PHYSICS

The following question given below consist of an "Assertion" (A) and "Reason" (R) Type questions. Use the following Key to choose the appropriate answer.

(A) If both (A) and (R) are true, and (R) is the correct explanation of (A).

(B) If both (A) and (R) are true but (R) is not the correct explanation of (A).

(C) If (A) is true but (R) is false.

(D) If (A) is false but (R) is true.

Q.1 **Assertion :** Average speed is equal to the magnitude of average velocity.
Reason : Displacement of body is less than or equal to distance.

[D]

Sol. Since $|\text{Displacement}| \leq \text{Distance}$

$$\therefore \frac{|\text{Displacement}|}{\text{time}} \leq \frac{\text{Distance}}{\text{time}}$$

$|\text{Average velocity}| \leq \text{Average speed}$

Q.2 **Assertion :** Average velocity of any body is an approximate value but instantaneous velocity is an accurate value.
Reason : Instantaneous velocity is the limiting value of average velocity.
[A]

Sol. Average velocity $v_{av} = \frac{\Delta x}{\Delta t}$

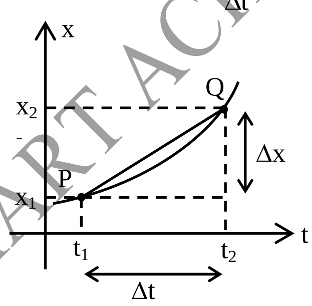


Figure – 1

$$v_{ins} = \frac{dx}{dt} = \lim_{\Delta t \to 0} v_{av} = \lim_{\Delta t \to 0} \frac{\Delta x}{\Delta t}$$

Instantaneous velocity is velocity at any instant at any point in the path of particle.
From figure 1 :- Average velocity is the slope of secant PQ.

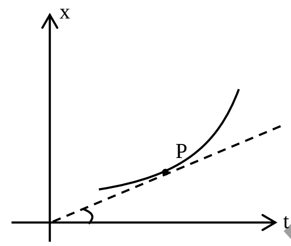


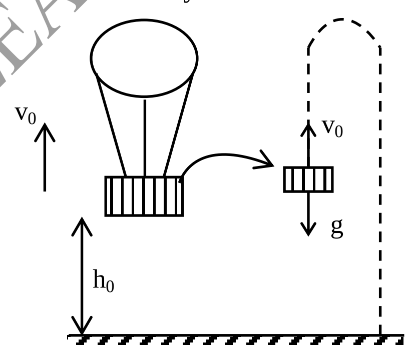
Figure – 2

From figure 2 instantaneous velocity is the slope of tangent drawn at point P.

Q.3 **Assertion :** A packet is dropped from rising balloon. The initial velocity of packet is zero.
Reason : Initial velocity of a dropping packet is equal to the velocity of the body from which it is dropped.

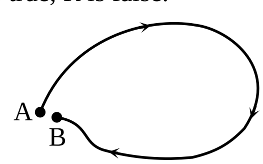
[D]

Sol. The initial velocity of packet is equal to the velocity of balloon from which it is dropped.



Q.3 **Assertion :** Magnitude of instantaneous velocity is equal to instantaneous speed.
Reason : Distance is nearly equal to displacement if displacement is very small. **[C]**

Sol. A is true, R is false.



Consider motion from A to B along path shown.

Q.4 **Assertion :** A body may be accelerated even when it is moving with uniform speed.

Reason : Acceleration is rate at which speed of body changes.

[C]

Sol. Acceleration is rate of change of velocity.

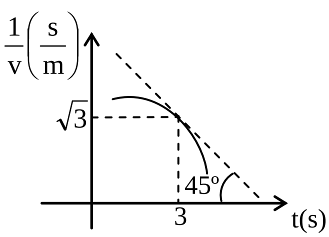
Q.5 **Assertion :** A body, whatever it's motion is always at rest in reference frame which is fixed to the body itself.

Reason : The relative velocity of a body with respect to itself is always zero.

[A]

Sol. Conceptual.

Q.6 **Assertion (A) :** The following graph represents relation between instantaneous velocity (v) and time (t) for a body moving on a straight line.



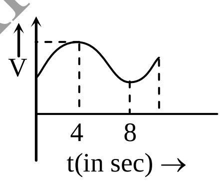
Then the magnitude of instantaneous acceleration at t = 3s in 3 m/s^2.

Reason (R) : The slope of tangent at a point on velocity-time curve gives instantaneous acceleration at that point.

[D]

Sol. Conceptual

Q.7 **Assertion (A) :** Figure shows velocity vs time graph of a particle moving from t = 0 to t = 10 sec. on straight line, velocity of particle is maximum at t = 4 sec.



Reason (R) : At maximum velocity, acceleration of particle is zero.

[B]

Sol. 'A' & 'R' both correct but 'R' is not correct explanation of 'A'.

Q.8 **Assertion (A) :** Velocity of a particle varies as

v = 2 cos πt m/s where t is time in sec. Least count of time-measuring device is 0.1 sec. Maximum probable absolute error in measurement of velocity at t = 1/3 sec. can be calculated as

$$dv = \left\{ \frac{dv}{dt}\bigg|_{t=1/3\,sec} \right\} . dt, \text{ where } dt = 0.1 \text{ sec.}$$

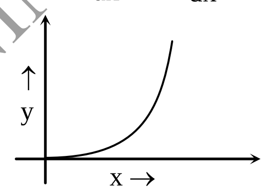
& dv = max. probable error in v at t = 1/3 sec.

Reason (R) : Absolute error is equal to difference of measured value & actual value.

Sol.[D] 'A' wrong and 'R' correct

Q.9 Assertion : If y vs x graph shown in figure at

$x = 0; y = 0, \frac{dy}{dx} = 0, \frac{d^2y}{dx^2} > 0.$



Reason : $\frac{dy}{dx}\Big|_{x=0}$ given slope of tangent drawn at x = 0 while $\frac{d^2y}{dx^2}\Big|_{x=0}$ gives the rate of change of slope of tangent in near vicinity of x = 0.

[A]

Sol. 'A' & 'B' both correct D 'A' is correct explanation of 'R'.

Q.10 **Assertion :** Speed of a particle moving on straight line decreases if acceleration is negative.

Reason : Speed of particle moving on the straight line of decreases if acceleration is opposite to velocity.

[D]

Sol. A : False, R : True.

Q.11 **Statement-I :** Velocity-time graph for an object in uniform motion along a straight path is a straight line parallel to the time axis.

Statement-II : In uniform motion of an object velocity increases as the square of time elapsed.

Sol. [C] ∵ v = const.
Statement-I is true but Statement-II is wrong.

Q.12 **Statement-I :** In a free fall, weight of a body becomes effectively zero.

Statement-II : Acceleration due to gravity acting on a body having free fall is zero.

Sol. [C] Statement-I is true but Statement-II is wrong.

Q.13 **Assertion :** A body can have acceleration even if its velocity is zero at a given instant of time.

Reason : A body is momentarily at rest when it reverses its direction of motion.

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

Sol.[1]

Q.14 **Assertion :** If the displacement of the body is zero, the distance covered by it may not be zero.

Reason : Displacement is a vector quantity and distance is a scalar quantity.

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

Sol.[1]

Q.15 **Assertion :** An object can have constant speed but variable velocity.

Reason : Speed is a scalar but velocity is a vector quantity.

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

Sol.[1]

Q.16 Assertion : An object can have constant speed but variable velocity.

Reason : Speed is a scalar but velocity is a vector quantity.

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

Sol.[1]

Q.17 **Assertion :** A body having non-zero acceleration can have a constant velocity.

Reason : Acceleration is the rate of change of velocity.

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

Sol.[4]

Q.18 **Assertion :** A body having non-zero acceleration can have a constant velocity.

Reason : Acceleration is the rate of change of velocity.

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

Sol.[4]

Q.19 Assertion : The equation of motion can be applied only if acceleration is along the direction velocity and is constant.

Reason : If the acceleration of a body is constant then its motion is known as uniform motion

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

Sol.[4]

Q.20 **Assertion :** The displacement-time graph of a body moving with uniform acceleration is a straight line.

Reason : The displacement is proportional to time for uniformly accelerated motion.

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

Sol.[4]

Q.1 For one dimensional motion if

v_{av} = average speed $\vec{v}_{av}$ = average velocity

v_{inst} = instantaneous speed

$\vec{v}_{inst}$ = instantaneous velocity; v = speed

Then match the following

Column-I	**Column-II**
(A) $\vec{v}_{inst} = \vec{v}_{av}$	(P) for uniform motion in any direction
(B) $\lvert\vec{v}_{inst}\rvert = v$	(Q) for uniform motion in given direction
(C) $v_{inst} = v_{av}$	(R) Always true
(D) $\lvert\vec{v}_{inst}\rvert < v$	(S) Never trae

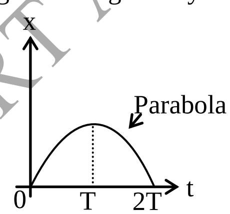
(A) → Q (B) → R (C) → P,Q (D) → S

Q.2 Match the following

Column-I	**Column-II**
(A) Motion of dropped ball	(P) Two dimensional motion
(B) Motion of a snake	(Q) Three dimensional motion
(C) Motion of a bird	(R) One-Dimensonal motion
(D) Earth	(S) Absolute rest

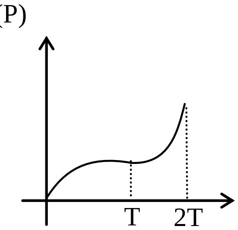
(A) → R (B) → P (C) → Q (D) → P

Q.3 The displacement - time graph of a body moving on a straight line is given by

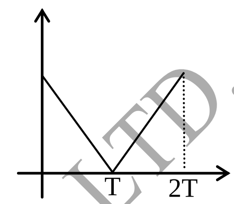


Column-I	**Column-II**
(A) Velocity – time graph	(P)
(B) Acceleration-time graph	(Q)
(C) Distance – time graph	(R)
(D) speed – time graph	(S)

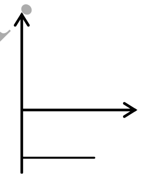
(P)



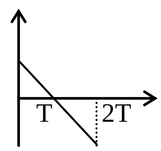
(Q)



(R)

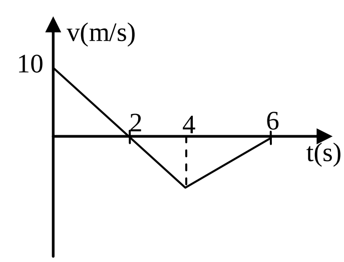


(S)



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

Q.4 For the velocity-time graph shown in figure, in a time interval from t = 0 to t = 6 s, match the following :



Column –I	**Column-II**
(A) Change in velocity	(P) –5/3 SI unit
(B) Average acceleration	(Q) – 20 SI unit
(C) Total displacement	(R) – 10 SI unit
(D) Acceleration at t = 3s	(S) – 5 SI unit

Sol. **(A) → R ; (B) → P ; (C) → R ; (D) → S**

v_i = +10 m/s and v_f = 0

$\Delta v = v_f - v_f = -10$ m/s

$$a_{av} = \frac{\Delta v}{\Delta t} = \frac{-10}{6} = \frac{-5}{3}\ m/s^2$$

Total displacement = area under v-t graph (with sign) and acceleration = slope of v-t graph.

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

Column-I	Column-II
(A) Height of particle Ground	(P) Zero
(B) Speed of particle	(Q) 10 SI units
(C) Displacement of particle	(R) 40 SI units
(D) Acceleration of particle	(S) 20 SI units

Sol. **A → R , B → P, C → S , D → Q**

After 2s velocity of balloon and hence the velocity of the particle will be 20 m/s (= at) and its height from the ground will be 20 m $\left(=\frac{1}{2}at^2\right)$. Now g, will stare acting on the particle.

Q.6 A body accelerates from rest for time t_1 at a constant rate α for distance x then it decelerates at constant rate β for time t_2 and covers distance y in this time and come at rest If all quantities are in SI units, then match the following columns :

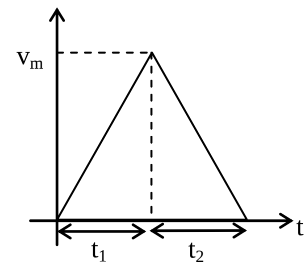
Column I	Column II
(A) x/y	(P) t_1/t_2
(B) α/β	(Q) t_2/t_1
(C) average speed for whole journey	(R) $\sqrt{\frac{2\alpha\beta}{\alpha+\beta}(x+y)}$
(D) maximum speed attained in it whole journey	(S) $\sqrt{\frac{\alpha\beta}{\alpha+\beta}\left(\frac{x+y}{2}\right)}$

Sol. **A → P ; B → Q ; C → S ; D → R**

$\frac{v_m}{t_1} = \alpha$ and $\frac{v_m}{t_2} = \beta$

also $x + y = \frac{1}{2} \times v_m \times (t_1 + t_2)$

$\therefore (x + y) = \frac{1}{2} \times v_m \times \left(\frac{v_m}{\alpha} + \frac{v_m}{\beta}\right)$



$\Rightarrow v_m = \sqrt{\frac{2(x+y).\alpha\beta}{(\alpha+\beta)}}$

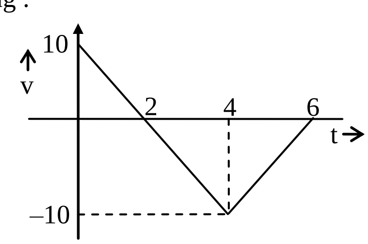
Now, $v_{av} = \frac{x+y}{t_1+t_2} = \frac{x+y}{\frac{v_m}{\alpha}+\frac{v_m}{\beta}} = \frac{\alpha\beta}{\alpha+\beta}.\frac{x+y}{v_m}$

Q.7 The equation of one dimensional motion of particle is described in column I. At t = 0, particle is at origin and at rest. Match the column I with the statements in column II.

Column-I	Column-II
(A) $x = (3t^2 + 2)$m	(P) velocity of particle at t = 1 s is 8 m/s
(B) v = 8t m/s	(Q) particle moves with uniform acceleration
(C) a = 16 t	(R) particle moves with variable acceleration
(D) $v = 6t - 3t^2$	(S) particle will change its direction some time

Ans. **A → Q ; B → P,Q ; C → P,R ; D → R,S**

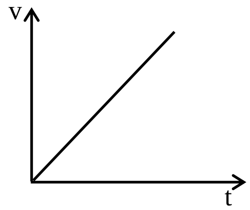
Q.8 For the velocity-time graph shown in figure, in a time interval from t = 0 to t = 6 s, match the following :



Column-I	Column-II
(A) Change in velocity	(P) –5/3 SI unit
(B) Average acceleration	(Q) –20 SI unit
(C) Total displacement	(R) –10 SI unit
(D) Acceleration at t = 3 s	(S) – 5 SI unit

Ans. **A → R ; B → P ; C → R ; D → S**

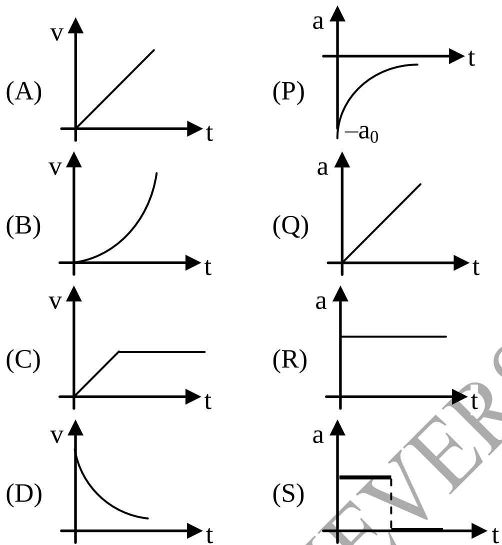
Q.9 v-t graph of a particle moving along positive direction x is shown in figure.



Column – I	Column - II
(A) a-x graph	(P) Parabola
(B) v-x graph	(Q) Circle
(C) a-t graph	(R) Straight line
(D) a-v graph	(S) None

A → R ; B → P ; C → R ; D → R

Q.10 **Column I** **Column II**



Sol. **A → R, B → Q, C → S, D → P**

A → v = Kt

$a = \frac{dv}{dt} = K$

B → $v = Kt^2$

$a = \frac{dv}{dt} = 2Kt$

C → K_1t → First part of graph

$a = \frac{dv}{dt} = K_1$

$v = K_2$ → Second part of graph

$a = \frac{dv}{dt} = 0$

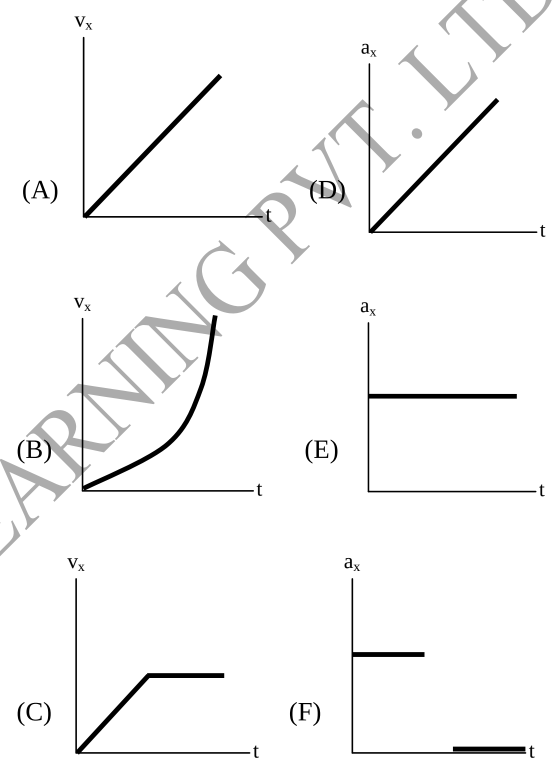
D → $v = v_0e^{-Kt}$

$a = \frac{dv}{dt} = (-v_0K)\ e^{-Kt}$

$a = -a_0\,e^{-Kt}$

$a_0 = v_0K$

Q.11 In figure, match each v_x–t graph on the left with the a_x–t graph on the right that best describes the motion.



Sol. A → E, B → D, C → F

Graph (A) has constant slope, indicating a constant acceleration; this is represented by graph (E).

Graph (B) represents a speed that is increasing constantly but not at a uniform rate. Thus, the acceleration must be increasing, and the graph that best indicates this is (D).

Graph (C) depicts a velocity that first increases at a constant rate, indicating constant acceleration. Then the velocity stops increasing and becomes constant, indicating zero acceleration. The best match of this situation is graph (F).

Q.12 Let us call a motion, A when velocity is positive and increasing. A^{-1} when velocity is negative and increasing. R when velocity is positive and decreasing and R^{-1} when velocity is negative and decreasing. Now match the following two tables for the given s-t graph:

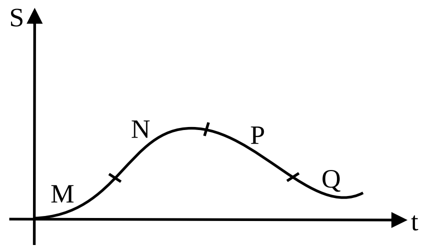


Fig.

Column I	**Column II**
(A) M	(P) A^{-1}
(B) N	(Q) R^{-1}
(C) P	(R) A
(D) Q	(S) R

Sol. (A) → (R); (B) → (S); (C) → (P); (D) → (Q)

In motion M: slope of s-t graph is positive and increasing. Therefore, velocity of the particle is positive and increasing. Hence, it is A type motion. Similarly, N, P and Q can be observed from the slope.

Q.13 For the velocity-time graph shown in figure, in a time interval from t = 0 to t = 6 s, match the following:

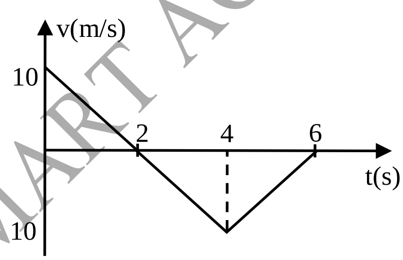


Fig.

Column I	**Column II**
(A) Change in velocity	(P) – 5/3 SI unit
(B) Average acceleration	(Q) – 20 SI unit
(C) Total displacement	(R) – 10 SI unit
(D) Acceleration at t = 3 s	(S) – 5 SI unit

Sol. (A) → (R); (B) → (P); (C) → (R); (D) → (S)

$v_i = +10$ m/s and $v_f = 0$

$\therefore \Delta v = v_f - v_i = -10$ m/s

$a_{av} = \frac{\Delta v}{\Delta t} = \frac{-10}{6} = \frac{-5}{3}$ m/s^2

Total displacement = area under v-t graph (with sign)

And acceleration = slope of v-t graph.

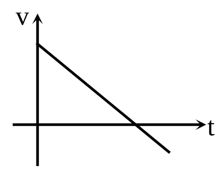
Q.14 In the s-t equation ($s = 10 + 20t - 5t^2$) match the following:

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

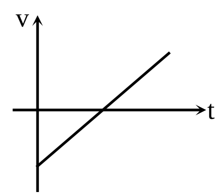
Ans. **A → R; B → Q; C → S; D → P**

Q.15 The velocity time graphs for a particle moving along a straight line is given in each situation of Column – I. Match the graph in Column–I with corresponding statements in Column-II.

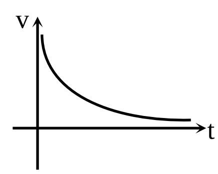
Column-I | **Column-II**

(A) 

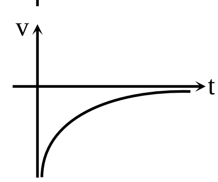
(P) Speed of particle is continuously decreasing

(B) 

(Q) Magnitude of acceleration of particle is decreasing with time

(C) 

(R) Direction of acceleration of particle does not change

(D) 

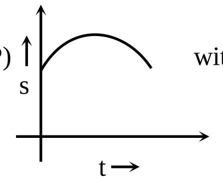
(S) Magnitude of acceleration of particle does not change

(T) Acceleration is always opposite to the direction of velocity

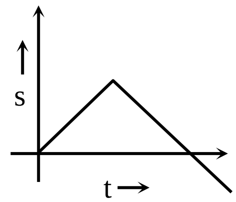
Ans. **A → R,S** **B → R,S**
C → P,Q,R,T **D →P,Q,R,T**

Q.16 **Column-I** **Column-II**

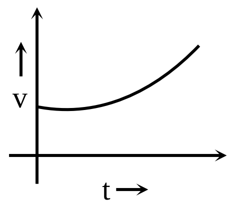
(A) Particle moving with constant speed

(P) 

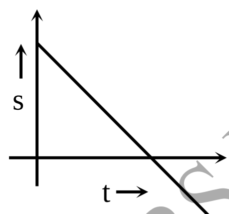
(B) Particle moving with increasing acceleration

(Q) 

(C) Particle moving with constant negative acceleration

(R) 

(D) Particle moving with zero acceleration

(S) 

Ans. **A → Q,S; B → R ; C → P; D → S**

Q.17 **Column-I** **Column-II**

	Column-I		Column-II
(A)	Area under acceleration vs displacement curve	(P)	Instantaneous velocity
(B)	Total work done per unit mass	(Q)	Change in K.E. unit mass
(C)	Area under the net force vs time	(R)	Average acceleration
(D)	Slope of line joining two points on velocity vs time graph	(S)	Change in momentum

Sol. **A→Q; B→Q; C→S; D→R**

Area under 'a' vs 's' curve

$$= \int a\,ds = \int v\,dv = \frac{v_2^2 - v_1^2}{2}$$

$$= \frac{K_2 - K_1}{m}$$

Q.18 The motion of an object over time can often be communicated by graphs of its distance, velocity or acceleration with time. Different features of these graphs correspond to quantities of the motion. Match each quantity in the left column with its graphical manifestation in the right column.

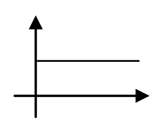
Column I	Column II
(A) Distance traveled Δd	(P) Slope of a distance-time graph
(B) Velocity change Δv	(Q) Slope of velocity-time graph
(C) Velocity v	(R) Area under a velocity-time graph
(D) Acceleration a	(S) Area under an acceleration-time graph

Ans. **A→ R ; B → S ; C→ P; D→ Q**

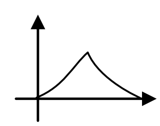
Q.19 A particle is dropped vertically downward under gravity. Consider the downward direction as positive. Ball collides elastically with ground.

Column – I **Column – II**

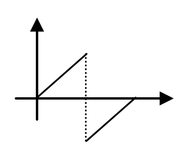
(A) The distance travelled by particle varies with time as

(P) 

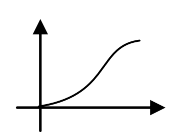
(B) Velocity of particle changes with time as

(Q) 

(C) Displacement of particle depends on time as

(R) 

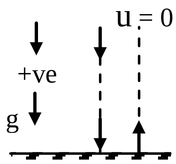
(D) Dependency of acceleration on time is given by

(S) 

Sol. **A→ S; B → R; C → Q; D → P**

$v_y = u_y + a_y t$

$y = u_y t + \frac{1}{2} a_y t^2$



*** Velocity :** $u_y = 0$

$v_y = a_y t$ (before collision)

$v_0 = v_y = gt_0$ (at $t = t_0$)

Which is straight line with positive slope.

$v_y = -v_0 + gt$: after collision

*** Displacement :**

$y = \frac{1}{2}gt^2$; before collision

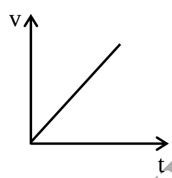
$y = -v_0 t + \frac{1}{2} gt^2$; after collision

Which is a parabola opening upwards.

* Distance-time graph is always increasing.

* Acceleration is constant and is equal to acceleration due to gravity.

Q.20 v-t graph of a particle moving along +ive direction of x is shown in figure :



Column-I	**Column-II**
(A) a-x graph	(P) Parabola
(B) v-x graph	(Q) Circle
(C) a-t graph	(R) Straight line
(D) a-v graph	(S) None

Sol. **(A)** → R, **(B)** → P, **(C)** → R, **(D)** → R

PHYSICS

Q. 1 Instantaneous velocity of a particle –
(A) depends on instantaneous position
(B) depends on instantaneous speed
(C) independent of instantaneous position
(D) independent of instantaneous speed
[B,C]

Q. 2 Two bodies A and B are moving with speeds v and 2v respectively, then –
(A) distance moved by A must be greater than that of B.
(B) distance moved by A must be smaller than that of B.
(C) displacement of A may be greater than that of B
(D) displacement of A may be smaller than that of B **[B,C,D]**

Q.3 For a body moving on a straight line if x is position co-ordinate and t is time then acceleration of body is constant when –
(A) x and velocity is linear
(B) x and square of velocity is linear
(C) t and velocity is linear
(D) t and square of velocity is linear.
[B,C]

Q.4 A body moves so that it follows the following relation $\frac{dv}{dt} = -v^2 + 2v - 1$ where v is speed in m/s and t is time. If at t = 0, v = 0 then
(A) the terminal velocity is 1m/s
(B) the magnitude of initial acceleration is $1 m/s^2$
(C) Instantaneous speed is $v = \frac{-1}{1+t}$
(D) the speed is 1.5m/s when acceletation is one fourth of it's initial value. **[A,B,D]**

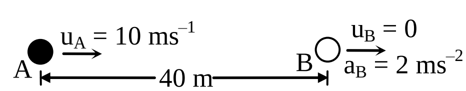
Q. 5 For a body moving on a straight line –
(A) average speed can be less than the minimum speed attained by the body.
(B) average speed cannot be less than the minimum speed attained by the body
(C) magnitude of average velocity can be less than the minimum speed attained
(D) magnitude of average velocity cannot be less than minimum speed attained.
[B,C]

Q. 6 A particle moves on a straight line position at any time t is given by
$x = x_o e^{-kt}$
(k is a constant) –
(A) distance moved is infinite
(B) distance moved in the total motion is finite
(C) average speed for total motion is zero
(D) average speed for total motion is infinite
[B,C]

Q.7 For a body moving on a straight line if x is position co-ordinate and t is time then acceleration of body is constant when -
(A) x and velocity is linear
(B) x and square of velocity is linear
(C) t and velocity is linear
(D) t and square of velocity is linear
[B,C]

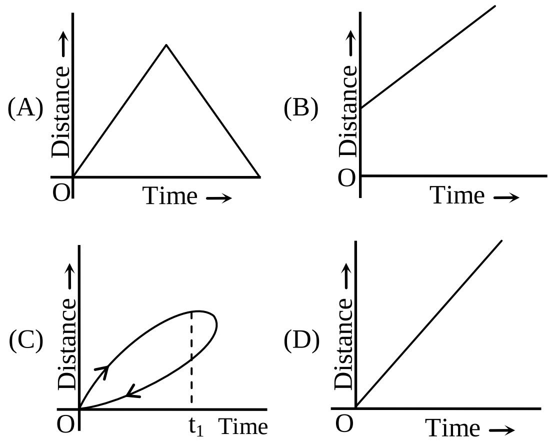
Q.8 A body moves so that it follows the following relation $\frac{dv}{dt} = -v^2 + 2v - 1$ where v is speed in m/s and t is time in second. If at t = 0, v = 0 then
(A) terminal velocity is 1 m/s
(B) the magnitude of initial acceleration is $1 m/s^2$
(C) instantaneous speed is $v = \frac{-1}{1+t}$
(D) the speed is 1.5 m/s when acceleration is one fourth of its initial value
[A,B,D]

Q.9 Two particles A and B are initially 40 m apart. A is behind B. Particle A is moving with uniform velocity of 10 m/s towards B. Particle B starts moving away from A with constant acceleration of $2 m/s^2$.



(i) The time at which minimum distance between the two occurs is -
(A) 2 s (B) 4 s
(C) 5 s (D) 6 s
(ii) The minimum distance between the two is -
(A) 20 m (B) 15 m
(C) 25 m (D) 30 m **[C,B]**

Q.10 Which of the following graph(s) is / are not possible ?



[A,C]

Q.11 If the velocity of a body is constant -

(A) |Velocity| = speed

(B) |Average velocity| = speed

(C) Velocity = average velocity

(D) Speed = average speed **[All]**

Q.12 The position of particle travelling along x-axis is given by $x_t = t^3 - 9t^2 + 6t$ where x_t is in cm and t is in second. Then–

(A) the body comes to rest firstly at $(3 - \sqrt{7})$s and then at $(3 + \sqrt{7})$ s

(B) the total displacement of the particle in travelling from the first zero of velocity to the second zero of velocity is zero

(C) the total displacement of the particle in travelling from the first zero of the velocity to the second zero of velocity is –74 cm

(D) the particle reverses its velocity at $(3 - \sqrt{7})$ s and then at $(3 + \sqrt{7})$s and has a negative velocity for $(3 - \sqrt{7})\text{s} < t < (3 + \sqrt{7})\text{s}$

[A,C,D]

Q.13 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 **[A,D]**

Q.14 Equation of a particle moving along the x axis is :

$$x = u(t - 2) + a(t - 2)^2$$

(A) the initial velocity of the particle is u

(B) the acceleration of the particle is a

(C) the acceleration of the particle is 2a

(D) at t = 2 particle is at origin **[C,D]**

Q.15 An object may have–

(A) varying speed without having varying velocity

(B) varying velocity without having varying speed

(C) non-zero acceleration without having varying velocity

(D) non-zero acceleration without having varying speed **[B,D]**

Q.16 The velocity of a particle is zero at t = 0, then -

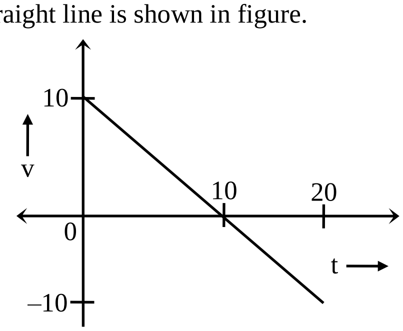
(A) the acceleration at t = 0 must be zero

(B) the acceleration at t = 0 may be zero

(C) if the acceleration is zero from t = 0 to t = 10 s. the speed is also zero in this interval.

(D) if the speed is zero from t = 0 to t = 10 sec, then the acceleration is also zero in the interval **[B,C,D]**

Q.17 The velocity-time plot for a particle moving on a straight line is shown in figure.



(A) the particle has constant acceleration

(B) the particle has never turned around

(C) the particle has zero displacement

(D) the average speed in the interval 0 to 10 sec is same as the average speed in the interval 10 sec to 20 sec **[A,D]**

Q.18 A train accelerates from rest for time t_1, at a constant acceleration α for distance x. Then it decelerates to rest at constant retardation β in time t_2 for distance y. Then -

(A) $\frac{x}{y} = \frac{\beta}{\alpha}$ (B) $\frac{\beta}{\alpha} = \frac{t_1}{t_2}$

(C) $\frac{x}{y} = \frac{t_1}{t_2}$ (D) x = y **[A,B,C]**

Q.19 A particle of mass m moves on the x-axis as follows : it starts from rest at t = 0 from the point x = 0, and comes to rest at t = 1 at the point x = 1. No other information is available about its motion at intermediate times (0 < t < 1). If α denotes the instantaneous acceleration of the particle, then - **[IIT- 1993]**

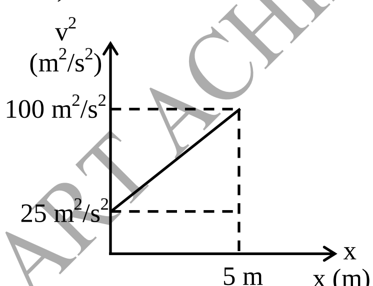
(A) α cannot remain positive for all t in the interval $0 \leq t \leq 1$

(B) $|\alpha|$ cannot exceed 2 at any point or points in its path

(C) $|\alpha|$ must be ≥ 4 at some point or in its path

(D) α must change sign during the motion, but no other assertion can be made with the information given **[A,D]**

Q.20 A particle is moving along x-axis and graph between square of speed and position of the particle is given in the figure. At t = 0 and x = 0 m, select correct statement –



(A) Acceleration of the particle is 15 m/s at $t = \frac{1}{2}$ s

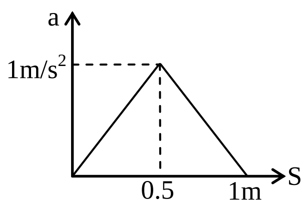
(B) Acceleration of the particle is 7.5 m/s at t = 1s

(C) Acceleration of the particle is constant

(D) At t = 1 s, velocity of particle is 12.5 m/s

[B,C,D]

Q.1 A body initially at rest moving along x-axis in such a way so that its acceleraation Vs displacement plot is as shown in figure. What will be the maximum velocity of particle in m/sec.



Sol.[1] vdv = ads

$\Rightarrow \frac{v^2}{2}$ = Area of A-S graph

$\frac{v^2}{2} = \frac{1}{2} \Rightarrow v = 1$ m/sec

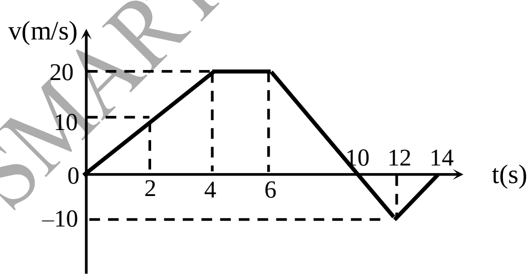
Q.2 A particle moving in a straight line covers half the distance with speed of 3 m/s. The other half of the distance is covered in two equal time intervals with a speeds of 4.5 m/s and 7.5 m/s, respectively. Find the average speed of the particle during this motion.

Sol. **[0004]** $v_{avg} = \frac{2v_0(v_1+v_2)}{2v_0+v_1+v_2}$

$= \frac{2\times3(4.5+7.5)}{6+4.5+7.5}$ m/s

$= \frac{6\times12}{18}$ m/s = 4m/s

Q.3 Velocity-time graph of a particle moving in a straight line is shown in figure. In the time interval from t = 0 to t = 14 s, find:

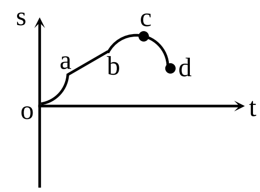


(a) average velocity and

(b) average speed of the particle

Sol. (a) $\left(\frac{50}{7}\right)$ m/s (b)10 m/

Q.4 Displacement-time graph of a particle moving in a straight line is as shown in figure.



(a) Find the sign of velocity in regions oa, ab, bc and cd

(b) Find the sign of acceleration in the above region

Sol. (a) positive , positive, positive, negative

(b) positive , zero, negative, negative

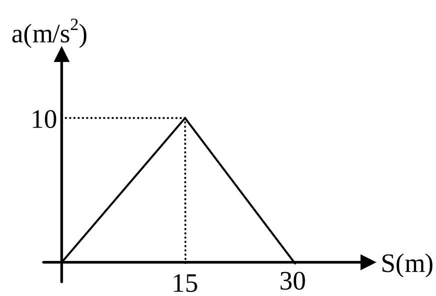
Q. 5 The speed of a motor launch with respect to the water is v = 5 m/s, the speed of stream u = 3 m/s. When the launch began travelled 3.6 km up stream, turned about and caught up with the float. How long is it before the launch reaches the float again ? (Find answer in hour).

Sol.[1] $t = \frac{2\ell}{v-u} = \frac{2\times3600}{2}$

= 3600 sec

= 1 hr.

Q.6 The particle moves with rectilinear motion given the acceleration-displacement (a-S) curve is shown in figure, determine the velocity after the particle has traveled 30 m. If the initial velocity is 10 m/s. **[0020]**



Sol. Area under curve is $= \frac{1}{2}\times10\times30$

= 150 ……..(i)

Area under curve is also equal to $= \frac{v^2-u^2}{2}$ …….(ii)

From (i) and (ii)

$\frac{1}{2}(v^2 - u^2) = 150$

$v^2 = u^2 + 300$

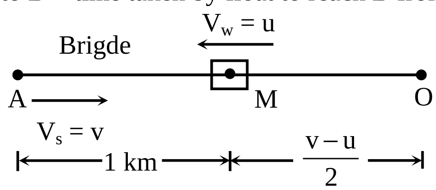
$v^2 = (10)^2 + 300$

$v = \sqrt{400} = 20$m/s.

Q.7 A swimmer jumps from a bridge over a canal and swims 1 km up stream. After that first km, he passes a floating cork. He continues swimming for half an hour and then turns around and swims back to the bridge. The swimmer and the cork reach the bridge at the same time. The swimmer has been swimming at a constant speed. How fast does the water in the canal flow in km/hr.

Sol. Let $V_w = u$ & $U_{sw} = v$

Time taken by swimmer to go from M to O and O to B = time taken by float to reach B from M.



$= \frac{1}{2} + \frac{1+\frac{v-u}{2}}{v+u} = \frac{1}{u}$

$\Rightarrow \frac{1}{2} + \frac{2+v-u}{2(v+u)} = \frac{1}{u}$

$\Rightarrow \frac{(v+u+2+v-u)}{2(v+u)} = \frac{1}{u}$

$\Rightarrow$ (2v + 2) u = 2(v + u)

$\Rightarrow$ 2vu + 2u = 2v + 2u

u = 1 km/hr

Q.8 A ball is thrown upwards from the foot of a tower. The ball crosses the top of tower twice after an interval of 4 seconds and the ball reaches ground after 8 seconds, then the height of tower in meters is : ($g = 10$ m/s^2) **[0060]**

Sol. $h = ut - \frac{1}{2}gt^2$

or $gt^2 - 2ut + 2h = 0$

$t_1t_2 = \frac{2h}{g}$ and $t_1 + t_2 = \frac{2u}{g} = T$

$\therefore (t_2 - t_1)^2 = (t_1 + t_2)^2 - 4t_1t_2$

$16 = 64 - 4 \times \frac{2h}{g} \Rightarrow h = 60$ m

Q.9 An insect moves with a constant velocity v from one corner of a room to other corner which is opposite of the first corner along the largest diagonal of room. If the insect can not fly and dimensions of room is $a \times a \times a$, then the minimum time in which the insect can move is $\frac{a}{v}$ times the square root of a number n, then n is equal to ? **[5]**

Sol. $(\Delta S)_{min} = \left(\sqrt{a^2 + \frac{a^2}{4}}\right) \times 2 = \sqrt{5}\, a$

Q.10 A particle is moving on a straight line with constant retardation of 1 m/s^2. what is the average speed of the particle on the last two meters betore it stops(in m/s.) **[1]**

Sol. ΔS in last two sec $= \frac{1}{2} \times 1 \times 4 = 2$m

$\therefore v_{av} = \frac{\Delta S}{\Delta t} = 1$ m/s

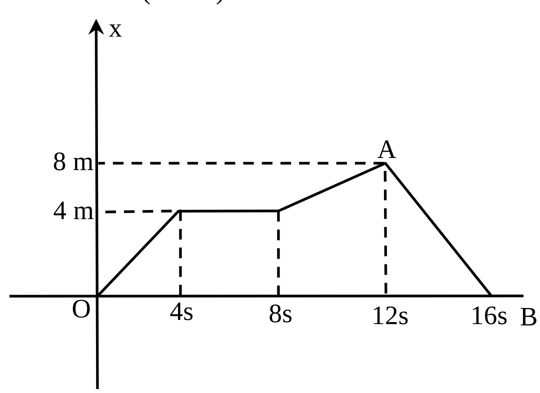
Q.11 A point moves with uniform acceleration and its initial speed and final speed are 2 m/s and 8 m/s respectively then, the space average of velocity over the distance moved is. (in m/s)

[6]

Sol. $[v_{av}]_x = \frac{\int_{x_1}^{x_2} v\,dx}{x_2 - x_1} = \frac{\int_0^x \sqrt{u^2 + 2ax}\,dx}{x}$

Q.12 A body moves with constant acceleration covers 16 m and 24 m in successive intervals of 4 sec and 2 sec. Then its acceleration in m/s^2 is. **[4]**

Q.13 Figure shows the graph of the x-co-ordinate of a particle going along the x-axis as function of time. Find the instantaneous speed of particle at t = 12.5 s (in m/s)



Sol. **[2]**

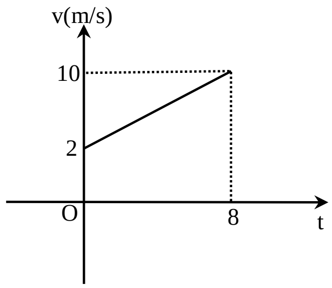
B = 2m/s

Slope of line AB = – 2m/s

Speed of particle at t = 12.5 s

v = 2m/s

Q.14 Figure shows the graph of velocity versus time for a particle going along x axis. Initially at t = 0, particle is at x = 3m. Find position of particle at t = 2s. (in m)



Sol. **[9]**

v = t + 2

v_2 = 4 m/s, at t_2 = s.

$x_2 - x_0 = \frac{1}{2} \times (2 + 4) \times 2$

= 6m

x_2 = 9m

Q.15 An athlete takes 2s to reach his maximum speed of 36 km/h.What is the magnitude of his average acceleration ? (in m/s)

Sol. **[5]**

5m/s

$< v > = \frac{v_i + v_f}{2}$ (for constant acceleration)

Q.16 A car travelling at 60 km/h over takes another car travelling at 42 km/h. Assuming each car to be 5.0 m long. Find the time taken during the over take. (in sec)

Sol. **[2]**

$s_{A/B} = v_{A/B}\, t + \frac{1}{2} a_{A/B}\, t^2$

Q.17 A police jeep is chasing a culprit going on a motor bike. The motor bike crosses a turning at a speed of 72 km/h. The jeep follows it a speed of 90 km/h crossing the turning ten seconds later than the bike. Assuming that they travel at constant speeds, how far from the turning will the jeep catch up with the bike ? (in km)

Sol. **[1]**

Speed of bike = $72 \times \frac{5}{18}$ = 20 m/s

speed of jeep = $90 \times \frac{5}{18}$ = 25 m/s.

relative velocity of jeep w. r. t. bike = 25 – 20 = 5 m/s

distance covered by bike in 10s = 20 × 10

= 200 m.

time taken by Jeep to cover 200 m with velocity 5 m/s.

$t = \frac{200}{5}$ = 40 s.

Therefore distance covered by police jeep in40 s

= 40 × 25 = 1000 m

= 1 km.

Q.18 A bullet going with speed 16 m/s enters a concrete wall and penetrates a distance of 0.4 m before coming to rest. Then the time taken during the retardation is

………… × 10^{-2} s. (in sec)

Sol. **[5]**

$0 = 16^2 - 2a\,s$ ($\because v^2 = u^2 + 2as$)

$a = \frac{16 \times 16}{2 \times 0.4} = 320\ m/s^2$

$t = \frac{v}{a} = \frac{16}{320} = 5 \times 10^{-2}$ s

Q.19 A boy standing on a long railroad car throws a ball straight upwards. The car is moving on the horizontal road with an acceleration of $1 m/s^2$ and projection velocity in the vertical direction is 9.8m/s. How far behind the boy will the ball fall on the car ? (in m)

Sol. **[2]**

Time when velocity of ball is zero

$0 = 9.8 \times gt \Rightarrow t = \frac{9.8}{9.8} = 1s.$

$\therefore$ total time when it comes back = 2s

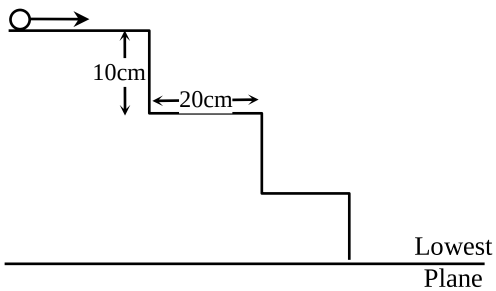
distance travelled by trolley in 2s

$s = \frac{1}{2} at^2 = \frac{1}{2} \times 1 \times 2^2 = 2m.$

ball will fall 2m behind the boy.

Q.20 A Staircase contains three steps each 10 cm high and 20 cm wide. What should be the minimum horizontal velocity of a ball rolling off the uppermost plane so as to hit directly the lowest plane. (in m/s)

Sol. **[2]**



horizontal distance travelled by ball = 3 × 0.2 = 0.6 m.

vertical distance = 3 × 0.1 = 0.3 m.

let velocity along horizontal = v m/s.

velocity along vertical = 0

therefore 0.6 = vt

$$t = \frac{0.6}{v}$$

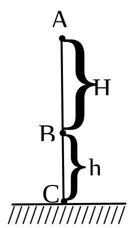
and $$0.3 = \frac{1}{2} gt^2$$

$$0.3 = \frac{1}{2} g\left(\frac{0.6}{v}\right)^2$$

$$\Rightarrow \quad v^2 = \frac{5\times0.6\times0.6}{0.3}$$

$$v \approx 2.4 \text{ m/s.}$$

Q.1 One body falls freely from a point A at a height H + h (Fig.) whilst another body is projected upwards with an initial velocity v_0 from point C at the same time as the first body begins to fall. What thould the initial velocity v_0 of the second body be so that the bodies meet at a point B at a height h ? What is the maximum height attained by the second body for the given initial velocity ? Consider the case H = h separately.



Sol. $\mathbf{v_0 = \frac{H+h}{2H}\sqrt{2gH}\ ;\ h_{max} = \frac{(H+h)^2}{4H}}$.

The path traversed by the first body before it meets the second is

$H = \frac{gt^2}{2}$ and by the second body before it meets the first is

$H = v_0t - \frac{gt^2}{2}$ After a simultaneous solution of these equations

$v_0 = \frac{H+h}{2H}\sqrt{2gH}$

hence, $h_{max} = \frac{v_0^2}{2g} = \frac{(H+h)^2}{4H}$ $(h_{max} > h)$

When H = h we have; $v_0 = \sqrt{2gh}$; $h_{max} = h$

Q.2 How long before or after the first body starts to fall and with what initial velocity should a body be projected upwards from point C (see problem 1) to satisfy simultaneously the following conditions:

(1) The bodies meet at point B at a height h

(2) the height h is the maximum height which the projected body reaches ?

Sol. $\mathbf{t = \frac{\sqrt{2gH}-\sqrt{2gh}}{g}\ ;\ v_0 = \sqrt{2gh}}$

The time the body takes in falling from A to B is $t_1 = \sqrt{\frac{2H}{g}}$. The time of rise of the body from C to the highest point is $t_2 = \sqrt{\frac{2h}{g}}$.

The required time $t = t_1 - t_2 = \frac{\sqrt{2H}-\sqrt{2h}}{g} = \frac{\sqrt{2gH}-\sqrt{2gh}}{g}$.

If H > h, the second body should be thrown after some delay; when H = h, the bodies should be thrown simultaneously; when H < h the second body should be thrown before the first begins to fall.

Q.3 A heavy elastic ball falls freely from point A at a height H_0 onto the smooth horizontal surface of an elastic plate. As the ball strikes the plate another such ball is dropped from the same point A. At what time t, after the second ball is dropped, and at what height will the balls meet ?

Sol. $\mathbf{t = \sqrt{\frac{H_0}{2g}}\ ;\ h_1 = \frac{3}{4}H_0}$

The velocity of the first ball at the moment it strikes the plate will be $v_0 = \sqrt{2gH_0}$. Since the impact is elastic, the ball will begin to rise after the impact with a velocity of the same magnitude v_0. During the time t the first ball will rise to a height

$$h_1 = v_0t - \frac{gt^2}{2}$$

During this time the second ball will move down from a point A a distance

$$h_2 = \frac{gt^2}{2}$$

At the moment the balls meet, $h_1 + h_2 = H_0$. Hence,

$$t = \frac{H_0}{v_0} = \sqrt{\frac{H_0}{2g}}$$

Q.4 Two bodies are thrown vertically upwards with the same initial velocities v_0, the second τ sec. after the first. (1) With what velocity will be second body move relative to the first ? Indicate the magnitude and direction of this relative velocity. According to what law will the distance between the bodies change ? (2) Solve this problem when the initial velocity of the second body v_0 is half the initial velocity of the first.

Sol. **(1) $v = g\tau$; (2) $v = -v_0 + g\tau$.**

In the first case the velocity of the first body at any moment relative to the earth is

$$v_1 = v_0 - gt$$

The velocity of the second body relative to the earth is

$$v_2 = v_0 - g(t - \tau)$$

The required velocity of the second body relative to the first will be

$$v = v_2 - v_1 = g\tau$$

The velocity v is directed upwards both during the ascent and descent of both bodies. During the ascent the distance between the bodies diminishes uniformly and during the descent it increases uniformly

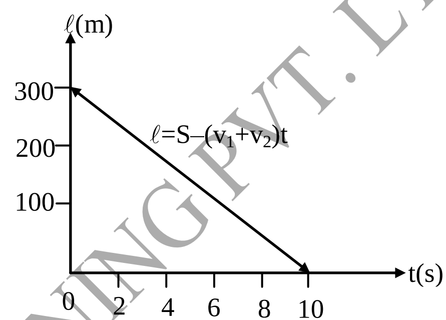
Q.5 Two motor-cyclists set off from points A and B towards each other. The one leaving point A drives uphill with a uniform acceleration a = 2 m/s^2 and an initial velocity v_1 = 72 km/hr, whilst the other goes downhill from point B with an initial velocity v_2 = 36 km/hr and with an acceleration of the same magnitude as the other car. Determine the time of motion and the distance covered by the first motor-cyclist before they meet, if the distance between A and B is S = 300m. Show how the distance between the motor-cyclists will change with time. Plot the change of distance between the motor-cyclists against time. Use the graph to find the moment when the motor-cyclists meet.

Sol. **t = 10s; ℓ_1 = 100m.**

The distance between the motor-cyclists uniformly diminishes with time according to the law

$\ell = S - t(v_1 + v_2)$

And becomes zero after 10s (fig.)



If the distance from the point where they meet to the point A is l_1 and to the point B is l_2, then

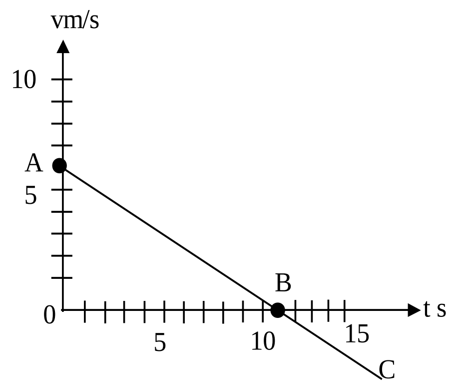
$\ell_1 = v_1 t - \frac{at^2}{2}$, $\ell_2 = v_2 t + \frac{at^2}{2}$

and $S = \ell_1 + \ell_2$

so $S = v_1 t + v_2 t = t(v_1 + v_2)$.

Hence, $t = \frac{S}{v_1 + v_2}$, $\ell_1 = \frac{v_1 S}{v_1 + v_2} - \frac{a}{2}\frac{S^2}{(v_1 + v_2)^2}$

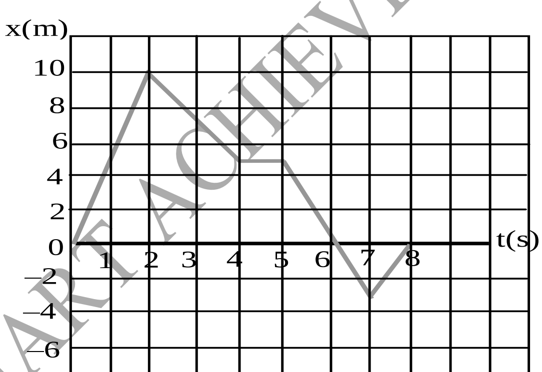
Q.6 Given fig. show the velocity-time graph for the motion of a certain body. Determine the nature of this motion. Find the initial velocity and acceleration and write the equation for the variation of displacement with time. What happens to the moving body at point B ? How will the body move after this moment ?



Sol. The motion is uniformly retarded up to the point B and uniformly accelerated after the point B. At the moment that corresponds to the point B the body stops and then the direction of its velocity is reversed.

The initial velocity v_0 = 7 m/s and the acceleration a ≈ 0.64 m/s^2. The equation of the path is $S = 7t - 0.32t^2$

Q.7 The displacement versus time for a certain particle moving along the x axis is shown in figure. Find the average velocity in the time intervals (a) 0 to 2s (b) 0 to 4s. (c) 2s to 4s (d) 4s to 7s (e) 0 to 8s.



Sol. (a) $v_{av} = \frac{\text{total displacement}}{\text{total time}}$

$$= \frac{\frac{1}{2} \times 2 \times 10}{2}$$

v_{av} = 5 m/s

(b) $$v_{av} = \frac{\frac{1}{2} \times 2 \times 10 + \frac{1}{2}(10+5) \times 2}{4}$$

$$= \frac{10+15}{4} = \frac{25}{4} = 6.25 \text{ m/s}$$

(c) $$v_{av} = \frac{15}{2} = 7.5 \text{ m/s}$$

(d) $$v_{av} = \frac{5 \times 1 + \frac{1}{2} \times 1 \times 5 - \frac{1}{2} \times 3 \times 1}{3}$$

$$= \frac{5 + 2.5 - 1.5}{3}$$

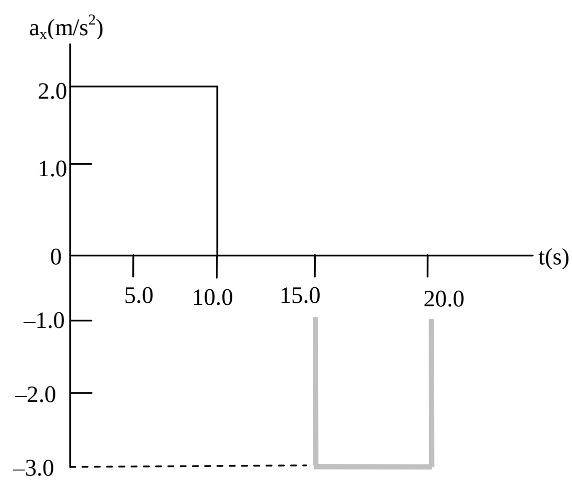
$$= \frac{5+1}{3} = 2 \text{m/s.}$$

(e) $$v_{av} = \frac{10 + 15 + \frac{1}{2} \times 5 \times [1+2] - \frac{1}{2} \times 2 \times 3}{8}$$

$$= \frac{25 + 7.5 - 3}{8}$$

$$v_{av} = \frac{29.5}{8} = 3.7 \text{ m/s.}$$

Q.8 A particle starts from rest and accelerates as shown in figure. Determine (a) the particle's speed at t = 10s and at t = 20s and (b) the distance traveled in the first 20s.



Sol. Initial velocity

(a) a t = 10 sec.

Area under a.t. curve b/w 0 & 10 sec.

$\Delta V = 2 \times 10 = 20$m/s

$V_f - V = 20$ m/s

$V_f = 20$ m/s

at t = 20 sec.

Total area under a-t curve between 0 & 20 sec.

$\Delta V = 2 \times 10 - 3 \times 5$

$\Delta V = 20 - 15$

$V_f' - V_i = \Delta V = 5$m/s

$V_f' = 5$m/s.

(b) **262 m**

First method:

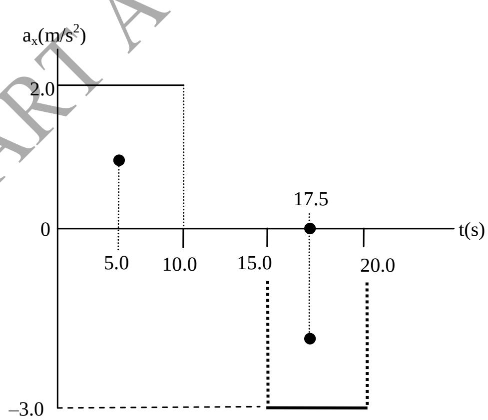
Calculation of displacement directly from a–t curve by using following formula.

$\Delta s = ut_0 + (\text{area under a–t curve}) (t_0 - t_c)$

$u \rightarrow$ initial velocity

$t_0 \rightarrow$ total time

$t_c \rightarrow$ abscissa of centroid of corresponding area.



$\Delta s = ut_0 + (\text{area under a–t cure}) (t_0 - t_c)$

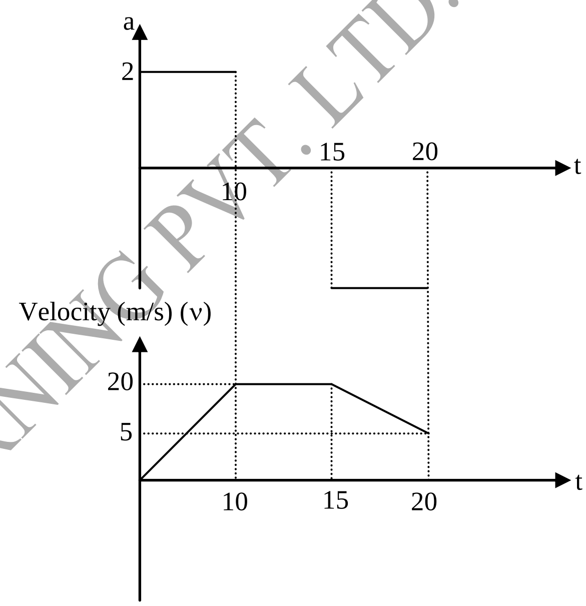
$\Delta s = 20 \times 15 - 15 \times 2.5$

$= 300 - 37.5$

$\Delta s = 262.5$m

Displacement & distance traveled are same in this case.

Second method:



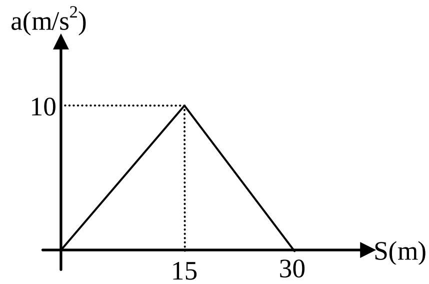
Area under velocity-time curve gives displacement.

$\Delta s = \frac{1}{2} \times 10 \times 20 + 20 \times 5 + \frac{1}{2} \times [20 + 5] \times 5$

$= 100 + 100 + 25 \times 2.5$

$\Delta s = 262.5$ m

Q.9 The particle moves with rectilinear motion given the acceleration-displacement (a-s) curve is shown in figure, determine the velocity after the particle has traveled 30m. If the initial velocity is 10m/s.



Sol. Area under curve is $= \frac{1}{2} \times 10 \times 30$

$= 150$ ……..(i)

Area under curve is also equal to $= \frac{v^2 - u^2}{2}$ …….(ii)

From (i) & (ii)

$\frac{1}{2}(v^2 - u^2) = 150$

$v^2 = u^2 + 300$

$v^2 = (10)^2 + 300$

$v = \sqrt{400} = 20$m/s

Q.10 A boy is throwing balls into the air, throwing one whenever the previous one is at its highest point. How high do the balls rise if he throws twice a second ?

Sol. Suppose that the boy throws n time a second. Then the time of flight of each ball upwards t = 1/nsec. The time of rise equals the time of fall. But the distance and time of fall are connected by the formula

$$s = \frac{gt^2}{2} = \frac{g}{2n^2}$$

Therefore the height equals

$$s = \frac{g}{2 \times 2^2} \approx \frac{9.8}{8} \approx \mathbf{1.23\ m}$$

Q.11 Two stone fall down a shaft, the second one beginning its fall 1 sec after the first. Find the second stone's motion in relation to that of the first. Ignore air-resistance.

Sol. Both stones move relative to the earth with the same constant and uniform acceleration g. Clearly one stone move uniformly in relation to the other, and the constant speed of the first stone acquires in 1 sec., i.e. in the period that elapses between the two moments at which the stones start falling.

It is not difficult to carry out the necessary calculation.

The distance traveled by the first stone is found from the equation

$$s_1 = \frac{gt^2}{2}$$

The distance traveled by the second stone from the equation

$$s_2 = \frac{g(t-1)^2}{2}.$$

The distance between the two stones increases with the lapse of time according to the formula

$$s_1 - s_2 = gt - \frac{g}{2},$$

i.e., the first stone moves uniformly in relation to the second stone with a velocity numerically equal to g.

Q.12 Two planes are flying at the same speed of 200m/sec in opposite directions. A machine-gun mounted in one plane fires at the other at right angle to their line of flight. How far apart will the bullet-holes made in the side of the second plane be, if the machine-gun fires 900 rounds per minute / What role does air-resistance play in this ?

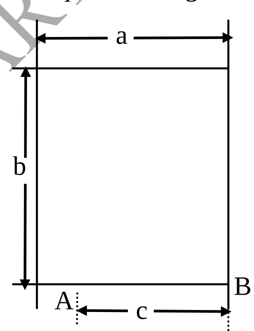
Sol. The aeroplanes are moving relative to each other at a speed equal to the sum of their speeds, i.e., at a speed, v of 400 m/sec. Between the firing of any two rounds a period of time, t, elapses = $\frac{1}{900}$ min = $\frac{1}{15}$ sec. The distance between the bullet-holes must equal the relative distance traveled by the second aeroplane during this time, i.e.,

$S = vt = \frac{400}{15} = 27$ m approx.

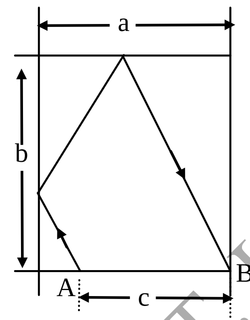
Since the length of the fuselage of an aeroplane rarely exceeds 27 m, not more than one bullet can normally hit the aeroplane the given conditions of fring.

As a result of air-resistance every bullet will require a greater length of time to traverse the distance between the two aeroplanes. But every bullet will be delayed by the same amount. Therefore the interval of time between the arrival at the target of any two consecutive bullets remains $\frac{1}{15}$ sec as before, and the distance, between the bullet-holes must, as before, **equal 27 m.**

Q.13 A billiards-ball is at point A on a billiards-table whose dimensions are given in fig. At what angle should the ball be struck so that it should rebound from two cushions and go into pocket B ? Assume that in striking the cushion, the ball's direction of motion changes according to the law of reflection of light from a mirror, i.e., the angle of reflection equals the angle of incidence.



Sol. Let us resolve the velocity v imparted to the ball into component parallel with the sides of the table and consider the path of a ball as shown, for example, in the diagram (fig.).



We obtain two equations, evident from the diagram :

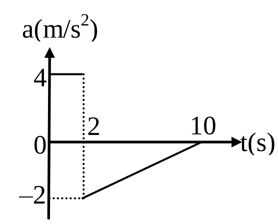
$\frac{2a-c}{t} = v \cos \alpha$, $\frac{2b}{t} = v \sin \alpha$,

From these equations we get :

$\mathbf{\cot\alpha = \frac{2a-c}{2b}}$ **,**

i.e., we find angle α, at which the ball must be struck. The value for the velocity v which is imparted to the ball plays no part at all.

Q.14 A particle moves in a straight line with an a–t curve shown in figure. The initial displacement and velocity are zero. At what time and with what displacement will particle come to rest again.



Sol. Area under a-t curve :

Δv = Area 1 = 2 × 4 = 8

$v - u = 8$

$v = u + 8 = 0 + 8 = 8$m/s

$v' - v$ = Area 2 = $-\left(\frac{1}{2}\times8\times2\right)$ = –8m/s

$v' = v - 8 = 8 - 8 = 0$

final velocity is zero at t = **10 sec.**

Displacement : Can be directly calculated from a–t cure without using v–t curve.

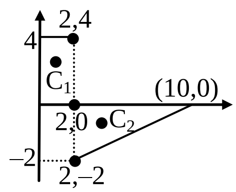
$\Delta S = u_0 t_0$ + (area under a–t curve) $(t_0 - t_c)$

Where ΔS = displacement

u_0 = initial velocity

t_0 = total time

t_c = Abscissa of cehtroid of corresponding area



Centroid of area 1: $C_1 = (1,2)$

Centroid of area 2 : $C_2 = \left(\frac{14}{3}, \frac{-2}{3}\right)$

$$\Delta S = 0 + 8\,[10 - 1] + \left[(-8)\left(10 - \frac{14}{3}\right)\right]$$

$$= 8 \times 9 + \left[-8 \times \frac{16}{3}\right]$$

$$= 8\left[9 - \frac{16}{3}\right]$$

$$= 8 \times \left[\frac{11}{3}\right]$$

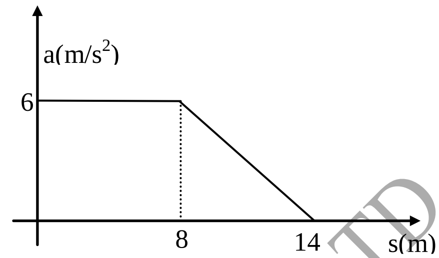
$= 8 \times 3.666$

$= 8 \times 3.67$

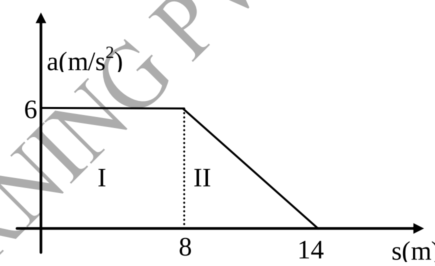
$\Delta s =$ **29.36 m**

Q.15 A particle moves in rectilinear motion such that acceleration – displacement curve is as shown in figure. If initially, s = 0 & v = 4 m/s. What is the velocity when position is

(i) 8m (ii) 12m.



Sol. (i)



Area I = 6 × 8 = 48

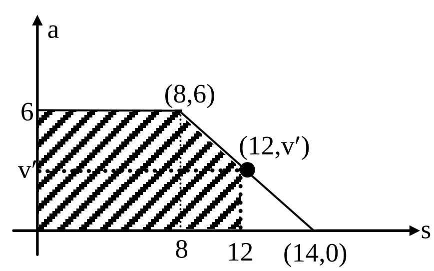
$$\frac{v^2 - u^2}{2} = 48$$

$v^2 = 4^2 + 96$

$v^2 = 16 + 96$

$v = \sqrt{112} = 10.2$ m/s.

(ii)



$$\frac{14-8}{0-6} = \frac{14-12}{0-v'}$$

$$-\frac{6}{6} = -\frac{2}{v'}$$

$v' = 2$m/s.

Area of shaded region

$$= 6 \times 8 + \frac{1}{2}\,(6+v') \times 4$$

$= 48 + \frac{1}{2}(6 + 2) \times 4$

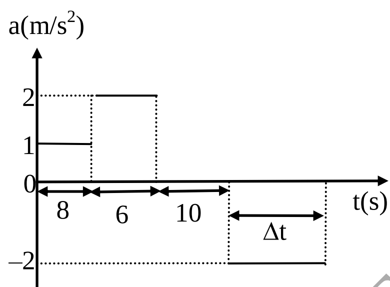
$= 48 + 16$

$\frac{v^2 - u^2}{2} = 64$

$v^2 = u^2 + 128$

$\mathbf{v = \sqrt{144} = 12 m/s}$

Q.16 A subway train travels between two of its station stops with the acceleration schedule shown. Determine the time interval Δt during which the train brakes to a stop with a deceleration of $2 m/s^2$ and find distance 's' between stations.



Sol. Area under graph gives change in velocity

Train starts from rest and comes to rest

Therefore,

Positive area = negative area

$8 \times 1 + 6 \times 2 = 2 \times \Delta t$

$8 + 12 = 2\Delta t$

$\Delta t = \frac{20}{2} = \mathbf{10 sec}$.

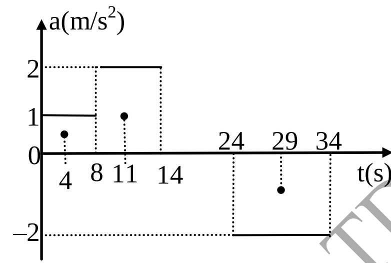
Displacement & distance are equal in this case displacement can be directly calculated from at curve without using v-t curve as follows

$\Delta S = ut_0 + (\text{area under a-t curve})(t_0 - t_c)$

Where u $\rightarrow$ initial velocity

$t_0 \rightarrow$ total time

$t_c \rightarrow$ abscissa of centroid of corresponding area



$\Delta s = 8[34 - 4] + 12[34 - 11] + (-20)[34 - 29]$

$= 8 \times 30 + 12 \times 23 - 20 \times 5$

$= 240 + 276 - 100$

$= 516 - 100$

$\mathbf{\Delta s = 416 m.}$

Q.17 A body covers half of its journey with a speed of 40 m/s and other half with a speed of 60 m/s. What is the average speed during the whole journey ?

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

Let x be the distance to be covered

$\therefore$ average speed $= \frac{x}{\frac{x}{2v_1} + \frac{x}{2v_2}} = \frac{2v_1v_2}{v_1 + v_2}$

$= \frac{2 \times 40 \times 60}{100} = 48 \ ms^{-1}$.

Q.18 The displacement (in metre) of a particle moving along X-axis is given by $x = 18t + 5t^2$.

Calculate (i) The instantaneous velocity at t = 2s, (ii) average velocity between t = 2s and t = 3s,

(iii) Instantaneous acceleration

Sol. $x = 18t + 5t^2$

(i) $v = \frac{dx}{dt} = 18 + 10t$

At t = 2s, $v = 18 + 10 \times 2 = 38 \ ms^{-1}$

(ii) $a = \frac{dv}{dt} = 10$ (a constant)

$\therefore \quad v_{av} = \frac{v_i + v_f}{2}$

i.e., $v_{av} = \frac{v_{t=2} + v_{t=3}}{2}$

$= \frac{38+48}{2} = 43 \text{ ms}^{-1}$

(iii) acceleration = 10 ms^{-2}

Q.19 Velocity and acceleration of a particle at time

t = 0 are $\vec{u} = (2\hat{i} + 3\hat{j})$ m/s and $\vec{a} = (4\hat{i} + 2\hat{j})$ m/s^2 respectively. Find the velocity and displacement of particle at t = 2s.

Ans. $\vec{v} = (10\hat{i} + 7\hat{j})$ m/s, $\vec{s} = (12\hat{i} + 10\hat{j})$ m

Q.20 Two cars start off the race with velocities 'u' and 'v' and travel in a straight line with uniform acceleration α and β. If race ends in the dead heat. Prove that the length of course is $\frac{2(u-v)(u\beta - v\alpha)}{(\alpha - \beta)^2}$.

Sol. $S = ut + \frac{1}{2}\alpha t^2 = vt + \frac{1}{2}\beta t^2$

$\therefore \quad t = \frac{2(u-v)}{\beta - \alpha}$

substitute t in S.