## EXERCISE–01   CHECK YOUR GRASP

SELECT THE CORRECT ALTERNATIVE (ONLY ONE CORRECT ANSWER)

**1.** A bird moves from point $(1, -2, 3)$ to $(4, 2, 3)$. If the speed of the bird is 10 m/s, then the velocity vector of the bird is :-

(A) $5\left(\tilde{i} - 2\tilde{j} + 3\tilde{k}\right)$ (B) $5\left(4\tilde{i} + 2\tilde{j} + 3\tilde{k}\right)$ (C) $0.6\tilde{i} + 0.8\tilde{j}$ (D) $6\tilde{i} + 8\tilde{j}$

2. A particle moves in straight line in same direction for 20 seconds with velocity 3 m/s and then moves with velocity 4 m/s for another 20 sec and finally moves with velocity 5 m/s for next 20 seconds. What is the average velocity of the particle?

(A) 3 m/s   (B) 4 m/s   (C) 5 m/s   (D) Zero

3. A particle is moving in x–y–plane at 2 m/s along x–axis. 2 seconds later, its velocity is 4 m/s in a direction making 60 with positive x–axis. Its average acceleration for this period of motion is:-

(A) $\sqrt{5}$ m/s^2, along y–axis   (B) $\sqrt{3}$ m/s^2, along y–axis

(C) $\sqrt{5}$ m/s^2, along at 60 with positive x–axis   (D) 3m/s^2, at 60 with positive x–axis.

4. The velocity of a particle moving along x–axis is given as $v = x^2 - 5x + 4$ (in m/s) where x denotes the x–coordinate of the particle in metres. Find the magnitude of acceleration of the particle when the velocity of particle is zero ?

(A) 0 m/s^2 (B) 2 m/s^2 (C) 3 m/s^2 (D) None of these

5. The coordinates of a moving particle at time t are given by $x = ct^2$ and $y = bt^2$. The speed of the particle is given by :–

(A) $2t(c+b)$ (B) $2t\sqrt{c^2 - b^2}$ (C) $t\sqrt{c^2 + b^2}$ (D) $2t\sqrt{c^2 + b^2}$

6. A particle has an initial velocity of $(3\tilde{i} + 4\tilde{j})$ m/s and a constant acceleration of $(4\tilde{i} - 3\tilde{j})$ m/s^2. Its speed after one second will be equal to :-

(A) 0   (B) 10 m/s   (C) $5\sqrt{2}$ m/s   (D) 25 m/s

7. A body starts from rest and is uniformly accelerated for 30 s. The distance travelled in the first 10 s is x_1, next 10 s is x_2 and the last 10 s is x_3. Then $x_1 : x_2 : x_3$ is the same as:-

(A) 1 : 2 : 4   (B) 1 : 2 : 5   (C) 1 : 3 : 5   (D) 1 : 3 : 9

8. A, B, C and D are points in a vertical line such that AB = BC = CD. If a body falls from rest from A, then the times of descend through AB, BC and CD are in the ratio :-

(A) $1 : \sqrt{2} : \sqrt{3}$ (B) $\sqrt{2} : \sqrt{3} : 1$

(C) $\sqrt{3} : 1 : \sqrt{2}$ (D) $1 : (\sqrt{2} - 1) : (\sqrt{3} - \sqrt{2})$

9. A particle is projected vertically upwards and it reaches the maximum height H in T seconds . The height of the particle at any time t will be :-

(A) $H - g(t - T)^2$ (B) $g(t - T)^2$ (C) $H - \dfrac{1}{2}g(t - T)^2$ (D) $\dfrac{g}{2}(t - T)^2$

10. A parachutist drops freely from an aeroplane for 10 s before the parachute opens out. Then he descends with a net retardation of 2.5 m/s^2. If he bails out of the plane at a height of 2495 m and g = 10 m/s^2, hit velocity on reaching the ground will be :-

(A) 5 m/s   (B) 10 m/s   (C) 15 m/s   (D) 20 m/s

11. With what speed should a body be thrown upwards so that the distances traversed in 5th second and 6th second are equal ?

(A) 58.4 m/s   (B) 49 m/s   (C) $\sqrt{98}$ m/s   (D) 98 m/s

12. A particle is projected vertically upwards from a point A on the ground. It takes t_1 time to reach a point B but it still continues to move up. If it takes further t_2 time to reach the ground from point B then height of point B from the ground is :-

(A) $\dfrac{1}{2}g(t_1 + t_2)^2$ (B) $gt_1 t_2$ (C) $\dfrac{1}{8}g(t_1 + t_2)^2$ (D) $\dfrac{1}{2}gt_1 t_2$

13. The velocity – time graph of a linear motion is shown in figure. The displacement & distance from the origin after 8 sec. is :-
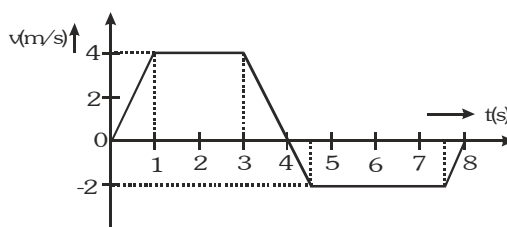

(A) 5 m, 19m   (B) 16 m,22m   (C) 8 m,19m   (D) 6 m, 5m

14. Initially car A is 10.5 m ahead of car B. Both start moving at time t=0 in the same direction along a straight line. The velocity time graph of two cars is shown in figure. The time when the car B will catch the car A, will be :-

(A) t = 21 sec   (B) t = $2\sqrt{5}$ sec

(C) 20 sec   (D) None of these
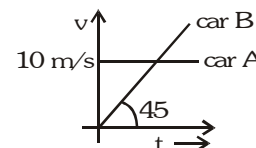
15. A man moves in x–y plane along the path shown. At what point is his average velocity vector in the same direction as his instaneous velocity vector. The man starts from point P.
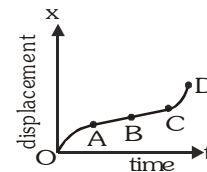

(A) A

(B) B

(C) C

(D) D
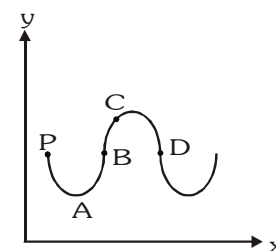
**16.** Which of the following velocity–time graph shows a realistic situation for a body in motion :–
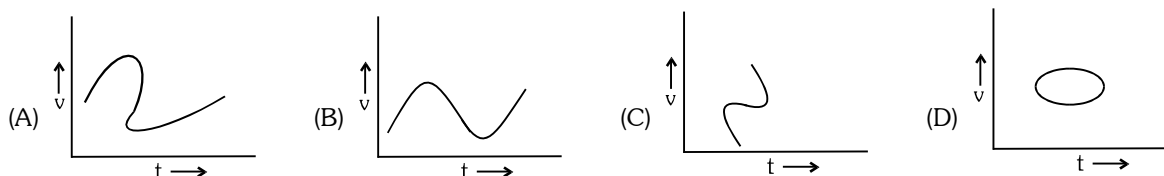
17. The graph between the displacement x and time t for a particle moving in a straight line is shown in figure. During the interval OA, AB, BC and CD, the acceleration of the particle is :
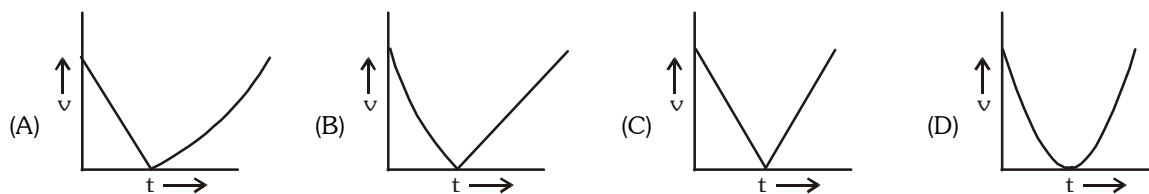
	OA,	AB,	BC,	CD
(A)	+	0	+	+
(B)	–	0	+	0
(C)	+	0	–	+
(D)	–	0	0	+

18. The velocity – time graph of a body falling from rest under gravity and rebounding from a solid surface is represented by which of the following graphs?
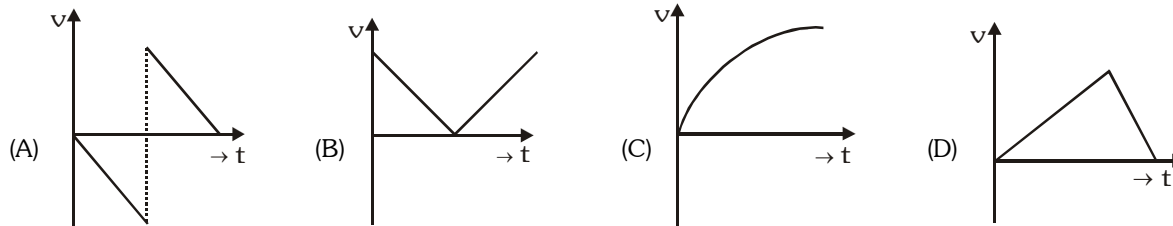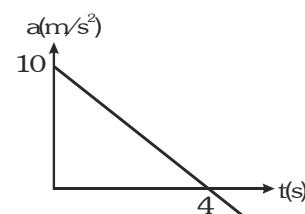

19. A ball is thrown vertically upwards. Which of the following plots represents the speed–time graph of the ball during its flight if the air resistance is ignored :–


20. The acceleration–time graph of a particle moving along a straight line is as shown in figure. At what time the particle acquires its initial velocity?
(A) 12 sec
(B) 5 sec
(C) 8 sec
(D) 16 sec

**21.** Which of the following situation is represented by the velocity–time graph as shown in the diagram :–
(A) A stone thrown up vertically, returning back to the ground
(B) A car decelerating at constant rate and then accelerating at the same rate
(C) A ball falling from a height and then bouncing back
(D) None of the above
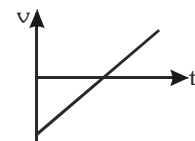
22. A man starts running along a straight road with uniform velocity $\vec{u} = u\tilde{i}$ feels that the rain is falling vertically down along $\tilde{j}$. If he doubles his speed he finds that the rain is coming at an angle θ to the vertical . The velocity of rain with respect to the ground is :-

(A) $u\tilde{i} - u\tan\theta\,\tilde{j}$　　(B) $u\tilde{i} - \dfrac{u}{\tan\theta}\tilde{j}$　　(C) $u\tan\theta\,\tilde{i} - u\tilde{j}$　　(D) $\dfrac{u}{\tan\theta}\tilde{i} - u\tilde{j}$

23. A river is flowing from west to east at a speed of 5 meters per minute. A man on the south bank of the river, capable of swimming at 10 meters per minute in still water, wants to swim across the river in the shortest time. He should swim in a direction :-

   (A) Due north   (B) 30 east of north   (C) 30 north of west   (D) 60 east of north

24. A boat moving towards east with velocity 4 m/s with respect to still water and river is flowing towards north with velocity 2 m/s and the wind is blowing towards north with velocity 6 m/s. The direction of the flag blown over by the wind hoisted on the boat is :-

   (A) North–west   (B) South–east   (C) $\tan^{-1}(1/2)$ with east   (D) North

25. Raindrops are falling vertically with a velocity 10m/s. To a cyclist moving on a straight road the rain drops appear to be coming with a velocity of 20m/s. The velocity of cyclist is :-

   (A) 10m/s   (B) $10\sqrt{3}$ m/s   (C) 20 m/s   (D) $20\sqrt{3}$ m/s

26. A man is crossing a river flowing with velocity of 5m/s. He reaches a point directly across at distance of 60 m in 5s. His velocity in still water should be :–
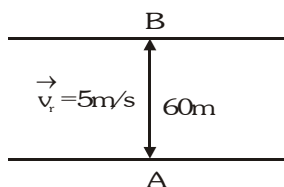

   (A) 12 m/s   (B) 13 m/s   (C) 5 m/s   (D) 10 m/s

27. A boat which has a speed of 5km per hour in still water crosses a river of width 1km along the shortest possible path in fifteen minutes. The velocity of the river water in km per hour is :-

   (A) 1   (B) 2   (C) 3   (D) $\sqrt{41}$

28. A river is flowing from east to west at a speed of 5 m/min. A man on south bank of river, capable of swimming 10 m/min in still water, wants to swim across the river in shorter time; he should swim :–

   (A) Due north   (B) Due north–east
   (C) Due north–east with double the speed of river   (D) None of the above

29. Two particles P and Q are moving with velocities of $(\tilde{i} + \tilde{j})$ and $(-\tilde{i} + 2\tilde{j})$ respectively. At time t = 0, P is at origin and Q is at a point with position vector $(2\tilde{i} + \tilde{j})$. Then the shortest distance between P & Q is :-

   (A) $\dfrac{2\sqrt{5}}{5}$ (B) $\dfrac{4\sqrt{5}}{5}$ (C) $\sqrt{5}$ (D) $\dfrac{3\sqrt{5}}{5}$

30. From a motorboat moving downstream with a velocity 2 m/s with respect to river, a stone is thrown. The stone falls on an ordinary boat at the instant when the motorboat collides with the ordinary boat. The velocity of the ordinary boat with respect to the river is equal to zero. The river flow velocity is given to be 1 m/s. The initial velocity vector of the stone with respect to earth is :-
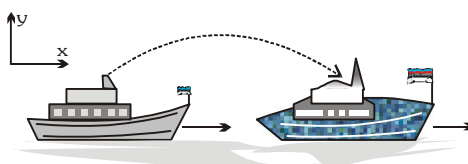
Take the value of g = 10 m/s²
Initial separation between the two boats is 20m.

   (A) 2i + 20j   (B) 3i + 40j   (C) 3i + 50j   (D) 2i + 50j

31. Graphs I and II give coordinates x(t) and y(t) of a particle moving in the x–y plane. Acceleration of the particle is constant and the graphs are drawn to the same scale. Which of the vector shown in options best represents the acceleration of the particle :-

(A) (B) (C) (D)
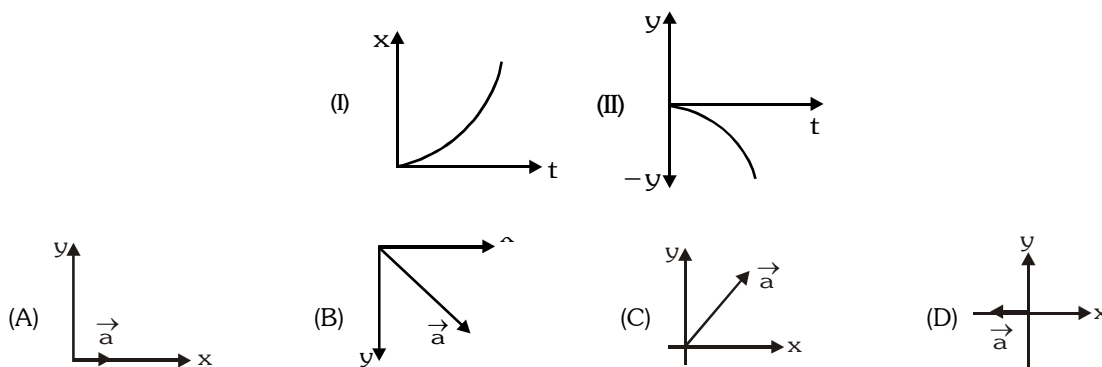
32. Particle is dropped from the height of 20m on horizontal ground. There is wind blowing due to which horizontal acceleration of the particle becomes 6 ms^{-2}. Find the horizontal displacement of the particle till it reaches ground.

(A) 6m (B) 10 m (C) 12m (D) 24 m

33. The total speed of a projectile at its greatest height is $\sqrt{\dfrac{6}{7}}$ of its speed when it is at half of its greatest height . The angle of projection will be :-

(A) 60 (B) 45 (C) 30 (D) 50

34. **A projectile is projected at an angle** ($\alpha > 45$) with an initial velocity u. The time t, at which its magnitude of horizontal velocity will equal the magnitude of vertical velocity is :-

(A) $t = \dfrac{u}{g}(\cos\alpha - \sin\alpha)$ (B) $t = \dfrac{u}{g}(\cos\alpha + \sin\alpha)$ (C) $t = \dfrac{u}{g}(\sin\alpha - \cos\alpha)$ (D) $t = \dfrac{u}{g}(\sin^2\alpha - \cos^2\alpha)$.

35. A particle is projected from a horizontal plane (x–z plane) such that its velocity vector at time t is given by $\vec{v} = a\tilde{i} + (b - ct)\tilde{j}$. Its range on the horizontal plane is given by :-

(A) $\dfrac{ba}{c}$ (B) $\dfrac{2ba}{c}$ (C) $\dfrac{3ba}{c}$ (D) None

36. A particle is dropped from a height h . Another particle which was initially at a horizontal distance 'd' from the first, is simultaneously projected with a horizontal velocity 'u' and the two particles just collide on the ground . The three quantities h. d and u are related to :-
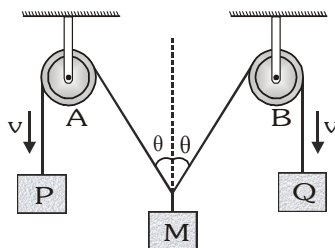
(A) $d^2 = \dfrac{u^2 h}{2g}$ (B) $d^2 = \dfrac{2u^2 h}{g}$ (C) $d = h$ (D) $gd^2 = u^2h$

37. A particle is projected from a tower as shown in figure, then the distance from the foot of the tower where it will strike the ground will be :- (take g = 10 m/s^2)
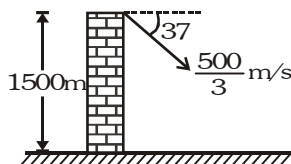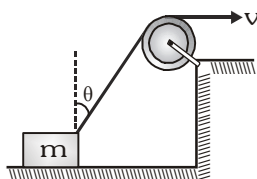

(A) 4000/3 m (B) 5000/3 m (C) 2000 m (D) 3000 m

E

38. In the figure, the ends P and Q of an unstrechable string move downwards with uniform speed v. Mass M moves upward with speed

(A) v cosθ

(B) $\dfrac{v}{\cos\theta}$

(C) 2v cos θ

(D) $\dfrac{2}{v\cos\theta}$

39. A block is dragged on a smooth plane with the help of a rope which moves with a velocity v as shown in figure. The horizontal velocity of the block is :

(A) v

(B) $\dfrac{v}{\sin\theta}$

(C) v sinθ

(D) $\dfrac{v}{\cos\theta}$

40. A weightless inextensible rope rest on a stationary wedge forming an angle α with the horizontal. One end of the rope is fixed on the wall at point A. A small load is attached to the rope at point B. The wedge starts moving to the right with a constant acceleration a. The acceleration of the load is given by:

(A) a

(B) 2a sinα

(C) 2a $\sin\dfrac{\alpha}{2}$

(D) gsinα
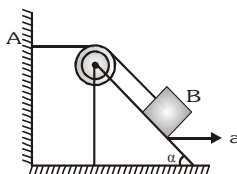
41. If acceleration of M is a then acceleration of m is
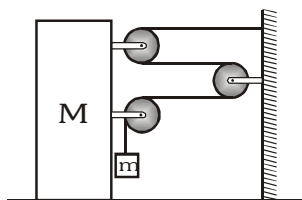
(A) 3a

(B) $\dfrac{a}{3}$

(C) a

(D) $\sqrt{10}$ a

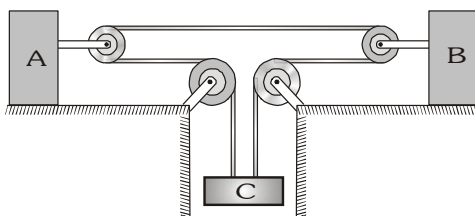**42.** If acceleration of A is 2 m/s² towards left and acceleration of B is 1 m/s² towards left, then acceleration of C is :–


(A) 1 m/s² downwards   (B) 1 m/s² upwards   (C) 2 m/s² downwards   (D) 2 m/s² upwards

43. If angular velocity of a disc depends an angle rotated θ as $\omega = \theta^2 + 2\theta$, then its angular acceleration α at $\theta = 1$ rad is :

(A) 8 rad/s²   (B) 10 rad/s²   (C) 12 rad/s²   (D) None of these

44. If the radii of circular path of two particles are in the ratio of 1 : 2, then in order to have same centripetal acceleration, their speeds should be in the ratio of :

(A) 1 : 4   (B) 4 : 1   (C) $1 : \sqrt{2}$ (D) $\sqrt{2} : 1$

45. A stone tied to the end of a string 80 cm long is whirled in a horizontal circle with a constant speed. If the stone makes 14 revolutions in 25 s, the magnitude of acceleration is :

(A) 20 ms⁻²   (B) 12 m/s²   (C) 9.9 ms⁻²   (D) 8 ms⁻²

46. A particle starts moving along a circle of radius $(20/\pi)$m with constant tangential acceleration. If the velocity of the particle is 50 m/s at the end of the second revolution after motion has began, the tangential acceleration in m/s² is :

(A) 1.6   (B) 4   (C) 15.6   (D) 13.2

47. For a body in circular motion with a constant angular velocity, the magnitude of the average acceleration over a period of half a revolution is.... times the magnitude of its instantaneous acceleration.

(A) $\dfrac{2}{\pi}$ (B) $\dfrac{\pi}{2}$ (C) π (D) 2

48. The second's hand of a watch has length 6 cm. Speed of end point and magnitude of difference of velocities at two perpendicular positions will be

(A) 2π & 0 mm/s   (B) $2\sqrt{2}\,\pi$ & 4.44 mm/s

(C) $2\sqrt{2}\,\pi$ & 2π mm/s   (D) 2π & $2\sqrt{2}\pi$ mm/s

49. A particle is kept fixed on a turntable rotating uniformly. As seen from the ground, the particle goes in a circle, its speed is 20 cm/s and acceleration is 20 cm/s². The particle is now shifted to a new position to make the radius half of the original value. The new values of the speed and acceleration will be

(A) 10 cm/s, 10 cm/s²   (B) 10 cm/s, 80 cm/s²   (C) 40 cm/s, 10 cm/s²   (D) 40 cm/s, 40 cm/s²

50. A spot light S rotates in a horizontal plane with a constant angular velocity of 0.1 rad/s. The spot of light P moves along the wall at a distance 3m. What is the velocity of the spot P when θ=45 ?
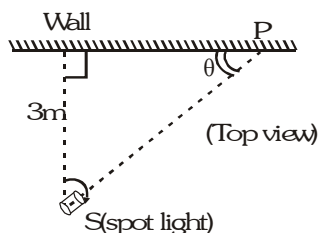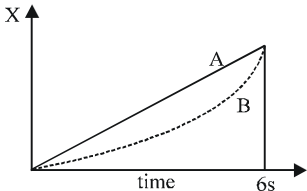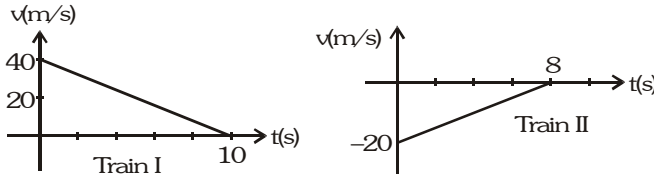

(A) 0.6 m/s　　　　(B) 0.5 m/s　　　　(C) 0.4 m/s　　　　(D) 0.3 m/s

51. A particle A moves along a circle of radius R=50 cm so that its radius vector r relative to the point O (figure) rotates with the constant angular velocity ω=0.40 rad/s. Then modulus of the velocity of the particle, and the modulus of its total acceleration will be
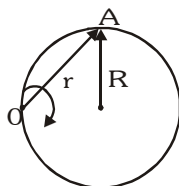
(A) v= 0.4 m/s, a = 0.4 m/s^2

(B) v = 0.32 m/s, a = 0.32 m/s^2

(C) v = 0.32 m/s, a = 0.4 m/s^2

(D) v = 0.4 m/s, a = 0.32 m/s^2

CHECK YOUR GRASP								ANSWER KEY									EXERCISE –1		
Que.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Ans.	D	B	B	A	D	C	C	D	C	A	B	D	A	A	C	B	D	A	C	C
Que.	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40
Ans.	A	B	A	A	B	B	C	A	B	C	B	C	C	C	B	B	A	B	B	C
Que.	41	42	43	44	45	46	47	48	49	50	51									
Ans.	D	B	C	C	C	C	A	D	A	A	D									

EXERCISE–02

BRAIN TEASERS

SELECT THE CORRECT ALTERNATIVES (ONE OR MORE THEN ONE CORRECT ANSWERS)

1. A particle is moving in a plane with velocity given by $\vec{u} = u_0 \tilde{i} + (a\omega \cos \omega t)\tilde{j}$, where $\tilde{i}$ and $\tilde{j}$ are unit vectors along x and y axes respectively. If particle is at the origin at t = 0. Calculate the trajectory of the particle :-

(A) $y = a \sin\left(\dfrac{u_0}{\omega x}\right)$ (B) $y = a \sin\left(\dfrac{\omega x}{u_0}\right)$ (C) $y = \dfrac{1}{a}.\sin\left(\dfrac{u_0}{\omega x}\right)$ (D) $y = \dfrac{1}{a}.\sin\left(\dfrac{\omega x}{u_0}\right)$

2. A point moves in a straight line under the retardation av^2. If the initial velocity is u, the distance covered in 't' seconds is :-

(A) aut   (B) $\dfrac{1}{a} \ell n(aut)$ (C) $\dfrac{1}{a} \ell n(1+aut)$ (D) $a\ell n(aut)$

3. The relation between time t and distance x is $t = \alpha x^2 + \beta x$ where α and β are constants. The retardation is :-
(A) $2\alpha v^3$ (B) $2\beta v^2$ (C) $2\alpha\beta v^2$ (D) $2\beta^2 v^3$

4. A particle is moving with uniform acceleration along a straight line . Its velocities at A & B are respectively 7 m/s & 17 m/s . M is mid point of AB . If t_1 is the time taken to go from A to M and t_2 the time taken to go from M to B, the ratio $\dfrac{t_1}{t_2}$ is equal to :-

(A) 3 : 2   (B) 3 : 1   (C) 2 : 1   (D) 2 : 3

5. A, B & C are three objects each moving with constant velocity . A's speed is 10 m/s in a direction $\overrightarrow{PQ}$. The velocity of B relative to A is 6 m/s at an angle of, $\cos^{-1}(15/24)$ to PQ . The velocity of C relative to B is 12 m/s in a direction $\overrightarrow{QP}$. Then the magnitude of the velocity of C is :-

(A) 5 m/s   (B) $2\sqrt{10}$ m/s   (C) 3 m/s   (D) 4 m/s

6. A person drops a stone from a building of height 20 m . At the same instant the front end of a truck passes below the building moving with constant acceleration of 1 m/s² and velocity of 2 m/s at that instant. Length of the truck if the stone just misses to hit its rear part is :-
(A) 6 m   (B) 4 m   (C) 5 m   (D) 2 m

7. In the diagram shown, the displacement of particles is given as a function of time. The particle A is moving under constant velocity of 9 m/s. The particle B is moving under variable acceleration. From time t = 0 s. to t = 6 s., the average velocity of the particle B will be equal to :-
(A) 2.5 m/s   (B) 4 m/s
(C) 9 m/s   (D) None

8. Two trains, which are moving along different tracks in opposite directions, are put on the same track due to a mistake. Their drivers, on noticing the mistake, start slowing down the trains when the trains are 300 m apart. Given graphs show their velocities as function of time as the trains slow down. The separation between the trains when both have stopped,, is :-


(A) 120 m   (B) 280 m   (C) 60 m   (D) 20 m

E

9. The position vector of a particle is given as $\vec{r} = (t^2 - 4t + 6)\,\vec{i} + (t^2)\,\vec{j}$. The time after which the velocity vector and acceleration vector becomes perpendicular to each other is equal to :-
   (A) 1 sec
   (B) 2 sec
   (C) 1.5 sec
   (D) Not possible

10. A 2m wide truck is moving with a uniform speed of 8 m/s along a straight horizontal road. A pedestrian starts crossing the road at an instant when the truck is 4 m away from him. The minimum constant velocity with which he should run to avoid an accident is :-
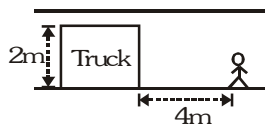

   (A) $1.6\sqrt{5}$ m/s
   (B) $1.2\sqrt{5}$ m/s
   (C) $1.2\sqrt{7}$ m/s
   (D) $1.6\sqrt{7}$ m/s

11. If some function say x varies linearly with time and we want to find its average value in a given time interval we can directly find it by $\dfrac{x_i + x_f}{2}$. Here, x_i is the initial value of x and x_f its final value.

    x and y co-ordinates of a particle moving in x–y plane at some instant are : $x = 2t^2$ and $y = 3/2\ t^2$. The average velocity of particle in at time interval from t = 1 s to t = 2s is :-
    (A) $(8\vec{i} + 5\vec{j})$ m/s
    (B) $(12\vec{i} + 9\vec{j})$ m/s
    (C) $(6\vec{i} + 4.5\vec{j})$ m/s
    (D) $(10\vec{i} + 6\vec{j})$ m/s

12. A particle moves with uniform acceleration and v_1, v_2 and v_3 denote the average velocities in the three successive intervals of time t_1, t_2 and t_3. Which of the following relations is correct ?
    (A) $(v_1 - v_2) : (v_2 - v_3) = (t_1 - t_2) : (t_2 + t_3)$
    (B) $(v_1 - v_2) : (v_2 - v_3) = (t_1 + t_2) : (t_2 + t_3)$
    (C) $(v_1 - v_2) : (v_2 - v_3) = (t_1 - t_2) : (t_1 - t_3)$
    (D) $(v_1 - v_2) : (v_2 - v_3) = (t_1 - t_2) : (t_2 - t_3)$

13. A particle starts from rest with constant acceleration. The ratio of space–average velocity to the time average velocity is :–
    (A) 1/2
    (B) 3/4
    (C) 4/3
    (D) 3/2

14. A particle moves along a straight line OX. At a time t (in seconds) the distance x (in metres) of the particle from O is given by $x = 40 + 12t - t^3$. How long would the particle travel before coming to rest ?
    (A) 24 m
    (B) 40 m
    (C) 56 m
    (D) 16 m

15. A ball is dropped from the top of a building. The ball takes 0.5 s to fall the 3m length of a window some distance from the top of the building. If the velocities of the ball at the top and at the bottom of the window are v_T and v_B respectively, then (take g = 10 m/s²) :-

    (A) $v_T + v_B = 12$ ms⁻¹
    (B) $v_B - v_T = 4.9$ ms⁻¹
    (C) $v_B v_T = 1$ ms⁻¹
    (D) $\dfrac{v_B}{v_T} = 1$ ms⁻¹

16. A particle is thrown upwards from ground. It experiences a constant resistance force which can produce retardation 2 m/s². The ratio of time of ascent to the time of descent is :- [g = 10 m/s²]
    (A) 1 : 1
    (B) $\sqrt{\dfrac{2}{3}}$
    (C) $\dfrac{2}{3}$
    (D) $\sqrt{\dfrac{3}{2}}$

17. Drops of water fall from the roof of a building 9m. high at regular intervals of time, the first drop reaching the ground at the same instant fourth drop starts to fall. What are the distances of the second and third drops from the roof ?
    (A) 6 m and 2 m
    (B) 6 m and 3 m
   (C) 4 m and 1 m
    (D) 4 m and 2 m

18. A disc in which several grooves are cut along the chord drawn from a point 'A', is arranged in a vertical plane, several particles starts slipping from 'A' along the grooves simultaneously. Assuming friction and resistance negligible, the time taken in reaching the edge of disc will be :-
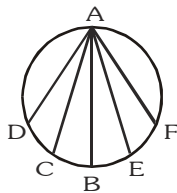
(A) Maximum in groove AB   (B) Maximum in groove AD
(C) Same in all groove   (D) According to the heights of B, C, D, E, F

19. Two boats A and B are moving along perpendicular paths in a still lake at night. Boat A move with a speed of 3 m/s and boat B moves with a speed of 4 m/s in the direction such that they collide after sometime. At t = 0, the boats are 300 m apart. The ratio of distance travelled by boat A to the distance travelled by boat B at the instant of collision is:-
(A) 1   (B) 1/2   (C) 3/4   (D) 4/3

20. A trolley is moving horizontally with a constant velocity of v m/s w.r.t. earth. A man starts running from one end of the trolley with a velocity 1.5v m/s w.r.t. to trolley. After reaching the opposite end, the man return back and continues running with a velocity of 1.5 v m/s w.r.t. the trolley in the backward direction. If the length of the trolley is L then the displacement of the man with respect to earth during the process will be :-
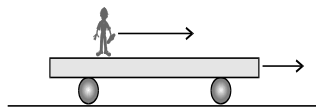
(A) 2.5L   (B) 1.5 L   (C) $\dfrac{5L}{3}$ (D) $\dfrac{4L}{3}$

21. A particle P is projected from a point on the surface of smooth inclined plane (see figure). Simultaneously another particle Q is released on the smooth inclined plane from the same position. P and Q collide after t = 4 second. The speed of projection of P is :-
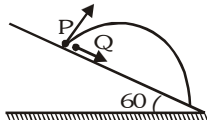

(A) 5 m/s   (B) 10 m/s   (C) 15 m/s   (D) 20 m/s

22. A particle is projected from a point P(2,0,0)m with a velocity 10m/s making an angle 45 with the horizontal. The plane of projectile motion passes through a horizontal line PQ which makes an angle of 37 with positive x–axis, xy plane is horizontal. The coordinates of the point where the particle will strike the line PQ is :- (take g = 10 m/s²)
(A) (10,6,0)m   (B) (8,6,0)m   (C) (10,8,0)m   (D) (6,10,0)m

23. A body is thrown horizontally with a velocity $\sqrt{2gh}$ from the top of a tower of height h. It strikes the level ground through the foot of the tower at a distance x from the tower. The value of x is :-
(A) h   (B) h/2   (C) 2h   (D) 2h/3

24. A particle A is projected with speed v_A from a point making an angle 60 with the horizontal. At the same instant, a second particle B is thrown vertically upward from a point directly below the maximum height point of parabolic path of A with velocity v_B. If the two particles collide then the ratio of v_A/v_B should be :-

(A) 1   (B) $\dfrac{2}{\sqrt{3}}$ (C) $\dfrac{\sqrt{3}}{2}$ (D) $\sqrt{3}$

node6\X.E_NODE6 (E)\Data\2013\Kota\JEE-Advanced\SMP\Phy-Kinematics\English\Exercise.p65

25. A ball is projected from a certain point on the surface of a planet at a certain angle with the horizontal surface. The horizontal and vertical displacements x and y vary with time t in second as : $x = 10\sqrt{3}\,t$; $y = 10t - t^2$ the maximum height attained by the ball is :-
(A) 100m   (B) 75m   (C) 50 m   (D) 25m

26. A particle moves in the xy plane and at time t is at the point $(t^2, t^3 - 2t)$. Then :-
(A) At t = 2/3 s, directions of velocity and acceleration are perpendicular
(B) At t = 0, directions of velocity and acceleration are perpendicular
(C) At $t = \sqrt{\dfrac{2}{3}}$ s, particle is moving parallel to x–axis
(D) Acceleration of the particle when it is at point (4, 4) is $2\tilde{i} + 24\tilde{j}$

27. The figure shows the velocity time graph of a particle which moves along a straight line starting with velocity at 5 m/sec and coming to rest at t = 30s . Then :-
(A) Distance travelled by the particle is 212.5 m
(B) Distance covered by the particle when it moves with constant velocity is 100 m
(C) Velocity of the particle at t = 25s is 5 m/sec
(D) Velocity of the particle at t = 9s is 8 m/sec .

28. An object may have :-
(A) Varying speed without having varying acceleration
(B) Varying velocity without having varying speed
(C) Non–zero acceleration without having varying velocity
(D) Non–zero acceleration without having varying speed .

29. A particle moves with constant speed v along a regular hexagon ABCDEF in the same order . Then the magnitude of the average velocity for its motion from A to :-
(A) F is $\dfrac{v}{5}$ (B) D is $\dfrac{v}{3}$ (C) C is $\dfrac{v\sqrt{3}}{2}$ (D) B is v .

30. A particle moves along x–axis according to the law $x = (t^3 - 3t^2 - 9t + 5)$m. Then :-
(A) In the interval 3<t<5, the particle is moving in +x direction
(B) The particle reverses its direction of motion twice in entire motion if it starts at t=0
(C) The average acceleration from $1 \leq t \leq 2$ seconds is 6m/s^2.
(D) In the interval $5 \leq t \leq 6$ seconds, the distance travelled is equal to the displacement.

31. A particle moving along a straight line with uniform acceleration has velocities 7m/s at A and 17m/s at C. B is the mid point of AC. Then :-
(A) The velocity at B is 12m/s
(B) The average velocity between A and B is 10m/s
(C) The ratio of the time to go from A to B to that from B to C is 3 : 2
(D) The average velocity between B and C is 15m/s

32. A particle moves along the X–axis as $x = u(t - 2s) + a(t - 2s)^2$:-
(A) The initial velocity of the particle is u   (B) The acceleration of the particle is a
(C) The acceleration of the particle is 2a   (D) At t = 2s particle is at the origin.

33. The co–ordinate of the particle in x–y plane are given as $x = 2 + 2t + 4t^2$ and $y = 4t + 8t^2$:-
The motion of the particle is :-
(A) Along a straight line   (B) Uniformly accelerated
(C) Along a parabolic path   (D) Non-uniformly accelerated

34. A particle leaves the origin with an initial velocity $\vec{u} = 3\tilde{i}$ m/s and a constant acceleration $\vec{a} = (-1.0\tilde{i} - 0.5\tilde{j})$ m/s^2. Its velocity $\vec{v}$ and position vector $\vec{r}$ when it reaches its maximum x–co–ordinate are :-
(A) $\vec{v} = -2\tilde{j}$ (B) $\vec{v} = -1.5\tilde{j}$ m/s   (C) $\vec{r} = (4.5\tilde{i} - 2.25\tilde{j})$ m   (D) $\vec{r} = (3\tilde{i} - 2\tilde{j})$ m

35. Pick the correct statements :-

(A) Average speed of a particle in a given time is never less than the magnitude of the average velocity.

(B) It is possible to have a situation in which $\left|\dfrac{d\vec{u}}{dt}\right| \neq 0$ but $\dfrac{d}{dt}|\vec{u}| = 0$.

(C) The average velocity of a particle is zero in a time interval. It is possible that the instantaneous velocity is never zero in the interval.

(D) The average velocity of a particle moving on a straight line is zero in a time interval. It is possible that the instantaneous velocity is never zero in the interval. (infinite acceleration is not allowed)

36. Which of the following statements are true for a moving body ?

(A) If its speed changes, its velocity must change and it must have some acceleration

(B) If its velocity changes, its speeds must change and it must have some acceleration

(C) If its velocity changes, its speed may or may not change, and it must have some acceleration

(D) If its speed changes but direction of motion does not change, its velocity may remain constant

37. If velocity of the particle is given by $v = \sqrt{x}$, where x denotes the position of the particle and initially particle was at x = 4m, then which of the following are correct.

(A) At t = 2 s, the position of the particle is at x = 9m

(B) Particle acceleration at t = 2 s. is 1 m/s^2

(C) Particle acceleration is 1/2 m/s^2 through out the motion

(D) Particle will never go in negative direction from it's starting position

38. The velocity – time graph of the particle moving along a straight line is shown. The rate of acceleration and deceleration is constant and it is equal to 5 ms^{-2}. If the average velocity during the motion is 20 ms^{-1}, then the value of t is
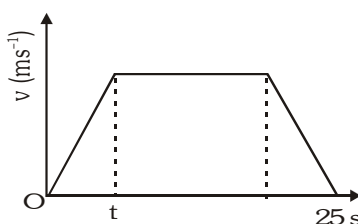

(A) 3 sec   (B) 5 sec   (C) 10 sec   (D) 12 sec

39. The figure shows the v–t graph of a particle moving in straight line. Find the time when particle returns to the starting point.
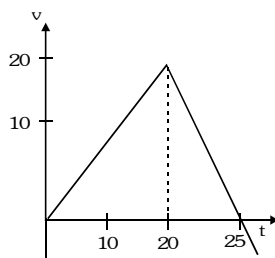
(A) 30 sec   (B) 34.5 sec   (C) 36.2 sec   (D) 35.4 sec

40. In a projectile motion assuming no air drag let $t_{0A} = t_1$ and $t_{AB} = t_2$. The horizontal displacement from O to A is R_1 and from A to B is R_2. Maximum height is H and time of flight is T. Now if air drag is to be considered, then choose the correct alternative(s).

(A) t_1 will decrease while t_2 will increase
(B) H will increase
(C) R_1 will decrease while R_2 will increase
(D) T may increase or decrease
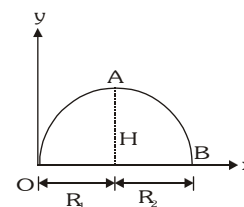
41. A particle is projected from a point P with a velocity v at an angle θ with horizontal. At a certain point Q it moves at right angle to its initial direction. Then :-
(A) Velocity of particle at Q is $v\sin\theta$
(B) Velocity of particle at Q is $v\cot\theta$
(C) Time of flight from P to Q is $(v/g)\csc\theta$
(D) Time of flight from P to Q is $(v/g)\sec\theta$

42. If T is the total time of flight, H the maximum height and R is the horizontal range of a projectile. Then x and y co-ordinates at any time t are related as :-

(A) $y = 4H\left(\dfrac{t}{T}\right)\left(1 - \dfrac{t}{T}\right)$

(B) $y = 4H\left(\dfrac{T}{t}\right)\left(1 - \dfrac{T}{t}\right)$

(C) $y = 4H\left(\dfrac{x}{R}\right)\left(1 - \dfrac{x}{R}\right)$

(D) $y = 4H\left(\dfrac{R}{x}\right)\left(1 - \dfrac{R}{x}\right)$

43. A gun is set up in such a way that the muzzle is at ground level as in figure. The hoop A is located at a horizontal distance 40m from the muzzle and is 50m above the ground level. Shell is fired with initial horizontal component of velocity as 40m/s. Which of the following is/are correct?
(A) The vertical component of velocity of the shell just after it is fired is 55m/s, if the shell has to pass through the hoop A.
(B) The shell will pass through both the hoops if x=40m.
(C) The shell will pass through both the hoops if x=20m.
(D) The vertical component of velocity of the shell just after it is fired is 45m/s, if the shell is to pass through both the hoops.
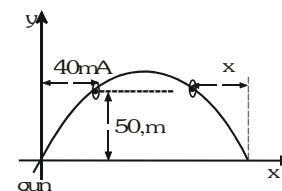
44. Two particles A & B projected along different directions from the same point P on the ground with the same velocity of 70 m/s in the same vertical plane . They hit the ground at the same point Q such that PQ = 480 m. Then :- ($g = 9.8 m/s^2$]
(A) Ratio of their times of flight is 4 : 5
(B) Ratio of their maximum heights is 9 : 16
(C) Ratio of their minimum speeds during flights is 4 : 3
(D) The bisector of the angle between their directions of projection makes 45^0 with horizontal

45. Two particles P & Q are projected simultaneously from a point O on a level ground in the same vertical plane with the same speed in directions making angle of 30^0 and 60^0 respectively with the horizontal.
(A) Both reach the ground simultaneously
(B) P reaches the ground earlier than Q
(C) Both strike the same point on the level ground
(D) The maximum height attained by Q is thrice that attained by P

46. A particle of mass m moves along a curve $y = x^2$. When particle has x – co–ordinate as 1/2 and x–component of velocity as 4m/s. Then :-
(A) The position coordinate of particle are (1/2, 1/4)
(B) The velocity of particle will be along the line $4x - 4y - 1 = 0$
(C) The magnitude of velocity at that instant is $4\sqrt{2}$ m/s
(D) The magnitude of angular momentum of particle about origin at that position is 0.

47. A ball is projected on smooth inclined plane in direction perpendicular to line of greatest slope with velocity of 8m/s. Find it's speed after 1 sec.
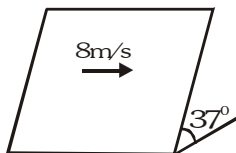

(A) 10 m/s   (B) 12 m/s   (C) 15 m/s   (D) 20 m/s

48. The horizontal range of a projectile is R and the maximum height attained by it is H. A strong wind now begins to blow in the direction of motion of the projectile, giving it a constant horizontal acceleration = g/2. Under the same conditions of projection. Find the horizontal range of the projectile.

(A) R +H   (B) R + 2H   (C) R   (D) R +H/2

49. Balls are thrown vertically upward in such a way that the next ball is thrown when the previous one is at the maximum height. If the maximum height is 5m, the number of balls thrown per minute will be :-

(A) 40   (B) 50   (C) 60   (D) 120

50. Acceleration versus velocity graph of a particle moving in a straight line starting from rest is as shown in figure. The corresponding velocity – time graph would be:-

(A)   (B)   (C)   (*D)
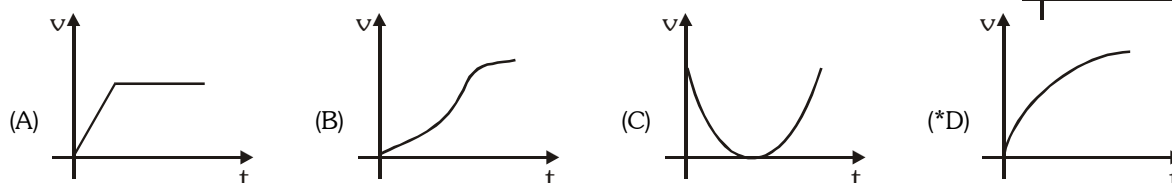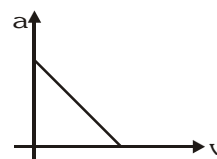
51. In the figure shown the acceleration of A is, $\vec{a}_A = 15\tilde{i} + 15\tilde{j}$ then the acceleration of B is (A remains in contact with B)
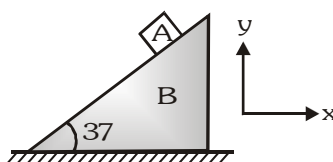
(A) $6\tilde{i}$ (B) $-15\tilde{i}$ (C) $-10\tilde{i}$ (D) $-5\tilde{i}$

52. Block B has a downward velocity in m/s and given by $v_B = \dfrac{t^2}{2} + \dfrac{t^3}{6}$, where t is in s. Acceleration of A at t = 2 second is
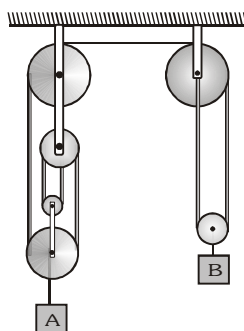
(A) 2 m/s²   (B) 4 m/s²   (C) 6 m/s²   (D) None of these

E

53. If block A is moving with an acceleration of 5 m/s², the acceleration of B w.r.t. ground is

(A) 5 m/s²   (B) $5\sqrt{2}$ m/s²   (C) $5\sqrt{5}$ m/s²   (D) 10 m/s²

54. In the figure acceleration of A is 1 m/s² upwards, acceleration of B is 7 m/s² upwards and acceleration of C is 2m/s² upwards. Then acceleration of D will be

(A) 7 m/s² downwards

(B) 2 m/s² downwards

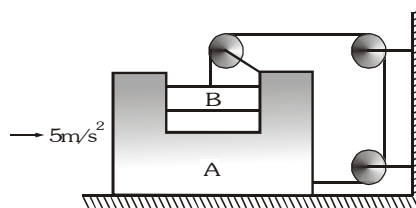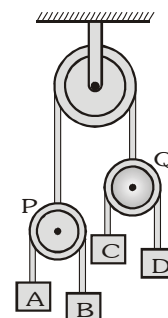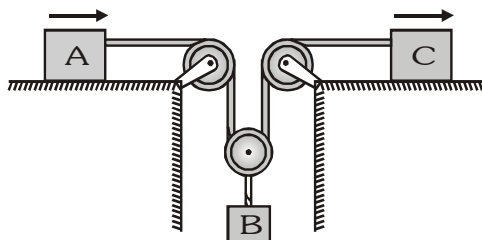(C) 10 m/s² downwards

(D) 8 m/s² downwards

55. Block A and C start from rest and move to the right with acceleration a_A=12t m/s² and a_C=3 m/s² . Here t is in seconds. The time when block B again comes to rest is

(A) 2s   (B) 1s   (C) $\dfrac{3}{2}$ s   (D) $\dfrac{1}{2}$ s

56. A particle moves with deceleration along the circle of radius R so that at any moment of time its tangential and normal accelerations are equal in moduli. At the initial moment t =0 the speed of the particle equals v_0, then the speed of the particle as a function of the distance covered S will be

(A) $v = v_0\, e^{-S/R}$ (B) $v = v_0 e^{S/R}$ (C) $v = v_0\, e^{-R/S}$ (D) $v = v_0\, e^{R/S}$

57. A particle moves along an arc of a circle of radius R. Its velocity depends on the distance covered as $v=a\sqrt{s}$, where a is a constant then the angle α between the vector of the total acceleration and the vector of velocity as a function of s will be

(A) $\tan\alpha = \dfrac{R}{2s}$ (B) $\tan\alpha = \dfrac{2s}{R}$ (C) $\tan\alpha = \dfrac{2R}{s}$ (D) $\tan\alpha = \dfrac{s}{2R}$

BRAIN TEASERS						ANSWER KEY							EXERCISE –2		
Que.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Ans.	B	C	A	A	A	A	C	D	A	A	C	B	C	D	A,B
Que.	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
Ans.	B	C	C	C	D	B	A	C	B	D	A,B,C,D	A,C,D	A,B,D	A,C,D	A,D
Que.	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45
Ans.	B,C,D	C,D	A,B	B,C	A,B,C	A,C	A,C,D	B	C	A,D	B,C	A,C	A,B	B,C,D	B,C,D
Que.	46	47	48	49	50	51	52	53	54	55	56	57			
Ans.	A,B,C	A	B	C	D	D	A	C	C	D	A	B			

EXERCISE–03   MISCELLANEOUS TYPE QUESTIONS

TRUE / FALSE

1. When a particle is in motion, its acceleration may be in any direction.

2. When a particle moves with uniform velocity, its displacement always increases with time.

3. If a ball starts falling from the position of rest, then it travels a distance of 25m during the third second of its fall. If $g = 10$ ms^{-2} and air friction absent.

4. A packet dropped from a rising balloon first moves upwards and then moves downward as observed by a stationary observer on the ground.

5. In the absence of air resistance, all bodies fall on the surface of earth with the same rate.

6. The normal acceleration of the projectile at its highest position is equal to g.

7. The greatest height to which a man can throw a stone is H. The greatest distance upto which he can throw the stone is H/2.

8. The instantaneous velocity of a particle is always tangential to the trajectory of the particle.

9. The direction of acceleration of a moving particle may be directly obtained from the trajectory of the particle.

10. Tangential acceleration changes the speed of the particle whereas the normal acceleration changes its direction.

11. The speed acquired by a body when falling in vacuum for a given time is dependent on the mass of the falling body under gravity.

12. Two balls of different masses are thrown vertically upwards with the same speed. They pass through the point of projection in their downward motion with the same speed (Neglect air resistance).

13. A projectile fired from the ground follows a parabolic path. The speed of the projectile is minimum at the top of its path.

FILL IN THE BLANKS

1. A point starts moving in a straight line with some acceleration. At a time t after beginning, the acceleration suddenly reverses (becomes retardation of same value) The time from start in which the particle returns to the initial point is ....

2. The equation of a projectile is $y = \sqrt{3}x - \dfrac{gx^2}{2}$. The angle of projection is ....and initial velocity is ....

3. A particle is projected with initial velocity 40 m/s . The particle is located at the same height 1s and 3s after it was thrown . The time of flight of the projectile is............ The angle of projection is ....and the height at those instants is...........(g = 10 m/s^2)

4. A stone of weight 10 kg is dropped from a cliff in a high wind . The wind exerts a steady horizontal force of 50 N on the stone as it falls .The path that the stone follows is ....

5. The velocity of a particle when it is at its greatest height is $\sqrt{\dfrac{2}{5}}$ of its velocity when it is at its half the maximum height . The angle of projection is...........and the velocity vector angle at half the maximum height is ....

MATCH THE COLUMN

1. The equation of one dimensional motion of the particle is described in column I. At t= 0, particle is at origin and at rest. Match the column I with the statements in Column II.

	Column I		Column II
(A)	$x = (3t^2 + 2)$m	(p)	Velocity of particle at $t = 1$s is 8 m/s
(B)	$v = 8t$ m/s	(q)	Particle moves with uniform acceleration
(C)	$a = 16\,t$	(r)	Particle moves with variable acceleration
(D)	$v = 6t - 3t^2$	(s)	Particle will change its direction some time.

2.

	Column I
(A)	Zero acceleration
(B)	Infinite acceleration
(C)	Constant positive acceleration, with zero initial velocity
(D)	Constant positive acceleration, with non–zero initial velocity
(E)	Constant Negative acceleration
(F)	Increasing acceleration
(G)	Decreasing acceleration
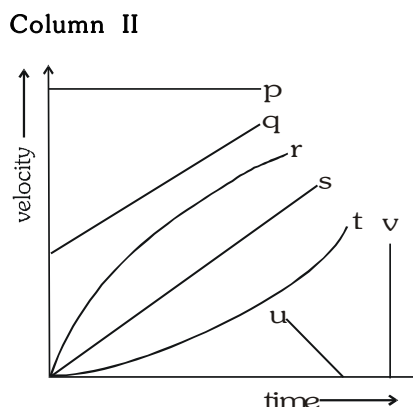
Column II

3. For the velocity–time graph shown in figure, in a time interval from t = 0 to t = 6 s, match the following:
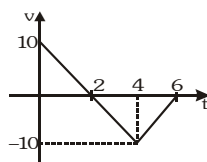
	Column I		Column II
(A)	Change in velocity	(p)	– 5/3 SI unit
(B)	Average acceleration	(q)	– 20 SI unit
(C)	Total displacement	(r)	– 10 SI unit
(D)	Acceleration at t=3s	(s)	– 5 SI unit

4. a particle is rotating in a circle of radius 1m with constant speed 4 m/s. In time 1 s, match the following (in SI units)

	Column I		Column II
(A)	Displacement	(p)	8 sin 2
(B)	Distance	(q)	4
(C)	Average velocity	(r)	2 sin 2
(D)	Average acceleration	(s)	4 sin 2

5. A balloon rises up with constant net acceleration of 10m/s^2. After 2 s a particle drops from the balloon. After further 2 s match the following : (Take g = 10 m/s^2)

	Column I		Column II
(A)	Height of particle from ground	(p)	Zero
(B)	Speed of particle	(q)	10 SI units
(C)	Displacement of Particle	(r)	40 SI units
(D)	Acceleration of particle	(s)	20 SI units

6.   In the figure shown, acceleration of 1 is x (upwards). Acceleration of pulley P_3, w.r.t. pulley P_2 is y (downwards) and acceleration of 4 w.r.t. to pulley P_3 is z (upwards). Taking upward +ve and downward –ve then
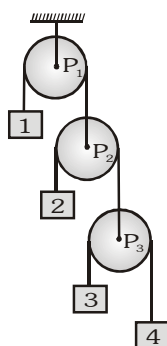
	Column I			Column II
(A)	Absolute acceleration of 2		(p)	(y–x) downwards
(B)	Absolute acceleration of 3		(q)	(z–x–y) upwards
(C)	Absolute acceleration of 4		(r)	(x+y+z) downwards
			(s)	None

ASSERTION & REASON

These questions contains, Statement I (assertion) and Statement II (reason).

1.   **Statement–I**   : A projectile is thrown with an initial velocity of $\left(a\tilde{i}+b\tilde{j}\right)$ m/s. If range of projectile is maximum then a = b.

because

Statement–II   : In projectile motion, angle of projection is equal to 45 for maximum range condition.

(A) Statement–I is true, Statement–II is true ; Statement–II is correct explanation for Statement–I.

(B) Statement–I is true, Statement–II is true ; Statement–II is NOT a correct explanation for statement–I.

(C) Statement–I is true, Statement–II is false.

(D) Statement–I is false, Statement–II is true.

2.   **Statement–I**   : Path of a projectile is a parabola irrespective of its velocity of projection.

because

Statement–II   : Trajectory of a projectile is a parabola when variation of g, (acceleration due to gravity) can be neglected.

(A) Statement–I is true, Statement–II is true ; Statement–II is correct explanation for Statement–I.

(B) Statement–I is true, Statement–II is true ; Statement–II is NOT a correct explanation for statement–I.

(C) Statement–I is true, Statement–II is false.

(D) Statement–I is false, Statement–II is true.

3.   **Statement I**   : When velocity of a particle is zero then acceleration of particle is zero.

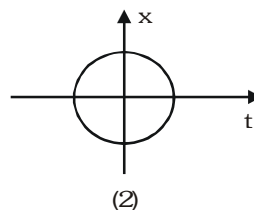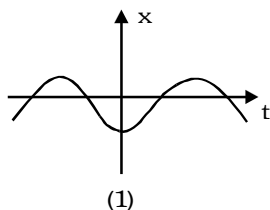**because**

Statement II   : Acceleration is equal to rate of change of velocity.

(A) Statement–I is true, Statement–II is true ; Statement–II is correct explanation for Statement–I.

(B) Statement–I is true, Statement–II is true ; Statement–II is NOT a correct explanation for statement–I.

(C) Statement–I is true, Statement–II is false.

(D) Statement–I is false, Statement–II is true.

E

4. **Statement I** : A particle moves in a straight line with constant acceleration. The average velocity of this particle cannot be zero in any time interval.

because

Statement II : For a particle moving in straight line with constant acceleration, the average velocity in a time interval is $\dfrac{u+v}{2}$, where u and v are initial and final velocity of the particle of the given time interval.

(A) Statement–I is true, Statement–II is true ; Statement–II is correct explanation for Statement–I.

(B) Statement–I is true, Statement–II is true ; Statement–II is NOT a correct explanation for statement–I.

(C) Statement–I is true, Statement–II is false.

(D) Statement–I is false, Statement–II is true.

5. **Statement–I** : If two particles, moving with constant velocities are to meet, the relative velocity must be along the line joining the two particles.

because

Statement–II : Relative velocity means motion of one particle as viewed from the other.

(A) Statement–I is true, Statement–II is true ; Statement–II is correct explanation for Statement–I.

(B) Statement–I is true, Statement–II is true ; Statement–II is NOT a correct explanation for statement–I.

(C) Statement–I is true, Statement–II is false.

(D) Statement–I is false, Statement–II is true.

6. **Statement–I** : Two balls are dropped one after the other from a tall tower. The distance between them increases linearly with time (elapsed after the second ball is dropped and before the first hits ground).

because

Statement–II : Relative acceleration is zero, whereas relative velocity is non–zero in the above situation.

(A) Statement–I is true, Statement–II is true ; Statement–II is correct explanation for Statement–I.

(B) Statement–I is true, Statement–II is true ; Statement–II is NOT a correct explanation for statement–I.

(C) Statement–I is true, Statement–II is false.

(D) Statement–I is false, Statement–II is true.

7. **Statement–I** : A man can cross river of width d in minimum time t. On increasing river velocity, minimum time to cross the river by man will remain unchanged.

because

Statement–II : Velocity of river is perpendicular to width of river. So time to cross the river is independent of velocity of river.

(A) Statement–I is true, Statement–II is true ; Statement–II is correct explanation for Statement–I.

(B) Statement–I is true, Statement–II is true ; Statement–II is NOT a correct explanation for statement–I.

(C) Statement–I is true, Statement–II is false.

(D) Statement–I is false, Statement–II is true.

8. **Statement–I** : When a body is dropped or thrown horizontally from the same height, it reaches the ground at the same time.

because

Statement–II : They have same acceleration and same initial speed in vertical direction.

(A) Statement–I is true, Statement–II is true ; Statement–II is correct explanation for Statement–I.

(B) Statement–I is true, Statement–II is true ; Statement–II is NOT a correct explanation for statement–I.

(C) Statement–I is true, Statement–II is false.

(D) Statement–I is false, Statement–II is true.

9. **Statement–I** : The maximum range along the inclined plane, when thrown downward is greater than that when thrown upward along the same inclined plane with same velocity.
    because
    Statement–II : The maximum range along inclined plane is independent of angle of inclination.
    (A) Statement–I is true, Statement–II is true ; Statement–II is correct explanation for Statement–I.
    (B) Statement–I is true, Statement–II is true ; Statement–II is NOT a correct explanation for statement–I.
    (C) Statement–I is true, Statement–II is false.
    (D) Statement–I is false, Statement–II is true.

10. **Statement–I** : Two particles of different mass, are projected with same velocity at same angles. The maximum height attained by both the particles will be same.
    because
    Statement–II : The maximum height of projectile is independent of particle mass
    (A) Statement–I is true, Statement–II is true ; Statement–II is correct explanation for Statement–I.
    (B) Statement–I is true, Statement–II is true ; Statement–II is NOT a correct explanation for statement–I.
    (C) Statement–I is true, Statement–II is false.
    (D) Statement–I is false, Statement–II is true.

11. **Statement–I** : The speed of a body can be negative.
    because
    Statement–II : If the body is moving in the opposite direction of positive motion, then its speed is negative.
    (A) Statement–I is true, Statement–II is true ; Statement–II is correct explanation for Statement–I.
    (B) Statement–I is true, Statement–II is true ; Statement–II is NOT a correct explanation for statement–I.
    (C) Statement–I is true, Statement–II is false.
    (D) Both Statement-I and Statement-II are false.

12. **Statement–I** : A positive acceleration can be associated with a 'slowing down' of the body.
    because
    Statement–II : The origin and the positive direction of an axis are a matter of choice.
    (A) Statement–I is true, Statement–II is true ; Statement–II is correct explanation for Statement–I.
    (B) Statement–I is true, Statement–II is true ; Statement–II is NOT a correct explanation for statement–I.
    (C) Statement–I is true, Statement–II is false.
    (D) Statement–I is false, Statement–II is true.

13. **Statement–I** : In a free fall, the initial velocity of a body may or may not be zero.
    because
    Statement–II : A heavy body falls at a faster rate as compared to a lighter body.
    (A) Statement–I is true, Statement–II is true ; Statement–II is correct explanation for Statement–I.
    (B) Statement–I is true, Statement–II is true ; Statement–II is NOT a correct explanation for statement–I.
    (C) Statement–I is true, Statement–II is false.
    (D) Statement–I is false, Statement–II is true.

14. **Statement–I** : Graph (1) represent one dimensional motion of a particle. While graph (2) can not represent 1–D motion of the particle. (here x is position and t is time)

(1) (2)

    because

Statement–II : Particle can have only one position at an instant.

(A) Statement–I is true, Statement–II is true ; Statement–II is correct explanation for Statement–I.

(B) Statement–I is true, Statement–II is true ; Statement–II is NOT a correct explanation for statement–I.

(C) Statement–I is true, Statement–II is false.

(D) Statement–I is false, Statement–II is true.

15. **Statement–I** : When a body is dropped or thrown horizontally from the same height, it would reach the ground at the same time.

because

Statement–II : Horizontal velocity has no effect on the vertical direction.

(A) Statement–I is true, Statement–II is true ; Statement–II is correct explanation for Statement–I.

(B) Statement–I is true, Statement–II is true ; Statement–II is NOT a correct explanation for statement–I.

(C) Statement–I is true, Statement–II is false.

(D) Statement–I is false, Statement–II is true.

(E) Both Statement–I and Statement–II are false.

16. **Statement–I** : When the direction of motion of a particle moving in a circular path is reversed the direction of radial acceleration still remains the same (at the given point).

because

Statement–II : Particle revolves on circular path in any direction such as clockwise or anticlockwise the direction of radial acceleration is always towards the centre of the circular path.

(A) Statement–I is true, Statement–II is true ; Statement–II is correct explanation for Statement–I.

(B) Statement–I is true, Statement–II is true ; Statement–II is NOT a correct explanation for statement–I.

(C) Statement–I is true, Statement–II is false.

(D) Statement–I is false, Statement–II is true.

17. **Statement–I** : A cyclist must adopt a zig–zag path while ascending a steep hill.

because

Statement–II : The zig–zag path prevent the cyclist to slip down.

(A) Statement–I is true, Statement–II is true ; Statement–II is correct explanation for Statement–I.

(B) Statement–I is true, Statement–II is true ; Statement–II is NOT a correct explanation for statement–I.

(C) Statement–I is true, Statement–II is false.

(D) Statement–I is false, Statement–II is true.

18. **Statement–I** : Mountain roads rarely go straight up the slope.

because

Statement–II : Slope of mountains are large therefore more chances of vehicle to slip from roads.

(A) Statement–I is true, Statement–II is true ; Statement–II is correct explanation for Statement–I.

(B) Statement–I is true, Statement–II is true ; Statement–II is NOT a correct explanation for statement–I.

(C) Statement–I is true, Statement–II is false.

(D) Statement–I is false, Statement–II is true.

19. **Statement–I** : When a particle is thrown obliquely from the surface of the Earth, it always moves in a parabolic path, provided the air resistance is negligible.

because

Statement–II : A projectile motion is a two dimensional motion.

(A) Statement–I is true, Statement–II is true ; Statement–II is correct explanation for Statement–I.

(B) Statement–I is true, Statement–II is true ; Statement–II is NOT a correct explanation for statement–I.

(C) Statement–I is true, Statement–II is false.

(D) Statement–I is false, Statement–II is true.

COMPREHENSION BASED QUESTIONS

Comprehension # 1

Distance is a scalar quantity. Displacement is a vector quantity. The magnitude of displacement is always less than or equal to distance. For a moving body displacement can be zero but distance cannot be zero. Same concept is applicable regarding velocity and speed. Acceleration is the rate of change of velocity. If acceleration is constant, then equations of kinematics are applicable for one dimensional motion under the gravity in which air resistance is considered, then the value of acceleration depends on the density of medium. Each motion is measured with respect of frame of reference. Relative velocity may be greater/smaller to the individual velocities.

1. A particle moves from A to B. Then the ratio of distance to displacement is :-
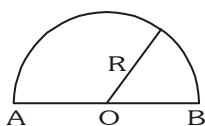

(A) $\dfrac{\pi}{2}$ (B) $\dfrac{2}{\pi}$ (C) $\dfrac{\pi}{4}$ (D) 1 : 1

2. A person is going 40m north, 30 m east and then $30\sqrt{2}$ m southwest. The net displacement will be :-

(A) 10 m towards east   (B) 10 m towards west

(C) 10 m towards south   (D) 10 m towards north

3. A particle is moving along the path $y = 4x^2$. The distance and displacement from x = 1 to x = 2 is (nearly) :-

(A) $\sqrt{150}$, 12   (B) $\sqrt{160}$, 20   (C) $\sqrt{200}$, 30   (D) $\sqrt{150}$, 20
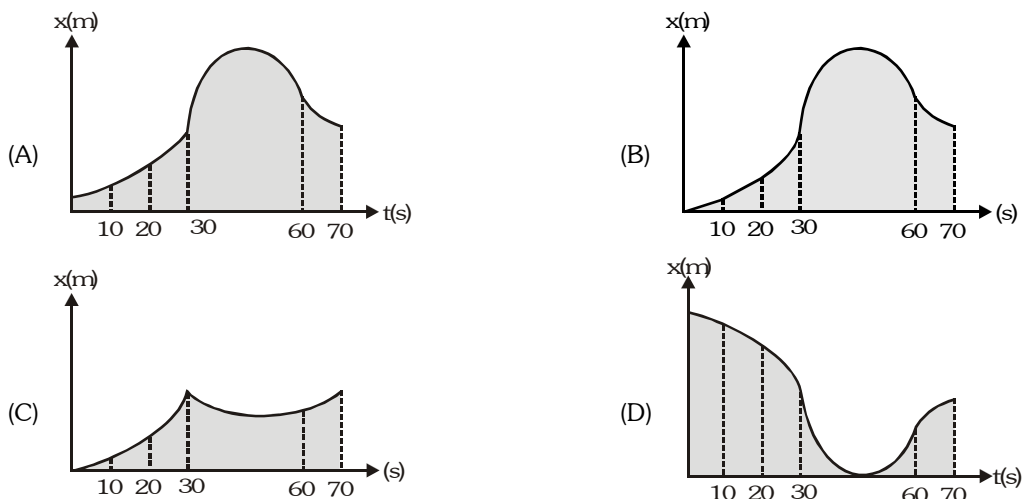
Comprehension # 2

A car is moving on a straight road. The velocity of the car varies with time as shown in the figure. Initially (at t = 0), the car was at x = 0, where, x is the position of the car at any time 't'.
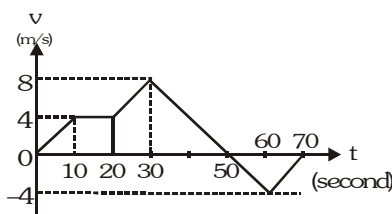
1. The variation of acceleration (a) with time (t) will be best represented by :-
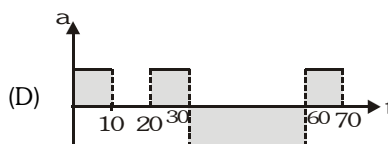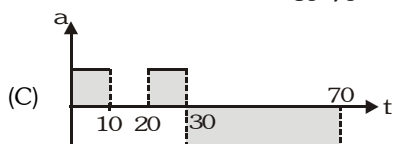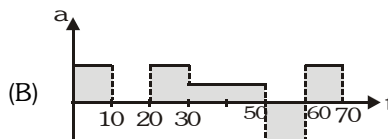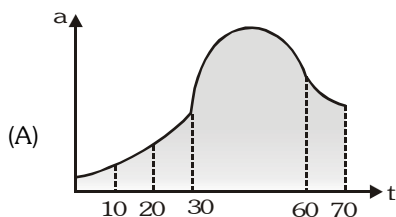
2.   The displacement time graph will be best represented by :-

(A)

(B)

(C)

(D)

3.   The maximum displacement from the starting position will be :-
(A) 200 m   (B) 250 m   (C) 160 m   (D) 165 m

4.   Average speed from t = 0 to t = 70 s will be :-

(A) $\dfrac{16}{7}$ m/s   (B) $\dfrac{24}{7}$ m/s   (C) $\dfrac{20}{7}$ m/s   (D) zero

5.   The time interval during which the car is retarding can be :-
(A) t = 50s to t = 70s   (B) t = 30s to t = 50s
(C) t = 30s to t = 60s   (D) t = 10s to t = 20s

Comprehension # 3

The trajectory of a projectile in a vertical plane is $y=\sqrt{3}\ x-2x^2$. [g = 10 m/s^2]
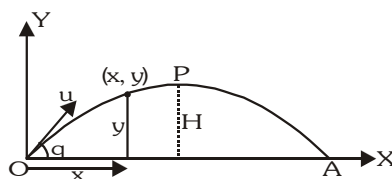
1.   Angle of projection θ is :-

(A) 30   (B) 60   (C) 45   (D) $\sqrt{3}$ rad

2.   Maximum height H is :-

(A) $\dfrac{8}{3}$ (B) $\dfrac{3}{8}$ (C) $\sqrt{3}$ (D) $\dfrac{2}{\sqrt{3}}$

3.   Range OA is :-

(A) $\dfrac{\sqrt{3}}{2}$ (B) $\dfrac{\sqrt{3}}{4}$ (C) $\sqrt{3}$ (D) $\dfrac{3}{8}$

4.   Time of flight of the projectile is :-

(A) $\sqrt{\dfrac{3}{10}}$ s   (B) $\sqrt{\dfrac{10}{3}}$ s   (C) 1s   (D) 2s

5.   Radius of curvature of the path of the projectile at the topmost point P is :-

(A) $\dfrac{1}{2}$ m   (B) 1m   (C) 4m   (D) $\dfrac{1}{4}$ m

Comprehension # 4

A student performs an experiment to determine how the range of a ball depends on the velocity with which it is projected. The "range" is the distance between the points where the ball lands and from where it was projected, assuming it lands at the same height from which it was projected. It each trial, the student uses the same baseball, and launches it at the same angle. Table shows the experimental results.

Trail	Launch speed (m/s)	Range (m)
1	10	8
2	20	31.8
3	30	70.7
4	40	122.5

Based on this data, the student then hypothesizes that the range, R, depends on the initial speed v_0, according to the following equation : $R = Cv_0^n$, where C is a constant and n is another constant.

1.   Based on this data, the best guess for the value of n is :-

(A) $\dfrac{1}{2}$ (B) 1   (C) 2   (D) 3

2.   The student speculates that the constant C depends on :-
(i) The angle at which the ball was launched (ii) The ball's mass (iii) The ball's diameter
If we neglect air resistance, then C actually depends on :-
(A) I only   (B) I and II   (C) I and III   (D) I, II and III

3.   The student performs another trial in which the ball is launched at speed 5.0 m/s. Its range is approximately:
(A) 1.0 m   (B) 2.0 m   (C) 3.0 m   (D) 4.0 m

Comprehension # 5

A circus wishes to develop a new clown act. Fig. (1) shows a diagram of the proposed setup. A clown will be shot out of a cannon with velocity v_0 at a trajectory that makes an angle $\theta = 45$ with the ground. At this angle, the clown will travel a maximum horizontal distance. The cannon will accelerate the clown by applying a constant force of 10,000N over a very short time of 0.24s. The height above the ground at which the clown begins his trajectory is 10m.
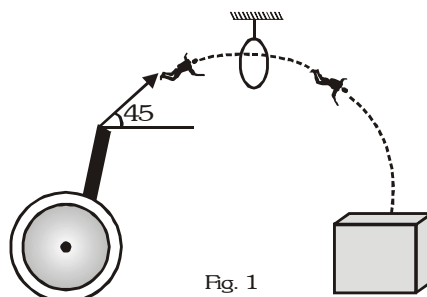

Fig. 1

A large hoop is to be suspended from the ceiling by a massless cable at just the right place so that the clown will be able to dive through it when he reaches a maximum height above the ground. After passing through the hoop he will then continue on his trajectory until arriving at the safety net. Fig. (2) shows a graph of the vertical component of the clown's velocity as a function of time between the cannon and the hoop. Since the velocity depends on the mass of the particular clown performing the act, the graph shows data for several different masses.
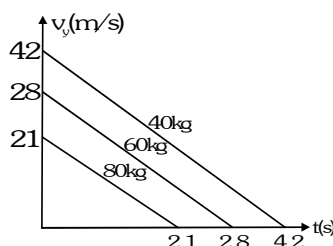

Fig. 2

E

1. If the angle the cannon makes with the horizontal is increased from 45 , the hoop will have to be :-
   (A) Moved farther away from the cannon and lowered
   (B) Moved farther away from the cannon and raised
   (C) Moved closer to the cannon and lowered
   (D) Moved closer to the cannon and raised

2. If the clown's mass is 80 kg, what initial velocity v_0 will he have as he leaves the cannon ?
   (A) 3 m/s
   (B) 15 m/s
   (C) 30 m/s
   (D) 300 m/s

3. The slope of the line segments plotted in figure 2 is a constant. Which one of the following physical quantities does this slope represent ?
   (A) – g
   (B) v_0
   (C) $y - y_0$
   (D) $\sin\theta$

4. From figure 2, approximately how much time will it take for clown with a mass of 60 kg to reach the safety net located 10 m below the height of the cannon ?
   (A) 4.3s
   (B) 6.4s
   (C) 5.9s
   (D) 7.2s

5. If the mass of a clown doubles, his initial kinetic energy, $mv_0^2/2$, will :-
   (A) Remain the same
   (B) Be reduce to half
   (C) Double
   (D) Four times

6. If a clown holds on to hoop instead of passing through it, what is the position of the cable so that he doesn't hit his head on the ceiling as he swings upward ?

   (A) $\dfrac{2v_0^2}{g}$
   (B) $\dfrac{v_0^2}{g}$
   (C) $\dfrac{v_0^2}{2g}$
   (D) $\dfrac{v_0^2}{4g}$

Comprehension # 6

When a particle is undergoing motion, the displacement of the particle has a magnitude that is equal to or smaller than the total distance travelled by the particle. In many cases the displacement of the particle may actually be zero, while the distance travelled by it is non–zero. Both these quantities, however depend on the frame of reference in which motion of the particle is being observed. Consider a particle which is projected in the earth's gravitational field, close to its surface, with a speed of $100\sqrt{2}$ m/s, at an angle of 45 with the horizontal in the eastward direction. Ignore air resistance and assume that the acceleration due to gravity is 10 m/s².

1. The motion of the particle is observed in two different frames : one in the ground frame (A) and another frame (B), in which the horizontal component of the displacement is always zero. Two observers located in these frames will agree on :-
   (A) The total distance travelled by the particle
   (B) The horizontal range of the particle
   (C) The maximum height risen by the particle
   (D) None of the above

2. "A third observer (C) close to the surface of the earth reports that particle is initially travelling at a speed of 100 √2 m/s making on angle of 45 with the horizontal, but its horizontal motion is northward". The third observer is moving in :-
   (A) The south–west direction with a speed of 100 √2 m/s
   (B) The south–east direction with a speed of 100 √2 m/s
   (C) The north–west direction with a speed of 100 √2 m/s
   (D) The north–east direction with a speed of 100 √2 m/s

3. There exists a frame (D) in which the distance travelled by the particle is a minimum. This minimum distance is equal to :-
   (A) 2 km
   (B) 1 km
   (C) 0 km
   (D) 500 m

4. Consider an observer in frame D (of the previous question), who observes a body of mass 10 kg accelerating in the upward direction at 30 m/s² (w.r.t. himself). The net force acting on this body, as observed from the ground is :-

(A) 400 N in the upward direction   (B) 300 N in the upward direction

(C) 200 N in the upward direction   (D) 500 N in the upward direction

Comprehension # 7

A projectile is projected with some initial velocity and some initial angle of projection. A wind is also blowing, due to which constant horizontal retardation a is imparted to the particle in the plane of motion. It is found that, the particle is **at same height at two different time** t_1 & t_2 and particle is at same horizontal distance at two different time t_3 & t_4.

1. Angle of projection of particle is :–

(A) $\tan^{-1}\left(\dfrac{t_1 + t_2}{t_3 + t_4}\right)$ (B) $\tan^{-1}\left[\dfrac{a(t_1 + t_2)}{g(t_3 + t_4)}\right]$ (C) $\tan^{-1}\left[\dfrac{g(t_1 + t_2)}{a(t_3 + t_4)}\right]$ (D) None of these

2. Maximum height of the particle is :–

(A) $\dfrac{g}{8}(t_1 + t_2)^2$ (B) $\dfrac{g}{4}(t_1 + t_2)^2$ (C) $\dfrac{g}{2}(t_1 + t_2)^2$ (D) None of these

**3.** Range of the projectile is :–

(A) $\dfrac{1}{2}g(t_1 + t_2)^2$ (B) $\dfrac{1}{2}g(t_1 + t_2)(t_3 + t_4 - t_1 - t_2)$ (C) $\dfrac{1}{2}g(t_3 + t_4 - t_1 - t_2)^2$ (D) can't determined

MISCELLANEOUS TYPE QUESTION	ANSWER KEY				EXERCISE –3

- **True / False**

1. T	**2.** T	**3.** T	**4.** T	**5.** T	**6.** T
7. F	**8.** T	**9.** F	**10.** T	**11.** F	**12.** T **13.** T

- **Fill in the Blanks**

  1. $(2 + \sqrt{2})$ t   **2.** 60⁰, 2ms⁻¹ **3.** 4s, 30⁰, 15 m

  4. Straight line   **5.** 60⁰, $\tan^{-1}\left(\sqrt{\dfrac{3}{2}}\right)$

- **Match the Column**

  1. (A) –q, (B)– p, q (C) –p, r, (D) –r, s

  2. (A) –p, (B)–v, (C) –s, (D), –q, (E) – u, (F) –t, (G) – r

  3. (A) –r, (B) –p, (C)–r (D)–s

  4. (A)–r, (B) –q, (C) –r (D) –p

  5. (A)–r, (B) –p, (C) –s, (D) –q

  6. (A) -s, (B)-r, (C)-q

- **Assertion – Reason Questions**

1. A	**2.** D	**3.** D	**4.** D	**5.** B	**6.** A
7. A	**8.** A	**9.** C	**10.** A	**11.** D	**12.** A
13. C	**14.** A	**15.** B	**16.** A	**17.** A	**18.** A
19. D					

- **Comprehension Based Questions**

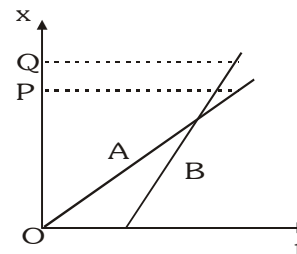|					
Comprehension #1 :	**1.** (A)	**2.** (D)	**3.** (A)		
Comprehension #2 :	**1.** (D)	**2.** (B)	**3.** (A)	**4.** (B)	**5.** (C)
Comprehension #3 :	**1.** (B)	**2.** (B)	**3.** (A)	**4.** (A)	**5.** (D)
Comprehension #4 :	**1.** (C)	**2.** (A)	**3.** (B)		
Comprehension #5 :	**1.**(D)	**2.** (C)	**3.** (A)	**4.** (C)	**5.** (B) **6.** (D)
Comprehension #6 :	**1.** (C)	**2.** (B)	**3.** (C)	**4.** (C)	
Comprehension #7 :	**1.** (C)	**2.** (A)	**3.** (B)		

E

EXERCISE–04 [A]

CONCEPTUAL SUBJECTIVE EXERCISE

1. For shown situation in which interval is the average speed greatest ? (Given each interval is of equal duration)
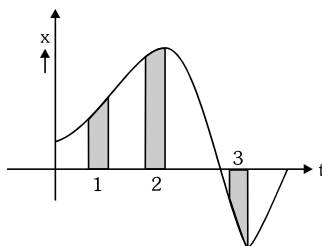
2. The position–time (x–t) graphs for two children A and B returning from their school O to their homes P and Q respectively are shown in fig. Choose correct entries in the brackets below :
   (i)   (A/B) lives closer to the school than (B/A)
   (ii) (A/B) starts from the school earlier than (B/A)
   (iii) (A/B) walks faster than (B/A)
   (iv) A and B reach home at the (same / different) time
   (v)   (A/B) overtakes (B/A) on the road (once/ twice).

3. A particle is moving along x – axis with acceleration $a = a_0 (1 - t/T)$ where a_0 and T are constants. The particle at t = 0 has zero velocity. Calculate the average velocity between t = 0 and the instant when a = 0.

4. A body moving with uniform acceleration, covers a distance of 20 m in the 7th second and 24 m in the 9th second. How much shall it cover in 15th second ?

5. A lift accelerates downwards from rest at rate of 2 m/s^2, starting 100 m above the ground. After 3 sec, an object falls out of the lift. Which will reach the ground first ? What is the time interval between their striking the ground ?

6. A parachutist after bailing out falls 52 m without friction . When the parachute opens, she decelerates at 2.1 ms^{-2} & reaches the ground with a speed of 2.9 ms^{-1} .
   (i) How long has been the parachutist in the air ?   (ii) At what height did the fall begin ?

7. A train, travelling at 20 km/hr is approaching a platform. A bird is sitting on a pole on the platform. When the train is at a distance of 2 km from pole, brakes are applied which produce a uniform deceleration in it. At that instant the bird flies towards the train at 60 km/hr and after touching the nearest point on the train flies back to the pole and then flies towards the train and continues repeating itself. Calculate how much distance will the bird have flown before the train stops ?

8. A driver travelling at speed 36 kmh^{-1} sees the light turn red at the intersection. If his reaction time is 0.6s, and then the car can deaccelerate at 4ms^{-2}. Find the stopping distance of the car.

9. A ball is thrown vertically upwards with a velocity of 20 ms^{-1} from the top of a tower. The height of the tower is 25 m from the ground.
   (i) How high will the ball rise ?
   (ii) How long will it be before the ball hits the ground ? (Take g = 10 ms^{-2})

10. A balloon is going upwards with a constant velocity 15 m/s. When the balloon is at 50 m height, a stone is dropped outside from the balloon. How long will stone take to reach at the ground ? (take g = 10 m/s^2)

11. A train moves from one station to another in two hours time. Its speed during the motion is shown in the graph. Calculate
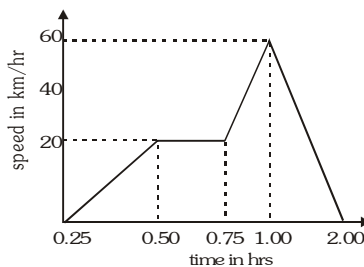
(i) Maximum acceleration during the journey .

(ii) Distance covered during the time interval from 0.75 hour to 1 hour .

12. A particle starts motion from rest and moves along a straight line. Its acceleration–time graph is shown. Find out speed of particle at t = 2s and at t = 3s.
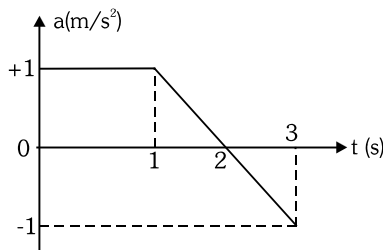

13. Two cars travelling towards each other on a straight road at velocity 10 m/s and 12 m/s respectively. When they are 150 metre apart, both drivers apply their brakes and each car decelerates at 2 m/s² until it stops. How far apart will they be when they have both come to a stop ?

14. Two trains A and B 100 m and 60 m long are moving in opposite directions on the parallel tracks. The speed of shorter train is 3 times that of the longer one. If the train take 4 seconds to cross each other then find the velocities of the trains ?

15. In a harbour, wind is blowing at the speed of 72 km/hr and the flag on the mast of a boat anchored in the harbour flutters along the N – E direction. If the boat starts moving at a speed of 51 km/hr to the north, what is the direction of flag on the mast of the boat ?

16. Two motor cars start from A simultaneously & reach B after 2 hour . The first car travelled half the distance at a speed of $v_1 = 30$ km hr^{-1} & the other half at a speed of $v_2 = 60$ km hr^{-1} . The second car covered the entire distance with a constant acceleration . At what instant of time, were the speeds of both the vehicles same ? Will one of them overtake the other enroute ?

17. 'n' number of particles are located at the vertices of a regular polygon of n sides having the edge length 'a'. They all start moving simultaneously with equal constant speed 'v' heading towards each other all the time. How long will the particles take to collide ?

18. A man crosses a river in a boat. If he crosses the river in minimum time he takes 10 minutes with a horizontal drift 120 m. If he crosses the river taking shortest path in 12.5 minutes then find width of the river, velocity of the boat w.r.t. water and speed of flow of river.

19. A particle is projected with a speed v and an angle θ to the horizontal. After a time t, the magnitude of the instantaneous velocity is equal to the magnitude of the average velocity from 0 to t. Find t.

20. A projectile is thrown with speed u making angle θ with horizontal at t =0. It just crosses the two points at equal height at time t=1 s and t = 3sec respectively. Calculate maximum height attained by it. (g=10m/s²)

21. A particle is projected horizontally as shown from the rim of a large hemispherical bowl. The displacement of the particle when it strikes the bowl the first time is R. Find the velocity of the particle at that instant and the time taken.

E
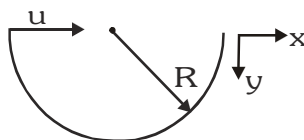
22. A food package was dropped from an aircraft flying horizontally. 6 s before it hit the ground, it was at a height of 780 m, and had travelled a distance of 1 km horizontally. Find the speed and the altitude of the aircraft.

23. A Bomber flying upward at an angle of 53° with the vertical releases a bomb at an altitude of 800 m . The bomb strikes the ground 20s after its release . Find :[Given sin 53 = 0.8 ; g = 10 ms⁻²]
(i) The velocity of the bomber at the time of release of the bomb .
(ii) The maximum height attained by the bomb .
(iii) The horizontal distance travelled by the bomb before it strikes the ground
(iv) The velocity (magnitude & direction) of the bomb just when it strikes the ground .

24. A body falls freely from some altitude H. At the moment the first body starts falling another body is thrown from the earth's surface which collides with the first at an altitude h = H/2 . The horizontal distance is ℓ. Find the initial velocity and the angle at which it was thrown.
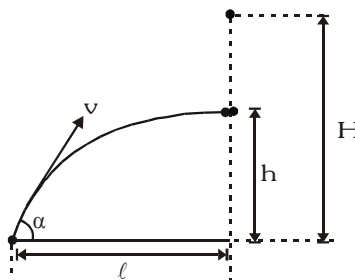

25. Two particles are projected from the two towers simultaneously, as shown in the figure. What should be value of 'd' for their collision.
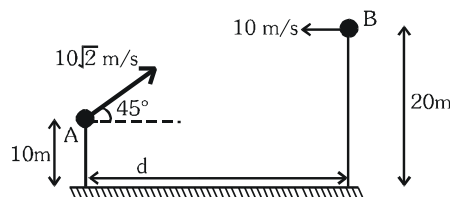

26. Calculate the relative acceleration of A w.r.t. B if B is moving with acceleration a_0 towards right.
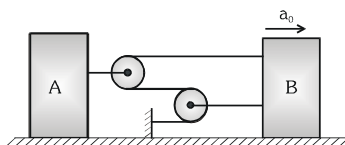

27. A ring rotates about z axis as shown in figure. The plane of rotation is xy.

At a certain instant the acceleration of a particle P (shown in figure) on the ring is $\left(6\tilde{i}-8\tilde{j}\right)m/s^2$. Find the angular acceleration of the ring & the angular velocity at that instant. Radius of the ring is 2m.
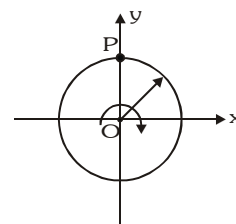
28. A particle is performing circular motion of radius 1 m. Its speed is v = (2t²) m/s. What will be magnitude of its acceleration at t = 1s.

29. Two particles A and B start at O and travel in opposite directions along the circular path at constant speed v_A = 0.7 m/s and v_B= 1.5 m/s respectively. Determine the time when they collide and the magnitude of the acceleration of B just before this happening. (radius = 5m)
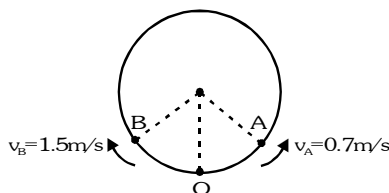
30. A particle is moving in a circular orbit with a constant tangential acceleration . After a certain time t has elapsed after the beginning of motion, the angle between the total acceleration a and the direction along the radius r becomes equal to 45 . What is the angular acceleration of the particle .

31. A particle moves clockwise in a circle of radius 1m with centre at (x,y) = (1m,0). It starts at rest at the origin at time t=0. Its speed increases at the constant rate of $\left(\dfrac{\pi}{2}\right)$ m/s^2. (i) How long does it take to travel halfway around the circle? (ii) What is the speed at that time?

32. Figure shows the total acceleration and velocity of a particle moving clockwise in a circle of radius 2.5m at a given instant of time. At this instant, Find :(i) the radial acceleration, (ii) the speed of the particle and (iii) its tangential acceleration.
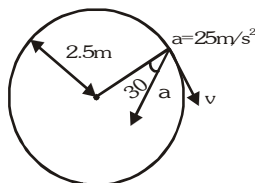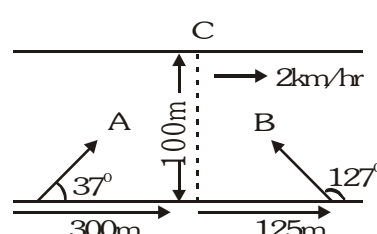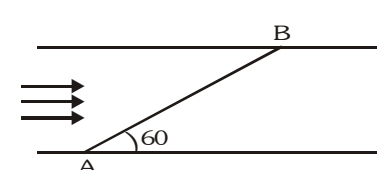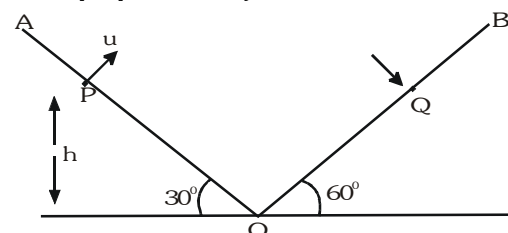

33. Two particles A and B move anticlockwise with the same speed v in a circle of radius R and are diametrically opposite to each other. At t=0, A is given a constant acceleration (tangential) a_t = $\dfrac{72v^2}{25\pi R}$. Calculate the time in which A collides with B, the angle traced by A, its angular velocity and radial acceleration at the time of collision.

CONCEPTUAL SUBJECTIVE EXERCISE	ANSWER KEY	EXERCISE–4(A)

1.   3
2.   (i) A, B (ii) A, B (iii) B, A (iv) same (v) B, A, once
3. $a_0 T/3$
4.   36 m
5.   object, 3.3 s
6.   (i) 17.1s (ii) 293.8 m
7.   12 km
8.   18.5 m
9.   (i) 20 m (ii) 5s
10.   5s
11.   **(i) 160 km/hr^2** (ii) 10 km
12.   1.5 m/s, 1 m/s
13.   89m
14. v_A = 10 ms^{-1}, v_B = 30 ms^{-1}
15.   east
16.   0.75 hr, 1.5 hr after the moment of departure,No overtaking
17. $\dfrac{a}{v\left(1-\cos\dfrac{2\pi}{n}\right)}$
18.   200m, v_{boat}= 1.20 km/hr, v_{water} = 0.72 km/hr,
19. $\dfrac{4}{3}\dfrac{v\sin\theta}{g}$
20.   20 m
21. $u\tilde{i}+\sqrt{\sqrt{3}Rg}\,\tilde{j}$, $\sqrt{\dfrac{\sqrt{3}R}{g}}$
22.   360 km/hr, 1.28 km
23. (i) 100 m/s (ii) 980 m (iii) 1600 m (iv) $\left(80\tilde{i}-140\tilde{j}\right)$
24. $v_0 = \sqrt{gH\left(1+\dfrac{\ell^2}{H^2}\right)}$, $\tan\alpha = \dfrac{H}{\ell}$ 25. 20 m
26. $\dfrac{a_0}{2}$ 27. $-3\tilde{k}$ rad/s^2 , $-2\tilde{k}$ rad/s
28. $4\sqrt{2}$ ms^{-2} 29. 14.3s, 0.45 ms^{-2}
30. $\dfrac{1}{t^2}$
31. (i) t= 2s, (ii) 3.14 m/s
32. (i) $25\dfrac{\sqrt{3}}{2}$ m/s^2 (ii) $\left(125\dfrac{\sqrt{3}}{4}\right)^{1/2}$ m/s (iii) $\dfrac{25}{2}$ m/s^2
33. $\dfrac{5\pi R}{6v}$, $\dfrac{11\pi}{6}$, $\dfrac{17v}{5R}$, $\dfrac{289v^2}{25R}$

EXERCISE–04 [B] BRAIN STORMING SUBJECTIVE EXERCISE

1. Two towns A and B are connected by a regular bus service with a bus leaving in either direction every T minutes. A man cycling with a speed of 20 km h$^-$ in the direction A to B notices that a bus goes past him every 18 min. in the direction of his motion, and every 6 min. in the opposite direction. What is the period T of the bus service and with what speed (assumed constant) do the buses ply on the road ?

2. The brakes of a train which is travelling at 30 m/s are applied as the train passes point A. The brakes produce a constant retardation of magnitude 3 λ m/s^2 until the speed of the train is reduced to 10 m/s. The train travels at this speed for a distance and is then uniformly accelerated at λ m/s^2 until it again reaches a speed of 30 m/s as it passes point B . The time taken by the train in travelling from A to B, a distance of 4 km, is 4 min. Sketch the speed time graph for this motion and calculate :-
   (i) The value of λ (ii) Distance travelled at 10 m/s .

3. A ship is moving at a constant speed of 10 km/hr in the direction of the unit vector $\tilde{i}$. Initially, its position vector, relative to a fixed origin is $10\left(-\tilde{i}+\tilde{j}\right)$ where $\tilde{i}\,\&\,\tilde{j}$ are perpendicular vectors of length 1 km . Find its position vector relative to the origin at time t hours later. A second ship is moving with constant speed u km/hr parallel to the vector $\tilde{i}+2\tilde{j}$ and is initially at the origin .

   (i) If u=$10\sqrt{5}$ km / h . Find the minimum distance between the ships and the corresponding value of t
   (ii) Find the value of u for which the ships are on a collision course and determine the value of t at which the collision would occur if no avoiding action were taken .

4. A balloon starts ascending from the ground at a constant speed of 25 m/s. After 5 s, a bullet is shot vertically upwards from the ground.
   (i) What should be the minimum speed of the bullet so that it may reach the balloon ?
   (ii) The bullet is shot at twice the speed calculated in (i). Find the height at which it passes the balloon.

5. Two bodies move towards each other in a straight line at initial velocities v_1 & v_2 & with constant accelerations a_1 & a_2 directed against the corresponding velocities at the initial instant . What must be the maximum initial separation ℓ_{max} between the bodies for which they meet during the motion ?

6. A helicopter takes off along the vertical with an acceleration of 3 m/sec & zero initial velocity . In a certain time , the pilot switches off the engine . At the point of take–off, the sound dies away in 30 sec. Determine the velocity of the helicopter at the moment when its engine is switched off, assuming the velocity of sound is 320 m/s.

7. Two swimmers start a race. One who reaches the point C first on the other bank wins the race. A makes his strokes in a direction of 37^0 to the river flow with velocity 5km/hr relative to water. B makes his strokes in a direction 127^0 to the river flow with same relative velocity. River is flowing with speed of 2km/hr and is 100m wide. Who will win the race? Compute the time taken by A and B to reach the point C if the speeds of A and B on the ground are 8 km/hr and 6 km/hr respectively.

8. A swimmer starts to swim from point A to cross a river. He wants to reach point B on the opposite side of the river. The line AB makes an angle 60 with the river flow as shown. The velocity of the swimmer in still water is same as that of the water
   (i) In what direction should he try to direct his velocity? Calculate angle between his velocity and river velocity.
   (ii) Find the ratio of the time taken to cross the river in this situation to the minimum time in which he can cross this river.

9. Hailstones falling vertically with speed of 10 m/s hit the windscreen of a moving car and rebound elastically . Find the velocity of the car if the driver find the hailstones rebound vertically after striking . Windscreen makes an angle 30 with the horizontal.

10. A shell is fired from a point O at an angle of 60 with a speed of 40 m/s & it strikes a horizontal plane through O, at a point A . The gun is fired a second time with the same angle of elevation but a different speed v . If it hits the target which starts to rise vertically from A with a constant speed $9\sqrt{3}$ m/s at the same instant as the shell is fired, find v .

11. Two inclined planes OA and OB having inclinations 30^0 and 60^0 respectively, intersect each other at O as in figure. A particle is projected from point P with velocity u = $10\sqrt{3}$m/s along a direction perpendicular to plane OA. If the particle strikes the plane OB perpendicularly at Q. Calculate

    (i) Time of flight.

    (ii) Velocity with which particle strikes the plane OB.

    (iii) Vertical height of P from O.

    (iv) Maximum height from O attained by the particle .

    (v) Distance PQ.

12. A stone is projected from the point of a ground in such a direction so as to hit a bird on the top of a telegraph post of height h and then attain the maximum height 2h above the ground. If at the instant of projection, the bird were to fly away horizontally with a uniform speed, find the ratio between the horizontal velocities of the bird and the stone, if the stone still hits the bird while descending.

13. A projectile is launched at an angle α from a cliff of height H above the sea level. If it falls into the sea at a distance D from the base of the cliff, show that its maximum height above the sea level is $\left[H+\dfrac{D^{2}\tan^{2}\alpha}{4\left(H+D\tan\alpha\right)}\right]$.

14. A particle is projected with a velocity $2\sqrt{ag}$ so that it just clears two walls of equal height 'a'. which are at a distance 2a apart. Show that the time of passing between the walls is $2\sqrt{a/g}$.

BRAIN STORMING SUBJECTIVE EXERCISE	ANSWER KEY	EXERCISE–4(B)

1. 9 min, 40 km hr^{-1}

2. (i)$\lambda=\dfrac{1}{6}$, (ii) 800m

3. $\vec{s}=10(t-1)\tilde{i}+10\tilde{j}$ (a) t = $\dfrac{1}{2}$h,10km (b) $\dfrac{10\sqrt{5}}{2}$, t = 2 hr

4. 75 ms^{-1}, (437.5 ± 62.5 $\sqrt{21}$)m

5. $\dfrac{\left(v_{1}+v_{2}\right)^{2}}{2\left(a_{1}+a_{2}\right)}$

6. 80 ms^{-1}

7. B, t_A = 165 s, t_B = 150 s

8. (a) 120^0 (b) 2/ $\sqrt{3}$

9. 10 $\sqrt{3}$ ms^{-1}

10. 50 ms^{-1}

11. (i) 2s (ii) 10 ms^{-1} (iii) 5m(iv) 16.25 m (v) 20 m

12. $\dfrac{2}{\sqrt{2}+1}$

EXERCISE–05 [A]   PREVIOUS YEAR QUESTIONS

1. A ball whose kinetic energy is E, is projected at an angle of 45 to the horizontal. The kinetic energy of the ball at the highest point of its flight will be-   **[AIEEE - 2002]**
   (1) E   (2) $E/\sqrt{2}$ (3) E/2   (4) zero

2. A boy playing on the roof of a 10 m high building throws a ball with a speed of 10 m/s at an angle of 30 with the horizontal. How far from the throwing point will the ball be at the height of 10 m from the ground ?
   [g = 10 m/s^2, sin30 = 1/2, cos 30 = $\sqrt{3}$ /2]   **[AIEEE - 2003]**
   (1) 5.20 m   (2) 4.33 m   (3) 2.60 m   (4) 8.66 m

3. A ball is thrown from a point with a speed v_0 at an angle of projection θ. From the same point and at the same instant, a person starts running with a constant speed $\frac{v_0}{2}$ to catch the ball. Will the person be able to catch the ball ? If yes, what should be the angle of projection ?   **[AIEEE - 2004]**
   (1) Yes, 60   (2) Yes, 30   (3) No   (4) Yes, 45

4. A projectile can have the same range R for two angles of projection. If t_1 and t_2 be the times of flights in the two cases, then the product of the two times of flights is proportional to-   **[AIEEE - 2005]**
   (1) R^2 (2) $\frac{1}{R^2}$ (3) $\frac{1}{R}$ (4) R

5. A particle is projected at 60 to the horizontal with a kinetic energy K. The kinetic energy at the highest point is-
   (1) K   (2) zero   (3) K/4   (4) K/2 **[AIEEE - 2007]**

6. A particle is moving with velocity $\vec{v}$ = K(y $\hat{i}$ + x $\hat{j}$), where K is a constant. The general equation for its path is: **[AIEEE - 2010]**
   (1) $y^2 = x^2$ + constant   (2) y = x^2 + constant
   (3) $y^2 = x$ + constant   (4) xy = constant

7. A water fountain on the ground sprinkles water all around it. If the speed of water coming out of the fountain is v, the total area around the fountain that gets wet is :-   **[AIEEE - 2011]**
   (1) $\frac{\pi}{2}\frac{v^4}{g^2}$ (2) $\pi\frac{v^2}{g^2}$ (3) $\pi\frac{v^2}{g}$ (4) $\pi\frac{v^4}{g^2}$

8. A boy can throw a stone up to a maximum height of 10 m. The maximum horizontal distance that the boy can throw the same stone up to will be :-   **[AIEEE - 2012]**
   (1) 20 m   (2) $20\sqrt{2}$ m   (3) 10 m   (4) $10\sqrt{2}$ m

9. A projectile is given an initial velocity of $(\hat{i}+2\hat{j})$ m/s, where $\hat{i}$ is along the ground and $\hat{j}$ is along the vertical. If g = 10 m/s², the equation of its trajectory is :   **[JEE (Main) - 2013]**
   (1) y = x – 5x²   (2) y = 2x – 5x²   (3) 4y = 2x – 5x²   (4) 4y = 2x – 25x²

PREVIOUS YEARS QUESTIONS			**ANSWER KEY**				EXERCISE–5(A)	
Que.	1	2	3	4	5	6	7	8	9
Ans.	3	4	1	4	3	1	4	1	2

EXERCISE–05 [B]   PREVIOUS YEAR QUESTIONS

MCQ'S WITH ONE CORRECT ANSWER

1.   In 1.0s, a particle goes from point A to point B, moving in a semicircle (see figure).
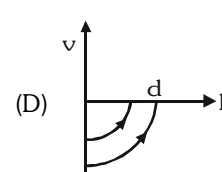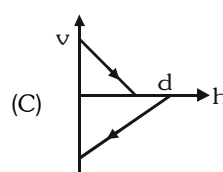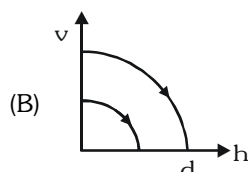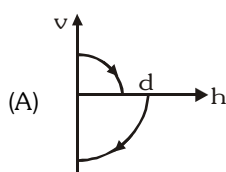   The magnitude of the average velocity is :–   **[IIT-JEE 1999]**
      (A) 3.14 m/s
      (B) 2.0 m/s
      (C) 1.0 m/s
      (D) zero

2.   A ball is dropped vertically from a height d above the ground. It hits the ground and bounces up vertically
      to a height d/2. Neglecting subsequent motion and air resistance, its velocity v varies with height h above
      the ground as :–   **[IIT-JEE 2000]**

      (A)   (B)   (C)   (D)

3.   A particle starts from rest. Its acceleration (a) versus time (t) is as shown in the figure. The maximum speed
      of the particle will be :–   **[IIT-JEE 2004]**
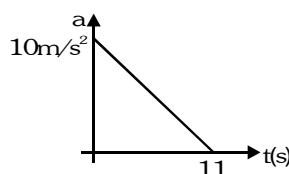
      (A) 110 m/s   (B) 55 m/s   (C) 550 m/s   (D) 660 m/s

4.   A small block slides without friction down an inclined plane starting from rest. Let s_n be the distance travelled
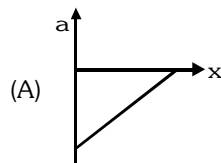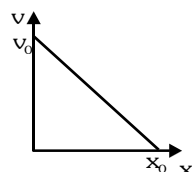
      from t = n − 1 to t = n. Then $\dfrac{s_n}{s_{n+1}}$ is :–   **[IIT-JEE 2004]**

      (A) $\dfrac{2n-1}{2n}$ (B) $\dfrac{2n+1}{2n-1}$ (C) $\dfrac{2n-1}{2n+1}$ (D) $\dfrac{2n}{2n+1}$

5.   The given graph shows the variation of velocity with displacement. Which one of the graph given below
      correctly represents the variation of acceleration with displacement :–   **[IIT-JEE 2005]**

      (A)   (B)   (C)   (D)
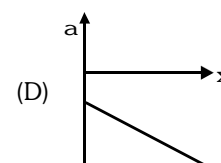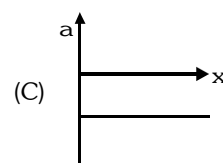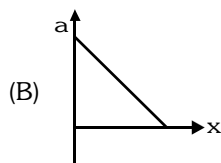
ASSERTION-REASONING TYPE QUESTIONS

1. **STATEMENT–I :** For an observer looking out through the window of a fast moving train, the nearby objects appear to move in the opposite direction to the train, while the distant objects appear to be stationary.

[IIT-JEE 2008]

and

STATEMENT-2 : If the observer and the object are moving at velocities $\vec{V}_1$ and $\vec{V}_2$ respectively with reference to a laboratory frame, the velocity of the object with respect to the observer is $\vec{V}_2 - \vec{V}_1$.

(A) STATEMENT-1 is True, STATEMENT-2 is True; STATEMENT-2 is a correct explanation for STATEMENT-1

(B) STATEMENT-1 is True, STATEMENT-2 is True; STATEMENT-2 is **NOT** a correct explanation for STATEMENT-1

(C) STATEMENT-1 is True, STATEMENT-2 is False

(D) STATEMENT-1 is False, STATEMENT-2 is True

MCQ'S WITH ONE OR MORE THAN ONE CORRECT ANSWER

1. The coordinates of a particle moving in a plane are given by x(t) = acos(pt) and y(t) = bsin(pt) where a, b (<a) and p are positive constants of appropriate dimensions. Then : **[IIT-JEE 1999]**

(A) The path of the particle is an ellipse.

(B) The velocity and acceleration of the particle are normal to each other at t = π/2p

(C) The acceleration of the particle is always directed towards a focus.

(D) The distance travelled by the particle in time interval t = 0 to t = $\dfrac{\pi}{2p}$ is a

SUBJECTIVE QUESTIONS

1. A large heavy box is sliding without friction down a smooth plane of inclination θ. From a point P on the bottom of the box, a particle is projected inside the box. The initial speed of the particle with respect to the box is u and the direction of projection makes an angle α with the bottom as shown in the figure.
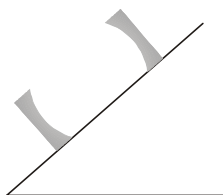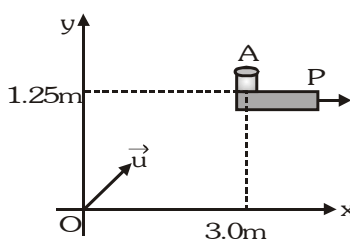
3. On a frictionless horizontal surface, assumed to be the x–y plane, a small trolley A is moving along a straight line parallel to the y–axis (see figure) with a constant velocity of $(\sqrt{3}-1)$ m/s. At a particular instant when the line OA makes an angle of 45 with the x–axis, a ball is thrown along the surface from the origin O. Its velocity makes on angle ϕ with the x–axis and it hits the trolly.
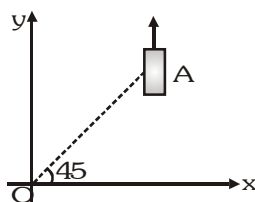
(i) The motion of the ball is observed from the frame of the trolley. Calculate the angle θ made by the velocity vector of the ball with the x–axis in this frame.

(ii) Find the speed of the ball with respect to the surface, if $\phi = \dfrac{4\theta}{3}$. **[IIT-JEE 2002]**

INTEGER TYPE QUESTION

1. A train is moving along a straight line with a constant acceleration 'a'. A boy standing in the train throws a ball forward with a speed of 10 m/s, at an angle of 60 to the horizontal. The boy has to move forward by 1.15 m inside the train to catch the ball back at the initial height. The acceleration of the train, in m/s², is **[IIT-JEE 2011]**

PREVIOUS YEARS QUESTIONS	ANSWER KEY				EXERCISE–5(A)
• *MCQ's with one correct answer*	1. (B)	2. (A)	3. (B)	4. (C)	5. (A)
• *Assertion-Reasoning*	1. (B)				
• *MCQ's with one or more than one correct answer*	1. A,B,C				
• *Subjective Questions*	1. (i) $\dfrac{u^2 \sin 2\alpha}{g\cos\theta}$ (ii) $v = \dfrac{u\cos(\alpha+\theta)}{\cos\theta}$		2. u=7.29 ms⁻¹, t = 1s		
	3. (i) 45^0 (ii) 2 ms⁻¹				
• *Integer Type Question*	1. 5				