RECTILINEAR MOTION

Contents

Syllabus

Kinematics in one dimension.

Name : _____ Contact No. _____

RECTILINEAR MOTION

KEY CONCEPTS

THINGS TO REMEMBER :

1. $v = \frac{ds}{dt}$; $a = \frac{dv}{dt} = v\frac{dv}{ds}$; $s = \int v\,dt$; $v = \int a\,dt$; $\frac{v^2}{2} = \int a\,ds$

where the symbols have their usual meaning .

2. The equations of motion for a body moving in straight line with uniform acceleration, are

(i) $v = u + at$

(ii) $s = \left(\frac{u+v}{2}\right)t = ut + \frac{at^2}{2} = vt - \frac{at^2}{2}$

(iii) $v^2 = u^2 + 2as$

(iv) $s_n = u + \frac{1}{2}a(2n-1)$

(v) $S = \left(\frac{v+u}{2}\right)t$

3. If a body is thrown vertically up with a velocity u in the uniform gravitational field then (neglecting air resistance) :

(i) Maximum height attained $H = \frac{u^2}{2g}$

(ii) Time of ascent = time of descent = $\frac{u}{g}$

(iii) Total time of flight = $\frac{2u}{g}$

(iv) Velocity of fall at the point of projection = u downwards

4. **KINEMATIC GRAPH :**

Slope of the displacement time graph at any particular time gives the magnitude of the instantaneous velocity at that particular time .

Slope of the v - t graph will give the magnitude of the instantaneous acceleration.

The area between the v - t graph , the time axis and the ordinates erected at the beginning & end of time interval considered will represent the total displacement of the body.

EXERCISE # 1

PART - I : OBJECTIVE QUESTIONS

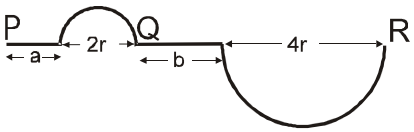
** Marked Questions are having more than one correct option.*

Section : (A) Distance and Displacement

A-1. A man walks 3m in east direction and then 4m in north direction. Distance covered and the displacement covered by man.

(A) 7m, 6m (B) 7m, 5m (C) 7m, 1m (D) 7m, 7m

A-2. A car starts from P and follows the path as shown in figure. Finally car stops at R. Distance travelled and displacement of the car if a = 7 m, b = 8 m and r = $\frac{11}{\pi}$ m? [Take $\pi = \frac{22}{7}$]



(A) 48m, 36m (B) 48m, 42m (C) 48m, 32m (D) 48m, 40m

Section : (B) Average speed and average velocity

B-1. A car travels from A to B at a speed of 20 km h^{-1} and returns at a speed of 30 km h^{-1}. The average speed of the car for the whole journey is :

(A) 5 km h^{-1} (B) 24 km h^{-1} (C) 25 km h^{-1} (D) 50 km h^{-1}

B-2*. Consider the motion of the tip of the minute hand of a clock. In one hour

(A) the displacement is zero (B) the distance covered is zero

(C) the average speed is zero (D) the average velocity is zero

B-3.* A person travelling on a straight line without changing direction moves with a uniform speed v_1 for half distance and next half distance he covers with uniform speed v_2. The average speed v is given by

(A) $v = \frac{2v_1v_2}{v_1+v_2}$ (B) $v = \sqrt{v_1v_2}$ (C) $\frac{2}{v} = \frac{1}{v_1} + \frac{1}{v_2}$ (D) $\frac{1}{v} = \frac{1}{v_1} + \frac{1}{v_2}$

B-4. A body covers first $\frac{1}{3}$ part of its journey with a velocity of 2 m/s, next $\frac{1}{3}$ part with a velocity of 3 m/s and rest of the journey with a velocity 6m/s. The average velocity of the body will be

(A) 3 m/s (B) $\frac{11}{3}$ m/s (C) $\frac{8}{3}$ m/s (D) $\frac{4}{3}$ m/s

Section : (C) Equations of motion and motion under gravity

C-1. The distance travelled by a particle is proportional to the squares of time, then the particle travels with

(A) Uniform acceleration (B) Uniform velocity

(C) Increasing acceleration (D) Decreasing velocity

C-2. A stone is released from an elevator going up with an acceleration a and speed u. The acceleration and speed of the stone just after the release is

(A) a upward, zero (B) (g-a) upward, u

(C) (g-a) downward, zero (D) g downward, u

C-3. A particle moving with a constant acceleration from *A* to *B* in the straight line *AB* has velocities *u* and *v* at *A* and *B* respectively. If *C* is the mid-point of *AB* then the velocity of particle while passing *C* will be

(A) $\sqrt{\frac{v^2+u^2}{2}}$ (B) $\frac{v+u}{2}$ (C) $\frac{v-u}{2}$ (D) $\frac{\left(\frac{1}{v}+\frac{1}{u}\right)}{2}$

C-4. A stone A is dropped from rest from a height h above the ground. A second stone B is simultaneously thrown vertically up from a point on the ground with velocity v. The line of motion of both the stones is same. The value of v which would enable the stone B to meet the stone A midway (at mid point) between their initial positions is

(A) 2 gh (B) $2\sqrt{gh}$ (C) $\sqrt{gh}$ (D) $\sqrt{2gh}$.

C-5. A ball thrown up in vacuum returns after 12 sec. Its position after five seconds will be same as after :

(A) 7 sec (B) 3 sec (C) 4 sec (D) 3.5 sec

C-6. The points *A*, *B*, *C* and *D* lie in a vertical line such that *AB* = *BC* = *CD*. If a body falls from rest at *A*, then the times of descent through *AB*, *BC* and *CD* are in the ratio of

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

C-7. A body when projected vertically up covers a total distance D. The time of its flight is t. If there were no gravity, the distance covered by it during the same time is equal to

(A) 0 (B) D (C) 2D (D) 4D

C-8. A particle is projected vertically upwards from a point A on the ground. It takes t_1 time to reach a point B but it still continues to move up. If it takes further t_2 time to reach the ground from point B then height of point B from the ground is

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

C-9. Balls are thrown vertically upward in such a way that the next ball is thrown when the previous one is at the maximum height. If the maximum height is 5m, the number of balls thrown per minute will be

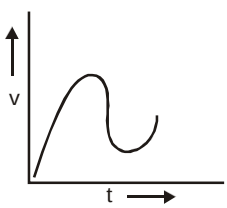
(A) 40 (B) 50 (C) 60 (D) 120

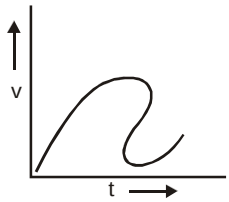
C-10. An object is tossed vertically into the air with an initial velocity of 8 m/s. Using the sign convention upwards as positive, how does the vertical component of the acceleration a_y of the object (after leaving the hand) vary during the flight of the object?

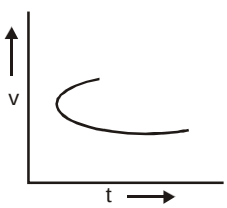
(A) On the way up $a_y > 0$, on the way down $a_y > 0$
(B) On the way up $a_y < 0$, on the way down $a_y > 0$
(C) On the way up $a_y > 0$, on the way down $a_y < 0$
(D) On the way up $a_y < 0$, on the way down $a_y < 0$

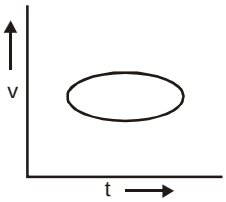
Section : (D) Graph related questions

D-1*. Which of the following v-t graphs are not possible :

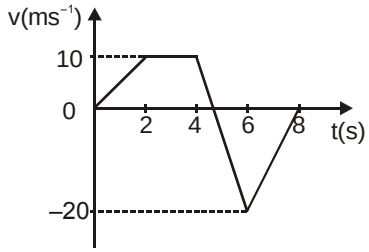
(A) 

(B) 

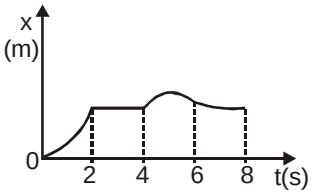
(C) 

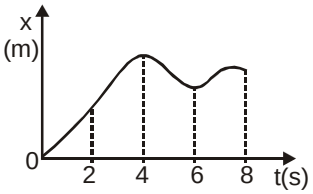
(D) 

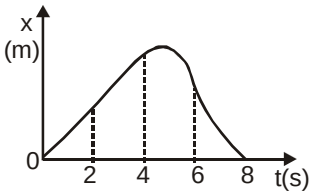
D-2. The figure shows a velocity-time graph of a particle moving along a straight line,

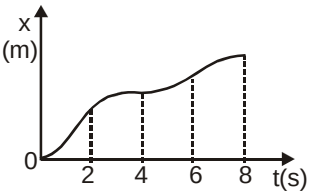


The correct displacement-time graph of the particle is shown as :

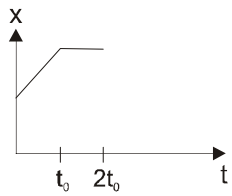
(A) 

(B) 

(C) 

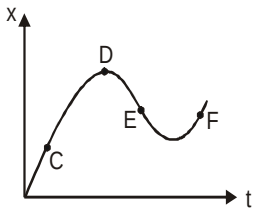
(D) 

D-3. Figure shows the position time graph of a particle moving on the X-axis.



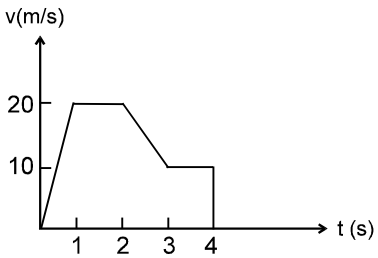
(A) the particle is continuously going in positive x direction
(B) area under x–t curve shows the displacement of particle
(C) the velocity increases up to a time t_o, and then becomes constant.
(D) the particle moves at a constant velocity up to a time t_o, and then stops.

D-4. The displacement–time graph of a moving particle is shown. The instantaneous velocity of the particle is negative at the point :



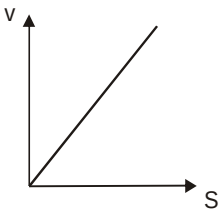
(A) C (B) D
(C) E (D) F

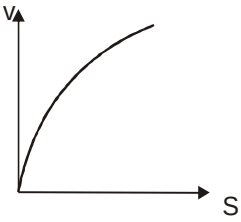
D-5. The variation of velocity of a particle moving along a straight line is shown in the figure. The distance travelled by the particle in 4 s is :

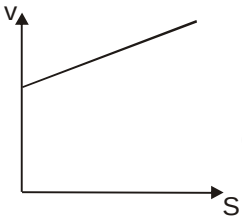


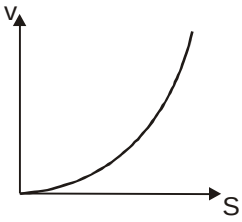
(A) 25 m (B) 30 m (C) 55 m (D) 60 m

D-6. A particle starts from rest and moves along a straight line with constant acceleration. The variation of velocity v with displacement S is :

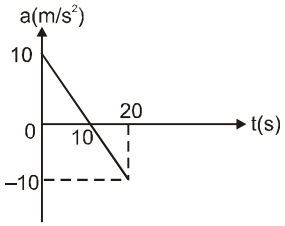
(A) 

(B) 

(C) 

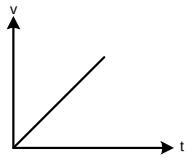
(D) 

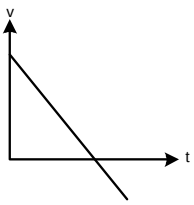
D-7*. The acceleration time plot for a particle (starting from rest) moving on a straight line is shown in figure for given time interval.

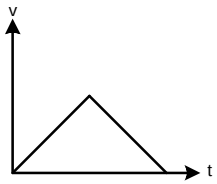


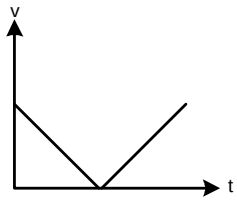
(A) The particle has zero average acceleration
(B) The particle has never turned around.
(C) The particle has zero displacement
(D) The average speed in the interval 0 to 10s is the same as the average speed in the interval 10s to 20s.

D-8. Which of the following graph correctly represents velocity-time relationship for a particle released from rest to fall freely under gravity?

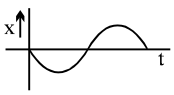
(A) 

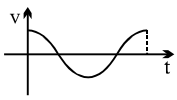
(B) 

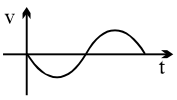
(C) 

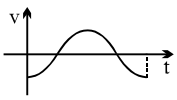
(D) 

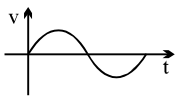
D-9. If position time graph of a particle is sine curve as shown, what will be its velocity-time graph.



(A) 

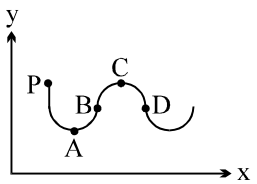
(B) 

(C) 

(D) 

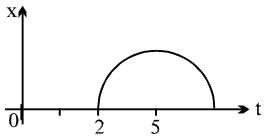
D-10. A man moves in x-y plane along the path shown. At what point is his average velocity vector in the same direction as his instantaneous velocity vector. The man starts from point P.

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



D-11. Position-time graph is shown which is a semicircle from t = 2 to t = 8 sec. Find time t at which the instantaneous velocity, is equal to average velocity over first t seconds

(A) 4.8 sec (B) 3.2 sec
(C) 2.4 sec (D) 5 sec



Section : (E) Variable Acceleration

E-1. For motion of an object along the x-axis, the velocity v depends on the displacement x as $v = 3x^2 - 2x$, then what is the acceleration at x = 2 m.

(A) 48 ms^{-2} (B) 80 ms^{-2} (C) 18 ms^{-2} (D) 10 ms^{-2}

E-2. The initial velocity of a particle is given by u (at t = 0) and the acceleration by f, where f = at (here t is time and a is constant). Which of the following relation is valid?

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

E-3. A particle moves along a straight line according to the law $S^2 = at^2 + 2bt + c$. The acceleration of the particle varies as :

(A) S^{-3} (B) $S^{2/3}$ (C) S^2 (D) $S^{5/2}$.

E-4. A point moves rectilinearly with deceleration whose modulus depends on the velocity v of the particle as $a = -k\sqrt{v}$ where k is a constant, $k > 0$. At the initial moment the velocity of particle is v_0. At some moment velocity of particle is zero. find the distance travelled by the particle till that instant.

(A) $t = \frac{2\sqrt{v_0}}{k}$ (B) $t = \frac{\sqrt{v_0}}{k}$ (C) $t = \frac{\sqrt{v_0}}{2k}$ (D) $t = \frac{3\sqrt{v_0}}{k}$

E-5. An object is moving along the x axis with position as a function of time given by x = x(t). Point O is at x = 0. The object is definitely moving toward O when

(A) dx/dt < 0 (B) dx/dt > 0 (C) $d(x^2) / dt < 0$ (D) $d(x^2)/dt > 0$

E-6. A particle starts moving rectilinearly at time t = 0 such that its velocity 'v' changes with time 't' according to the equation $v = t^2 - t$ where t is in seconds and v is in m/s. The time interval for which the particle retards is

(A) t < 1/2 (B) 1/2 < t < 1 (C) t > 1 (D) t < 1/2 and t > 1

PART - II : MISCELLANEOUS QUESTIONS

Comprehension Type Questions

Comprehension # 1

A particle starting from rest has a constant acceleration of 4 m/s^2 for 4 seconds. It then retards uniformly for next 8 seconds and comes to rest.

1. Average acceleration during the motion of the particle is

(A) 4 m/s^2 (B) zero (C) 8 m/s^2 (D) –4 m/s^2

2. Average speed during the motion of the particle is

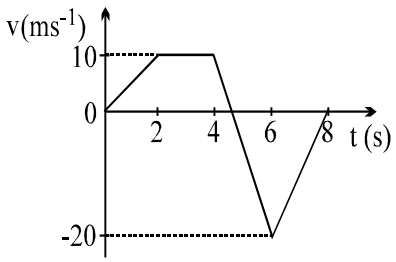
(A) 8 m/s (B) zero (C) 4 m/s (D) 16 m/s

3. Average velocity during the motion of the particle is

(A) zero (B) 8 m/s (C) 2 m/s (D) 4 m/s

Comprehension # 2

The figure shows a velocity-time graph of a particle moving along a straight line



4. Choose the incorrect statement. The particle comes to rest at

(A) t = 0 s (B) t = 5 s (C) t = 8 s (D) none of these

5. Identify the region in which the rate of change of velocity $\left|\frac{\Delta\vec{v}}{\Delta t}\right|$ of the particle is maximum

(A) 0 to 2s (B) 2 to 4s (C) 4 to 6 s (D) 6 to 8 s

6. If the particle starts from the position $x_0 = -15$ m, then its position at t = 2s will be

(A) –5 m (B) 5 m (C) 10 m (D) 15 m

7. The maximum displacement of the particle is

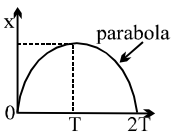
(A) 33.3 m (B) 23.3 m (C) 18.3 m (D) zero

8. The total distance travelled by the particle is

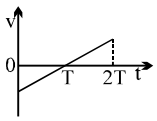
(A) 66.7 m (B) 51.6 m (C) zero (D) 36.6 m

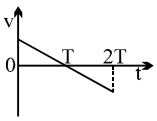
Comprehension # 3

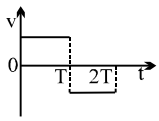
The x-t graph of a particle moving along a straight line is shown in figure

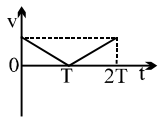


9. The v-t graph of the particle is correctly shown by

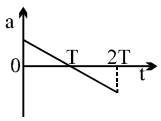
(A) 

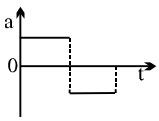
(B) 

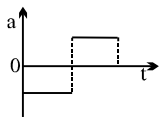
(C) 

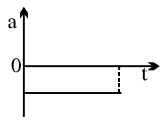
(D) 

10. The a-t graph of the particle is correctly shown by

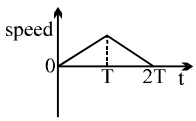
(A) 

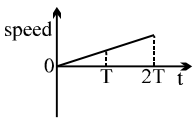
(B) 

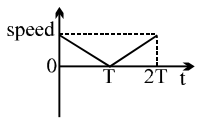
(C) 

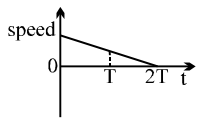
(D) 

11. The speed-time graph of the particle is correctly shown by

(A) 

(B) 

(C) 

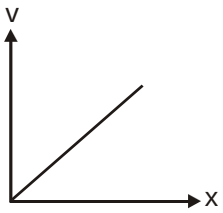
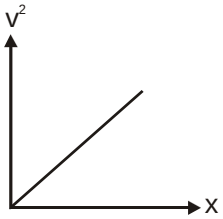
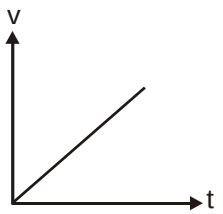
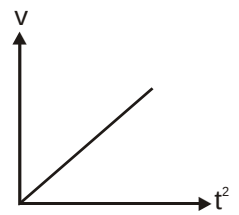
(D) 

Match the Column :

12. In the s-t equation ($s = 10 + 20t - 5t^2$) match the following :

Table-1	**Table-2**
(A) Distance travelled in 3s	(p) – 20 unit
(B) Displacement in 1s	(q) 15 unit
(C) Initial acceleration	(r) 25 unit
(D) Velocity at 4s	(s) – 10 unit

13. Column I gives some graphs for a particle moving along x-axis in positive x–direction. The variables v, x and t represent speed of particle, x–coordinate of particle and time respectively. Column II gives certain resulting interpretation. Match the graphs in Column I with the statements in Column II.

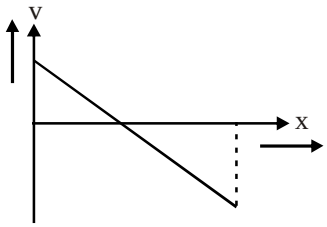
Column I	**Column II**
(A)  v - x graph	(p) Acceleration of particle is uniform
(B)  v^2 - x graph	(q) Acceleration of particle is nonuniform
(C)  v - t graph	(r) Acceleration of particle is directly proportional to 't'
(D)  v - t^2 graph	(s) Acceleration of particle is directly proportional to 'x'.

Assertion & Reason type questions

14. **Statement-1 :** Positive acceleration in rectilinear motion of a body does not imply that the body is speeding up.
Statement-2 : Both the acceleration and velocity are vectors.
(A) Statement-1 is true, statement-2 is true and statement-2 is correct explanation for statement-1.
(B) Statement-1 is true, statement-2 is true and statement-2 is NOT the correct explanation for statement-1.
(C) Statement-1 is true, statement-2 is false.
(D) Statement-1 is false, statement-2 is true.

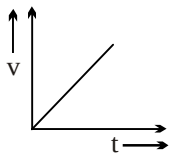
15. **Statement -1 :** A particle having zero acceleration must have constant speed.
Statement -2 : A particle having constant speed must have zero acceleration.
(A) Statement-1 is true, statement-2 is true and statement-2 is correct explanation for statement-1.
(B) Statement-1 is true, statement-2 is true and statement-2 is NOT the correct explanation for statement-1.
(C) Statement-1 is false, statement-2 is true.
(D) Statement-1 is true, statement-2 is false.

16. **Statement-1 :** A student performed an experiment by moving a certain block in a straight line. The velocity position graph cannot be as shown.



Statement-2 : When a particle is at its maximum position in rectilinear motion its velocity must be zero.
(A) Statement-1 is true, statement-2 is true and statement-2 is correct explanation for statement-1.
(B) Statement-1 is true, statement-2 is true and statement-2 is NOT the correct explanation for statement-1.
(C) Statement-1 is true, statement-2 is false.
(D) Statement-1 is false, statement-2 is true.

17. **Statement-1 :** If the velocity time graph of a body moving in a straight line is as shown here, the acceleration of the body must be constant.



Statement-2 : The rate of change of quantity which is constant is always zero.
(A) Statement-1 is true, statement-2 is true and statement-2 is correct explanation for statement-1.
(B) Statement-1 is true, statement-2 is true and statement-2 is NOT the correct explanation for statement-1.
(C) Statement-1 is false, statement-2 is true.
(D) Statement-1 is true, statement-2 is false.

EXERCISE # 2

PART - I : MIXED OBJECTIVE

Single Correct Answer Type

1. An object moving with uniform acceleration has a velocity of 12.0 cm/s in the positive x direction when its x coordinate is 3.00 cm. If its x coordinate 2.00 s later is – 5.00 cm, what is its acceleration(in cm/s^2)?
(A) –16 (B) 16 (C) 12 (D) 8

2. A body starts from rest and is uniformly acclerated for 30 s. The distance travelled in the first 10 s is x_1, next 10 s is x_2 and the last 10 s is x_3. Then $x_1 : x_2 : x_3$ is the same as
(A) 1 : 2 : 4 (B) 1 : 2 : 5 (C) 1 : 3 : 5 (D) 1 : 3 : 9

3. The position coordinate of a particle that is confined to move along a straight line is given by $x = 2t^3 – 24t + 6$ where x is measured from a convenient origin and t is in seconds. Determine the distance travelled by the particle during the interval from t=1 sec to t = 4 sec.
(A) 72m (B) 74m (C) 68m (D) 37m

4. The deceleration experienced by a moving motor boat, after its engine is cut-off is given by $\frac{dv}{dt} = -kv^3$, where k is constant. If v_0 is the magnitude of the velocity at cut-off the magnitude of the velocity at a time t after the cut-off is :

(A) $v_0/2$ (B) v (C) v_0e^{-kt} (D) $\frac{v_0}{\sqrt{2v_0^2kt+1}}$

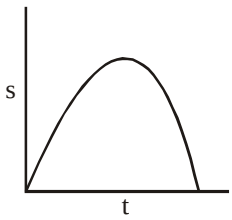
5. A lift is descending with uniform acceleration. To measure the acceleration , a person in the lift drops a coin at the moment when lift was descending with speed 6 ft/s. The coin is 5 ft above the floor of the lift at time it is dropped. The person observes that the coin strikes the floor in 1 second. Calculate from these data, the acceleration of the lift. [Take g = 32 ft/s^2]

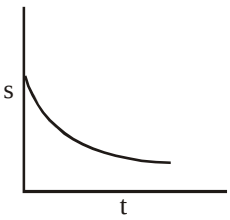
(A) 20 ft/s^2 (B) 11 ft/s^2 (C) 22 ft/s^2 (D) 12 ft/s^2

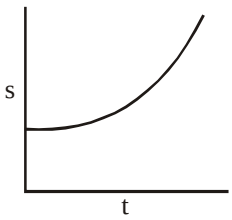
6. A body starts with an initial velocity of 10 m/s and moves along a straight line with a constant acceleration. When the velocity of the particle is 50 m/s the acceleration is reversed in direction. Find the velocity of the particle when it reaches the starting point.

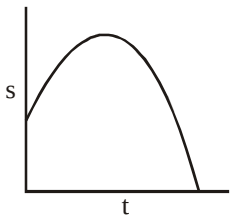
(A) 70 m/s (B) 50 m/s (C) 45 m/s (D) 49 m/s

7. The displacement of a particle in a straight line motion is given by $s = 1 + 10t - 5t^2$. The correct representation of the motion is

(A) 

(B) 

(C) 

(D) 

.

8. A ball is thrown upwards with speed v from the top of a tower and it reaches the ground with speed 3v. What is the height of the tower?

(A) $\frac{v^2}{g}$ (B) $\frac{2v^2}{g}$ (C) $\frac{4v^2}{g}$ (D) $\frac{8v^2}{g}$

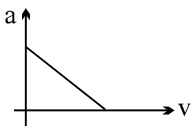
9. A stone falls freely from rest and the total distance covered by it in the last second of its motion equals the distance covered by it in the first three seconds of its motion. The stone remains in the air for

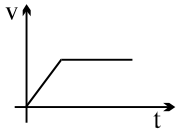
(A) 5 s (B) 8 s (C) 10 s (D) 15 s

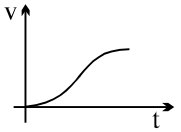
10. The greatest acceleration or deceleration that a train may have is a. The minimum time in which the train may reach from one station to the other separated by a distance d is

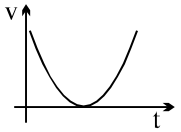
(A) $\sqrt{\frac{d}{a}}$ (B) $\sqrt{\frac{2d}{a}}$ (C) $\frac{1}{2}\sqrt{\frac{d}{a}}$ (D) $2\sqrt{\frac{d}{a}}$

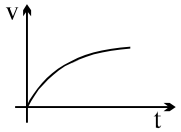
11. Acceleration versus velocity graph of a particle moving in a straight line starting from rest is as shown in figure. The corresponding velocity-time graph would be



(A) 

(B) 

(C) 

(D) 

12. It takes one minute for a passenger standing on an escalator to reach the top. If the escalator does not move it takes him 3 minute to walk up . How long will it take for the passenger to arrive at the top if he walks up the moving escalator ?

(A) 30 sec (B) 45 sec (C) 40 sec (D) 35 sec

Multiple Correct Answer(s) Type

13. A particle moves with constant speed v along a regular hexagon ABCDEF in the same order. Then the magnitude of the average velocity for its motion from A to :

(A) F is v/5 (B) D is v/3 (C) C is v $\frac{\sqrt{3}}{2}$ (D) B is v

14. Mark the correct statements for a particle going on a straight line :
(A) if the velocity is zero at any instant, the acceleration should also be zero at that instant
(B) if the velocity is zero for a time interval, the acceleration is zero at any instant within the time interval
(C) if the velocity and acceleration have opposite sign, the object is slowing down
(D) if the position and velocity have opposite sign, the particle is moving towards the origin

15. Let $\vec{v}$ and $\vec{a}$ denote the velocity and acceleration respectively of a body in one–dimensional motion

(A) I $\vec{v}$ I must decrease when $\vec{a} < 0$

(B) Speed must increase when $\vec{a} > 0$

(C) Speed will increase when both $\vec{v}$ and $\vec{a}$ are < 0

(D) Speed will decrease when $\vec{v} < 0$ and $\vec{a} > 0$

16. Let **v** and **a** denote the velocity and acceleration respectively of a body :
(A) **a** can be non zero when **v** = 0
(B) **a** must be zero when **v** = 0
(C) **a** may be zero when **v** $\neq$ 0
(D) the direction of a must have some correlation with the direction of **v**

17. A particle initially at rest is subjected to two forces. One is constant, the other is a retarding force proportional to the particle velocity. In the subsequent motion of the particle :
(A) the acceleration will increase from zero to a constant value
(B) the acceleration will decrease from its initial value to zero
(C) the velocity will increase from zero to maximum and then decrease
(D) the velocity will increase from zero to a constant value.

18. Pick the correct statements :
(A) two stones are dropped from the same point after an interval of 1 second. If g is 10 ms $^{-2}$, then the separation after 3 seconds of the release of first stone is 25m
(B) a ball projected up with a velocity v reaches a point P in its path at t_1 and t_2 seconds. The height of point P above the ground is $\frac{1}{2} g t_1 t_2$
(C) a ball projected up with velocity v reaches a point P in its paths at t_1 and t_2 seconds. Then $v = \frac{1}{2} g (t_1 + t_2)$
(D) the acceleration of a body thrown vertically upwards is g at the highest point

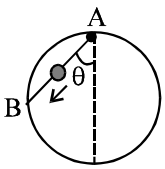
19. Starting from rest a particle is first accelerated for time t_1 with constant acceleration a_1 and then stops in time t_2 with constant retardation a_2. Let v_1 be the average velocity in this case and s_1 the total displacement. In the second case, it is accelerated for the same time t_1 with constant acceleration $2a_1$ and comes to rest with constant retardation a_2 in time t_3. If v_2 is the average velocity in this case and s_2 the total displacement, then :
(A) $v_2 = 2v_1$ (B) $2v_1 < v_2 < 4v_1$ (C) $s_2 = 2s_1$ (D) $2s_1 < s_2 < 4s_1$

20. A particle is projected vertically upwards with velocity u from a point A, when it returns to point of projection:
(A) Its average speed is u/2
(B) Its average velocity is zero
(C) Its displacement is zero
(D) Its average speed is u

21. A particle moving with a speed v changes direction by an angle θ, without change in speed.
(A) The change in the magnitude of its velocity is zero.
(B) The change in the magnitude of its velocity is $2v\sin(\theta/2)$.
(C) The magnitude of the change in velocity is $2v\sin(\theta/2)$
(D) The magnitude of the change in its velocity is $v(1 - \cos\theta)$.

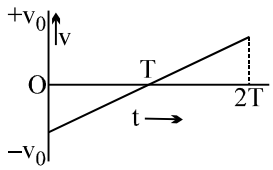
22. A particle has initial velocity 10 m/s. It moves due to constant retarding force along the line of velocity which produces a retardation of 5 m/s^2. Then
(A) the maximum displacement in the direction of initial velocity is 10 m
(B) the distance travelled in first 3 seconds is 7.5 m
(C) the distance travelled in first 3 seconds is 12.5 m
(D) the distance travelled in first 3 seconds is 17.5 m.

23. A bead is free to slide down a smooth wire tightly stretched between points A and B on a vertical circle. If the bead starts from rest at A, the highest point on the circle :



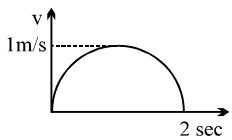
(A) its velocity v on arriving at B is proportional to $\cos\theta$
(B) its velocity v on arriving at B is proportional to $\tan\theta$
(C) time to arrive at B is proportional to $\cos\theta$
(D) time to arrive at B is independent of θ

24. The figure shows the velocity (v) of a particle plotted against time (t)



(A) The particle changes its direction of motion at some point
(B) The acceleration of the particle remains constant
(C) The displacement of the particle is zero
(D) The initial and final speeds of the particle are the same

25. Velocity-time graph for a car is semicircle as shown here. Which of the following is correct :

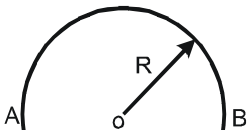


(A) Car must move in circular path.
(B) Acceleration of car is never zero.
(C) Mean speed of the particle is $\pi/4$ m/s.
(D) The car makes a turn once during its motion.

PART - II : SUBJECTIVE QUESTIONS

1. A particle covers each $\frac{1}{3}$ of the total distance with speed v_1, v_2 and v_3 respectively. Find the average speed of the particle ?

2. A particle moves along a semi circular path A to B in a time T as shown in the following fig.



(a) Determine the average speed of the particle.
(b) Determine the average velocity of the particle.

3. An engine driver running a train at full speed suddenly applies brakes and shuts off steam. The train then travels 24 m in the first second and 22 m in the next second. Assuming that the brakes produce a constant retardation, find
(a) original speed of the train,
(b) the time elapsed before it comes to rest
(c) the distance travelled during the interval.
(d) If the length of the train is 44 m, find the time that the train takes to pass an observer standing at a distance 100 m ahead of the train at the time when the brake was applied.

4. A particle moving along a straight line with constant acceleration is having initial and final velocity as 5 m/s and 15 m/s respectively in a time interval of 5 s. Find the distance travelled by the particle and the acceleration of the particle. If the particle continues with same acceleration, find the distance covered by the particle in the 8th second of its motion.

5. A bird flies with a speed v = |t – 2| m/s along a straight line, where t is time in seconds. The distance (in metre) travelled by the bird during first four seconds is equal to ?

6. A car moving along a straight line starts from rest with uniform acceleration a = 2 m/s^2, then moves with constant velocity and finally comes to rest decelerating at the same rate. The total time of motion is 10 s and average speed during complete motion is 3.2 m/s. How long (in sec) did the car move uniformly ?

7. From the top of a tower, a stone is thrown up. It reaches the ground in 5 s. A second stone is thrown down with the same speed and reaches the ground in 1 s. A third stone is released from rest and reaches the ground in $\sqrt{X}$ sec. Find X .

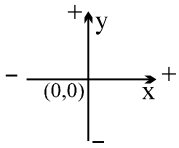
8. At a distance L = 400m from the traffic light brakes are applied to a locomotive moving at a velocity v = 54 km/hr. Determine the position of the locomotive relative to the traffic light 1 minute after the application of the brakes if its acceleration is –0.3m/sec^2.

9. A particle goes from A to B with a speed of 40km/h and B to C with a speed of 60km/h. If AB = 6BC, the average speed in km/h between A and C is ____

[**Hint**: Average speed = $\frac{\text{total distance travelled}}{\text{time taken}}$]

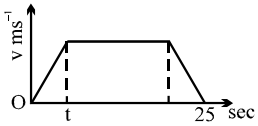
10. An object moving with uniform acceleration has a velocity of 12.0 cm/s in the positive x direction when its x coordinate is 3.00 cm. If its x coordinate 2.00 s later is – 5.00 cm, what is its acceleration?

11. A particle is moving along x-axis. Initially it is located 5 m left of origin and it is moving away from the origin and slowing down. In this coordinate system, what are the signs of the initial velocity and acceleration.

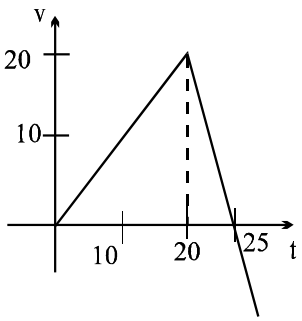


v_0	a

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



13. The figure shows the v–t graph of a particle moving in straight line. Find the time when particle returns to the starting point.



14. A stone is dropped from a height h . Simultaneously another stone is thrown up from the ground with such a velocity that it can reach a height of 4h. Find the time when two stones cross each other.

15. A balloon is ascending vertically with an acceleration of 0.2m/s^2. Two stones are dropped from it at an interval of 2 sec. Find the distance between them 1.5 sec after the second stone is released. (use g = 9.8m/s^2)

16. A speeder in an automobile passes a stationary policeman who is hiding behind a bill board with a motorcycle. After a 2.0 sec delay (reaction time) the policeman accelerates to his maximum speed of 150 km/hr in 12 sec and catches the speeder 1.5 km beyond the billboard. Find the speed of speeder in km/hr.

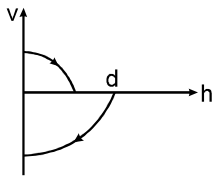
17. The position coordinate of a particle that is confined to move along a straight line is given by $x = 2t^3 - 24t + 6$ where x is measured from a convenient origin and t is in seconds. Determine the distance travelled by the particle during the interval from t=1 sec to t = 4 sec.

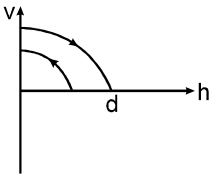
EXERCISE # 3

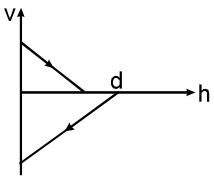
PART - I : IIT-JEE PROBLEMS (PREVIOUS YEARS)

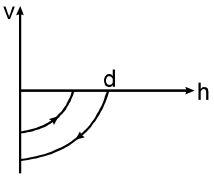
** Marked Questions are having more than one correct option.*

1. A ball is dropped vertically from a height d above the ground. It hits the ground and bounces up vertically to a height d/2. Neglecting subsequent motion and air resistance, its velocity v varies with the height h above the ground as **[JEE '2000, 1/35]**

(A) 

(B) 

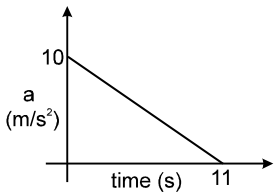
(C) 

(D) 

2. A block is moving down a smooth inclined plane starting from rest at time t = 0. Let S_n be the distance travelled by the block in the interval t = n – 1 to t = n. The ratio $\frac{S_n}{S_{n+1}}$ is **[JEE (Scr.), 2004, 3]**

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

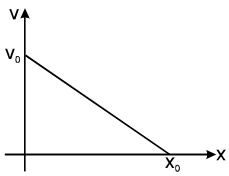
3. A particle is initially at rest, It is subjected to a linear acceleration a , as shown in the figure. The maximum speed attained by the particle is



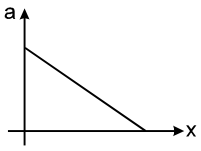
[JEE Scr. 2004; 3]

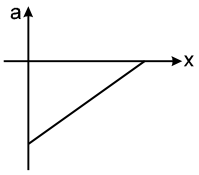
(A) 605 m/s (B) 110 m/s (C) 55 m/s (D) 550 m/s

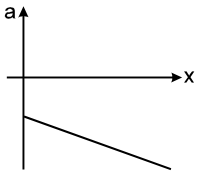
4. The velocity displacement graph of a particle moving along a straight line is shown.

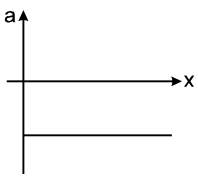


The most suitable acceleration-displacement graph will be **[JEE Scr. 2005; 3]**

(A) 

(B) 

(C) 

(D) 

PART - II : AIEEE PROBLEMS (PREVIOUS YEARS)

1. If a body loses half of its velocity on penetrating 3 cm in a wooden block, then how much will it penetrate more before coming to rest? **[AIEEE - 2002, 4/300]**

(1) 1 cm (2) 2 cm (3) 3 cm (4) 4 cm

2. From a building two balls A and B are thrown such that A is thrown upwards and B downwards (both vertically). If V_A and V_B are their respective velocities on reaching the ground, then **[AIEEE - 2002, 4/300]**

(1) $v_B > v_A$ (2) $v_A = v_B$

(3) $v_A > v_B$ (4) their velocities depends on their masses

3. Speeds of two identical cars are u and 4u at a specific instant. The ratio of the respective distances at which the two cars are stopped from that instant is : **[AIEEE - 2002, 4/300]**

(1) 1 : 1 (2) 1 : 4 (3) 1 : 8 (4) 1 : 16

4. The coordinates of a moving particle at any time t are given by $x = \alpha t^3$ and $y = \beta t^3$. The speed of the particle at time t is given by : **[AIEEE - 2003, 4/300]**

(1) $\sqrt{\alpha^2 + \beta^2}$ (2) $3t^2\sqrt{\alpha^2 + \beta^2}$ (3) $t^2\sqrt{\alpha^2 + \beta^2}$ (4) $\sqrt{\alpha^2 + \beta^2}$

5. A car moving with a speed of 50 km/hr, can be stopped by brakes after at least 6 m. if the same car is moving at a speed of 100 km/hr, the minimum stopping distance is : **[AIEEE - 2003, 4/300]**

(1) 12 m (2) 18 m (3) 24 m (4) 6 m

6. A ball is released from the top of a tower of height h metres. It takes T seconds to reach the ground. What is the position of the ball in T/3 seconds? **[AIEEE - 2004, 4/300]**

(1) h/9 metre from the ground (2) 7h/9 metre from the ground

(3) 8h/9 metre from the ground (4) 17h/9 metre from the ground

7. An automobile travelling with a speed of 60 km/h, can brake to stop within a distance of 20 m. If the car is going twice as fast, ie. 120 km/h, the stopping distance will be **[AIEEE - 2004, 4/300]**

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

8. The relation between time t and distance x is $t = ax^2 + bx$, where a and b are constants. The acceleration is: **[AIEEE 2005, 4.300]**

(1) $-2abv^2$ (2) $2bv^2$ (3) $-2av^3$ (4) $2av^3$

9. A car, starting from rest, accelerates at the rate f through a distance S, then continues at constant speed for time t and then decelerates at the rate $\frac{f}{2}$ to come to rest. If the total distance travelled is 15 S, then : **[AIEEE 2005, 4/300]**

(1) $S = ft$ (2) $S = \frac{1}{6}ft^2$ (3) $S = \frac{1}{72}ft^2$ (4) $S = \frac{1}{4}ft^2$

10. A particle is moving eastwards with a velocity of 5 ms^{-1}. In 10 second the velocity changes to 5 ms^{-1} northwards. The average acceleration in this time is : **[AIEEE 2005, 4/300]**

(1) $\frac{1}{\sqrt{2}}$ ms^{-1} towards north-west (2) $\frac{1}{2}$ ms^{-2} towards north

(3) zero (4) $\frac{1}{2}$ ms^{-2} towards north-west.

11. A parachutist after bailing out falls 50 m without friction. When parachute opens, it decelerates at 2 m/s^2. He reaches the ground with a speed of 3 m/s. At what height, did he bail out? **[AIEEE 2005, 4/300]**

(1) 91 m (2) 182 m (3) 293 m (4) 111 m

12. A particle located at x = 0 at time t = 0, starts moving along the positive x-direction with a velocity v that varies as $v = \alpha\sqrt{x}$ The displacement of the particle varies with time as **[AIEEE-2006, 3/180]**

(1) $t^{1/2}$ (2) t^3 (3) t^2 (4) t

13. The velocity of a particle is $v = v_0 + gt + ft^2$. If its position is x = 0 at t = 0, then its displacement after unit time (t = 1) is **[AIEEE 2007, 3/120]**

(1) $v_0 + 2g + 3f$ (2) $v_0 + \frac{g}{2} + \frac{f}{3}$ (3) $v_0 + g + f$ (4) $v_0 + \frac{g}{2} + f$

14. 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 : **[AIEEE 2009, 4/144]**

(1) $7\sqrt{2}$ units (2) 7 units (3) 8.5 units (4) 10 units

15. A particle is moving with velocity $\vec{v} = K(y\,\hat{i} + x\,\hat{j})$, where K is a constant. The general equation for its path is: **[AIEEE 2010, 4/144]**

(1) $y = x^2$ + constant (2) $y^2 = x$ + constant (3) xy = constant (4) $y^2 = x^2$ + constant

16. 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 : **[AIEEE 2011]**

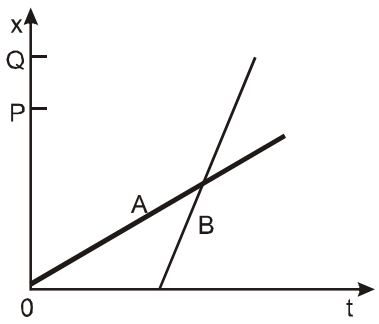
(1) 1s (2) 2s (3) 4s (4) 8s

EXERCISE # 4

NCERT QUESTIONS

1. In which of the following examples of motion, can the body be considered approximately a point object :
(a) a railway carriage moving without, jerks between two stations
(b) a monkey sitting on top of a man cycling smoothly on a circular track.
(c) a spinning cricket ball that turns sharply on hitting the ground.
(d) a tumbling beaker that has slipped off the edge of a table.

2. The position-time (x-t) graphs for two children ?A and B returning from their school O to their homes P and Q respectively are shown in figure. Choose the correct entries in the brackets below :



(a) (A/B) lives closer to the school than (B/A)

(b) (A/B) starts from the school earlier than (B/A)

(c) (A/B) walks faster than (B/A)

(d) A and B reach home at the (same/different) time

(e) (A/B) overtakes (B/A) on the road (once/twice)

3. A woman starts from her home at 9.00 am, walks with a speed of 5 km h^{-1} on a straight road up to her office 2.5 km away, stays at the office up to 5.00 pm, and returns home by an auto with a speed of 25 km h^{-1}. Choose suitable scales and plot the *x-t* graph of her motion.

4. A drunkard walking in a narrow lane takes 5 steps forward and 3 steps backward, followed again by 5 steps forward and 3 steps backward, and so on. Each step is 1 m long and requires 1 s. Plot the *x-t* graph of his motion. Determine graphically and otherwise how long the drunkard takes to fall in a pit 13 m away from the start.

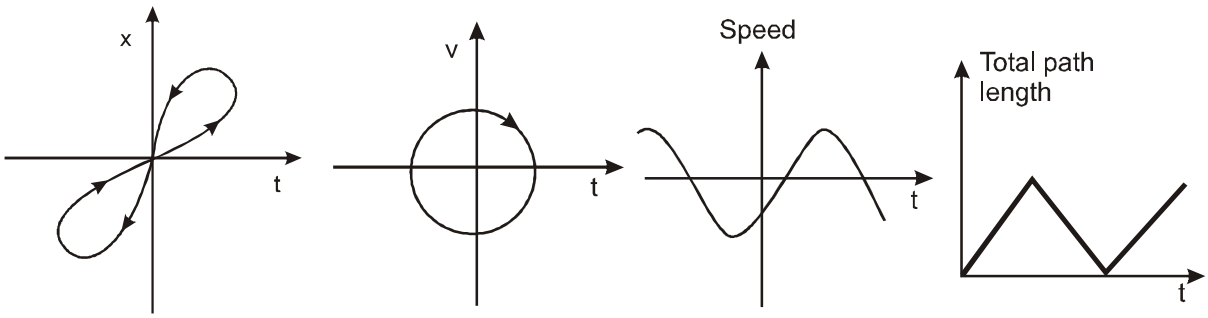
5. A car moving along a straight highway with speed of 126 km h^{-1} is brought to a stop within a distance of 200 m. What is the retardation of the car (assumed uniform), and how long does it take for the car to stop ?

6. A player throws a ball upwards with an initial speed of 29.4 m s^{-1}.
(a) What is the direction of acceleration during the upward motion of the ball ?
(b) What are the velocity and acceleration of the ball at the highest point of its motion ?
(c) Choose the x = 0 m and t = 0 s to be the location and time of the ball at its highest point, vertically downward direction to be the positive direction of x-axis and give the signs of position, velocity and acceleration of the ball during Its upward, and downward motion.
(d) To what height does the ball rise and alter how long does the ball return to the player's hands ? (Take 9 = 9.8 m s^{-2} and neglect air resistance).

7. A ball is dropped from a height of 90 m on a floor. At each collision with the floor, the ball loses one tenth of its speed, Plot the speed-time graph of its motion between t = 0 to 12 s.

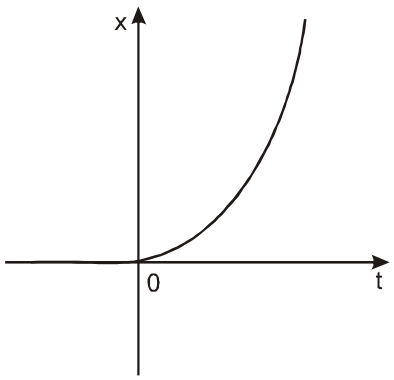
8. A man walks on a straight road from his home to a market 2 .5 km away with a speed of 5 km h^{-1} Finding the market closed, he instantly turns and walks back home with a speed of 7.5 km h^{-1}. What is the :
(a) magnitude of average velocity, and
(b) average speed of the man over the interval of time (i) 0 to 30 min. (ii) 0 to 50 min (iii) 0 to 40 min ?
[Note: You will appreciate from this exercise why it is better to define average speed as total path length divided by time, and not as magnitude of average velocity. You would not like to tell the tired man on his return home that his average speed was zero !]

9. Look at the graphs (a) to (d) (Fig.) carefully and state, with reasons which of these cannot possibly represent one-dimensional motion of a particle.

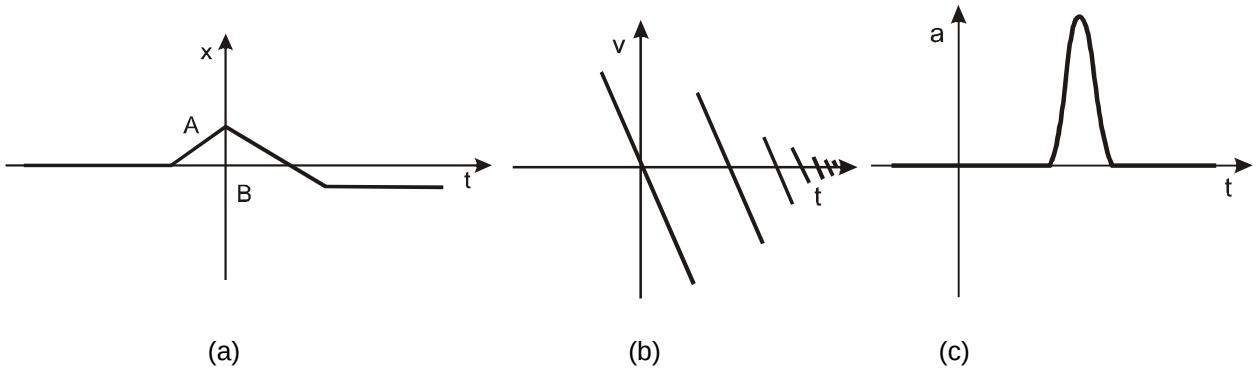


(a) (b) (c) (d)

10. Figure shows the *x-t* plot of one-dimensional motion of a particle. Is it correct to say from the graph that the particle moves in a straight line for t < 0 and on a parabolic path for t >0 ? If not, suggest a suitable physical context for this graph.

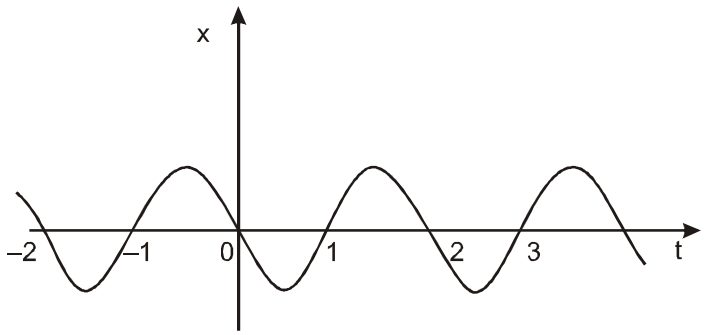


11. Suggest a suitable physical situation for each of the following graphs (Fig) :

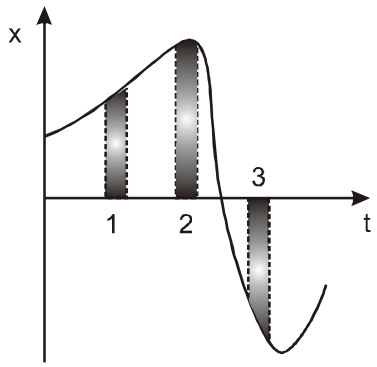


(a) (b) (c)

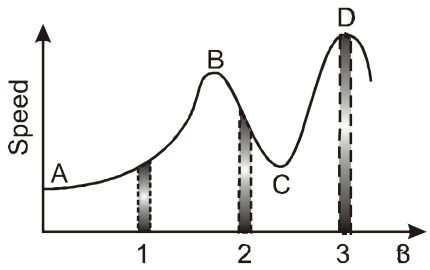
12. Figure gives the *x-t* plot of a particle executing one-dimensional simple harmonic motion. (You will learn about this motion in more detail in Chapter14). Give the signs of position, velocity and acceleration variables of the particle at t = 0.3 s, 1.2 s, – 1.2 s.



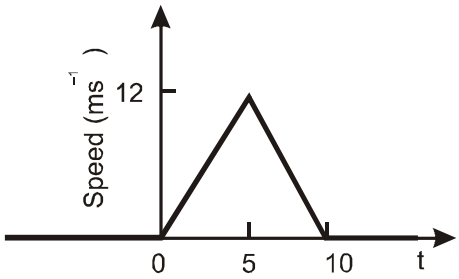
13. Figure gives the *x-t* plot of a particle in one-dimensional motion. Three different equal intervals of time are shown. In which interval is the average speed greatest, and in which is it the least? Give the sign of average velocity for each interval.



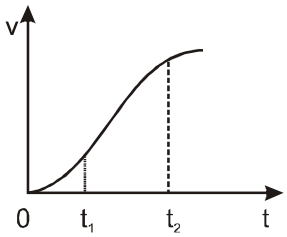
14. Figure gives a speed-time graph of a particle in motion along a constant direction. Three equal intervals of time are shown. In which interval is the average acceleration greatest in magnitude ? In which interval is the average speed greatest? Choosing the positive direction as the constant direction of motion, give the signs of v and a in the three intervals. What are the accelerations at the points A, B. C and D?



15. The speed-time graph of a particle moving along a fixed direction is shown in figure. Obtain the distance traversed by the particle between (a) t = 0 s to 10 s, (b) t = 2 s to 6 s.



16. The velocity lime graph of a particle in one-dimensional motion is shown in figure.



Which of the following formulae are correct for describing the motion of the particle over the time-interval t_1 to t_2.

(a) $x(t_2) = x(t_1) + v\,(t_1)\,(t_2 - t_1) + (1/2)\,a\,(t_2 - t_1)^2$

(b) $v(t_2) = v(t_1) + a\,(t_2 - t_1)$

(c) $v_{average} = (x(t_2) - x(t_1)) / (t_1 - t_1)$

(d) $v_{average} = (v(t_2) - v(t_1)) / (t_2 - t_1)$

(e) $x(t_2) = x(t_1) + v_{average}\,(t_2 - t_1) + (1/2)\,a_{average}\,(t_2 - t_1)^2$

(f) $x(t_2) - x(t_1)$ = area under the v-t curve bounded by the t-axis and the dotted line shown.

ANSWER KEY

EXERCISE-1

PART - I

A-1.	(B)	**A-2.**	(A)	**B-1.**	(B)	**B-2*.**	(AD)	**B-3.***	(AC)	**B-4.**	(A)	**C-1.**	(A)
C-2.	(D)	**C-3.**	(A)	**C-4.**	(C)	**C-5.**	(A)	**C-6.**	(D)	**C-7.**	(C)	**C-8.**	(D)
C-9.	(C)	**C-10.**	(D)	**D-1*.**	(BCD)	**D-2.**	(C)	**D-3.**	(D)	**D-4.**	(C)	**D-5.**	(C)
D-6.	(B)	**D-7*.**	(ABD)	**D-8.**	(A)	**D.9**	(C)	**D.10**	(C)	**D.11**	(B)	**E-1.**	(B)
E-2.	(B)	**E-3.**	(A)	**E-4.**	(A)	**E-5.**	(C)	**E-6.**	(B)				

PART - II

1.	(B)	**2.**	(A)	**3.**	(B)	**4.**	(B)	**5.**	(C)	**6.**	(A)	**7.**	(A)
8.	(A)	**9.**	(B)	**10.**	(D)	**11.**	(C)	**12.**	(A) r (B) q (C) s (D) p				
13.	(A) q, s (B) p (C) p (D) q, r					**14.**	(A)	**15.**	(D)	**16.**	(A)	**17.**	(B)

EXERCISE-2

PART - I

1.	(A)	**2.**	(C)	**3.**	(B)	**4.**	(D)	**5.**	(C)	**6.**	(A)	**7.**	(D)
8.	(C)	**9.**	(A)	**10.**	(D)	**11.**	(D)	**12.**	(B)	**13.**	(ACD)		
14.	(BCD)	**15.**	(CD)	**16.**	(AC)	**17.**	(BD)	**18.**	(ABCD)	**19.**	(AD)		
20.	(ABC)	**21.**	(AC)	**22.**	(AC)	**23.**	(AD)	**24.**	(ABCD)	**25.**	(C)		

PART - II

1. $\frac{3v_1v_2v_3}{v_1v_2+v_2v_3+v_1v_3}$ **2.** (a) $\frac{\pi R}{T}$ (b) $\frac{2R}{T}$

3. (a) **25 m/s.** (b) **12.5 sec.** (c) **156.25 m** (d) **9 seconds**

4. **50m ; 2m/s² ; 20 m** **5.** **4** **6.** **6** **7.** **5** **8.** **25m**

9. **42km/hr** **10.** **–16 cm/s²**

11.

v_0	a
—	+

vel ←

Because particle is slowing down so velocity & acceleration are in opposite direction.

12. **5 s** **13.** **36.2 sec.** **14.** $\sqrt{\left(\frac{h}{8g}\right)}$ **15.** **50m** **16.** **122.7 km/hr**

17. **74m**

EXERCISE-3

PART - I

1. (A) **2.** (B) **3.** (C) **4.** (B)

PART - II

1. (1) **2.** (2) **3.** (4) **4.** (2) **5.** (3) **6.** (3) **7.** (4)

8. (3) **9.** (3) **10.** (1) **11.** (3) **12.** (3) **13.** (2) **14.** (1)

15. (4) **16.** (2)

EXERCISE-4

1. (a), (b)

2. (a) A....B, (b) A....B, (c) B....A, (d) Same, (e) B....A....once.

4. 37s

5. 3.06 ms^{-2} ; 11.4 s

6. (a) Vertically downwards ; (b) zero velocity, acceleration of 9.8 m s^{-2} downwards ;
(c) $x > 0$ (upwards and downward motion); $v < 0$ (upward), $v > 0$ (downward), $a > 0$ throughout ;
(d) 44.1 m, 6s.

8. (a) 5 km h^{-1}, 5 km h^{-1} ; (b) 0; 6 km h^{-1} ; (c) $\frac{15}{8}kmh^{-1}, \frac{45}{8}kmh^{-1}$

9. All the four graphs are impossible. (a) a particle cannot have two different positions ate the same time; (b) a particle cannot have velocity in opposite directions at the same time ; (c) speed is always non-negative; (d) total path length of a particle can never decreases with time. (Note, the arrows on the graphs are meaningless).

10. No, wrong. *x-t* plot does not show the trajectory of a particle. Context : A body is dropped from a tower ($x = 0$) at $t = 0$.

11. (a) A ball at rest on a smooth floor is kicked, it rebounds from a wall with reduced speed and moves to the opposite wall which stops it; (b) A ball thrown up with some initial velocity rebounding from the floor with reduced speed after each hit; (c) A uniformly moving cricket ball turned back by hitting it with a bat for a very short time-interval.

12. $x < 0, v < 0, a > 0$; $x > 0, v > 0, a < 0$; $x < 0, v > 0, a > 0$

13. Greatest in 3, least in 2; $v > 0$ in 1 and 2, $v < 0$ in 3.

14. Acceleration magnitude greatest in 2; speed greatest in 3; $v > 0$ in 1, 2 and 3; $a > 0$ in 1 and 3, $a < 0$ in 2; $a = 0$ at A, B, C, D.

15. (a) 60 m, 6 m s^{-1} ; (b) 36 m, 9 m s^{-1}

16. (c), (d), (f)