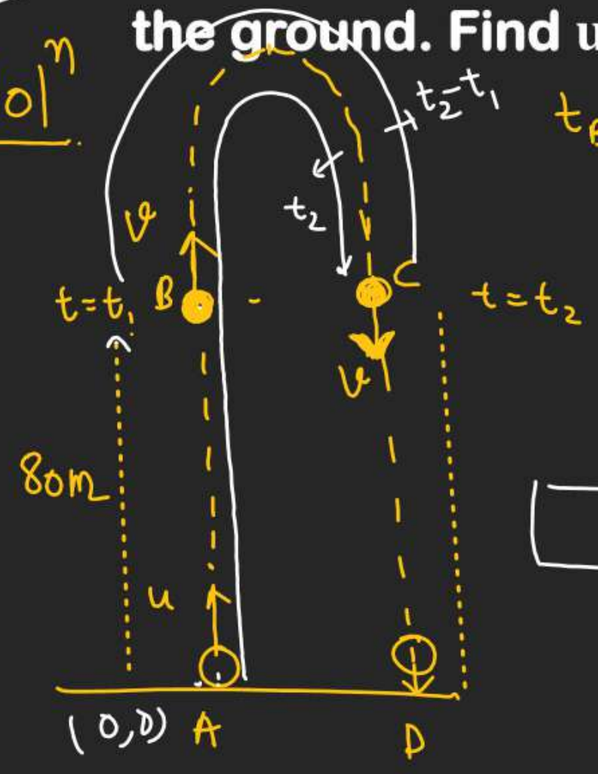
Q.1 A ball is thrown upwards from the ground with an initial speed of u. At two instants of time, having an interval of $6\ s$, the ball is at a height of $80\ m$ from the ground. Find u. Take $g = 10\ ms^{-2}$.

Method (1)

Soln



$t_{BC} = 6\ Sec$

$t_2 - t_1 = 6\ Sec$ ✓

$(t_2 - t_1) = \sqrt{(t_1 + t_2)^2 - 4t_1t_2}$

$36 = \frac{u^2}{25} - 4 \times 16$

$36 + 64 = \frac{u^2}{25}$

$\sqrt{100 \times 25} = u$

$u = 50\ m/s$

$80 = ut - \frac{1}{2} \times 10 \times t^2$

$80 = ut - 5t^2$

$5t^2 - ut + 80 = 0$

$t_1 + t_2 = \left(\frac{u}{5}\right)$

$t_1 t_2 = \frac{80}{5} = 16$

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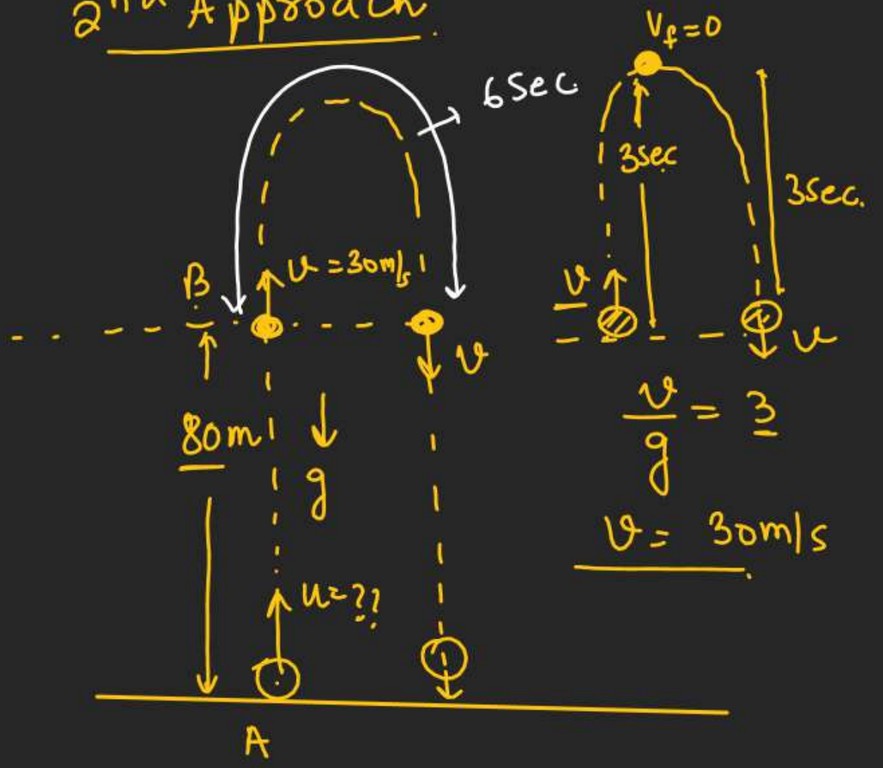
Motion under gravity

KINEMATICS

2nd Approach



$$\frac{v}{g} = 3$$

$v = 30 m/s$

For A-B Motion

3rd Equation.

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

$$\Downarrow$$

$$(30)^2 = u^2 - 2 \times 10 \times 80.$$

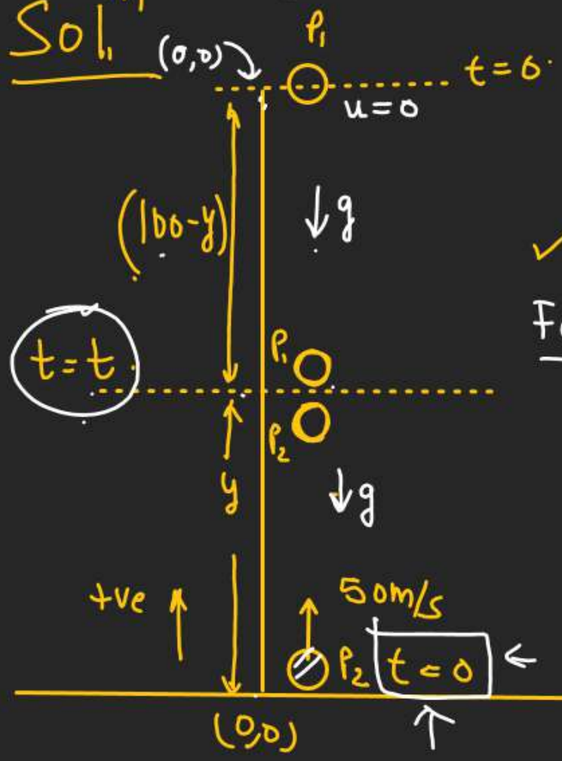
$$u^2 = 900 + 1600$$

$$u^2 = 2500.$$

$$\boxed{u = 50 m/s}$$ Ans ✓

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?

Soln



For particle P_1

$+(100-y) = +\frac{1}{2} \times 10 \times t^2$

$100 - y = 5t^2 - (1)$

For particle-2

$y = 50t - \frac{1}{2} \times 10 \times t^2$

$y = 50t - 5t^2 - (2)$

(1) + (2)

$100 = 50t$

$t = 2sec$

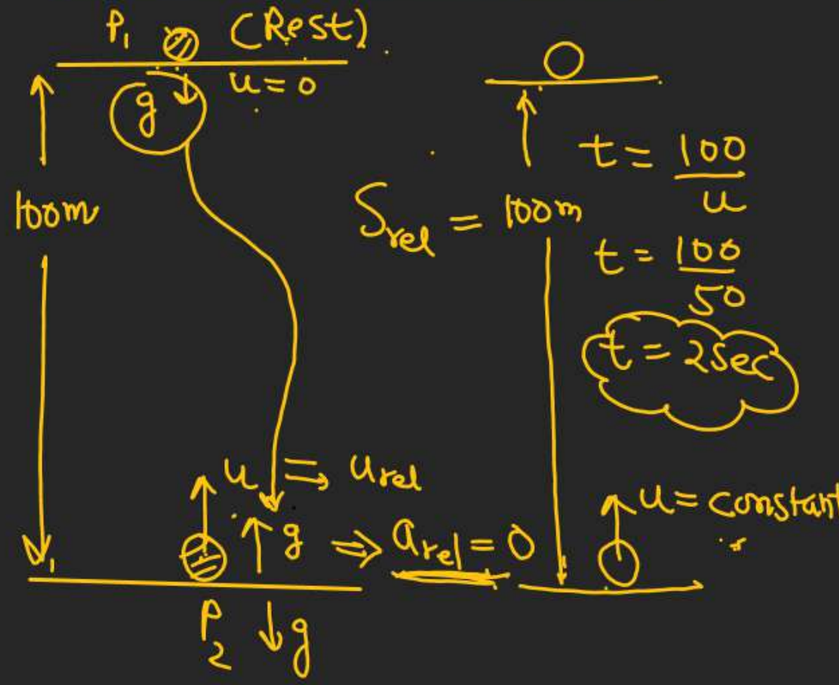
Put $t = 2sec$ in (1)

$100 - y = 5(2)^2$

$y = 80m$

Method-2

↳ Time is frame independent



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⇒ Distance travelled by the particle in n^{th} second :→

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

upward journey

$t = n$ sec

$t = (n-1)$

$S_n - S_{n-1} = u - \frac{g}{2}(2n-1)$

$= u - 5(2n-1)$

$a \to (-g)$ ✓

Downward journey.

$u = 0$ (Released)

$\downarrow g$

$a = +g$

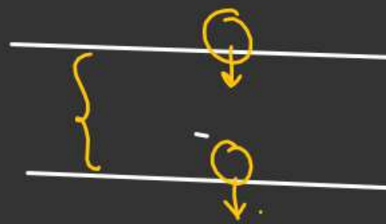
$S_n - S_{n-1} = \frac{g}{2}(2n-1)$

$= 5(2n-1)$ ✓

If $u \neq 0$

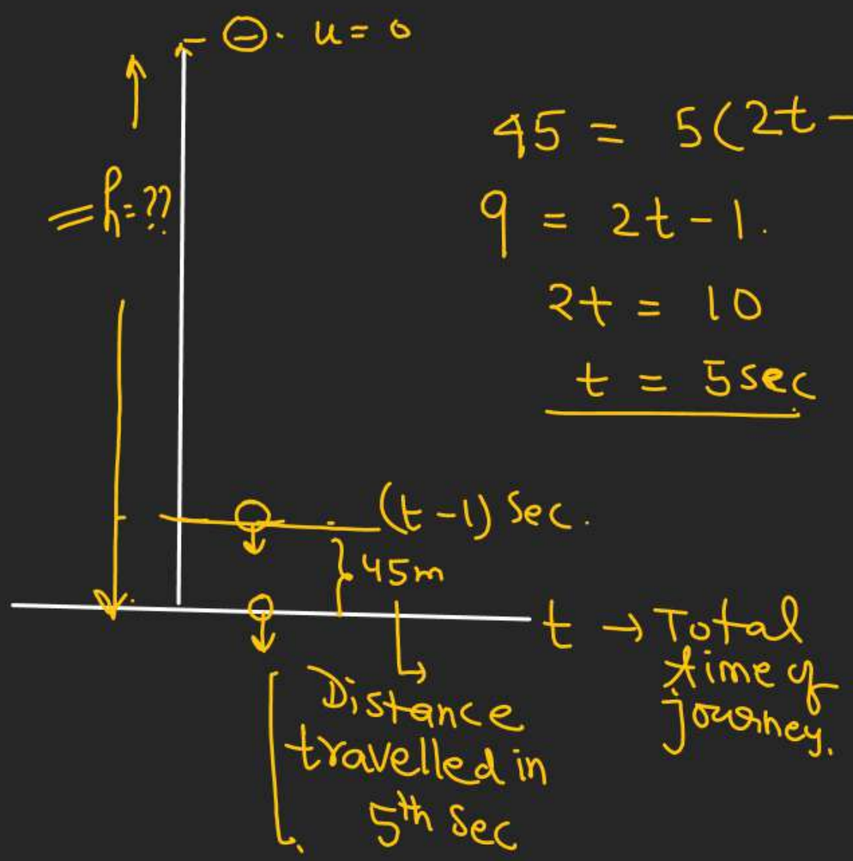
$S_n - S_{n-1} =$

$u + \frac{g}{2}(2n-1)$



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.

Sol^{n}.



$45 = 5(2t-1)$

$9 = 2t - 1$

$2t = 10$

$t = 5\,sec$

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

$h = \frac{1}{2} \times 10 \times (5)^2$

$h = 5 \times (5)^2$

$\boxed{h = 125\,m}$

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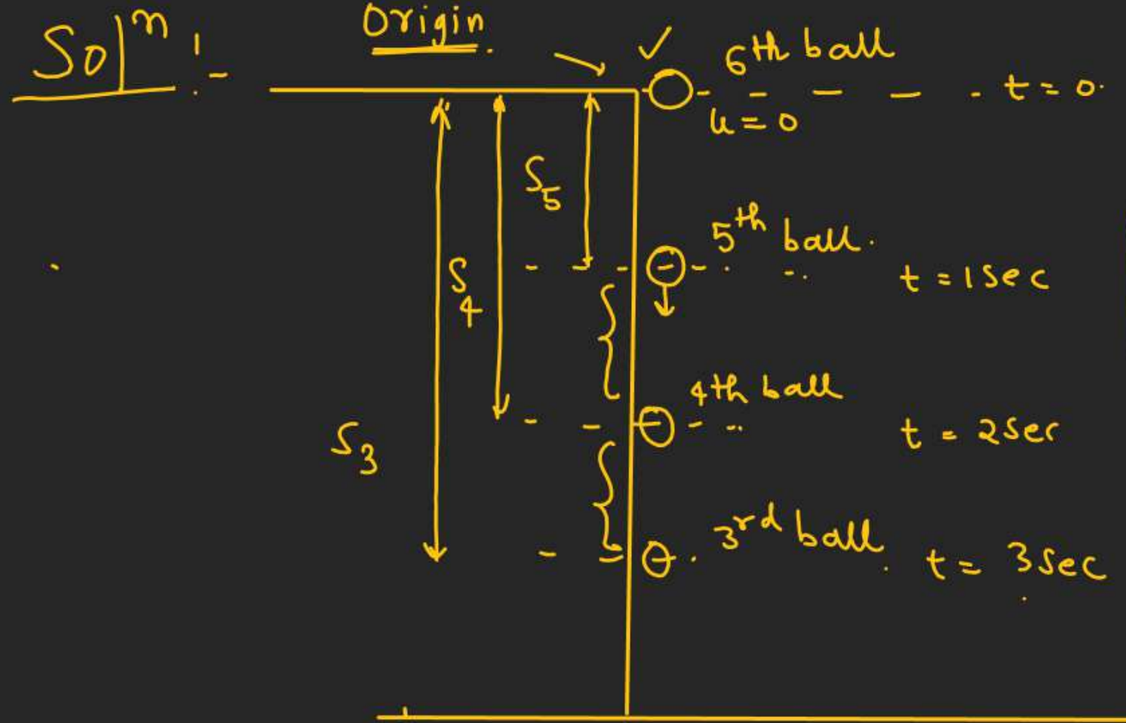
MOTION UNDER GRAVITY

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 3rd, 4th and 5th ball when the 6th ball is being dropped. Take $g = 10\ m/s^2$



Sol^n :-

$S_3 = \frac{1}{2} \times 10 \times (3)^2 = 45m$ ✓

$S_4 = \frac{1}{2} \times 10 \times (2)^2 = 20m$ ✓

$S_5 = \frac{1}{2} \times 10 \times (1)^2 = 5$ ✓

Ans

Distance b/w 6th & 5th ball = 5

Distance b/w 5th & 4th ball = $S_4 - S_5$

Distance b/w 3rd & 4th ball = $S_3 - S_4 = 25$

$= (15)$

5 : 15 : 25

1 : 3 : 5 : 7 ←

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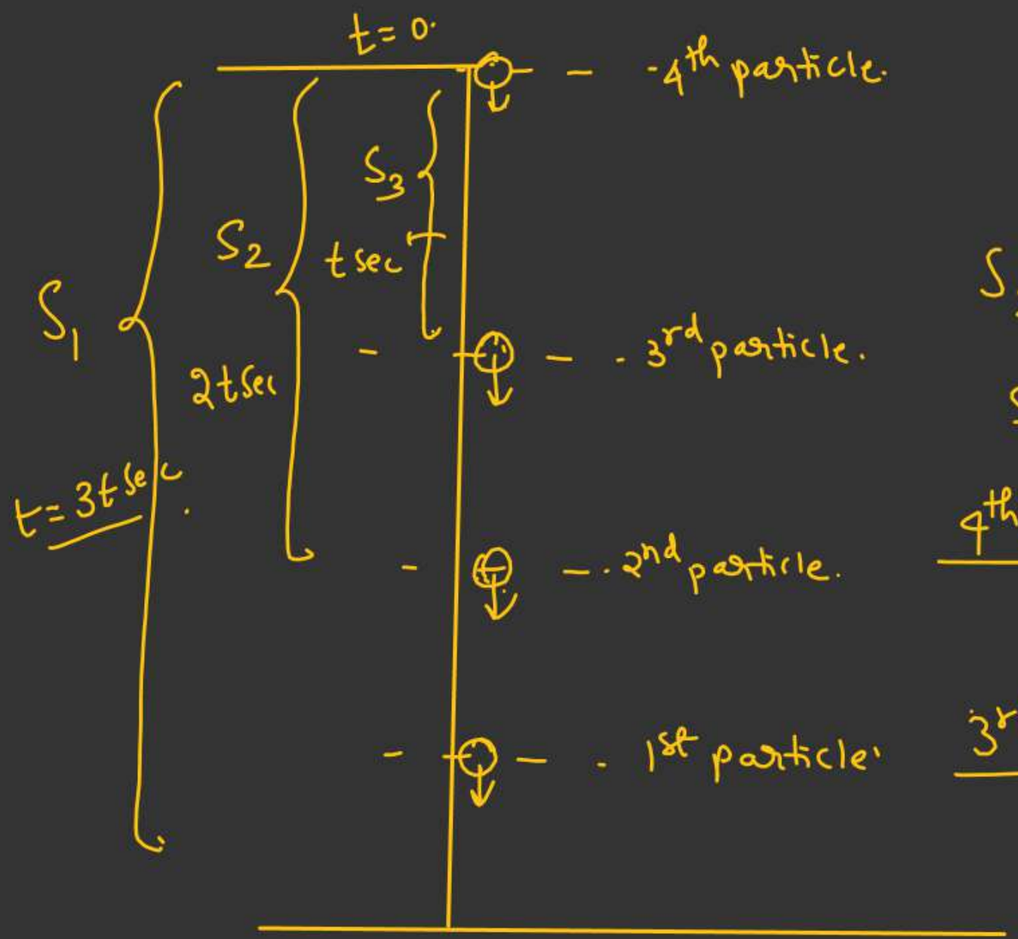
Particles are dropped in a regular interval of 't' sec.



$S_1 = \frac{1}{2} g (3t)^2$.

$S_1 = \frac{9}{2} g t^2$.

$S_2 = \frac{1}{2} g (2t)^2 = \frac{4}{2} g t^2$

$S_3 = \frac{1}{2} g t^2$.

4th & 3rd :- (Relative seperation)

$S_{3-4} = S_3 = \frac{1}{2} g t^2$.

3rd & 2nd

$S_{3-2} = S_2 - S_3$

$= \frac{1}{2} g t^2 (4 - 1)$

$= (\frac{1}{2} g t^2)(3)$

2nd & 1st

$= S_1 - S_2$

$= \frac{1}{2} g t^2 (9 - 4)$.

$= (\frac{1}{2} g t^2)(5)$.

$S_{4-3} : S_{3-2} : S_{2-1}$

$:: 1 : 3 : 5$

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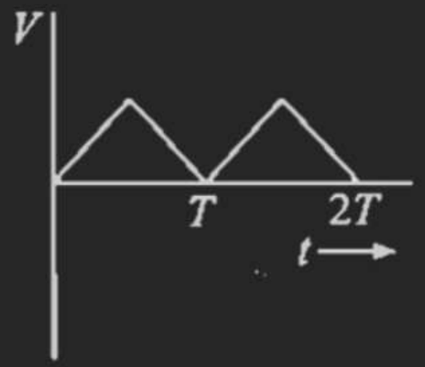
MOTION UNDER GRAVITY

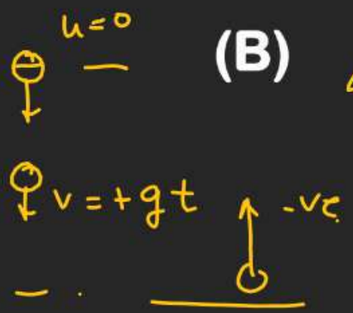
H-W

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:

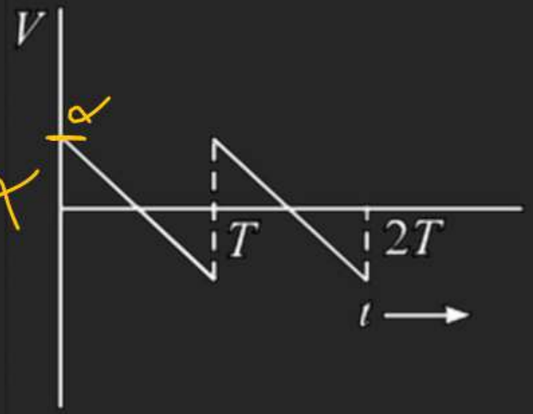
↓ → (+ve)

(A)

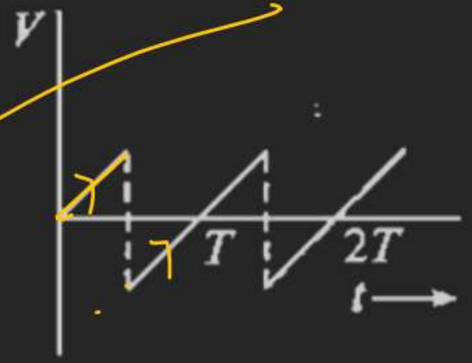




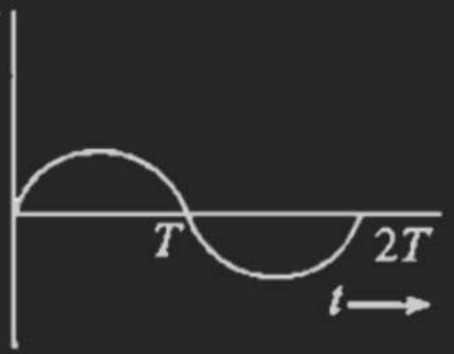
(B)



(C)



(D)



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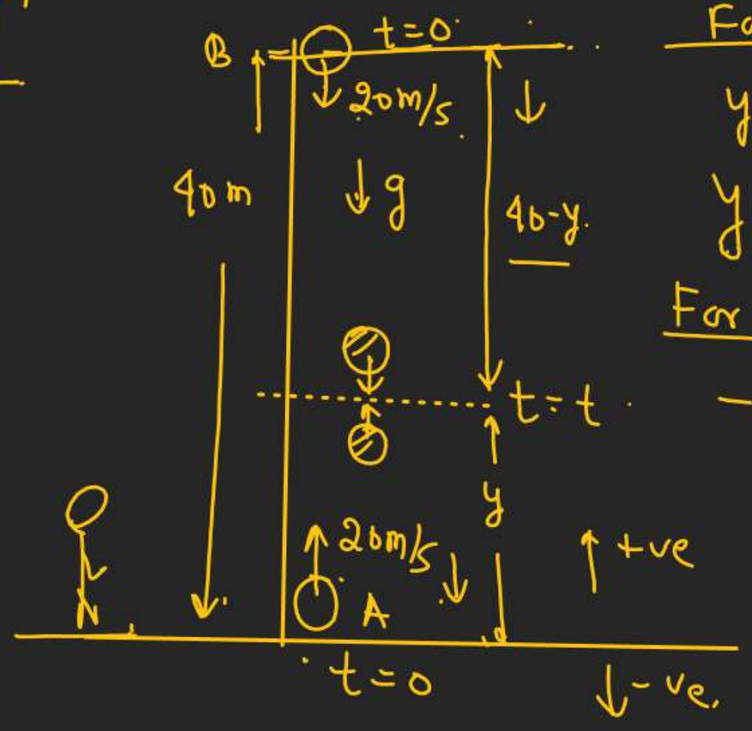
MOTION UNDER GRAVITY

H.W

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

Sol^{n}



For A

$$y = 20t - \frac{1}{2}\times 10\times t^2$$

$$y = (20t - 5t^2) \quad -(1)$$

For B

$$-(40-y) = -20t - \frac{1}{2}\times 10t^2$$

$$(40-y) = 20t + 5t^2 \quad -(2)$$

(1) + (2)

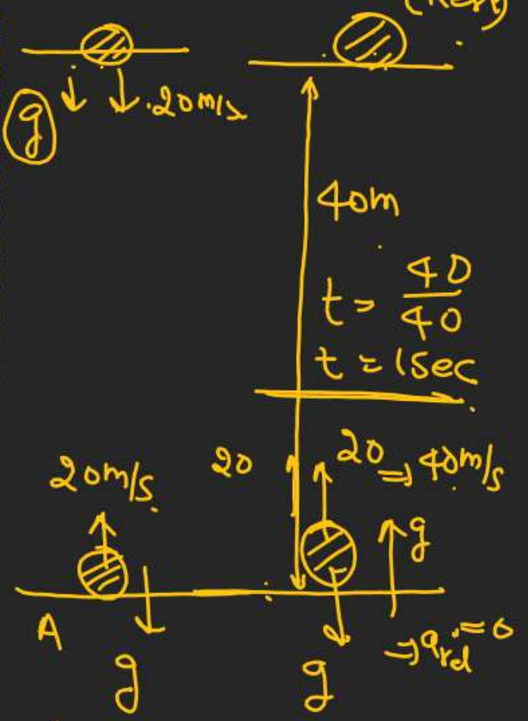
$$40 = 40t$$

$$t = 1\ \text{Sec}$$

$$y = 20\times(1) - 5\times(1)^2$$

$$y = 15\ \text{m}$$

2nd Method



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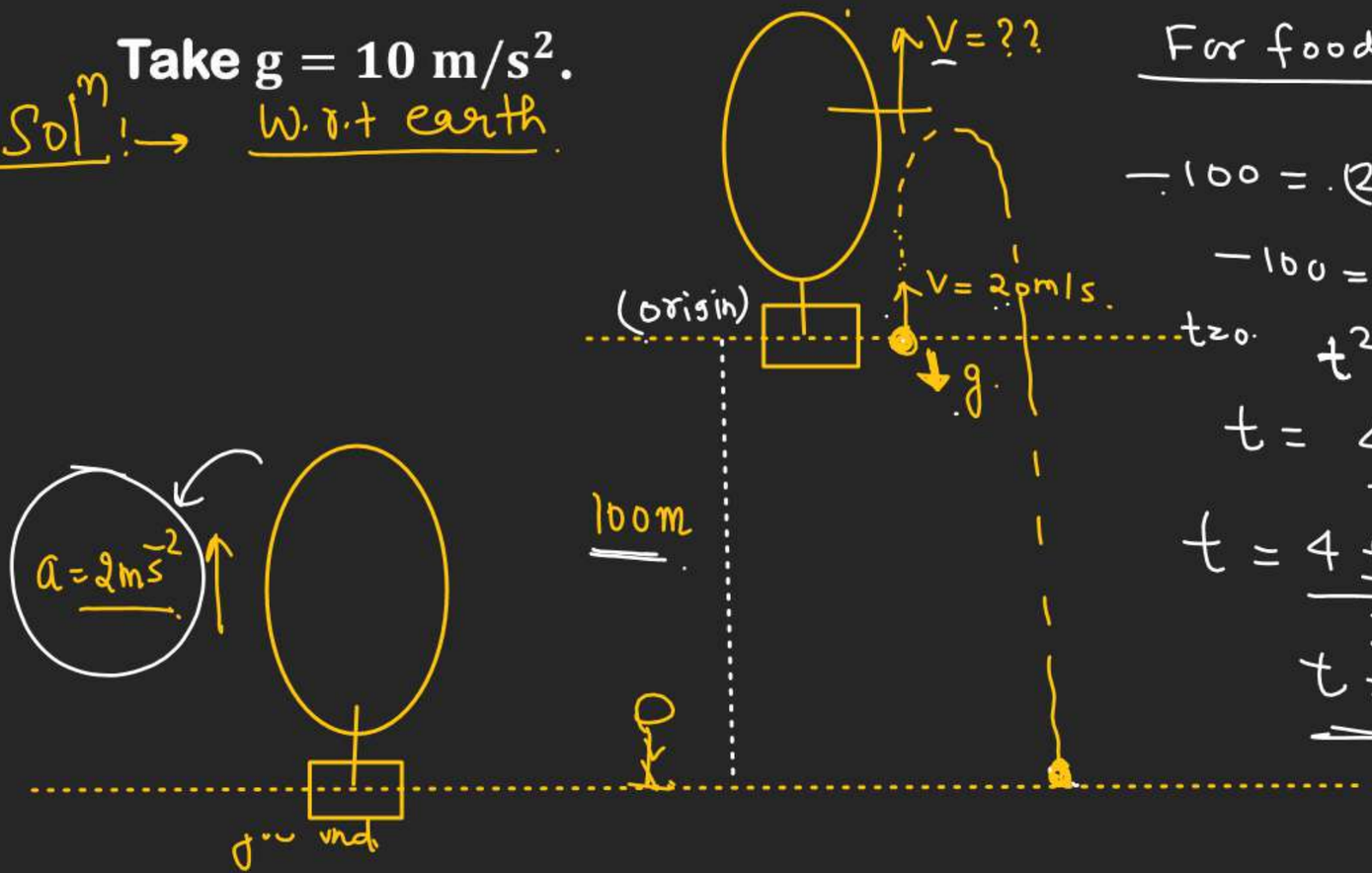
MOTION UNDER GRAVITY

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

Soln :→ W.r.t earth



u = 0

2 | 96
16 | 48

For food packet

$-100 = (20)t - \frac{1}{2} \times 10t^2$

$-100 = 20t - 5t^2$

$t^2 - 4t - 20 = 0$

$t = \frac{4 \pm \sqrt{16+80}}{2}$

$t = \frac{4 \pm \sqrt{96}}{2}$, $t = \frac{4 \pm 4\sqrt{6}}{2}$

$t = 2(1+\sqrt{6})$, $2(1-\sqrt{6})$ (−ve Root)

For balloon

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

$v^2 = 2 \times 2 \times 100$

$v = \sqrt{400} = 20\ \mathrm{m/s}$

$t = 2(1+\sqrt{6})\ \mathrm{sec}$