CHAPTER 2

Kinematics

SYNOPSIS

- Mechanics is the branch of physics that deals with the effect of forces on matter. Statics, kinematics and dynamics are its different branches.
- **Statics:** It deals with bodies at rest under the action of forces.
- **Dynamics:** Dynamics deals with behaviour of the bodies under the action of forces causing their motion.
- **Kinematics:** It deals with the motion of bodies without considering the cause of motion.
- **Distance:** It is the length of the path from the initial position to the final position, traced by the particle while in motion. It is a scalar quantity and is path dependent.
- **Displacement:** It is a straight line connecting the initial and the final positions of a body in motion in a given time interval.
  Displacement is a vector quantity, and is independent of the path.
- Average speed = $\frac{\text{Total distance}}{\text{Total time}} = \frac{s}{t}$
- **Uniform speed:** A particle is said to be moving with uniform speed, if it covers equal distances in equal intervals of time.
- A body moving with uniform velocity is in motion along a straight line path with a constant speed.
- Average velocity = $\frac{\text{Total displacement}}{\text{Total time}}$
- acceleration, $\vec{a} = \frac{\text{Change in velocity}}{\text{Time}} = \frac{\vec{v} - \vec{u}}{t}$
- If the velocity decreases with time, it is called as deceleration or retardation.
- The equations of motion are
  (i) $v = u + at$
  (ii) $s = ut + ½ at^2$
  (iii) $v^2 = u^2 + 2as$
  (iv) $S_n = u\,(1s) + a\,(n - 1/2)\,(1s)$
- The equations of motion for a body moving vertically under the influence of gravity are
  (1) $v = u \pm gt$
  (2) $s = ut \pm ½ gt^2$
  (3) $v^2 = u^2 \pm 2gs$
- Equations of motion for a freely falling body
  (1) $v = gt$ (2) $h = ½ gt^2$
  (3) $v^2 = 2gh$
- Considering the upward direction as positive the equations of motion for a body projected vertically upwards are obtained by substituting ‘h’ for ‘s’ and –‘g’ for ‘a’ as follows.
  (1) $v = u - gt$
  (2) $h = ut - ½ gt^2$
  (3) $v^2 = u^2 - 2gh$

- Maximum height reached by a body projected vertically upwards
  At the maximum height, v = 0
  ∴ From $v^2 = u^2 - 2gh$ we get,
  $$0 = u^2 - 2g\,h_{max} \Rightarrow h_{max} \text{ or } H = \frac{u^2}{2g}$$
  Time of ascent (t_a): It is the time taken by a body, projected vertically upwards, to reach the maximum height.
  At maximum height the final velocity of the body, v = 0.
  From the equation,
  $$v = u + at, \text{ we get } 0 = u - gt_a \Rightarrow t_a = \frac{u}{g}$$
- **Time of descent (t_d):** It is the time taken by a body, projected vertically upwards, to reach the point of projection from its position of maximum height. $t_d = \frac{u}{g}$
- the time of ascent is always equal to the time of descent.
- **Time of flight (T):** It is the total time taken by a body projected vertically upwards to reach the position of maximum height and then return to the point of projection. $T = \frac{2u}{g}$
- The magnitude of the velocity with which the body reaches the ground is equal to the magnitude of the velocity with which it is projected vertically upwards.
- At any point, the upward velocity in its motion is equal to the downward velocity at the same point.
- **Projectile motion:** Any object which is thrown obliquely with a certain initial velocity and whose path is determined by the gravitational force is called a projectile.
- For a body projected obliquely making an a angle θ with the horizontal, its vertical velocity is u sinθ and horizontal velocity is u cosθ.
- The horizontal distance covered in t s is (u cosθ)t.
- The maximum horizontal distance covered by a projectile is called range R which it covers in a time 't' equal to time of flight, t_f. Thus
  $$R = u\cos\theta \times t_f = \frac{u^2 \sin 2\theta}{g}$$
- The maximum height attained by the projectile is given by $H_{max} = \frac{u^2 \sin^2\theta}{2g}$
- The trajectory of a projectile is a parabola.

Solved Examples

1. Two cars arrive at certain point with velocities of 30 ms^{-1}, 25 ms^{-1} and travel in a straight line with uniform acceleration 0.25 ms^{-2} and 0.5 ms^{-2} respectively.

(A) Find the distance at which they meet again.

(B) Also determine the time after which the final velocity one of the cars is equal to the initial velocity of the other.

Solution: (A) Both cars travel for same time(t)

First car	Second car
$u = 30\ ms^{-1}$; $a = 0.25\ ms^{-2}$	$u = 25\ ms^{-1}$
	$a = 0.5\ ms^{-2}$
$S_1 = (30 \times t) + \frac{1}{2}(0.25 \times t^2)$	$S_2 = (25 \times t) + \frac{0.5}{2}t^2$

But $s_1 = s_2$

$$\therefore 30\,t + \frac{1}{2}0.25\,t^2$$

$$= 25\,t + \frac{1}{2}0.5t^2 = 10t = 0.25t^2$$

$$t = \frac{10}{0.25} = 40\ s$$

Length of the path travelled

$$(S) = (30 \times 40) + \frac{0.25}{2} \times (40)^2$$

$$= 1200 + 200 = 1400\ m.$$

(B) $v = 30\ ms^{-1}$, $u = 25\ ms^{-1}$

$a = 0.5\ ms^{-2}$, t = ?

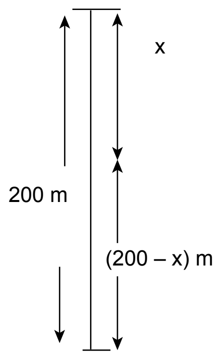
$v = u + at \Rightarrow 30 = 25 + 0.5 \times t$

$\Rightarrow 5 = 0.5\,t \Rightarrow t = 10\ s$

2. A stone is dropped by a person from the top of a tower, which is 200 m tall. At the same time, another stone is thrown upwards, with a velocity of 50 ms^{-1} by a person standing at the foot of the tower. Find the time after which the two stones meet.

Solution: Let the two stones meet at a distance of x m from the top of the tower, and 't' be the time taken. Let us assume the downward direction as positive.

For the stone, that is dropped, its initial velocity u = 0 ms^{-1}; displacement s = x and acceleration = acceleration due to gravity (g).



Using $s = ut + \frac{1}{2}at^2$,

we get $x = (0)\,t + \frac{1}{2}gt^2 \rightarrow (1)$

For the stone that is projected vertically upwards, its initial velocity, u = –50 ms^{-1}; displacement s = – (200 – x) and acceleration a = g.

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

we get $-(200 - x) = -50 \times t + ½\,gt^2$

$200 = 50\,t - ½\,gt^2 + x \rightarrow (1)\ (2)$

From the equations (1) and (2),

we have$200 = 50t - ½\,gt^2 + ½\,gt^2$

$\Rightarrow 200 = 50t \therefore t = 4$ s

3. A small steel ball is dropped from a height of 2.5 m into a tall glycerine jar. It hits the surface of glycerine with certain velocity and sinks to it. When it reached the bottom its velocity is found to be 80% of its velocity at the surface. If the time taken to reach the bottom after it is dropped is 2 s and velocity in glycerine is lost at a constant rate, then find the average velocity of the ball over the whole journey.

Solution: The body falls freely under gravity before hitting the glycerine surface. To find the time taken by the body to reach the glycerine surface (t_1) after being dropped, use $t = \sqrt{\frac{2h}{g}}$

substitute h = 2.5 m, g = 9.8 ms^{-2};

$$t_1 = \sqrt{\frac{2\times2.5}{9.8}} = \sqrt{\frac{25}{49}} = \frac{5}{7} \quad \rightarrow \quad (1)$$

The velocity on reaching the glycerine surface,

$$V = \sqrt{2gh}$$

substitute g = 9.8 ms^{-2}, h = 2.5 m

$$V = \sqrt{2\times9.8\times2.5} = \sqrt{\frac{4\times49\times25}{100}} = \frac{2\times7\times5}{10}$$

$$= 7\ ms^{-1} \quad \rightarrow \quad (2)$$

The time (t_2) taken by the body to reach the bottom of glycerine surface

$$t_2 = 2 - t_1 = 2 - \frac{5}{7} = \frac{14-5}{7} = \frac{9}{7}\ \ldots\ldots \rightarrow (3)$$

To find the distance covered by the body in glycerine, use $S_g = \frac{V+u}{2}\times t$

Substitute V = 80% of velocity at the surface

$$= \frac{8}{10}\times 7 \text{ (from eqn (2))} = 5.6\ ms^{-1}$$

$$S_g = \frac{7+5.6}{2}\times\frac{9}{7} = \frac{12.6}{2}\times\frac{9}{7} = 6.3\times\frac{9}{7} = 0.9 \times 9$$

$$= 8.1\text{ m} \quad \rightarrow \quad (4)$$

$$\text{Average speed} = \frac{\text{total distance}}{\text{total time}} = \frac{2.5+8.1}{2}$$

$$= \frac{10.6}{2} = 5.3\ ms^{-1}.$$

4. A stone, projected up vertically with a velocity v, reaches points x, y and z in its path with velocities $\frac{v}{\sqrt{5}}$, $\frac{v}{\sqrt{10}}$ and $\frac{v}{\sqrt{15}}$ respectively. Find the ratio xy : yz.

Solution: The distance travelled between $xy = \frac{v^2 - u^2}{2(-g)}$, where $v = \frac{v}{\sqrt{10}}$, $u = \frac{v}{\sqrt{5}}$

$$\therefore \quad xy = \frac{\left(\frac{v}{\sqrt{10}}\right)^2 - \left(\frac{v}{\sqrt{5}}\right)^2}{-2g}$$

$$= \frac{v^2}{-2g}\left[\frac{1-2}{10}\right] = \frac{v^2}{20g}$$

$$\text{Similarly, } yz = \frac{\left(\frac{v}{\sqrt{15}}\right)^2 - \left(\frac{v}{\sqrt{10}}\right)^2}{-2g}$$

$$= \frac{v^2}{-2g}\left[\frac{2-3}{30}\right] = \frac{v^2}{60g}$$

$$\therefore \quad \frac{xy}{yz} = \frac{v^2}{20g} \times \frac{60g}{v^2} = 3:1$$

5. When a body is dropped from a tower, it covers 75% of the total height of the tower in the last second of its fall. What is the total height of the tower?

Solution: Let h be the height of the tower the initial velocity u = 0

$$h = \frac{1}{2}gt^2 \qquad \ldots.(1)$$

$$S_n = \frac{g}{2}(2t-1) = 0.75\,h$$

$$= \frac{g}{2}(2t-1) = 0.75\left(\frac{1}{2}gt^2\right) \text{ (from (1))}$$

$$2t - 1 = \frac{75t^2}{100} = \frac{3}{4}t^2$$

$8t - 4 = 3t^2$

$3t^2 - 8t + 4 = 0$

$$t = \frac{8 \pm \sqrt{64 - 4\times3\times4}}{2\times3} = \frac{8 \pm \sqrt{16}}{12} = \frac{8 \pm 4}{12}$$

$t = 1, -2/3 \Rightarrow t = 1$ s

$$h = \frac{1}{2}\times gt^2 = \frac{1}{2}\times 9.8 \times 1 = 4.9 \text{ m}$$

6. A hot air balloon, released from the ground, moves up with a constant acceleration of 5 ms^{-2}.A stone is released from it at the end of 8 seconds. Find the height of the stone from the ground at the end of 8 seconds after it is released from the balloon. (Take g = 10 ms^{-2})

Solution: The velocity of the stone, when it is released from the balloon is given by v = u + at and is equal to the velocity of the balloon. Consider downward direction as positive and substitute, v = ?, u = 0, a = –5 ms^{-2}, t = 85

$v = -5 \times 8 = -40\ ms^{-1}$ -------- (1)

The displacement of the stone after 8 s is

$s = -ut + 1/2\,gt^2$

Substituting s = .h, u = – 40 ms^{-1},

t = 8 s, g = 10 ms^{-2}

$$h = -40 \times 8 + \frac{1}{2}\times 10 \times 8^2$$

$h = -320 + 320 \quad h = 0.$

i.e., the stone returns back to the position from where it was released, i.e., the height of the balloon from the ground at the end of 8 seconds

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

substitute u = 0,

a = – 5 ms^{-2}, t = 8 s

$s = -1/2 \times 5 \times 8 \times 8 = -5 \times 4 \times 8$

s = – 160 m

∴ The height of the balloon from the ground is 160 m.

7. A body takes 't' seconds to reach a maximum height 'H' m, when projected vertically upward from the ground. Find the position of the body after $\frac{t}{2}$ seconds from the ground in terms of H.

Solution: Let 'h' be the height attained by the body in $\frac{t}{2}$ second $s = ut - \frac{1}{2}gt^2$

Substituting s = h, $t = \frac{t}{2}$

$$h = u \times \frac{t}{2} - \frac{1}{2}g\left(\frac{t^2}{4}\right) \qquad \ldots\ldots\ldots (1)$$

$$H = \frac{u^2}{2g} \Rightarrow u = \sqrt{2gH} \qquad \ldots\ldots. (2)$$

$$t = \frac{u}{g} = \frac{\sqrt{2gH}}{g} \qquad \ldots\ldots\ldots\ldots\ldots (3)$$

Substituting (2) and (3) in (1)

$$h = \sqrt{2gH} \times \frac{\sqrt{2gH}}{2g} - \frac{g}{2} \times \frac{2gH}{4g^2} = \frac{2gH}{2g} - \frac{H}{4}$$

$$= H - \frac{H}{4} = \frac{3}{4}H$$

8. A ball is dropped from a height of 45 m. Two seconds later, another ball is thrown downward from the same height. If both hit the ground simultaneously, find the difference between velocities of the two balls, just before hitting the ground. (Take g = 10 ms^{-2})

Solution: The velocity of the first ball on reaching the ground is given by $v_1 = \sqrt{2gh}$.

Substituting g = 10 ms^{-2} and h = 45 m we get

$v_1 = \sqrt{2 \times 10 \times 45} = \sqrt{900} = 30\ ms^{-1}$ ------ (1)

The time taken by the first ball to reach the ground, $t = \frac{v_1}{g}$. Substituting the value of v_1, we get $t = \frac{30}{10} = 3s$

Hence, the time taken by the second ball to reach the ground = 3 – 2 = 1 s ------ (2)

To find the initial velocity v_2 of the second ball, we use the formula $s = ut + \frac{1}{2}gt^2 \Rightarrow s = v_2\,t - \frac{1}{2}gt^2$

Substituting s = 45 m

t = 1 second, v_2 = ?

$45 = -v_2 \times 1 - 1/2 \times 10 \times 1^2$

$v_2 = 45 + 5 = 50\ ms^{-1}$ ....(3)

Difference in the velocity = $v_2 - v_1$

$= 50\ ms^{-1} - 30\ ms^{-1} = 20\ ms^{-1}$

9. A missile is launched from the ground, making an angle of 45° with the ground, so as to hit an aeroplane which is moving horizontally at a height of 840 m. If the missile hit the target at a horizontal distance 1 km from it, find the speed with which the missile was launched. (Take g = 10 ms^{-2}).

Solution: For horizontal motion of the missile, we can write

$x = u\cos\theta \times t$, Substituting x = 1000 m, θ = 45°

we get $1000 = u\cos 45° \times t$

$$1000 = \frac{ut}{\sqrt{2}};\ ut = 1000\sqrt{2} \rightarrow (1)$$

For vertical motion of the missile, we can write

$$y = u\sin\theta \times t - \frac{1}{2}gt^2;$$

Substitute y = 840 m, θ = 45°; g = 10 ms^{-2}

$$\Rightarrow 840 = \frac{ut}{\sqrt{2}} - 5t^2;$$

Substituting $\frac{ut}{\sqrt{2}}$ from equation (1)

$840 = 1000 - 5t^2,\ 5t^2 = 160 \Rightarrow t = 4\sqrt{2}$ s

substituting value of 't' in equation (1)

we get $u \times 4\sqrt{2} = \sqrt{2} \times 1000$

$\Rightarrow u = 250\ ms^{-1}$

10. A bullet is fired from the gun held horizontally such that the velocity of the bullet is 200 ms^{-1} and the gun is held 5 m above the ground. Find the horizontal distance covered by the bullet on reaching the ground. (Take g = 10 ms^{-2})

Solution: Given, initial horizontal velocity, u = 200 ms^{-1}.

The vertical height, y = 5 m.

Let the time taken to cover 5 m, = t s.

g = 10 ms^{-2}

$$\therefore\ y = \frac{1}{2}gt^2$$

$$\Rightarrow t^2 = \frac{2y}{g} = \frac{2 \times 5}{10} = 1$$

t = 1 s

∴ The horizontal distance covered in 1 s,

x = u t = 200 × 1 = 200 m

PRACTICE EXERCISE 2 (A)

Directions for questions 1 to 40: Select the correct alternative from the given choices.

1. What would be the path of a body dropped from an aeroplane moving horizontally with reference to an observer sitting in the plane?

(1) Parabolic (2) Vertically downword
(3) Horizontally (4) Elliptical

2. An automobile travelling with a speed of 72 km h^{-1}, can be stopped within a distance of 20 m, by applying brakes.

(A) Determine the retardation.

(1) 100 ms^{-2} (2) -10 ms^{-2}
(3) 5 ms^{-2} (4) -5 ms^{-2}

(B) Determine the distance travelled in the first second.

(1) 10 m (2) 15 m
(3) 25 m (4) 35 m

3. The length of a minutes hand of a clock is 4 cm. The average velocity of the tip of the minutes hand when it moves during a time interval from 3 pm to 3.45 p.m. is ______ ms^{-1}.

(1) 2.2×10^{-3} (2) 210
(3) 2.1×10^{-5} (4) 3.2×10^{-2}

4. An automobile travelling with a speed of 72 km h^{-1}, can be stopped within a distance of 30 m, by applying brakes. What will be the stopping distance, if the automobile speed is increased to $\sqrt{3}$ times and the same breaking force is applied?

(1) 30 m (2) 90 m'
(3) 60 m (4) 120 m

5. A body when dropped from certain height falls to the ground in 4 s. What is the time taken by the body to cover the last 100 cm? (Take g = 10 ms^{-2})

(1) 0.65 s (2) 0.15 s
(3) 0.125 s (4) 0.025 s

6. A body is projected from the ground with a velocity of 30 ms^{-1}, making an angle of 30° with the horizontal. Find the maximum height obtained by it. (Take g = 10 ms^{-2}).

(1) 32.5 m (2) 62.5 m
(3) 11.25 m (4) 12.55 m

7. Two bodies are projected horizontally from the top of a tower of height 20 m with velocities 30 ms^{-1} and 60 ms^{-1}. The ratio of time taken by them to reach the ground is _____.

(1) 1 : 2 (2) 2 : 1
(3) 1 : 1 (4) 3 : 2

8. A stone is thrown horizontally from the top of a tower with a velocity of 12 ms^{-1}. If it reaches the ground in 2 s, find the horizontal distance covered and the height of the tower.

(1) 24 m , 20 m
(2) 20 m, 24 m
(3) 12 m, 24 m
(4) 36 m, 20 m

9. A stone thrown vertically upward passes a certain point P at the end of 2 seconds and 8 seconds respectively. Find the maximum height reached by the stone. (Take g = 10 ms^{-2}).

(1) 625 m (2) 125 m
(3) 225 m (4) 350 m

10. A stone is released from a hot-air balloon which is rising steadily with a velocity of 4 ms^{-1}. The velocity of the stone at the end of 3 s after it is released is _____ ms^{-1}.

(1) 29.4 (2) 25.4
(3) 32.5 (4) 62.7

11. A ball is thrown vertically upwards from the top of a tower with a velocity 10 ms^{-1}. The ball reaches the ground with a velocity 30 ms^{-1}. What is the height of the tower? (Take g = 10 ms^{-2})

(1) 40 m (2) 20 m
(3) 60 m (4) 80 m

12. A stone projected vertically upwards reaches to the level of a window 10 m from the ground. Find the magnitude of velocity of the stone at the time of its projection.

(1) 7 ms^{-1} (2) 36 ms^{-1}
(3) 28 ms^{-1} (4) 14 ms^{-1}

13. The time of ascent of a body projected with a velocity u ms^{-1} is ______

(1) g/u (2) $u^2/2g$
(3) u/g (4) 2u/g

14. The ratio of magnitude of velocity of projection in the upward direction to the magnitude of velocity of the body on reaching the point of projection on its downward motion is _______.

(1) 9 : 1 (2) 1 : 1
(3) 2 : 1 (4) 4 : 1

15. When a body is projected upward it moves with a _______.

(1) uniform velocity
(2) uniform acceleration
(3) uniform speed
(4) Both (1) and (3)

16. What is the velocity of a vertically projected body at its maximum height (h)?

(1) $\sqrt{2gh}$ (2) zero
(3) $\frac{h^2}{g}$ (4) $\sqrt{\frac{2h}{g}}$

17. A hollow iron ball (A) and a solid iron ball (B) and cricket ball (C) are dropped from the same height. Which among the three balls reaches the ground first?

(1) A
(2) B
(3) C
(4) All the three balls will reach the ground simultaneously.

18. The speed of a body projected upwards ______

(1) decreases
(2) increases
(3) remains same
(4) first decreases then increases

19. A body 'A' is dropped from a height h and the another body B is thrown horizontally with a velocity of 10 ms^{-1} from the same height simultaneously. If the time taken by the body A to reach the ground is 3 s, the time taken by the body B to reach the ground is _______ s.

(1) 3 (2) 25
(3) 75 (4) 5

20. A stone dropped from the top of a building takes 5 s to reach the ground. If it is stopped momentarily 4 s after it is dropped and then released again, how much time would it take from the moment it is released again to reach the ground?
(Take g = 10 ms^{-2})

(1) 1 s (2) 3 s
(3) 4 s (4) 5 s

21. The distance travelled by a body starting with a velocity of 20 ms^{-1}, and moving with an acceleration of 2 ms^{-2}, in the 8th second is _______ m.

(1) 35 (2) 20
(3) 120 (4) 10

22. The final velocity of a body starts from rest and moving with an acceleration 2 ms^{-2} and covering a distance of 10 m is _______ ms^{-1}.

(1) $\sqrt{98}$ (2) $\sqrt{40}$
(3) $\sqrt{20}$ (4) $\sqrt{12}$

23. The acceleration of a body initially moving with a velocity of 5 ms^{-1}, if it attains a velocity of 25 ms^{-1} in 5s is _______ ms^{-2}.

(1) 8 (2) 7
(3) 4 (4) 3

24. The displacement of a body starts from rest, and moving with an acceleration of 1 ms^{-2} at the end of 5 s is _______ m.

(1) 12.5 (2) 25
(3) 7.5 (4) 15

25. A body starts moving with an initial velocity of 5 ms^{-1} and an accele ration of 1 ms^{-2}. The distance travelled by it in the 5th second is

(1) 9.5 m (2) 22.5 m
(3) 50 cm (4) 10 cm

26. A bus travels the first one-third distance at a speed of 10 km h^{-1}, the next one-third distance at a speed of 20 km h^{-1} and the next one-third distance at a speed of 30 km h^{-1}.

The average speed of the bus is

(1) 20 ms^{-1} (2) $\frac{50}{11}$ ms^{-1}
(3) $\frac{180}{11}$ ms^{-1} (4) 30 ms^{-1}

27. The ratio of the time taken by a body moving with uniform acceleration in reaching two points P and Q along a straight line path is 1 : 2. If the body starts from rest and moves linearly, the ratio of the distances of P and Q from the starting point is

(1) 4 : 1 (2) 1 : 4
(3) 2 : 3 (4) 3 : 1

28. A body starts from rest and moves with uniform acceleration for 3 s. It then decelerates uniformly for 2 s and stops. If the deceleration is 3 ms^{-2}, the maximum velocity of the body is ________ ms^{-1}.

(1) zero
(2) 2
(3) 6
(4) Cannot be determined

29. An ant moves from one corner of a hall to the diagonally opposite corner. If the dimensions of the hall are 8 m × 6 m, the displacement of the ant is _____ m.

(1) 14 (2) 10
(3) 28 (4) 2

30. A particle moves from P to Q with a uniform velocity v_1 and Q to P with a velocity v_2. If it moves along a straight line between P and Q then its average velocity will be _______.

(1) $\frac{2v_1v_2}{v_1+v_2}$ (2) $\frac{v_1v_2}{2}$

(3) $\frac{v_1+v_2}{2}$ (4) zero

31. When brakes are applied the velocity of a car changes from 30 ms^{-1} to 10 ms^{-1} in 5 s. The acceleration produced in it is ______ ms^{-2}.

(1) 4 (2) −4
(3) 20 (4) −20

32. A body starts from rest and moves with uniform acceleration for 2 s. It then decelerates uniformly for 3 s and stops. If deceleration is 4 ms^{-2}, the acceleration of the body is _______ ms^{-2}.

(1) 10 (2) 8.7
(3) 4 (4) 6

33. The ratio of the heights from which two bodies are dropped is 3 : 5 respectively. The ratio of their final velocities is

(1) $\sqrt{5}:\sqrt{3}$ (2) $\sqrt{3}:\sqrt{5}$
(3) 9 : 25 (4) 5 : 3

34. If a body is projected vertically up from a point and it returns to the same point, its

(1) average speed is zero, but not average velocity.
(2) Both average speed and average velocity are zero.
(3) average velocity is zero but not average speed.
(4) Both average speed and velocity depend upon the path.

35. If a ball thrown vertically up attains a maximum height of 80 m, its initial speed is ($g = 10\ ms^{-2}$)

(1) 40 ms^{-1}
(2) 20 ms^{-1}
(3) 50 ms^{-1}
(4) 10 ms^{-1}

36. A vertically projected body travels with

(1) uniform velocity.
(2) uniform speed.
(3) uniform acceleration.
(4) uniform retardation.

37. A particle revolves along a circle with a uniform speed. The motion of the particle is _______.

(1) one dimensional
(2) two dimensional
(3) translatory
(4) oscillatory

38. A body is projected horizontally from a certain height, (h) then time of descent is

(1) $t_d = \sqrt{\frac{2h}{g}}$

(2) $t_d = \sqrt{\frac{h}{g}}$

(3) $t_d = \sqrt{hg}$

(4) $t_d = \sqrt{h+g}$

39. If u is the initial velocity, of a body projected with an angle θ with the horizontal, then the maximum height reached is _______.

(1) $\frac{u^2}{g}$ (2) $\frac{u^2 \sin\theta}{2g}$

(3) $\frac{u \sin\theta}{2g}$ (4) $\frac{u^2 \sin^2\theta}{2g}$

40. If the initial velocity of a body has both horizontal and vertical components and it is projected up with certain angle, then what is the path followed by it?

(1) Linear path (2) Elliptical path
(3) Parabolic path (4) Spherical path

PRACTICE EXERCISE 2 (B)

Directions for questions 1 to 50: Select the correct alternative from the given choices.

1. Find the initial velocity of projection of a ball thrown vertically up if the distance moved by it in 3rd second is twice the distance covered by it in 5th second. (Take $g = 10\ ms^{-2}$)

(1) $45\ ms^{-1}$ (2) $65\ ms^{-1}$
(3) $20\ ms^{-1}$ (4) $85\ ms^{-1}$

2. A stone dropped from the top of a building takes 5 seconds to reach the ground. If it is stopped momentarily 3 s after it is dropped and then released again, the average velocity of the body is _____ ms^{-1} (take $g = 10\ ms^{-2}$)

(1) 25 (2) 41.66
(3) 62.5 (4) 17.85

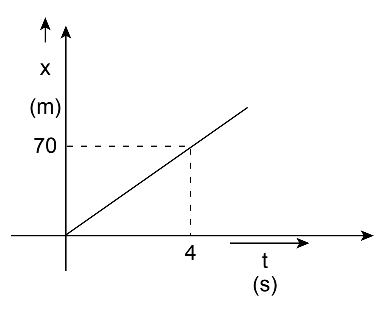
3. A body when projected at an angle 60° with the horizontal covers a horizontal distance of 90 m in 5 s. Instead, if the body is thrown upward with the same velocity. The maximum height attained by it is _______ m. (Take $g = 10\ ms^{-2}$)

(1) 68.8 (2) 64.8
(3) 34.8 (4) 36.4

4. For a projectile, an of the horizontal distance covered by it is maximum when the angle of projection is ______.

(1) 90° (2) 45°
(3) zero (4) 30°

5. The variation of horizontal displacement (x) of a projectile with time (t) is as shown in the figure. If the angle of projection is 60°, find the velocity of projection is ___ ms^{-1}.



(1) 35 (2) 65
(3) 30 (4) 50

6. Two bodies are projected from the ground with the same speed. If the angles of their projection from the ground are 30° and 60° respectively, what is the ratio of their horizontal displacements after 2 s?

(1) $1 : \sqrt{2}$ (2) $\sqrt{3} : 1$
(3) $1 : \sqrt{3}$ (4) $\sqrt{2} : 1$

7. A football is kicked from the ground in air such that it covers a maximum horizontal distance of 44 m. What is the maximum height attained by it?
(Take $g = 10\ ms^{-2}$)

(1) 11 m (2) 22 m
(3) 44 m (4) 88 m

8. A stone thrown from the ground just crosses a wall of height 5 m in 2 s. If the wall is at a horizontal distance 25 m, from the point of projection of the stone, find at what distance the stone falls behind the wall. ($g = 10\ ms^{-2}$).

(1) 31.25 m (2) 6.25 m
(3) 25 m (4) 32.5 m

9. Two bodies of different masses m_1 and m_2 are dropped from two different heights h_1 and h_2. What is the ratio of the times taken by the two to reach the ground?

(1) $\sqrt{h_1} : \sqrt{h_2}$ (2) $\sqrt{h_2} : \sqrt{h_1}$
(3) $m_1h_2 : m_2h_1$ (4) $m_1h_1 : m_2h_2$

10. A particle is projected up with a velocity of $\sqrt{29}\ m\ s^{-1}$ from the tower of height 10 m. What is its velocity on reaching the ground?

(1) $25\ ms^{-1}$ (2) $15\ ms^{-1}$
(3) $12.5\ ms^{-1}$ (4) $7.5\ ms^{-1}$

11. A cannon elevated at an angle of 15°, throws a shell with a muzzle speed of $196\ ms^{-1}$. Due to air resistance the range decreases by 100 m, then what is the observed range?

(1) 1960 m (2) 1860 m
(3) 2000 m (4) 1660 m

12. A person travels two parts of the total distance in the ratio 2 : 1 with constant speeds of $30\ km\ h^{-1}$ and $40\ km\ h^{-1}$ respectively. The average speed of the journey is _______ $km\ h^{-1}$.

(1) 13.5 m (2) 62.2
(3) 42.5 (4) 32.7

13. A person starts from point A and walks 120 m in north east direction, 120 m in south east direction, 120 m in north west direction and finally he is taken vertically upwards by a distance of 50 m with the help of a parachute. Find his total displacement from A.

(1) 130 m (2) 250 m
(3) 350 m (4) 670 m

14. Two bodies are projected from the ground with the same speed. If the angles of their projection from the ground are 45° and 15° respectively, the ratio of their range is

(1) $1:2$ (2) $2:1$
(3) $\sqrt{3}:2$ (4) $1:\sqrt{2}$

15. Two balls are projected horizontally from the top of a building simultaneously with velocities 15 ms^{-1} and 20 ms^{-1} respectively. The ratio of times taken by them to reach the ground is ________.

(1) $2:3$ (2) $3:4$
(3) $1:1$ (4) $4:9$

16. A freely falling body crosses points P, Q and R with velocities V, 2V and 3V respectively. Find the ratio of the distances PQ to QR.

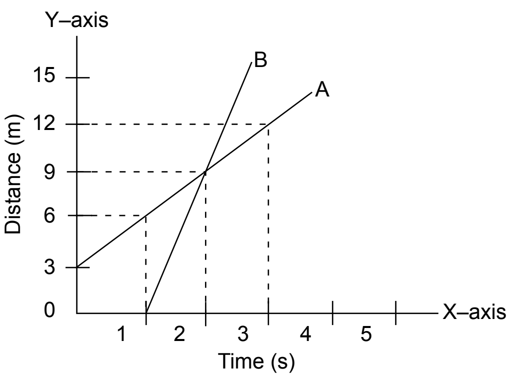
(1) $5:3$ (2) $3:5$
(3) $1:2$ (4) $2:1$

17. A bike moving along a straight road covers 35 m in the 4th second and 40 m in the 5th second. What is its initial velocity and acceleration (if the acceleration is assumed to be uniform)?

(1) 17.5 ms^{-1} (2) 8 ms^{-1}
(3) 7.8 ms^{-1} (4) 38.5 ms^{-1}

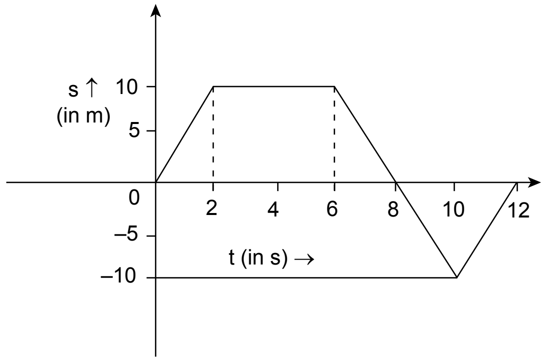
18. The adjacent figure shows the distance-time graph of two bodies A and B.

What is the distance travelled by A and B at the end of 2 s?



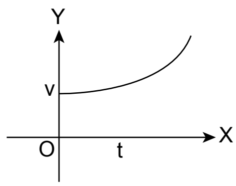
(1) 3 m, 6 m (2) 6 m, 9 m
(3) 9 m, 6 m (4) 3 m, 6 m

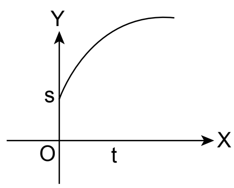
19. From the adjacent figure a displacement-time graph of a body moving in a straight line. Find the distance covered and the displacement of the body at the end of 12 seconds.

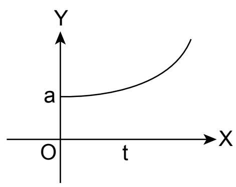


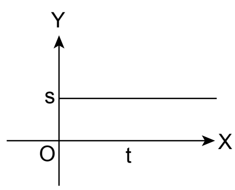
(1) 40 m, zero
(2) 20 m, zero
(3) 10 m, 10 m
(4) 20 m, 20 m

20. Which of the following graphs indicates that a body is undergoing retardation?

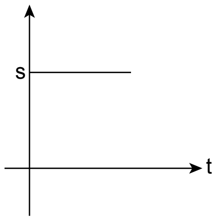
(1) 

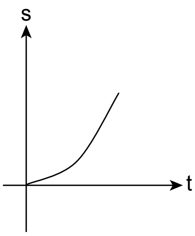
(2) 

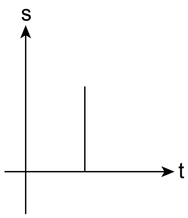
(3) 

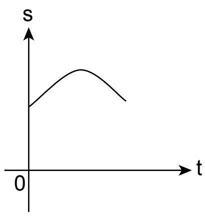
(4) 

21. Which of the following graphs given below is impossible?

(1) 

(2) 

(3) 

(4) 

22. A car moves with a constant velocity of 10 ms^{-1} for 10 s along a straight road. Then it moves with uniform acceleration of 2 ms^{-2} for 5 seconds. Find the total displacement at the end of the 15 s of its motion.

(1) 175 m (2) 125 m
(3) 150 m (4) 105 m

23. A person travels 6 m towards east and 8 m towards north from there again he travelled 16 m towards south. What is the displacement covered by the person?

(1) 10 m (2) 20 m
(3) 30 m (4) 40 m

24. The velocity of a retarding body changes from 90 km h^{-1} to 36 km h^{-1}. Find its change in velocity in ms^{-1}.

(1) -20 ms^{-1} (2) -15 ms^{-1}
(3) -18 ms^{-1} (4) -36 ms^{-1}

25. A person is running along a circular track of area 625 π m^2 with a constant speed. Find the distance travelled and displacement in 30 s and 15 s, if he has to complete the race in 30 s.

(1) 200 π m (2) 100 π m
(3) 25 π m (4) 50 π m

26. An object travels for 10 s with uniform acceleration along a straight line path. During this period if the velocity of the object is increased from 5 ms^{-1} to 25 ms^{-1}, then find the distance travelled by the body.

(1) 150 m (2) 100 m
(3) 125 m (4) 175 m

27. A pendulum of 28 cm length oscillates such that its string makes an angle of 30° with the vertical when it is at one of the extreme positions. Find the ratio of the distance to displacement of the bob of the pendulum when it moves from one extreme position to the other.

(1) 22 : 21 (2) 42 : 21
(3) 1 : 1 (4) 43 : 22

28. A train leaves station 'A' for station 'B'. The train travels along a straight line without any halts between the stations. During the first and last 200 m of its journey, the train has uniform acceleration and retardation both equal to 1 ms^{-2} respectively. For the rest of the journey, the train maintains uniform speed. Calculate the average speed of the train, given the distance between the two stations is 4 km.

(1) $18\frac{2}{11}$ ms^{-1} (2) $9\frac{2}{5}$ ms^{-1}
(3) $\frac{100}{11}$ ms^{-1} (4) $17\frac{6}{5}$ ms^{-1}

29. A body falls from a height of 45 m above the ground. Find the time taken by the body to reach the ground. (Take g = 10 ms^{-2})

(1) 5 s (2) 2 s
(3) 3 s (4) 6 s

30. A ball thrown vertically upwards with speed 'u' from the top of a tower reaches the ground in 9 s. Another ball thrown vertically downwards from the same position with speed 'u', takes 4 s to reach ground. Calculate the value of 'u'. (Take g = 10 ms^{-2})

(1) 15 ms^{-1} (2) 20 ms^{-1}
(3) 25 ms^{-1} (4) 45 ms^{-1}

31. A body is dropped from a certain height 'h' metres. Assuming that the gravitational field is nullified, after the body has travelled h/2 metres such that g = 0, discuss the motion of the body. Find an expression for the time taken by the body to reach the ground.

(1) $\frac{3}{2}\sqrt{\frac{h}{g}}$ (2) $\sqrt{\frac{g}{h}}$
(3) $\sqrt{gh}$ (4) $\frac{1}{2}\sqrt{2gh}$

32. A ball thrown vertically upwards with speed 'u' from the top of a tower reaches the ground in 9 s. Another ball thrown vertically downwards from the same position with speed 'u', takes 4 s to reach ground. Calculate the value of 'u'.

(Take g = 10 ms^{-2})

(1) 125 ms^{-1} (2) 75 ms^{-1}
(3) 25 ms^{-1} (4) 175 ms^{-1}

33. An object projected vertically up from the top of a tower took 5 s to reach the ground. If the average velocity of the object is 5 ms^{-1}, find its average speed. (given g = 10 ms^{-1}).

(1) 65 ms^{-1} (2) 13 ms^{-1}
(3) 26 ms^{-1} (4) 25 ms^{-1}

34. Two stones A and B are dropped from the top of two different towers such that they travel 44.1 m and 63.7 m in the last second of their motion respectively. Find the ratio of the heights of the two towers from where the stones were dropped.

(1) 16 : 25 (2) 7 : 9
(3) 5 : 7 (4) 25 : 49

35. A ball which is thrown vertically up from the top of a tower reaches the ground in 12 s. Another ball thrown vertically downwards from the same position with same velocity takes 4 s to reach the ground. Find the height of the tower. (Take g = 10 ms^{-2})

(1) 180 m (2) 120 m
(3) 220 m (4) 240 m

36. A body is dropped from a height of 2 m. It penetrates into the sand on the ground through a distance of 10 cm before coming to rest. What is the retardation of the body in the sand?

(1) −9.8 ms^{-1} (2) 196 ms^{-2}
(3) −196 ms^{-2} (4) 9.8 ms^{-2}

37. A ball is thrown vertically upwards with an initial velocity such that it can reach a maximum height of 15 m. If, at the same instance, a stone is dropped from a height of 15 m, find the ratio of distances travelled by them when they cross each other.

(1) 4 : 3 (2) 2 : 3
(3) 1 : 2 (4) 3 : 1

38. A balloon starts rising from the ground, vertically upwards, uniformly at the rate of 1 ms^{-1}. At the end of 4 seconds a body was released from the balloon. Calculate the time taken by the released body to reach the ground. Take g = 10 ms^{-2}.

(1) 4 s (2) 1 s
(3) 6 s (4) 3 s

39. A body is projected from the ground with a velocity of 10 ms^{-1} such that it makes an angle 30° with the horizontal. What is the horizontal velocity at the maximum height?

(1) $6\sqrt{2}$ m s^{-1} (2) $9\sqrt{2}$ ms^{-1}
(3) $3\sqrt{5}$ ms^{-1} (4) $5\sqrt{3}$ ms^{-1}

40. A body is projected horizontally with a velocity $\sqrt{23}$ ms^{-1} from a height of 5 m. What is the velocity of the body on reaching the ground?

(1) 22 ms^{-1} (2) 11 ms^{-1}
(3) 62 ms^{-1} (4) 12 ms^{-1}

ANSWER KEYS

PRACTICE EXERCISE 2 (A)

1. 2	**2.** (A) 2	(B) 2	**3.** 3	**4.** 2	**5.** 4	**6.** 3	**7.** 3	**8.** 1	**9.** 2
10. 2	**11.** 1	**12.** 4	**13.** 3	**14.** 2	**15.** 3	**16.** 2	**17.** 3	**18.** 4	**19.** 1
20. 2	**21.** 1	**22.** 2	**23.** 3	**24.** 1	**25.** 1	**26.** 2	**27.** 2	**28.** 3	**29.** 2
30. 4	**31.** 2	**32.** 4	**33.** 2	**34.** 3	**35.** 1	**36.** 3	**37.** 2	**38.** 1	**39.** 4
40. 3									

PRACTICE EXERCISE 2 (B)

1. 2	**2.** 4	**3.** 2	**4.** 2	**5.** 1	**6.** 2	**7.** 1	**8.** 2	**9.** 1	**10.** 2
11. 2	**12.** 4	**13.** 1	**14.** 2	**15.** 3	**16.** 2	**17.** 1	**18.** 2	**19.** 1	**20.** 2
21. 3	**22.** 1	**23.** 1	**24.** 2	**25.** 4	**26.** 1	**27.** 1	**28.** 1	**29.** 3	**30.** 3
31. 1	**32.** 3	**33.** 2	**34.** 4	**35.** 4	**36.** 2	**37.** 4	**38.** 2	**39.** 4	**40.** 2