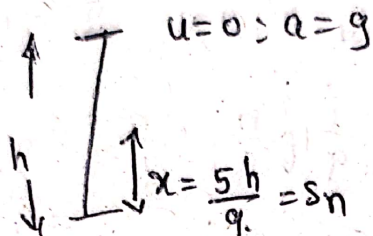


WS-11 - Freely falling body 8th foundation +
Task

- ①, let 'h' be the height of the tower.
and 'n' be the total time taken by the stone
to reach ground



in n^{th} sec it covers a distance

$$\frac{5h}{9}$$

From ~~$s_n = \frac{1}{2}gt^2$~~

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

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

$$\Rightarrow h = \frac{1}{2}gn^2 \rightarrow \textcircled{1}$$

$$\frac{5h}{9} = \frac{g}{2}(2n-1) \rightarrow \textcircled{2}$$

From $\textcircled{1}$ & $\textcircled{2}$

$$\frac{5}{9} \times \frac{1}{2}gn^2 = \frac{g}{2}(2n-1)$$

$$\Rightarrow 5n^2 = g(2n-1)$$

$$\Rightarrow 5n^2 = 18n - 9$$

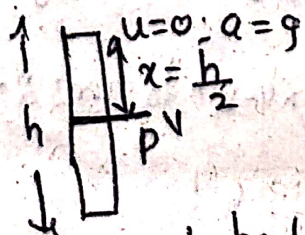
$$\Rightarrow 5n^2 - 18n + 9 = 0$$

$$\Rightarrow 5n^2 - 15n - 3n + 9 = 0$$

$$\Rightarrow 5n(n-3) - 3(n-3) = 0 \Rightarrow (5n-3)(n-3) = 0$$

$$\Rightarrow n = 3 \text{ sec.} \rightarrow \textcircled{B}$$

②



From $v = u + at$

velocity at mid point $v = 0 + gt$

$$\Rightarrow v = gt$$

t be the time taken to reach P

$$\therefore t = \sqrt{\frac{2x}{g}} = \sqrt{\frac{2(\frac{h}{2})}{g}} = \frac{1}{\sqrt{g}} \sqrt{\frac{h}{g}}$$

From 'p' No gravity

distance travelled $s = \frac{h}{2}$ to reach ground, and time taken t'

we know time = $\frac{\text{distance}}{\text{velocity}}$

$$\Rightarrow t' = \frac{\frac{h}{2}}{v} = \frac{h}{2v} = \frac{h}{2 \times g t}$$

$$\Rightarrow t' = \frac{h}{2} \times \frac{1}{g} \times \frac{1}{\sqrt{\frac{h}{g}}} \quad \left[\begin{array}{l} v = g t \\ = g \sqrt{\frac{h}{g}} \end{array} \right]$$

$$= \frac{1}{2} \sqrt{\frac{h}{g}}$$

$$\text{Total time} = t + t' = \sqrt{\frac{h}{g}} + \frac{1}{2} \sqrt{\frac{h}{g}} = \frac{3}{2} \sqrt{\frac{h}{g}} \rightarrow D$$

(3)

Given

$$\langle \text{velocity} \rangle = 7 \text{ m/s}$$

$$\frac{u+v}{2} = 7 \Rightarrow \frac{v}{2} = 7 \quad \left[\begin{array}{l} u=0 \text{ for} \\ \text{FFB} \end{array} \right]$$

$$\Rightarrow v = 14 \text{ m/s}$$

$$\text{From } v^2 - u^2 = 2as \quad ; \quad a=g \quad ; \quad s=h$$

$$\Rightarrow (14)^2 - 0^2 = 2 \times 9.8 \times h \quad (\text{or}) \quad 2 \times 10 \times h$$

$$\Rightarrow 14 \times 14 = 19.6 h$$

$$\Rightarrow h = \frac{14 \times 14}{19.6} = 10 \text{ m} \rightarrow B$$

(4)

Given let 'h' be the height from which a body is released

$$\text{Given } h = 8 \text{ m}$$

we know $u=0$; $a=g$ for FFB

$$\text{From } v^2 - u^2 = 2as$$

$$\Rightarrow h^2 - 0^2 = 2gh$$

here $v \rightarrow$ final velocity = h

$$\Rightarrow h^2 = 2gh \Rightarrow h = 2g \rightarrow B$$

(5)

$$\text{let } h = 19.6 \text{ m}$$

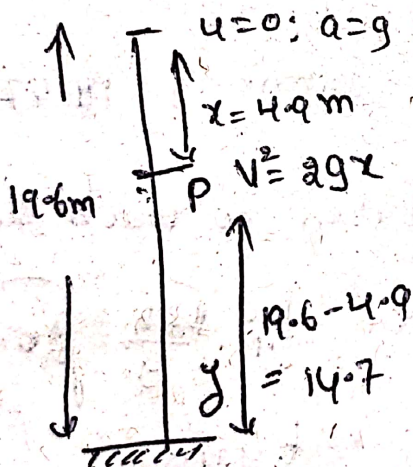
$P \rightarrow$ point from where gravity disappears

v be the velocity at P

$$\text{From } v^2 - u^2 = 2as$$

$$\Rightarrow v^2 - 0^2 = 2gx$$

$$\Rightarrow v^2 = 2gx$$



T_1 be the time taken by FFB to reach P

$$t = \sqrt{\frac{2x}{g}} = \sqrt{\frac{2 \times 4.9}{9.8}} = 1 \text{ sec.}$$

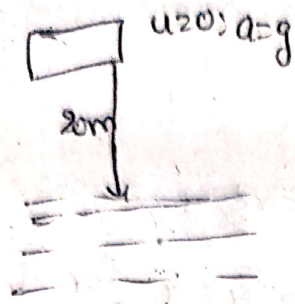
$$v = \sqrt{2gx} = \sqrt{2 \times 9.8 \times 4.9} = 9.8 \text{ m/s}$$

T_2 be the time taken by FFB to reach ground from P

$$T_2 = \frac{y}{v} = \frac{14.7}{9.8} = \frac{3}{2}$$

$$\therefore \frac{T_1}{T_2} = \frac{1}{\frac{3}{2}} = \frac{2}{3} \rightarrow B$$

⑥



$u=0, a=g$

Time taken to reach the surface of water $t = \sqrt{\frac{2h}{g}} = \sqrt{\frac{2 \times 20}{10}} = 2 \text{ sec}$

Total time of journey to reach bottom of lake = $T = 6 \text{ sec}$.

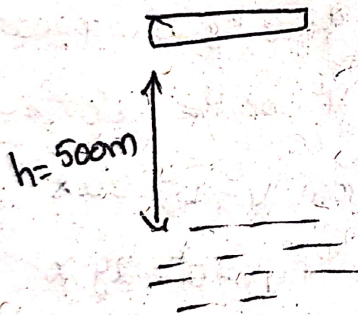
$\therefore$ The velocity with which the stone reaches surface of water $v = \sqrt{2gh}$

$v = \sqrt{2 \times 10 \times 20} = 20 \text{ m/s}$

The time to reach bottom of lake from surface = $T - t = 4 \text{ sec}$ [t' let it be]

depth = distance = $v \times t' = 20 \times 4 = 80 \text{ m}$
 $\rightarrow A$

⑦



Time of journey $T = 11.47 \text{ sec}$.

Time taken to reach surface of water

$t_1 = \sqrt{\frac{2h}{g}} = \sqrt{\frac{2 \times 500}{10}}$

$t_1 = 10 \text{ sec}$

$\therefore$ Time taken by the sound of stone slashed in the pond to reach back to the top of water

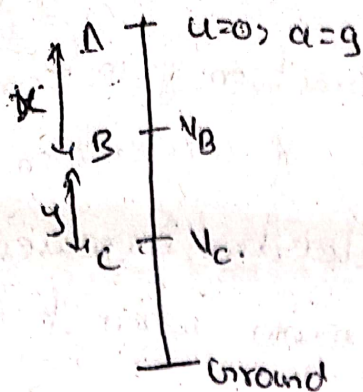
$t_2 = T - t_1 = 11.47 - 10 = 1.47 \text{ sec}$

$\Rightarrow t = \frac{\text{distance}}{\text{speed}} \Rightarrow \text{speed} = \frac{500}{1.47}$

$\Rightarrow \text{speed} = 340 \text{ m/s} \rightarrow$

$\rightarrow$

8)



For AB $s=x : t=2s$
 From $s = \frac{1}{2} g t^2$
 $x = \frac{1}{2} \times g \times 2^2$
 $= 2g \rightarrow B$

9)

If u be the initial velocity, then distance covered by it 2 sec is $s = ut + \frac{1}{2} at^2 : a=g$

$$\Rightarrow S = 2u + \frac{1}{2} g(2)^2 = 2u + 20 \rightarrow (1)$$

now distance covered in next sec i.e. 3rd sec

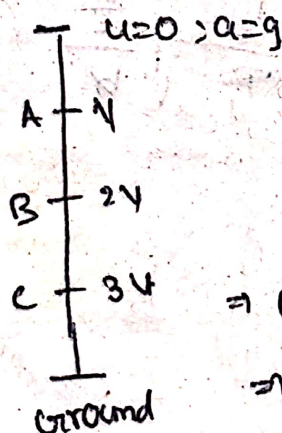
$$S' = u + \frac{g}{2} (2 \times 3 - 1) \quad \text{From } S_n = u + \frac{g}{2} (2n-1)$$

$$\Rightarrow S' = u + \frac{10}{2} (6-1) = 2u + 25 \rightarrow (2)$$

From (1) and (2) $u + 25 = 2u + 20 \Rightarrow u = 5 \text{ m/s}$

$$\therefore S = 2u + 20 = 2 \times 5 + 20 = 30 \text{ m} \rightarrow C$$

10)



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

AB	AC
$u=V; v=2V$	$u=V; v=3V$
$S=AB$	$S=AC$

$$\Rightarrow (2V)^2 - V^2 = 2g(AB)$$

$$\Rightarrow (3V)^2 - V^2 = 2g(AC)$$

$$\Rightarrow 3V^2 = 2g(AB)$$

$$\Rightarrow 8V^2 = 2g(AC)$$

$$\therefore \frac{AB(2g)}{AC(2g)} = \frac{3V^2}{8V^2} \Rightarrow \frac{AB}{AC} = \frac{3}{8} \rightarrow D$$

(11)

For a FFB the direction of motion of the body is same as that of acceleration due to gravity, so its velocity increases gradually and becomes maximum when it reaches the ground.

(13), (14), (15)

Given $h = 49\text{m}$, $u = 0$, $a = 9.8\text{m/s}^2$

Time of descent $t_d = \sqrt{\frac{2h}{g}} = \sqrt{\frac{2 \times 49}{9.8}} = \sqrt{10} \text{ s.}$

velocity ~~at~~ with which the body reaches

ground $v = \sqrt{2gh} = \sqrt{2 \times 9.8 \times 49} = \frac{98}{\sqrt{10}}$
 $\approx 31\text{m/s}$

we know $T_d = \sqrt{\frac{2h}{g}}$ $T_d \propto \sqrt{h}$

If the body reaches half of maximum height

$$T_d' \propto \sqrt{\frac{h}{2}}$$

$$\frac{T_d'}{T_d} = \sqrt{\frac{\frac{h}{2}}{h}} \Rightarrow \frac{T_d'}{\sqrt{10}} = \frac{1}{\sqrt{2}}$$

$$T_d' = \sqrt{5} \text{ s.} \rightarrow D$$

(17)

Distance covered in the last sec of fall

$S_n = 24.5\text{m}$, let n be the total time taken

$$\therefore \text{From } S_n = u + \frac{a}{2}(2n-1)$$

$$a = g = u = 0$$

$$\therefore 24.5 = 0 + \frac{g}{2}(2n-1)$$

$$\Rightarrow \frac{24.5}{5} = \frac{9.8}{2}(2n-1)$$

$$S = \frac{1}{2}gt^2 = \frac{1}{2} \times 9.8 \times 3^2 = 44.1\text{m}$$

$$\Rightarrow 5 = 2n-1 \Rightarrow 2n = 6 \Rightarrow n = 3\text{sec}$$

(18)

Here For a FFB time of descent $t_d = \sqrt{\frac{2h}{g}}$

So time of descent depends on height not

on mass

Given $h_1 = 16\text{m}$, $h_2 = 25\text{m}$

$$\therefore \frac{t_1}{t_2} = \sqrt{\frac{h_1}{h_2}} = \sqrt{\frac{16}{25}} = \frac{4}{5}$$

Task over

(1)

Time of descent $t_d = \sqrt{\frac{2h}{g}}$

$$\therefore t_d \propto \sqrt{h} \therefore \frac{t_1}{t_2} = \sqrt{\frac{h_1}{h_2}} \rightarrow A$$

②, ③, ④

for a FFB $u=0$; $a=g$.

distance covered in n^{th} sec

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

$$\Rightarrow S_n = \frac{g}{2} (2n-1) \Rightarrow S_n \propto (2n-1)$$

Distance covered in n sec

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

$$\Rightarrow S = 0 \times n + \frac{1}{2} g(n)^2$$

$$\Rightarrow S = \frac{g}{2} n^2 \Rightarrow S \propto n^2$$

Velocity after n sec From $V = u + at$

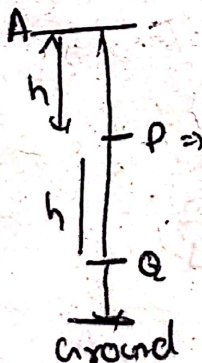
$$V = 0 + g(n)$$

$$V = gn \Rightarrow V \propto n$$

SAQ's

①

For a FFB $u=0$; $a=g$



After falling through h meter

$$\text{Velocity } V = \sqrt{2as} = \sqrt{2gh}$$

From 'A' after falling through next h meter it reaches 'Q'.

So distance $S = 2h$; $V = V_Q$

$$\text{From } V^2 - u^2 = 2as \Rightarrow V_Q^2 - 0 = 2g(2h)$$

$$\Rightarrow V_Q^2 = 2(2gh)$$

$$\Rightarrow V_Q = \sqrt{2} \sqrt{2gh} = \sqrt{2} V \rightarrow B$$

②

let 'n' be the no. of floors
and x be the height of each floor.

Total height $h = nx$.

Total time $T = 3 \text{ sec}$

$$\Rightarrow \sqrt{\frac{2h}{g}} = 3 \Rightarrow \sqrt{\frac{2nx}{g}} = 3 \rightarrow \textcircled{1}$$

Time for crossing top most floor $t = \frac{3}{4} \text{ sec}$

$$\Rightarrow \sqrt{\frac{2x}{g}} = \frac{3}{4} \rightarrow \textcircled{2}$$

From $\textcircled{1}$ $\sqrt{\frac{2nx}{g}} = 3 \Rightarrow \sqrt{\frac{2x}{g}} \times \sqrt{n} = 3$

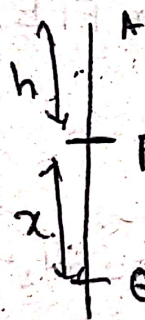
$$\Rightarrow \frac{3}{4} \times \sqrt{n} = 3$$

$$\Rightarrow \sqrt{n} = 4$$

$$\Rightarrow n = 16 \rightarrow A$$

③

For a FFB $u=0$; $a=g$



$P=V$

$Q=2V$

For AP use $u=0$; V ; $s=h$

$$V^2 - 0^2 = 2gh$$

$$V^2 = 2gh$$

$$\Rightarrow x = 3h \rightarrow A$$

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

For PQ

$$u=V$$

$$V=2V$$

$$s=x$$

$$(2V)^2 - V^2 = 2gx$$

$$\Rightarrow 3V^2 = 2gx$$

$$\Rightarrow 3(2gh) = 2gx$$



(4)

let s be the distance covered in 3 sec

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

$$s = 0 \times (3) + \frac{1}{2}(g)(3)^2$$

$$s = \frac{9}{2} \times g = 4.5g$$

let s' be the distance covered in n^{th} sec.

$$s_n = u + \frac{a}{2}(2n-1) \quad [u=0; a=g]$$

$$\Rightarrow s_n = \frac{g}{2}(2n-1) \quad [\text{Given } s = s_n]$$

$$\Rightarrow 4.5g = \frac{g}{2}(2n-1)$$

$$\Rightarrow 9 = 2n-1 \Rightarrow n = \underline{5 \text{ sec}} \rightarrow A$$

(5)

let $g_p \rightarrow$ Acceleration due to gravity

$$\text{Use } s = ut + \frac{1}{2}at^2 \quad \text{For FFB } u=0 \rightarrow (1)$$

$$s_1 = 10 \text{ m}, \quad t_1 = 1 \text{ sec}$$

$$\text{From (1): } 10 = 0 \times 1 + \frac{1}{2}g_p(1)^2$$

$$\Rightarrow 10 = \frac{g_p}{2} \Rightarrow g_p = 20 \text{ m/s}^2$$

(7)

we know For FFB $t_d = \sqrt{\frac{2h}{g}} \Rightarrow t_d \propto \sqrt{h}$

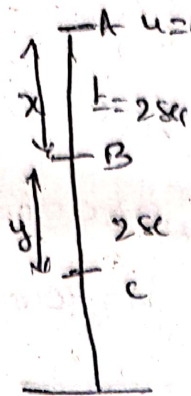
For $h_1 = h \rightarrow$ time $t_d = t_1$

For $h_2 = \frac{h}{2} \rightarrow t_d = t_2$

$$\therefore \frac{t_2}{t_1} = \sqrt{\frac{h_2}{h_1}} \Rightarrow \frac{t_2}{t_1} = \sqrt{\frac{\frac{h}{2}}{h}} = \frac{1}{\sqrt{2}}$$

$$\Rightarrow t_2 = \frac{t_1}{\sqrt{2}} \rightarrow B$$

⑥



use $s = ut + \frac{1}{2}at^2 \rightarrow 0$

A B	A C
$s = x; t = 2 \text{ sec}$	$s = x + y$ $t = 4 \text{ sec}$
$x = 0 \times (2) + \frac{1}{2}g(2)^2$	$x + y = 4 \times 0 + \frac{1}{2}g(4)^2$
$x = 2g$	$2g + y = \frac{1}{2}g \times 16$
	$2g + y = 8g$

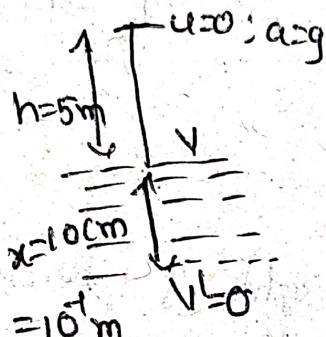
$$\Rightarrow y = 8g - 2g$$

$$= 6g$$

$$= 3(2g)$$

$$\Rightarrow y = 3x \rightarrow D$$

⑧



$v \rightarrow$ velocity with which the body reaches sand

$$\therefore \text{From } v^2 - u^2 = 2ax \rightarrow (1)$$

$$\Rightarrow v^2 - 0^2 = 2g(5)$$

$$\Rightarrow v^2 = 2 \times 9.8 \times 5 = 98 \text{ m/s}$$

$$(or) v = 7\sqrt{2} \text{ m/s}$$

Here the sand resists motion of a body so the body is in retardation

$$\text{From (1)} \quad v'^2 - v^2 = 2ax$$

$$\Rightarrow 0^2 - 98 = 2a(10^{-1})$$

$$\Rightarrow 2a = \frac{-98}{10^{-1}} \Rightarrow a = -490 \text{ m/s}^2$$

ve sign shows the body is in retardation

9

Given

height ^{above} of window $h_w = 10 \text{ cm} = 0.1 \text{ m}$

height of window $h_w = 80 \text{ cm} = 0.8 \text{ m}$

Total distance fallen $H = 90 \text{ cm} = 0.9 \text{ m}$

Time to fall 10 cm is $t_1 = \sqrt{\frac{2h}{g}} = \sqrt{\frac{2 \times 0.1}{9.8}} = \frac{1}{7} \text{ s}$

Time to fall 90 cm is $T = \sqrt{\frac{2H}{g}} = \sqrt{\frac{2 \times 0.9}{9.8}} = \frac{3}{7} \text{ s}$

∴ Time to cross window

$$t_w = T - t_1 = \frac{3}{7} - \frac{1}{7} = \frac{2}{7} \text{ sec} \rightarrow C$$

10

Let H be the height of tower

time taken to cross $H \Rightarrow T = 8 \text{ sec}$

Time taken to cover $h = \frac{1}{4}H$ is t .

we know for a FFB $T_d = \sqrt{\frac{2h}{g}} \Rightarrow T_d \propto \sqrt{h}$

$$\Rightarrow \frac{t}{T} = \sqrt{\frac{h}{H}}$$

$$\Rightarrow \frac{t}{8} = \sqrt{\frac{\frac{1}{4}H}{H}} = \frac{1}{2} \Rightarrow$$

$$\Rightarrow \frac{t}{8} = \frac{1}{2}$$

$$\Rightarrow t = \frac{8}{2} = 4 \text{ sec} \rightarrow B$$

(16)

let $h = 320$

For a FFB Time of descent $t_d = \sqrt{\frac{2h}{g}}$

$\therefore t_d = \sqrt{\frac{2 \times 320}{10}} = 8 \text{ sec.}$

(7)

let $h = 20 \text{ m}$

The velocity with which a FFB reaches

the ground $v = \sqrt{2gh} = \sqrt{2 \times 10 \times 20} = 20 \text{ m/s}$

(12) & (15)

Time of descent for a FFB $T_d = \sqrt{\frac{2h}{g}}$

$\therefore$ so T_d depends on height from which the bodies are dropped not on mass of the bodies

(11)

For a FFB $u = 0, a = g$

From $v^2 - u^2 = 2as \Rightarrow v^2 - 0^2 = 2gh$

$\Rightarrow v^2 = 2gh \Rightarrow v = \sqrt{2gh}$

$\therefore v \propto \sqrt{h}$

From $s = ut + \frac{1}{2}at^2 \Rightarrow s = 0 \times t + \frac{1}{2}gt^2$

$\Rightarrow s = \frac{1}{2}gt^2 \Rightarrow s \propto t^2$

For 1 sec, 2 sec, 3 sec —

$s_1, s_2, s_3 \rightarrow s_1, s_2, s_3 \rightarrow 1^2, 2^2, 3^2 \rightarrow 1, 4, 9$

$s_1 : s_2 : s_3 \rightarrow 1 : 4 : 9$