

KINEMATICS

1. Position of an ant (S in metres) moving in Y-Z plane is given by $S = 2t^2\hat{j} + 5\hat{k}$ (where t is in second). The magnitude and direction of velocity of the ant at $t = 1$ s will be :
 - (1) 16 m/s in y-direction
 - (2) 4 m/s in x-direction
 - (3) 9 m/s in z-direction
 - (4) 4 m/s in y-direction
2. A particle starts from origin at $t = 0$ with a velocity $5\hat{i}$ m/s and moves in x-y plane under action of a force which produces a constant acceleration of $(3\hat{i} + 2\hat{j})\text{m/s}^2$. If the x-coordinate of the particle at that instant is 84 m, then the speed of the particle at this time is $\sqrt{\alpha}$ m/s. The value of α is _____.
3. A bullet is fired into a fixed target loses one third of its velocity after travelling 4 cm. It penetrates further $D \times 10^{-3}$ m before coming to rest. The value of D is :
 - (1) 2
 - (2) 5
 - (3) 3
 - (4) 4
4. A body falling under gravity covers two points A and B separated by 80 m in 2s. The distance of upper point A from the starting point is _____ m (use $g = 10 \text{ ms}^{-2}$).
5. A body starts moving from rest with constant acceleration covers displacement S_1 in first $(p - 1)$ seconds and S_2 in first p seconds. The displacement $S_1 + S_2$ will be made in time :
 - (1) $(2p + 1)\text{s}$
 - (2) $\sqrt{(2p^2 - 2p + 1)}\text{s}$
 - (3) $(2p - 1)\text{s}$
 - (4) $(2p^2 - 2p + 1)\text{s}$
6. A ball rolls off the top of a stairway with horizontal velocity u. The steps are 0.1 m high and 0.1 m wide. The minimum velocity u with which that ball just hits the step 5 of the stairway will be $\sqrt{x} \text{ ms}^{-1}$ where $x =$ _____ [use $g = 10 \text{ m/s}^2$].
7. A particle is moving in a straight line. The variation of position 'x' as a function of time 't' is given as $x = (t^3 - 6t^2 + 20t + 15)$ m. The velocity of the body when its acceleration becomes zero is :
 - (1) 4 m/s
 - (2) 8 m/s
 - (3) 10 m/s
 - (4) 6 m/s
8. The displacement and the increase in the velocity of a moving particle in the time interval of t to $(t + 1)$ s are 125 m and 50 m/s, respectively. The distance travelled by the particle in $(t + 2)^{\text{th}}$ s is _____ m.
9. Projectiles A and B are thrown at angles of 45° and 60° with vertical respectively from top of a 400 m high tower. If their ranges and times of flight are same, the ratio of their speeds of projection $v_A : v_B$ is:
 - (1) $1 : \sqrt{3}$
 - (2) $\sqrt{2} : 1$
 - (3) $1 : 2$
 - (4) $1 : \sqrt{2}$
10. The relation between time 't' and distance 'x' is $t = \alpha x^2 + \beta x$, where α and β are constants. The relation between acceleration (a) and velocity (v) is:
 - (1) $a = -2\alpha v^3$
 - (2) $a = -5\alpha v^5$
 - (3) $a = -3\alpha v^2$
 - (4) $a = -4\alpha v^4$

KINEMATICS

11. A particle moving in a circle of radius R with uniform speed takes time T to complete one revolution. If this particle is projected with the same speed at an angle θ to the horizontal, the maximum height attained by it is equal to $4R$. The angle of projection θ is then given by :

(1) $\sin^{-1} \left[\frac{2gT^2}{\pi^2 R} \right]^{\frac{1}{2}}$ (2) $\sin^{-1} \left[\frac{\pi^2 R}{2gT^2} \right]^{\frac{1}{2}}$

(3) $\cos^{-1} \left[\frac{2gT^2}{\pi^2 R} \right]^{\frac{1}{2}}$ (4) $\cos^{-1} \left[\frac{\pi R}{2gT^2} \right]^{\frac{1}{2}}$

12. A particle is moving in one dimension (along x axis) under the action of a variable force. Its initial position was 16 m right of origin. The variation of its position (x) with time (t) is given as $x = -3t^3 + 18t^2 + 16t$, where x is in m and t is in s. The velocity of the particle when its acceleration becomes zero is _____ m/s.

13. Train A is moving along two parallel rail tracks towards north with speed 72 km/h and train B is moving towards south with speed 108 km/h. Velocity of train B with respect to A and velocity of ground with respect to B are (in m/s) :

- (1) -30 and 50 (2) -50 and -30
 (3) -50 and 30 (4) 50 and -30

14. A particle initially at rest starts moving from reference point. $x = 0$ along x -axis, with velocity v that varies as $v = 4\sqrt{x}m/s$. The acceleration of the particle is _____ m/s^2 .

15. A body travels 102.5 m in n^{th} second and 115.0 m in $(n + 2)^{\text{th}}$ second. The acceleration is :

- (1) $9 m/s^2$ (2) $6.25 m/s^2$
 (3) $12.5 m/s^2$ (4) $5 m/s^2$

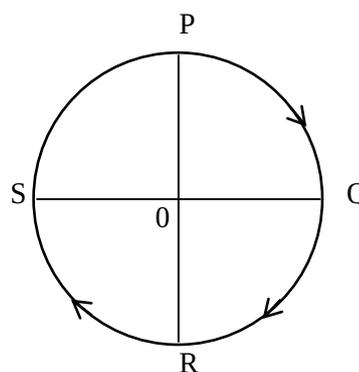
16. The co-ordinates of a particle moving in x - y plane are given by :

$$x = 2 + 4t, y = 3t + 8t^2.$$

The motion of the particle is :

- (1) non-uniformly accelerated.
 (2) uniformly accelerated having motion along a straight line.
 (3) uniform motion along a straight line.
 (4) uniformly accelerated having motion along a parabolic path.

17. A cyclist starts from the point P of a circular ground of radius 2 km and travels along its circumference to the point S. The displacement of a cyclist is :



- (1) 6 km (2) $\sqrt{8}$ km
 (3) 4 km (4) 8 km

18. A bus moving along a straight highway with speed of 72 km/h is brought to halt within 4s after applying the brakes. The distance travelled by the bus during this time (Assume the retardation is uniform) is _____ m.

19. A body moves on a frictionless plane starting from rest. If S_n is distance moved between $t = n - 1$ and $t = n$ and S_{n-1} is distance moved between $t = n - 2$ and $t = n - 1$, then the ratio $\frac{S_{n+1}}{S_n}$

is $\left(1 - \frac{2}{x} \right)$ for $n = 10$. The value of x is

20. The maximum height reached by a projectile is 64 m. If the initial velocity is halved, the new maximum height of the projectile is _____ m.
21. A train starting from rest first accelerates uniformly up to a speed of 80 km/h for time t , then it moves with a constant speed for time $3t$. The average speed of the train for this duration of journey will be (in km/h) :
- (1) 80 (2) 70
 (3) 30 (4) 40
22. A particle moves in a straight line so that its displacement x at any time t is given by $x^2 = 1 + t^2$. Its acceleration at any time t is x^{-n} where $n =$ _____.
23. The angle of projection for a projectile to have same horizontal range and maximum height is :
- (1) $\tan^{-1}(2)$ (2) $\tan^{-1}(4)$
 (3) $\tan^{-1}\left(\frac{1}{4}\right)$ (4) $\tan^{-1}\left(\frac{1}{2}\right)$
24. A body of mass M thrown horizontally with velocity v from the top of the tower of height H touches the ground at a distance of 100m from the foot of the tower. A body of mass $2M$ thrown at a velocity $\frac{v}{2}$ from the top of the tower of height $4H$ will touch the ground at a distance ofm.
25. A particle moving in a straight line covers half the distance with speed 6 m/s. The other half is covered in two equal time intervals with speeds 9 m/s and 15 m/s respectively. The average speed of the particle during the motion is :
- (1) 8.8 m/s (2) 10 m/s
 (3) 9.2 m/s (4) 8 m/s
26. A particle of mass m moves on a straight line with its velocity increasing with distance according to the equation $v = \alpha\sqrt{x}$, where α is a constant. The total work done by all the forces applied on the particle during its displacement from $x = 0$ to $x = d$, will be:
- (1) $\frac{m}{2\alpha^2 d}$ (2) $\frac{md}{2\alpha^2}$
 (3) $\frac{m\alpha^2 d}{2}$ (4) $2m\alpha^2 d$
27. Two cars are travelling towards each other at speed of 20 m s^{-1} each. When the cars are 300 m apart, both the drivers apply brakes and the cars retard at the rate of 2 m s^{-2} . The distance between them when they come to rest is :
- (1) 200 m (2) 50 m
 (3) 100 m (4) 25 m

SOLUTIONS

1. **Ans. (4)**

Sol. $v = \frac{ds}{dt} = 4t \text{ j}$

At $t = 1 \text{ sec } v = 4 \text{ j}$

2. **Ans. (673)**

Sol $u_x = 5 \text{ m/s } \quad a_x = 3 \text{ m/s}^2 \quad x = 84 \text{ m}$

$v_x^2 - u_x^2 = 2ax$

$v_x^2 - 25 = 2(3)(84)$

$V_x = 23 \text{ m/s}$

$v_x - u_x = a_x t$

$t = \frac{23 - 5}{3} = 6 \text{ s}$

$v_y = 0 + a_y t = 0 + 2 \times (6) = 12 \text{ m/s}$

$v^2 = v_x^2 + v_y^2 = 23^2 + 12^2 = 673$

$v = \sqrt{673} \text{ m/s}$

3. **Ans. (Bonus)**

Sol. $v^2 - u^2 = 2aS$

$\left(\frac{2u}{3}\right)^2 = u^2 + 2(-a)(4 \cdot 10^{-2})$

$\frac{4u^2}{9} = u^2 - 2a(4 \cdot 10^{-2})$

$\frac{5u^2}{9} = -2a(4 \cdot 10^{-2}) \quad \dots(1)$

$0 = \left(\frac{2u}{3}\right)^2 + 2(-a)(x)$

$\frac{4u^2}{9} = -2ax \quad \dots(2)$

(1)/(2)

$\frac{5}{4} = \frac{4 \cdot 10^{-2}}{x}$

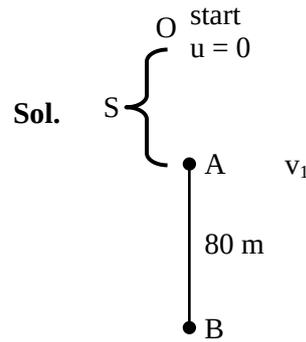
$x = \frac{16}{5} \cdot 10^{-2}$

$x = 32 \cdot 10^{-2} \text{ m}$

$x = 32 \cdot 10^{-3} \text{ m}$

Note : Since no option is matching, Question should be bonus.

4. **Ans. (45)**



From $A \rightarrow B$

$-80 = -v_1 t - \frac{1}{2} \cdot 10t^2$

$-80 = -2v_1 - \frac{1}{2} \cdot 10 \cdot 2^2$

$-80 = -2v_1 - 20$

$-60 = -2v_1$

$v_1 = 30 \text{ m/s}$

From O to A

$v^2 = u^2 + 2gS$

$30^2 = 0 + 2 \cdot (-10)(-S)$

$900 = 20S$

$S = 45 \text{ m}$

5. **Ans. (2)**

Sol. S_1 in first $(p - 1)$ sec

S_2 in first p sec

$S_1 = \frac{1}{2} a (p - 1)^2$

$S_2 = \frac{1}{2} a (p)^2$

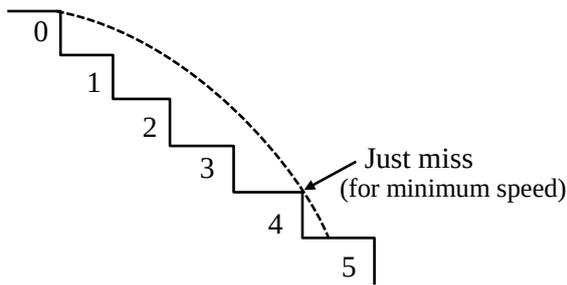
$S_1 + S_2 = \frac{1}{2} at^2$

$(p - 1)^2 + p^2 = t^2$

$t = \sqrt{2p^2 + 1 - 2p}$

6. Ans. (2)

Sol.



The ball needs to just cross 4 steps to just hit 5th step

Therefore, horizontal range (R) = 0.4 m

$$R = u \cdot t$$

Similarly, in vertical direction

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

$$0.4 = \frac{1}{2}gt^2$$

$$0.4 = \frac{1}{2}g \left(\frac{0.4}{u} \right)^2$$

$$u^2 = 2$$

$$u = \sqrt{2} \text{ m/s}$$

Therefore, $x = 2$

7. Ans. (2)

Sol. $x = t^3 - 6t^2 + 20t + 15$

$$\frac{dx}{dt} = v = 3t^2 - 12t + 20$$

$$\frac{dv}{dt} = a = 6t - 12$$

When $a = 0$

$$6t - 12 = 0; t = 2 \text{ sec}$$

At $t = 2 \text{ sec}$

$$v = 3(2)^2 - 12(2) + 20$$

$$v = 8 \text{ m/s}$$

8. Ans. (175)

Sol. Considering acceleration is constant

$$v = u + at$$

$$u + 50 = u + a \Rightarrow a = 50 \text{ m/s}^2$$

$$125 = ut + \frac{1}{2}at^2$$

$$125 = u + \frac{a}{2}$$

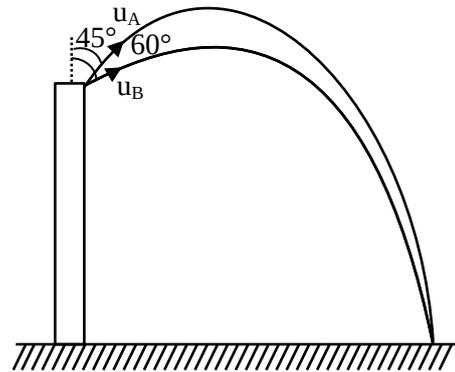
$$\Rightarrow u = 100 \text{ m/s}$$

$$\therefore S_{n^{\text{th}}} = u + \frac{a}{2}[2n - 1] = 175 \text{ m}$$

9. Ans. NTA (4)

Allen (Bonus)

Sol.



For u_A & u_B time of flight and range can not be same. So above options are incorrect.

10. Ans. (1)

Sol. $t = \alpha x^2 + \beta x$ (differentiating wrt time)

$$\frac{dt}{dx} = 2\alpha x + \beta$$

$$\frac{1}{v} = 2\alpha x + \beta$$

(differentiating wrt time)

$$-\frac{1}{v^2} \frac{dv}{dt} = 2\alpha \frac{dx}{dt}$$

$$\frac{dv}{dt} = -2\alpha v^3$$

11. Ans. (1)

$$\text{Sol. } \frac{2\pi R}{T} = V$$

$$\text{Maximum height } H = \frac{v^2 \sin^2 \theta}{2g}$$

$$4R = \frac{4\pi^2 R^2}{T^2 2g} \sin^2 \theta$$

$$\sin \theta = \sqrt{\frac{2gT^2}{\pi^2 R}}$$

$$\theta = \sin^{-1} \left(\frac{2gT^2}{\pi^2 R} \right)^{\frac{1}{2}}$$

12. Ans. (52)

Sol. $x = 3t^3 + 18t^2 + 16t$

$$v = -9t^2 + 36 + 16$$

$$a = -18t + 36$$

$$a = 0 \text{ at } t = 2 \text{ s}$$

$$v = -9(2)^2 + 36 \times 2 + 16$$

$$v = 52 \text{ m/s}$$

KINEMATICS
13. Ans. (3)

Sol. \downarrow 30m/s
 \uparrow 20m/s
 A

$$V_A = 20 \text{ m/s}$$

$$V_B = -30 \text{ m/s}$$

Velocity of B w.r.t. A

$$V_{B/A} = -50 \text{ m/s}$$

Velocity of ground w.r.t. B

$$V_{G/B} = 30 \text{ m/s}$$

14. Ans. (8)

Sol. $V = 4\sqrt{x}$

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

$$= 4\sqrt{x} \cdot 4 \cdot \frac{1}{2} x^{-1/2} = 8 \text{ m/s}^2$$

15. Ans. (2)

Sol. Given, $102.5 = u + \frac{a}{2}(2n - 1)$ &

$$115 = u + \frac{a}{2}(2n + 3)$$

$$\Rightarrow 102.5 = u + an - \frac{a}{2} \text{ &}$$

$$115 = u + an + \frac{3a}{2}$$

$$12.5 = 2a \Rightarrow a = 6.25 \text{ m/s}^2$$

Hence option (2)

16. Ans. (4)

Sol. $x = 2 + 4t$

$$\frac{dx}{dt} = v_x = 4; \frac{dv_x}{dt} = a_x = 0$$

$$y = 3t + 8t^2$$

$$\frac{dy}{dt} = v_y = 3 + 16t$$

$$\frac{dv_y}{dt} = a_y = 16$$

the motion will be uniformly accelerated motion.

For path

$$x = 2 + 4t$$

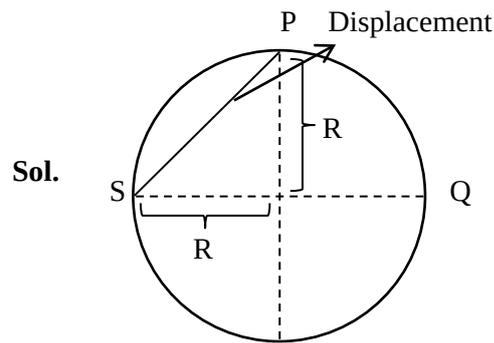
$$\frac{(x - 2)}{4} = t$$

Put this value of t is equation of y

$$y = 3\left(\frac{x - 2}{4}\right) + 8\left(\frac{x - 2}{4}\right)^2$$

this is a quadratic equation so path will be parabolic.

Correct answer (4)

17. Ans. (2)


$$\therefore \text{Displacement} = R\sqrt{2} = 2\sqrt{2} = \sqrt{8} \text{ km}$$

18. Ans. (40)

Sol. Initial velocity = $u = 72 \text{ km/h} = 20 \text{ m/s}$

$$v = u + at$$

$$\Rightarrow 0 = 20 + a \times 4$$

$$a = -5 \text{ m/s}^2$$

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

$$\Rightarrow 0^2 - 20^2 = 2(-5)s$$

$$s = 40 \text{ m}$$

19. Ans. (19)

Sol. $S_n = \frac{1}{2}a(2n - 1) = \frac{19a}{2}$

$$S_{n+1} = \frac{1}{2}a(2n - 3) = \frac{17a}{2}$$

$$\frac{S_{n+1}}{S_n} = \frac{17}{19} = 1 - \frac{2}{x} \Rightarrow x = 19$$

20. Ans. (16)

Sol. $H_{\max} = \frac{u^2 \sin^2 \theta}{2g}$

$$\frac{H_{1\max}}{H_{2\max}} = \frac{u_1^2}{u_2^2}$$

$$\frac{64}{H_{2\max}} = \frac{u^2}{(u/2)^2}$$

$$H_{2\max} = 16 \text{ m}$$

21. Ans. (2)

Sol. Average speed = $\frac{\text{total distance}}{\text{time taken}}$

$$= \frac{80 \cdot t + 80 \cdot 3t}{4t} = 70 \text{ km/hr.}$$

22. **Ans. (3)**

Sol. $x^2 = 1 + t^2$

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

$$xv = t$$

$$x \frac{dv}{dt} + v \frac{dx}{dt} = 1$$

$$x \cdot a + v^2 = 1$$

$$a = \frac{1 - v^2}{x} = \frac{1 - t^2 / x^2}{x}$$

$$a = \frac{1}{x^3} = x^{-3}$$

23. **Ans. (2)**

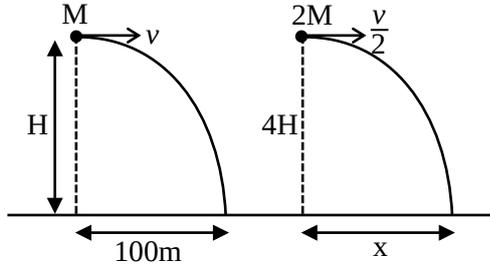
Sol. $\frac{u^2 \sin^2 2\theta}{g} = \frac{u^2 \sin^2 \theta}{2g}$

$$4 \sin \theta \cos \theta = \sin^2 \theta$$

$$4 = \tan \theta$$

24. **Ans. (100)**

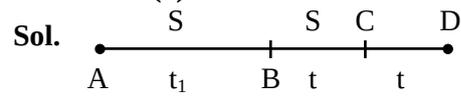
Sol.



$$100 = v \sqrt{\frac{2H}{g}}; \quad x = \frac{v}{2} \sqrt{\frac{2(4H)}{g}} = v \sqrt{\frac{2H}{g}}$$

$$\Rightarrow x = 100$$

25. **Ans. (4)**



$$BD \Rightarrow S = 9t + 15t = 24t$$

$$AB \Rightarrow S = 6t_1 = 24t \Rightarrow t_1 = 4t$$

$$\langle \text{speed} \rangle = \frac{\text{dist.}}{\text{time}} = \frac{48t}{2t + t_1}$$

$$= \frac{48t}{2t + 4t} \Rightarrow \frac{48t}{6t} \Rightarrow 8 \text{ m/s}$$

26. **Ans. (3)**

Sol. $v = \alpha \sqrt{x}$

$$\text{at } x = 0 : v = 0$$

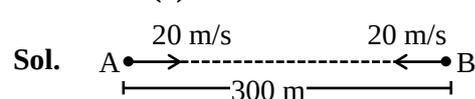
$$\& \text{ at } x = d ; v = \alpha \sqrt{d}$$

$$W.D = K_f - K_i$$

$$W.D = \frac{1}{2} m (\alpha \sqrt{d})^2 - \frac{1}{2} m (0)^2$$

$$\Rightarrow W.D = \frac{m \alpha^2 d}{2}$$

27. **Ans. (3)**



$$|u_{BA}| = 40 \text{ m/s}$$

$$|a_{BA}| = 4 \text{ m/s}$$

$$\text{Apply } (v^2 = u^2 + 2as)_{\text{relative}}$$

$$0 = (40)^2 + 2(-4)(S)$$

$$S = 200 \text{ m}$$

$$\text{Remaining distance} = 300 - 200 = 100 \text{ m}$$