac{30\,m}{10\,m/s} = 3\,sec$



$$V_{CB} = V_C - V_B$$
$$V_{CB} = 0 - 0 = 0$$

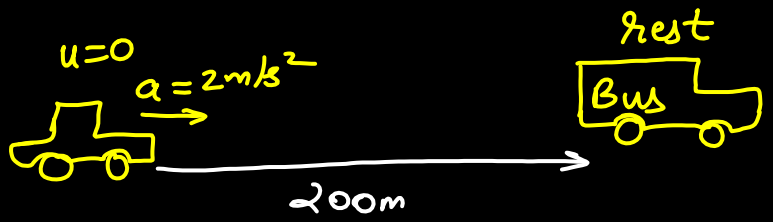
$$a_{CB} = a_C - a_B = (+4) - (+2)$$
$$a_{CB} = +2 m/s^2$$

A car is standing 200 m behind a bus , which is also at rest . The two start moving at the same instant but with different forward accelerations. The bus has acceleration 2 m/s^2 and the acceleration of the car is 4 m/s^2 . The car will catch up with the bus after a time of:

[JEE Main 2017]

A. √110S
B. √120S
C. 10√2s ✓
D. 15 s

Relative Frame



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

$$200 = 0 + \frac{1}{2} \times (2) t^2$$

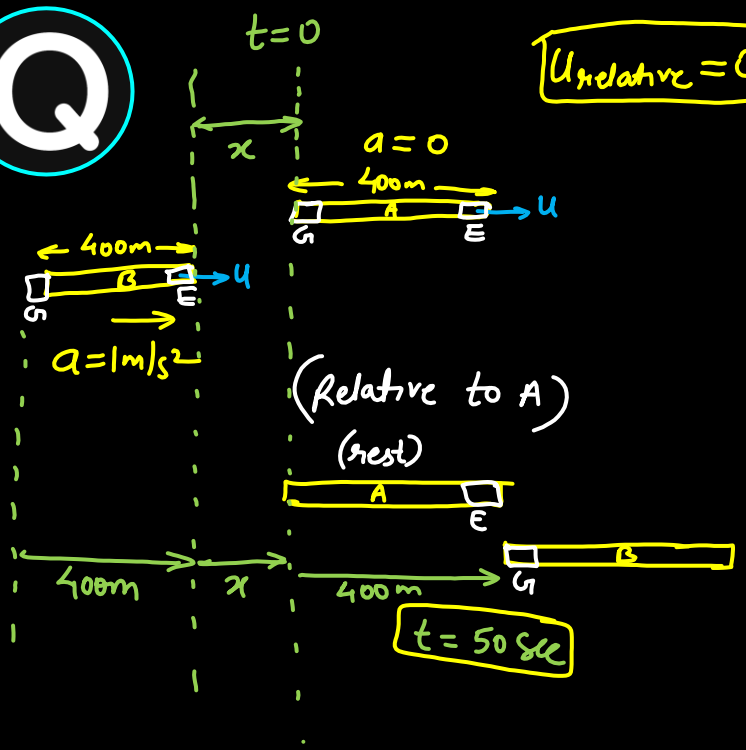
$$t = \sqrt{200} = 10\sqrt{2} \text{ sec}$$

HW

Ans in Comment

A man in a balloon, throws a stone downwards with a speed of 5 m/s with respect to balloon. The balloon is moving upwards with a constant acceleration of 5 m/s^2. The velocity of the stone relative to the man after 2 seconds is

A. 10 m/s
B. 30 m/s
C. 15 m/s
D. 35 m/s



$u_{relative} = 0$

Two trains A and B of length 400 m each are moving on two parallel tracks with a uniform speed of 72 km/h in the same direction, with A ahead of B. The driver of B decides to overtake A and accelerates by 1 m/s². If after 50 s, the guard of B just brushes past the driver of A and the original distance between them is x, then calculate value of x/10 ? 45

$a_{BA} = a_B - a_A$

$= 1 - 0$

$a_{relative} = 1\ m/s^2$

$S_{relative} = 400 + x + 400$

$S_{relative} = 800 + x$

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

$$800 + x = 0 + \frac{1}{2}(1)(50)^2$$

$$800 + x = 1250$$

$$x = 450\ m$$

$$\frac{x}{10} = 45$$

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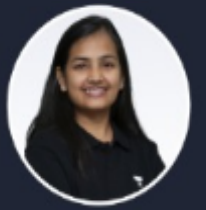

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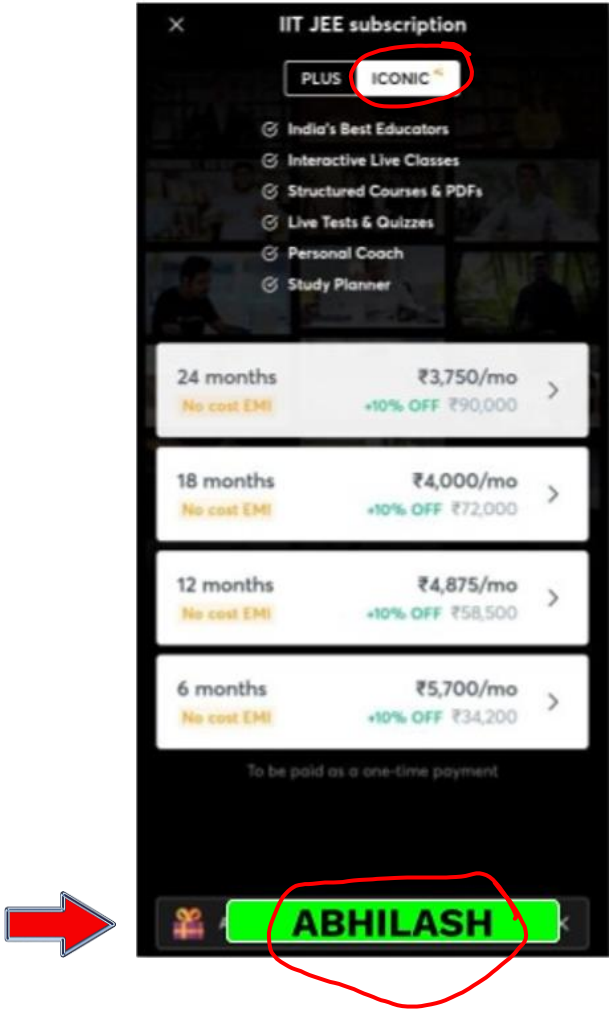
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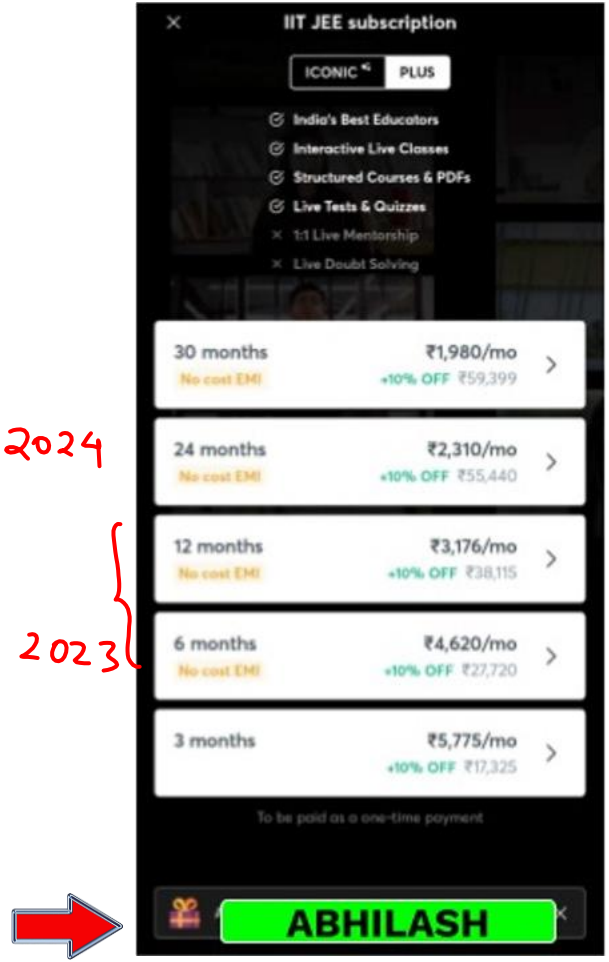
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