SAMPLE CONTENT

HOLISTIC

MHT-CET

ROADMAP TO SUCCESS

2024

- Based on latest paper pattern
- Important Formulae & Shortcuts
- Subtopic wise segregation
- Classwork/Homework segregation
- Previous Years' Questions

PHYSICS (STD.XI)

Target Publications® Pvt. Ltd.

Textbook Chapter No.

03 Motion in a plane

Subtopics

Water fountain

This fountain of water is an example of projectile motion. The water falling through, describes an ellipse.

Formulae

1. Basic kinematical formulae:

i. Average speed $= \dfrac{\text{Total path length}}{\text{Total time interval}}$

$$= \frac{\text{Total distance}}{\text{Total time}} = \frac{x}{t}$$

ii. Instantaneous speed:

$$\vec{v} = \lim_{\Delta t \to 0} \frac{\Delta \vec{x}}{\Delta t} = \frac{d\vec{x}}{dt}$$

iii. Average velocity:

$$\vec{v}_{avg} = \frac{\text{Displacement}}{\text{Time interval}} = \frac{x_2 - x_1}{t_2 - t_1} = \frac{\Delta \vec{x}}{\Delta t}$$

iv. Acceleration:

$$a = \frac{\text{Change in velocity}}{\text{Time}} = \frac{d\vec{v}}{dt}$$

v. Average acceleration: $\vec{a}_{av} = \dfrac{\vec{v}_2 - \vec{v}_1}{t_2 - t_1} = \dfrac{\Delta \vec{v}}{\Delta t}$

vi. Instantaneous acceleration: $\vec{a}_{inst} = \lim\limits_{\Delta t \to 0} \dfrac{\Delta \vec{v}}{\Delta t} = \dfrac{d\vec{v}}{dt}$

2. Kinematic Equations of linear motion:

i. $\vec{v} = \vec{u} + \vec{a}t$

ii. $\vec{s} = \vec{u}t + \dfrac{1}{2}\vec{a}t^2$

iii. $v^2 = u^2 + 2\,\vec{a}\,.\,\vec{s}$

iv. $\vec{s} = \dfrac{(\vec{v} + \vec{u})}{2}t$

3. Relative velocity of a body A with respect to B:

i. $\vec{v}_{AB} = \vec{v}_A - \vec{v}_B$;

ii. $v = \sqrt{v_x^2 + v_y^2}$ (in magnitude)

4. Velocity of projectile:

i. $u_x = u \cos \theta$ (along horizontal)

ii. $u_y = u \sin \theta$ (along vertical)

5. Horizontal distance covered by projectile:
$x = (u \cos \theta) t$

6. Vertical distance of projectile:
$y = (u \sin \theta) t - \frac{1}{2} gt^2$

7. Equation of trajectory:
$y = x (\tan \theta) - \frac{gx^2}{2u^2 \cos^2 \theta}$

8. Maximum height: $H = \frac{u^2 \sin^2 \theta}{2g}$

9. Time of flight: $T = \frac{2u \sin \theta}{g}$

10. Time of ascent = Time of descent $= \frac{u \sin \theta}{g}$

11. Horizontal range: $R = \frac{u^2 \sin 2\theta}{g}$

12. Maximum horizontal range: $R_{max} = \frac{u^2}{g}$

13. Time period in uniform circular motion:
$T = \frac{2\pi r}{v}$

14. Angular speed in uniform circular motion:
$\omega = \frac{v}{r}$

15. Centripetal acceleration:
i. $\vec{a} = -\omega^2 \vec{r}$
ii. $a = \omega^2 r$ (in magnitude)

16. Centripetal force:
$F = m\omega^2 r = \frac{mv^2}{r} = m\omega v$

17. Time period of a conical pendulum:
$T = 2\pi \sqrt{\frac{l \cos \theta}{g}} = 2\pi \sqrt{\frac{h}{g}}$

Notes

1. If a body starts its motion from rest then the equations of motion become
i. $v = at$ ii. $s = \frac{1}{2} at^2$
iii. $v^2 = 2as$

2. If a body is thrown vertically upward then g is taken negative due to decrease in velocity. If the body falls downward velocity gradually increases hence g is positive.

3. Downward motion of free falling body
i. $v = u + gt$ ii. $h = ut + \frac{1}{2} gt^2$
iii. $v^2 = u^2 + 2gh$

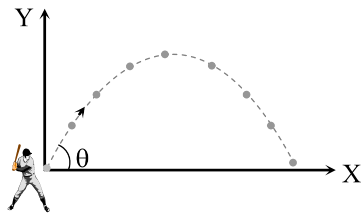
4. In vertical upward motion final velocity is zero at highest point. Thus in case of vertically upward motion
i. $u = -gt$ ii. $h = ut - \frac{1}{2} gt^2$
iii. $u^2 = -2gh$

5. For a ball dropped from height h, time taken to reach ground is given by
$t = \sqrt{\frac{2h}{g}}$

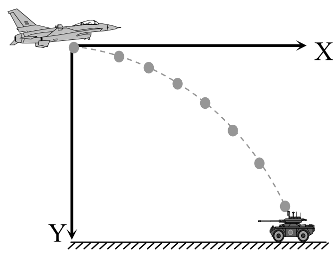
6. When two bodies A and B move towards each other, then relative velocity of A w.r.t, B is given by $\vec{v}_{AB} = \vec{v}_A + \vec{v}_B$

7. When two bodies move in the same direction then relative velocity of A w.r. t. B is given by
$\vec{v}_{AB} = \vec{v}_A - \vec{v}_B$

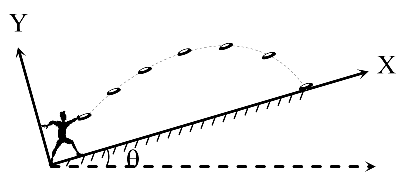
8. A projectile motion can be classified into three categories as follows:
i. Oblique projectile motion:



ii. Horizontal projectile motion:



iii. Projectile motion on an inclined plane:



9. Resultant velocity of projectile projected obliquely is given by
$v = \sqrt{{v_x}^2 + {v_y}^2}$

10. *When a projectile is projected at an angle 45°, the range is maximum and the height attained by the projectile is*

$$H = \frac{u^2}{4g} = \frac{R_{max}}{4}$$

11. *The height attained by a projectile is maximum, when θ = 90°.*

$$H_{max} = \frac{u^2}{4g}$$

12. *When the range of the projectile is maximum, the time of flight is*

$$T = 2t = \frac{\sqrt{2}u}{g}$$

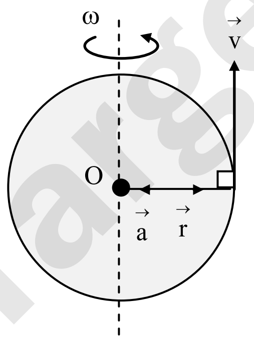
13. *The time of flight of the projectile is also largest for θ = 90°.*

$$T_{max} = \frac{2u}{g}$$

14. *In U.C.M., angular velocity* $\left(\vec{\omega}\right)$ *is only constant vector but angular acceleration* $\left(\vec{\alpha}\right)$ *and angular displacement* $\left(\vec{\theta}\right)$ *are variable vectors.*

15. *All the points on a rotating body in U.C.M. have same ω except centre as it is not rotating.*

16. *When a particle moves so that its position vector is given by* $\vec{r} = \cos\omega t\ \hat{i} + \sin\omega t\ \hat{j}$, *then the particle is performing uniform circular motion.*



Here,

Linear velocity is perpendicular to $\vec{r}$ *and linear acceleration is directed towards the centre.*

Mindbenders

1. If the two bodies are moving with unequal uniform velocities, then their position-time graphs must intersect each other.

2. The kinematic equations of motion cannot be applied to circular motion or simple harmonic motion.

3. A body may have zero velocity but can still accelerate.
eg.: When an object is thrown straight up, at the highest point, its velocity is zero and acceleration is 9.8 m/s^2 downward.

4. A projectile fired at an angle with horizontal returns to ground at the same angle and with the same velocity with which it is projected.

5. In practical situation, where the friction of air comes into the play, an object thrown upward has higher time of descent than time of ascent. i.e., $t_D > t_A$.

Shortcuts

1. To convert speed of km/h into m/s multiply given speed with $\frac{5}{18}$ and from m/s to km/h multiply with $\frac{18}{5}$.

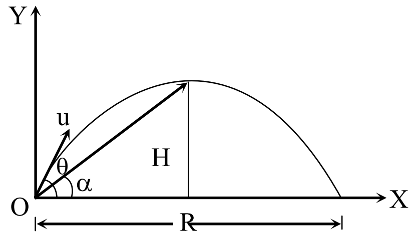
2. If a particle is accelerated for time t_1 with acceleration a_1 and for time t_2 with acceleration a_2 then average acceleration is $\vec{a}_{av} = \frac{\vec{a}_1 t_1 + \vec{a}_2 t_2}{t_1 + t_2}$

3. If a particle moves in two equal intervals of time at different speed v_1 and v_2 respectively, then $v_{av} = \frac{v_1 + v_2}{2}$

4. Horizontal range of projectile is same when angle of projection is
   i. θ and 90° − θ or
   ii. (45° + θ) and (45° − θ)

5. A ball is dropped from a building of height h and it reaches after t seconds on earth. From the same building if two balls are thrown (one upwards and other downwards) with the same velocity u and they reach the earth surface after t_1 and t_2 seconds respectively then
$t = \sqrt{t_1 t_2}$

6. The angle of elevation α of the highest point of the projectile and the angle of projection θ are related to each other as
$\tan\alpha = \frac{1}{2}\tan\theta$



7. In U.C.M., if central angle or angular displacement is given, then simply apply $dv = 2v\sin\frac{\theta}{2}$ to determine change in velocity.

Catapult

A catapult is a device used to launch a projectile to a great distance without the aid of explosive devices. The word itself means to hurl or toss downwards. Primitive catapults were designed to increase the range and penetrating power of missiles by strengthening the bow which propelled them.

Classwork

3.2 Rectilinear Motion

1. Select the incorrect statements from the following
   S1: Average velocity is path length divided by time interval.
   S2: In general, speed is greater than the magnitude of the velocity.
   S3: A particle moving in a given direction with a non-zero velocity can have zero speed.
   S4: The magnitude of average velocity is the average speed.
   (A) S2 and S3
   (B) S1 and S4
   (C) S1, S3 and S4
   (D) All four statements

2. **Assertion:** The average velocity of the object over an interval of time is either smaller than or equal to the average speed of the object over the same interval.
   Reason: Velocity is a vector quantity and speed is a scalar quantity.
   (A) Assertion is True, Reason is True; Reason is a correct explanation for Assertion
   (B) Assertion is True, Reason is True; Reason is not a correct explanation for Assertion
   (C) Assertion is True, Reason is False
   (D) Assertion is False, Reason is True.

3. Two particles A and B having different masses are projected from a tower with same speed. A is projected vertically upward and B vertically downward. On reaching the ground
   (A) velocity of A is greater than that of B.
   (B) velocity of B is greater than that of A.
   (C) both A and B attain the same velocity.
   (D) the particle with the larger mass attains higher velocity.

4. A person travelling in a straight line moves with a constant velocity v_1 for certain distance 'x' and with a constant velocity v_2 for next equal distance. The average velocity v is given by the relation.
   (A) $v = \sqrt{v_1 v_2}$
   (B) $\frac{1}{v} = \frac{1}{v_1} + \frac{1}{v_2}$
   (C) $\frac{2}{v} = \frac{1}{v_1} + \frac{1}{v_2}$
   (D) $\frac{v}{2} = \frac{v_1 + v_2}{2}$

5. A body travelling along a straight line path travels first half of the distance with a velocity $7 ms^{-1}$. During the travel time of the second half of the distance, first half time is travelled with a velocity $14\ ms^{-1}$ and the second half time is travelled with a velocity $21\ ms^{-1}$. Then the average velocity of the body during the journey is
   (A) $14\ ms^{-1}$
   (B) $10\ ms^{-1}$
   (C) $9\ ms^{-1}$
   (D) $12\ ms^{-1}$

6. Preeti reached the metro station and found that the escalator was not working. She walked up the stationary escalator in time t_1. On other days, if she remains stationary on the moving escalator, then the escalator takes her up in time t_2. The time taken by her to walk up on the moving escalator will be:
(A) $\frac{t_1+t_2}{2}$ (B) $\frac{t_1 t_2}{t_2-t_1}$
(C) $\frac{t_1 t_2}{t_2+t_1}$ (D) $t_1 - t_2$

7. A particle moves along x-axis obeying the equation x = t (t − 1)(t − 2), where x (in metres) is the position of the particle at any time t (in seconds). The displacement when the velocity of the particle is zero, is
(A) $-\frac{2}{3\sqrt{3}}$ m, $\frac{2}{3\sqrt{3}}$ m (B) $-\frac{5}{3\sqrt{3}}$ m, $\frac{5}{3\sqrt{3}}$ m
(C) −3 m, 3 m (D) −5 m, 5 m

8. If the velocity of a particle is $v = At + Bt^2$, where A and B are constants, then the distance travelled by it between 1 s and 2 s is
(A) $\frac{3}{2}A+\frac{7}{3}B$ (B) $\frac{A}{2}+\frac{B}{3}$
(C) $\frac{3}{2}A+4B$ (D) 3A + 7B

9. The displacement of a body along x-axis depends on time as $\sqrt{x} = t+1$. Then the velocity of body
(A) increases with time
(B) decreases with time
(C) independent of time
(D) none of these

10. The displacement of a particle moving in a straight line is given by the expression $x = At^3 + Bt^2 + Ct + D$ in metres, where 't' is in second and A, B, C and D are constants. The ratio between the initial acceleration and initial velocity is
(A) $\frac{2C}{B}$ (B) $\frac{2B}{C}$
(C) 2C (D) $\frac{C}{2B}$

11. An object moving with a speed of 6.25 m/s, is decelerated at a rate given by $\frac{dv}{dt} = -2.5\sqrt{v}$ where v is the instantaneous speed. The time taken by the object, to come to rest, would be
(A) 1s (B) 2s
(C) 4s (D) 8s

12. A particle is moving with constant acceleration and v_1, v_2 and v_3 are the average velocities of the particle in three successive intervals t_1, t_2 and t_3. Which of the following relations will be correct?
(A) $\frac{v_1-v_3}{v_2-v_3} = \frac{t_1-t_2}{t_2+t_3}$
(B) $\frac{v_1-v_2}{v_2-v_3} = \frac{t_1-t_2}{t_1-t_3}$
(C) $\frac{v_1-v_2}{v_2-v_3} = \frac{t_1-t_2}{t_2-t_3}$
(D) $\frac{v_1-v_2}{v_2-v_3} = \frac{t_1+t_2}{t_2+t_3}$

13. Two cars P and Q start from a point at the same time in a straight line and their positions are represented by $x_P(t) = at + bt^2$ and $x_Q(t) = ft - t^2$. At what time do the cars have the same velocity?
(A) $\frac{f-a}{2(1+b)}$ (B) $\frac{a-f}{1+b}$
(C) $\frac{a+f}{2(b-1)}$ (D) $\frac{a+f}{2(1+b)}$

14. A car moving with a velocity $6.25 ms^{-1}$ is decelerated with $2.5\sqrt{v}\ ms^{-2}$ ('v' is instantaneous velocity). Time taken by the car to come to rest is
(A) 2s (B) 3s
(C) 2.5s (D) 4s

15. A particle first accelerates from rest and then retards to rest during the time interval of 8s. If the retardation is 3 times the acceleration, then the time for which it accelerated is
(A) 2s (B) 3s
(C) 4s (D) 6s

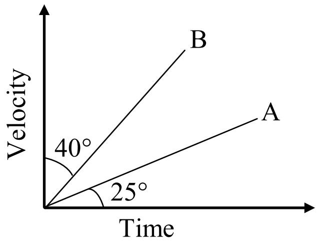
16. A car accelerates from rest with 2 m/s^2 on a straight line path and then comes to rest after applying brakes. Total distance travelled by the car is 100 m in 20 seconds. Then the maximum velocity attained by the car is
(A) 10 m/s (B) 20 m/s
(C) 15 m/s (D) 4 m/s

17. The velocity of an object moving in a straight line path is given as a function of time by $v = 6t - 3t^2$, where v is in ms^{-1}, t is in s. The average velocity of the object between t = 0 and t = 2 second is
(A) 0 (B) 3 ms^{-1}
(C) 2 ms^{-1} (D) 4 ms^{-1}

18. Consider a car initially at rest, starts to move along a straight road first with acceleration $5 m/s^2$, then with uniform velocity and finally, decelerating at $5 m/s^2$, before coming to a stop. Total time taken from start to end is t = 25s. If the average velocity during that time is 72 km/hr, the car moved with uniform velocity for a time of

(A) 15s (B) 30s (C) 155s (D) 2s

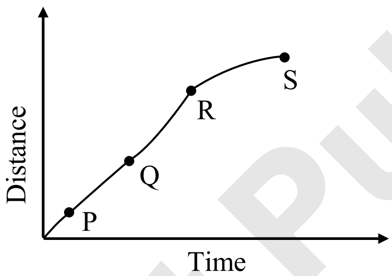
19. The velocity – time graph for two bodies A and B are shown. Then the acceleration of A and B are in the ratio



(A) sin 25° to sin 50° (B) tan 25° to tan 40°
(C) cos 25° to cos 50° (D) tan 25° to tan 50°

20. A particle shows distance-time curve as shown in the figure. The maximum instantaneous velocity of the particle is around the point

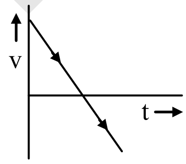
(A) P
(B) S
(C) R
(D) Q

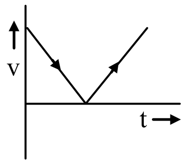


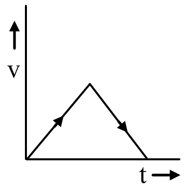
21. The nature of graph drawn for a freely falling body with time on the x-axis and speed on the y-axis is (Assuming initial speed to be zero)

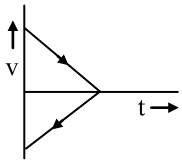
(A) A straight line with positive y-axis intercept.
(B) A straight line passing through origin.
(C) A parabola.
(D) A straight line parallel to y-axis with positive x-axis intercept.

22. A body is thrown vertically upwards. Which one of the following graphs correctly represent the velocity vs time?

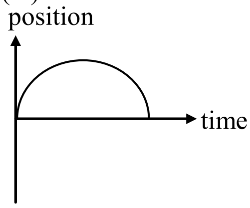
(A)


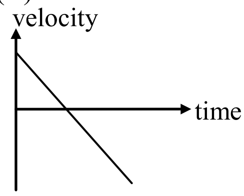
(B)


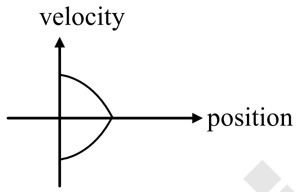
(C)


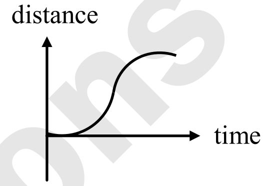
(D)


23. All the graphs below are intended to represent the same motion. One of them does it incorrectly. Pick it up.

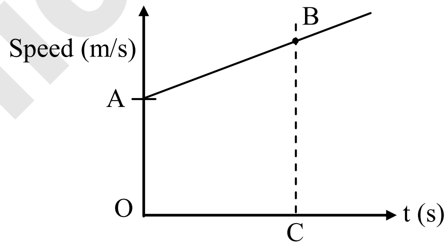
(A)


(B)


(C)


(D)


24. The speed versus time graph of a moving particle is shown in the following figure. If 'u' is the initial speed at t = 0, v is the speed at time t, 'a' is the acceleration and 's' is the distance covered in time 't', then total area OABC is best described using, (Assume O as origin)

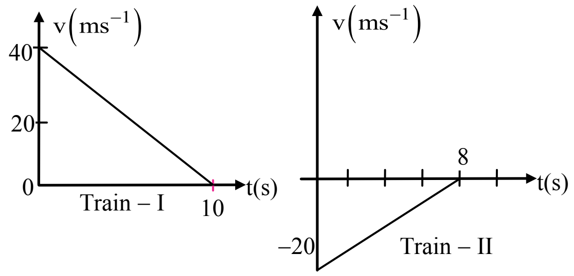


(A) $v = u + at$ (B) $s = ut + \frac{1}{2}at^2$
(C) $v^2 = u^2 + 2as$ (D) $v = at$

25. A toy car with charge q moves on a frictionless horizontal plane surface under the influence of a uniform electric field $\vec{E}$. Due to the force $q\vec{E}$, its velocity increases from 0 to 6 m/s in one second duration. At that instant the direction of the field is reversed. The car continues to move for two more seconds under the influence of this field. The average velocity and the average speed of the toy car between 0 to 3 seconds are respectively

(A) 2 m/s, 4 m/s
(B) 1 m/s, 3 m/s
(C) 1 m/s, 3.5 m/s
(D) 1.5 m/s, 3 m/s

26. Two trains, which are moving along different tracks in opposite direction, are put on the same track by mistake. On noticing the mistake, when the trains are 300 m apart the drivers start slowing down the trains. The graphs given below show decrease in their velocities as function of time. The separation between the trains when both have stopped is



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

27. A stone falls freely under gravity. It covers distances h_1, h_2 and h_3 in the first 5 seconds, the next 5 seconds and the next 5 seconds respectively. The relation between h_1, h_2 and h_3 is
(A) $h_1 = 2h_2 = 3h_3$
(B) $h_1 = \frac{h_2}{3} = \frac{h_3}{5}$
(C) $h_2 = 3h_1$ and $h_3 = 3h_2$
(D) $h_1 = h_2 = h_3$

28. A, B, C are points in a vertical line such that AB = BC. If a body falls freely from rest at A, and t_1 and t_2 are times taken to travel distances AB and BC, then ratio $\left(\frac{t_2}{t_1}\right)$ is
(A) $\sqrt{2} + 1$ (B) $\sqrt{2} - 1$
(C) $2\sqrt{2}$ (D) $\frac{1}{\sqrt{2}+1}$

29. 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 ms^{-2}. If he jumps out of the plane at a height of 2495 m and g = 10 ms^{-2}, then his velocity on reaching the ground will be
(A) 2.5 ms^{-1} (B) 7.5 ms^{-1}
(C) 5 ms^{-1} (D) 10 ms^{-1}

30. Two bodies of different masses m_a and m_b are dropped from two different heights a and b. The ratio of the time taken by the two to cover these distances are
(A) a : b (B) b : a
(C) $\sqrt{a} : \sqrt{b}$ (D) $a^2 : b^2$

31. A body falls freely for 10s. Its average velocity during this journey (take g = 10ms^{-2})
(A) 100 ms^{-1} (B) 10 ms^{-1}
(C) 50 ms^{-1} (D) 5 ms^{-1}

32. An object is thrown vertically upward with a speed of 30 m/s. The velocity of the object half a second before it reaches the maximum height is
(A) 4.9 m/s (B) 9.8 m/s
(B) 19.6 m/s (D) 25.1 m/s

33. Ball-1 is dropped from the top of a building from rest. At the same moment, ball-2 is thrown upward towards ball-1 with a speed 14 m/s from a point 21m below the top of building. How far will the ball-1 have dropped when it passes ball-2. (Assume g = 10 m/s^2)
(A) $\frac{45}{4}$ m (B) $\frac{52}{6}$ m
(C) $\frac{37}{2}$ m (D) $\frac{25}{2}$ m

34. From the top of a tower of height 'H', a body is thrown vertically upwards with a speed 'u'. Time taken by the body to reach the ground is '3' times the time taken by it to reach the highest point in its path. Then, the speed u is
(A) $\sqrt{gH}$ (B) $\sqrt{\frac{gH}{2}}$
(C) $\sqrt{\frac{2gH}{3}}$ (D) $\sqrt{\frac{gH}{3}}$

35. Points P, Q and R are in a vertical line such that PQ = QR. A ball at P is allowed to fall freely with zero initial speed. The ratio of the times of descent through PQ and QR is
(A) $1 : (\sqrt{2} + 1)$ (B) $1 : (\sqrt{2} - 1)$
(C) 1 : 2 (D) $1 : \sqrt{2}$

36. A person standing on the floor of an elevator drops a coin. The coin reaches the floor in time t_1 if the elevator is at rest and in time t_2 if the elevator is moving uniformly. Then
(A) $t_1 = t_2$
(B) $t_1 < t_2$ or $t_1 > t_2$ depending upon whether the lift is going up or down
(C) $t_1 < t_2$
(D) $t_1 > t_2$

37. The relative velocity of geostationary satellite with respect to the spinning motion of the earth is _______. **[MH CET 2013]**
(A) 0 m/s (B) 6 m/s
(C) 12 m/s (D) 14 m/s

3.3 Motion in Two Dimensions – motion in a Plan

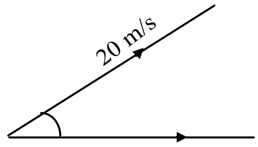
38. A particle moves so that its position vector is given by $\vec{r} = \cos\omega t\ \hat{x} + \sin\omega t\ \hat{y}$, where ω is a constant. Which of the following is true?
    (A) Velocity is perpendicular to $\vec{r}$ and acceleration is directed towards the origin.
    (B) Velocity is perpendicular to $\vec{r}$ and acceleration is directed away from the origin.
    (C) Velocity and acceleration both are perpendicular to $\vec{r}$.
    (D) Velocity and acceleration both are parallel to $\vec{r}$.

39. A particle has an initial velocity of $3\hat{i} + 4\hat{j}$ and an acceleration of $0.4\hat{i} + 0.3\hat{j}$. Its speed after 10 s is
    (A) 10 units (B) $7\sqrt{2}$ units
    (C) 7 units (D) 8.5 units

40. The position vector of a particle $\vec{R}$ as a function of time is given by $\vec{R} = 4\sin(2\pi t)\ \hat{i} + 4\cos(2\pi t)\ \hat{j}$ where, R is in metres, t is in seconds and $\hat{i}$ and $\hat{j}$ denote unit vectors along x and y-directions, respectively. Which one of the following statements is wrong for the motion of particle?
    (A) Path of the particle is a circle of radius 4 metre.
    (B) Acceleration vector is along $-\vec{R}$.
    (C) Magnitude of acceleration vector is $\frac{v^2}{R}$ where v is the velocity of particle.
    (D) Magnitude of the velocity of particle is 8 metre/second.

41. A particle is moving such that its position coordinates (x, y) are
    (2m, 3m) at time t = 0.
    (6m, 7m) at time t = 2 s and
    (13m, 14m) at time t = 5 s.
    Average velocity vector $\vec{v}_{av}$ from t = 0 to t = 5 s is
    (A) $\frac{1}{5}(13\hat{i} + 14\hat{j})$ (B) $\frac{7}{3}(\hat{i} + \hat{j})$
    (C) $2(\hat{i} + \hat{j})$ (D) $\frac{11}{5}(\hat{i} + \hat{j})$

42. Particle A moves along X-axis with a uniform velocity of magnitude 10 m/s. Particle B moves with uniform velocity 20 m/s along a direction making an angle of 60° with the positive direction of X-axis as shown in the figure. The relative velocity of B with respect to that of A is



    (A) 10 m/s along X-axis
    (B) $10\sqrt{3}$ m/s along Y-axis (perpendicular to X-axis)
    (C) $10\sqrt{5}$ along the bisection of the velocities of A and B
    (D) 30 m/s along negative X-axis

43. A ship A is moving Westwards with a speed of 10 km h^{-1} and a ship B which is at 100 km South of A, is moving Northwards with a speed of 10 km h^{-1}. The time after which the distance between them becomes shortest, is
    (A) 0 h (B) 5 h
    (C) $5\sqrt{2}$ h (D) $10\sqrt{2}$ h

44. The speed of swimmer in still water is 20 m/s. The speed of river water is 10 m/s and is flowing due east. If he is standing on the south bank and wishes to cross the river along the shortest path, the angle at which he should make his strokes w.r.t. north is given by:
    (A) 60° west (B) 45° west
    (C) 30° west (D) 0°

45. The speed of a projectile at its maximum height is half of its initial speed. The angle of projection is
    (A) 60° (B) 15°
    (C) 30° (D) 45°

46. Two bodies are thrown with the same velocity at an angle of 30° and 60° to the horizontal. The ratio of maximum heights reached is
    (A) $\sqrt{3}$ (B) 3
    (C) $\frac{1}{3}$ (D) $\frac{1}{\sqrt{3}}$

47. A body projected from the ground reaches a point 'X' in its path after 3 seconds and from there it reaches the ground after further 6 seconds. The vertical distance of the point 'X' from the ground is (acceleration due to gravity = 10 ms^{-2})
    (A) 30 m (B) 60 m
    (C) 80 m D) 90 m

48. Three projectiles A, B and C are projected at an angle of 30°, 45°, 60° respectively. If R_A, R_B and R_C are ranges of A, B and C respectively, then (velocity of projection is same for A, B and C)
(A) $R_A = R_B = R_C$ (B) $R_A = R_C > R_B$
(C) $R_A < R_B < R_C$ (D) $R_A = R_C < R_B$

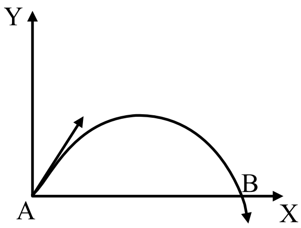
49. Two particles are simultaneously projected in the horizontal direction from a point P at a certain height. The initial velocities of the particles are oppositely directed to each other and have magnitude v each. The separation between the particles at a time when their position vectors (drawn from the point P) are mutually perpendicular, is
(A) $\frac{v^2}{2g}$ (B) $\frac{v^2}{g}$ (C) $\frac{4v^2}{g}$ (D) $\frac{2v^2}{g}$

50. The trajectory of a projectile projected from origin is given by the equation $y = x - \frac{2x^2}{5}$. The initial velocity of the projectile is
(A) 25 ms^{-1} (B) $\frac{2}{5} ms^{-1}$
(C) $\frac{5}{2} ms^{-1}$ (D) 5 ms^{-1}

51. A particle is projected with velocity $2\sqrt{gh}$ and at an angle 60° to the horizontal so that it just clears two walls of equal height 'h' which are at a distance 2h from each other. The time taken by the particle to travel between these two walls is
(A) $2\sqrt{\frac{2h}{g}}$ (B) $\sqrt{\frac{h}{2g}}$
(C) $2\sqrt{\frac{h}{g}}$ (D) $\sqrt{\frac{h}{g}}$

52. A body projected from the ground reaches a point 'X' in its path after 3 seconds and from there it reaches the ground after further 6 seconds. The vertical distance of the point 'X' from the ground is (acceleration due to gravity = 10 ms^{-2}
(A) 30 m (B) 60 m
(C) 80 m (D) 90 m

53. The velocity of a projectile at the initial point A is $(2\hat{i}+3\hat{j})$ m/s. Its velocity (in m/s) at point B is
(A) $-2\hat{i}-3\hat{j}$
(B) $-2\hat{i}+3j$
(C) $2\hat{i}-3\hat{j}$
(D) $2\hat{i}+3j$



54. A projectile is given an initial velocity of $\hat{i}+2\hat{j}$. The Cartesian equation of its path is ($g = 10\ m/s^2$)
(A) $y = 2x - 5x^2$ (B) $y = x - 5x^2$
(C) $4y = 2x - 5x^2$ (D) $y = 2x - 25x^2$

55. A body is projected vertically upwards with a velocity of 10 ms^{-1} and another body is projected simultaneously from the same point with a velocity of 20 ms^{-1} at an angle of $\frac{\pi}{6}$ with the horizontal. The distance between the two bodies after one second from the time of projection is (Acceleration due to gravity is 10 ms^{-2})
(A) 10 m (B) $10\sqrt{3}$ m
(C) 20 m (D) $20\sqrt{3}$ m

56. The maximum height attained by a projectile is increased by 10% by increasing its speed of projection, without changing the angle of projection. The percentage of increase in the time of flight of the projectile will be
(A) 5% (B) 10% (C) 15% (D) 20%

57. A particle is projected with a velocity v so that its horizontal range twice the greatest height attained. The horizontal range is
(A) $\frac{4v^2}{5g}$ (B) $\frac{v^2}{g}$ (C) $\frac{v^2}{2g}$ (D) $\frac{2v^2}{3g}$

3.4 Uniform circular motion

58. A particle moves so that its position vector is given by $\vec{r} = \cos\omega t\ \hat{x} + \sin\omega t\ \hat{y}$, where ω is a constant. Which of the following is true?
(A) Velocity is perpendicular to $\vec{r}$ and acceleration is directed towards the origin.
(B) Velocity is perpendicular to $\vec{r}$ and acceleration is directed away from the origin.
(C) Velocity and acceleration both are perpendicular to $\vec{r}$.
(D) Velocity and acceleration both are parallel to $\vec{r}$.

59. The angle between velocity and acceleration of a particle describing uniform circular motion is
(A) 180° (B) 90° (C) 45° (D) 60°

60. Angular speed of hour hand of a clock in degree per second is **[MHT CET 2016]**
(A) $\frac{1}{30}$ (B) $\frac{1}{60}$
(C) $\frac{1}{120}$ (D) $\frac{1}{720}$

61. The ratio of angular speed of a second-hand to the hour-hand of a watch is
(A) 3600 : 1 (B) 720 : 1
(C) 72 : 1 (D) 60 : 1

62. The difference between angular speed of minute hand and second hand of a clock is **[MH CET 2015]**
(A) $\frac{59\pi}{900}$ rad / s (B) $\frac{59\pi}{1800}$ rad / s
(C) $\frac{59\pi}{2400}$ rad / s (D) $\frac{59\pi}{3600}$ rad / s

63. For a particle in uniform circular motion, the acceleration $\vec{a}$ at a point P(R, θ) on the circle of radius R is (Here θ is measured from the x-axis)
(A) $\frac{v^2}{R}\hat{i}+\frac{v^2}{R}\hat{j}$
(B) $-\frac{v^2}{R}\cos\theta\hat{i}+\frac{v^2}{R}\sin\theta\hat{j}$
(C) $-\frac{v^2}{R}\sin\theta\hat{i}+\frac{v^2}{R}\cos\theta\hat{j}$
(D) $-\frac{v^2}{R}\cos\theta\hat{i}-\frac{v^2}{R}\sin\theta\hat{j}$

64. Two cars of masses m_1 and m_2 are moving in circles of radii r_1 and r_2 respectively. Their speeds are such that they make complete circles in the same time t. The ratio of their centripetal acceleration is
(A) $m_1r_1 : m_2r_2$ (B) $m_1 : m_2$
(C) $r_1 : r_2$ (D) 1 : 1

65. A particle moves in a circle of radius 5 cm with constant speed and time period 0.2 π s. The acceleration of the particle is
(A) 5 m/s^2 (B) 15 m/s^2
(C) 25 m/s^2 (D) 36 m/s^2

66. A particle moves in a circle of radius 25 cm at two revolutions per second. The acceleration of the particle in m/s^2 is
(A) π^2 (B) $8\pi^2$
(C) $4\pi^2$ (D) $2\pi^2$

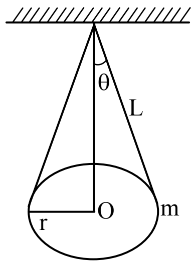
67. The angular separation between the minute hand and the hour hand of a clock at 12:20 pm is **[MHT CET 2019]**
(A) 120° (B) 90°
(C) 110° (D) 100°

68. Two particles A and B are moving in uniform circular motion in concentric circles of radii r_A and r_B with speed v_A and v_B respectively. Their time period of rotation is the same. The ratio of angular speed of A to that of B will be:
(A) $r_B : r_A$ (B) 1 : 1
(C) $r_A : r_B$ (D) $v_A : v_B$

69. A particle is moving with a uniform speed in a circular orbit of radius R in a central force inversely proportional to the nth power of R. If the period of rotation of the particle is T, then:
(A) $T \propto R^{(n+1)/2}$ (B) $T \propto R^{n/2}$
(C) $T \propto R^{3/2}$ for any n (D) $T \propto R^{\frac{n}{2}+1}$

70. One end of string of length l is connected to a particle of mass 'm' and the other end is connected to a small peg on a smooth horizontal table. If the particle moves in circle with speed 'v', the net force on the particle (directed towards centre) will be (T represents the tension in the string)
(A) T (B) $T+\frac{mv^2}{l}$
(C) $T-\frac{mv^2}{l}$ (D) Zero

71. A particle of mass 'm' is suspended from a ceiling through a string of length 'L'. If the particle moves in a horizontal circle of radius 'r' as shown in the figure, then the speed of the particle is
(A) $r\sqrt{\frac{g}{\sqrt{L^2-r^2}}}$
(B) $g\sqrt{\frac{r}{\sqrt{L^2-r^2}}}$
(C) $r\sqrt{\frac{g}{L^2-r^2}}$
(D) $g\sqrt{\frac{r}{L^2-r^2}}$



72. A particle of mass m is executing uniform circular motion on a path of radius r. If p is the magnitude of its linear momentum, the radial force acting on the particle is
(A) pmr (B) $\frac{rm}{p}$
(C) $\frac{mp^2}{r}$ (D) $\frac{p^2}{rm}$

73. A toy cart is tied to the end of an unstretched string of length 'l'. When revolved, the toy cart moves in horizontal circle with radius '2l' and time period T. If it is speeded until it moves in horizontal circle of radius '3l' with period T_1, relation between T and T_1 is (Hooke's law is obeyed) **[MH CET 2015]**
(A) $T_1 = \frac{2}{\sqrt{3}}T$ (B) $T_1 = \sqrt{\frac{3}{2}}T$
(C) $T_1 = \sqrt{\frac{2}{3}}T$ (D) $T_1 = \frac{\sqrt{3}}{2}T$

Miscellaneous

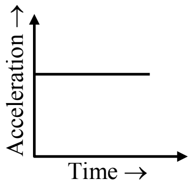
74. A body at rest starts sliding from top of a smooth inclined plane and requires 4 second to reach bottom. How much time does it take, starting from rest at top, to cover one-fourth of a distance ? **[MH CET 2014]**

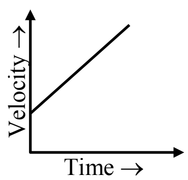
(A) 1 second (B) 2 second
(C) 3 second (D) 4 second

75. A wheel of circumference C is at rest on the ground. When the wheel rolls forward through half a revolution, then the displacement of initial point of contact will be

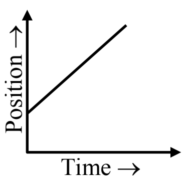
(A) $C\sqrt{\frac{1}{\pi^2}+\frac{1}{4}}$ (B) $\frac{C}{2}$
(C) $\pi\sqrt{C^2+4}$ (D) $C\sqrt{\frac{1}{\pi}+\frac{1}{2}}$

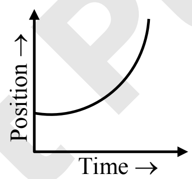
76. The velocity-time and acceleration-time graphs of a particle are given as

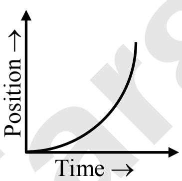


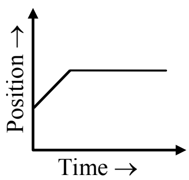


Its position-time graph may be given as

(A)


(B)


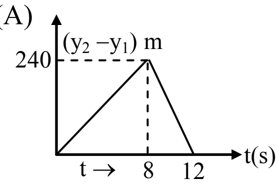
(C)


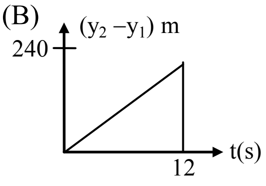
(D)


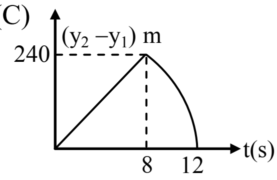
77. Two stones are thrown up simultaneously from the edge of a cliff 240 m high with initial speed of 10 m/s and 40 m/s respectively. Which of the following graphs best represents the time variation of relative position of the second stone with respect to the first?

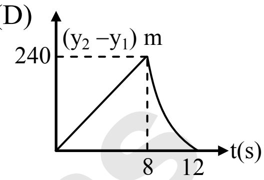
(Assume stones do not rebound after hitting the ground and neglect air resistance, take $g = 10\ m/s^2$)

(The figures are schematic and not drawn to scale).

(A)


(B)


(C)


(D)


78. A body starting from rest at t = 0 moves along a straight line with a constant acceleration. At t = 2s, the body reverses its direction keeping the acceleration same. The body returns to the initial position at $t = t_0$, then t_0 is

(A) 4s (B) $\left(4+2\sqrt{2}\right)$s
(C) $\left(2+2\sqrt{2}\right)$s (D) $\left(4+4\sqrt{2}\right)$s

79. Two particles are simultaneously projected in the horizontal direction from a point P at a certain height. The initial velocities of the particles are oppositely directed to each other and have magnitude v each. The separation between the particles at a time when their position vectors (drawn from the point P) are mutually perpendicular, is

(A) $\frac{v^2}{2g}$ (B) $\frac{v^2}{g}$
(C) $\frac{4v^2}{g}$ (D) $\frac{2v^2}{g}$

80. A stone is dropped from the top of a tower of height 45 m. One second later another stone is thrown down from the top of the same tower. Both stones reach the ground at the same time. If $g = 10\ m/s^2$, magnitude of the initial velocity of the second stone is

(A) 16 m/s (B) 25 m/s
(C) 12.5 m/s (D) 8 m/s

81. A particle of unit mass undergoes one-dimensional motion such that its velocity varies according to $v(x) = \beta x^{-2n}$ where β and n are constants and x is the position of the particle. The acceleration of the particle as a function of x, is given by

(A) $-2n\beta^2 x^{-2n-1}$
(B) $-2n\beta^2 x^{-4n-1}$
(C) $-2\beta^2 x^{-2n+1}$
(D) $-2n\beta^2 e^{-4n+1}$

82. Two balls are thrown horizontally in opposite directions from the same point from a height h with velocities 4 m/s and 3 m/s. The separation between the two balls when their velocities are perpendicular will be
(A) 6.5 m (B) 5.25 m
(C) 2.45 m (D) None of these

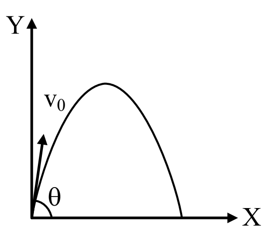
83. A projectile has same range R when the maximum height attained by it is either h_1 or h_2, Then R, h_1 and h_2 will be related as
(A) $R = \sqrt{h_1h_2}$ (B) $R = 2\sqrt{h_1h_2}$
(C) $R = 3\sqrt{h_1h_2}$ (D) $R = 4\sqrt{h_1h_2}$

84. A body of mass m thrown up vertically with velocity v_1 reaches maximum height h_1 in t_1 seconds. Another body of mass 2m is projected with a velocity v_2 at an angle θ. The second body reaches a maximum height h_2 in time t_2 seconds. If $t_1 = 2t_2$, ratio $\left(\frac{h_1}{h_2}\right)$ is
(A) 1 : 2 (B) 4 : 1
(C) 1 : 1 (D) 3 : 2

85. A large number of bullets are fired in all directions with same speed v. What is the maximum area on the ground on which these bullets will spread
(A) $\pi\frac{v^2}{g}$ (B) $\pi\frac{v^4}{g^2}$
(C) $\pi^2\frac{v^4}{g^2}$ (D) $\pi^2\frac{v^2}{g^2}$

86. The ceiling of a tunnel is 5 m high. What is the maximum horizontal distance that a ball thrown with a speed of 20 m/s, can go without hitting the ceiling of the tunnel? ($g = 10\ m/s^2$)
(A) $10\sqrt{3}$ m (B) $20\sqrt{3}$ m
(C) $30\sqrt{3}$ m (D) 40 m

87. A small particle of mass m is projected at an angle θ with the x-axis with an initial velocity v_0 in the x-y plane as shown in the figure. At a time $t < \frac{v_0 \sin\theta}{g}$, the angular momentum of the particle is
(A) $\frac{1}{2}mgv_0t^2\cos\theta\hat{i}$
(B) $-mgv_0t^2\cos\theta\hat{j}$
(C) $mgv_0t\cos\theta\hat{k}$
(D) $-\frac{1}{2}mgv_0t^2\cos\theta\hat{k}$



where $\hat{i}$, $\hat{j}$ and $\hat{k}$ are unit vectors along x, y and z-axis respectively.

88. A projectile is fired from the surface of the earth with a velocity of 7 m s^{-1} and angle θ with the horizontal. Another projectile fired from another planet with a velocity of 2.5 m s^{-1} at the same angle follows a trajectory which is identical with the trajectory of the projectile fired from the earth. The value of the acceleration due to gravity on the planet is (in m s^{-2}) (given g = 9.8 m s^{-2})
(A) 9.8 (B) 0.98
(C) 16.3 (D) 1.25

89. From a tower of height H, a particle is thrown vertically upwards with a speed u. The time taken by the particle, to hit the ground, is n times that taken by it to reach the highest point of its path. The relation between H, u and n is:
(A) $2gH = n^2u^2$
(B) $gH = (n-2)^2u^2$
(C) $2gH = nu^2(n-2)$
(D) $gH = (n-2)u^2$

90. The relation between linear speed v, angular speed ω and angular acceleration α in circular motion is **[MH CET 2010]**
(A) $\alpha = \frac{a\omega}{v}$
(B) $\alpha = \frac{av}{\omega}$
(C) $\alpha = \frac{v\omega}{a}$
(D) $\alpha = \frac{\omega}{av}$

91. If K.E. of the particle of mass m performing U.C.M. in a circle of radius r is E. The acceleration of the particle is **[MH CET 2010]**
(A) $\frac{2E}{mr}$ (B) $\left(\frac{2E}{mr}\right)^2$
(C) 2Emr (D) $\frac{4E}{mr}$

92. A particle at rest is moved along a straight line by a machine giving constant power. The distance moved by the particle in time 't' is proportional to **[MH CET 2014]**
(A) $t^{1/2}$ (B) $t^{2/3}$
(C) t (D) $t^{3/2}$

93. A coin is placed on a rotating turn table rotated with angular speed ω. The coin just slips if it is placed at 4 cm from the center of the table. If angular velocity is doubled, at what distance will coin starts to slip. **[MH CET 2010]**
(A) 1 cm (B) 4 cm
(C) 9 cm (D) 16 cm

Homework

3.1 Introduction

1. When the force acting on the object and the velocity of the object both are along the same line, it is called _______.
   (A) rectilinear motion
   (B) vibratory motion
   (C) rotational motion
   (D) oscillatory motion

3.2 Rectilinear Motion

2. The actual distance travelled by the particle during its motion is called _______.
   (A) speed (B) displacement
   (C) path length (D) position

3. If distance covered by a particle is zero, what can you say about displacement?
   (A) It is positive
   (B) It is negative
   (C) It cannot be zero
   (D) It must be zero

4. Choose the CORRECT statement.
   (A) The magnitude of displacement is less than or equal to the path length.
   (B) The magnitude of displacement is greater than the path length.
   (C) The magnitude of displacement is infinite.
   (D) The magnitude of displacement is twice the path length.

5. The average speed is equal to the magnitude of average velocity, for the motion of the particle along a straight line and in the same direction, then
   (A) path length is less than the distance between them.
   (B) path length is less than the magnitude of velocity.
   (C) path length is greater than the magnitude of displacement.
   (D) path length is equal to the magnitude of displacement.

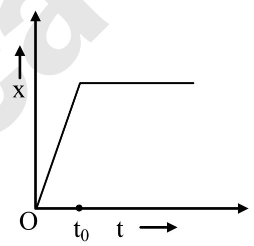
6. If the particle moves with a constant velocity its acceleration is _______.
   (A) maximum
   (B) minimum
   (C) depends on frame of reference
   (D) zero

7. Choose the WRONG statement.
   (A) Speed can never be negative.
   (B) When the particle returns to the starting point, its average velocity is zero but average speed is not zero.
   (C) Displacement does not tell the nature of the actual motion of a particle between the points.
   (D) If the velocity of a particle is zero at an instant, its acceleration should also be zero at that instant.

8. While plotting graph, independent variable (i.e., time) is plotted along _______.
   (A) x-axis (B) y-axis
   (C) z-axis (D) negative z-axis

9. Displacement time graph cannot be
   (A) below the time axis.
   (B) straight line perpendicular to time axis as well as normal above and below the time axis.
   (C) straight line parallel to time axis.
   (D) inclined to the time axis.

10. Figure shows the displacement-time graph of a particle moving along x-axis.



   (A) The particle is continuously going in positive x- direction.
   (B) The particle is at rest.
   (C) The velocity increases upto time t_0 and then becomes constant.
   (D) The particle moves at a constant velocity upto a time t_0 and then stops.

11. The slope of x – t graph at any point gives
   (A) instantaneous velocity.
   (B) instantaneous acceleration.
   (C) force at that instant.
   (D) momentum at that instant.

12. Area under the curve of velocity-time graph of a particle moving with constant velocity is
   (A) acceleration of the particle.
   (B) distance travelled by the particle.
   (C) constant speed of the particle.
   (D) variable speed of the particle.

13. A body is projected vertically upwards from the ground. On reaching the greatest height
   (A) its velocity is zero and acceleration is not zero.
   (B) its acceleration is zero and velocity is not zero.
   (C) both velocity and acceleration are non zero.
   (D) both velocity and acceleration are zero.

14. When a car moves towards east 50 m then towards south 50 m, later on towards west 50 m, finally towards north 50 m, the displacement of the car in magnitude is
(A) 200 m (B) 100 m
(C) 50 m (D) zero

15. A person travels along a straight road due east for the first half distance with speed v_1 and the second half distance with speed v_2, the average speed of the person is
(A) $\frac{v_1 + v_2}{2}$ (B) $\frac{v_1}{2} + \frac{v_2}{2}$
(C) $\frac{v_1 + v_2}{2v_1v_2}$ (D) $\frac{2v_1v_2}{v_1 + v_2}$

16. A bus travels its onward journey with a constant speed of 30 km/hr while its return journey with a constant speed of 60 km/hr, the average speed for its entire journey is
(A) 90 km/hr (B) 45 km/hr
(C) 40 km/hr (D) 15 km/hr

17. A body covers one-half of its journey at 40 m s^{-1} and the next half at 50 m s^{-1}. Its average velocity is
(A) 44.44 m s^{-1} (B) 50 m s^{-1}
(C) 45 m s^{-1} (D) 40 m s^{-1}

18. A train covers the first half of the distance between two stations at the speed of 40 km h^{-1} and the other half at 60 km h^{-1}. Its average speed is
(A) 52 km h^{-1} (B) 50 km h^{-1}
(C) 48 km h^{-1} (D) 42 km h^{-1}

19. The position of an object moving along x-axis is given by $x = a + bt^2$ where a = 8.5 m and b = 2.5 m and t is measured in second. If the object starts from t = 0, the velocity at t = 2 s is
(A) 18.5 m/s (B) 10 m/s
(C) 9.25 m/s (D) 1.5 m/s

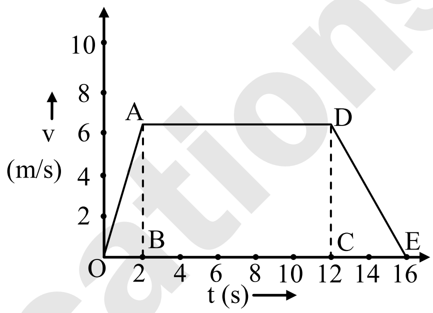
20. An electron travelling with a speed of 5×10^3 m/s passes through an electric field with an acceleration of 10^{12} m/s^2. How long will it take for electron to double its speed?
(A) 0.5×10^{-9} s (B) 0.5×10^{-10} s
(C) 5×10^{-9} s (D) 5×10^{-10} s

21. An aeroplane takes off the ground after covering a distance of 800 m of runway in 16 s. Its acceleration will be
(A) 100 m/s^2 (B) 50 m/s^2
(C) 16.25 m/s^2 (D) 6.25 m/s^2

22. A bullet strikes a plank of thickness 5 cm with a velocity of 1000 m/s and emerges out with a velocity of 400 m/s, the average retardation of the bullet is
(A) -8.4×10^6 m/s^2 (B) 8.4×10^6 m/s^2
(C) -60×10^5 m/s^2 (D) 60×10^5 m/s^2

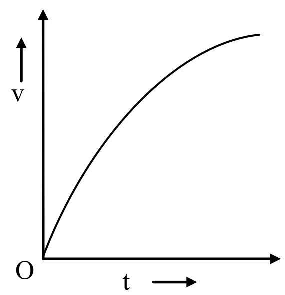
23. A local train, travelling at 72 km/hr is brought to rest in 10 seconds by applying the brake. How much is the acceleration produced in this case? Also how much is distance (s) covered by the train before coming to rest?
(A) a = 2 m/s^2, s = 300 m
(B) a = –2 m/s^2, s = 300 m
(C) a = 2 m/s^2, s = 100 m
(D) a = –2 m/s^2, s = 100 m

24. The v-t graph of an athlete is shown below. The distance travelled by him between t = 0 and t = 12 s is



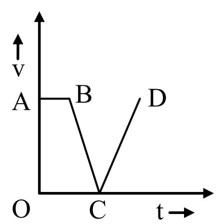
(A) 36 m (B) 46 m
(C) 66 m (D) 78 m

25. The v-t graph of a particle moving with variable acceleration is given below. Which of the following statement is correct?



(A) Slope of the graph is positive but decreases with time.
(B) Slope of the graph is negative but decreases with time.
(C) Slope of the graph is positive and increases with time.
(D) Slope of the graph is negative and increases with time.

26. The velocity-time graph of a body is shown in the following graph. At point C



(A) the force acting on the body is zero.
(B) only gravitational force is present.
(C) the force opposes the motion of the body.
(D) the force is maximum.

27. A body projected vertically upwards with a velocity of u returns to the starting point in 6 second. If $g = 9.8\ m\ s^{-2}$, the value of 'u' is
(A) 60 m/s (B) 30.4 m/s
(C) 29.4 m/s (D) 15 m/s

28. A body released from rest to fall freely under gravity reaches the ground in 4 s. Then the height from which it is released is
(A) 98 m (B) 78.4 m
(C) 49 m (D) 24.5 m

29. A stone is thrown vertically upwards with initial velocity of $14\ m\ s^{-1}$. The maximum height it will reach is [$g = 9.8\ m\ s^{-2}$]
(A) 16 m (B) 14 m
(C) 10 m (D) 9.8 m

30. A man swims relative to water with a velocity greater than velocity of water. Then
(A) man may cross the river along shortest path.
(B) man cannot cross the river.
(C) man cannot cross the river without drifting.
(D) man may cross the river along longest path.

31. Two trains A and B are moving on parallel tracks with velocities 60 km/h and 90 km/h respectively, in opposite directions. The relative velocity of train A with respect to train B is
(A) 30 km/h (B) 60 km/h
(C) 90 km/h (D) 150 km/h

32. If a car travelling at 58 km/h overtakes another car travelling at 40 km/h, the relative velocity of first car with respect to another car is
(A) −18 km/h (B) 18 km/h
(C) 98 km/h (D) 49 km/h

33. A thief is running away on a straight road in jeep moving with a speed of $9\ m\ s^{-1}$. A police man chases him on a motor cycle moving at a speed of $10\ ms^{-1}$. If the instantaneous separation of the jeep from the motorcycle is 100 m, how long will it take for the police to catch the thief ?
(A) 1 s (B) 19 s
(C) 90 s (D) 100 s

3.3 Motion in Two Dimensions – motion in a Plane

34. If car travelling at 58 km/h overtakes another car travelling at 40 km/h, the relative velocity of first car with respect to another car is
(A) −18 km/h (B) 18 km/h
(C) 98 km/h (D) 49 km/h

35. The two dimensional motion of a body in which a vertical motion with constant acceleration (g) and a horizontal motion with constant velocity acts, such a motion is _______.
(A) curved motion
(B) circular motion
(C) sinusoidal motion
(D) projectile motion

36. Which of the following is NOT an example of a projectile?
(A) Aeroplane in flight.
(B) A bullet fired from the gun.
(C) A hammer thrown by an athlete.
(D) A stone thrown from the top of the building.

37. The path followed by projectile is called _______.
(A) ellipse (B) projection
(C) trajectory (D) parabola

38. While studying projectile motion
(A) air resistance is negligible with greater speed.
(B) air resistance affects 0.5% of its motion.
(C) air resistance is negligible with very small speed.
(D) air resistance affects 0.7% of its motion without change in its speed.

39. The only force acting on the projectile is
(A) gravitational force acting vertically downward.
(B) the effect of rotation of the earth.
(C) the effect of moon on the earth.
(D) attractive force between earth's magnetic field and the projectile.

40. In projectile motion, a body is projected at an angle θ with velocity u then the horizontal component of velocity will be
(A) $u \cos \theta$ = constant
(B) $u \sin \theta$ = constant
(C) $u \tan \theta$ = constant
(D) $u \cot \theta$ = constant

41. The angle of projection for a projectile thrown parallel to horizontal is
(A) 90° (B) 60°
(C) 45° (D) 0°

42. A projectile is projected with velocity u making an angle θ with the horizontal, the equation of the path of the projectile is given by
(A) $x = (\tan\theta)\, y - \left(\frac{g}{2u^2\cos^2\theta}\right)y^2$
(B) $y = (\tan\theta)\, x - \left(\frac{g}{2u\cos\theta}\right)x^2$
(C) $y = (\tan\theta)\, x - \left(\frac{g}{2u^2\cos\theta}\right)x^2$
(D) $y = (\tan\theta)\, x - \left(\frac{g}{2u^2\cos^2\theta}\right)x^2$

43. Time taken by the projectile to cover entire trajectory is called as _______.
(A) time of ascent (B) periodic time
(C) time of descent (D) time of flight

44. The time (T) required by the projectile to return to original plane of projection is given by
(A) $T = \frac{u\sin\theta}{g}$
(B) $T = \frac{u\cos\theta}{g}$
(C) $T = \frac{2u\sin\theta}{g}$
(D) $T = \frac{2u\cos\theta}{g}$

45. The relation between time of ascent t_a and time of descent t_d is
(A) $t_a = t_d$ (B) $t_a < t_d$
(C) $t_a > t_d$ (D) $t_a = 2t_d$

46. A shell is fired at an angle of 30° to the horizontal with velocity 196 m/s. The time of flight is
(A) 6.5 s (B) 10 s
(C) 16.5 s (D) 20 s

47. A body is thrown with velocity of 49 m/s at an angle of 30° with the horizontal, the time required to attain maximum height is
(A) 5 s (B) 4 s
(C) 3.5 s (D) 2.5 s

48. A projectile is launched at an angle of θ above the horizontal. The elevation angle α of the highest point of the trajectory as seen from the launching position is given by
(A) $\tan\alpha = \frac{1}{2}\tan\theta$ (B) $\sin\alpha = \frac{1}{2}\sin\theta$
(C) $\tan\alpha = \tan\frac{\theta}{2}$ (D) $\sin\alpha = \sin\frac{\theta}{2}$

49. The horizontal distance between the point of projection and the point on the same horizontal plane, at which, the projectile returns after moving along its trajectory, is called ________ of the projectile.
(A) maximum height
(B) maximum velocity
(C) horizontal range
(D) vertical range

50. At the point of horizontal range (R), the coordinates are
(A) x = 0, y = R (B) x = 0, y = 0
(C) x = R, y = 0 (D) x = R, y = R

51. A shell is fired from canon with a velocity of 200 m/s at an angle of 30° with the horizontal. The horizontal range attained by it is
$[g = 10\ m\,s^{-2}]$
(A) $2 \times 10^2\sqrt{2}$ m (B) $2 \times 10^2\sqrt{3}$ m
(C) $4 \times 10^4\sqrt{3}$ m (D) $2 \times 10^3\sqrt{3}$ m

52. A gun throws a shell with muzzle speed of 98 m s^{-1}. When the gun is elevated at 45°, the range is observed as 900 m. Due to air resistance its range is decreased by
(A) 160 m (B) 120 m
(C) 80 m (D) 40 m

53. The initial velocity of the projectile is u and its maximum range is R_{max} then u is given by
(A) $u = R_{max} \times g$ (B) $u = \frac{R_{max}}{g}$
(C) $u = \sqrt{\frac{R_{max}}{g}}$ (D) $u = \sqrt{R_{max}\, g}$

54. A shell fired from a canon can cover maximum horizontal distance of 10 km. Then velocity of projection is
(A) $\sqrt{980}$ m/s (B) $\sqrt{9800}$ m/s
(C) $\sqrt{98000}$ m/s (D) $10^2\sqrt{98}$ m/s

55. For the maximum height of a projectile
(A) horizontal component of velocity is zero.
(B) vertical component of velocity is zero.
(C) vertical acceleration is zero.
(D) initial velocity should be zero.

56. The projectile attains maximum height when it is projected at an angle of
(A) 30° (B) 45°
(C) 90° (D) 120°

57. A man can jump on the moon ______ times as high as on the earth.
(A) two (B) three
(C) four (D) six

58. A cricketer can throw a ball to a maximum horizontal distance of 100 m. How much high above the ground can the cricketer throw the same ball?
(A) 100 m (B) 75 m
(C) 50 m (D) 25 m

59. For a projectile motion, the horizontal range of projectile is same for any two angles which are
(A) vertically opposite.
(B) complementary angles.
(C) supplementary angles.
(D) equal angles.

60. A stone is projected with velocity of 100 m/s at an angle of 60° with the horizontal, its maximum height is
(A) 883.6 m (B) 683.8 m
(C) 382.6 m (D) 196.3 m

61. The maximum horizontal range of a projectile is 980 m. Its initial speed and maximum height is
(A) 98 m s^{-1}, 245 m (B) 245 m s^{-1}, 98 m
(C) 196 m s^{-1}, 245m (D) 98 m s^{-1}, 490 m

62. The height y and the distance x along the horizontal, for a body projected in the vertical plane are given by $y = 8t - 5t^2$ and $x = 6t$, the initial velocity at t = 0 of the body is
(A) 18 m/s (B) 10 m/s
(C) 6 m/s (D) 4 m/s

63. A body is projected with a vertical velocity of 30 m/s at an angle of 30° with the horizontal, the maximum height and horizontal range are respectively
(A) 79.53 m, 1148 m (B) 11.48 m, 79.53 m
(C) 159.06 m, 11.48 m (D) 22.96 m, 79.53 m

64. When the particle is projected vertically upwards then θ, H and R of it respectively are
(A) $0°, \frac{u^2}{2g}, 0$ (B) $90°, 0, \frac{u^2}{g}$
(C) $0°, 0, \frac{u^2}{2g}$ (D) $90°, \frac{u^2}{2g}, 0$

3.4 Uniform Circular Motion

65. In uniform circular motion,
(A) both velocity and acceleration are constant.
(B) velocity changes and acceleration is constant.
(C) velocity is constant and acceleration changes.
(D) both velocity and acceleration change.

66. Select the WRONG statement.
(A) In U.C.M. linear speed is constant.
(B) In U.C.M. linear velocity is constant.
(C) In U.C.M. magnitude of angular momentum is constant.
(D) In U.C.M. angular velocity is constant.

67. If a particle moves in a circle describing equal angles in equal intervals of time, the velocity vector
(A) remains constant.
(B) changes in magnitude only.
(C) changes in direction only.
(D) changes both in magnitude and direction.

68. A particle moves along a circle with a uniform speed v. After the position vector has made an angle of 30° with the reference position, its speed will be
(A) $v\sqrt{2}$ (B) $\frac{v}{\sqrt{2}}$
(C) $\frac{v}{\sqrt{3}}$ (D) v

69. A particle in U.C.M. possesses linear acceleration since
(A) its linear speed changes continuously.
(B) both magnitude and direction of linear velocity change continuously.
(C) direction of linear velocity changes continuously.
(D) its linear speed does not change continuously.

70. The acceleration of a particle in U.C.M. directed towards centre and along the radius is called
(A) centripetal acceleration.
(B) centrifugal acceleration.
(C) gravitational acceleration.
(D) tangential acceleration.

71 The angular velocity of a particle rotating in a circular orbit 100 times per minute is
(A) 1.66 rad/s (B) 10.47 rad/s
(C) 10.47 deg/s (D) 60 deg/s

72. A body of mass 100 g is revolving in a horizontal circle. If its frequency of rotation is 3.5 r.p.s. and radius of circular path is 0.5 m, the angular speed of the body is
(A) 18 rad/s (B) 20 rad/s
(C) 22 rad/s (D) 24 rad/s

73. What is the angular velocity of the earth?
(A) $\frac{2\pi}{86400}$ rad/s (B) $\frac{2\pi}{3600}$ rad/s
(C) $\frac{2\pi}{24}$ rad/s (D) $\frac{2\pi}{6400}$ rad/s

74. An electric motor of 12 horse-power generates an angular velocity of 125 rad/s. What will be the frequency of rotation?
(A) 20 Hz (B) 20/π Hz
(C) 20/2π Hz (D) 40 Hz

75. What is the angular speed of the seconds hand of a watch?
(A) 60 rad/s (B) π rad/s
(C) $\pi/30$ rad/s (D) 2 rad/s

76. The ratio of angular speeds of minute hand and hour hand of a watch is
(A) 1 : 12 (B) 60 : 1
(C) 1 : 60 (D) 12 : 1

77. If ω_E and ω_H are the angular velocities of the earth rotating about its own axis and the hour hand of the clock respectively, then
(A) $\omega_E = \frac{1}{4}\omega_H$ (B) $\omega_E = 2\omega_H$
(C) $\omega_E = \omega_H$ (D) $\omega_E = \frac{1}{2}\omega_H$

78. A fan is making 600 revolutions per minute. If after some time it makes 1200 revolutions per minute, then increase in its angular velocity is
(A) 10π rad/s (B) 20π rad/s
(C) 40π rad/s (D) 60π rad/s

79. Angular velocity of hour arm of a clock, in rad/s, is
(A) $\frac{\pi}{43200}$ (B) $\frac{\pi}{21600}$
(C) $\frac{\pi}{30}$ (D) $\frac{\pi}{1800}$

80. Two particles of mass M and m are moving in a circle of radii R and r. If their time periods are same, what will be the ratio of their linear velocities?
(A) MR : mr (B) M : m
(C) R : r (D) 1 : 1

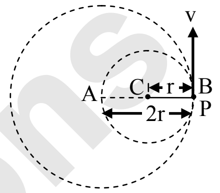
81. A wheel having a diameter of 3 m starts from rest and accelerates uniformly to an angular velocity of 210 r.p.m. in 5 seconds. Angular acceleration of the wheel is
(A) 4.4 rad s^{-2} (B) 3.3 rad s^{-2}
(C) 2.2 rad s^{-2} (D) 1.1 rad s^{-2}

82. A wheel has circumference C. If it makes f r.p.s., the linear speed of a point on the circumference is
(A) $2\pi fC$ (B) fC
(C) $fC/2\pi$ (D) fC/60

83. A body is whirled in a horizontal circle of radius 20 cm. It has angular velocity of 10 rad/s. What is its linear velocity at any point on circular path?
(A) 10 m/s (B) 2 m/s
(C) 20 m/s (D) $\sqrt{2}$ m/s

84. A particle moves in a circular path, 0.4 m in radius, with constant speed. If particle makes 5 revolutions in each second of its motion, the speed of the particle is
(A) 10.6 m/s (B) 11.2 m/s
(C) 12.6 m/s (D) 13.6 m/s

85. A particle P is moving in a circle of radius 'r' with a uniform speed v. C is the centre of the circle and AB is a diameter. When passing through B, the angular velocity of P about A and C are in the ratio



(A) 1 : 1
(B) 1 : 2
(C) 2 : 1
(D) 4 : 1

86. An electric fan has blades of length 30 cm as measured from the axis of rotation. If the fan is rotating at 1200 r.p.m., the acceleration of a point on the tip of the blade is about
(A) 1600 cm/s^2 (B) 4740 cm/s^2
(C) 2370 cm/s^2 (D) 5055 cm/s^2

87. The diameter of a flywheel is 1.2 m and it makes 900 revolutions per minute. Calculate the acceleration at a point on its rim.
(A) 540 π^2 m/s^2 (B) 270 m/s^2
(C) 360 π^2 m/s^2 (D) 540 m/s^2

88. The angular speed (in rev/min) needed for a centrifuge to produce an acceleration of 1000 g at a radius arm of 10 cm is
(Take g = 10 m/s^2)
(A) 1500 rev/min (B) 4000 rev/min
(C) 2000 rev/min (D) 3000 rev/min

89. A racing car of mass 10^2 kg goes around a circular track (horizontal) of radius 10 m. The maximum thrust that track can withstand is 0^5 N. The maximum speed with which car can go around is
(A) 10 m/s (B) 100 m/s
(C) 50 m/s (D) 20 m/s

90. Two particles of equal masses are revolving in circular paths of radii r_1 and r_2 respectively with the same speed. The ratio of their centripetal forces is
(A) $\frac{r_2}{r_1}$ (B) $\sqrt{\frac{r_2}{r_1}}$
(C) $\left(\frac{r_1}{r_2}\right)^2$ (D) $\left(\frac{r_2}{r_1}\right)^2$

91. A 10 kg object attached to a nylon cord outside a space vehicle is rotating at a speed of 5 m/s. If the force acting on the cord is 125 N, its radius of path is
(A) 2 m (B) 4 m (C) 6 m (D) 1 m

92. The breaking tension of a string is 50 N. A body of mass 1 kg is tied to one end of a 1 m long string and whirled in a horizontal circle. The maximum speed of the body should be
(A) $5\sqrt{2}$ m/s (B) 10 m/s
(C) 7.5 m/s (D) 5 m/s

93. A proton of mass 1.6×10^{-27} kg goes round in a circular orbit of radius 0.12 m under a centripetal force of 6×10^{-14} N. Then the frequency of revolution of the proton is about
(A) 1.25×10^{6} cycles per second
(B) 2.50×10^{6} cycles per second
(C) 3.75×10^{6} cycles per second
(D) 5.00×10^{6} cycles per second

94. When the bob of a conical pendulum is moving in a horizontal circle at constant speed, which quantity is fixed?
(A) Velocity (B) Acceleration
(C) Centripetal force (D) Kinetic energy

95. The period of a conical pendulum is
(A) equal to that of a simple pendulum of same length *l*.
(B) more than that of a simple pendulum of same length *l*.
(C) less than that of a simple pendulum of same length *l*.
(D) independent of length of pendulum.

96. Consider a simple pendulum of length 1 m. Its bob performs a circular motion in horizontal plane with its string making an angle 60° with the vertical. The centripetal acceleration experienced by the bob is
(A) 17.3 m/s^2 (B) 5.8 m/s^2
(C) 10 m/s^2 (D) 5 m/s^2

97. A particle of mass 1 kg is revolved in a horizontal circle of radius 1 m with the help of a string. If the maximum tension the string can withstand is $16\pi^2$ N, then the maximum frequency with which the particle can revolve is
(A) 3 Hz (B) 2 Hz
(C) 4 Hz (D) 5 Hz

Miscellaneous

98. Which of the following changes, when a particle is moving with uniform velocity?
(A) speed (B) velocity
(C) acceleration (D) position vector

99. In an inertial frame of reference, a body performing uniform circular motion in clockwise direction has
(A) constant velocity.
(B) zero angular acceleration.
(C) centripetal acceleration.
(D) tangential acceleration.

Answer Key

Classwork

1.	(C)	2.	(A)	3.	(C)	4.	(C)	5.	(B)	6.	(C)	7.	(A)	8.	(A)	9.	(A)	10.	(B)
11.	(B)	12.	(C)	13.	(A)	14.	(A)	15.	(D)	16.	(A)	17.	(C)	18.	(A)	19.	(D)	20.	(C)
21.	(B)	22.	(A)	23.	(D)	24.	(B)	25.	(B)	26.	(B)	27.	(B)	28.	(B)	29.	(C)	30.	(C)
31.	(C)	32.	(A)	33.	(A)	34.	(C)	35.	(B)	36.	(A)	37.	(A)	38.	(A)	39.	(B)	40.	(D)
41.	(D)	42.	(B)	43.	(B)	44.	(C)	45.	(A)	46.	(C)	47.	(D)	48.	(D)	49.	(C)	50.	(D)
51.	(C)	52.	(D)	53.	(C)	54.	(A)	55.	(B)	56.	(A)	57.	(A)	58.	(A)	59.	(B)	60.	(C)
61.	(B)	62.	(B)	63.	(D)	64.	(C)	65.	(A)	66.	(C)	67.	(C)	68.	(B)	69.	(A)	70.	(A)
71.	(A)	72.	(D)	73.	(D)	74.	(B)	75.	(A)	76.	(B)	77.	(C)	78.	(B)	79.	(C)	80.	(C)
81.	(B)	82.	(C)	83.	(D)	84.	(B)	85.	(B)	86.	(B)	87.	(D)	88.	(D)	89.	(C)	90.	(A)
91.	(A)	92.	(D)	93.	(A)														

Homework

1.	(A)	2.	(C)	3.	(D)	4.	(A)	5.	(D)	6.	(D)	7.	(D)	8.	(A)	9.	(B)	10.	(D)
11.	(A)	12.	(B)	13.	(A)	14.	(D)	15.	(D)	16.	(B)	17.	(A)	18.	(C)	19.	(B)	20.	(C)
21.	(D)	22.	(A)	23.	(D)	24.	(C)	25.	(A)	26.	(C)	27.	(C)	28.	(B)	29.	(C)	30.	(A)
31.	(D)	32.	(B)	33.	(D)	34.	(B)	35.	(D)	36.	(A)	37.	(C)	38.	(C)	39.	(A)	40.	(A)
41.	(D)	42.	(D)	43.	(D)	44.	(C)	45.	(A)	46.	(D)	47.	(D)	48.	(A)	49.	(C)	50.	(C)
51.	(D)	52.	(C)	53.	(D)	54.	(C)	55.	(B)	56.	(B)	57.	(D)	58.	(D)	59.	(B)	60.	(C)
61.	(A)	62.	(B)	63.	(B)	64.	(D)	65.	(D)	66.	(B)	67.	(C)	68.	(D)	69.	(C)	70.	(A)
71.	(B)	72.	(C)	73.	(A)	74.	(A)	75.	(C)	76.	(D)	77.	(D)	78.	(B)	79.	(B)	80.	(C)
81.	(A)	82.	(B)	83.	(B)	84.	(C)	85.	(B)	86.	(B)	87.	(A)	88.	(D)	89.	(B)	90.	(A)
91.	(A)	92.	(A)	93.	(D)	94.	(D)	95.	(C)	96.	(A)	97.	(B)	98.	(D)	99.	(C)

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