8th → advanced

WS-4. Acceleration and Equations of motion

T task

① Given that in the last sec [n^{th} sec] the Particle describing $\frac{9}{25}$ th of whole distance [let it be s]

$\Rightarrow S_n = \frac{9}{25} S$

we know that

$\Rightarrow \frac{S_n}{S} = \frac{9}{25}$ $\quad$ $\frac{S_n}{S} = \frac{2n-1}{n^2}$

$\Rightarrow \frac{9}{25} = \frac{2n-1}{n^2}$

$\Rightarrow 9n^2 = 25(2n-1) \Rightarrow 9n^2 = 50n-25$

$\Rightarrow 9n^2 - 50n + 25 = 0$

$\Rightarrow 9n^2 - 45n - 5n + 25 = 0$

$\Rightarrow 9n(n-5) - 5(n-5) = 0$

$\Rightarrow (9n-5)(n-5) = 0 \rightarrow 9n-5=0 \text{ (or) } n-5$

$\Rightarrow n = \frac{5}{9}$ (or) $n = 5$

From question

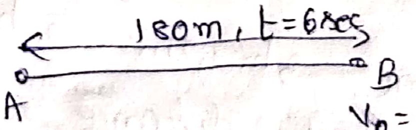
$S_1 = 6\text{ m}$ $\quad$ $u = 0 \Rightarrow S \propto t^2$

$t_1 = 1\text{ sec}$

$t_2 = 5\text{ sec}$

$\Rightarrow \frac{S_1}{S_2} = \left(\frac{t_1}{t_2}\right)^2 \Rightarrow \frac{6}{S_2} = \left[\frac{1}{5}\right]^2 \Rightarrow S_2 = 150$

② let us consider that the car is moving from A →



$V_A = ?$

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

$\Rightarrow 150 = V_A \times 6 + \frac{1}{2} a \times (6)^2$

$\Rightarrow \frac{\overset{30}{\cancel{180}}}{} = \cancel{6}V_A + \overset{\cancel{18}\,3}{\cancel{36}}\frac{a}{\cancel{2}}$

$\Rightarrow 30 = V_A + 3a \rightarrow ①$

$V_B = 45\text{ m/s}$

From $v = u + at$

$\Rightarrow V_B = V_A + at$

$\Rightarrow 45 = V_A + 6a \rightarrow ②$

By solving ① & ②

$\Rightarrow V_A + 6a = 45$

$-\ V_A \pm 3a = 30$

$\Rightarrow 3a = 15 \Rightarrow a = 5\text{ m/s}^2$

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

$\Rightarrow \cancel{V_B^2 - V_A^2} = 2a \times \cancel{150}$

sub 'a' value in ① get $30 = V_A + 3(5)$

$\Rightarrow 30 = V_A + 15$

$\Rightarrow V_A = 15\text{ m/s}$

③ The speed of a car $u_1 = 50$ kmph $= 50 \times \frac{5}{18} = \frac{250}{18}$ m/s

It is stopped [V=0] after travelling through a distance $= 6m = s_1$

If the speed of car is $u_2 = 100$ kmph

Then $s_2 = ?$

From $v^2 - u^2 = 2as \Rightarrow -u^2 = 2as$ [Here car is in Retardation]

$$\Rightarrow u^2 \propto s$$

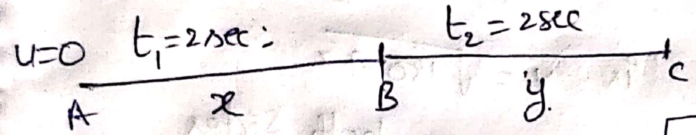
$$\Rightarrow \frac{s_2}{s_1} = \left[\frac{u_2}{u_1}\right]^2 \Rightarrow \frac{s_2}{6} = \left(\frac{\overset{2}{\cancel{100}}}{\cancel{50}}\right)^2$$

$$\Rightarrow \frac{s_2}{6} = 2^2 = 4$$

$$\Rightarrow s_2 = 24\ m$$

④ Given Particle is starting from rest $u=0$

a = constant



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

$t_1 = 2sec$ | Total 4sec

$s = x + y$

$$x = 0 \times 2 + \frac{1}{2}a(2)^2$$

$$x + y = 0 \times 4 + \frac{1}{2}a \times 4^2$$

$$\Rightarrow x = 2a$$

$$\Rightarrow 2a + y = \frac{1}{\cancel{2}}a \times \cancel{16}\,8$$

$$\Rightarrow 2a + y = 8a$$

$$\Rightarrow y = 6a$$

$$\therefore y = 3(2a)$$

$$y = 3x.$$

⑤ Given acceleration $a = -5$ m/s² ; Initial velocity

$u = 8.33$ m/s

$v = 0$

Reaction time $t = 0.7$ sec

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

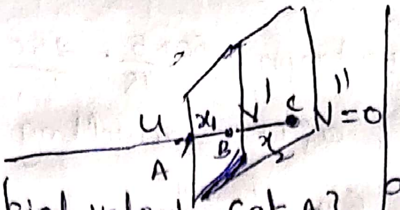
$$\Rightarrow s = 8.33 \times 0.7 + \frac{1}{2}(-5)(0.7)^2$$

$$= 5.831 - \frac{1}{2}(2.45)$$

$$\Rightarrow 5.831 - 1.225$$

$$= 4.606\ m.$$

⑥



Given that After $x_1 = 15cm$

velocity $v' = \frac{u}{2}$ [At B]

$u \to$ initial velocity [at A] and ~~the~~ bullet is coming to rest After travelling through a distance (x_2)

ie Final velocity $v'' = 0$ [at

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

For AB

$v'^2 - u^2 = 2ax_1$

$\Rightarrow (\frac{u}{2})^2 - u^2 = 2ax_1$

$\Rightarrow -\frac{3u^2}{4} = 2a \times 15$

$\Rightarrow -\frac{u^2}{2a} = \frac{4\times15}{3} \to ①$

For BC

$v''^2 - v'^2 = 2ax_2$

$\Rightarrow 0^2 - (\frac{u}{2})^2 = 2a x_2$

$\Rightarrow -\frac{u^2}{4} = 2a x_2$

$\Rightarrow -\frac{u^2}{2a} = 4x_2 \to ②$

From ① & ②

$\cancel{4}x_2 = \frac{\cancel{4}\times\cancel{15}^{5}}{\cancel{3}}$

$x_2 = 5cm$

⑦ Given equation is $v = \sqrt{180 - 7x}$

By squaring on both sides

$\Rightarrow v^2 = 180 - 7x$

$\Rightarrow v^2 = (\sqrt{180})^2 - 7x$

$\Rightarrow v^2 - (\sqrt{180})^2 = -7x$

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

$\therefore u = \sqrt{180}$; $2a = -7 \Rightarrow a = -3.5 \ m/s^2$

⑧ Given velocity $= 60 \ m/s$; $t = 2s$.

$\therefore$ distance $=$ vel $\times$ time $= 60 \times 2 = 120 m.$

⑨ Given the displacement of a Particle $s = t^3 - 6t^2 + 3t +$

$\therefore$ velocity $v = \frac{ds}{dt} = \frac{d}{dt}[t^3 - 6t^2 + 3t + 4]$

$v = \frac{d}{dt}t^3 - 6\frac{d}{dt}t^2 + 3\frac{\cancel{dt}}{\cancel{dt}} + \frac{d}{dt}(4)$

Ate From $\frac{d}{dx} x^n = nx^{n-1}$ $\frac{d}{dx}$ (constant) = 0

Ist term $n = 3$; IInd term $n = 2$

$$v = 3t^{3-1} - 6(2t^{2-1}) + 3 + 0$$

$$\Rightarrow v = 3t^2 - 12t + 3 \rightarrow ①$$ From def of acceleration

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

$$\Rightarrow a = \frac{d}{dt}[3t^2 - 12t + 3]$$

$$\Rightarrow a = 3\frac{d}{dt}t^2 - 12\frac{dt}{dt} + \frac{d}{dt}(3)$$

$$= 3(2t^{2-1}) - 12 + 0$$

$$a = 6t \rightarrow ②$$ when acceleration is zero $6t = 0$

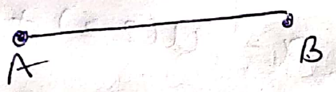
$\Rightarrow t = 0$ sec

From 1

$$v = 3(0)^2 - 12(0) + 3$$

$$v = 3 \text{ m/s}$$

⑩ From the question $u_B = 0$; $a_B = 5 \text{ m/s}^2$



let B is over taking point

According to question $u_{car} = 50$ m/s., s - be the distance travelled and t is time taken for both Bus and car.

For Bus

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

$$\Rightarrow s = 0 \times t + \frac{1}{2} 5 t^2$$

$$\Rightarrow s = \frac{1}{2} 5 t^2 \rightarrow ①$$

For car ; $a_c = 0$

~~s = ut + at~~ $s = 50t \rightarrow ②$

From ① & ②

$$\cancel{50}^{10} \cancel{t} = \frac{1}{2} 5 t^{\cancel{2}}$$

$$\Rightarrow t = 20 \text{ sec}$$

∴ The speed of bus when both car and bus are side by side is determined by using

$$v = u + at$$

$$v_B = 0 + 5 \times 20$$

$$\Rightarrow v_B = 100 \text{ m/s}$$

[$a_{car} = 0$ because car is moving with constant velocity]

⑬ Given Displacement $x = u(t-2) + a(t-2)^2 \rightarrow ①$

velocity of Particle is $v = \frac{dx}{dt} = \frac{d}{dt}(u(t-2) + a(t$

$\frac{d}{dx}(\text{constant}) = 0$

$\frac{d}{dx} x^n = n x^{n-1}$

$v = \frac{d}{dt}[ut - 2u + a(t^2 + 4 - 4t)$

$\Rightarrow v = u\frac{dt}{dt} - \frac{d}{dt}(2u) + a[\frac{d}{dt}t^2 + \frac{d}{dt}4$

$4\frac{dt}{dt}$

$\Rightarrow v = u - 0 + a\,2t^{2-1} + 0 - 4$

$\Rightarrow v = u + 2at - 4 \rightarrow ②$ at $t = 0$

initial velocity $v = u + 2a(0) - 4 = u - 4$

Acceleration $a = \frac{dv}{dt} = \frac{d}{dt}[u + 2at - 4] = \frac{d}{dt}u + 2a\frac{dt}{dt}$

$a = 0 + 2a - 0 \Rightarrow$ a acceleration =

From ①

At $t = 2$ $x = u(2-2) + a(2-2)^2$

$x = 0$ so the Particle is at orig

⑮ Give Particle starts from rest i.e) $u = 0$

Acceleration $a = 2\ ms^{-2}$; $t = 10$ sec

The velocity of a Particle after 10 sec

$v = u + at$ $\Rightarrow v = 0 + 2(10)$

$\Rightarrow v = 20\ ms^{-1}$

with 20 m/s it travels for 30 sec After this it has retardation $a = -4\ m/s^2$ and final velocity (let it be $v' =$

in first 10 sec S_1 be the distance travelled

$S_1 = ut + \frac{1}{2}at^2$

$S_1 = 0 \times 10 + \frac{1}{2} 2 \times 10^2 \Rightarrow S_1 = 100m.$

distance travelled for next 30 sec with velocity 20 m/s

is $S_2 = v \times time \Rightarrow S_2 = 20 \times 30 = 600$ m

After this the body is in retardation

let the distance travelled S_3 is calculated by

using $v^2 - u^2 = 2as$ $\Rightarrow \cancel{-}400 = \cancel{-}8\, S_3$

$\Rightarrow v'^2 - v^2 = 2aS_3$ $\Rightarrow S_3 = \frac{400}{8} = 50$ m

$\Rightarrow 0^2 - (20)^2 = 2(-4)\, S_3$

∴ Total distance travelled by the body $= S_1 + S_2 + S_3$

$= 100 + 600 + 50$

$= 750$m

⑯. the equation $y = 9x^2$

Also x-component of velocity $V_x = \frac{dx}{dt} = \frac{1}{3}$ m/s

y-component of velocity $V_y = \frac{dy}{dt} = \frac{d}{dt}[9x^2]$

$V_y = 9\frac{d}{dt}x^2$ $\left[\because \frac{d}{dx}x^n = nx^{n-1}\right]$

$\Rightarrow V_y = 9(2x^{2-1}\frac{dx}{dt} = 18x\frac{dx}{dt}$

Acceleration $= \frac{d}{dt}V_y$ Here x-component of velocity is constant so acceleration due to this component is zero

$= \frac{d}{dt}[(18x)\frac{dx}{dt}]$

∴ $a = \cancel{18\frac{d}{dt}x} \Rightarrow \cancel{a = 18} \frac{dx}{dt} \times 18\frac{dx}{dt}$

$V_y = 18x[V_x] = 18x \times \frac{1}{3} = 6x.$

∴ Acceleration $a_y = \frac{dV_y}{dt} = \frac{d}{dt}(6x) = 6\frac{d}{dt}x$

$a_y = 6 \times V_x = 6 \times \frac{1}{3}$

$a_y = 2$ m/s^2

⑰ Given train starts from rest $u=0$; $a = 2\,m/s^2$

$time = \frac{1}{2}\,min = 30\,sec.$

let S_1 be the ~~total~~ distance travelled for 30

From $S_1 = ut + \frac{1}{2}at^2$

$S_1 = 0 \times 30 + \frac{1}{2}(2)(30)^2$

$\Rightarrow S_1 = 900\,m$

velocity $v = u + a$

$v = 0 + 2 \times 3$

$v = 60\,m/s$

After 1 min the train coming to rest $t_2 =$
$a = 0$ [Because $V = 60\,m/s$ is Constant] $= 30$

$\therefore$ Distance travelled $S_2 = Vt_2 + \frac{1}{2}at_2^2$

$S_2 = 60 \times 30 + \frac{1}{2}\,0 \times (30)^2$

$= 1800$ $= 1800$

Total distance $= 900 + 1800 = 2700\,m = 2.7\,km$

⑱ The maximum speed attained by the boat $= 60$

⑲ position of the train at half of maximum spe
is calculated By using $v^2 - u^2 = 2as$

$V = \frac{60}{2}$ [half of maximum speed]

$= 30\,m/s$

$\therefore 30^2 - u^2 = 2 \times 2\,S$

$\Rightarrow 900 = 4S$

$\Rightarrow S = 225\,m$

SAQ's

① length of each train $l = 50m$

let velocities of two trains be V_1 & V_2

so $V_1 = 10\ m/s$ & $V_2 = 15\ m/s$

As the approach each other their relative velocity $V = V_1 + V_2$ $\Rightarrow V = 10+15$

$$\Rightarrow \frac{l_1 + l_2}{time} = 25$$

$$\Rightarrow \frac{50+50}{t} = 25 \Rightarrow t = \frac{100}{25} = 4\ sec$$

② the initial speed of a car $u = 4.1\ m/s$

Final speed of a car $v = 6.9\ m/s$

time = 5 sec

∴ From $v = u + at$

$$\Rightarrow 6.9 = 4.1 + a \times 5$$

$$\Rightarrow 6.9 - 4.1 = 5a$$

$$\Rightarrow 2.8 = 5a \Rightarrow a = \frac{2.8}{5} = 0.56\ m/s^2$$

③ Given the speed at initial point is $u = V$

After 't' sec the car returns back with a speed $v = -v$

∴ From $v = u + at$ $\Rightarrow -V - V = at$

$$\Rightarrow -V = V + at \qquad \Rightarrow -2V = at \Rightarrow a = \frac{-2V}{t}.$$

④ in first case the speed of student is $u = 2\ kmph$

time taken to reach college is $t_1 = 3\ min$

$= \frac{3}{60}\ hr$

$s_1 = u \times t_1 = 2 \times \frac{3}{60}$ ~~$= 0.1\ km = 100\ m$~~ $\qquad = t + 3\ mint$

Here ~~let~~ 't' be time taken by the student to reach college

$$s_1 = 2\left(t + \frac{3}{60}\ hr\right) \rightarrow ①$$

As the student increases his speed by 1 kmph i.e. $V = 3$ kmph.

time taken to reach college $t_2 = 3\,\text{min} - t$

$$S = V \times t_2 = \left(t - \frac{3}{60}\text{hrs}\right)3 \rightarrow ②$$

$\therefore$ From ① and ②

$$2\left[t + \frac{3}{60}\right] = 3\left[t - \frac{3}{60}\right]$$

$$\Rightarrow 2t + \frac{2\times3}{60} = 3t - \frac{3\times3}{60}$$

$$\Rightarrow 2t + \frac{1}{10} = 3t - \frac{3}{20}$$

$$\Rightarrow 3t - 2t = \frac{1}{10} + \frac{3}{20} \Rightarrow t = \frac{5}{20} = \frac{1}{4}\text{hrs.}$$

$\therefore$ From ① $S = 2\times\left(t + \frac{3}{60}\text{hr}\right)$

$$= 2\left(\frac{1}{4} + \frac{1}{20}\right) = \cancel{2}\left[\frac{5+1}{\cancel{20}_{10}}\right] = 0.6\ \text{km}$$

⑤ speed of police car $V_1 = 30\times\frac{5}{18} = \frac{25}{3}$ m/s

speed of thief's car $V_2 = 190\times\frac{5}{18} = \frac{160}{3}$ m/s

muzzle speed of bullet is $V_3 = 150$ m/s.

velocity of bullet with respect to ground

$$V_{BG} = \frac{25}{3} + 150 = \frac{475}{3}\ \text{m/s}$$

Velocity of Bullet with respect to theif's car

$$V_{BT} = V_{BG} - V_{TG}$$

$$= \frac{475}{3} - 192\times\frac{5}{18}$$

$$= \frac{475}{3} - \frac{160}{3} = \frac{315}{3} = 105\ \text{m/s}$$

⑥ length of train A is $L_A = 100$ m

length of train B is $L_B = 60$ m

Given $V_B = 3V_A$

Time taken to cross each other is 4 sec

$$\therefore \text{Time} = \frac{L_A + L_B}{V_A + V_B}$$

$$\Rightarrow 4 = \frac{100+60}{V_A + 3V_A} \Rightarrow 4 = \frac{\overset{40}{\cancel{160}}}{\cancel{4}V_A}$$

$$\Rightarrow V_A = 10\ m/s$$

$$\therefore V_B = 3V_A = 3 \times 10 = 30\ m/s.$$

⑦ From the Relation

$S = ut + \frac{1}{2}at^2 \rightarrow ①$: At $t = 1$ sec $S_1 = 18$

$\Rightarrow 18 = u(1) + \frac{1}{2}a(1)^2 \Rightarrow 18 = u + \frac{a}{2} \rightarrow ②$

In $t = 2$ sec $\quad S_2 = 18 + 14 \Rightarrow$ From ① $\quad 32 = u(2) + \frac{1}{\cancel{2}}a(2)^{\cancel{2}}$

$\Rightarrow 32 = 2u + 2a$

$\Rightarrow u + a = 16 \rightarrow ③$

From ② & ③

$$\begin{array}{l} \cancel{u} + a = 16 \\ \cancel{u} + \frac{a}{2} = 18 \\ \hline \end{array}$$

$\Rightarrow (a - \frac{a}{2}) = 16 - 18$

$\Rightarrow \frac{a}{2} = -2$

$\Rightarrow a = -4\ m/s^2 \therefore$

$\Rightarrow$ From $V = u + at$

$\Rightarrow$ ~~20~~ $V = 20 + (-4)(3)$

$\Rightarrow V = 20 - 12$

$= 8\ m/s$

From $V^2 - u^2 = 2as$

$\Rightarrow 0^2 - 8^2 = 2(-4)s$

$\Rightarrow -64 = -8s$

$\Rightarrow s = 8m$

⑧ The Position of a particle $x = at^2 - bt^3$.

Then the velocity of a Particle $V = \frac{dx}{dt} = \frac{d}{dt}(at^2 - bt^3)$

$\Rightarrow V = a\frac{d}{dt}t^2 - b\frac{d}{dt}t^3$

$\Rightarrow V = a[2t^{2-1}] - b[3t^{3-1}]$

$V = 2at - 3bt^2$

Acceleration $a = \frac{dv}{dt} = \frac{d}{dt}[2at - 3bt^2]$

$$a = 2a\frac{dt}{dt} - 3b\frac{d}{dt}t^2$$

$$\Rightarrow a = 2a - 3b(2t)$$

$$\Rightarrow a = 2a - 6bt$$

Given acceleration is zero $a = 0$

$$\Rightarrow 2a - 6bt = 0$$

$$\Rightarrow t = \frac{a}{3b}.$$

⑨ Given Relation $3t = \sqrt{3x} + 6.$

$$\Rightarrow \sqrt{3x} = 3t - 6$$

on squaring both sides $3x = (3t-6)^2$

$$\Rightarrow 3x = 9t^2 + 36 - 36t$$

$$\Rightarrow x = 3t^2 + 12 - 12t \rightarrow ①$$

$\Rightarrow$ Velocity $v = \frac{dx}{dt} = \frac{d}{dt}(3t^2 + 12 - 12t)$

$$v = 3\frac{d}{dt}t^2 + \frac{d}{dt}(12) - 12\frac{dt}{dt}$$

$$v = 3(2t^{2-1}) + 0 - 12$$ [we know that $\frac{d}{dx}x^n = nx^{n-1}$]

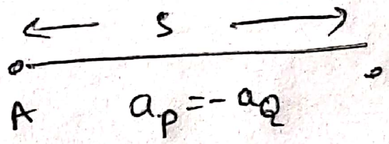
$\Rightarrow v = 6t - 12$ At $v = 0$

$\therefore 6t - 12 = 0 \Rightarrow 6t = 12$

$$\Rightarrow t = 2 \text{ sec}$$

$\therefore$ From ① $x = 3(2)^2 + 12 - 12(2)$

$$= 12 + 12 - 24 = 0$$



From, $v = u + at$

For P:

$V_P = u_P + a_P t$

$\Rightarrow 30 = 15 + a_p t$

$\Rightarrow a_p t = 15$

$u_p = 15$ m/s $v_p = 30$ m/s

$u_Q = 20$ m/s $v_Q = ?$

For Q

$v_Q = u_Q + a_Q t$

$= 20 - a_p t$

$= 20 - 15 = 5$ m/s.

⑭

$n_1 = 5^{th}$ $n_2 = 7$

$s_1 = 50m$ $s_2 = 70m$

let 'u' be initial velocity use:

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

$n_1 = 5,\ s_1 = 50$ $n = 7,\ s = 70$

$50 = u + \frac{a}{2}(2(5) - 1)$ $\Rightarrow 70 = u + \frac{a}{2}(2(7) - 1)$

$\Rightarrow 50 = u + \frac{a}{2} \times 9 \rightarrow ①$ $\Rightarrow 70 = u + \frac{a}{2} \times 13 \rightarrow ②$

By solving ① & ②

$$\Rightarrow \begin{array}{r} 70 = \cancel{u} + \frac{13a}{2} \\ -\ 50 = \cancel{u} + \frac{9a}{2} \\ \hline \end{array}$$

$\Rightarrow 20 = \frac{4a}{2}$

$\Rightarrow 2a = 20$

$\Rightarrow a = 10 m/s^2$

From ① $50 = u + \frac{10}{2} \times 9$

$\Rightarrow 50 = u + 45$

$\Rightarrow u = 5 m/s^2$

14th continuation

For n = 9

$S_n = 5 + \frac{10}{2}(2(9)-1)$

$= 5 + 5 \times 18 = 95m$

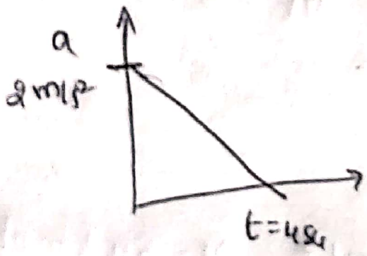
From $v = u + at = $ ~~50~~ $10 \times 9 = 90$ m/s

⑮

$u = 0$; $a = 2\ m/s^2$; $t = 4sec$

velocity after 2 sec. $v = u + at$

~~$v = 0 + 2 \times 2$~~



From graph: $\frac{a}{2} + \frac{t}{4} = 1$

$\Rightarrow 2a + t = 4$

$\Rightarrow 2a = 4 - t \Rightarrow a = 2 - \frac{t}{2}$

$\Rightarrow \frac{dv}{dt} = 2 - \frac{t}{2} \Rightarrow dv = (2 - \frac{t}{2})dt$

$\Rightarrow \int dv = \int (2 - \frac{t}{2}) dt$

$\Rightarrow v = \int_0^2 2\,dt - \frac{1}{2}\int_0^2 t\,dt$

$= 2(t)_0^2 - \frac{1}{2}\left(\frac{t^2}{2}\right)_0^2$

$= 2(2-0) - \frac{1}{2}\left(\frac{2^2 - 0^2}{2}\right)$

$= 4 - \frac{1}{4} \times 4 = 4 - 1$

$= 3 m/s$

⑯

Given $v = 2t(3-t)$

$= 6t - 2t2$

$\frac{d}{dx} x^n = n x^{n-1}$

$\frac{dv}{dt} = \frac{d}{dt}(6t - 2t^2)$

$= 6\frac{d}{dt} t - 2\frac{d}{dt} t^2$

$= 6 - 2(2t^{2-1})$

$= 6 - 4t$

For maximum velocity $\frac{dv}{dt} = 0$

$\Rightarrow 6 - 4t = 0 \Rightarrow 4t = 6 \Rightarrow t = \frac{6}{4} = \frac{3}{2}$ sec

⑰, ⑱, ⑲

$u = 0, \quad a = 0.5\, m/s^2 \quad v = 54$ kmph $= 54 \times \frac{5}{15}$

$= 15\, m/s$

From $v = u + at \Rightarrow 15 = 0 + 0.5t$

$\Rightarrow 15 = \frac{1}{2}t \Rightarrow t = 30$ sec

After 5 sec $\quad v = u + at \Rightarrow v = 0 + 0.5 \times 5 = 2.5\, m/s$

After 7 sec $\quad v_7 = 0 + 7 \times a = 7a$

After 21 sec $\quad v_{21} = 0 + 21 \times a = 21a$

$\frac{v_{21}}{v_7} = \frac{21a}{7a} = \frac{3}{1}$