# CBSE 9th : PHYSICS : NOTES

## MOTION

# LET US RECAPITULATE

- **Motion :** An object which changes its position with respect to a fixed point is said to be in motion.
- **Motion is a relative term :** An object at rest with respect to one object may also be in motion with respect to another object.
- **Reference point :** A fixed point with respect to which an object changes its position is known as a reference point.
- **Distance :** The length of actual path between the initial position and the final position of a moving object or body is known as distance travelled by the particle.
- **Displacement :** The shortest distance between the initial and final positions of a moving object or body in a direction from initial to the final position of the particle is known as displacement of the particle.
- **Units of distance and displacement :** SI unit of distance and displacement is metre (m).
- **Distance** travelled by a body is always positive.
- **Displacement** of body may be **positive, negative** or **zero**.
- Ratio of the magnitude of displacement and the distance is equal to less than 1.
- **Uniform Motion :** The motion of a body is said to be uniform if (i) it moves along a straight line and (ii) it covers equal distance in equal intervals of time, how-so-ever, small these intervals may be.
- **Non-uniform motion :** The motion of a body is said to be non-uniform if it covers unequal distance in equal intervals of time.
- **Speed :** The distance travelled by a body in unit time is known as the speed of the body. That is

$$\text{Speed} = \frac{\text{Distance}}{\text{time}}$$

- **Unit of speed :** SI unit of speed is $ms^{-1}$.
- **Uniform speed :** If a moving body covers equal distances in equal intervals of time, the speed of the body is uniform.
- **Non-Uniform speed :** If a moving body covers unequal distances in equal intervals of time, the speed of the body is non-uniform.
- **Average speed :** The total distance travelled by a body during non-uniform motion divided by the time taken to travel this distance is called average speed.

$$\text{i.e. Average speed} = \frac{\text{Total distance travelled by body during non} - \text{uniform motion}}{\text{Total time taken}}$$

- **Velocity :** The displacement of the body per unit time is known as the velocity of the body. That is,

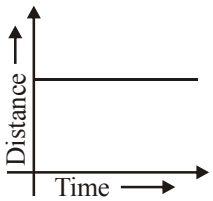
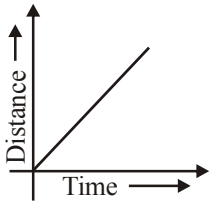
$$\text{Velocity} = \frac{\text{Displacement}}{\text{Time}}$$

- **Unit of velocity :** SI unit of velocity is $ms^{-1}$.
- **Uniform velocity :** Velocity of a body is said to be uniform velocity if it covers equal displacements in equal intervals of time.
- **Non-uniform velocity :** Velocity of a body is said to be non-uniform if it covers unequal displacement in equal intervals of time.
- **Average velocity :** $\frac{\text{Total displacement of the body}}{\text{Total time taken}}$
- **Speed** is a scalar quantity, whereas velocity is a vector quantity.
- **Speed** of a body is always **positive.**
- **Velocity** of body can be **positive** as well as **negative.**
- **Acceleration :** Acceleration of a body is defined as the change in velocity per unit time.

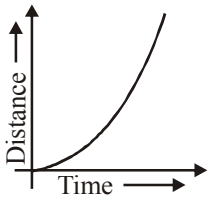
  i.e. $\text{Acceleration} = \frac{\text{Change in velocity}}{\text{Time}}$
- **Positive acceleration :** When the velocity of a body increases with time, acceleration of body is said to be positive acceleration.

  Or When the change in velocity ($\Delta v$) of a body takes place in the direction of the motion of the body, then the acceleration of the body positive.
- **Negative acceleration or retardation or deceleration :** If the velocity of the body decreases with time, then acceleration of body is negative acceleration of retardation.

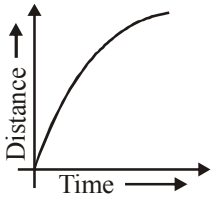
  Or When the change in velocity ($\Delta v$) of a body takes place in a direction opposite to the direction of motion of the body, then the acceleration of the body is negative.
- **S.I.** unit of acceleration is $m/s^2$
- **GRAPH**

| S.No. | State of object /body | Slope of Distance-time graph |
|---|---|---|
| 1. | Rest or stationary |   |
| 2. | Uniform motion |   |

3. Non-uniform motion (speed is increasing)



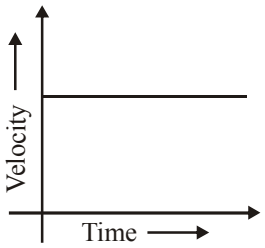
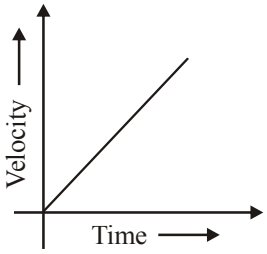
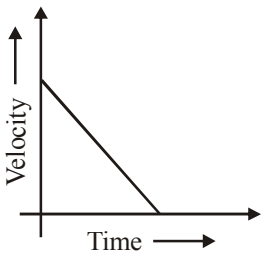
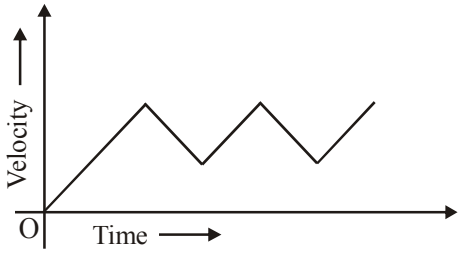

4. Non-uniform motion (speed is decreasing)




5. Slope or gradient of distance-time graph = speed of body.

6. Area under speed-time graph = distance travelled by a body.

▶ **Velocity–time graph :**

| **S.No.** | **State of object / body** | **Slope of Velocity-time graph** |
|---|---|---|
| 1. | Object is moving with constant velocity |  |
| 2. | Object has uniform motion (Velocity is increasing at a constant rate) |  |
| 3. | Object has uniform motion (Velocity is decreasing at a constant rate) |  |
| 4. | Object is moving with non-uniform velocity |  |

- The slope of velocity–time graph = Acceleration of the body.
- Area under velocity–time graph = magnitude of the displacement of a body.
- **Equations of motion :**
  (i) Velocity of a uniform accelerated body after time t is given by
  $$v = u + at$$
  (ii) Distance travelled by a uniformly accelerated body after time t is given by
  $$S = ut + \frac{1}{2} at^2$$
  (iii) $v^2 - u^2 = 2aS$
- **Uniform circular motion :** The circular motion of a body having constant speed is known as uniform circular motion.
- Uniform circular motion is accelerated motion.

# *NCERT ACTIVITIES* (Real Life application)

## ACTIVITY 1

Discuss whether the walls of your classroom are at rest or in motion.
**Explanation :** The walls of our classroom are at rest with respect to other houses on the Earth. But these walls share the earth's motion as it moves in space. Thus, when the classroom is seen outside the Earth, the walls are in motion.

## ACTIVITY 2

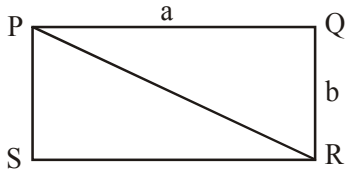
Have your ever experienced that the train in which you are sitting appears to move while it is at rest? Discuss and share you experience.
**Explanation :** Yes. When we are sitting in a train which is at rest, and the train on the adjoining track moves, we feel as if our train is also moving in the opposite direction. This is because the state of rest and of motion are relative.

## ACTIVITY 3

Take a metre scale and a long rope.

- Walk from one corner of a basket-ball court to its opposite corner along its sides.
- Measure the distance covered by you and magnitude of the displacement.
- What difference would you notice between the two in this case?

**Explanation :** When we walk from one corner P of a basket ball court to its opposite corner R along its sides, distance covered = PQ + QR = a + b and displacement is given by the expression PR = $\sqrt{a^2 + b^2}$ .




We find that both displacement and distance are not same. The displacement is less than the distance.

## ACTIVITY 4

Automobiles are fitted with a device that shows the distance travelled. Such a device is known as an odometer. A car is driven from Bhuvaneshwar to New Delhi. The difference between the final reading and the initial reading of the odometer is 1850 km. Find the magnitude of the displacement between Bhuvaneshwar and New Delhi by using the Road Map of India.

**Explanation :** The odometer measures the actual travelled by the car in going from Bhuvaneshwar to New Delhi. It is 1850 km.

From the road map of India, locate Bhuvaneshwar and New Delhi. Measure the length of the line joining these two cities. Multiply this length with the chosen scale of distance on the road map. This would give us the displacement, i.e., shortest distance between the two stations. Obviously, it will be less than 1850 km. Thus, actual path length is greater than the displacement.

## ACTIVITY 5

The data regarding the motion of two different objects A and B are given in Table. Examine them carefully and state whether the motion of the objects is uniform or non-uniform.

| Time | Distance travelled by object A in m | Distance travelled by object B in m |
|---|---|---|
| 09.30 am | 10 | 12 |
| 09.45 am | 20 | 19 |
| 10.00 am | 30 | 2 |
| 10.15 am | 40 | 35 |
| 10.30 am | 50 | 37 |
| 10.45 am | 60 | 41 |
| 11.00 am | 70 | 44 |

**Explanation :** From the table, we find that in equal intervals of time (= 15 minutes), object A travels equal distances, and object B travels unequal distances. Therefore, motion of object A is uniform and motion of object B is non-uniform.

## ACTIVITY 6

Measure the time taken by you to walk from your house to your bus stop or the school. If you consider that your average walking speed is 4 km $h^{-1}$, estimate the distance of the bus stop or school from your house.

**Explanation :** Suppose, we take 20 minutes to walk from our house to our bus stop or the school. Taking average walking speed be 4 km $h^{-1}$, distance of bus stop or school from our house is

Distance = average speed × time = 4 × 20/60 = 1.33 km.

## ACTIVITY 7

At a time when it is cloudy, there may be frequent thunder and lightning. The sound of thunder takes some time to reach you after you see the lightning. Can you answer why this happens? Measure this time interval using a digital wrist watch or a stop watch. Calculate the distance of the nearest point of lightning. (Speed of sound in air = 346 $ms^{-1}$).

**Explanation :** Lightning travels with the speed of light ($3 \times 10^8$ $ms^{-1}$) and thunder travels with the speed of sound in air = 346 $ms^{-1}$ ). That is why sound of thunder reaches us sometime later than we see the lightning. Using a digital watch or a stop watch, we measure this time interval. Let it be 2 second.
As distance = speed × time, distance = 346 × 2 = 692 m.
Note that in calculating the distance of the nearest point of lightning, we have taken the speed of sound and multiplied it by the measured time interval. This is because speed of light is almost infinite and takes almost no time to reach us. The measured time interval is time taken by sound of thunder to reach us. Thus, Light travels much faster than sound.

## ACTIVITY 8

In your everyday life, you come across a range of motions in which
(a) acceleration is in the direction of motion.
(b) acceleration is against the direction of motion.
(c) acceleration is uniform.
(d) acceleration is non-uniform.
Can you identify one example each of the above type of motion?

**Explanation :**
(a) When speed of a car on a road increases, the acceleration of the car is in the direction of motion.
(b) When we apply brakes, the speed of the car decreases. Thus acceleration produced in the car is against the direction of motion.
(c) When a body is falling freely under the action of gravity, it has a uniform acceleration of 9.8 $ms^{-2}$, i.e. speed of the falling body is increasing at a constant rate.
(d) When a car is passing through the city limits on a highway, its acceleration/retardation is non-uniform depending on traffic.

## ACTIVITY 9

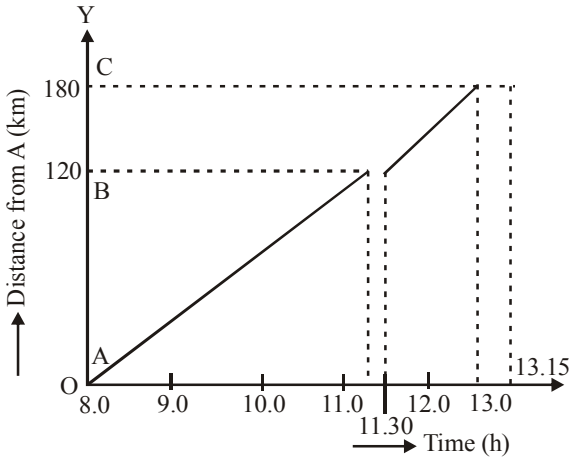
The times of arrival and departure of a train at three stations A, B and C and the distance of stations B & C and from A are given in table.

**Table : Distances of stations B and C from A and times of arrival and departure of the train.**

| Station | Distance from A (km) | Time of arrival (hours) | Time of departure (hours) |
|---|---|---|---|
| A | 0 | 08:00 | 08:15 |
| B | 120 | 11:15 | 11:30 |
| C | 180 | 13:00 | 13:15 |

Plot and interpret the distance-time graph for the train assuming that its motion between any two stations is uniform.

**Explanation :** The distance-time graph for the train is shown in figure. From 8.00 to 8.15, the train is standing on station (Let us say the origin O). From 8.15 to 11.15 the train moves with uniform speed and reaches station B at distance of 120 km from A. From 11.15 to 11.30, train is at rest at the station B. From 11.30 to 13.00, the train moves uniformly from station B to station C covering a distance of (180-120) km = 60 km. From 13.00 to 13.15 it is stationary at C.
The distance-time graph of the motion of the train is therefore as shown below.




The distance of 120 km from A to B is covered by the train in 3 hours with a uniform speed $v_1$, therefore, Uniform speed of the train is $v_1 = \frac{120}{3} = 40\ kmh^{-1}$.

A distance of 60 km from B to C is covered in 1 h 30 min with uniform speed $v_2$, therefore,

Uniform speed of the train $v_2 = \frac{60}{1.5} = 40\ kmh^{-1}$. As $v_1 = v_2$, therefore, slope of distance-time graph of the two portions is the same. Thus the motion of the train is uniform motion.

## ACTIVITY 10

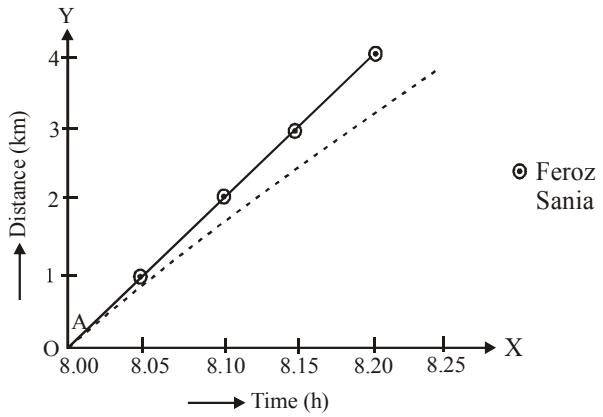
Feroz and his sister Sania go to school on their bicycles. Both of them start at the same time from their home, but take different times to reach the school although they follow the same route. Table shows the distance travelled by them in different times.

**Table : Distance covered by Feroz and Sania at different times on their bicycle.**

| Time | Distance travelled by Feroz | Distance travelled by Sania |
|---|---|---|
| 08:00:00 AM | 0 | 0 |
| 08:05:00 AM | 1.0 | 0.8 |
| 08:10:00 AM | 1.9 | 1.6 |
| 08:15:00 AM | 2.8 | 2.3 |
| 08:20:00 AM | 3.6 | 3.0 |
| 08:25:00 AM | – | 3.6 |

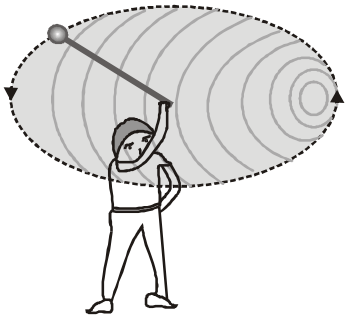
Plot the distance-time graph for their motions on the same scale and interpret.

**Explanation :** In the distance-time graph shown below, we have taken time along X-axis and distance along Y axis, choosing suitable scales. The distance-time graph of Feroz is shown by a bold line and distance-time graph of Sania is shown by a dashed line.




## ACTIVITY 11

Take a piece of thread and tie a small piece of stone at one of its ends. Move the stone to describe a circular path with constant speed by holding the thread at the other end, as shown in figure.



Now, let the stone go by releasing the thread.

Can you tell the direction in which the stone moves after it is released?

By repeating the activity for a few times and releasing the stone, at different positions of the circular path, check whether the direction in which the stone moves remains the same or not.

**Explanation :** When the stone is released, it will move along a tangent to the circular path at that particular moment. By releasing the stone at different positions of the circular path, we will find that direction in which the stone moves is always different, but it is always along the tangent to the circular path at that instant.

In fact, the stone is moving along a circular path due to centripetal force being provided by pull of our hand on the stone. When the stone is let off, centripetal force ceases to act. Due to inertia of direction, the stone moves along the straight line path, i.e., along the tangent to the circular path at that instant.

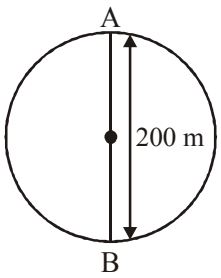
# CONCEPT APPLICATION LEVEL - I [NCERT Questions]

**Q.1 An athlete completes one round of a circular track of diameter 200 m in 40 s. What will be the distance covered and the displacement at the end of 2 minutes 20 s?**

**Sol.** Given : Diameter of circular track, 2r = 200m

$$\text{Circumference of circular track} = 2\pi r = 2 \times \frac{22}{7} \times 100 = \frac{4400}{7} \text{ m.}$$

Time for completing one round = 40s.
Time for which athlete ran = 2 min and 20 s = 140 s
Now distance covered by the athlete in 40 s




$$S = \frac{4400}{7} \text{ m}$$

(i) Distance covered by athlete in 140 s

$$S = \frac{4400}{7} \times \frac{140}{40} = 2200 \text{ m.}$$

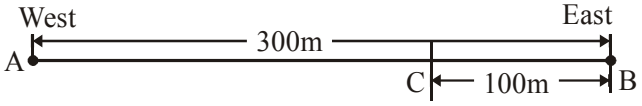
(ii) As the athlete returns to the initial point in 40s, this displacement = 0
Now
Number of rounds in 40 seconds = 1

$$\text{Hence number of rounds in 140 s is} = \frac{140}{40} = 3.5$$

For each complete round the displacement is zero. Therefore for 3 complete rounds, the displacement will be zero.
The final displacement will be due to half the round. In half round distance covered = half of circumference.
Thus, his displacement = diameter of circular track = 200 m
Displacement after 140 s = 200 m.

**Q.2 Joseph jogs from one end A to the other end B of a straight 300 m road in 2 minutes 30 seconds and then turns around and jogs 100 m back to point C in another 1 minute. What are Joseph's average speeds and velocities in Jogging.**

**Sol.** The required figure is as shown :




Distance covered = 300 + 100 = 400 m and
Time taken = 150 + 60 = 210 s.
Therefore average speed from A to C is

$$v_{av} = \frac{\text{distance covered}}{\text{time}} = \frac{400}{210} = 1.90 \text{ ms}^{-1}$$

Now displacement from A to C 200 m.
There average velocity from A to C is

$$v_{av} = \frac{\text{displacement}}{\text{time}} = \frac{200}{210} = 0.952 \text{ ms}^{-1}$$

**Q.3 Abdul while driving to school computes the average speed for his trip to be 20 $kmh^{-1}$. On his return trip along the same route, there is less traffic and the average speed is 30 $kmh^{-1}$. What is the average speed for Abdul's trip ?**

**Sol.** Let one way distance for his trip be S. Let $t_1$ be the time for his trip from home to school and $t_2$ be the time for his return trip.

Then $t_1 = \frac{S}{v_1} = \frac{S}{20}$ h and $t_2 = \frac{S}{v_2} = \frac{S}{30}$ h.

Therefore total time of trip is

$$T = t_1 + t_2 = \frac{S}{20} + \frac{S}{30} = \frac{S}{12} \text{ h}$$

Total distance covered = 2S

Therefore average speed of Abdul

$$v_{av} = \frac{\text{total distance}}{\text{total time}} = \frac{2S \times 12}{S} = 24 \text{ kmh}^{-1}$$

**Q.4 A motorboat starting from rest on a lake accelerates in a straight line at a constant rate of 3.0 $ms^{-2}$ for 8.0s. How far does the boat travel during this time ?**

**Sol.** **Given :** Initial velocity of boat, u = 0,

Acceleration , a = 3.0 $ms^{-2}$

Time, t = 8s

Distance covered, S = ?

Using the relation $S = ut + \frac{1}{2} at^2$ we have

$$S = 0 \times 8 + \frac{1}{2} \times 3 \times (8)^2 = 96 \text{ m}$$

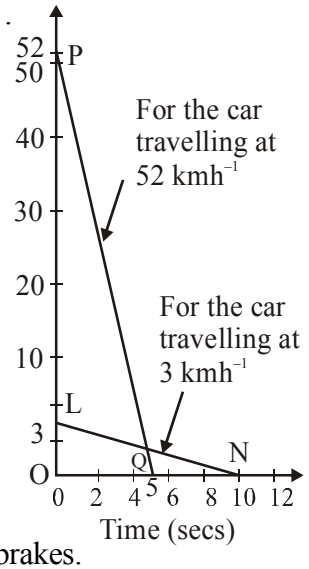
**Q.5 A driver of a car travelling at 52 km $h^{-1}$ applies the brakes and accelerates uniformly in the opposite direction. The car stops in 5s. Another driver going at 3 $kmh^{-1}$ in another car applies his brakes slowly and stops in 10s. On the same graph paper plot the speed versus time graphs for the two cars. Which of the two cars travelled farther after the brakes were applied?**

**Sol.** Since the speed of both the cars is decreasing with time, therefore both have a retarded motion.

Now initial velocity of the first car is $u = 52 \text{ km h}^{-1} = 52 \times \frac{5}{18} = 14.4 \text{ ms}^{-1}$ .

Initial velocity of the first car is $u = 3 \text{ kmh}^{-1} = 3 \times \frac{5}{18} = 0.83 \text{ ms}^{-1}$

The speed time graphs of both the cars are shown below.




(i) Distance covered by car moving at 14.4 $ms^{-1}$.

$$= \text{area of PQO} = \frac{1}{2} \times OQ \times PO$$

$$= \frac{1}{2} \times 14.4 \times 5 = 36 \text{ m}$$

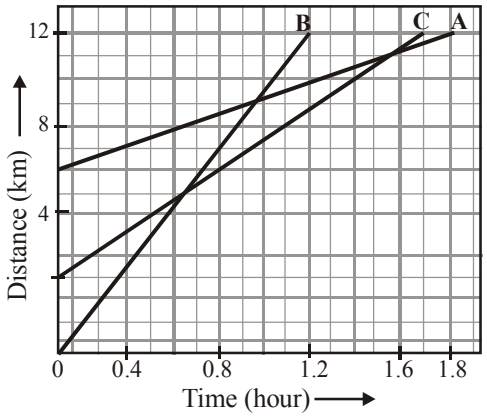
(ii) Distance covered by car moving at 0.83 $ms^{-1}$.

$$= \text{area of OLN}$$

$$= \frac{1}{2} \times LO \times ON = \frac{1}{2} \times 0.83 \times 10 = 4.15 \text{ m.}$$

The car moving at 52 km $h^{-1}$ travels more distance on the application of brakes.

**Q.6 Figure below shown the distance-time graph of three objects A, B and C. Study the graph and answer the following questions.**




**(a) Which of the three is travelling the fastest?**
**(b) Are all three ever at the same point on the road?**
**(c) How far has C travelled when B passes A?**
**(d) How far has B travelled by the time it passes C ?**

**Sol.** (a) Speed of car A $v_A = \frac{S_{final} - S_{initial}}{time} = \frac{12-6}{1.8} = 3.34 \text{ km h}^{-1}$

Speed of car B $v_B = \frac{S_{final} - S_{initial}}{time} = \frac{12-0}{1.4} = 8.57 \text{ km h}^{-1}$

Speed of car C $v_C = \frac{S_{final} - S_{initial}}{time} = \frac{12-2}{1.76} = 5.68 \text{ km h}^{-1}$

Car B is travelling the fastest.

(b) No, they are never at the point because all the graphs of A, B and C do not intersect at one point.

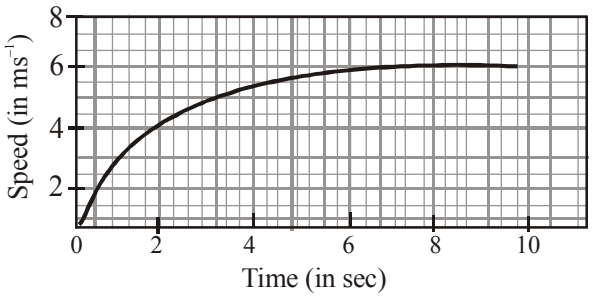
(c) When car B passes car A at point P, the distance covered by car C is 7 km.

(d) Car B and C pass each other at point 0. The distance travelled by B at that point is slightly more than 5 km.

**Q.7 A ball is gently dropped from a height of 20 m. If its velocity increases uniformly at the rate of 10 $ms^{-2}$, with what velocity will it strike the ground ? After what time will it strike the ground?**

**Sol.** **Given :** Initial velocity of ball, u = 0 Final velocity of ball, v = ?
Distance through which the ball falls, S = 20 m
Acceleration, a = 10 $ms^{-2}$
Time of fall, t = ?
We know $v^2 - u^2 = 2aS$
or $v^2 - 0 = 2 \times 10 \times 20 = 400$
or $v = 20 \text{ ms}^{-1}$
Now using v = u + at we have
$20 = 0 + 10 \times t$ or
$t = 2s$

**Q.8 The speed-time graph for a car is shown below in figure.**



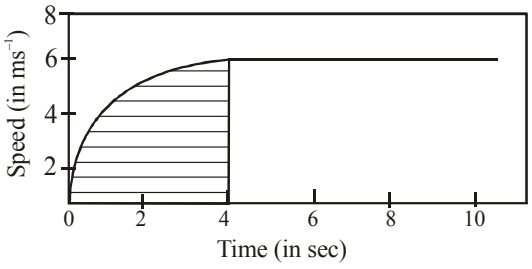

**(a) Find how far does the car travel in the first 4 seconds. Shade the area on the graph that represents the distance travelled by the car during the period.**

**(b) Which part of the graph represents uniform motion of the car?**

**Sol.** (a) The car travels with a non-accelerated nature.

The distance travelled by the car in the first four second is given by the area enclosed by the speed-time graph and X-axis from t = 0 to t = 4s.

To calculate the distance, in such cases, we actually count the number of squares in the shaded portion of the graph. This gives the distance travelled by the car in first four seconds as 17.80 m.




(b) The straight line portion of the graph represents uniform motion of the car.

**Q.9 State which of the following situations are possible and give an example for each of these**

**(a) An object with a constant acceleration but with zero velocity.**

**(b) An object moving in a certain direction with acceleration in the perpendicular direction.**

**Sol.** (a) A body with a constant acceleration but with zero velocity is possible. For example, when a body is released, its initial velocity u = 0, but acceleration g = 10 ms$^{-2}$.

(b) When a stone, tied to a string, is whirled in a circular path, the acceleration acting on it is always at right angles to the direction of motion of stone.

**Q.10 An artificial satellite is moving in a circular orbit of radius 42250 km. Calculate its speed if it takes 24 hours to revolve around the earth.**

**Sol.** Distance covered by the satellite in 24 hours.

$$S = 2\pi r = 2 \times \frac{22}{7} \times 42250 = 265571.43 \text{ km}$$

Therefore speed of the satellite is

$$v = \frac{\text{distance travelled}}{\text{time}} = \frac{265571.43}{24 \times 60 \times 60} = 3.07 \text{ km s}^{-1}$$

# CONCEPT APPLICATION LEVEL - II

## SECTION-A (REASONING ABILITY)

**Q.1 An object has moved through a distance. Can it have zero displacement? If yes, support your answer with an example.**

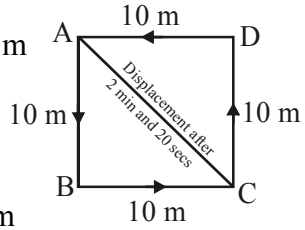
**Ans.** Yes, an object which has moved through a distance can have zero displacement.
**Example :** When a person, walking along a circular path, returns back to the starting point, after completing a circle, his displacement is zero. But he covers a distance $2\pi r$ where 'r' is the radius of circular path. The displacement is zero, as the shortest distance between the initial and final position of the person is zero.

**Q.2 A farmer moves along the boundary of a square field of side 10 m in 40 s. What will be the magnitude of displacement of the farmer at the end of 2 minutes 20 seconds ?**

**Ans.** The perimeter of square field ABCD = $4 \times 10\text{m} = 40\text{m}$.
Time for moving around the 10 m square field once = 40s.
Time for journey of farmer = 2 min and 20 s = 14 s.

Number of times the farmer moves around the square field = $\frac{140}{40} = 3.5$ times.

For going once around the square field, the displacement = 0
For going thrice around the square field, the displacement = 0
For going ½ times the square field, the distance covered = 40 m × ½ = 20 m
It is obvious from the figure that if the farmer starts pt A, then he will cover 10 m along AB and then 10 m along BC.
Therefore displacement of farmer from the pt A to point C.




$$AC = \sqrt{(AB)^2 + (BC)^2} = \sqrt{(10)^2 + (10)^2} = 14.14\text{m}$$

**Q.3 Which of the following is true for displacement? (a) It cannot be zero. (b) Its magnitude is greater than the distance travelled by the object.**

**Ans.** None of the statement (a) or (b) is true for displacement.

**Q.4 Distinguish between speed and velocity.**

**Ans.** (i) Speed is the rate of change of distance but velocity is the rate of change of distance in a specified direction.
(ii) Speed is a scalar quantity, but velocity is a vector quantity.

**Q.5 Under what condition (s) is the magnitude of average velocity of an object equal to average speed?**

**Ans.** The magnitude of average velocity of an object is equal to its average speed when the velocity of an object changes at uniform rate. .i.e., the body is in uniform motion. If a body is moving with uniform acceleration.
Initial velocity = u, Final velocity = v

Therefore average speed is $\frac{u+v}{2}$.

**Q.6 What does the odometer of an automobile measure ?**

**Ans.** The odometer measures the distance travelled by an automobile.

**Q.7 What does the path of an object look like when it is in uniform motion ?**

**Ans.** The path of an object will be a straight line.

**Q.8 During an experiment, a signal from a spaceship reached the ground station in five minutes. What was the distance of the spaceship from the ground station? The signal travels at the speed of light, that is $3 \times 10^8$ ms$^{-1}$.**

**Ans.** Speed of signal = $3 \times 10^8$ ms$^{-1}$

Time in which signal reaches ground = 5 min = $5 \times 60 = 300$ s.

Distance of spaceship from the ground level = speed × time = $3 \times 10^8 \times 300 = 9 \times 10^{10}$ m.

**Q.9 When will you say a body is in (i) uniform acceleration (ii) non-uniform acceleration ?**

**Ans.** (i) A body is in uniform acceleration when equal changes in velocity takes place in equal intervals of time, however small these intervals may be.

(ii) A body is said to be possessing non-uniform acceleration when unequal changes in velocity take place in equal intervals of time, however small these intervals may be.

**Q.10 A bus decreases its speed from 80 kmh$^{-1}$ to 60 kmh$^{-1}$ in 5 s. Find the acceleration of the bus.**

**Ans.** Given t = 5 s, Initial speed of bus u = 80 km h$^{-1}$ = $80 \times \frac{5}{18} = 22.2$ ms$^{-1}$.

Final speed of the bus v = 60 km h$^{-1}$ = $60 \times \frac{5}{18} = 16.7$ ms$^{-1}$.

Now acceleration is given by the relation.

$$a = \frac{u - v}{t} = \frac{16.7 - 22.2}{5} = -1.11 \text{ ms}^{-2}$$

**Q.11 A train starting from a railway station and moving with uniform acceleration attains a speed 40 kmh$^{-1}$ in 10 minutes. Find its acceleration.**

**Ans.** Given t = 10 min = $10 \times 60 = 600$ s.

Final speed of train v = 40 kmh$^{-1}$ = $40 \times \frac{5}{18} = 11.1$ ms$^{-1}$

Now, acceleration is given by the relation

$$a = \frac{v - u}{t} = \frac{11.1 - 0}{600} = 0.0185 \text{ ms}^{-2}$$

**Q.12 What is the nature of the distance-time graphs for uniform and non-uniform motion of an object?**

**Ans.** The distance-time graph for uniform motion is a straight line not parallel to the time axis. The distance-time graph for non-uniform motion is not a straight line. It can be a curve or a zigzag line not parallel to time axis.

**Q.13 What can you say about the motion of an object whose distance-time graph is a straight line parallel to the time axis ?**

**Ans.** The object is stationary.

**Q.14 What can you say about the motion of an object if its speed-time graph is a straight line parallel to the time axis**.

**Ans.** The object has uniform motion.

**Q.15 What is the quantity which is measured by the area occupied below the velocity-time graph?**

**Ans.** Displacement is the quantity which is measured by the area under velocity-time graph.

## SECTION-B (NUMERICAL & GRAPHICAL QUESTIONS)

**Numerical analysis:**

**Q.1** Let an electron moves in circular path around the nucleus. If the radius of the path is r metre find the displacement and distance travelled by the electron in following situation :

(i) For one full revolution

(ii) For half revolution

(iii) For hundred revolutions

**Sol.**

(i) In full revolution the initial and final positions are same hence the displacement of electron will be zero. While the distance travelled by the electron in one revolution equals to the circumference of the circular path i.e. = $2\pi r$ metre

(ii) In half revolution the initial and final positions are opposite to each other, hence the displacement of the electron is equal to the diameter of the circular path i.e. 2r metre while the distance travelled by the electron will be equal to $\pi r$ metre

(iii) For 100 revolutions the initial and final positions of the electron will remain same one hence its displacement will be zero. While the distance travelled by the electrons in 100 full revolutions will be equal to $100 \times 2\pi r$.

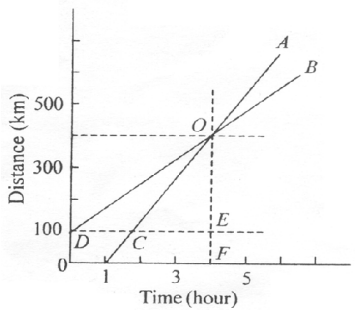
**Q.2** In figure time-distance graph for two cars is given. Then find out that

(i) Initially which car is ahead and how much?

(ii) Which car starts moving after and after how much time?

(iii) What is the speed of two cars?

(iv) After how much time and at what distance the car moving faster will catch the second car.




**Sol.**

(i) Initially at t = 0 the car B was at a distance 100 km and the car At t = 1 hour was at zero km. Hence the car B is 100 km ahead of car A.

(ii) The car A starts at t = 1 hour and car B at t = 0

(iii) (a) The speed of car A = Slope of time graph

= Slope of line COA = OF/CF

= (400–0)/(4–1) km/hr = 133.33 km/hour

(b) Similarly the speed of car B = Slope of line DOB = OE/DE

= (400–100)/(4–0) km/hour = 75 km/hour

(iv) The intersection of two lines will be the point of meeting of two cars. So the two cars will meat at a distance of 400 km. From the initial point and after 4 hours.

**Q.3** A student travels with a speed of 4 km/hour from his house to his school situated at a distance of 2 km. But seeing that school is closed, return home quickly with a speed of 6 km/hour then find out

(i) Average speed of the student

(ii) Average velocity of the student and

(iii) Average speed of the student for first 30 minute and first 50 minute

**Sol.**

(i) The time taken by the student to reach the school = distance/speed

= 2 km/4 (km/hour)

Time taken in returning to home = 2 km/ (6 km/hour) = 1/3 h = 20 minute

So, the total time taken by student in whole of the journey

= 30 + 20 = 50 minute = 5/6 h

And the total distance travelled in that journey

Hence the average speed of the student = 4/(5/6) = (4×6)/5 = 4.8 km/h

(ii) After starting from home as student returns back to the home. Since the resultant displacement is zero then velocity is also zero.

(iii) In first 30 minutes (students reaches school) the distance travelled is 2km and time taken is 1/2 hour. So the average speed of the student is

= 2 km/30 minute = 4 km/h

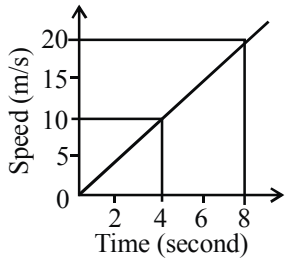
In first 50 minutes students reaches school in first 30 minute and covers a distance of 2 km then in next 20 minute students returns home from the school speed with 6 km/h.

Hence the distance travelled by the student in 20 minutes when he returns to home = 6 × (1/3) = 2 km

So, the total distance travelled by the student in first 50 minutes (2 + 2) = 4 km

Hence, the average speed = 4 km/50 minute = 4/5/6 = 4.8 km/hour

**Q.4** In given figure change in instantaneous speed of a particle with time is shown then find the acceleration and distance covered by the particle in first 8 seconds.




**Sol.** From figure the distance travelled by the particle = Area of speed – time graph with time axis

= 1/2 ×(8–0) × (20–0) = 80 metre

Similarly,

Acceleration = Slope of the line = (20–0)/(8–0) = 2.5 metre/sec$^2$

**Q.5** Truck 'A' is going on a road with velocity 10 m/s. The second truck 'B' is coming from its back and an another truck 'C' is coming from as front. The velocity of truck B and C is 15 m/s for each. When the distance AB and AC is 500 metre each. The driver of truck B thinks to cross the truck A before truck 'C'. In this position how much minimum acceleration required for truck B.

**Sol.** The relative velocity of truck 'C' with respect to truck 'A'

= Velocity of truck 'C' – Velocity of truck 'A' = 15 – (–10) = 25 m/s

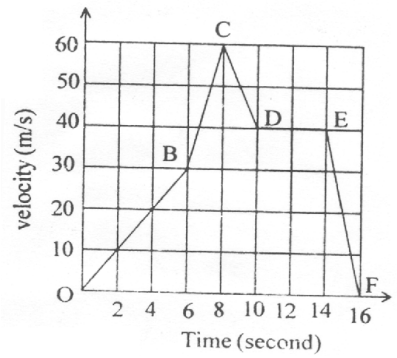
and the distance of truck 'C' from truck 'A' = 500 metre

So the time taken by truck 'C' to cross truck 'A' = 500/25 = 20 sec
Hence the time taken by truck 'B' to reach up to 'A' should be less than 20 sec.
Again the velocity of truck 'B' with respect to truck 'A'
= Velocity of truck 'B' – Velocity of truck 'A' = 15 –10 = 5m/s
If the minimum acceleration 'a' is required for truck 'B' to cover a distance of 500 metre with a relative velocity 5 m/s in 20 seconds then by the second equation of motion.

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

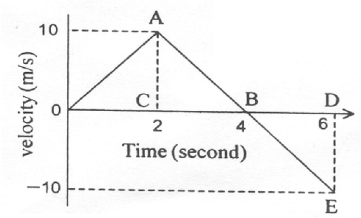
$500 = 5 \times 20 + 1/2 \times a \times 20 \times 20$ or $a = (500–100)/200 = 2$ m/s

**Q.6** In figure the velocity–time graph for a particle is shown. Then find out the following
(i) The average acceleration of the particle in between 6 to 8 seconds.
(ii) At what time interval the average acceleration of the particle becomes zero?
(iii) What will be the maximum acceleration?
(iv) What is the displacement of the particle in first 6 seconds?




**Sol.**
(i) Average acceleration of the particle in between 6 to 8 seconds = Slope of line BC
= (60–30)/(8–6) = 30/2 or a = 15 metre/sec$^2$
(ii) For zero average acceleration the velocity-time graph should be parallel to time axis. In figure portion DE is parallel to the time axis. Hence for this portion the average acceleration will become zero. Where the time interval is in between 10 to 14 second.
(iii) Retardation is a negative acceleration so the portion for which the velocity-time graph makes the smallest angle with the velocity axis, the retardation is the maximum. In figure the line EF has the maximum acceleration.
(iv) displacement of the particle in first 6 seconds will be area under the velocity time graph for first 6 seconds. So, displacement = Area OBCO = ½ × 6 × 30 = 90 m

**Q.7** The velocity-time graph for a particle is according to figure. So, find the total displacement of the particle.
**Sol.** According to the figure the velocity of the particle for first 4 second will be in positive direction and from 4 to 6 seconds as the velocity of particle in opposite direction so the displacement of particle will be negative. So the total displacement.



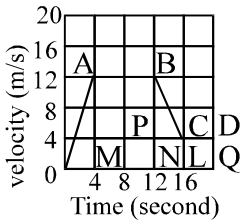
$\Delta x$ = Area of $\Delta OAB$ – Areas of $\Delta BED$

$= \frac{1}{2} \times 4 \times 10 - \frac{1}{2} \times 2 \times 10 = 10$ metre

So the displacement of the particle is 10 metre and will be in positive direction.

**Q.8** A runner races in straight line and his velocity time graph is shown in figure. Find the distance covered by the runner in 20 second and also the maximum instantaneous acceleration of the runner.

**Sol.**




Distance covered by the runner in 20 second = Area of graph in between velocity and time

= $\Delta OAM$ + rectangle MABN + $\Delta BPC$ + rectangle PDQN

$= \frac{1}{2} \times (4 \times 12) + (12 \times 8) + \frac{1}{2} \times (8 \times 4) + 4 \times 8 = 24 + 96 + 16 + 32 = 168$ m

and the maximum acceleration = (12–0)/(4–0) = 3 metre/sec$^2$

**Q.9** If minute hand of a clock is 5 cm long. Find its angular velocity and linear velocity.

**Sol.** Since, minute hand of clock rotates and completes one rotation in 60 minutes.

Therefore, angled described in 60 minutes = $2\pi$ radian

Hence angular velocity of minute hand,

$$\omega = \frac{2\pi \text{ radian}}{60 \text{ minutes}} = \frac{2 \times 22 \text{ radian}}{7 \times 60 \times 60 \text{ sec}}$$

$$= \frac{11}{7 \times 900} = \frac{110}{63} \times 10^{-3} = 1.74 \times 10^{-3} \, rad / s$$

Now, length of minute hand, l = r = 5 cm

Therefore, Linear velocity of minute hand, $v = r\omega$

$= 5 \times 1.74 \times 10^{-3}$ cm/s

$= 8.70 \times 10^{-3}$ cm/s

**Q.10** An aircraft completes a horizontal loop of radius 1 km with a uniform speed of 900 km/h. Find the angular velocity of the aircraft.

**Sol.** Given, radius of orbital of aircraft

r = 1 km

and uniform linear speed V = 900 km/h

Now, linear speed, V = radius (r) × angular velocity ($\omega$)

Angular velocity, $\omega = \frac{v}{r} = \frac{900 \ km / h}{1 \ km}$

= 900 rad/h

$= \frac{900}{60 \times 60} rad / s$ = 1/4 rad/s = 0.25 rad/s

**Q.11** A body covers a distance of 20m in the 7th second and 24m in the 9th second. How much distance shall it cover in 15th sec.

**Sol.** $S_7th = u + \frac{a}{2}(2\times 7 - 1)$ but $S_7th = 20m$

$\therefore 20 = u + \frac{a}{2}\times 13 \Rightarrow 20 = u + \frac{13}{2}$ .....(i)

also $s_9$ th = 24

$\therefore 24 = u + \frac{17a}{2}$ .....(ii)

from (i) equation u = $u = 20 - \frac{13a}{2}$ .....(iii)

Substitute this value in (ii)

$24 = 20 - \frac{13a}{2} + \frac{17a}{2}$

$24 - 20 = \frac{17a}{2} + \frac{13a}{2}$

$4 = \frac{4a}{2} \Rightarrow 4 = 2a \Rightarrow a = \frac{4}{2} = 2m/s^2$

Use this value of (iii) $u = 20 - \frac{13a}{2}$

$\therefore\ u = 20 - \frac{13\times 2}{2} \Rightarrow u = 20 - 13$ $\therefore$ u = 7 m/s

Now, $S_{15}$th = $u + \frac{a}{2}(2\times 15 - 1) = 7 + \frac{2}{2}(29) = 7 + 29 = 36m$

**Q.12** The driver of a train travelling at 40 $ms^{-1}$ applies the brakes as a train enters a station. The train slow down at a rate of 2 $ms^{-2}$. The platform is 400 m long. Will the train stop in time?

**Sol.** Given u = 40 $ms^{-1}$ v = 0, a = –2 $ms^{-2}$, S = ?

Using equation, we have

$0 = (40)^2 + 2(-2)\,S$ or $4S = 1600$ or S = 400 m.

Thus the train stops in 400 m. Since the platform is 400 m long, therefore, the train just stops in time.

**Q.13** A girl running a race accelerates at 2.5 $ms^{-2}$ for the first 4 s of the race. How far does she travel in time?

**Sol.** Given u = 0, a = 2.5 $ms^{-2}$ , t = 4 s and S = ?

Substituting the values in equation S = ut + $\frac{1}{2}$ $at^2$, we have $S = 0\times 4 + \frac{1}{2}\times 2.5\times 4^2 = 20$ m.

**Q.14** Two trains A and B of length 400 m each are moving on two parallel tracks with uniform speed of 72 $kmh^{-1}$ in the same direction with A ahead of B. The driver of B decides to overtake A and accelerates by 1 $ms^{-2}$. If after 50 s, the guard of B just passes the driver of A, what was the original distance between them ?

**Sol.** Initial speed of each train, $u = 72\ kmh^{-1} = 20\ ms^{-1}$
Distance travelled by train A in 50 s $= 20 \times 50 = 1000$ m
Distance travelled by train B in 50 s with an acceleration of 1 $ms^{-2}$ is

$$20 \times 50 + \frac{1}{2}(1) \times (50)^2 = 2250 \text{ m} \qquad (\text{using } S = ut + \frac{1}{2}at^2)$$

Therefore, the original distance between the trains is 2250 m – 1000 m = 1250 m.

**Q.15** The velocity of a car is 18 $ms^{-1}$. Express this velocity in $kmh^{-1}$.

**Sol.** $\text{Velocity} = 18 \times \frac{18}{5} \text{km/h} = 64.8\ kmh^{-1}$

**Q.16** An electric engine has a velocity of 120 $kmh^{-1}$. How much distance will it travel in 30 s?

**Sol.** $\text{Velocity} = \frac{\text{distance}}{\text{time}}$ or distance = velocity × time.

Therefore, $S = \frac{120 \times 1000}{3600} \times 30 = 1000$ m.

**Q.17** A car travels a certain distance with a speed of 50 $kmh^{-1}$ and returns with a speed of 40 $kmh^{-1}$. Calculate the average speed for the entire journey ?

**Sol.** Given $v_1 = 50\ kmh^{-1}$ and $v_2 = 40\ kmh^{-1}$
Let S be the distance. Therefore, total distance travelled by the body = S + S = 2S

Now, time taken for the first motion $t_1 = \frac{S}{v_1} = \frac{S}{50}$

Time taken for the second motion $t_2 = \frac{S}{v_2} = \frac{S}{40}$

Total time taken $t = t_1 + t_2 = \frac{S}{50} + \frac{S}{40}$

Hence, average speed $v_{av} = \frac{\text{total distance travlled}}{\text{total time taken}} = \frac{2S}{t} = \frac{2S}{\frac{S}{40} + \frac{S}{50}} = 44.5\ kmh^{-1}$.

**Q.18** The distance between two stations is 200 km. A train travels for the first 100 km at a speed of 50 $kmh^{-1}$. How fast should the train travels the next 100 km so as to average 70 $kmh^{-1}$ for the whole journey?

**Sol.** Given total distance travelled = 200 km

Time taken for the first half $t_1 = \frac{S}{v_1} = \frac{100}{50} = 2$ h

Time taken for the second half $t_2 = \frac{S}{v_2} = \frac{100}{v_2}$

Now, $v_{av} = 70\ kmh^{-1}$

Therefore, $v_{av} = \frac{\text{total distance travelled}}{\text{total time taken}} = \frac{S}{t_1 + t_2} = \frac{200}{\frac{100}{50} + \frac{100}{v_2}} = 70$

Solving for $v_2$, we get $116.6\ kmh^{-1}$.

**Q.19** A train travels the first 15 km at a uniform speed of 30 $kmh^{-1}$, the next 75 km at a uniform speed of 50 $kmh^{-1}$, and the last 10 km at a uniform speed of 20 $kmh^{-1}$. Calculate the average speed for the entire train journey.

**Sol.** Given total distance travelled $= 15 + 75 + 10 = 100$ km

Time taken in the first part of motion $t_1 = \frac{S}{v_1} = \frac{15}{30}$

Time taken in the second part of motion $t_2 = \frac{S}{v_2} = \frac{75}{50}$

Time taken in the third part of motion $t_3 = \frac{S}{v_3} = \frac{10}{20}$

Total time taken $t = t_1 + t_2 + t_3$

$$t = \frac{15}{30} + \frac{75}{50} + \frac{10}{20} = 2.5 \text{ h.}$$

Therefore, $v_{av} = \frac{\text{total distance travelled}}{\text{total time taken}} = \frac{100}{2.5} = 40\ kmh^{-1}$.

**Q.20** Find the initial velocity of a car if it can be stopped in 10 sec by applying brakes which provide it a retardation of 2.5 $ms^{-2}$.

**Sol.** Given u = ?, v = 0, t = 10 s, $a = -2.5\ ms^{-2}$
Using v = u +at, we have
$0 = u - 2.5 \times 10$, Therefore, $u = 25\ ms^{-1}$.

**Q.21** A car acquires a velocity of 72 $kmh^{-1}$ in 10 second after starting from rest. Find (a) the acceleration (b) the average velocity and (c) the distance travelled in the time.

**Sol.** Given $v = 72\ kmh^{-1}$, t = 10 second, u = 0, a = ?, $v_{av}$ = ?, S = ?, also $v = 72 \times \frac{5}{18} = 20\ ms^{-1}$ .
Using v = u + at, we have
$20 = 0 + a \times 10$, Therefore, $a = 2\ ms^{-2}$
Using $v^2 - u^2 = 2aS$, we have

$$S = \frac{v^2 - u^2}{2a} = \frac{(20)^2 - 0}{2 \times 2} = \frac{400}{4} = 100 \text{ m}$$

Aslo, $v_{av} = \frac{S}{t} = \frac{100}{10} = 10\ ms^{-1}$

**Q.22 A bus starting from rest moves with a uniform acceleration of 0.1 $ms^{-2}$ for 2 minutes. Find (a) the speed acquired, (b) the distance travelled.**

**Ans.** Given: Initial speed of bus, $u = 0\ ms^{-1}$
Final speed of bus, $v = ?$
Acceleration, $a = 0.1\ ms^{-2}$
Time, $t = 2\ min = 120\ s$
Distance travelled, $S = ?$

(i) We know, $v = u + at$ **Or** $v = 0 + 0.1 \times 120 = 12\ ms^{-1}$

(ii) To find distance travelled, we use the equation

$S = ut + \frac{1}{2} at^2$ **Or** $S = 0 \times 120 + \frac{1}{2} \times 0.1 \times (120)^2 = 720\ m$

Therefore,
Final speed acquired = $12\ ms^{-1}$
Distance travelled = 720 m.

**Q.23 A train is travelling at a speed of 90 $kmh^{-1}$. Brakes are applied so as to produce a uniform acceleration of – 0.5 $ms^{-2}$. Find how far the train will go before it is brought to rest.**

**Sol.** Given Initial speed of train, $u = 90\ km\ h^{-1} = 90 \times \frac{5}{18} = 25\ ms^{-1}$
Final speed, $v = 0\ ms^{-1}$
Acceleration, $a = -0.5\ ms^{-2}$
Distance covered, $S = ?$
Using the relation $v^2 - u^2 = 2aS$, we have

$$S = \frac{v^2 - u^2}{2a} = \frac{0 - (25)^2}{2 \times (-0.5)} = 625\ m.$$

**Q.24 A trolley, while going down an inclined plane, has an acceleration of 2 $cm/s^{-2}$. What will be its velocity 3 s after the start?**

**Sol.** Given: Initial velocity, $u = 0$
Final velocity, $v = ?$
Time, $t = 3\ s$
Acceleration, $a = 2\ cms^{-2}$
We know that $v = u + at$ **Or** $v = 0 + 2 \times 3 = 6\ cms^{-1}$

**Q.25 A racing car has uniform acceleration of 4 $ms^{-2}$. What distance will it cover in 10 s after start?**

**Sol.** Given: Initial velocity, $u = 0$
Acceleration, $a = 4\ ms^{-2}$
Time, $t = 10s$
Distance covered, $S = ?$
We know ; $S = ut + \frac{1}{2} at^2$

$S = 0 \times 10 + \frac{1}{2} \times 4 \times (10)^2 = 0 + 200 = 200\ m$

Therefore, distance covered = 200m.

**Q.26 A stone is thrown in a vertically upward direction with a velocity of 5 $ms^{-1}$. If the acceleration of the stone during its motion is 10 $ms^{-2}$ in the downward direction, what will be the height attained by the stone and how much time will it take to reach there?**

**Ans.** Given : Initial velocity, $u = 5\ ms^{-1}$

Final velocity, $v = 0$

Acceleration in the downward direction $= 10\ ms^{-2}$

Therefore acceleration in the upward direction

$a = -10\ ms^{-2}$

Height attained by stone, $S = ?$

Time taken to attain height, $t = ?$

(i) Using the relation; $v = u + at$

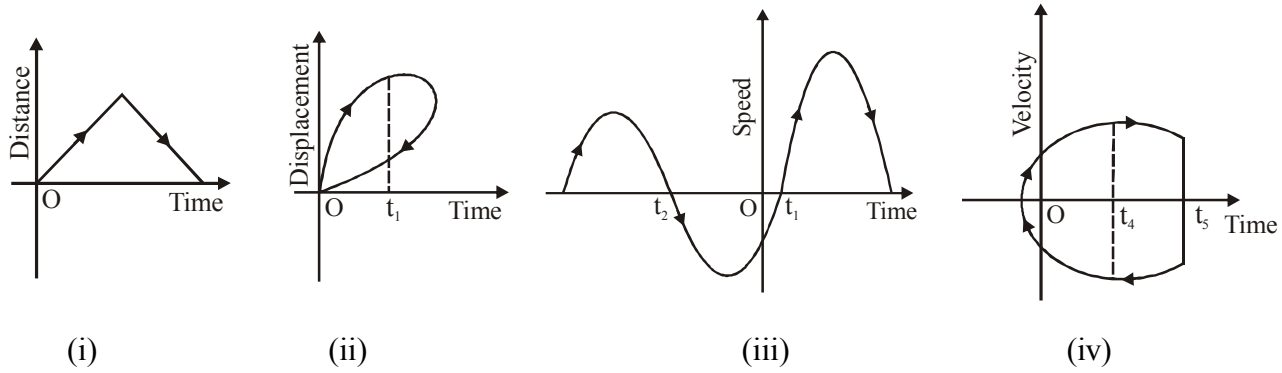
$$0 = 5 + (-10)\, t = \frac{5}{10} = 0.5\ s$$

(ii) Using the relation; $v^2 - u^2 = 2aS$, we have

$$S = \frac{v^2 - u^2}{2a} = \frac{(0)^2 - (5)^2}{2 \times (10)} = 1.25\ m.$$

## SECTION-C (GRAPHICAL ANALYSIS)

**Q.1** Explain with reason, which of the following graphs can possibly represent the motion of a particle observed in nature.




(i) (ii) (iii) (iv)

**Ans.**

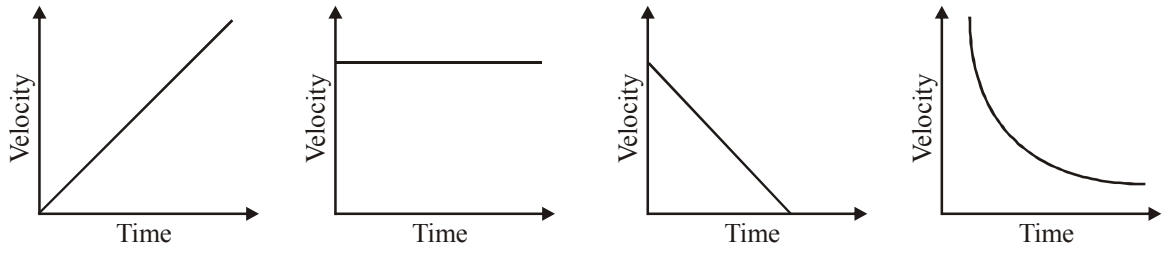
(i) This graph shows that with increase in time, distance first increases and then decreases. However, distance can never decrease with time, so this graph is not possible.

(ii) This graph shows that at a certain time $t_1$ the body is present at two positions. It also shows that first time increases and then decreases. Since both these condition cannot be realized in practice, hence this graph is not possible.

(iii) This graph shows that speed is negative for some interval of time. Since speed cannot be negative, this graph is also not possible.

(iv) This graph show that at a given instant of time the particle has two velocities. Also it shows that at sometime it has infinite acceleration (graph parallel to the velocity axis). Both these conditions cannot be achieved in practice; therefore, this graph is also not possible.

**Q.2** What type of motion is represented by the following graphs?




(i) (ii) (iii) (iv)

**Ans.**

(i) Velocity-time graph is a straight line inclined equally towards the speed and time axis. Therefore, it represents uniformly accelerated motion.

(ii) Velocity-time graph is a straight line parallel to the time axis. It represents uniform motion.

(iii) Velocity-time graph is a straight line having a negative slope. It represents uniformly retarded motion.

(iv) Velocity-time graph is a curve having a negative slope. It represents non-uniformly retarded motion.

**Q.3** Study the velocity graph of a car given alongside and answer the questions that follow :

(i) What type of motion is represented by OA ?

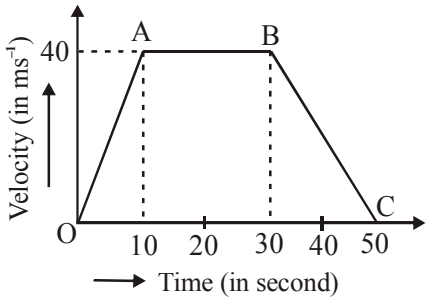
(ii) What type of motion is represented by AB ?

(iii) What type of motion is represented by BC ?

(iv) What is the acceleration of the car from O to A ?

(v) What is the acceleration of the car from A to B?

(vi) What is the retardation of the car from B to C?




**Ans.**

(i) Velocity-time graph is a straight line inclined to the time axis from O to A. This represents a uniformly accelerated motion.

(ii) Velocity-time graph is a straight line parallel to time axis from A to B. This represents uniform motion.

(iii) The velocity-time graph is a straight line from B to C having a negative slope. This represents a uniformly retarded motion.

(iv) Change in velocity $= 40 - 0 = 40^{-1}$

Change in time $= 10 - 0 = 10$ s

$$a = \frac{\text{change in velocity`}}{\text{change in time}} = \frac{40}{10} = 4 \text{ ms}^{-2}$$

(v) Since motion is uniform, therefore, $a = 0$

(vi) Change in velocity $= 0 - 40 = -40 \text{ ms}^{-1}$

Change in time $= 50 - 30 = 20$s, $a = \frac{\text{change in velocity`}}{\text{change in time}} = \frac{-40}{20} = -2 \text{ ms}^{-2}$

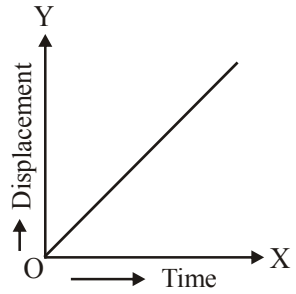
**Q.4** In your everyday life, you come across a range of motions in which
(i) acceleration is in the direction of motion.
(ii) acceleration is against the direction of motion.
(iii) acceleration is uniform.
(iv) acceleration is non-uniform.
Can you identify one example each of the above type of motion.

**Ans.**
(i) When the speed of a car on a road increases, the acceleration of the car is in the direction of motion.
(ii) When brakes are applied to a car in motion, its speed decreases. The acceleration produced in the car is against the direction of motion.
(iii) When a body is falling freely under the action of gravity, it has a uniform $g = 9.8\ ms^{-2}$.
(iv) When a car is passing through city limits on a highway, its acceleration/retardation is non-uniform depending on the volume of traffic.

**Q.5** Take a piece of thread and tie a small piece of stone at one of its ends. Move the stone to describe a circular path with constant speed by holding the thread at the other end. Now, let the stone go by releasing the thread. Can you tell the direction in which the stone moves after it is released?

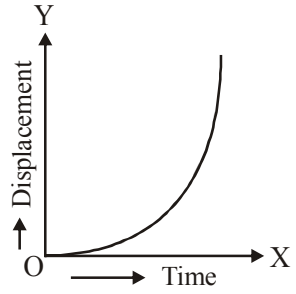
**Ans.** The moment the stone is released, it moves along the tangent to the circular path at that moment. By releasing the stone at different positions of the circular path, one will find that although the stone moves in different directions, but always tangent to the circular path at that instant. In fact, the stone is moving along a circular path due to centripetal force being provided by pull of our hand on the stone. When we let the stone go, centripetal force ceases to act. Due to inertia of direction, the stone moves along the straight line path, i.e., along the tangent to the circular path at that instant.

**Q.6** What conclusion can you draw from the displacement - time graph of a body shown below ?



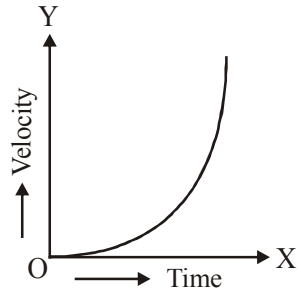

**Ans.** Since the graph is straight line, therefore, the body must be moving with a uniform velocity.

**Q.7** What conclusion can you draw from the displacement-time graph of a body as shown below?



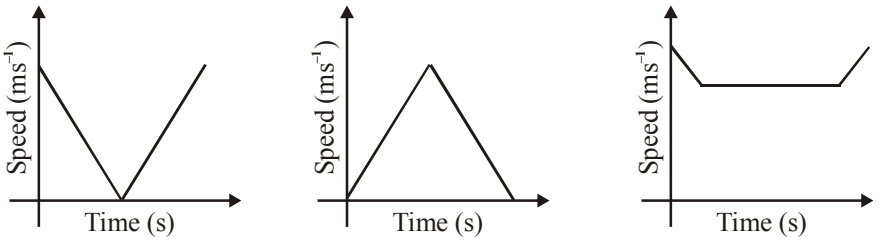

**Ans.** A curved displacement-time graph represents non-uniform motion.

**Q.8** The velocity-time graph of a body is as shown. What type of motion does the body posses?




**Ans.** Since the velocity-time graph is a curved line, therefore, the body's velocity changes non-uniformly with time. Thus the body has variable acceleration.

**Q.9** Out of the three speed-time graphs shown below :
Identify the graph for the following cases :
Case (i) A ball thrown vertically upward and returning to the hand of the thrower.
Case (ii) A body decelerating to a constant speed and then accelerating



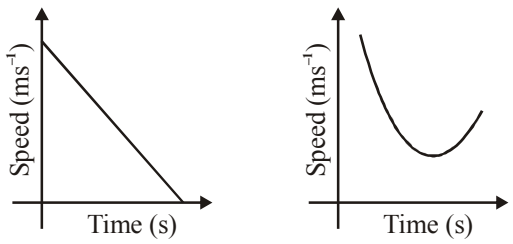

(a) (b) (c)

**Ans.**

(i) Graph (a) shows that the speed of a body decreases with time becomes zero and then again starts increasing. This graph, therefore, represents the case of a ball thrown vertically upward and then caught by the thrower. Initially the ball is thrown with some speed. As the ball rises up its speed decreases at a constant rate and becomes zero at maximum height. The ball then falls with a uniform acceleration till its speed becomes equal to speed of projection.

(ii) Graph (c) represents deceleration of the body to some constant speed, and then accelerating after sometime.

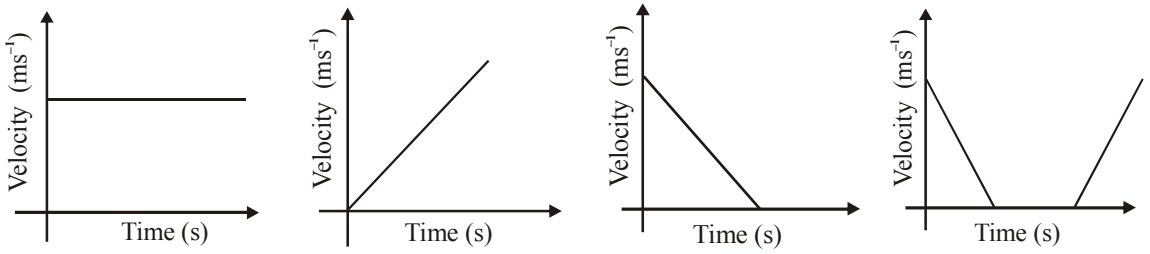
**Q.10** Identify what do the graphs shown below indicate?




(i) (ii)

**Ans.** Graph (i) show that speed decreases continuously with time. This therefore shows constant retardation. Graph (ii) show that speed first decreases and then increases. Thus the body show non-uniform retardation first and then non-uniform acceleration.

**Q.11** What can we conclude about the motion of a body depicted by following velocity-time graphs ?




(i) (ii) (iii) (iv)

**Ans.**

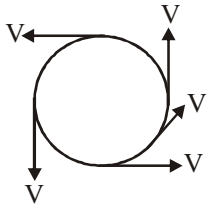
(i) It represents a body moving with uniform velocity.
(ii) It represents a body moving with uniform acceleration.
(iii) It represents a body moving with uniform retardation.
(iv) It represents a body first retarding uniformly, remaining at rest for sometime, and then accelerated uniformly.

**Q.12** What does the slope of a displacement-time graph represent ? Can displacement-time sketch be parallel to be displacement axis ? Give reason to your answer.

**Ans.** The slope of a displacement-time graph gives the velocity. The displacement-time graph can never be a straight line, parallel to the displacement axis because it would mean that the distance covered by the body in a certain direction is increasing without any increase in time i.e., the velocity of the body is infinite which is impossible.

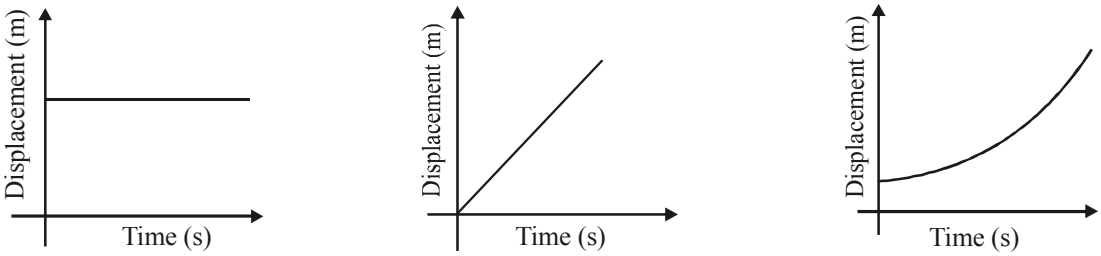
**Q.13** Draw a diagram to show the motion of a body whose speed remains constant but velocity continuously changes.

**Ans.** Uniform circular motion is an example of the motion where speed remains constant but the velocity changes continuously. The motion is represented by the diagram given below.




**Q.14** Draw displacement-time graphs for the following situations.
(i) When body is stationary
(ii) When body is moving with uniform velocity.
(iii) When body is moving with variable velocity.

**Ans.**




(i) For a stationary body. (ii) For a body moving with uniform velocity (iii) For a body moving with variable velocity.

**Q.15** Draw velocity-time graphs for the following situations :

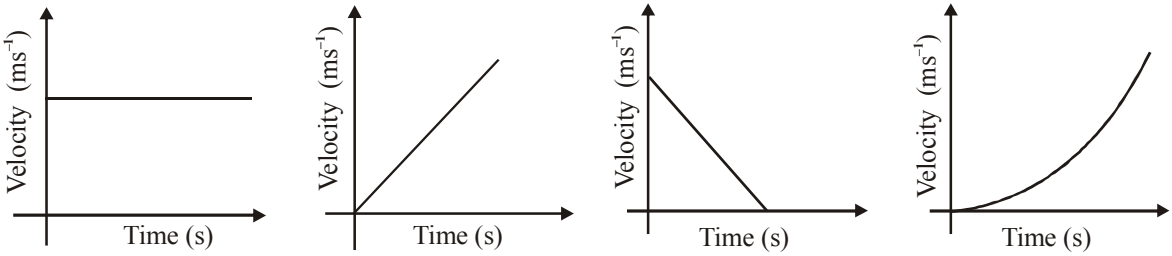
(i) When body is moving with uniform velocity.

(ii) When body is moving with variable velocity, but uniform acceleration.

(iii) When body is moving with variable velocity, but uniform retardation.

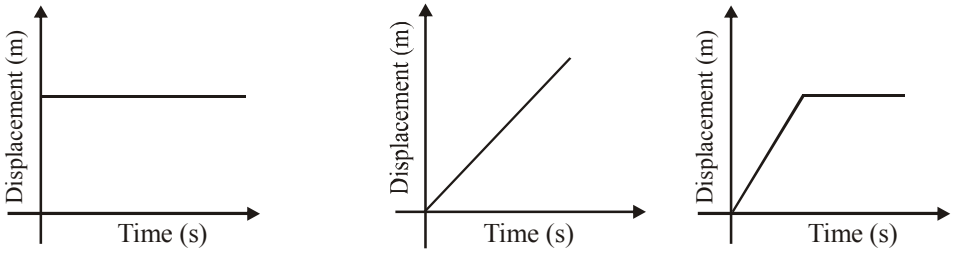
(iv) When body is moving with a variable velocity and variable acceleration.

**Ans.**




(i) (ii) (iii) (iv)

**Q.16** Can you suggest about the kind of motion of a body from following displacement-time graphs?




(i) (ii) (iii)

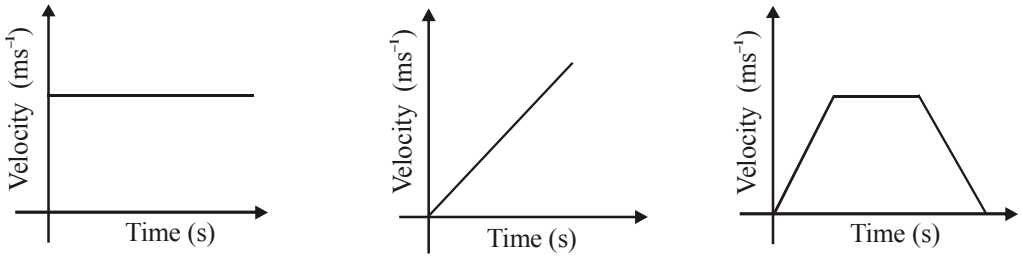
**Ans.**

(i) Body is stationary.

(ii) Body is moving with uniform velocity.

(iii) Initially the body moves with uniform velocity and then stops suddenly.

**Q.17** Can you suggest real life examples about the motion of a body from the following velocity-time graphs?




(i) (ii) (iii)

**Ans.**

(i) A car moving with uniform velocity.

(ii) A freely falling body under the action of gravity.

(iii) A train starts from rest, picks up velocity, moves with uniform velocity for sometime and then retards.

**Q.18** Figure (i) below shows the displacement-time graph for the motion of a body. Draw the velocity-time graph in figure (ii) for it.

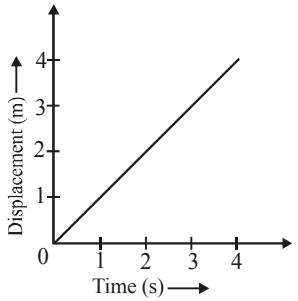


Fig (i)

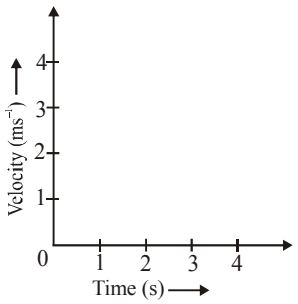
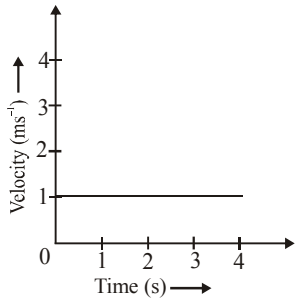


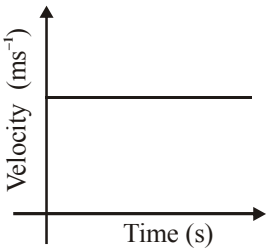
Fig (ii)

**Ans.** The displacement-time graph shows that the object has a uniform velocity. From the graph, we find that this velocity is $1 ms^{-1}$. The velocity-time graph therefore is as shown below.

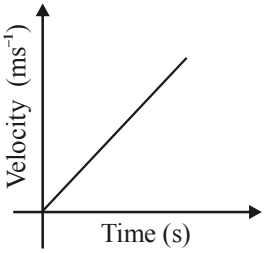



**Q.19** Sketch the shape of the velocity-time graph for a body moving with (i) uniform velocity (ii) uniform acceleration.

**Ans.**



(i)



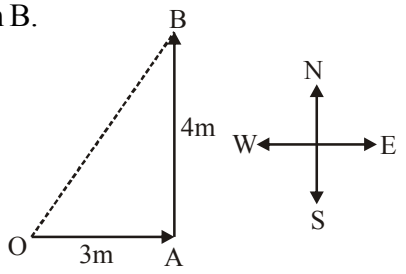
(ii)

**Q.20** A particle moves through a distance of 3m due east and then 4m due north.

(a) How much is the net distance traversed?

(b) What is the magnitude of the net displacement?

**Ans.** The situation is shown in figure. The particle starts from O. It moves through a distance of 3m due east to reach A and then through a distance of 4m due north to reach B.




(a) The total distance moved is 3m + 4m = 7m.

(b) The magnitude of the net displacement is OB.

In the right angled triangle OAB,

$OB^2 = OA^2 + AB^2$

$= (3m)^2 + (4m)^2$

$= 9m^2 + 16\ m^2 = 25m^2$

or OB = 5m.

**Q.21** A car covers 30 km in 30 minutes and the next 30 km in 40 minutes. Calculate the average speed for the entire journey.

**Ans.** As given, the total time taken is 30 min + 40 min = 40 min = 70 min, and the total distance traversed is 30 km + 30 km = 60km. The average speed is

$$v_{av} = \frac{60\,km}{70\,min} = \frac{60\,km}{\left(70/60\right)h} = \frac{3600}{70}\ km/h \approx 51.4\ km/h$$

**Q.22** A car covers 30 km at a uniform speed of 30 km/h. What should be its speed for the next 90 km if the average speed for the entire journey is 60 km/h?

**Ans.** The total distance = 30 km + 90 km = 120 km.
The average speed for the entire journey = 60 km/h.
Using = vt,

$$t = \frac{s}{v} = \frac{120\,km}{60\,km/h} = 2h.$$

Thus, it takes 2 hours to complete the journey. The first 30 km is covered at a speed of 30 km/h. Suppose the time taken to cover the first 30 km is $t_1$. Using s = vt,

$$t_1 = \frac{30km}{30km/h} = 1h.$$

Thus, the remaining 90 km must be covered in (2h – 1h) = 1h. The speed during this 90 km should be

$$v = \frac{s}{t} = \frac{90km}{1h} = 90\ km/h.$$

**Q.23** A body runs for 10 min at a uniform speed of 9 km/h. At what speed should he run for the next 20 min so that the average speed comes to 12 km/h ?

**Ans.** Total time = 10 min + 20 min = 30 min.
The average speed is 12 km/h. Using s = vt, the total distance covered in 30 min is

$$12\ km/h \times 30\ min = 12\ \frac{km}{h} \times \frac{1}{2}h = 6\ km$$

The distance covered in the first 10 min is

$$9\ km/h \times 10\ min = 9\ \frac{km}{h} \times \frac{1}{6}h = 1.5\ km.$$

Thus, he has to cover 6 km – 1.5 km = 4.5 km in the next 20 min. The speed required is

$$\frac{4.5\,km}{20\,min} = \frac{4.5\,km}{\left(20/60\right)h} = 13.5\ km/h.$$

**Q.24** A particle was at rest from 9.00 a.m. to 9.30 a.m. It moved at a uniform speed of 10 km/h from 9.30 a.m. to 10.00 a.m. Find the average speed between

(a) 9.00 a.m. and 10.00 a.m.

(b) 9.15 a.m. and 10.00 a.m.

**Ans.**

(a) The distance moved by the particle between 9.30 a.m. and 10.00 a.m. is

$$s = vt = 10\ \frac{km}{h} \times \frac{1}{2}\ h = 5\ km.$$

This is also the distance moved between 9.00 a.m. and 10.00 a.m. Thus, the average speed during this interval is

$$v_{av} = \frac{s}{t} = \frac{5km}{1h} = 5km/h.$$

(b) The distance moved between 9.30 a.m. and 10.00 a.m. is 5 km. This is also the distance moved in the interval 9.15 a.m. to 10.00 a.m. The average speed during this interval is

$$v_{av} = \frac{s}{t} = \frac{5km}{45\,min} = \frac{5\,km}{(45/60)h} = \frac{5\times 60}{45}\ km/h \approx 6.67\ km/h.$$

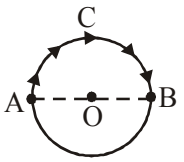
**Q.25** An insect moves along a circular path of radius 10 cm with a constant speed. If it takes 1 minute to move from a point on the path to the diametrically opposite point, find

(a) the distance covered,

(b) the speed,

(c) the displacement, and

(d) the average velocity.




**Ans.** Suppose the insect was at A initially, and it moved along ACB to reach the diametrically opposite point B in 1 minute.

(a) The distance moved in 1 minute = $\pi r = 3.14 \times 10$ cm = 31.4 cm.

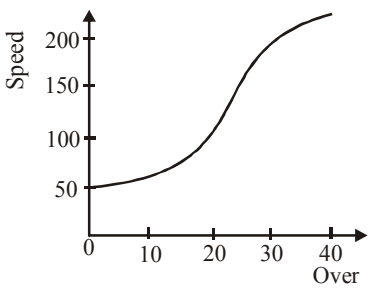
(b) The speed is $\frac{31.4\,cm.}{1\,min} = 31.4$ cm/min.

(c) The displacement is AB = 2r = 20 cm in the direction A to B.

(d) The average velocity is

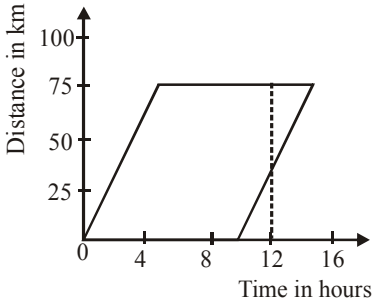
$$v_{av} = \frac{displacement}{time} = \frac{20cm}{1min} = 20\ cm/min \text{ in the direction A to B.}$$

**Q.26** What is wrong with the following graphs ?



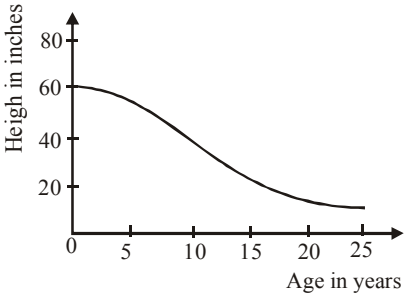

Score-over graph in a one-day cricket match

(a)




Distance-time graph for an object

(b)




Height-age graph for a person

(c)

**Ans.**

(a) 50 runs are shown at the end of the 0th over, i.e., at the beginning. This is not possible in a one-day cricket match under the present rules.

(b) If we draw a perpendicular on the time-axis at the point corresponding to 12 hours, it cuts the graph at two points. One corresponds to 25 km and the other corresponds to 75 km. Thus according to the graph, the distance travelled in 12 hours is 25 km as well as 75 km, which is not possible.

(c) According to the graph, the height of a person gradually decreases as his age increases. Such a thing does not happen.

**Q.27** The distance-time table for a car is given. Assuming that the car moves with uniform speed between the indicated times, answer the following questions.

(a) Plot the graph of the distance travelled with time.

(b) During which period was the car travelling at the greatest speed?

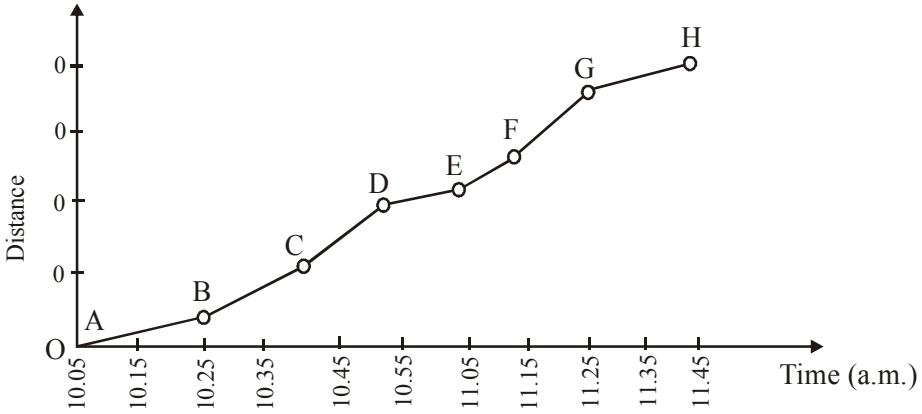
(c) During which period was the car moving with the least speed?

(d) What is the average speed of the car between 10.05 a.m. and 11.00 a.m.?

(e) What is the average speed of the car for the entire journey?

| Time | Distance in km |
|---|---|
| 10.05 am | 0 |
| 10.25 am | 5 |
| 10.40 am | 12 |
| 10.50 am | 22 |
| 11.00 am | 23 |
| 11.10 am | 28 |
| 11.25 am | 38 |
| 11.40 am | 42 |

**Ans. (a)**




The graph is shown in figure. The consecutive points are joined by straight lines. This is because we have assumed that the car moves with uniform speed in each interval.

(b) The greatest inclination (slope) with the time-axis occurs in the part CD of the graph. Thus, the speed is the greatest in this part, i.e., between 10.40 a.m. and 10.50 a.m.

(c) The least inclination with the time-axis occurs in the part EF. Thus, the speed is the least in this part, i.e., between 11.00 a.m. and 11.10 a.m.

(d) The distance travelled between 10.05 a.m. and 11.00 a.m. is 26 km. The time interval is 55 min. The average speed is

$$v = \frac{26\text{km}}{55\,\text{min}} = \frac{26\text{km}}{\left(55/60\right)\text{h}} = \frac{26\times 60}{55}\ \text{km/h} \approx 28.4\ \text{km /h.}$$

(e) The total distance travelled is 42 km and the total time taken is 1 h 35 min. The average speed is

$$v = \frac{42\text{km}}{1\text{h}\,35\,\text{min}} = \frac{42\text{km}}{\left(1+\frac{35}{60}\right)\text{h}} = \frac{42\times 60}{95}\ \text{km/h} \approx 26.5\ \text{km/h.}$$

**Q.28** A train is moving at a speed of 40 km/h at 10.00 a.m. and at 50 km/h at 10.02 a.m. Assuming that the train moves along a straight track and the acceleration is constant, find the value of the acceleration.

**Ans.** The acceleration is

$$a = \frac{v-u}{t} = \frac{50\text{km/h} - 40\text{km/h}}{2\text{min}}$$

$$= \frac{10\text{km/h}}{\left(2/60\right)\text{h}} = \frac{10\times 60}{2}\ \text{km/h}^2 = 300\ \text{km/h}^2.$$

**Q.29** A particle with a velocity of 2 m/s at t = 0 moves along a straight line with a constant acceleration of 0.2 m/s$^2$. Find the displacement of the particle in 10 s.

**Ans.** $s = ut + \frac{1}{2}at^2 = (2\text{m/s})\,(10\text{s}) + \frac{1}{2}\,(0.2\ \text{m/s}^2)\,(10\text{s})^2$

$= 20\text{m} + 10\ \text{m} = 30\ \text{m}.$

**Q.30** A particle is pushed along a horizontal surface in such a way that it starts with a velocity of 12 m/s. Its velocity decreases at a rate of 0.5 m/s$^2$. (a) Find the time it will take to come to rest. (b) Find the distance covered by it before coming to rest.

**Ans.**

(a) Initial velocity $u = 12$ m/s

Acceleration $a = -0.5\ \text{m/s}^2$ (as the velocity is deceasing)

Final velocity $u = 0$ (as it comes to rest)

We have $v = u + at$

or $0 = (12\ \text{m/s}) + (-0.5\ \text{m/s}^2)\,t$

or $(0.5\ \text{m/s}^2)\ t = 12\ \text{m/s}$

or $$t = \frac{12\text{m/s}}{0.5\text{m/s}} = \frac{12}{0.5}\ \frac{\text{m}}{\text{s}} \times \frac{\text{s}^2}{\text{m}} = 24\ \text{s}$$

So the particle takes 24 s to stop.

(b) We have $v^2 = u^2 + 2aS$ .

or $0 = (12\ \text{m/s})^2 + 2\,(-0.5\ \text{m/s}^2)S$

or $(1\ \text{m/s}^2)\,S = 144\ \text{m}^2/\text{s}^2$

or $$S = \frac{144\ \text{m}^2/\text{s}^2}{1\ \text{m/s}^2} = 144\ \text{m}.$$

So the particle covers 144 m before stopping.

**Q.31** A train accelerates from 20 km/h to 80 km/h in 4 minutes. How much distance does it cover in this period? Assume that the tracks are straight.

**Ans.** We will first find the acceleration and then the distance.

At t = 0, the velocity is u = 20 km/h

At $t = 4\ \text{min} = \frac{1}{15}\text{h}$, the velocity is v = 80 km/h.

Using v = u +at,

$$a = \frac{v-u}{t} = \frac{80\text{km/h} - 20\text{km/h}}{\left(1/15\right)\text{h}} = 60\ \text{km/h}^2 \times 15 = 900\ \text{km/h}^2.$$

The distance covered is

$$x = ut + \frac{1}{2}at^2 = (20\ km/h) \times \left(\frac{1}{15}\ h\right) + \frac{1}{2}(900\ km/h^2) \times \left(\frac{1}{15}\ h\right)^2 = \frac{20}{15}\ km + 2\ km = \frac{10}{3}\ km.$$

**Q.32** A car moving along a straight line at a speed of 54 km/h stops in 5 seconds after the brakes are applied.

(a) Find the acceleration, assuming it to be constant.

(b) Plot the graph of speed versus time.

(c) Using the graph, find the distance covered by the car after the brakes are applied.

**Ans.** (a) The initial velocity is

$$u = 54\ km/h = \frac{54km}{1h} = \frac{54 \times 1000m}{3600s} = 15m/s$$

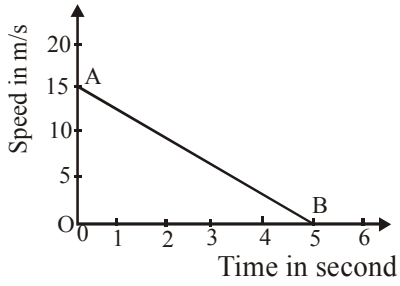
The velocity v at t = 5s is zero.

The acceleration is

$$a = \frac{v-u}{t} = \frac{0-15m/s}{5s} = -3\ m/s^2$$

Since the sign of the acceleration is opposite to that of the velocity, the car is decelerating.

(b) At t = 0, the speed is 15 m/s, and at t = 5 s, it is 0. Thus, we get two point A and B on the graph (figure).

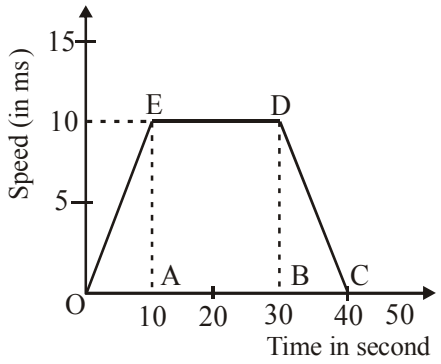



The acceleration is constant and the car moves in a fixed direction, the speed-time graph should be a straight line. Therefore we join the points A and B by a straight line to get the required graph.

(c) The distance covered between 0 and 5 s is equal to the area under the graph, i.e., the area of the triangle OAB. It is $\frac{1}{2} \times$ height $\times$ base $= \frac{1}{2} \times (15\ m/s) \times (5s) = 37.5\ m.$

**Q.33** Figure shows the speed-time graph of a particle.

Find the distance travelled in the time interval 0 to 40s.



**Ans.** The distance travelled is equal to the area under the graph. From figure, this area is equal to the area of the triangle OAE + the area of the rectangle ABDE + the area of the triangle BCD.

The areas of the triangle OAE is

$$A_1 = \frac{1}{2} \times OA \times AE = \frac{1}{2} \times (10\ s) \times (10\ m/s) = 50\ m.$$

The area of the rectangle ABDE is

$$A_2 = AE \times AB = (10\ m/s) \times (20\ s) = 200\ m.$$

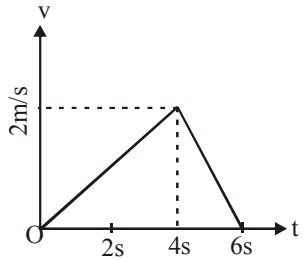
The area of the triangle BCD is

$$A_3 = \frac{1}{2} \times BC \times BD = \frac{1}{2} \times (10\ s) \times (10\ m/s) = 50\ m.$$

The total area is $A_1 + A_2 + A_3 = 50\ m + 200\ m + 50\ m = 300\ m$.

The total distance covered is 300 m.

**Q.34** The velocity-time graph of a particle moving along a straight line is shown in figure.




(a) Is the motion uniform ?

(b) Is the acceleration uniform?

(c) Does the particle change its direction of motion?

(d) Find the distances covered from 0 to 4s and from 4 to 6s.

**Ans.**

(a) The velocity is changing with time. So the motion is not uniform.

(b) The acceleration is given by the slope of the velocity-time graph. The slope are different before and after t = 4 s. So the acceleration is not uniform for the entire time shown. It is uniform between 0 and 4 s and also between 4 and 6 s as the slope does not change in these periods.

(c) The velocity always remains positive. It means that the particle keeps moving in the positive direction. In other words, it does not change direction.

(d) The displacement during the period 0–4 s is equal to the area under the velocity-time graph for this period. This area is in the shape of a triangle.

$$\text{Area of the triangle} = \frac{1}{2} \times \text{base} \times \text{height}$$

$$= \frac{1}{2} \times 4s \times (2\ m/s) = 4\ m.$$

As the particle moves in the same direction, this is also the distance moved.

For the period 4–6s, the area is

$$\frac{1}{2}(2s) \times 2\left(\frac{m}{s}\right) = 2m.$$

So the particle moves 2m in this period.

## SECTION-D [ PREVIOUS YEARS QUESTIONS, (1 MARK) ]

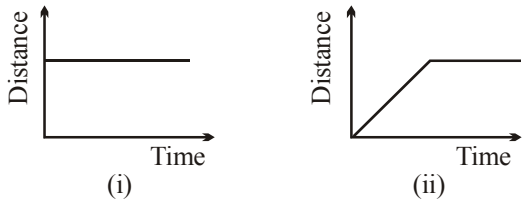
Q.1 Name a physical quantity that essentially changes as a body moves. **[SAI-2013]**

Ans. Distance.

Q.2 Give an expression for the speed of an athlete if he takes time 't' to go around a circular track, of radius r. **[SAI-2014]**

Ans. $v = \frac{2\pi r}{t}$

Q.3 What kind of motion of a body is represented by the graphs given below ? **[SAI-2010, 2014]**




Ans. (i) object is at rest.
(ii) Object has non-uniform motion.

Q.4 Which of the following is true for displacement ? (a) It cannot be zero. (b) Its magnitude is greater than the distance travelled by the object. **[SAI-2015]**

Ans. None of the statement (a) or (b) is true for displacement.

Q.5 What does the path of an object look like when it is in uniform motion ? **[SAI-2015]**

Ans. The path of an object will be a straight line.

Q.6 Mention the nature of motion of a body if its displacement-time graph is a straight line parallel to time axis. **[SAI-2015]**

Ans. No motion.

Q.7 Under what condition will the magnitude of the displacement be equal to the distance travelled by an object ? **[SAI-2015]**

Ans. When the object moves along a straight line.

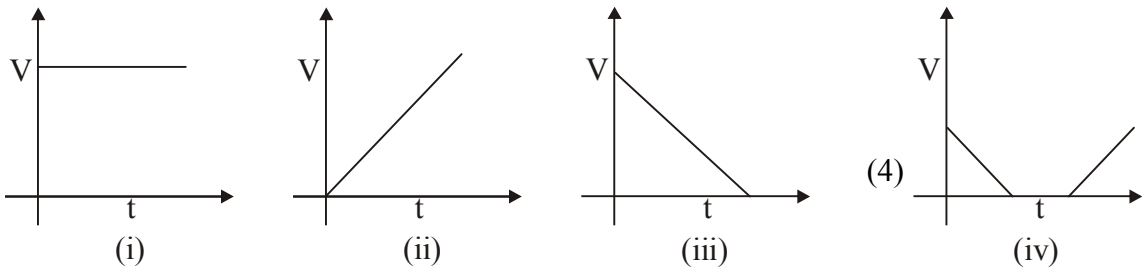
Q.8 A bus covers equal distance in equal intervals of time. What type of motion does the bus exhibit ? **[SAI-2015]**

Ans. Uniform motion.

Q.9 Name the physical quantity which corresponds to the rate of change of momentum. **[SAI-2015]**

Ans. Force.

Q.10 What can we conclude about the motion of a body depicted by following velocity-time graphs ? **[SAI-2015]**



Ans. (i) It represents a body moving with uniform velocity.
(ii) It represents a body moving with uniform acceleration.
(iii) It represents a body moving with uniform retardation
(iv) It represents a body first retarding uniformly, remaining at rest for some time, and then accelerating uniformly

## SECTION - E [ PREVIOUS YEARS QUESTIONS, (2 MARKS) ]

Q.1 Which of the following is true for displacement ? Justify your answer for the true statement.
(i) It can be zero.
(ii) Its magnitude is greater than the distance travelled by the object. **[SAI-2014]**

Ans. (i) True, e.g., if an object returns back to its original position.
(ii) False. Magnitude of displacement can be equal to or less than the distance travelled.

Q.2 What is the relation between distance and time:
(i) when body is moving with uniform velocity ?
(ii) body is moving with variable velocity ? **[SAI-2014]**

Ans. (i) The distance covered by the body is directly proportional to time.
(ii) The distance covered by the body not directly proportional to time.

Q.3 When is the acceleration :
(i) positive
(ii) negative ? **[SAI-2015]**

Ans. (i) If the velocity of a body is increasing with respect to time, the acceleration is said to be positive.
(ii) If the velocity of a body is decreasing with respect to time, the acceleration is said to be negative.

Q.4 Differentiate between distance and displacement. **[SAI-2015]**

Ans. Any three differences.

| S.No. | Distance | Displacement |
|---|---|---|
| **1.** | It is defined as the actual path traversed by a body. | It is the shortest distance between two points between which the body moves |
| **2.** | It is a scalar quantity. | It is a vector quantity. |
| **3.** | It can never be negative or zero. | It can be negative, zero or positive. |
| **4.** | Distance can be equal to or greater than displacement. | Displacement can be equal to or less than distance. |
| **5.** | Distance travelled is not a unique path between two points. | Displacement is a unique path between two points. |
| **6.** | Distance between two points gives full information of the type of path followed by the body. | Displacement between two points does not give full information of the type of path followed by the body. |
| **7.** | Distance never decreases with time. For a moving body it is never zero. | Displacement can decrease with time. For a moving body it can be zero. |
| **8.** | Distance in SI is measured in metre. | Displacement in SI is measured in metre. |

## SECTION - F [ PREVIOUS YEARS QUESTIONS, (3 MARKS) ]

Q.1 A fireworks shell is accelerated from rest to a velocity of 50 m $s^{-1}$ over a distance of 0.250 m. Calculate the acceleration. How long did the acceleration last ? **[SAI-2013]**

Ans. Given u = 0, v = 50 m $s^{-1}$,

S = 0.250 m, a = ? , t = ?

Using

$$a = \frac{(v^2 - u^2)}{2S} = \frac{(50)^2 - (0)^2}{2 \times 0.250}$$

$= 5000 \text{ m s}^{-2}$

$$\text{and } t = \frac{(v - u)}{a} = \frac{(50 - 0)}{5000} = 0.01\text{s}$$

Q.2 Give one example for each of the type of motion when:
(i) acceleration is in the direction of motion.
(ii) acceleration is against the direction of motion.
(iii) acceleration is uniform. **[SAI-2014]**

Ans.

(i) The motion of a car when it starts from rest and increases its velocity at a constant rate in a particular interval of time.

(ii) The motion of a train when it slows down while approaching a station.

(iii) The motion of a ball falling down freely.

Q.3 A bus is moving to the left (has a negative velocity) slows down and then comes to a stop:
(i) What is the direction of its acceleration ? Is the acceleration positive or negative?
(ii) What is the sign of acceleration that reduces the magnitude of a positive velocity? **[SAI-2014]**

Ans. (i) To the right side. The acceleration is negative.
(ii) Negative.

Q.4 (a) A body thrown vertically upwards reaches a maximum height h. It then returns to ground. Calculate the distance travelled and its displacement.
(b) In a long distance race, the athletes were expected to take four rounds of the track such that the line of finish was same as the line of start. Suppose the length of the track was 200 m.
(i) What is the total distance to be covered by the athletes ?
(ii) What is the displacement of the athletes when they touch the finish line?
(iii) Is the motion of the athletes' uniform or non-uniform? **[SAI-2014]**

Ans.

(a) Here, Distance travelled = h + h = 2 h
Displacement = 0

(b) Length of the track = 200 m.
(i) Total distance to be covered by the athletes in four rounds = 200 × 4 = 800 m.
(ii) Displacement of the athletes when they touch the finish line = 0.
(iii) Non-uniform.

Q.5 A cheetah can accelerate from rest at the rate of 4 m $s^{-2}$.
(i) What will be the velocity attained by it in 10s ?
(ii) How far will it travel in this duration? **[SAI-2014]**

Ans. Given, u = 0, a = 4 m $s^{-2}$
(i) From the first equation of motion,
$v = u + at = 0 + 4 \times 10 = 40$ m $s^{-1}$
(ii) From the second equation of motion,

$$S = ut + \frac{1}{2}at^2 = 0 \times 10 + \frac{1}{2} \times 4 \times (10)^2 = 200 \text{ m}.$$

Q.6 State which of the following situations are possible and give an example of each of these : **[SAI-2015]**
(a) A body moving with constant acceleration but with zero velocity.
(b) A body moving horizontally with an acceleration in vertical direction.
(c) A body moving with a constant speed in an accelerated motion.

Ans.
(a) Yes, at the highest point of a body thrown vertically upwards. At the highest point the body's velocity is zero but it has an acceleration of 9.8 m $s^{-2}$ in the downward direction.
(b) Yes, a projectile fired at an angle has a uniform velocity along the horizontal, but its motion along the vertical is uniformly accelerated.
(c) Yes, when a body moves along a circular path with constant speed. In this situation, the speed is constant but due to change in direction the body possesses acceleration.

Q.7 Explain the following type of motion with one example of each : **[SAI-2015]**
(i) Acceleration is positive.
(ii) Acceleration is negative.
(iii) Acceleration is zero.

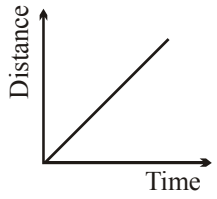
Ans. (i) Here, the, motion is accelerated motion. Ex. A car moving on a road with increasing velocity.
(ii) here, the motion is retarded motion. Ex. Brakes applied to a moving car.
(iii) Here, the motion is uniform motion. Ex. Motion of the second's hand of a clock.

Q.8 Answer the following questions :
(i) State the type of motion shown by a freely falling stone.
(ii) When a stone is thrown vertically upwards its velocity is continuously decreased. Why?
(iii) Give an example of a motion in which average velocity is zero, but the average speed is not zero. **[SAI-2015]**

Ans.
(i) Accelerated motion
(ii) The stone is continuously being attracted by the earth, this causes retardation in the stone's motion, hence its velocity goes on decreasing continuously.
(iii) Uniform circular motion.

Q.9 (a) When will You say a body is in:
(i) uniform motion ?
(ii) non-uniform motion ?
(b) Show the path of an object when it is in uniform motion with the help of a graph.
**[SAI-2015]**

Ans. (a) (i) When it covers equal displacements in equal intervals of time.
(ii) When it does not covers equal displacements in equal intervals of time.
(b) The distance-time graph is as shown. For uniform motion.




Q.10 An electric engine has a velocity of 120 km $h^{-1}$. How much distance will it travel in 30 s ? **[SAI - 2015]**

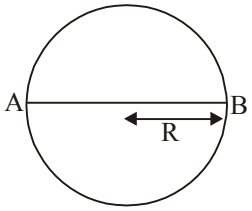
Ans. $\text{Velocity} = \frac{\text{distance}}{\text{time}}$

Distance = velocity × time ,

Therefore, $S = \frac{120 \times 1000}{3600} \times 30 = 1000\text{m}$

Q.11 A person is running along a circular path in a park.
(a) At what point he changes his direction while running ?
(b) If he covered half of the circular path, what will be his displacement ? Draw a diagram showing it. **[SAI-2015]**

Ans. (a) At each and every point.
(b) Displacement = Diameter of the circle.




Q.12 An object is moving with uniform speed in a circle of radius 7 m. Calculate the distance and displacement when it completes half the circle. What type of motion does the object possess ? **[SAI-2015]**

Ans. When it completes half cycle, then

$\text{Distance} = \pi R = \frac{22}{7} \times 7 = 22\text{m}$

Displacement = 14 m
It posses uniform circular motion.

Q.13 A cyclist goes once around a circular track of diameter 105 metre in 5 minutes. Calculate his speed. **[SAI - 2015]**

Ans. Given, D = 105 m, R = 105/2 = 52.5 m,
t = 5 × 60 = 300s

Now, $\text{speed} = \frac{\text{distance}}{\text{time}} = \frac{2 \times 3.14 \times 52.5}{300} = 1.1\text{ms}^{-1}$

Q.14 A train is travelling at a speed of 90 km $h^{-1}$. Breaks are applied so as to –0.5 $ms^{-2}$. Find how far the train will go before it is brought to rest. **[SAI-2015]**

Ans. Given, u = 90 km $h^{-1}$ = $90 \times \frac{5}{18}$ = 25 m $s^{-1}$, v = 0, a = – 0.5 m $s^{-2}$, S = ?

Using

$v^2 - u^2 = 2aS$

$0 - (25)^2 = 2\times - 0.5 \times S$

or S = 625 m

## SECTION - G [ PREVIOUS YEARS QUESTIONS, (5 MARKS) ]

Q.1 The position-time graph of three objects A, Band C in motion is shown below :

(i) Which of the three is travelling fastest?

(ii) Do any of the three objects meet at the same point on the road?

(iii) How far has C travelled at 11:15 a.m.?

(iv) Calculate the average speed of object B between 10:15 to 11:35 a.m.

(v) How much is A ahead of B at 10.55 a.m.? **[SAI-2013]**

Ans.

(i) A is travelling fastest.

(ii) Yes, firstly A and C meet at the same point on the road at 10:35 a.m., then B and C meet at another point on the road at 11 :15 a.m.

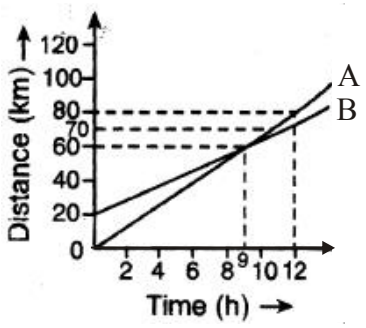
(iii) 20 km.

(iv) Total distance travelled by B between 10: 15 to 11 :35 a.m. = 60 km

$$\text{Average speed} = \frac{60\,\text{km}}{80\,\text{min}} = \frac{60\times 60}{80} = 45\,\text{km}\,\text{h}^{-1}$$

(v) 50 km – 20 km = 30 km.

Q.2 Distance -time graph represents the motion of two buses A and B:




(i) What is the distance by which bus B was ahead of bus A initially?
(ii) Do they ever meet each other ? If so, when ?
(iii) What is the distance travelled by bus A when it overtakes bus B ?
(iv) Find out the distance by which bus A was ahead of bus B at t =12 h.
(v) Which one of them is moving faster? Give reason. **[SAI-2013]**

Ans. (i) 20 km.
(ii) Yes, they meet after 9 hour.
(iii) 60 km
(iv) 80 – 70 = 10 km.
(v) A moves faster as its slope is higher than that of B.

Q.3 A body moves with a velocity of 2 m $s^{-1}$ for 5 s, then its velocity increases uniformly to 10 m $s^{-1}$ in next 5s. Thereafter, its velocity begins to decrease at a uniform rate until it comes to rest after 5 s.
(i) Plot a velocity-time graph for the motion of the body.
(ii) From the graph, find the total distance covered by the body after 2 s and 12 s.
**[SAI-2011,2013]**

Ans.
(i) The velocity-time graph is as shown :

(ii) According to the graph :
Distance moved by the body after 2s = Area OAB'C' = $2 \times 2 = 4$ m
Distance covered by the body after 12s = Area OAED + Area BEF + Area of DHGI + Area of FHG

$$= 2 \times 10 + \frac{1}{2} \times 5 \times 8 + 6 \times 2 + \frac{1}{2} \times 2 \times 4 = 56 \text{ m}$$

Q.4 Following figure is the speed-time graph for a rocket from the moment when the fuel starts to burn, i.e., at time t = 0.

(a) State the acceleration of the rocket at t = 0
(b) State what happens to the acceleration of the rocket between t = 5 s and t = 60 s.
(c) Calculate the acceleration of the rocket at t = 80 s. Give reason for your answer.
(d) The total mass of the rocket at t = 80s is $1.6 \times 10^6$ kg. Calculate the resultant force on the rocket at this time. Give reason for your answer. **[SAI-2015]**

Ans.

(a) No net acceleration,

(b) Increases after 10 sec. till t = 50 sec.
after t = 50 s acceleration is constant till t = 100 s

(c) Zero

$$a = \frac{\Delta v}{\Delta t} = \frac{1400 - 400}{50} = \frac{1000}{50} = 20 \text{ m/s}^2$$

t = 80s, a = 20 m/s²

(d) Zero as it is moving with constant velocity.
$F = 1.6 \times 10^6 \times 20$
$F = 32 \times 10^6$ N

# CONCEPT APPLICATION LEVEL - III

## SECTION-A

**Fill in the blanks with suitable words :**

**1.** Displacement is a .....quantity.

**2.** .....is defined as the distance travelled by a body per unit time.

**3.** .....indicates the instantaneous speed of the vehicle.

**4.** Rate of change of velocity is called.....

**5.** Negative acceleration is called.....

**6.** Speed of a body is always .....

**7.** Velocity = speed × .....

**8.** Speed is the magnitude of the .....

**9.** Acceleration is a .....quantity.

**10.** Acceleration of the body is increasing with passage of .....

**11.** In linear motion the body moves along a.....

**12.** In linear motion the direction of motion .....

**13.** I rad =.....

## SECTION-B

**Multiple choice question with one correct answers :**

**Q.1** If the speed of car is increased to two times the breaking force to stop the car over the same distance will be :

(A) one fourth (B) half (C) twice (D) four times

**Q.2** The numerical ratio of covering the distance is directly proportional to the square of the time. The acceleration of the body is

(A) $< 1$ (B) $=1$ (C) $> 1$ (D) $\leq 1$

**Q.3** A moving body is covering the distance directly proportional to the square of the time. The acceleration of the body is :

(A) increasing (B) decreasing (C) zero (D) constant

**Q.4** Distance travelled by a particle in a given interval of time is always

(A) zero (B) positive (C) negative (D) – ve and +ve

**Q.5** Distance is a

(A) vector quantity (B) Scalar quantity (C) both of them (D) none of these

**Q.6** Displacement is a

(A) vector quantity (B) Scalar quantity (C) both of them (D) none of these

**Q.7** A bus moving on a crowded road is in
(A) uniform quantity (B) non-uniform motion (C) both of them (D) none of these

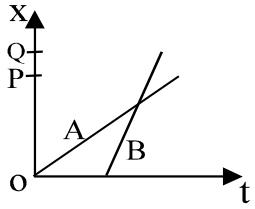
**Q.8** 1 km $h^{-1}$ is equal to
(A) $\frac{5}{18}$ $ms^{-1}$ (B) $\frac{18}{5}$ $ms^{-1}$ (C) both of them (D) none of these

**Q.9** 1 $km/h^2$ is equal to
(A) $\frac{1000m}{3600 \times 3600s^2}$ (B) $\frac{1}{12960}$ $m/s^2$ (C) both A & B are equal (D) none of these

**Q.10** 1 radian is equal to
(A) 75.3° (B) 30.3° (C) 22.1° (D) 57.3°

**Q.11** When a moving body makes a round trip and returns back to its initial position then its displacement is
(A) +1 (B) –1 (C) 0 (D) $\geq 1$

**Q.12** The position time (x– t) graph for two children A and B returning from their school O to their homes P and Q respectively are shown in fig. choose the correct entries in the brackets below :




(A) (B) lives closer to the school than (A).
(B) (B) starts from the school earlier than (A).
(C) (A) walks faster than (B).
(D) (A/B) overtakes (B/A) on the road (once/twice)

**Q.13** A particle has a velocity towards east at t = 0. Its accleration is towards west and is constant. Let $x_A$ and $x_B$ be the magnitude of displacments in the first 10 seconds and the next 10 seconds.
(A) $x_A < x_B$
(B) $x_A = x_B$
(C) $x_A > x_B$
(D) the information is in sufficient to decide the relation of $x_A$ with $x_B$.

**Q.14** A person travelling on a straight line moves with a uniform velocity $v_1$ for some time and with uniform velocity $v_2$ for the next equal time. The average velocity v is given by : –
(A) $v = \frac{v_1 + v_2}{2}$ (B) $v = \sqrt{v_1 v_2}$ (C) $\frac{2}{v} = \frac{1}{v_1} + \frac{1}{v_2}$ (D) $\frac{1}{v} = \frac{1}{v_1} + \frac{1}{v_2}$

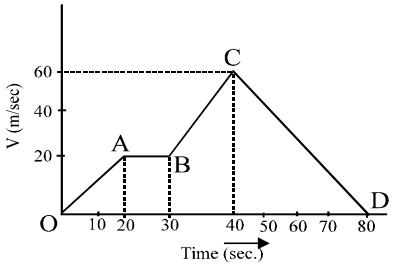
**Q.15** A stone is released from an elevator going up with an acceleration a. The acceleration of the stone after the release is:
(A) a upward (B) (g – a) upward (C) (g – a) downward (D) g downward

**Q.16** A person standing near the edge of the top of a building throws two balls A and B. The ball A is throwns vertically upward and B is thrown vertically downward with the same speed The ball A hits the ground with a speed $v_A$ and the ball B hits the ground with a speed $v_B$. we have :
(A) $V_A > V_B$
(B) $V_A < V_B$
(C) $V_A = V_B$
(D) the relation between $V_A$ and $V_B$ depends on height of the building above the ground

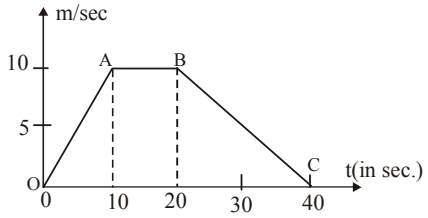
**Q.17** A player throws a ball upwards with an initial speed of 29.4 m $s^{-1}$. The time taken by the ball to return to the player's hands is. (Take g = 9.8 m $s^{-2}$ and neglect air resistance).
(A) 10 sec (B) 8 sec (C) 12 sec (D) 6 sec

**Q.18** Ratio of displacment to distance is:
(A) always < 1 (B) always = 1 (C) always > 1 (D) = or < 1

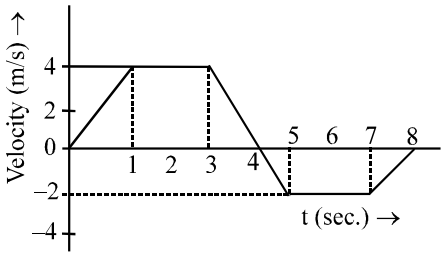
**Q.19** The following shows the time-velocity graph for a moving object. The maximum acceleration will be
(A) 1 m/$sec^2$ (B) 2 m/$sec^2$
(C) 3 m/$sec^2$ (D) 4 m/$sec^2$




**Q.20** The adjoining curve represents the velocity time graph of a particle, its acceleration values along OA, AB and BC in m,/$sec^2$. are respectively-
(A) 1, 0, –0.5 (B) 1 , 0, 0.5
(C) 1, 1, 0.5 (D) 1, 0.5, 0




**Q.21** The v-t graph of a linear motion is shown in adjoining figure. The distance from origin after 8 sec. is-
(A) 18 meters (B) 16 meters
(C) 8 meters (D) 6 meters




**Q.22** A motor car covers 1/3 part of total distance with $v_1$ = 10 km/hr, second 1/3 part with $v_2$ = 20 km/hr and rest 1/3 part with $v_3$ = 60 km/hr. What is the average speed the car-
(A) 18 km/hr (B) 45 km/hr (C) 6 km/hr (D) 22.5 km/hr

**Q.23** A car covers a distance of 2 km. in 2.5 min. if it covers half of the distance with speed 40 km/hr the rest distane it will cover with speed-
(A) 56 km/hr (B) 60 km/hr (C) 50 km/hr (D) 48 km/hr

**Q.24** A cyclist moving on a circular track of radius 40 m completes half a revolution in 40 sec. Its average velocity is-
(A) Zero (B) 5 m/sec. (C) 2 m/sec. (D) 3.5 m/sec.

**Q.25** Which of the following statements is wrong about a ball thrown vertically up
(a) It is moving with constant acceleration.
(b) It may have different velocities at the same position.
(c) It may have two positions at the same time.
(d) The angular momentum of the particle about origin remains conserved.
(A) c only (B) c, d (C) b, c, d (D) a, b, c and d

**Q.26** A bus accelerates uniformly from rest and acquires a speed of 36 km/hour in 10 seconds. The acceleration is :
(A) 1000 m/sec$^2$ (B) 1 m/sec$^2$ (C) 100 m/sec$^2$ (D) 10 m/sec$^2$

**Q.27** Acceleration of a particle changes when :
(A) direcion of velocity changes (B) magnitude of velocity changes
(C) both of above (D) speed changes

## SECTION-C

**More than one correct answers :**

**Q.1** The book lying on the table is
(A) at rest (B) in motion
(C) between rest and motion (D) none of these

**Q.2** Which of the following is/are scalar quantity ?
(A) acceleration (B) displacement (C) distance (D) volume

**Q.3** Which of the following is/are vector quantity ?
(A) acceleration (B) displacement (C) area (D) volume

**Q.4** $ms^{-1}$ is the SI unit of
(A) distance (B) speed (C) velocity (D) acceleration

**Q.5** m is the unit of
(A) distance (B) displacement (C) velocity (D) acceleration

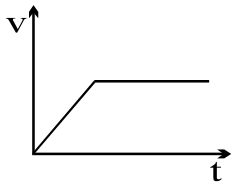
**Q.6** Which of the following is correct in terms of motion
(A) $v = u + at$ (B) $v^2 = u^2 + 2as$ (C) $s = ut + \frac{1}{2}at^2$ (D) none of these

**Q.7** Which is correct ?
(A) $\omega = \frac{\theta}{t}$ (B) $\omega = \theta t$ (C) $v = \frac{s}{t}$ (D) $v = st$

**Q.8** Which is correct?
(A) $\theta = \frac{1}{r}$ (B) $\omega = \frac{\theta}{t}$ (C) $\theta = \frac{s}{r}$ (D) none of these

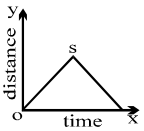
**Q.9** Which of the following statements regarding the freely falling body is/are correct?
(A) The body is uniformly accelerated
(B) The body is non-uniformly accelerated
(C) The distance travelled by the body in the first second, second second and third second are in the ratio of 1 : 3 : 5
(D) The distance travelled by the body in the first second, first two seconds and first three seconds are in the ratio of 1 : 4 : 9

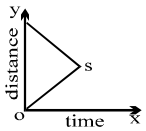
**Q.10** The velocity time graph of an object is shown in figure.
Which of the following statement is/are correct ?

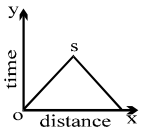


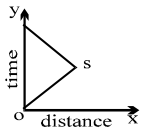

(A) The slanted portion of the v-t graph represents constant acceleration.
(B) The horizontal portion represents constant velocity
(C) Area under v-t graph gives the momentum change.
(D) Area under v-t graph is equal to acceleration

**Q.11** In an examination, the students were asked to draw distance -time graph of a school boy going from home straight to school and starting back home immediately (without any time loss). The following graphs were drawn by four students. Which of these graphs do not depict the real situation ?

(A) 


(B) 


(C) 


(D) 


## SECTION-D

**Assertion & Reason :**

Instructions: In the following questions as Assertion (A) is given followed by a Reason (R). Mark your responses from the following options.
(A) Both Assertion and Reason are true and Reason is the correct explanation of 'Assertion'.
(B) Both Assertion and Reason are true and Reason is not the correct explanation of 'Assertion'.
(C) Assertion is true but Reason is false.
(D) Assertion is false but Reason is true.

**Q.1** **Assertion :** The v–t graph perpendicular to the time axis is not possible.
**Reason :** If v–t graph is perpendicular to the time axis, then acceleration of the particle should be infinite.

**Q.2** **Assertion :** Retardation is directed opposite to the velocity.
**Reason :** Retardation is equal to the time rate of decrease of velocity.

**Q.3** **Assertion :** Relative velocity when particles are moving on the same straight line path can be greater in magnitude than velocity of either particle.
**Reason :** When the particles are moving with velocities $v_1$ and $v_2$ in opposite directions, then relative velocity = $v_1 + v_2$.

**Q.4** **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.

**Q.5** **Assertion :** The velocity of a particle may vary even when its speed is constant.
**Reason :** Such a body may move along a circular path.

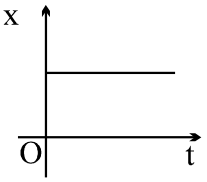
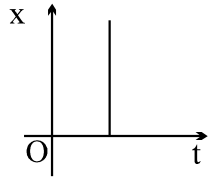
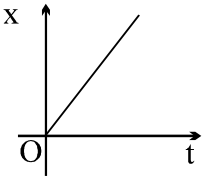
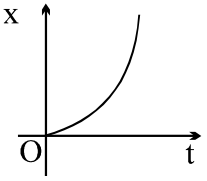
**Q.6** **Assertion :** The *x*–t graph for a body at rest is a straight line parallel to time axis.
**Reason :** A body at rest does not change its position with the lapse of time.

## SECTION-E

**Match the following (one to one):**

**Column-I** and **column-II** contains **four** entries each. Entries of column-I are to be matched with some entries of column-II. Only One entries of column-I may have the matching with the some entries of column-II and one entry of column-II Only one matching with entries of column-I.

**Q.1**

| **Column I** *(Distance time graph)* | | **Column II** *(Type of motion)* |
|---|---|---|
| (A)   | (P) | Body moves with constant speed |
| (B)   | (Q) | Non-uniform motion |
| (C)   | (R) | Body is stationary |
| (D)   | (S) | Not possible |

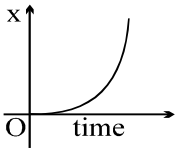
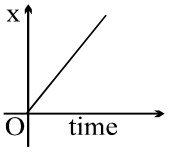
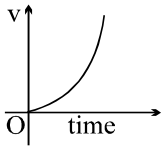
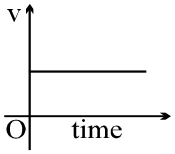
**Q.2**

| **Column I** *(Type of motion)* | | **Column II** *(Nature of Acceleration)* |
|---|---|---|
| (A) Circular Motion | (P) | Acceleration is along the direction of motion |
| (B) Uniform Motion | (Q) | Acceleration is along perpendicular direction of the motion. |
| (C) Free Fall | (R) | Acceleration is in the opposite direction of motion |
| (D) A stone thrown upward with initial velocity 'u' | (S) | Acceleration is Zero |

**Match the following (one to many) :**

**Column-I** and **column-II** contains **four** entries each. Entries of column-I are to be matched with some entries of column-II. One or more than one entries of column-I may have the matching with the some entries of column-II and one entry of column-II may have one or more than one matching with entries of column-I

**Q.3**

| **Column I** | | **Column II** |
|---|---|---|
| ***Displacement time(x - t)/velocity-time graph (v - t)*** | | ***Type of motion*** |
| (A)   | | (P) Uniform motion |
| (B)   | | (Q) Non-uniform motion |
| (C)   | | (R) constant velocity |
| (D)   | | (S) uniformly accelerated motion |

## SECTION-F

**Comprehension**

A "sun yacht" is a spacecraft with a large sail that is pushed by sunlight. Although such a push is tiny in every day circumstances, it can be large enough to send the space craft outward from the Sun on a cost-free but slow trip. Suppose that the spacecraft has a mass of 900 kg and received a push of 20 N.

**Q.1** The magnitude of the resulting acceleration is :

(A) 45 $ms^{-2}$ (B) 18000 $ms^{-2}$ (C) $\frac{1}{45}$ $ms^{-2}$ (D) None of these

**Q.2** If the craft starts from rest how far will it travel in 1 min :

(A) 40 m (B) 30 m (C) 100 m (D) None of these

**Q.3** How fast will it then be moving :

(A) 3/4 m/s (B) 4/3 m/s (C) 5/4 m/s (D) None of these

# ANSWER KEY

## CONCEPT APPLICATION LEVEL - III

### SECTION-A

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 1. | Vector | 2. | Speed | 3. | Speedometer | 4. | Acceleration. |
| 5. | Retardation | 6. | Positive | 7. | Direction of motion | 8. | Velocity |
| 9. | Vector | 10. | Time | 11. | Straight line | 12. | Does not change |
| 13. | 57.3º | | | | | | |

### SECTION-B

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 1. | D | 2. | D | 3. | D | 4. | B | 5. | B |
| 6. | A | 7. | B | 8. | A | 9. | C | 10. | D |
| 11. | C | 12. | D | 13. | D | 14. | A | 15. | D |
| 16. | C | 17. | D | 18. | D | 19. | D | 20. | A |
| 21. | A | 22. | A | 23. | B | 24. | C | 25. | A |
| 26. | B | 27. | C | | | | | | |

### SECTION-C

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 1. | A,B | 2. | C,D | 3. | A,B | 4. | B,C |
| 5. | A,B | 6. | A,B,C | 7. | A,C | 8. | A,B,C |
| 9. | A,C,D | 10. | A,B | 11. | ABCD | | |

### SECTION-D

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 1. | B | 2. | A | 3. | A | 4. | A | 5. | B |
| 6. | A | | | | | | | | |

### SECTION-E

| | | | |
|---|---|---|---|
| 1. | (A)-(R), (B)-(S), (C)-(P), (D)-(Q) | 2. | (A)-(Q), (B)-(S), (C)-(P), (D)-(R) |
| 3. | (A)-(Q,S), (B)-(P,R), (C)-(Q), (D)-(P,R) | | |

### SECTION-F

| | | | | | |
|---|---|---|---|---|---|
| 1. | C | 2. | A | 3. | B |

# Notes