Motion under gravity

KINEMATICS

Q.1 A ball is thrown upwards from the ground with an initial speed of u. At two instants of time, having an interval of $6\ s$, the ball is at a height of $80\ m$ from the ground. Find u. Take $g = 10\ ms^{-2}$.

Motion under gravity

Q.2 A particle is dropped from height 100 m and another particle is projected vertically up with velocity 50 ms^{-1} from the ground along the same line. Find out the position where two particle will meet?

H.W

Motion under gravity

KINEMATICS

Q.3 A particle is dropped from a tower is found to travel 45 m in the last second of its journey. Calculate the height of the tower.

H.W

Q.5 A particle is projected vertically upwards from a point A on the ground. It takes t_1 second to reach a point B at a height h from A but still continues to move up. If it takes further t_2 second from B to ground again, then show that

(a) $h = \frac{1}{2} g t_1 t_2$

$t_{ACD} = t_1 + (t_2 - t_1)\, t_{BCD}$

$= t_2$

(b) maximum height reached is $\frac{g(t_1+t_2)^2}{8}$ and

$t_{BC} = t_{CD} = \left(\frac{t_2 - t_1}{2}\right)$

(c) the velocity of the particle at a height $\frac{h}{2}$ is $\frac{g}{2}\left(t_1^2 + t_2^2\right)^{1/2}$.

$\frac{u^2}{2g} = h_{max}$

$t_{AC} = t_1 + \frac{t_2 - t_1}{2}$

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

$\frac{u}{g} = \frac{t_1 + t_2}{2} \Rightarrow u = \left(\frac{t_1 + t_2}{2}\right) g$

$h = \frac{g}{2}(t_1 t_2)$

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

$t^2 - \frac{2u}{g} t + \frac{2h}{g}$

$t_1 t_2 = \frac{2h}{g}$

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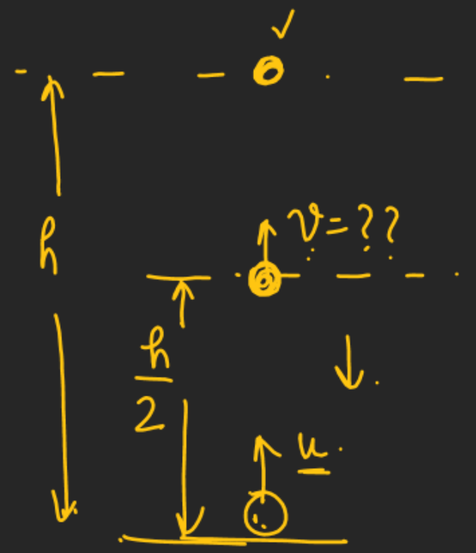
Motion under gravity

(C)



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

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

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

$$h = \frac{1}{2}g t_1 t_2 \Rightarrow \frac{h}{2} = \left(\frac{1}{4}g t_1 t_2\right)$$

$$v^2 = u^2 - 2g\left(\frac{h}{2}\right)$$

$$v^2 = \frac{g^2}{4}(t_1+t_2)^2 - g \times \frac{1}{2} g t_1 t_2$$

$$v^2 = \frac{g^2}{4}(t_1+t_2)^2 - \frac{g^2}{2} t_1 t_2$$

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

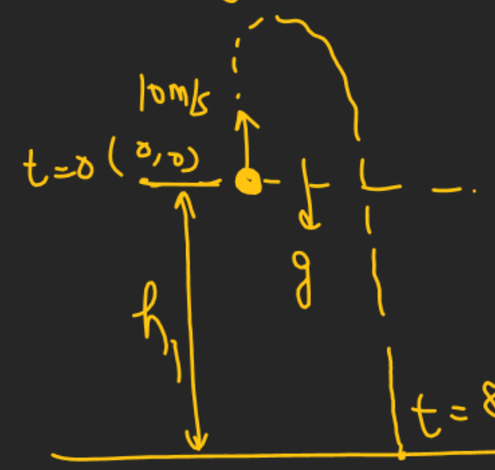
$$v^2 = \frac{g^2}{4}\left[t_1^2 + t_2^2 + 2t_1t_2 - 2t_1t_2\right]$$

$$v^2 = \frac{g^2}{4}(t_1^2+t_2^2) \Rightarrow v = \frac{g}{2}(t_1^2+t_2^2)^{1/2}$$

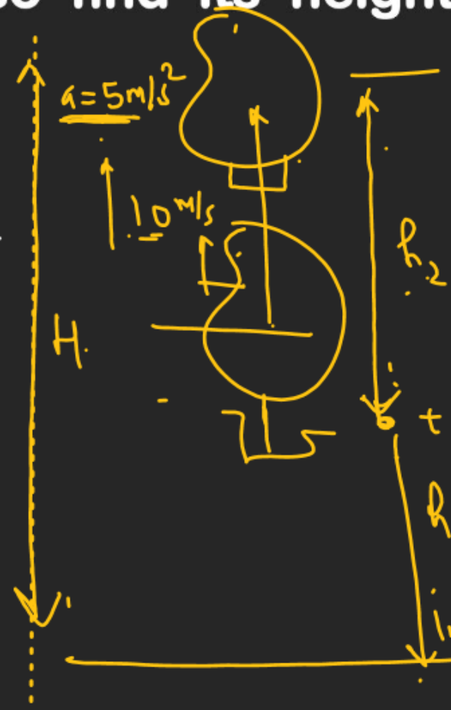
Q.6 A balloon is moving vertically upward with constant acceleration (g/2) in upward direction. When velocity of balloon is 10 m/sec vertically upward, a particle is dropped from balloon and motion of balloon remains unaffected. If particle strikes the ground after 8 sec., then find the height of balloon from the ground, when particle was dropped and also find its height when particle strikes the ground. ($g = 10\ m/sec^2$).

$a = 5\ m/s^2$

M-1 (w.r.t ground)



$$-h_1 = 10\times(8) - \frac{1}{2}\times10\times(8)^2$$
$$-h_1 = 80 - (5\times64)$$
$$h_1 = (5\times64) - 80$$
$$= 320 - 80$$
$$h_1 = 240\ m$$



$H = h_1 + h_2 = 480m$

$h_1 + h_2 = h$

$h_2 = 10\times(8) + \frac{1}{2}\times5\times(8)^2$

$h_2 = 80 + (32\times5)$

$= 80 + 160$

$= 240$

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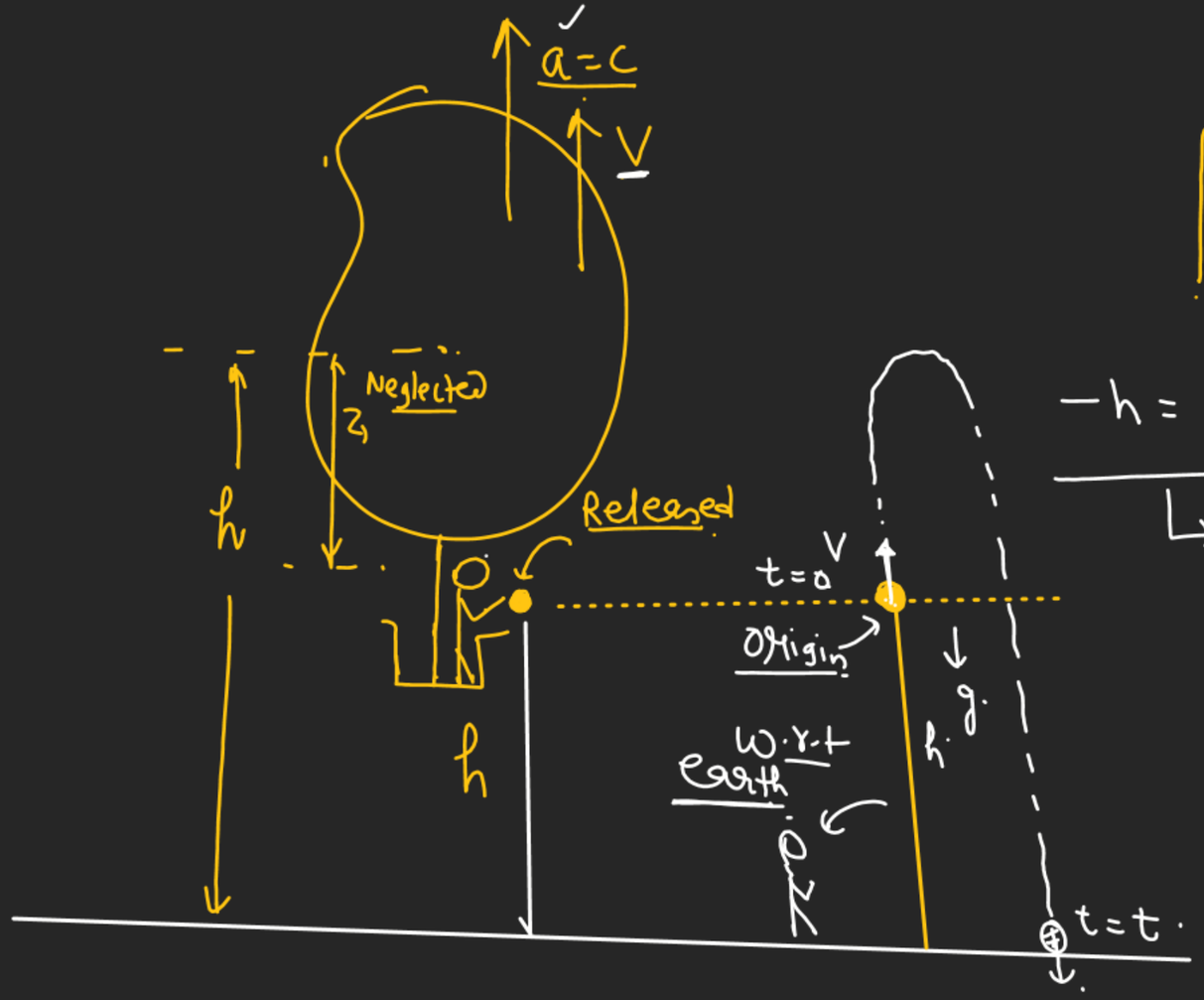
Motion under gravity

KINEMATICS

(☆) When particle is released from a moving frame :→



↳ Concept

- When a particle is released from a moving frame it will gain the same velocity of the moving frame at the time of released due to inertia

Another Method

$$-h = vt - \frac{1}{2}gt^2$$

↳ (+ve root is our answer.)

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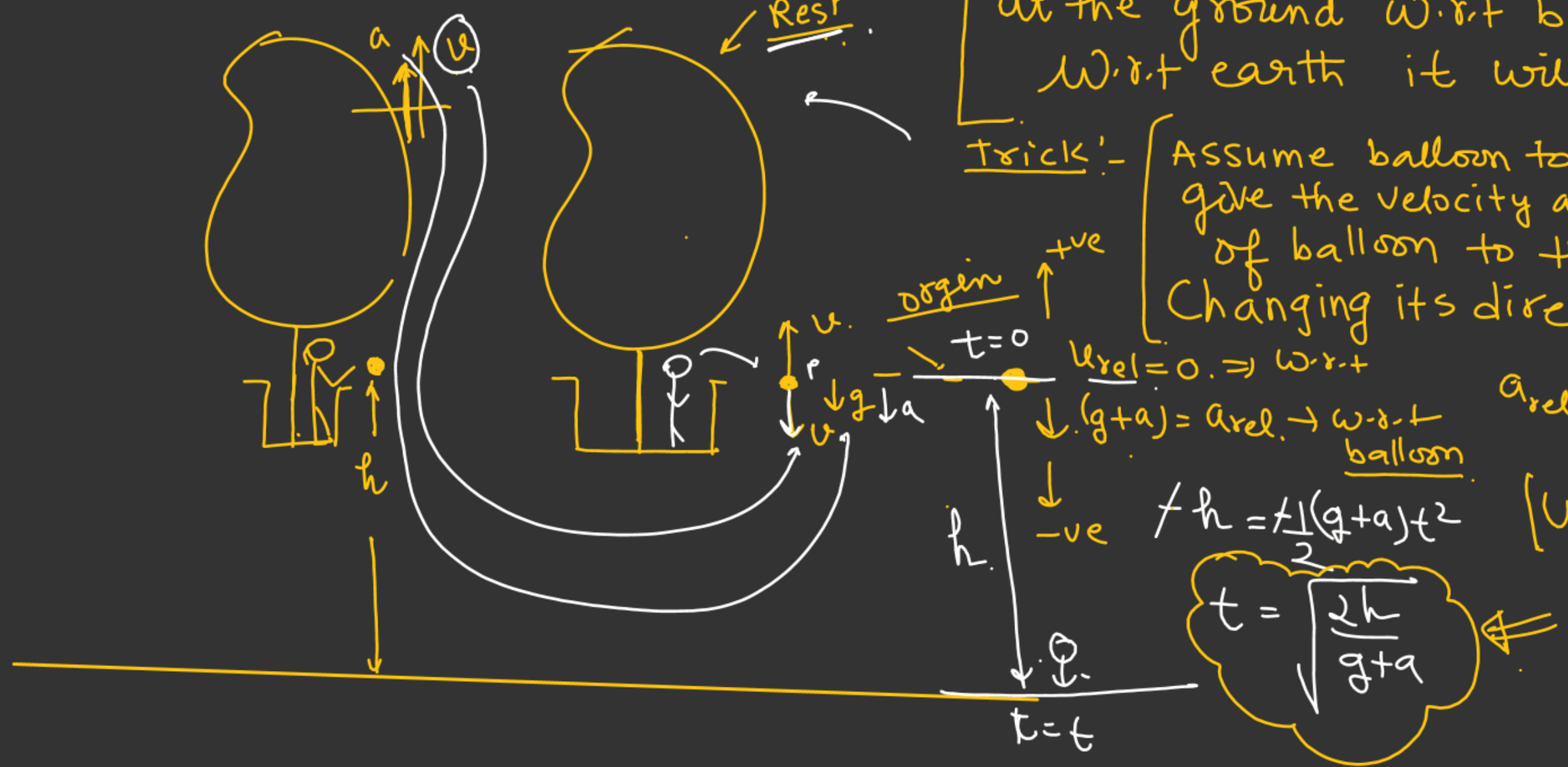
Another Method :→

W.r.t balloon :→

⇒ Concept :→ "Time is frame independent"

[i.e either we Calculate time to reach at the ground W.r.t balloon frame or W.r.t earth it will Same.]

Trick :- [Assume balloon to be at rest. give the velocity and acceleration of balloon to the particle by Changing its direction.]



$$\therefore h = \frac{1}{2}(g+a)t^2$$

$$t = \sqrt{\frac{2h}{g+a}}$$

a_{rel} → relative acceleration of Stone W.r.t balloon

[u_{rel} → initial velocity relative to balloon]

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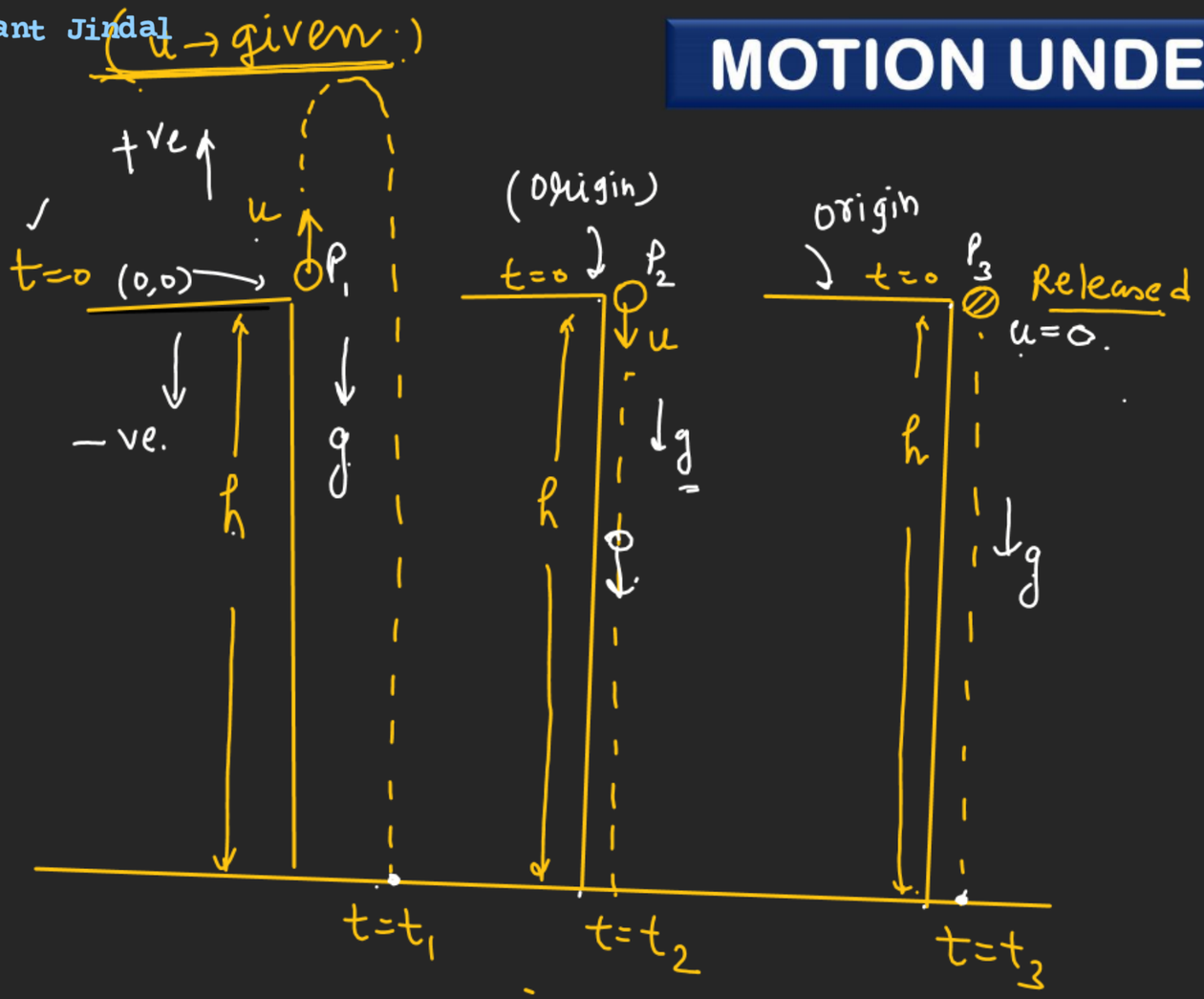
MOTION UNDER GRAVITY



P_1

$-h = ut_1 - \frac{1}{2}gt_1^2$

P_2

$[h = -ut_1 + \frac{1}{2}gt_1^2]$ — ①

$-h = -ut_2 - \frac{1}{2}gt_2^2$

$[h = ut_2 + \frac{1}{2}gt_2^2]$ — ②

t_2 ① + t_1 ②

$ht_2 = -ut_1t_2 + \frac{1}{2}gt_1^2t_2$

+

$ht_1 = ut_1t_2 + \frac{1}{2}gt_2^2t_1$

⇓

$h(t_1+t_2) = \frac{1}{2}gt_2^2t_1 + \frac{1}{2}gt_1^2t_2$

$h(t_1+t_2) = \frac{1}{2}gt_1t_2(t_1+t_2)$

P_3

$+h = +\frac{1}{2}gt_3^2$

$h = \frac{1}{2}gt_3^2$ — ③

$t_3^2 = \left(\frac{2h}{g}\right)$ ⇕ $\frac{2h}{g} = t_1t_2$

$t_3^2 = t_1t_2$

$t_3 = \sqrt{t_1t_2}$

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MOTION UNDER GRAVITY

H.W

A person sitting on the top of a tall building is dropping balls at regular intervals of one second. Find the positions of the 3^{rd}, 4^{th} and 5^{th} ball when the 6th ball is being dropped. Take $g = 10\ m/s^2$

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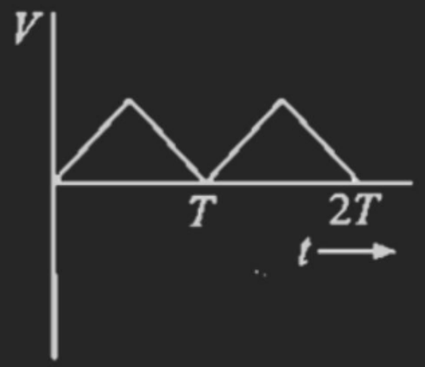
MOTION UNDER GRAVITY

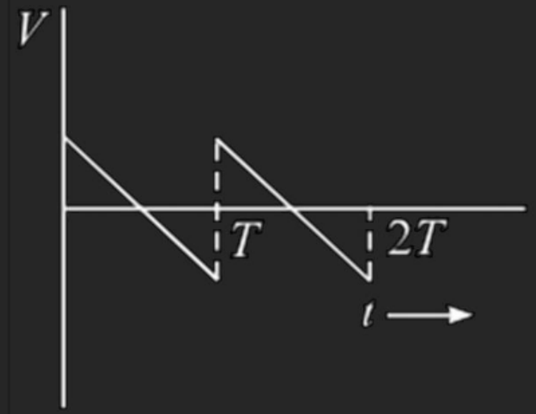
H-W

Q. A ball dropped from a height reaches the same height after elastic impact with a glass floor. If the event is continued, the velocity-time graph is shown by the adjoining figure:

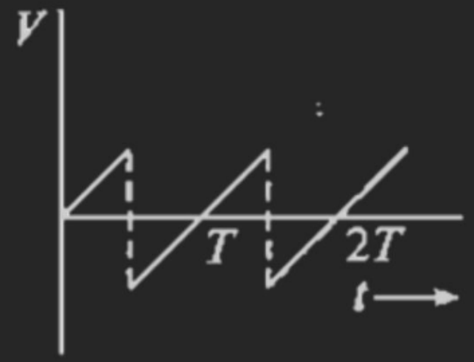
(A)



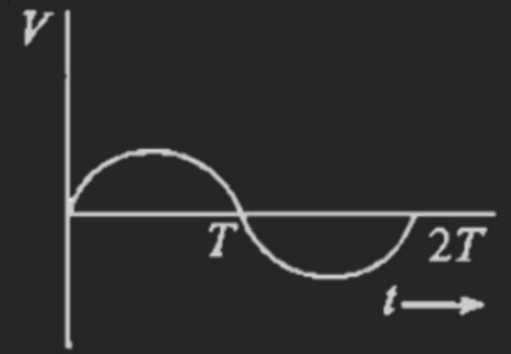
(B)



(C)



(D)



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MOTION UNDER GRAVITY

H.W

Q. Two balls are thrown simultaneously, A vertically upwards with a speed of $20\ \mathrm{m/s}$ from the ground, and B vertically downwards from height of $40\ \mathrm{m}$ with the same speed along the same line of motion. At what point do the two balls collide? Take $\mathrm{g} = 9.8\ \mathrm{m/s^2}$

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MOTION UNDER GRAVITY

H.W

Q. A balloon starts ascending at a constant acceleration of $2\ \mathrm{m/s^2}$. When it was at a height of $100\ \mathrm{m}$ from the ground, the food packet is dropped from the balloon. After how much time and with what velocity does it reach the ground?

Take $\mathrm{g} = 10\ \mathrm{m/s^2}$.

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MOTION UNDER GRAVITY

H-W

Q. A parachutist bails out from an aeroplane and after dropping through a distance of $40\ \mathrm{m}$, he opens the parachute and decelerates at $2\ \mathrm{m/s^2}$. If he reaches the ground with a speed of $2\ \mathrm{m/s}$, how long is he in the air ? A t what height did he bail out from the plane?