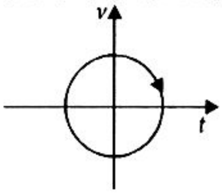
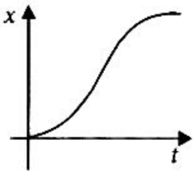
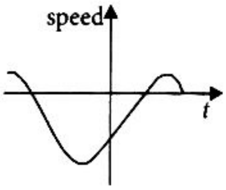
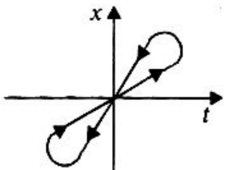
Motion in a Stright Line

1. Look at the graphs (a) to (d) carefully and indicate which of these possibly represents one dimensional motion of a particle?

(a) 

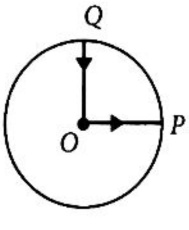
(b) 

(c) 

(d) 

(2006)

2. A cyclist starts from the centre O of a circular park of radius one kilometre, reaches the edge P of the park, then cycles along the circumference and returns to the centre along QO as shown in the figure. If the round trip takes ten minutes, the net displacement and average speed of the cyclist (in metre and kilometre per hour) is



(a) 0, 1 (b) $\frac{\pi + 4}{2}, 0$

(c) 21.4, $\frac{\pi + 4}{2}$ (d) 0, 21.4 *(2006)*

3. A body of mass m moving along a straight line covers half the distance with a speed of 2 ms^{-1}. The remaining half of the distance is covered in two equal time intervals with a speed of 3 ms^{-1} and 5 ms^{-1} respectively. The average speed of the particle for the entire journey is

(a) $\frac{3}{8}$ ms^{-1} (b) $\frac{8}{3}$ ms^{-1}

(c) $\frac{4}{3}$ ms^{-1} (d) $\frac{16}{3}$ ms^{-1}. *(2009)*

4. A train is moving slowly on a straight track with a constant speed of 2 m s^{-1}. A passenger in that train starts walking at a steady speed of 2 m s^{-1} to the back of the train in the opposite direction of the motion of the train. So to an observer standing on the platform directly in front of that passenger, the velocity of the passenger appears to be

(a) 4 m s^{-1} (b) 2 m s^{-1}

(c) 2 m s^{-1} in the opposite direction of the train

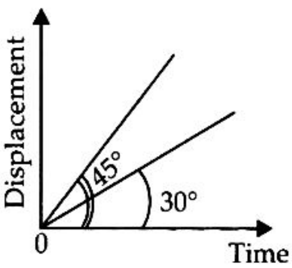
(d) zero *(2010)*

5. A motorboat covers a given distance in 6 hours moving downstream on a river. It covers the same distance in 10 hours moving upstream. The time it takes to cover the same distance in still water is

(a) 9 hours (b) 7.5 hours

(c) 6.5 hours (d) 8 hours *(2010)*

6. The displacement-time graphs of two moving particles make angles of 30° and 45° with the X-axis. The ratio of their velocities is



(a) $\sqrt{3} : 2$ (b) 1 : 1

(c) 1 : 2 (d) $1 : \sqrt{3}$ *(2011)*

7. A car moves from A to B with a speed of 30 kmph and from B to A with a speed of 20 kmph. What is the average speed of the car ?

(a) 50 kmph (b) 25 kmph

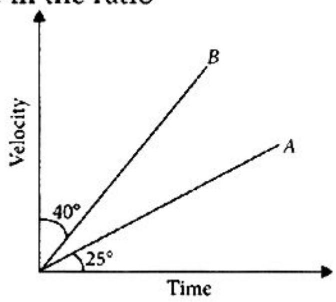
(c) 10 kmph (d) 24 kmph *(2014)*

8. A body starts from rest and moves with constant acceleration for t s. It travels a distance x_1 in first half of time and x_2 in next half of time, then

(a) $x_2 = 3x_1$ (b) $x_2 = x_1$

(c) $x_2 = 4x_1$ (d) $x_2 = 2x_1$ *(2014)*

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

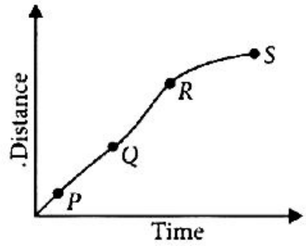


(a) tan25° to tan50° (b) cos25° to cos50°
(c) tan25° to tan40° (d) sin25° to sin50° *(2015)*

10. A body falls freely for 10 sec. Its average velocity during this journey (take $g = 10\ m\ s^{-2}$)
(a) $100\ m\ s^{-1}$ (b) $10\ m\ s^{-1}$
(c) $50\ m\ s^{-1}$ (d) $5\ m\ s^{-1}$ *(2016)*

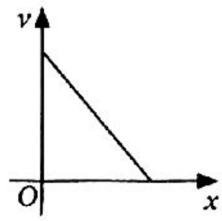
11. A car moving with a velocity of $20\ m\ s^{-1}$ is stopped in a distance of 40 m. If the same car is travelling at double the velocity, the distance travelled by it for same retardation is
(a) 640 m (b) 320 m
(c) 1280 m (d) 160 m *(2017)*

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

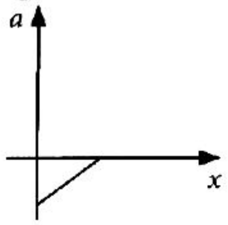


(a) P (b) S
(c) R (d) Q *(2018)*

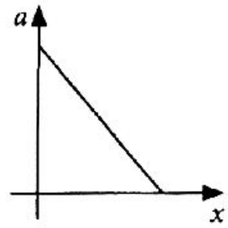
13. The given graph shows the variation of velocity (v) with position (x) for a particle moving along a straight line. Which of the following graph shows the variation of acceleration (a) with position (x)?



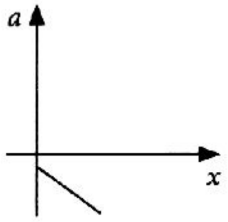
(a)



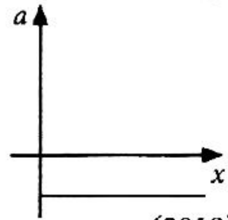
(b)



(c)



(d)



(2019)

ANSWER KEY

1.	(b)	**2.**	(d)	**3.**	(b)	**4.**	(d)	**5.**	(b)	**6.**	(d)	**7.**	(d)	**8.**	(a)
9.	(a)	**10.**	(c)	**11.**	(d)	**12.**	(c)	**13.**	(a)						

EXPLANATIONS

1. (b) : The particle is first slowly accelerated and reaches a constant velocity for the straight line portion where distance x is directly proportional to time and then velocity decreases and finally it stops when it reaches the top straight line portion. Therefore, the curve (b) depicts motion in one dimension.

2. (d) : Net displacement of the cyclist = zero Since the initial position coincide with the final position.

Average speed of the cyclist

$$= \frac{\text{total distance travelled}}{\text{total time taken}}$$

$$= \frac{OP + PQ + QO}{10} \text{ km/min} = \frac{1 + \frac{\pi}{2} \times 1 + 1}{10}$$

$$= \frac{\pi + 4}{20} \text{ km/min} = \frac{\pi + 4}{20} \times 60 \text{ km/h}$$

$= 21.4$ km/h.

3. (b) : Let $2S$ be the total distance travelled by the body.

Let t_1 be the time taken by the body to travel first half of the distance.

$$\therefore \quad t_1 = \frac{S}{2}$$

Let t_2 be the time taken by the body for each time interval for the remaining half journey.

$\therefore \quad S = 3t_2 + 5t_2$ or $t_2 = S/8$

$$\text{Average speed} = \frac{\text{Total distance travelled}}{\text{Total time taken}}$$

$$= \frac{2S}{t_1 + 2t_2} = \frac{2S}{\frac{S}{2} + 2\left(\frac{S}{8}\right)} = \frac{2S}{\frac{S}{2} + \frac{S}{4}} = \frac{8}{3} \text{ ms}^{-1}.$$

4. (d)

5. (b) : Let v_w be the velocity of water and v_b be the velocity of motorboat in still water.

The distance x covered by the motorboat in moving downstream in 6 h is

$$x = (v_b + v_w) \times 6 \qquad \text{...(i)}$$

Same distance x covered by the motorboat in moving upstream in 10 h is

$$x = (v_b - v_w) \times 10 \qquad \text{...(ii)}$$

Equating (i) and (ii), we get

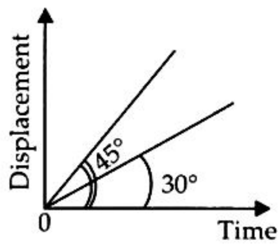
$$(v_b + v_w) \times 6 = (v_b - v_w) \times 10$$

$$v_w = \frac{v_b}{4} \quad \therefore \quad x = (v_b + v_w) \times 6 = 7.5\, v_b$$

Time taken by the motorboat to cover the same distance in still water is

$$t = \frac{x}{v_b} = \frac{7.5 v_b}{v_b} = 7.5 \text{ hours}$$

6. (d) : Slope of displacement-time graph gives velocity.



$$\therefore \quad \frac{v_1}{v_2} = \frac{\tan\theta_1}{\tan\theta_2}$$

$$= \frac{\tan 30°}{\tan 45°} = \frac{1}{\sqrt{3}}$$

7. (d) : Let S be distance between A and B.

Let t_1 be time taken by the car to move from A to B with speed v_1 and t_2 be time taken by the car to move from B to A with speed v_2. Then

$$t_1 = \frac{S}{v_1} \text{ and } t_2 = \frac{S}{v_2}$$

Average speed of the car

$$v_{av} = \frac{\text{Total distance travelled}}{\text{Total time taken}} = \frac{2S}{t_1 + t_2}$$

$$= \frac{2S}{\frac{S}{v_1} + \frac{S}{v_2}} = \frac{2v_1 v_2}{v_1 + v_2}$$

Here, $v_1 = 30$ kmph, $v_2 = 20$ kmph

$$\therefore \quad v_{av} = \frac{2 \times 30 \times 20}{30 + 20} = 24 \text{ kmph}$$

8. (a) : As the body starts from rest,

$\therefore \quad u = 0$

Let a be constant acceleration of the body.

Distance travelled by the body in $(t/2)$ s is

$$x_1 = \frac{1}{2} a \left(\frac{t}{2}\right)^2 = \frac{1}{8} a t^2 \qquad \text{...(i)}$$

Distance travelled by the body in t s is

$$x_1 + x_2 = \frac{1}{2}at^2 = 4x_1 \qquad \text{(Using (i))}$$

$$\therefore \quad x_2 = 4x_1 - x_1 = 3x_1$$

9. **(a)** : As the slope ofvelocity-time graph gives acceleration, so acceleration $a = \tan\theta$

$\therefore$ From the given graph,

The acceleration of A is

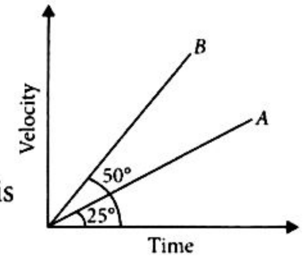
$$a_A = \tan 25°$$

and that of B is

$$a_B = \tan 50°$$

Their corresponding ratio is

$$\frac{a_A}{a_B} = \frac{\tan 25°}{\tan 50°}$$



10. **(c)** : Average velocity,

$$v_{av} = \frac{\text{Net displacement}}{\text{Time taken}} = \frac{s_2 - s_1}{t_2 - t_1}$$

Here, $t_1 = 0$ s, $s_1 = 0$ m, $t_2 = 10$ s, $g = 10$ m s^{-2}

$$s_2 = ut_2 + \frac{1}{2}gt_2^2 = 0 \times 10 + \frac{1}{2} \times 10 \times 10^2 = 500 \text{ m}$$

$$\therefore \quad v_{av} = \frac{500 - 0}{10 - 0} = 50 \text{ m s}^{-1}$$

11. **(d)** : Initial velocity, $u = 20$ m s^{-1};

Final velocity, $v = 0$ m s^{-1};

Distance travelled, $s = 40$ m

Using third equation of motion,

$v^2 - u^2 = 2as$; $0 - 20^2 = 2 \times a \times 40$

We get, $a = -5$ m s^{-2}

For second case, $u = 2 \times 20$ m s^{-1} = 40 m s^{-1},

$v = 0$ m s^{-1} and $a = -5$ m s^{-2}

Using the third equation of motion,

$$s = \frac{0 - (40)^2}{2(-5)} = 160 \text{ m}$$

$\therefore$ Distance travelled by the same car travelling at double velocity is 160 m.

12. **(c)** : The slope of the tangent to the curve at a point gives the instantaneous velocity. Thus, the maximum instantaneous velocity of the particle is around the point R.

13. **(a)** : $v = -kx + c$ (given line with negative slope)

$$\frac{dv}{dt} = -k\frac{dx}{dt} = -kv \Rightarrow a = -k(-kx + c) = k^2x - kc.$$

and $x = 0 \Rightarrow a = -$ve and slope of $a - x$ graph is positive.