Exercise -2(A)

1. Differentiate between the scalar and vector quantities, giving two examples of each.

Solution:

Scalar quantity	Vector quantity
It is a physical quantity that is expressed only by its magnitude	It is a physical quantity that requires the magnitude as well as the direction to express it, only after which its meaning is complete.
It is a pure number and has no unit	The numerical value of a vector quantity along with its unit gives us the magnitude of that quantity.
Scalars can be added, Subtracted, multiplied and divided by simple arithmetic methods	Vectors have a different algebra to perform basic addition, subtraction, multiplication and division
Example – mass of a body is 5kg The hospital is at a distance of 5kms.	Example – velocity, displacement, force

2. State whether the following quantity is a scalar or vector?

(a) Pressure
(b) Force
(c) Momentum
(d) Energy
(e) Weight
(f) Speed

Solution:

The table below depicts the categorization:

Scalar quantity	Vector quantity
Pressure	Force
Energy	Momentum
Speed	Weight

3. When is a body said to be at rest?

Solution:

A body is referred to be in a state of rest or stationary when there is no change in the position of the body with regards to its immediate surroundings.

4. When is a body said to be in motion?

Solution:

A body is referred to be in a state of motion when there are changes in the position of the body with regards to its immediate surroundings.

5. What do you mean by motion in one direction?

Solution:

Motion in one direction with reference to a body is when the body moves in a straight line path only.

6. Define displacement. State its unit.

Solution:

Displacement is the shortest distance from the initial to the final position of the body – magnitude wise. Direction of displacement is considered from the initial position to the final position.
The S.I unit of displacement is metre (m)

7. Differentiate between distance and displacement.

Solution:

The differences are as follows:

Distance	Displacement
It is the length of the pathway moved by any body/object at a particular time	It is the distance covered by an object in a particular direction at a certain time.
Scalar quantity	Vector quantity
Dependent on the path followed by the object	Independent of the path followed by the object
Since it has magnitude only, the value is always positive	Since it has both magnitude and direction, it value can be positive or negative
Can be more than or equal to the magnitude of displacement	Can be less than or equal to the distance, but never greater than the distance

8. Can displacement be zero even if distance is not zero? Give one example to explain your answer.

Solution:

Yes, the displacement can be zero even if the distance is not zero. Example – Circular motion of a body results in zero displacement but the distance cannot be zero.

9. When is the magnitude of displacement equal to the distance?

Solution:

The magnitude of displacement is equal to the distance when the motion is in a fixed direction.

10. Define velocity. State its unit.

Solution:

Velocity can be defined as the distance covered per second by a body in a particular direction. The S.I. unit of velocity is metre/second (m/s).

11. Define speed. What is its S.I. unit?

Solution:

Speed can be defined as the rate of change of distance with regards to time. The S.I. unit of time is metre/second (m/s).

12. Distinguish between speed and velocity.

Solution:

The difference between speed and velocity is:

Speed	Velocity
Rate of change of distance with time	Rate of change of displacement of a body with time
Scalar quantity	Vector quantity

It indicates rapidity of object	Along with rapidity, it indicates direction of a object
When the body returns to its initial position, speed will not be zero	When the body returns to its initial position, velocity can be zero
Speed can never be negative	It can either be negative or positive, sometimes zero

13. Which of the quantity speed or velocity gives the direction of motion of body.

Solution:

Speed is a scalar quantity whereas velocity is a vector quantity. Hence, velocity gives direction of motion of body.

14. When is the instantaneous speed same as the average speed?

Solution:

The instantaneous speed is same as the average speed when the acceleration of the body is zero. In order for the acceleration to be zero, neither the speed nor the direction changes.

15. Distinguish between uniform velocity and variable velocity.

Solution:

The difference between uniform velocity and variable velocity is:

Uniform velocity	Variable velocity
If a body travels equal distances in a particular direction, in equal intervals of time, the body is said to be moving with a uniform velocity	If a body moves unequal distances in a particular direction in equal intervals of time or it moves equal distances in equal intervals of time, but its direction of motion does not remain the same, then the velocity of the body is said to be variable.

16. Distinguish between average speed and average velocity.

Solution:

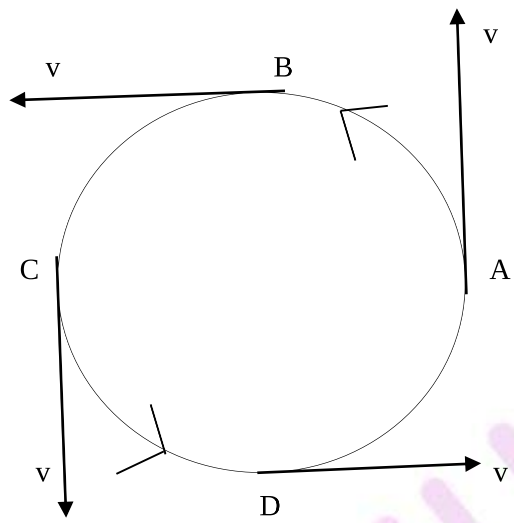
The differences between average speed and average velocity is:

Average speed	Average velocity
It is the ratio of the total distance covered by the body to the total time of journey.	It is the velocity of a body that moves in a specific direction and that which changes with time. This ratio of displacement to the total time taken gives the average velocity
Average speed can never be zero	It can be zero, even if average speed is a non-zero value.

17. Give an example of motion of a body moving with a constant speed, but with a variable velocity. Draw a diagram to represent such a motion.

Solution:

An example of motion of a body moving with a constant speed with variable velocity is the motion of a body in a circular path as in a circular path, the direction of motion of the body changes continuously with time. At any instant, the velocity is along the tangent to the circular path at that point.



18. Give an example of motion in which average speed is not zero, but average velocity is zero.

Solution:

When a body is travelling in a circular car race track where in the initial and the final path are the same, the average speed in not zero but the average velocity is zero.

19. Define acceleration. State its S.I unit.

Solution:

Acceleration can be defined as the rate of change of velocity with time. It can also be defined as the increase in velocity per second. The S.I unit of acceleration is meter per second square or ms^{-2}.

20. Distinguish between acceleration and retardation.

Solution:

The differences are as follows:

Acceleration	Retardation
It is the increase in velocity per second	It is the decrease in the velocity per second
If the final velocity is greater than initial velocity, acceleration is positive	If the final velocity is lesser than initial velocity, acceleration becomes negative, hence it is the retardation.

21. Differentiate between uniform acceleration and variable acceleration.

Solution:

The differences are as follows:

Uniform Acceleration	Variable acceleration
Here, equal changes in velocity occur in equal intervals of time	If change in velocity is not the same in the same intervals of time, then it is variable acceleration

Example – Motion of a body under gravity(free fall of a body)	Example – Motion of a vehicle on a hilly road

22. What is meant by the term retardation? Name its S.I. unit.

Solution:

Retardation can be defined as the decrease in the velocity per second. Since negative acceleration is retardation, its S.I. unit is the same as acceleration.
i.e., metre per second square ms^{-2}

23. Which of the quantity, velocity or acceleration determines the direction of motion?

Solution:

Velocity determines the direction of motion.
The acceleration of the body does not determine its direction of motion while velocity determines its direction of motion. Positive or negative sign of acceleration indicates if the velocity is increasing or decreasing whereas positive or negative sign of velocity indicates the direction of motion.

24. Give one example of each type of the following motion:
(a) Uniform velocity
(b) Variable velocity
(c) Variable acceleration
(d) Uniform retardation

Solution:

Examples for each are as follows:
(a) Uniform velocity – Rain drops reach the earth's surface falling with uniform velocity
(b) Variable velocity – Motion of a body in a circular path
(c) Variable acceleration – Motion of a vehicle on a crowded road
(d) Uniform retardation – A train reaching a station

25. The diagram below shows the pattern of the oil on the road, dripping at a constant rate from a moving car. What information do you get from it about the motion of car?

Solution:

Observing the car gives the following information.
- The car is initially moving with a constant speed
- The dripping of the oil shows that the car is slowing down.

26. Define the term acceleration due to gravity. State its average value.

Solution:

It can be defined as the acceleration produced by a body when it is falling freely under gravity. The acceleration is produced as a result of earth's gravitational attraction. Usually, it is denoted by the letter 'g'. The average value of 'g' is $9.8ms^{-2}$ or nearly 10 ms^{-2} and varies from place to place.

27. **'The value of g remains same at all places on the earth surface'. Is this statement true? Give reason for your answer.**

Solution:

No, the value of 'g' is not the same at all places. The average value of 'g' is 9.8 ms^{-2} and varies from place to place. The value of 'g' is minimum at the equator on the surface of the earth and the maximum at the poles.

28. **If a stone and a pencil are dropped simultaneously in vaccum from the top of a tower, which of the two will reach the ground first? Give reason.**

Solution:

In vaccum, there is no resistance from the viscous force of air hence both the objects i.e., the pencil and the stone will reach the ground at the same time from the top of the tower as the value of acceleration due to gravity 'g', is the same on both the objects.

Multiple choice type:

1. **A vector quantity is:**
   (a) Work
   (b) Pressure
   (c) Distance
   (d) Velocity
   Solution:
   (d) Velocity
   A vector quantity has both magnitude and direction.

2. **The S.I. unit of velocity is:**
   (a) Km h^{-1}
   (b) m min^{-1}
   (c) km min^{-1}
   (d) m s^{-1}
   Solution:
   (d) m s^{-1}
   Velocity is the rate of change of displacement (m) of a body with time(s).

3. **The unit of retardation is:**
   (a) ms^{-1}
   (b) ms^{-2}
   (c) m
   (d) ms^{-2}
   Solution:
   (b) ms^{-2}
   Retardation is negative value of acceleration.

4. **A body when projected up with an initial velocity u goes to a maximum height h in time t and then comes back at the point of projection. The correct statement is:**
   (a) The average velocity is 2h/t

(b) The acceleration is zero
(c) The final velocity on reaching the point of projection is 2u
(d) The displacement is zero

Solution:

(d) The displacement is zero

The displacement is zero if the initial and the final position of the body is same.

5. 18km h^{-1} is equal to:

(a) 10ms^{-1}
(b) 5 ms^{-1}
(c) 18 ms^{-1}
(d) 1.8 ms^{-1}

Solution:

(b) 5 ms^{-1}

Converting $\frac{18 \times 1000m}{60 \times 60}$ = 5ms^{-1}

Numericals:

1. The speed of a car is 72km h^{-1}. Express it in ms^{-1}.

Solution:

Given: speed = 72km/hr

Express speed in m/s

72 km/hr = $\frac{72 \times 1000m}{60 \times 60}$ = 20 m/s

2. Express 15 ms^{-1} in km h^{-1}

Solution:

Express ms^{-1} in km h^{-1}

15 ms^{-1} = $\frac{15 \times 60 \times 60}{1000}$ = 54 km h^{-1}

3. Express each of the following in ms^{-1}:

(a) 1km h^{-1}
(b) 18 km min^{-1}

Solution:

(a) Expressing 1km h^{-1} in ms^{-1}

1 km/hr = $\frac{1 \times 1000m}{60 \times 60}$ = 0.278 ms^{-1}

(b) Expressing 18km h^{-1} in ms^{-1}

18 km/hr = $\frac{18 \times 1000m}{60}$ = 300 ms^{-1}

4. Arrange the following speeds in increasing order:
10 ms^{-1}, 1km min^{-1}, 18 km h^{-1}

Solution:

In order to arrange the following in increasing order of their speeds, we must first bring them all to a similar unit.

Expressing all the three in ms^{-1}
10 ms^{-1} is already in ms^{-1}

1 km min^{-1} = 1 x 1000/60 = 16.67 ms^{-1}

18 km h^{-1} = $\frac{18 \text{ x } 1000\text{m}}{60\ x\ 60}$ = 5 ms^{-1}

Hence, the increasing order is 18 km h^{-1}, 10 ms^{-1}, 1 km min^{-1}

5. A train takes 3h to travel from Agra to Delhi with a uniform speed of 65 km h^{-1}. Find the distance between the two cities.

Solution:
Given: time = 3hours
Speed = 65 km h^{-1}
Distance =?

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

$$\Rightarrow \text{distance} = \text{speed x time}$$
$$= 65 \text{ x } 3$$
$$= 195 \text{ km}$$

6. A car travels first 30km with a uniform speed of 60km h^{-1} and then next 30km with a uniform speed of 40 km h^{-1}. Calculate: (i) the total time of journey, (ii) the average speed of the car.

Solution:
Given:
Let t1, d1 and s1 be the time, distance and speed travelled by the car in the first part of the journey.
Let t2, d2 and s2 be the time, distance and speed travelled by the car in the second part of the journey.
d1 = 30km, s1 = 60km h^{-1},t1 = ?
d2 = 30km, s2 = 40km h^{-1},t2 = ?

(i) Total time of the journey = t1 + t2
We know that,

$$\text{Speed} = \frac{\text{distance}}{\text{time}} \Rightarrow \text{time} = \frac{\text{distance}}{\text{speed}}$$

$$\Rightarrow t1 = \frac{d1}{s1}$$
= 30/60 = ½ hr = 0.5hr

$$\Rightarrow t2 = \frac{d2}{s2}$$

= 30/40 = 0.75 hr

Total time = t1 + t2 = 0.5 + 0.75 = 1.25hrs or 75 minutes

(ii) Average speed = $\frac{\text{total distance travelled}}{\text{total time taken}}$

$= \frac{d1+d2}{t1+t2} = \frac{30+30}{1.25} = \frac{60}{1.25} = 48 \text{ km h}^{-1}$

7. A train takes 2h to reach station B from station A, and then 3 h to return from station B to station A. The distance between the two stations is 200km. Find:

(i) The average speed

(ii) The average velocity of the train

Solution:

(i) Given: distance = 200km,

Let,

time taken to travel from station A to B be 't1'

time taken to travel back from station B to station A be 't2'.

Total time = t1+t2

Total distance travelled is from station A to B and back from station B to A, hence it is 200km+200km = 400km

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

$= \frac{400}{t1+t2} = \frac{400}{2+3} = \frac{400}{5} = 80 \text{ km h}^{-1}$

(ii) As the train travels from Station A to station B and back from station B to A, the displacement is zero. Hence, the average velocity is also zero.

8. A car moving on a straight path covers a distance of 1km due east in 100s. What is (i) the speed and (ii) the velocity of car?

Solution:

Given: d=1km = 1000m, t=100s

(i) Speed = $\frac{\text{distance}}{\text{time}}$

$= \frac{1000}{100} = 10\text{ms}^{-1}$

(ii) The velocity of the car is the same as speed in magnitude along with direction, hence velocity = 10 ms^{-1} due east

9. A body starts from rest and acquires a velocity 10 ms^{-1} in 2s. Find its acceleration.

Solution:

Given: velocity = 10 ms^{-1}, time = 2s

Acceleration = $\frac{\text{Change in velocity}}{\text{time interval}}$ = 10/2 = 5ms^{-2}

10. A car starting from rest acquires a velocity 180 ms^{-1} in 0.05h. Find the acceleration.

Solution:

Given: velocity = 180m/s, time = 0.05h = 0.05 x 60 x 60 = 180s

Acceleration = $\frac{\text{Change in velocity}}{\text{time interval}} = \frac{180}{180} = 1\ ms^{-2}$

11. A body is moving vertically upwards. Its velocity changes at a constant rate from 50 ms^{-1} to 20 ms^{-1} in 3s. What is its acceleration?

Solution:

Given: u=50m/s; v=20m/s, t=3s

Acceleration = $\frac{v-u}{t} = \frac{-30}{3} = -10m/s^2$

The negative sign indicates velocity decreases with time, hence retardation is $10m/s^2$.

12. A toy car initially moving with a uniform velocity of 18km h^{-1} comes to a stop in 2s. Find the retardation of the car in S.I units.

Solution:

Given: u=18km h^{-1}, v=0, t=2s

Converting 18km/hr to m/s

18 km $h^{-1} = \frac{18 \text{ x } 1000m}{60\ x\ 60} = 5\ ms^{-1}$

Acceleration = $\frac{v-u}{t} = \frac{0-5}{2} = -\ 2.5ms^{-2}$

Retardation is 2.5 ms^{-2}

13. A car accelerates at a rate of 5 ms^{-2}. Find the increase in its velocity in 2s.

Solution:

Given: a=5 ms^{-2}, t=2s, v=?

Acceleration = $\frac{\text{Change in velocity}}{\text{time interval}}$

$\Rightarrow$ change in velocity = acceleration x time

= 5 x 2 = 10 ms^{-1}

14. A car is moving with a velocity 20m/s. The brakes are applied to retard it at a rate of $2m/s^2$. What will be the velocity after 5s of applying the brakes?

Solution:

Given: u = 20m/s, retardation=$2m/s^2$, t=5s

If 'v' is the final velocity, then as we know,

Acceleration = $\frac{v-u}{t}$

$-2 = \frac{v-20}{5}$ (retardation is negative acceleration)

$\Rightarrow v - 20 = -(2 \times 5)$

$v = 10 - 20$

$= -10$ m/s

The negative sign is an indication that the velocity is decreasing.

15. A bicycle initially moving with a velocity 5m/s accelerates for 5s at a rate of 2 m/s^2. What will be its final velocity?

Solution:

Given: u = 5m/s, t=5s, a=2m/s^2. V=?

Acceleration = $\frac{v-u}{t}$

$2 = \frac{v-5}{5}$

$10 = v-5$

$v = 15$ m/s

16. A car is moving in a straight line with speed 18km h^{-1}. It is stopped in 5s by applying the brakes. Find: (i) the speed of car in m/s, (ii) the retardation and (iii) the speed of car after 2s of applying the brakes.

Solution:

Given: t=5s, intial velocity=18km/hr

(i) Expressing 18km/hr to m/s

$18 \text{ km h}^{-1} = \frac{18 \times 1000\text{m}}{60 \times 60} = 5 \text{ ms}^{-1}$

(ii) As the car comes to a halt, the final velocity is 0

Retardation is negative acceleration,

Retardation = $\frac{v-u}{t} = \frac{0-5}{5} = -1\text{m/s}^2$

Retardation is 1m/s^2

(iii) If 'v' is the speed of the car after 2s of applying brakes, then acceleration is

Acceleration = $\frac{v-u}{t}$

$-1 = \frac{v-5}{2}$

$v - 5 = -2$

$v = 3$m/s

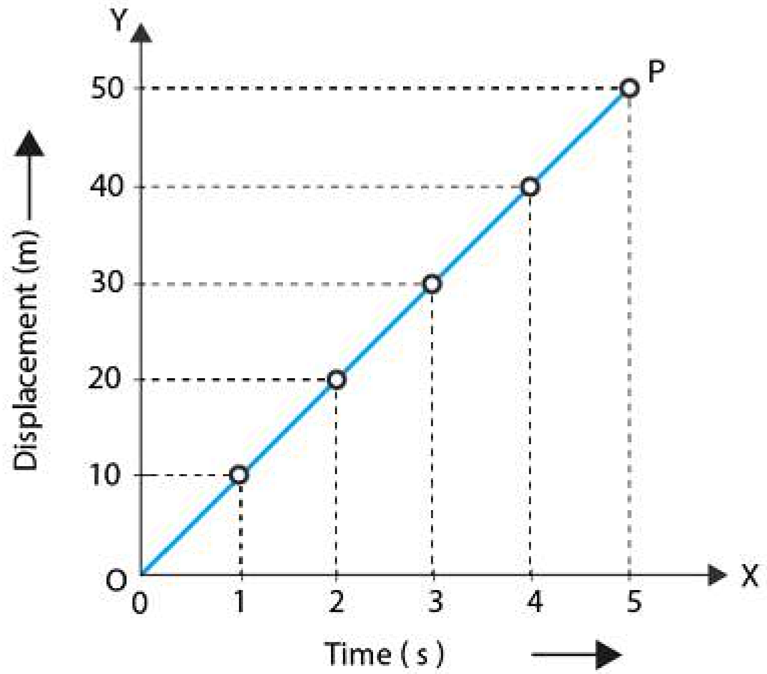
Exercise -2(B)

1. **For the motion with uniform velocity, how is the distance travelled related to the time?**
   Solution:
   Distance is directly proportional to time.

2. **What information about the motion of a body are obtained from the displacement-time graph?**
   Solution:
   The displacement-time graph gives us as idea about the motion of an object/body. With the help of displacement-time graph, a slope can be obtained, through which we can fetch the value of velocity of the body at any point of time that can also be used to trace the velocity-time graph.

3. **(a) What does the slope of a displacement-time graph represent?**
   (b) Can displacement-time sketch be parallel to the displacement axis? Give reason to your answer.
   Solution:
   (a) The slope of a displacement-time graph gives the velocity. If the slope is positive, it indicates that the body is moving away from the reference or the starting point. If the slope is negative, the body is reverting to the initial point.
   (b) No, the displacement-time sketch cannot be parallel to the displacement axis. A line parallel to the displacement axis would indicate that the time is at rest, which is not practically possible, as time is not constant.

4. **Draw a displacement-time graph for a boy going to school with a uniform velocity.**
   Solution:



5. **State how the velocity-time graph can be used to find (i) the acceleration of a body, (ii) the distance travelled by the body in a given time, and (iii) the displacement of the body in a given time.**

Solution:

The velocity-time graph can be used to determine the following:

(i) Acceleration of a body
The slope or gradient of the velocity-time graph gives the acceleration of the body as acceleration is the ratio of rate of change of velocity and time taken.

(ii) Distance travelled by body in a given time
The total distance travelled by the body can be obtained by the arithmetic sum of the distance travelled away from the starting point and the distance travelled towards the starting point.

(iii) Displacement of the body
It can be obtained by the area enclosed between the velocity-time sketch and x-axis.

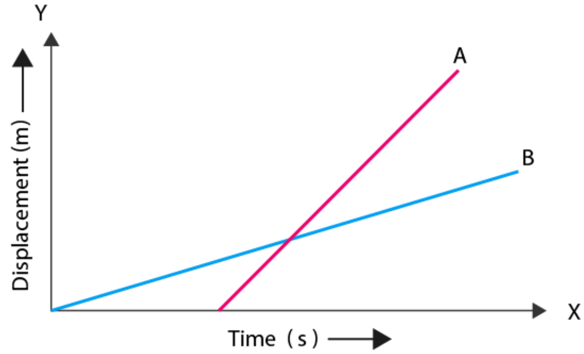
6. **What can you say about the nature of motion of a body if its displacement-time graph is**
(a) A straight line parallel to time axis?
(b) A straight line inclined to the time axis with an acute angle?
(c) A straight line inclined to the time axis with an obtuse angle?
(d) A curve

Solution:

The following can be deduced about the nature of motion of a body, if its displacement-time graph is;

(a) A straight line parallel to time axis – it depicts that the body is at rest. There is no motion
(b) A straight line inclined to the time axis with an acute angle – this indicates that there is motion but away from the reference or starting point, with a uniform velocity
(c) A straight line inclined to the time axis with an obtuse angle – it conveys that there is motion towards the reference or the start point with a uniform velocity
(d) A curve – It depicts that there is motion along with variable velocity

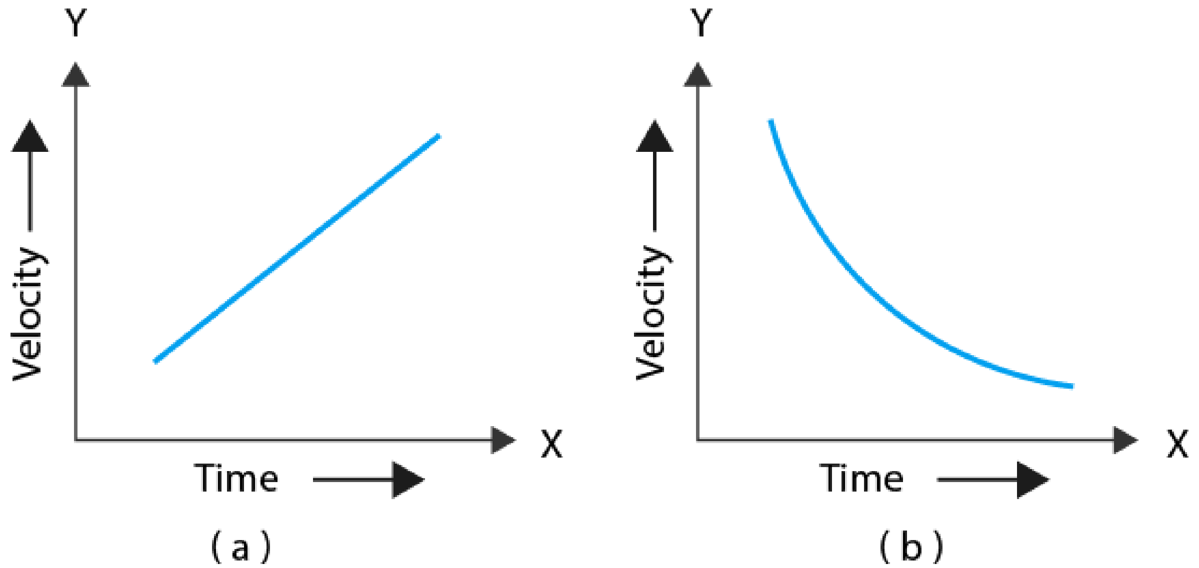
7. **The figure shows displacement-time graph of two vehicles A and B along a straight road. Which vehicle is moving faster? Give reason.**



Solution:

From the graph given it is evident that Vehicle A is moving faster than Vehicle B. It is because, the slope that Vehicle A fetches is more compared to that of Vehicle B.

8. State the type of motion represented by the following sketches in the figure. Give example of each type of motion.



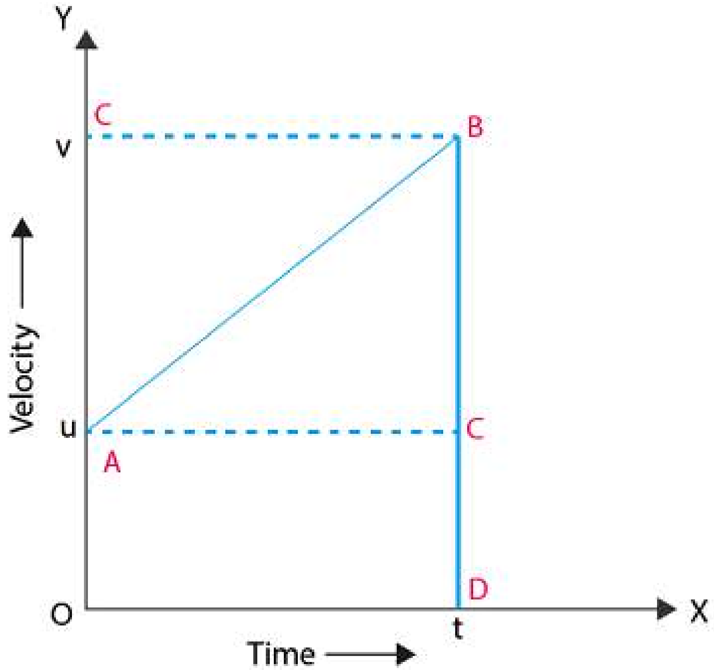
Solution:

(a) The graph depicts uniform accelerated motion.
Example - It is the motion of a body that is liberated downwards.

(b) The graph indicates the motion of a body with variable retardation.
Example – a car reaching its destination.

9. Draw a velocity-time graph for a body moving with an initial velocity u and uniform acceleration a. Use this graph to find the distance travelled by the body in time t.

Solution:



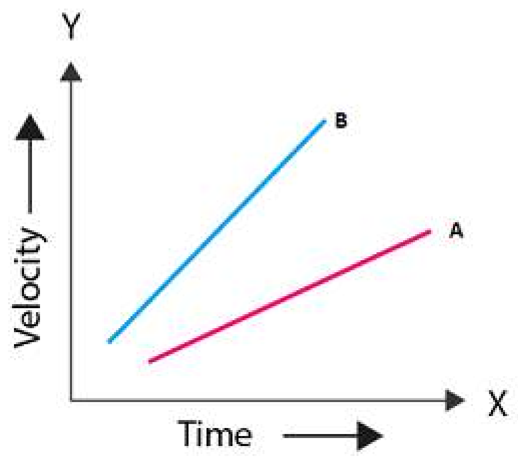
Let, ‘u’ be the initial velocity,
‘v’ be the velocity at time ‘t’ and ‘a’ be the acceleration.

The distance travelled by the body in ‘t’ seconds = area enclosed between the velocity-time graph and x-axis
Or
distance travelled by the body in ‘t’ seconds = area of trapezium OABD
= ½ x (sum of parallel sides) x height
= ½ x (u+v) x t
$= \frac{(u+v)t}{2}$

10. What does the slope of velocity-time graph represent?

Solution:
The slope of the velocity-time graph indicates the acceleration.

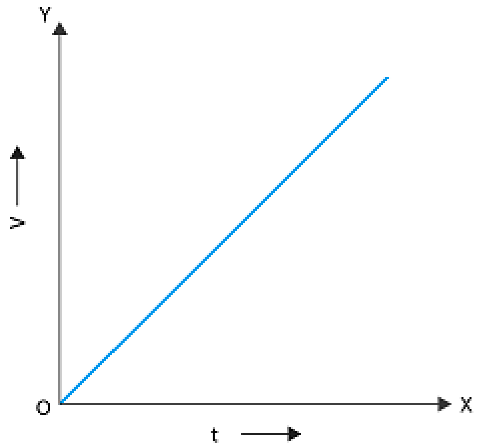
11. Figure shows the velocity-time graph for two cars A and B moving in same direction. Which car has the greater acceleration? Give reason to your answer.



Solution:
From the graph, we can deduce that car B has greater acceleration than car A as the slope of straight line for Car B in the graph is more compared to car A as seen in the graph.

12. Draw the shape of the velocity-time graph for a body moving with (a) uniform velocity, (b) uniform acceleration.

Solution:
Velocity-time graph for a body with uniform velocity and uniform acceleration is

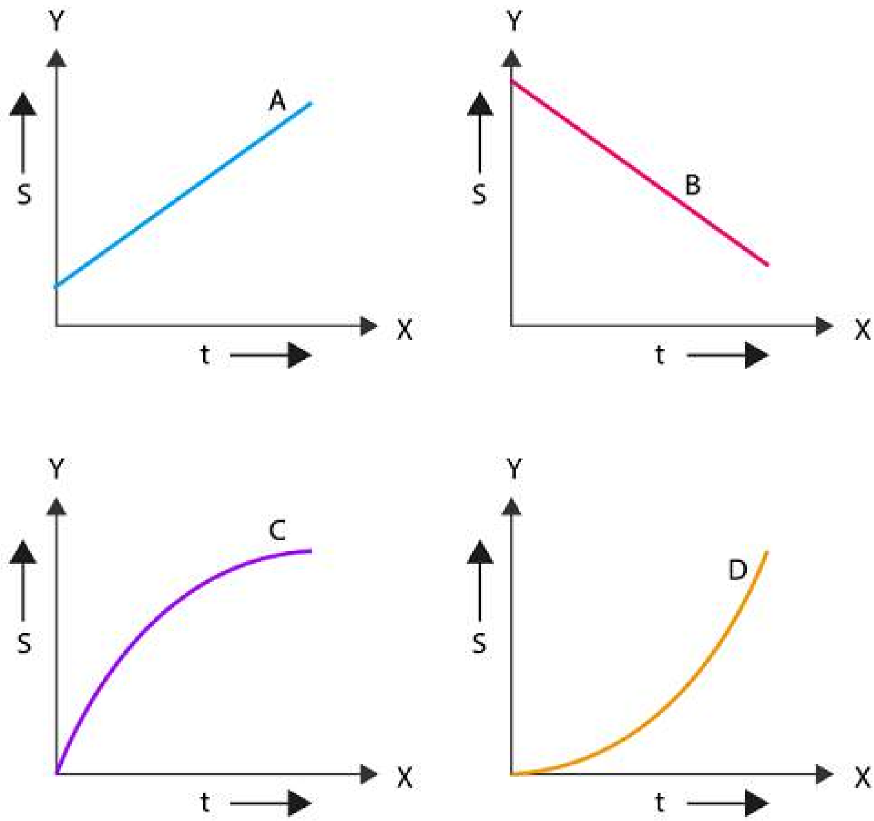


13. The velocity-time graph for a uniformly retarded body is a straight line inclined to the time axis with an obtuse angle. How is retardation calculated from the velocity-time graph?

Solution:

In order to calculate the retardation from the velocity-time graph, a negative slope should be obtained.

14. Figure shows the displacement-time graph for four bodies A, B, C and D. In each case state what information do you get about the acceleration (zero, positive or negative).



Solution:

The following information can be obtained about acceleration:

A – The slope here is constant, velocity is constant hence the acceleration is 0.

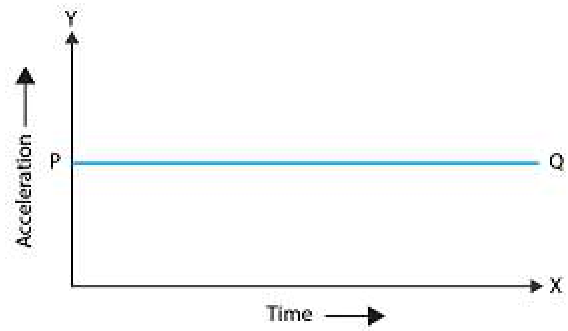
B – Since graph B has a slope that is constant, the acceleration is 0.

C – Graph C shows a slope that is decreasing with time. Hence the acceleration is negative, which is referred to as retardation.

D – Graph D shows a slope that is increasing with time. The acceleration is positive.

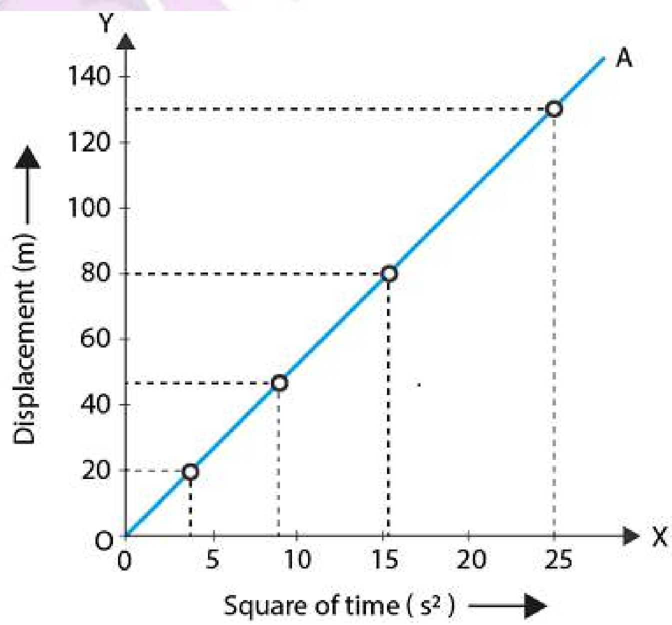
15. Draw a graph for acceleration against time for a uniformly accelerated motion. How can it be used to find the change in speed in a certain interval of time?

Solution:



Changing speed at a particular interval of time can be obtained by the area enclosed between the straight line and the time axis for that interval of time.

16. Draw a velocity-time graph for the free fall of a body under gravity, starting from rest. Take $g=10ms^{-2}$



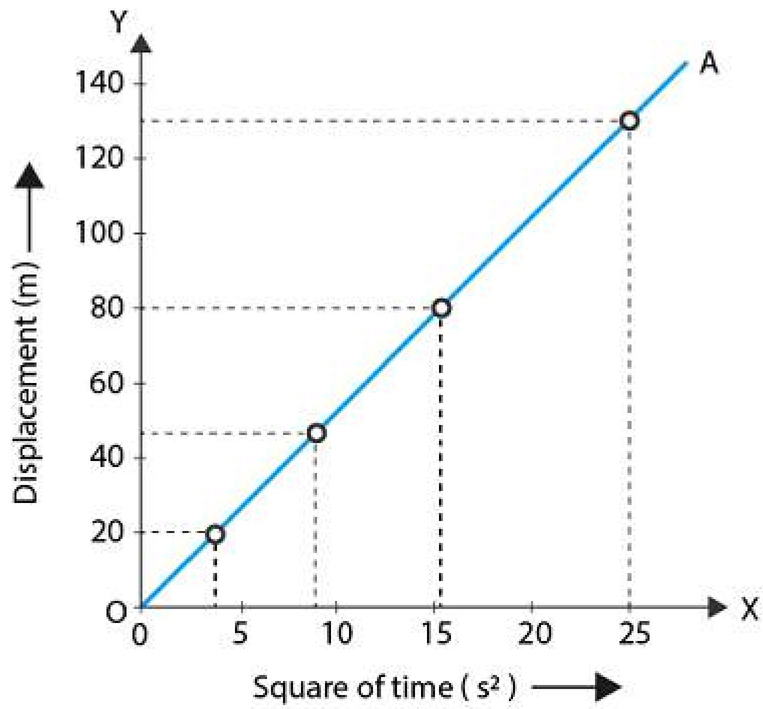
17. How is the distance related with time for the motion under uniform acceleration such as the motion of a freely falling body?

Solution:

For a freely falling body, the displacement is directly proportional to the square of time ($S \propto t^2$).

18. A body falls freely from a certain height. Show graphically the relation between the distance fallen and square of time. How will you determine g from this graph?

Solution:



For a freely falling body, the doubling of the slope of the displacement-time graph can fetch the value of acceleration due to gravity (g).

Multiple choice type:

1. **The velocity-time graph of a body in motion is a straight line inclined to the time axis. The correct statement is:**
   (a) Velocity is uniform
   (b) Acceleration is uniform
   (c) Both velocity and acceleration are uniform
   (d) Neither velocity nor acceleration is uniform

   Solution:

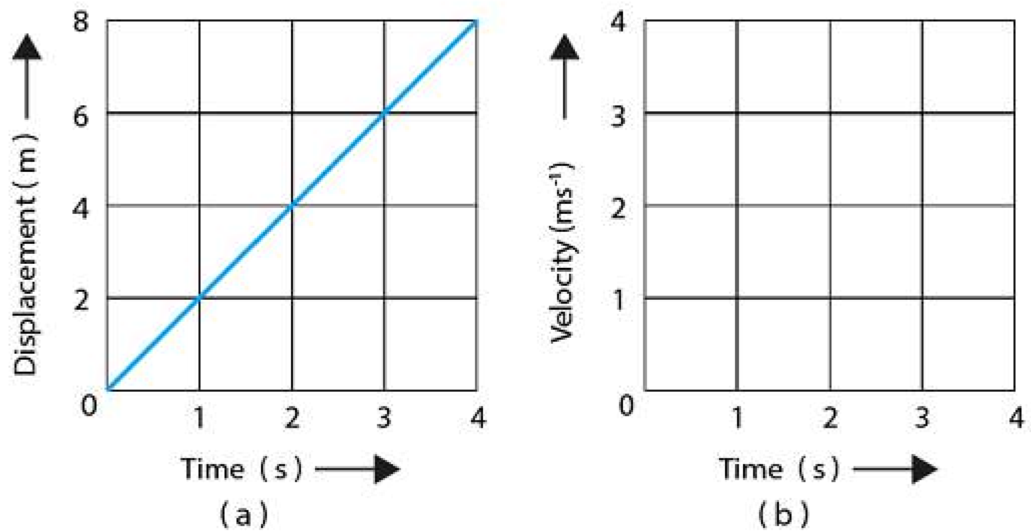
   (b) Acceleration is uniform
   If the velocity-time graph is a straight line inclined to the time axis, the motion is with uniform acceleration.

2. **For a uniformly retarded motion, the velocity-time graph is:**
   (a) A curve
   (b) A straight line parallel to the time axis
   (c) A straight line perpendicular to the time axis
   (d) A straight line inclined to the time axis
   Solution:
   (d) A straight line inclined to the time axis

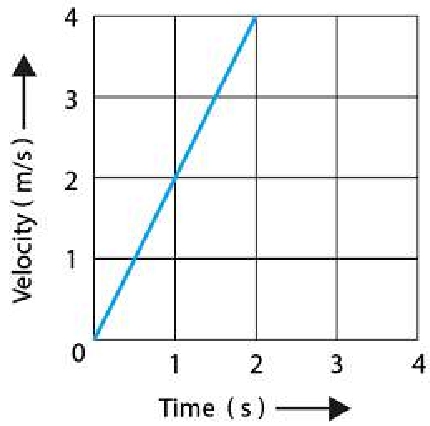
3. **For the uniform motion:**
   (a) The distance-time graph is a straight line parallel to the time axis
   (b) The speed-time graph is a straight line inclined to the time axis
   (c) The speed-time graph is a straight line parallel to the time axis
   (d) The acceleration-time graph is a straight line parallel to the time axis.
   Solution:
   (c) The speed-time graph is a straight line parallel to the time axis

Numericals:

1. **Figure shows the displacement-time graph for the motion of a body. Use it to calculate the velocity of body at t=1s, 2s and 3s, then draw the velocity-time graph for it in figure (b).**



Solution:
From the graph given, the velocity can be observed,
At time,
t=1s, velocity is 2ms^{-1}
t=2s, velocity is 4 ms^{-1}
t=3s, velocity is 6 ms^{-1}



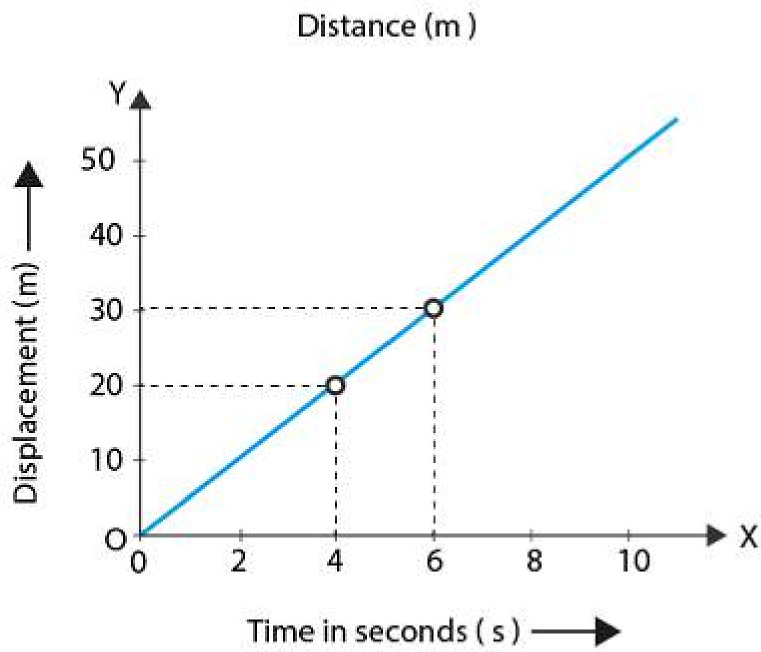
2. Following table gives the displacement of a car at different instants of time.

Time (s)	**0**	**1**	**2**	**3**	**4**
Displacement (m)	**0**	**5**	**10**	**15**	**20**

(a) Draw the displacement-time sketch and find the average velocity of car.
(b) What will be the displacement of car at (i) 2.5s and (ii) 4.5s?

Solution:

(a) Figure is as follows:



As per the graph,

Average velocity of car = $\frac{\text{displacement at point B – displacement at point A}}{\text{time taken}}$

$= \frac{30-20}{6-4} = 5$ m/s

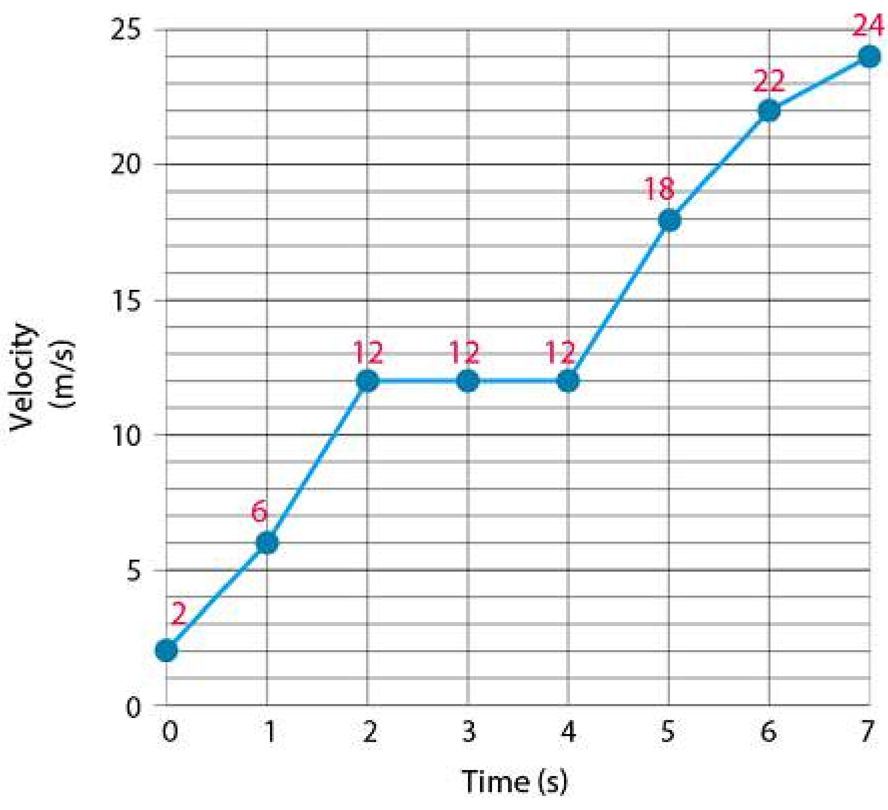
(b) We can observe from the graph, the displacement of the car at various points,
At t=2.5s, displacement is 12.5m
At t=4.5s, displacement is 22.5m

3. A body is moving in a straight line and its displacement at various instants of time is given in the following table:

Time (s)	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**
Displacement (m)	**2**	**6**	**12**	**12**	**12**	**18**	**22**	**24**

Plot displacement-time graph and calculate:
(i) Total distance travelled in interval 1s to 5s,
(ii) Average velocity in time interval 1s to 5s.

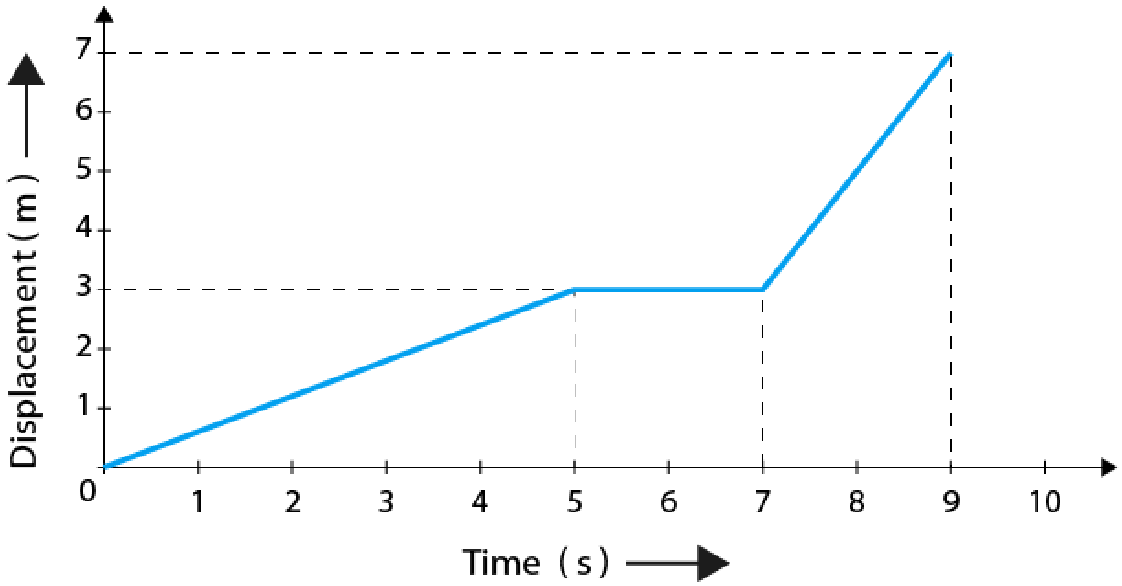
Solution:



(i) The total distance that is covered in interval 1s to 5s = 18m-6m = 12m

(ii) Average velocity = $\frac{\text{displacement in given time interval}}{\text{time interval}} = \frac{12}{4} = 3\text{m/s}$

4. **Figure shows the displacement of a body at different times.**



(a) Calculate the velocity of the body as it moves for time interval (i) 0 to 5s, (ii) 5s to 7s and (iii) 7s to 9s.
(b) Calculate the average velocity during the time interval 5s to 9s.
[Hint: From 5s to 9s, displacement=7m -3m = 4m]

Solution:

(a) Velocity = displacement/time

(i) at time interval 0s to 5s

velocity = 3/5 = 0.6m/s

(ii) at time interval 5s to 7s

velocity = 0/2 = 0m/s

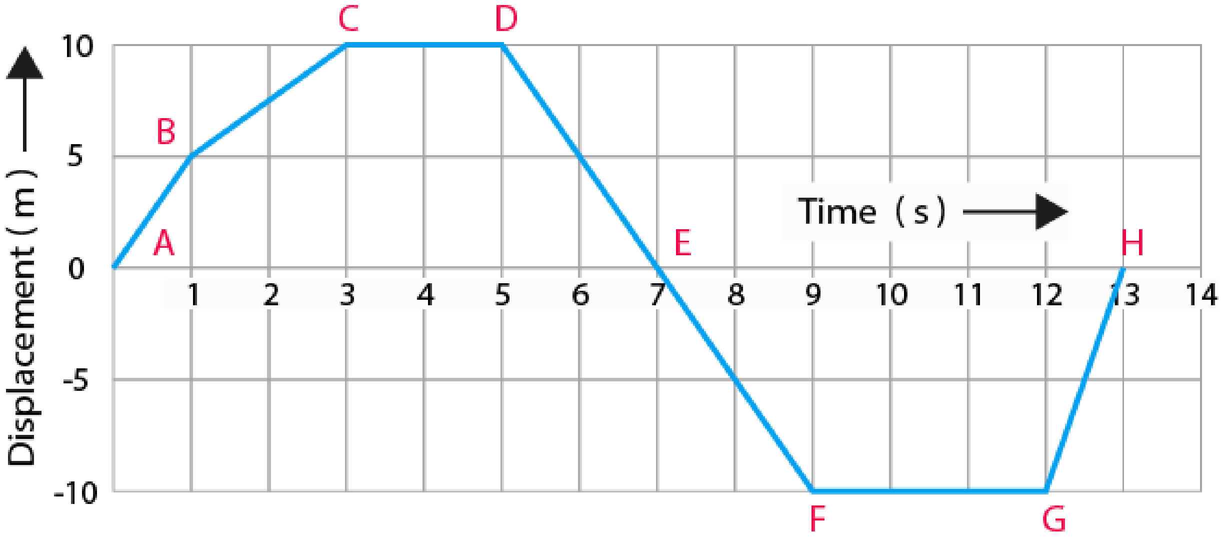
(iii) at time interval 7s to 9s

velocity = (7-3)/(9-7) = 4/2 = 2m/s

(b) Displacement = 7m-3m=4m, time interval = 9s-5s=4s

Average velocity = $\frac{\text{displacement in given time interval}}{\text{time interval}} = \frac{4m}{4s}$ = 1m/s

5. **From the displacement-time graph of a cyclist, given in figure, find:**
   - **(i) The average velocity in the first 4s,**
   - **(ii) The displacement from the initial position at the end of 10s**
   - **(iii) The time after which he reaches the starting point.**



Solution:

(i) As per the graph, displacement in 4s=10m,

Average velocity = displacement/time = 10/4 = 2.5m/s

(ii) The displacement at initial point = 0m

Final position at the end of 10s = -10m

Displacement = final position – initial point = (-10)m – 0 = -10m

(iii) The cyclist would reach the start point at two instances, one at the 7^{th} second and the other at the 13^{th} second.

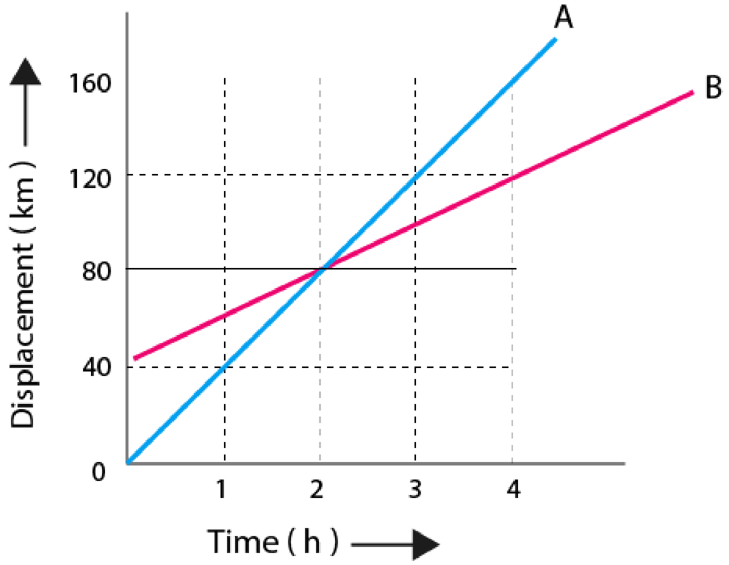
6. Figure ahead represents the displacement-time sketch of motion of two cars A and B. Find:

(i) The distance by which the car B was initially ahead of car A.

(ii) The velocities of car A and car B

(iii) The time in which car A catches car B

(iv) The distance from start when the car A will catch the car B



Solution:

(i) As per the graph, the car B was ahead of car A by 40km

(ii) The lines of car A and B as per the graph are straight indicating they have uniform velocities.

Displacement of car A:
Time = 1hour, distance = 40km
Velocity = displacement/time
= 40/1 = 40km/h

Displacement of car B:
Time=4 hour, distance = (120-40) = 80km
Velocity = displacement/time
= 80/4=20km/h

(iii) As per the graph, both cars A and B intersect at a point, it is at this point the car A catches car B, i.e., 2hours

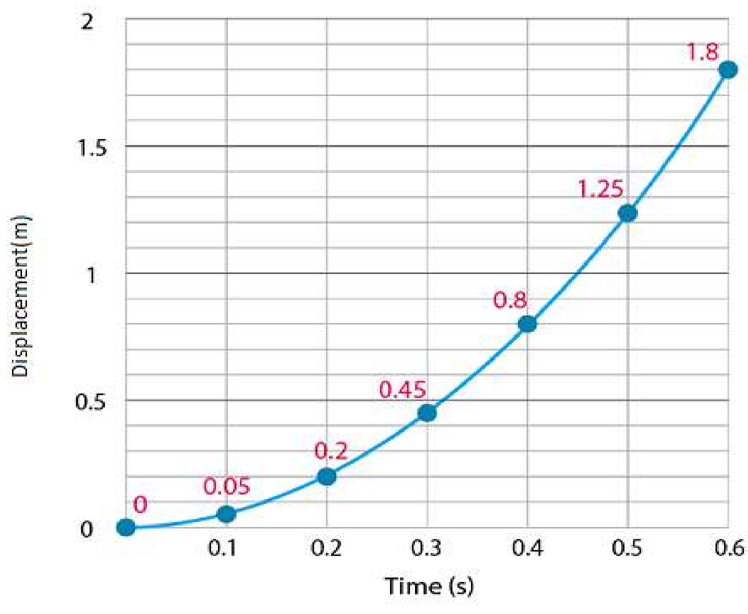
(iv) As observed in the graph, the distance from the start when car A will catch car B is 80km.

7. A body at rest is made to fall from the top of a tower. Its displacement at different instants is given in the following table:

Time (in s)	**0.1**	**0.2**	**0.3**	**0.4**	**0.5**	**0.6**
Displacement (in m)	**0.05**	**0.20**	**0.45**	**0.80**	**1.25**	**1.80**

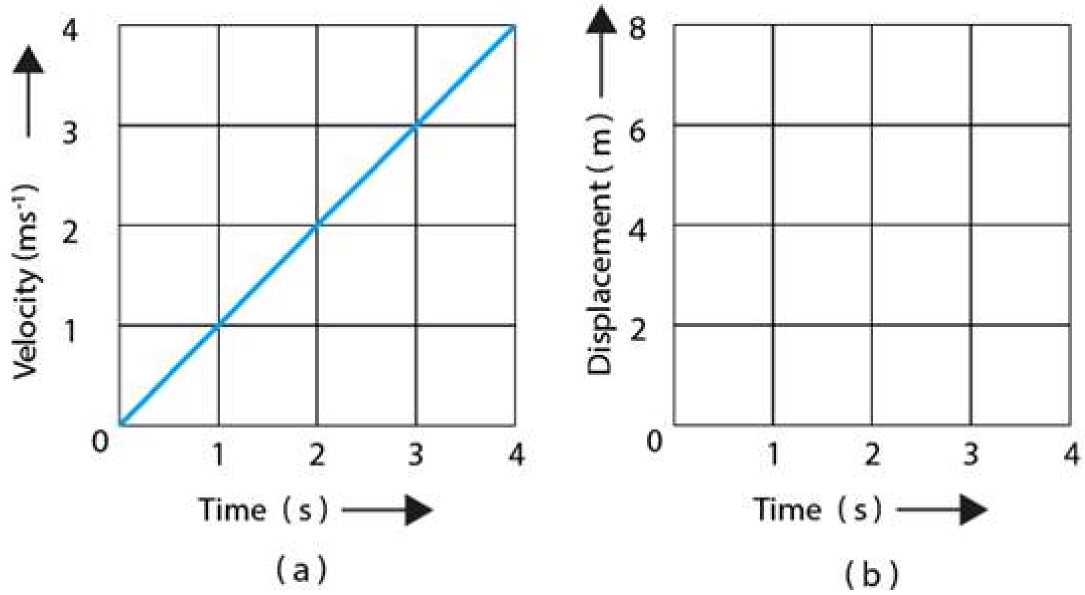
Draw a displacement-time graph and state whether the motion is uniform or non-uniform?

Solution:



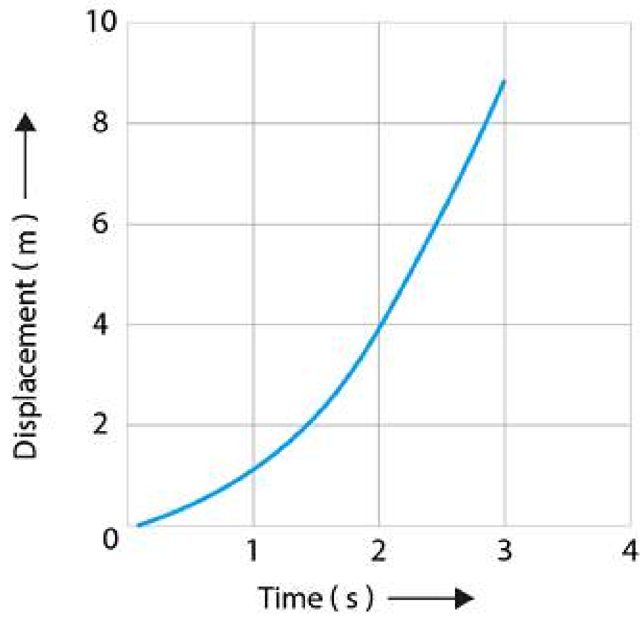
The motion is non-uniform as the displacement-time graph is a curve.

8. Figure shows the velocity-time graph for the motion of a body. Use it to find the displacement of the body at t=1s, 2s, 3s and 4s, then draw the displacement-time graph for it on figure (b).

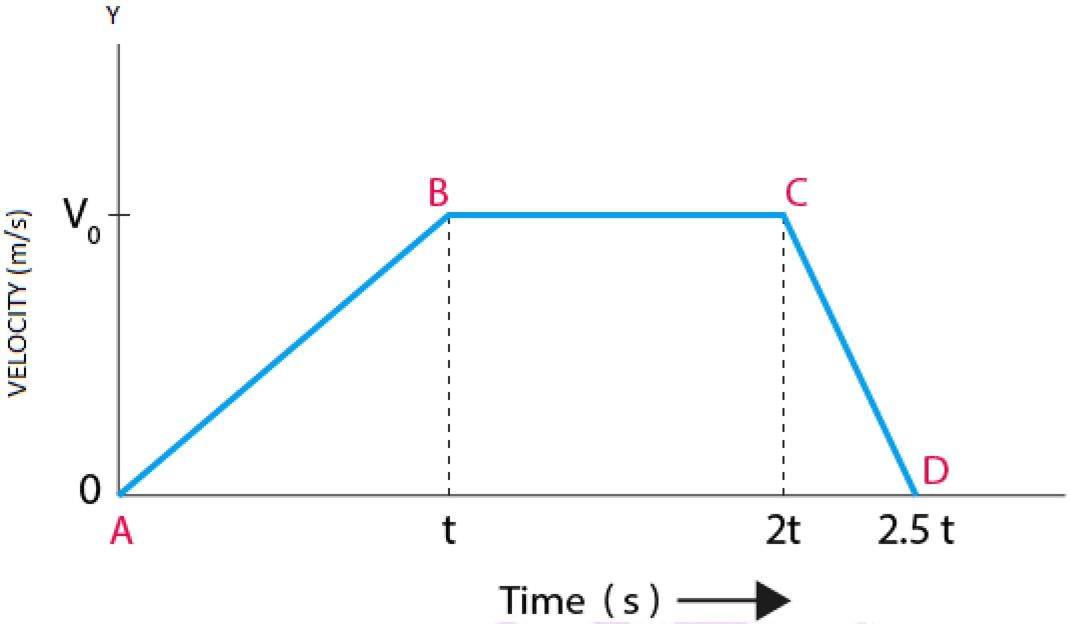


Solution:
As per the graph,

Velocity(m/s)	Time(s)	Displacement(m)= velocity x time
1	1	1
2	2	4
3	3	9



9. Figure below shows a velocity-time graph for a car starting from rest. The graph has three parts AB, BC and CD.



(i) State how is the distance travelled in any part determined from this graph

(ii) Compare the distance travelled in part BC with the distance travelled in part AB.

(iii) Which part of graph shows motion with uniform (a) Velocity (b) acceleration (c) retardation?

(iv) (a) Is the magnitude of acceleration higher or lower than that of retardation? Give a reason.

(b) Compare the magnitude of acceleration and retardation.

Solution:

(i) The distance travelled in any part of the graph can be determined by finding the area that is covered by the graph in that part with the time axis

(ii) As per the graph,

Distance travelled in part BC = Area of rectangle tBC2t

= length x breadth

= $(2t-t) \times v_0$

= $v_0 t$

Distance travelled in part AB = Area of triangle ABt

= ½ x base x height

= ½ x t x v_0

= $v_0 t/2$

The distance travelled in part BC can be compared to the distance travelled in part AB, it is in the ratio, 2:1.

(iii) (a) Uniform velocity is shown at BC

(b) Uniform acceleration is shown at AB

(c) Uniform retardation is shown at CD

(iv) (a) The magnitude of acceleration is lower than that of retardation as the slope of line AB is less in comparison to the line CD.

(b) Slope of line AB gives magnitude of acceleration while slope of line CD gives magnitude of retardation

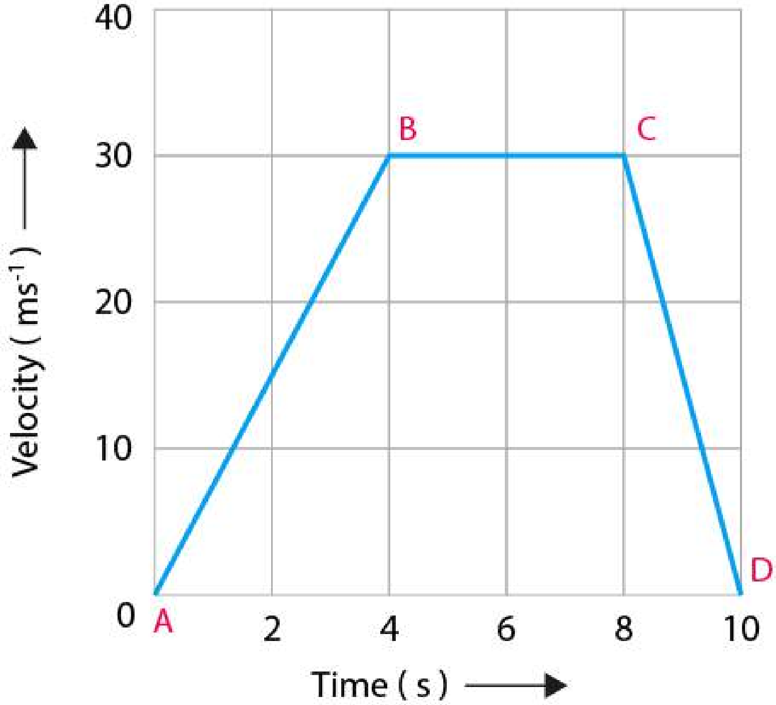
Slope of line AB = v_0 / t

Slope of line CD = $v_0/0.5t$

The magnitude of acceleration and retardation = Slope of line AB/ Slope of line CD

= $(v_0 / t) / (v_0/0.5t)$ = 1:2

10. The velocity-time graph of a moving body is given below in figure



Find:

(i) The acceleration in parts AB, BC and CD.

(ii) Displacement in each part AB, BC, CD, and

(iii) Total displacement.

Solution:

(i) The acceleration in the mentioned parts are given below:

Acceleration in AB=slope of AB

= tan (∠BAD) = 30 ÷4 m/s^2 = 7.5 m/s^2

Acceleration in BC is zero

Acceleration in CD=slope of CD

= tan (∠CDA) = - (30÷2) m/s^2 = -15 m/s^2

(ii) Displacement in each part can be expressed as area of rectangle and triangle.

Displacement of part AB= Area of triangle AB4

= ½ x base x height

= ½ x 4 x 30

= 60m

Displacement of part CD= Area of triangle CBD

= ½ x base x height

= ½ x 2 x 30

= 30m

Displacement of part BC= Area of rectangle 4BC8

= length x breadth

= 30 x 40

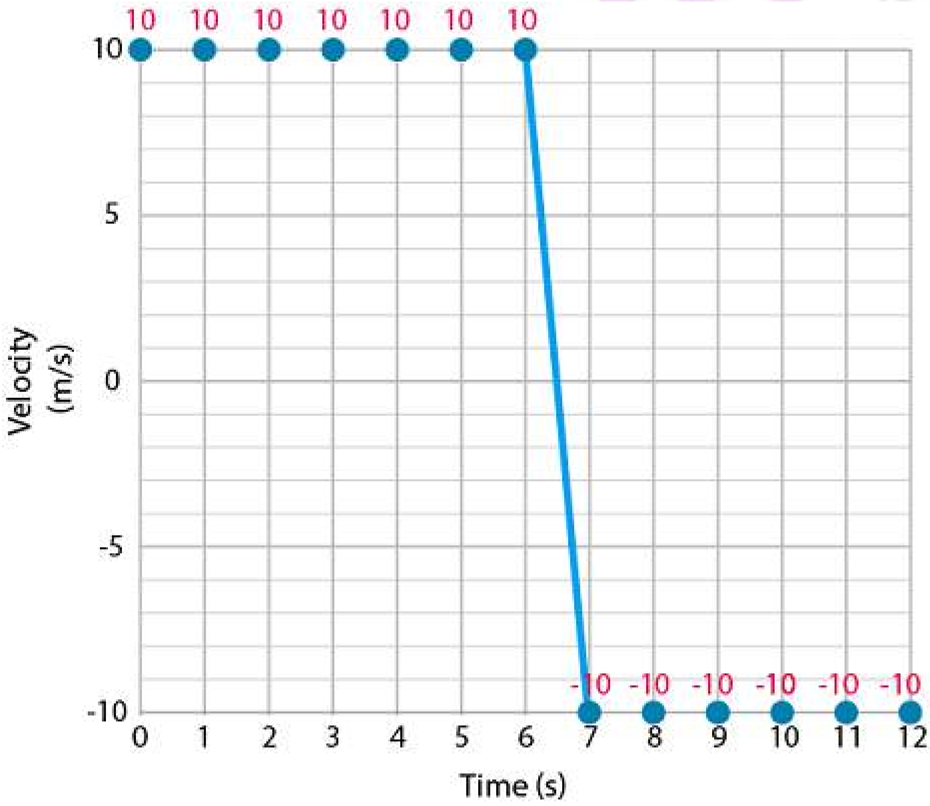
= 120m

(iii) Total displacement = Displacement of part AB + Displacement of part CD + Displacement of part BC

= 60 + 120 + 30 = 210m

11. A ball moves on a smooth floor in a straight line with a uniform velocity 10m/s for 6s. At t=6s, the ball hits a wall and comes back along the same line to the starting point with same speed. Draw the velocity-time graph and use it to find the total distance travelled by the ball and its displacement.

Solution:



To find the total distance, distance travelled in the first 6 seconds and next 6 seconds must be calculated.

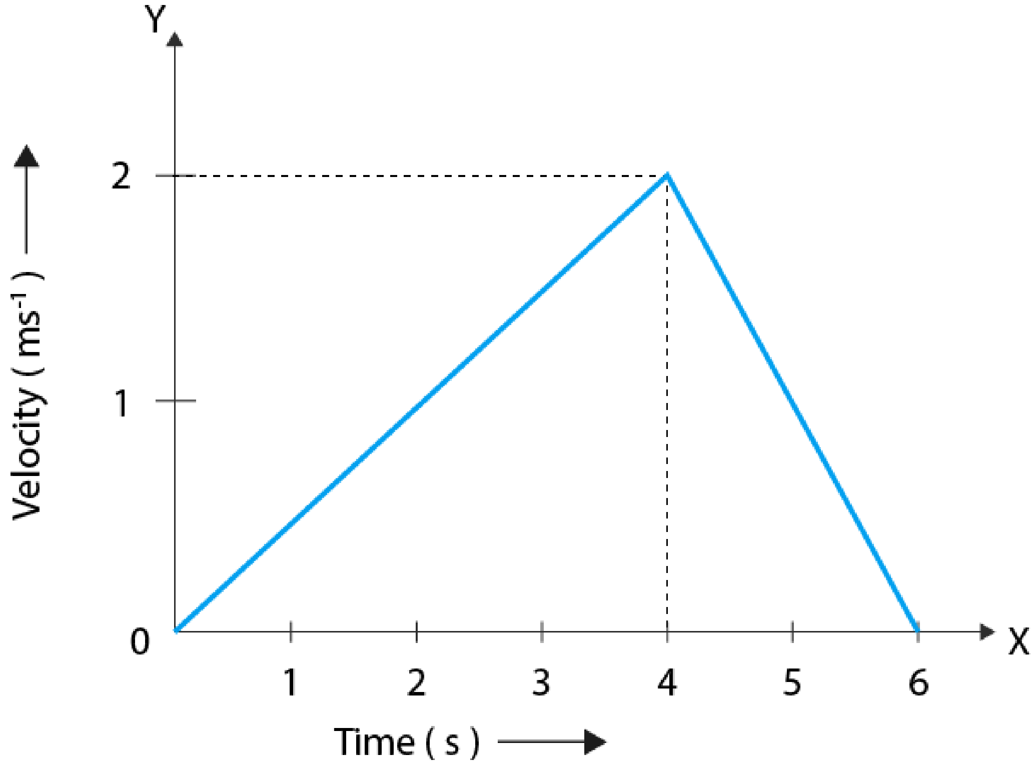
Distance covered in 6s = velocity x time
= 10 x 6 = 60 m/s

Distance covered in the next 6s = velocity x time
= 10 x 6 = 60 m/s

Total distance covered in a matter of 6+6= 12 seconds is
= 60 + 60 = 120m

As the ball returns to the initial point, the displacement is zero.

12. Figure shows the velocity-time graph of a particle moving in a straight line.



(i) State the nature of motion of particle.
(ii) Find the displacement of particle at t=6s.
(iii) Does the particle change its direction of motion?
(iv) Compare the distance travelled by the particle from 0 to 4s and from 4s to 6s.
(v) Find the acceleration from 0 to 4s and retardation from 4s to 6s.

Solution:

(i) The nature of motion of particle is that from 0s to 4s, particles are uniformly accelerated and then from 4s to 6s, particles are uniformly retarded.

(ii) Given: t=6s

Displacement = area of triangle
= ½ x 6 x 2 = 6m

(iii) No, the particle does not change its direction of motion

(iv) Distance travelled from 0s to 4s = area of triangle = ½ x 4 x 2 = 4m
Distance travelled from 4s to 6s = area of triangle = ½ x 2 x 2 = 2m
Comparing both distances obtained, ratio is 4:2 = 2:1

(v) The acceleration from 0s to 4s = velocity/ time taken = 2/4 = 0.5 m/s^2
Retardation from 4s to 6s = velocity/ time taken = 2/2 = 1 m/s^2

Exercise -2(C)

1. **Write three equations of uniformly accelerated motion relating the initial velocity (u), final velocity (v), time (t), acceleration (a) and displacement (S).**

Solution:

The three equations of uniformly accelerated motion relating to initial velocity(u), final velocity(v), time(t), acceleration(a) and displacement(S) are as follows:

(i) $v = u + at$

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

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

2. **Derive the following equations for a uniformly accelerated motion:**

(i) $v = u + at$

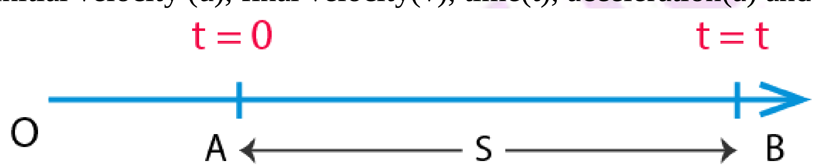
(ii) $S = ut + \frac{1}{2} at^2$

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

where the symbols have their usual meanings.

Solution:

Let initial velocity (u), final velocity(v), time(t), acceleration(a) and displacement(S)



First law of Motion

(i) We know that acceleration is the rate of change of velocity;

$$\text{Acceleration} = \frac{\text{change in velocity}}{\text{time taken}}$$

$$a = \frac{\text{Final velocity} - \text{Initial velocity}}{\text{time taken}}$$

$$a = \frac{v-u}{t}$$

$$at = v-u$$

$$\therefore v = u + at \quad \text{------------- equation (1)}$$

(ii) We know that distance travelled = average velocity x time

$$S = \frac{\text{Initial velocity} + \text{Final velocity}}{2} \times \text{time}$$

$$S = \frac{u+v}{2} \times \text{time}$$

From equation (1), $v = u + at$, substituting the value of v in the above equation;

$$S = \frac{u + u + at}{2} \times \text{time}$$

$$S = \frac{2u + at}{2} \times t$$

$\therefore S = ut + ½ at^2$ ------------- equation (2)

(iii) We know that distance travelled = average velocity x time

Or $S = \frac{u+v}{2} \times t$

From equation (1), v = u + at or $t = \frac{v-u}{a}$

$\therefore S = \frac{u+v}{2} \times \frac{v-u}{a} = \frac{v^2-u^2}{2a}$

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

$v^2 = u^2 + 2aS$

3. Write an expression for the distance S covered in time T by a body which is initially at rest and starts moving with a constant acceleration a.

Solution:

Let,

distance be 's'
acceleration 'a'
time taken 't'
initial velocity u=0

We know that distance can be expressed as:

$S = ut + ½ at^2$

Since u=0 here, equation becomes;

$S = ½ at^2$

Multiple choice type:

1. The correct equation of motion is:

(a) v = u + 2aS
(b) v = ut + a
(c) S = ut + ½ at
(d) v = u + at

Solution:
(d) $v = u + at$
Where u is the initial velocity, v is the final velocity, a is the acceleration and t is the time

2. **A car starting from rest accelerates uniformly to acquire a speed 20km/h in 30 min. The distance travelled by car in this time interval will be:**
(a) 600km
(b) 5km
(c) 6km
(d) 10km
Solution:
(b) 5km
$v = u + at$
$20 = 0 + a(1/2)$
$a = 40 km/h$
$S = ut + ½ at^2$
$= 0(1/2) + ½ (40)(1/2)^2$
$= 0+5 = 5km$

Numericals:

1. **A body starts from rest with a uniform acceleration of 2m/s. Find the distance covered by the body in 2s.**
Solution:
Given:
$u=0$; $a=2 m/s^2$; $t=2s$

$v = u + at$
$= 0 + 2 \times 2$
$v = 4 m/s$

distance travelled, $s = ut + ½ at^2$
$= 0(2) + ½ (2) (2)^2$
$= 0 + 4$
$= 4m$

2. **A body starts with an initial velocity of 10m/s and acceleration $5 m/s^2$. Find the distance covered by it in 5s.**
Solution:
Given:
$u=10 m/s$; $a=5 m/s^2$; $t=5s$; $s=?$

distance travelled, $s = ut + ½ at^2$
$= 10 \times 5 + ½ (5) (5)^2$
$= 50 + 62.5$
$= 112.5m$

3. **A vehicle is accelerating on a straight road. Its velocity at any instant is 30km/h, after 2s, it is 33.6km/h and after further 2s, it is 37.2km/h. Find the acceleration of vehicle in m/s^2. Is the acceleration uniform?**

Solution:
We know that acceleration = rate of change of velocity/time taken
Velocity in the first 2 seconds is 33.6km/h-30km/h = 3.6km/h
∴ Acceleration = 3.6/2 = $1.8km/h^2$
Converting km/h^2 to m/s^2
1.8 x 1000/60x60 = $0.5m/s^2$

Velocity after 2 seconds is 37.2km/h-33.6km/h = 3.6 km/h
∴ Acceleration = 3.6/2 = $1.8km/h^2$
Converting km/h^2 to m/s^2
1.8 x 1000/60x60 = $0.5m/s^2$

Comparing acceleration from both instances it can be said that the acceleration is uniform.

4. **A body, initially at rest, starts moving with a constant acceleration $2m/s^2$. Calculate: (i) the velocity acquired and (ii) and the distance travelled in 5s.**

Solution:
Given: $a=2m/s^2$, u=0m/s, v=?; t=5s; s=?
(i) v=u+at
= 0 + 2x5
v = 10m/s
(ii) $s = ut + \frac{1}{2} at^2$
$= 0(5) + \frac{1}{2}(2)(5)^2$
= 0 + 25
Distance travelled = 25m

5. **A body initially moving with a velocity 20m/s strikes a target and comes to rest after penetrating a distance 10cm in the target. Calculate the retardation caused by the target.**

Solution:
Given: u=20m/s, v=0, s=10cm or 0.1m
We know that;
$v^2 = u^2 + 2aS$
$(0)^2 = (20)^2 + 2(a)(0.1)$
0 = 400 + 0.2a
-a = 400/0.2
$a = -2000m/s^2$
∴ Retardation is $2000m/s^2$

6. **A train moving with a velocity of 20m/s is brought to rest by applying brakes in 5s. Calculate the retardation.**

Solution:
Given: u=20m/s; v=0; t=5s, a=?
We know that acceleration = (final velocity – initial velocity) / time taken

= (0-20)/5 = -4m/s^2
∴ Retardation is 4m/s^2

7. **A train travels with a speed of 60km/h from station A to station B and then comes back with a speed 80km/h from station B to station A. Find: (i) the average speed, and (ii) the average velocity of train.**

Solution:
Assume 'd' to be the distance between station A and station B.

(i) Average speed = $\frac{\text{total distance travelled}}{\text{total time taken}}$

Total distance travelled = d + d = 2d
Total time taken = travel time from station A to B + travel time from station B to A

$= \frac{\text{(distance travelled from station A to B)}}{\text{speed}} + \frac{\text{(distance travelled from station B to A)}}{\text{speed}}$

= (d/60) seconds + (d/80) seconds
= 140d/4800

Average speed = $\frac{\text{total distance travelled}}{\text{total time taken}} = \frac{2d}{\frac{140d}{4800}}$ = (2 x 4800)/140
= 68.57km/h

(ii) To find the average velocity, displacement should be known;
As we know, Average velocity = displacement/total time
Since the train starts the journey and end the journey at the same station, the displacement is zero, therefore, the average velocity is also zero.

8. **A train is moving with a velocity of 90km/h. It is brought to stop by applying the brakes which produce a retardation of 0.5m/s^2. Find: (i) the velocity after 10s, and (ii) the time taken by the train to come to rest.**

Solution:
Given:
u=90km/h , expressing in m/s = (90x1000)/60x60=25m/s
v=0m/s; a=-0.5m/s^2

(i) t=10s; We know that v=u+at
substituting values:
v=u+at
= 25+(-1/2)(10)
= 25 – 5
= 20m/s

(ii) v=0; u=25m/s
v = u + at
t = (v-u)/a
= (0-25)/(-0.5)
= 50s

9. **A car travels a distance 100m with a constant acceleration and average velocity of 20m/s. The final velocity acquired by the car is 25m/s. Find: (i) the initial velocity and (ii)**

acceleration of car.

Solution:

Given: v=25m/s; s=100m; average velocity=20m/s

(i) We know that average velocity = (u+v)/2

20 = (u+25)/2

u = 40-25 = 15m/s

(ii) $v^2 - u^2 = 2aS$

$(25)^2 - (15)^2 = 2 \times a \times 100$

625-225=200a

$a = 2m/s^2$

10. When brakes are applied to a bus, the retardation produced is 25cm/s and the bus takes 20s to stop. Calculate: (i) the initial velocity of bus, and (ii) the distance travelled by the bus during this time.

Solution:

Given: retardation=$-25cm/s^2$. Expressing in m/s^2 it is $-0.25\ m/s^2$; t=20s

(i) We know that v=u+at

u= v-at = (0-(-0.25) x 20 = 5 m/s

(ii) To find the distance travelled;

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

$(0)^2 - (5)^2 = 2\ (-0.25)(s)$

s = 25/0.5 = 50m

11. A body moves from rest with a uniform acceleration and travels 270m in 3s. Find the velocity of the body at 10s after the start.

Solution:

Given: u=0m/s; s=270m; t=3s;

We know that;

$S = ut + ½ at^2$

Substituting values;

$270 = 0 + (1/2)a(3)^2$

270 = 9/2a

$a = 60\ m/s^2$

after time = 10s, velocity is

v = u + at

= 0 + 60 x 10 = 600m/s

12. A body moving with a constant acceleration travels the distances 3m and 8m respectively in 1s and 2s. Calculate: (i) the initial velocity, and (ii) the acceleration of body.

Solution:

Let distance travelled in time t1=1s be s1=3m

Let distance travelled in time t2=2s be s2=8m

We know that $s = ut + ½ at^2$, substituting for s1 and s2 is:

$S1=ut1 + ½ at1^2$ and $S2=ut2 + ½ at2^2$

Subtracting s1 from s2, we get;

$S2-S1 = u(t2-t1) + 1/2a (t2^2 – t1^2)$
$8-3 = u(2-1) + 1/2 a(4-1)$
$5 = u + 3/2a$
$a = (10-2u)/3$ - equation 1

use this value of 'a' obtained in equation for S1, we get;

$S1=ut1 + ½ at1^2$
$3=u(1)^2 + ½ [(10-2u)/3](1)^2$
$3 = u + \frac{10-2u}{6}$
$18= 6u + 10 – 2u$
$u =2m/s$

using the value of u obtained in equation 1, we get;

$a= (10-2u)/3$
$a=6/3$
$a=2m/s^2$

13. A car travels with a uniform velocity of 25m/s for 5s. The brakes are then applied and the car is uniformly retarded and comes to rest in further 10s. Find: (i) the distance which the car travels before the brakes are applied, (ii) the retardation and (iii) the distance travelled by the car after applying the brakes.

Solution:

Given: u=25m/s; v=0;

(i) The distance which the car travels before brakes are applied is:
Distance = speed x time
= 25 x 5
= 125m

(ii) Retardation = (final velocity-initial velocity)/time taken
$= -(5/2) = -2.5m/s^2$

(iii) To find distance travelled by the car after applying brakes
Time taken by the car to stop after applying brakes =10s
Assume 's' to be the distance the car travels after brakes are applied
We know that $v^2 - u^2 = 2as$
$(0)^2-(25)^2 = 2(-2.5)(s)$
$– 625 = -5s$
s=125m

14. A space craft flying in a straight course with a velocity of 75km/s fires its rocket motors for 6.0s. At the end of this time, its speed is 120km/s in the same direction. Find: (i) the space craft's average acceleration while the motors were firing, (ii) the distance travelled by the space craft in the first 10s after the rocket motors were started, the motors having been in action for only 6.0s.

Solution:

Given: u=75km/s; v=120km/s; t=6s

(i) To find acceleration

acceleration = (final velocity-initial velocity)/time taken
= (120-75)/6
=7.5m/s^2

(ii) Distance travelled by the space craft in t=10s
=Distance travelled in first 6s + distance travelled in next 4s

Distance travelled in first 6 seconds: $s1=ut + ½ at^2$
Distance travelled in the next 4 seconds: $s2 = ut + ½ at^2$

$s1 = ut + ½ at^2$
$= (75)(6) + ½ (7.5)(6)^2$
= 450 + 135
= 585km

At the end of 6 seconds, the speed is 120km/s
Distance covered in the next 4s – s2 = speed x time
S2 = 120 x 4 = 480km

∴ the distance covered by the aircraft in 10s = s1+s2 = 585km+480km=1065km

15. A train starts from rest and accelerates uniformly at a rate of 2m/s^2 for 10s. It then maintains a constant speed for 200s. The brakes are then applied and the train is uniformly retarded and comes to rest in 50s. Find: (i) the maximum velocity reached, (ii) the retardation in the last 50s, (iii) the total distance travelled, and (iv)the average velocity of the train.

Solution:

(i) u=0, t=10s, a=2m/s^2
The maximum velocity reached is v=u+at
v = 0 + 2x10
= 20m/s

(ii) v=0m/s; t=50s; u=20m/s
Retardation = -(final velocity-initial velocity)/time taken
= (0-20)/50
=-0.4m/s^2

(iii) total distance=distance travelled in 10s+distance travelled in 200s + distance covered in last 50s

Distance travelled in 10s => $s1=ut+1/2at^2$
$=0+1/2(2)(10)^2$
=100m
Distance covered in 200s; s2 => speed x time
= 20 x 200 = 4000m
Distance travelled in last 50s => $s3=ut+1/2at^2$

$=(20)(50) + ½ (-0.4)(50)^2$

s3=500m

Total distance = s1+s2+s3=100m+4000m+500m=4600m

(iv) average velocity = total distance covered/time taken

=4600/260=17.69m/s