Motion

If we look around us, we find that there are number of objects which are in motion. An object is said to be in motion if it changes its position with the passage of time. In other words, the movement of an object is known as the motion of the object.

Now observe the following bodies or objects and you will be able to understand the meaning of the term "motion". Cars, cycles, motorcycles, scooters, buses, rickshaws, trucks etc. running on the road. Birds flying in the sky. Fish swimming in water. AIl these objects are in motion. Very small objects like atoms and moïecules (building blocks of substances) and very large objects like planets, stars and galaxies (building block of universe) are in motion.

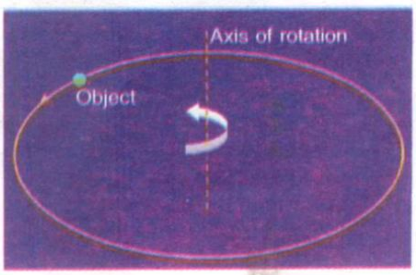
LINEAR MOTION OF A CAR

Thus, all objects ranging from a smallest atom to the largest galaxy are in continuous motion.

Type of motion

1. Linear motion. A body has linear motion if it moves in a straight line or path.

Example of linear motlon



CIRCULAR MOTION
OF AN OBJECT

(i) Motion of a moving car on a straight road.

(ii) Motion of a ball dropped from the roof of a building.

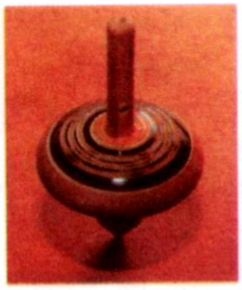
2. Circular (or rotntional) motion. A body has circular motion if it moves around a fixed point.

A vertical line passing through the fixed point around which the body moves is known as axis of frotation.

ExampIe of circular motion

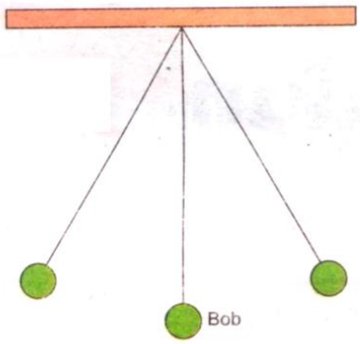
(i) Motion of an electric fan. (ii) Motion of merry-go-round. (iii) Motion of a spinmng top.

CIRCULAR MOTION OF
A MERRY-GO-ROUND



CIRCULAR MOTION
OF A SPINNING TOP.

3. Vibratory motion A body has vibratory motion if it moves to and fro about a fixed point (called rnean position or equilibrium position).



VIBRATORY MOTION OF
A SIMPLE PENDULUM

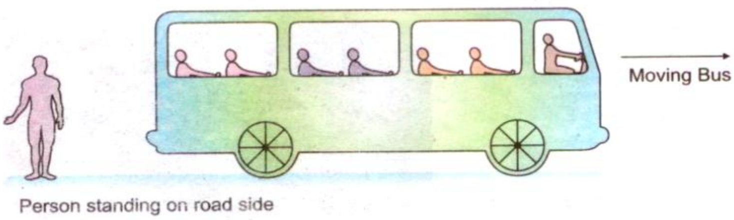
Examples of vibratory motion
(i) Motion of a pendulum of a wall clock.
(ii) Motion of a child swinging in a swing.
(iii) Motion of a simple pendulum.

DESCRIBING MOTION

To describe the motion of an object, its position, vclocity etc. are measured. When we measure the position of an object, then it is measured from some fixed point known as the **reference point.** For example, let us say that our school is 2 km away in the south direction from our home. It means, we measure the position of our school in the south direction from our home. So in this case, our home is the reference point. Similarly, suppose a person says that a bus is moving. It means, the bus is changing its position with respect to the person. So in that case, the person is the reference point.

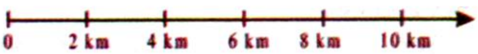
Definition of reference point
A fixed point or a fixed object with respect to which the given body changes its position is known as reference point or origin.

Motion is a relative term
When we say that a body or an object is in motion, then it is essential to see whether the body or object changes its position with respect to other bodies or objects around it or with respect to any fixed point known as reference point. For example, when a bus moves on a road, then the bus as well as the passengers sitting in it change their positions with respect to a person standing on the road side. So, the bus and the passengers sitting in it are in motion with respect to the person standing on the road side. However,the passengers sitting in the bus do not change their positions with respect to each other. It means, the passengers sitting in a moving bus are not in motion with respect to each other.



Conclusion. We find that an object is in motion only if it changes its position (or moves) with respect to a fixed point or a fixed body. Therefbre, a body or an object is in motion with respect to one thing but the same body or an object may not be in motion with respect to another thing. Thus, motion is a relative term**.**

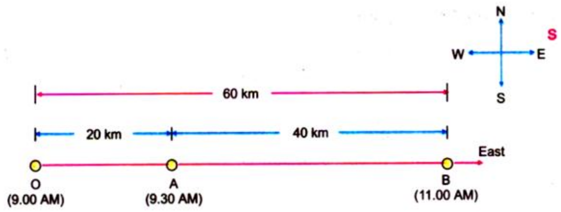
Motion Along A Straight Line
We shall discuss the motion of an object along a straight line. In this (case, the starting point of the line is taken as the **origin** O or the **reference point**. The position of the moving object changes with time. The different positions of the object are measured to the right side from the reference point or origin O as shown in figure



Distance and displacement

Distance

The length of the actual path between the initial (i.e,, starting or reference point) and the final positions of a moving object in the given time interval is known as the distance travelled by the object.
Consider a bus moving in a straight line in the east direction . Let O be the starting point or the reference point of the bus at 9.00 AM. Let at 9.30 AM, the position of the bus is at A which is 20 km away from the starting point. Let the bus is at the position B at 11.00 AM and the distance between positions A and B is 40 km.



A device known as **odometer** fitted on the dash. Board of a vehicle like car, bus etc. measures the distance travelled by the vehicle.

Now, distance travelled by the bus from the reference point (or starting point) in 30 minutes (i.e., from 9.00 AM to 9.30 AM) = 20 km.
Now, let the bus returns from the position B and reaches position A, then the distance travelled by the bus in the given interval of time.
Distance travelled has magnitude (i.e., size) only, so **distance** is a **scalar quantity**

Distance travelled by an object is also defined as thé length of the actual path between the initial position and final position of the object

Displacement. The shortest distance between the initial position and the final position of a moving object in the given interval of time from initial to the final position of the object is known as the displacement

As shown in figure 7(B), the displacement of the bus when it move from position O to position A = 20 km [East]. On the other hand, when the bus moves from position O to B and then moves back to position A, then displacement of the bus = 60 km - 40 km = 20 km [East]

Displacement of an object may also be defïned as the change in position of the object in a particular direction. That is, displacement of an object = (Final position - Initial position) of the object.
Displacement has magnitude as well as direction, so **displacement** is a vector quantity.

Let us know the more differences between distance and dispïacement

Displacement of an object may be zero but the distance travelled by the object is never zero.

Let a bus moves from position O to position B and then moves back from position B to position O as shown in figure.
Then, distance travelled by the bus during the whole joumey = 60 km + 60 km = 120 km.
But the displacement of the bus during the whole joumey
= Final position of the bus - Initial position of the bus
= zero, because its initial and final positons are same (i.e., point O)

Distance travelled by an object is either equal or greater than the magnitude of displacement of the object
Consider the motion of a bus as shown in figure.
Distance travelled by the bus between 9.00 AM and 11.00 AM = 60 km.
Magnitude of the displacement of bus during the time interval from 9.00 AM to 11.00 AM = 60 km.
Thus, distance travelled by an object is equal to the magnitude of the displacement of the object if the object continues to move in a straight line only in one direction.

Now consider the situation, when the bus moves from position 0 to position B and then back to the position O. In this case, the total distance travelled by the bus

= 60 km + 60 km = 120 km
But, the magnitude of the displacement of the bus
= 60 km - 60 km = 0
Thus, the distance travelled by an object is greater than the magnitude Of the displacement of the object if the object moving in a straight line changes its direction of motion.

DIFFERENCE BETWEEN DISTANCE AND DISPLACEMENT

S.NO	Distance	Displacement
1.	Distance is the length of the actual path travelled by a particle in a given interval of time.	Displacement is the shortest distance between the initial and final positions of a moving particle in a particular direction
2.	Distance travelled by a particle depends upon the path followed by the particle in going from initial positon to the final position.	The displacement of a particle between initial and final positions of the particle does not depend upon the path followed by it.
3.	Distance travelled by a particle in a given interval of time is always positive	Displacement of a particle in a given interval of time may be positive, negative or zero.
4.	Distance is a scalar quantity	Displacement is a vector quantity.

Uniform and Non-uniform Motion

Uniform motion

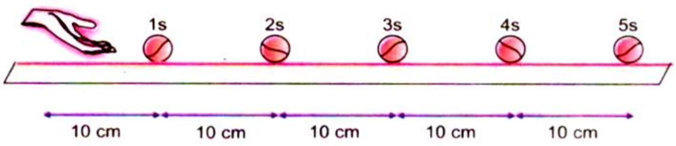
The motion of an object is uniform if (i) it moves along a straight line and (ii) it covers equal distances in equal intervals of time, howsoever, small these intervals may be.

Illustration. The distance covered by a ball along a straight line in the given intervals of time having uniform motion are given in the table 1

Table 1

Time (in seconds)	0	1	2	3	4	5	6	7	8	9	10	11
Distance covered (in metres)	0	10	20	30	40	50	60	70	80	90	100	110

Distance covered by ball in the first second = (10-0) = 10 m
Distance covered by ball in the second second = (20-10) = 10 m
Distance covered by ball in the third second = (30-20) = 10 m and so on.
The uniform otio of a ball in a straight line is shown in figure 8



UNIFORM MOTION OF A BALL.

Thus, we conclude that the ball covers 10 m in each second along a straight line. So, the motion of the ball is uniform motion

Remember these points

⇒ An object or a body will have uniform motion if if moves along a straight line in one direction.
⇒ For uniform motion, distance travelled by a moving object is directly proportional to the time taken

Non-uniform motion

The motion of an object is said to be non-uniform if it covers unequal distances in equal intervals of time, howsoever, small these intervals may be.

Examples of non-uniform motion

1. A bus moving on a crowded road.
2. A bus approaching a bus stop or leaving the bus stop.
3. A car moving on a hilly track.
4. A person jogging on a road./

Illustration. The non-uniform motion can be illustrated with the help of the values of distance covered and the time taken by a ball or an object given in table 2.

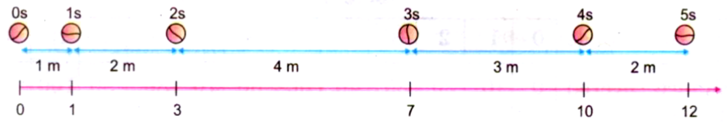
Remember this point

In non-uniform motion, distance travelled by an object is not proportional to the time taken.

Table 2

Time (in seconds)	0	1	2	3	4	5	6
Distance covered (in metres)	0	1	3	7	10	12	15

Distance covered by ball in first second = (1-0) = 1m
Distance covered by ball in second second = (3-1) = 2m
Distance covered by ball in third second = (7-3) = 4m
Distance covered by ball in fourth second =(10-7) = 3 m
And so on.
The non-uniform motion of a ball in a straight line is shown in figure 9.



NON-UNIFORM MOTION OF A BALL

SPEED (MEASURING RATE OF MOTION)

Different objects travels different distances in different time intervals. The distance travelled by a body in unit time is expressed by a quantity known as **speed. Speed of an object tells us how fast the object moves.**

Definition. Speed of an object is defined as the distance travelled by it per unit time.

Expression for speed

Let, distance travelled or covered by an object be S in time t, then

Speed of object, $\upsilon = \dfrac{\text{Distance}}{\text{time}}$

Or $\upsilon = \dfrac{S}{t}$

Important Points:

Speed is a scalar quantity because it has only magnitude and no direction.

Unit of Speed $= \dfrac{\text{Unit of distance}}{\text{Unit of time}}$

SI unit of speed is **metre/second** (ms^{-1})

In **CGS system**, unit of speed is **centrimetre/second** $(cm\,s^{-1})$

In our daily life, the speed of moving buses, cars, trains and aeroplanes is expressed in kilometre/hour ($km\,h^{-1}$)

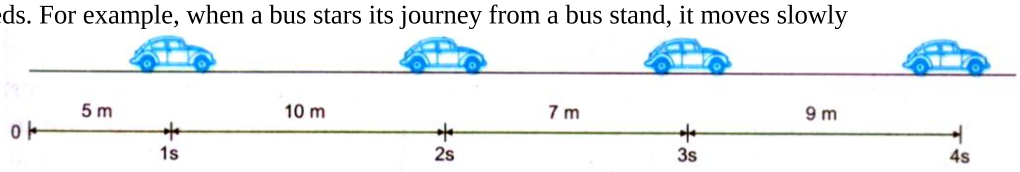
1. Uniform Speed or Constant Speed. If a moving body covers equal distances in equal intervals of time, then the speed of the body is said to be uniform speed.

It may be noted that wireless or radio signal travels with constant speed in a medium. The speed of wireless signal in air is equal to the speed of light in air = $3\times10^{8}\,ms^{-1}$

2. Non-uniform or Variable Speed. If a moving body covers unequal distances in equal intervals of time, then the speed of the body is said to be non-uniform or variable speed.

Example. Suppose a car travels 5 metres in first second, 10 metres in second second, 7 metres in third second, 9 metres in fourth second and so on. Then the speed of this car is changing and said to be **nonuniform** or **variable.**

3. Average Speed. Usually the buses, cars and trains etc. do not move with the uniform speed. They move with non-uniform speeds. For example, when a bus stars its journey from a bus stand, it moves slowly



(i.e., speed is small) and then its speed is increased. Now if it enters the crowded road, its speed decreases. After crossing the crowded road, its speed increases. After travelling few kilometres, suppose the bus has to be stopped, then its speed again decreases. Thus, we see that the bus is not moving with the same speed during the whole journey. In such a situation, we have to find the average speed of the bus.

Definition. Average speed of a moving body is defined as the ratio of the total distance travelled by it to the total time taken by it.

Thus, $\upsilon_{av} = \frac{Total\ distance\ travelled}{Total\ time\ taken}$

Example,

Let a bus travels 120 km in 5 hours between two stations, then the average speed of the bus is given by

Average speed = $\frac{Total\ distance\ travelled}{Total\ time\ taken} = \frac{120\,km}{5\,hours} = 24\ km\ h^{-1}$

Instantaneous speed. The speed of an object at any instant during its motion is called instantaneous speed.

A meter fitted on the dash board of a vehicle called **speedometer** indicates the instantaneous speed of the vehicle.

VELOCITY (Speed with Direction)

When the direction of motion of an object is also specified, then the term velocity of the body is defined instead of speed. For example, if a car is moving with a speed of $10\,ms^{-1}$ towards east, then we say that the velocity of the car is $10\,ms^{-1}$ towards east, then we any that the velocity of the car is $10ms^{-1}$ due east. Velocity of an object tells us how fast the object is moving and in which direction it is moving.

Definition. Velocity of an object is defined as the displacement of the body per unit time.

Expression For Velocity

It the displacement of the body is $\vec{S}$ in time t, then velocity of the body is given by

$$\vec{\upsilon} = \frac{Displacement}{Time} = \frac{\vec{S}}{t}$$

Unit of Velocity = $\frac{Unit\ of\ displacement}{Unit\ of\ time}$

SI unit of velocity is metre/second (ms^{-1})

In CGS system, unit of velocity is centimetre/second ($cm\,s^{-1}$ **) . Commonly used unit of velocity is kilometre/hour (** $km\ h^{-1}$ **).**

TYPES OF VELOCITY

1. Uniform Velocity or Constant Velocity. Let a car moves over a horizontal straight road along the east direction. Let it covers 30 km in each hour as shown in figure 11. This shows that the displacement of the car in each hour is equal. The velocity of this car is uniform velocity.

Definition. Velocity of an object is said to be uniform velocity, if it covers equal displacements (i.e. equal distances in a particular direction) in equal intervals of time

2. Non-uniform Velocity or Variable Velocity.

Let a car moves over a horizontal road along the east direction. Let it covers unequal distances in each hour as shown in figure 12. The velocity of this car is non-uniform or variable.

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Definition. Velocity of an object is said to be non-uniform or variable velocity, if it covers unequal displacements (i.e., unequal distances in a particular direction) in equal intervals of time

Examples of non-uniform or variable velocity

(i) A bus moving toward North on a crowded road.
(ii) A stone thrown vertically upward.
(iii) A stone dropped from the top of a building.
(iv) A body moving in a circular path. For example, a moving fan.

3. Average Velocity. When the speed of an object changes with time along a straight line, then the average velocity of the body is calculated.

Average Velocity $(\vec{\upsilon}_{av}) = \dfrac{Total\ Displacement\ of\ the\ body}{Total\ time\ taken}$

Note:- If the velocity of an object changes at a uniform rate (i.e.) in equal amount in equal intervals of time) in a particular direction, then the average velocity of the object is equal to velcotiy of the object is equal to the mean of the Initial and final velocities of the object. In this case

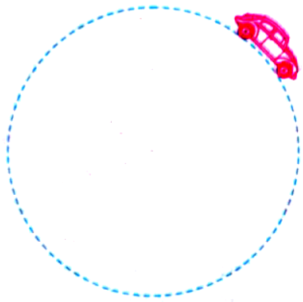
$$\vec{\upsilon}_{av} = \frac{\vec{u} + \vec{\upsilon}}{2}$$

Where, $\vec{u} = Initial\ velocity\ of\ the\ object\ and\ \vec{\upsilon} =$ Final velocity of the object

Remember:

Velocity of a body can be changed either

(i) by changing the speed of the body while keeping the direction of motion of the body same.
Or (ii) By changing the direction of motion of the body but keeping the speed of the body same.
Or (iii) by changing both the speed and direction of motion of the body.



CAR MOVING IN A CIRCULAR PATH.

For example.

1. The velocity of a ball dropped form the top of a building changes because its speed changes although its direction of motion is same.
2. The velocity of a car moving with a constant speed in a circular path changes because its direction of motion changes although it is moving (Figure 13.)

DIFFERENCE BETWEEN SPEED AND VELCOITY

S.NO	Distance	Displacement
1.	Distance travelled by an object per unit time is known as its speed.	The distance travelled by an object in a particular direction (i.e., displacement) per unit time is known as its velocity.
2.	Average speed of a moving object cannot be zero	Average velcoity of a moving object can be zero.
3.	Speed tells how fast an object moves.	Velocity tells how fast an object moves and in which direction it moves.
4.	Speed is scalar quantity.	Velocity is a vector quantity
5.	Speed of an object is always positive	Velocity of an object can be positive or negative

Special Case. When speed and velocity of an object are equal
Let us suppose an object is moving in a straight line along positive X-direction. In this case, the distance travelled and the displacement of the object in a given interval of time are equal. Hence speed and magnitude of the velocity of a object are equal if the object moves in a straight line in one direction.

ACCELERATION (RATE OF CHANGE OF VELOCITY)

In non-uniform motion, the velocity of a bond changes with time. For example, when a train leaves the platform or approaches the platform, its velocity changes with time. The changes in velocity of an object with time is expressed by a physical quantity known as **acceleration.** Acceleration tells by how much amount the velocity of a body changes in unit interval of time. In other words, the aceleration is a quantity which measures how quickly the velocity of a body or an object changes.
Definition. Acceleration of a a body or an object is defined as the change in velocity per unit time.
Or
Acceleration of an object may also be defined as the rate of the change of velocity of the object

i.e., Acceleration = $\dfrac{\text{Change in velocity}}{\text{Time taken}}$

It is denoted by $\vec{a}$ Acceleration is a vector quantity.

Expression for acceleration

Let the velocity of an object at time (t = 0) = $\vec{u}$ (known as initial velocity)

And the velocity of an object at time (= t) = $\vec{\upsilon}$ (Known as initial velocity)

And the velocity of an object at time (=t) = $\vec{\upsilon}$ (Known as final velocity)

Then change in velocity of the object = $\vec{\upsilon} - \vec{u}$

Time taken for this change in velocity = t – o = t

Now, acceleration of the object = $\dfrac{\text{Change in velocity of the object}}{\text{Time taken}}$

= $\dfrac{\text{Final velocity} - \text{Initial velocity}}{\text{Time taken}}$

$\therefore$ Acceleration, $\vec{a} = \dfrac{\vec{\upsilon} - \vec{u}}{t}$ .....(1)

Eqn. (1) can also be written as

$a = \dfrac{\upsilon - u}{t}$ (Here $\rightarrow$ are dropped)

Or $\upsilon - u = at$

Or $\upsilon = u + at$ ----(2)

POSITIVE ACCELERATION

If the velocity of an object increases with time in the direction of the motion of the object, then the acceleration of the body is known as positive acceleration.

CAUTION: Some students have misconception that acceleration of an object

= $\dfrac{\text{Velocity of body}}{\text{time}}$

They should remember that acceleration of an object

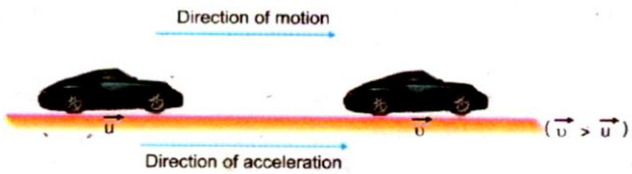
= $\dfrac{\text{Change in velocity}}{\text{time}}$

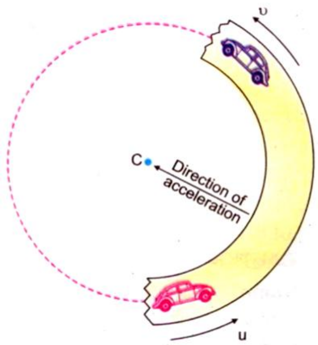
If change in velocity of an object is zero or velocity of an object is constant, then acceleration of the object is zero.

Acceleration of an object is positive If its direction is same as that of the direction of motion of the object.

Acceleration of an object is negative if its direction is opposite to the direction of motion of the object.

In this case, the object **picks up the speed** in a particular direction (i.e., velocity). For example, if an object starts from rest and its velocity goes on increasing with time in the direction of its motion, then the object has positive acceleration. The direction of positive acceleration is in the direction of motion of the object as shown in figure.





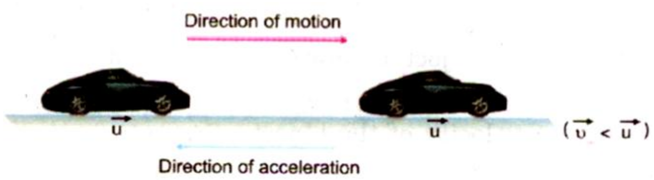
NEGATIVE ACCELERATION

If the velocity of an object dcreases with time, then the acceleration of the object is known as negative acceleration.

It is written as $-\vec{a}$

For example, if an object moving with certain velocity is brought to rest then the object is said to have negative acceleration.

The direction of negative acceleration is in a direction opposite to the direction of motion of the object as shown in figure



Remember:
Acceleration which is towards the centre of the circular path is known as centripetal acceleration. Centripital acceleration. Centripetal means centre seeking.

Note: An object will slow down if acceleration and velocity are in opposite direction.
Acceleration without changing speed
When an object moves in a circular path with constant speed, then its velocity changes due to the change in the direction of motion of the object. Hence, the object is accelerated without changing its speed.
In this case, the direction of acceleration is towards the centre of the circular path as shown in figure

UNITS OF ACCELERATIONS

Acceleration $= \dfrac{Change\ in\ velocity}{Time\ taken}$

$\therefore$ Unit of acceleration $= \dfrac{Unit\ of\ velocity}{Unit\ of\ time}$

SI unit of acceleration $= \dfrac{ms^{-1}}{s} = \mathbf{ms^{-2}}$

In CGS system. Unit of acceleration in cms^{-2}

Other unit of acceleration is $km\ h^{-2}$

UNIFORM ACCELERATION

If the velocity of an object changes by an equal amount in equal intervals of time, then the acceleration of the object is known as uniform acceleration.

The motion of an object having uniform acceleration is known as **uniformly acceleration motion.**

Examples of uniformly accelerated motion
(i) The motion of an object falling freely from the top of a building.
(ii) The motion of a ball rolling down a smooth inclined plane.

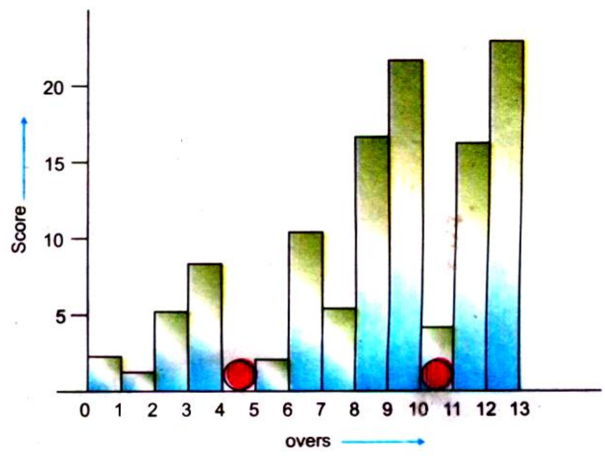
NON –UNIFORM ACCELERATION

If the velocity of an object changes by an unequal amount in equal intervals of time, then the acceleration of the object is known as non-uniform or variable acceleration.

The motion of an object having variable accelration is known as **non-uniformly acceleration motion**
Examples of non-uniformly accelerated motion
(i) The motion of a bus leaving or entering the bus stop.
(ii) The motion of a train leaving or entering the platform.
(iii) The motion of a bus on a crowded road.

GRAPHICAL PEPRESENTATION OF MOTION

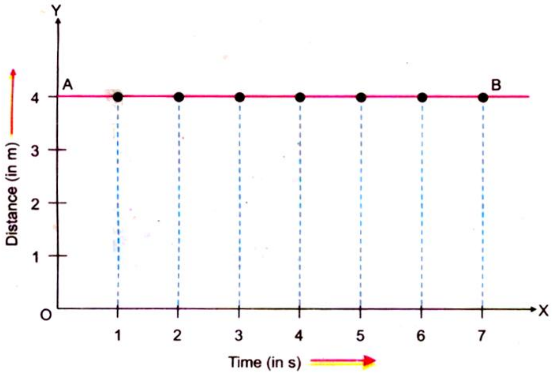
Graphs are the best tools to reprsent the motion of a body or an object. In order to describe the motion of an object, we have to represent the distnace or velocity of the object with the passage of time. The distance travelled by the object or the velocity of the object is different at different time. In other words, distance travelled by the object or the velocity of the object depends on the time. Therefore, distance travelled or the velocity of the object is **depenent quantity** and the time is an independent quantity. The variation of the dependent quantity with an



independent quantity is represented by a graph known as **line graph.**
You must have seen a graph showing the runs scored per over by a cricket team on your television screen.
The vertical bars show the runs scored by a team in different overs. This type of graph is knownas **bar graph.** The shaded circles along X-axis show the fall of a wicket in the given over.

DISTANCE-TIME GRAPHS

Distance-time graph shows how the distnace of a body from a fixed point changes with time. To draw distance-time graph, distance travelled by the body is plotted along Y-axis and the time taken by the body to travel this distnace is plotted along X-axis

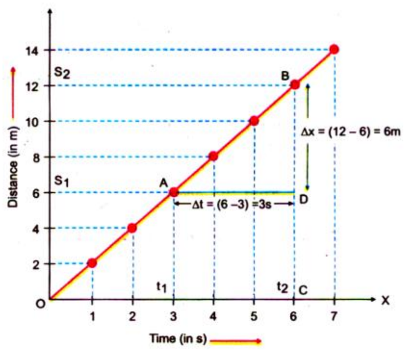


(A) DISTANCE-TIME GRAPH FOR A STATIONARY BODY

The distance of a stationary body from a fixed point does not change with the passage of time. It means, if the distance of a stationary body from a fixed point (Say O) is 4m at time t = 0, then the distance of this body will remain 4m for all times.
Distance-time graph for a stationary body is shown in figure.
CONCLUSION. Distance-time graph for a stationary body is a straight line (AB) parallel to time-axis.

(B) DISTANCE-TIME GRAPH FOR UNIFORM MOTION

If a body euqal distances in equal intervals of time, then the motion of the body is known as uniform motion.
Distance-time graph for such a uniform motion of the body is shown in figure 19.



CONCLUSION. Distance-time graph for the uniform motion of a body is a straight line having a constnat angle with the time axis or constant gradient or slope.

Use of distance-time graph for uniform motion.
Calculation of the speed of a Body
The speed of a body haivng uniform motion is constant throughout the motion.

We know, Speed= $\dfrac{Distance\ travelled}{Time\ taken\ to\ travel\ this\ distance}$

To calculate the speed of the body from a distance-time graph, choose any two points say A and B on the straight line. From points A and B, draw perpendiculars AE and BC respectively on time axis. Now draw a perpendicular AD on BC
The distance travelled by the body in going from point A to B

$= \Delta x = BC - CD \qquad = S_2 - S_1 = 12 - 6 = 6m$

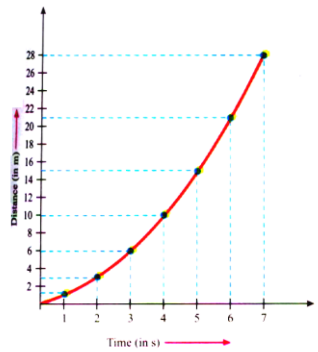
Time taken by the body to cover this distnace = Δt

= $t_2 - t_1 = 6 - 3 = 3s$

$\therefore$ Speed = $\dfrac{\Delta x}{\Delta t} = \dfrac{S_2 - S_1}{t_2 - t_1} = \dfrac{6m}{3s} = 2ms^{-1}$

Here $\dfrac{\Delta x}{\Delta t} =$ Slope of distance-time graph.

$\therefore$ Speed of a body = Slope of distnace-time graph.



(C) DISTANCE-TIME GRAPH FOR NON-UNIFORM MOTION

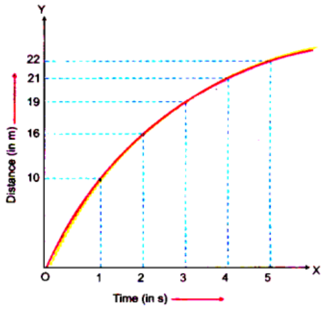
If a body travels unequal distances in equal intervals of time, then the motion of the boyd is known as **non-uniform motion.**
Non-uniform motion of a body is of two types:

1. When the speed of the body increases with passage of time

For example, when a train leaves the platform, its speed increases with passage of time. That is, the train covers more and more distance in unit time.
Distance-time graph for such a non-uniform motion of the body is shown in figure 20
CONCLUSION. Distance-time graph for the non-uniform motion of a body is a curve having increasing slope or gradient.

2. When the speed of the body decreases with passage of time.

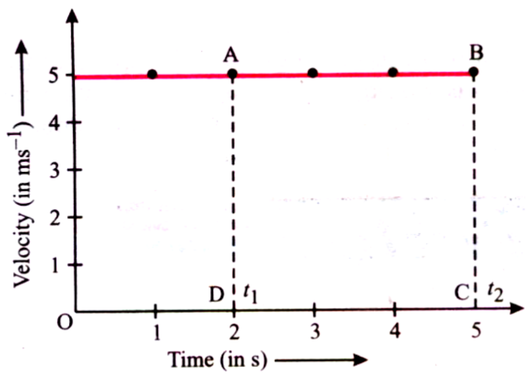
For example, when a train approaches the platform, its speed decreases with the passage of time. That is, the train covers less and less distance in unit time.
The distance-time graph for this type of motion is shown in figure
CONCLUSION. Distance-time graph for the decreasing non-uniform motion of a body is a curve having **decreasing slope.** That is, the speed of the body decreases with passage of time.



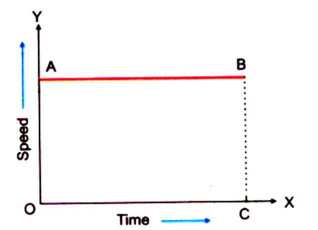
Remember these points:
⇒ Speed = slope of distnace-time graph.
⇒ If distnace-time graph is parallel to time axis, then the body is stationary.
⇒ If distnace-time graph is a straight line having constant gradient or slope, then the body has uniform motion.
⇒ If distnace-time graph is a curve with increasing gradient or slope, then the body has non-uniform motion.
⇒ If slope of distnace-time graph increases, the speed of the body increases.
⇒ If slope of distnace-time graph of non-uniform motion decreases, the speed of the body decreases.

VELOCITY-TIME GRAPHS

Velocity-time graph shows how the velocity of a body changes with passage of time. To draw velocity-time graph, velocity of the body is plotted laong Y-axis and the time taken by the body is plotted along X-axis.



(A) VELOCITY-TIME GRAPH FOR A BODY MOVING WITH OCNSTANT VLEOCITY
When a body moves with constant velocity i.e., its motion is uniform its velocity does not change with time. For example, if the velocity of the body at t = 0 is $5ms^{-1}$, then the velocity of the body will remain $5ms^{-1}$ for all times.
Velocity-time graph for such type of motion of the body is shown in figure
CONCLUSION. Velocity-time graph of a body moving with constant velocity is a straight line parallel to time axis.
Use of velocity-time graph for a body moving with constant velocity
Calculation of magnitude of displacement
Let us calculate the distance or magnitude of the displacemetn of a body beween time t_1 and t_2 using figure 22.
Step 1. Draw perpendiculars form the points corresponding to the time t_1 and t_2 on the graph. Let these perpendiculars are DA and CB respectively.
Step 2. Now, $DA = CB$
= Velocity of the body $(5m\ s^{-1})$
$CD = (t_2 - t_1)$
= Time interval $(5 - 2 = 3s)$
Step 3. Now, $DA \times CD =$ Area of the reactangle ABCD
Also $DA \times DB = Velocity \times Time$
= Distance of magnitude of the displacement
∴ Distance or magnitude of displacement of the body in the time interval $(t_2 - t_1)$
= Area of the rectangle ABCD
Thus, **magnitude of displacement of body**



Speed-time graph for a body moving with constant speed

= area under velocity-time graph.

Attention. Speed-time graph for a body moving with constant speed is same as shown in alongside ifgure. The only difference is that speed is written instead of velocity along along Y-axis.

With speed-time graph, we can calculate distance travelled by a body in the same manner as we calculate the magnitude of displacement of a body using velocity-time graph.

Distance travelled by a body= area under speed-time graph

= area of rectangle OABC = OA × OC

(B) VELOCITY-TIME GRAPH FOR UNIFORM MOTION WHEN INITIALLY THE BODY IS AT REST

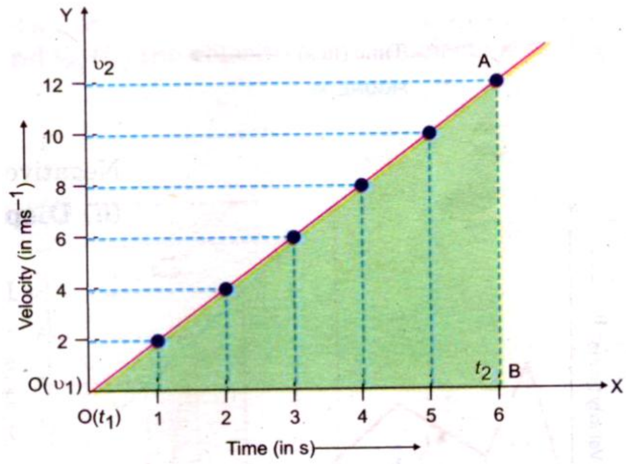
Let us suppose, initially the obdy is at rest, then vleocity of body at t = 0 is zero. After that, the velocity of the body incrases at a constant rate. That is, in every unit interval of time, the velocity of the body increases by an equal amount.

Velocity-time graph for such type of motion of the body is shown in figure.

CONCLUSION. Velocity-time graph of a body having uniform motion (initially at rest) is a straight line passing trhough the origin and have a constnat slope (or ocnstatn acceleration).

Uses of velocity-time graph for uniform motion

Velocity-time graph for uniform motion of a body is used to calculated acceleration and displacemetn of the body.



(i) Calculation of Acceleration

Acceleration = $\dfrac{\text{Change in velocity}}{\text{Time taken}}$

$= \dfrac{AB}{OB} = \dfrac{(\upsilon_2 - \upsilon_1)}{(t_2 - t_1)}$

$= \dfrac{(12-0)\,ms^{-1}}{(6-0)s} = \dfrac{12\,ms^{-1}}{6s} = 2\,ms^{-2}$

(ii) Calculation of magnitude of displacement

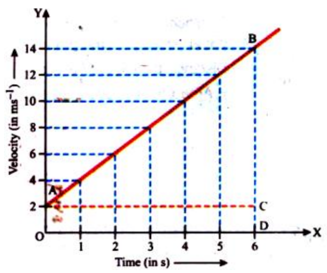
Magnitude of displacement = Area under velocity-time graph

= Area under OA = Area of triangle OAB

$= \dfrac{1}{2} \times Base \times Height$

$= \dfrac{1}{2} \times OB \times AB = \dfrac{1}{2}(t_2 - t_1)(\upsilon_2 - \upsilon_1)$

$= \dfrac{1}{2} \times 6s \times 12\,ms^{-1} = 36\,m$



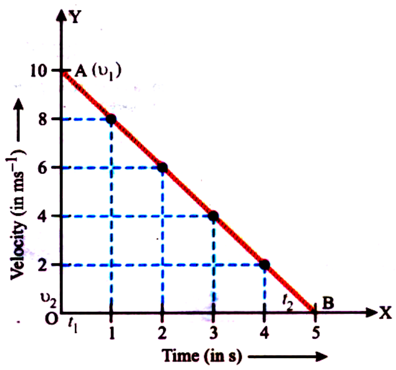
(C) VELOCITY-TIME GRAPH FOR UNIFORM MOTION WHEN INITIALLY BODY IS NOT AT REST

Let us suppose, initially (i.e, at t = 0), the velocity of a body is 2 ms^{-1}. After that, the velocity of the body increases at a constant rate. That is, in every unit interval of time, the velocity of the body increases by an equal amount.

Velocity-time graph for such type of motion of the body is shown in figure.

(D) VELOCITY-TIME GRAPH WHEN THE VELOCITY OF THE BODY DECREASES UNIFORMLY TO ZERO.

Let us suppose, the body is moving with a certain velocity at t = 0. Let, there after, the velocity of the body decrease uniformly and ultimately becomes zero after some time.



For example, let the velocity of a train at t = 0 is $10\,ms^{-1}$. The driver of the train applies brakes so that the velocity of the train decreases uniformly to zero.

Velocity-time graph for this type of motion is shown in figure.

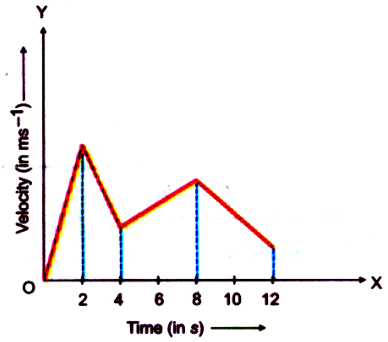
Uses:

(i) Calculation of Acceleration

Acceleration = Slope of velocity-time graph

= Slope of AB line

$= \frac{OA}{OB} = \frac{(\upsilon_2 - \upsilon_1)}{(t_2 - t_1)} = \frac{-10\,ms^{-1}}{5s}$



$= -2\,ms^{-2}$

Negative sign shows that acceleration of the train is negative

(ii) Displacement of Body

Displacem4etn = area of $\Delta OAB = \frac{1}{2} \times base \times height$

$= \frac{1}{2}(t_2 - t_1)(\upsilon_2 - \upsilon_1)$

$= \frac{1}{2} \times 5s \times 10ms^{-1}$

= **25 m**

(E) VELOCITY-TIME GRAPH OF NON-UNIFORM VELOCITY OF AN OBJECT.

Velocity-time graph of non-uniform velocity of an object is shown in figure. This graph shows that the velocity of the object is increasing at a constant rate upto 2s, then the velocity is decreasing at a constant rate upto 4s. Again increasing upto 8s. And then decreasing upto 12s.

EQUATIONS OF MOTION BY GRAPHICAL METHOD

The uniformly acceleration motion of a body is described by three equations known as **equation of motion.**

(i) The relation beween initial velocity (u), final velocity (υ), final velocity (υ), acceleration (a) and time (t) is known as the **first equation of motion or equaiton for velocity-time relation.** It is given by $\upsilon = u + at$

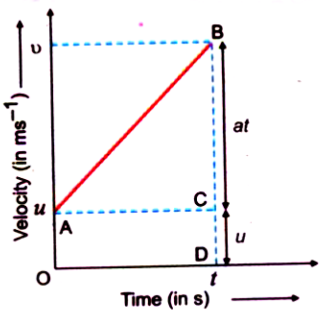
(ii) The relation between distnace travelled (s), initla velocity (u), acceleration (a) and time (t) is known as the **second equtiion of motion or equation for position-time relation.** It is given by $S = ut + \frac{1}{2}at^2$

(iii) The relation between initial velocity (u), final velocity (υ) acceleration (a) and distance travelled (s) by the body is known as **third equation of motion or equation for position velocity relation.** It is given by $\upsilon^2 - \upsilon^2 = 2aS$

DERIVATION OF FIRST EQUAITON OF MOTION FROM VELOCITY-TIME GRAPH (EQUATION FOR VELOCITY TIME RELATION)

The velocity-time graph of a uniformly acceleration motion of the body having initial velocity (u) is shown in figure.

The vleocity-time graph is a straight line AB.



Acceleration of the body = $\frac{Change\ in\ velocity}{Time\ taken} = \frac{CB}{AC} = \frac{DB - DC}{OD}$

$[\because AC = OD]$

Or $a = \frac{\upsilon - u}{t}$ or $at = \upsilon - u$

Or $\upsilon = u + at$ ....(1)

Which is first euqation of motion. Eqn . (1) is also known as equation for velocity-time relation.

DERIVATION OF SECOND EQUATION OF MOTION FROM VELOCITY-TIME GRAPH (EQUATION FOR POSITION-TIME RELATION)

We can find the distnace travelled by the body in time t.

Distance travelled, S = Area under velocity-time graph (AB)

Or S = Area of trapezium OABD

= Area of $\Delta ABC +$ Area of rectangle OACD

$= \frac{1}{2} \times AC \times CB + OD \times OA$ ....(1)

Here, $AC = OD = t,$ $CB = DB - DC = (\upsilon - u)$ and $OA = u$

$\therefore$ eqn. (1) becomes

$S = \frac{1}{2} \times t \times (\upsilon - u) + u \times t$

$= ut + \frac{1}{2}(\upsilon - u)t$ ....(2)

We know $\upsilon = u + at$ or $(\upsilon - u) = at$ ....(3)

Put the value of eqn. (3) in eqn. (2), we get $S = ut + \frac{1}{2}at \times t$

Or $S = ut + \frac{1}{2}at^2$ ....(4)

Note. If velocity of an object is constant, then $a = 0$. Hence eqn. (4) becomes $S = ut$

DERIVATION OF THIRD EQUATION OF MOTION FROM VELOCITY-TIME GRAPH (Equation for Position-velocity Relation)

We can find the distance travelled by a body during the period its velocity changes form u to υ.

Distance travelled, S = Area under velocity-time graph

= Area of trapezium OABD

= Area of $\Delta ABC +$ Area of rectangle $OACD$

Or $S = \frac{1}{2} \times AC \times CB + OD \times OA$ Here, $AC = OD = t$

$CB = DB - DC = (\upsilon - u)$ $\therefore$ eqn. (1) becomes

$S = \frac{1}{2}(u + \upsilon)t$ We know $\upsilon = u + at$ ....(2)

Or $at = \upsilon - u$ or $t = \left(\frac{\upsilon - u}{a}\right)$ Put this value of 't' in eqn. (2), we get

$S = \frac{1}{2}(\upsilon + u)\left(\frac{\upsilon - u}{a}\right)$ Or $2aS = (\upsilon + u)(\upsilon - u)$

$= \upsilon^2 - u^2$ $\left[\because A^2 - B^2 = (A+B)(A-B)\right] \therefore$ $\upsilon^2 - u^2 = 2aS,$ which is thrid equation of motion

CIRCULAR MOTION

The motion of a body moving around a fixed point in a circular path is known as circular motion.

Example of circular motion

1. The motion of the blades of an electric fan around the axle.
2. The motion of the moon around the earth.
3. The motion of an electron around the nucleus of an atom.
4. The motion of planets around the sun is also approximately circular motion.
5. The motion of the hammer before the athlete throws it.
6. The motion of a satellite around the earth.
7. A stone tied at one end of the string and whirled above the head of a person in circular path.

UNIFORM CIRCULAR MOTION

The circular motion of a body having uniform or constant speed is known as uniform circular motion.

Direction of motion of a body moving in a circular path at any instant is along a tangent to the position of the body on the circular path at that instant of time. This can be understood by performing the following simple activity.

Activity

Take a small stone and tie it with one end of a strong thread. Now, move the stone in a circular path by holding the second end of the thread in your hand as shown in figure. Leave the thread, when the stone is at position A on the circular path. You will find that the stone moves in a straight line which is the tangent to the position A on the circular path. Again, move the stone in the circular path and leave the thread, when stone is at position B. Onece again, you will find that the stone moves in a straight line which is the tangent to the position B on the circular path. Repeat the activity and leave the thread, when the stone is at different positions on the circular path.

From this simple activity, we conclude that the direction of motion of a body moving in a circular path is always along the tangent to a point on the circular path. Thus, the direction of motion of a body moving in a circular path is different at different position of the circular path.

UNIFORM CIRCULAR MOTION IS KNOWN AS ACCELERATED MOTION

When a body moves in a circular path with constant speed, its direction of motion changes continuously at every point. This shows that the velocity of the body moving in a circular path changes continuously due to change in direction of its motion. It means, the body moves the changing velocity in a circular path. The change in velocity of the body with time gives rise to an acceleration. Thus, change in velocity of the body with time gives rise to an acceleration. Thus, the uniform circular motion of a body is known as accelerated motion.

Important Points:

$\Rightarrow$ The acceleration of a body moving in a circular path is known as centripetal acceleration. [centripetal means centre seeking]. The direction of this acceleration is always towards the centre of the circle. The magnitude of the centripetal acceleration= υ^2 / r ,

Where $\upsilon = uniform\ speed\ of\ the\ body$

$r = radius\ of\ the\ circular\ path$

$\Rightarrow$ Linear velocity of a body moving in a circular path of radius r in time t is given by

$$\upsilon = \frac{distance}{time} = \frac{circumference\ of\ circular\ path}{time} = \frac{2\pi r}{t}$$

DIFFERENCE BETWEEN LINEAR MOTION AND CIRCULAR MOTION

S.NO	Linear Motion	Circular Motion
1.	The body moves along a straight line.	The body moves along a circular path around a fixed point.
2.	The direction of motion does not change.	The direction of motion changes continuously.
3.	In linear motion, if the body is moving with constant speed, there is no acceleration of the body.	In circular motion, there is acceleration of the body even if the body moves with constant speed.

Examination Corner Quick Revision of the Chapter

- **Motion-** An object which changes its position with respect to a fixed point is said to be in motion
- **Motion is a relative term.**
- **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 traveled by the particle.
- **Displacemetn.** The shortest distance between the initial and final positions of a moving object or body in a direction from initial to the final positon 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** traveled by a body is always **positive.**
- **Displacement** of body may be positive, negative or zero.
- **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 distances 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 distances in equal intervals to time.
- **Speed.** The distance traveled by a body in unit time is known as the speed of the body. That is

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

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

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

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

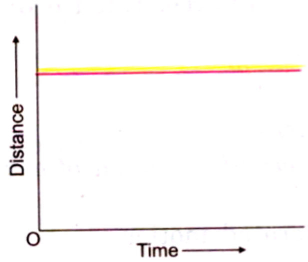
$$Velocity = \frac{Displacement}{Time}$$

- **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 displacements in equal intervals of time.
- **Average velocity.** $= \frac{Total\ displacement\ of\ the\ body}{Total\ time\ taken}$
- **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

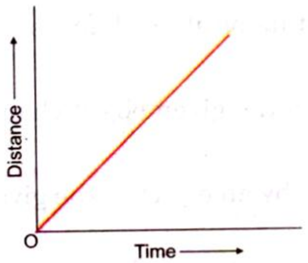
i.e. Acceleration = $\frac{Change\ \ in\ velocity}{Time}$

- **Positive acceleration.** When the velocity of a body increases with time, acceleration of body is said to be positive acceleration
- **Negative acceleration or Retardation of deceleration.** If the velocity of the body decreases with time, then acceleration of body is negative acceleration or retardation.
- **S.I unit** of acceleration is ms^{-2}
- **Distance-time graph**

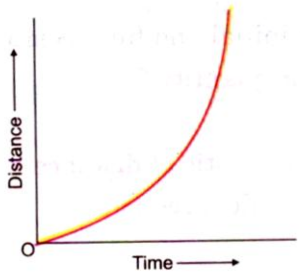
(i) If distance-time graph is parallel to time-axis, the body is at rest.



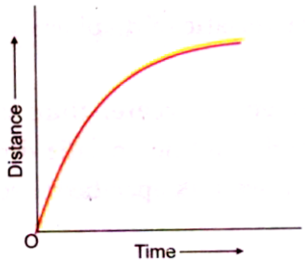
(ii) If distance-time graph is a straight line passing through origin and having a constant angle with time-axis, the body has uniform motion



(iii) Slope or gradient of distance-time graph = speed of body
(iv) Area under speed-time graph = distance traveled by a body
(v) If distance-time graph is a cirve having increasing slope, the body has non-uniform motion. The speed of the body increases with time



(vi) If distance-time graph is a cirve having decreasing slope, the body has non-uniform motion. The speed of the body decreases with time.



• Velocity-time graph
(i) If velocity-time graph is parallel to time axis, the body moves with constant velocity.
(ii) The lope of velocity-time graph = Velocity of the body.
(iii) Area under velocity-time graph = magnitude of the displacement of a body.

• Equations of motion
(i) Velocity of a uniformly accelerated body after time t is given by
$\upsilon = u + at$
(ii) Distance travelled by a uniformly accelerated body after time t is given by
$S = ut + \frac{1}{2}at^2$
(iii) $\upsilon^2 - u^2 = 2aS$

• Uniform circular motion. The circular motion of a body having constant speed is known as uniform circular motion.
• Uniform circular motion is accelerated motion.

The End

Very Short Answer Type Questions

1. What do you understand by the motion of an object ?
Ans. An object is said to be in motion if its position changes with time.

2. What is a reference point ?
Ans. A fixed point with respect to which the given object changes its position.

3. Define the term "distance".
ANS. The length of actual path travelled by an object in the given time is called the distance travelled by the object,

4. What does the odometer of a vehicle measure ?
Ans. Odometer measures distance travelled by a vehicle.

5. Is distance a scalar or a vector quantity?
Ans. Distance is a scalar quantity.

6. Define the term "displacement".
Ans. The shortest distance between the initial and final positions of the object in a particular direction.

7. Is displacement a scalar or a vector quantity?
Ans. Displacement is a vector quantity.
]
8. Which of the following is the characteristic of distance travelled by an object ?
(a) It has magnitude as well as specific direction.
(b) It can be zero.
(c) It has only magnitude and no specific direction.
(d) The distance travelled by an object is less than the magnitude of the displacement of the object.
Ans. (c)

9. Which of the following is the characteristic of displacement of an object?

(a) Displacement cannot be zero.
(b) The magnitude of the displacement is greater than the distance travelled by a moving object
(c) Displacement has only magnitude and no specific direction.
(d) Displacement has magnitude as well as specific direction.
Ans. (d)

10. What do you mean by uniform motion?
Ans. The motion of an object is uniform motion if it travels equal distances in equal intervals of time along a straight line.

11. What is the path of a body when it is in uniform motion?
Ans. A straight path.

12. What is non-uniform motion?
Ans. The motion of an object is non-uniform if it travels unequal distances in equal intervals of time.

13. Give one example of non-uniform motion.
Ans. A bus moving on a hilly road.

14. Define the term "speed".
Ans. The distance travelled by an object per unit time is known as speed of the object.

15. State SI unit of speed.
Ans. metre/second (ms^{-1})

16. Is speed a scalar quantity or a vector quantity?
Ans. Speed is a scalar quantity.

17. Define uniform speed.
Ans. The speed of an object is said to be uniform speed if it travels equal distances in equal intervals of time.

18. Define average speed.
Ans. Average speed is the ratio of the total distance travelled to the total time taken.

19. What does speedometer of a bus or a car measure?
Ans. Speedometer of a vehicle measures its instantaneous speed.

20. Define the term "velocity".
Ans. Velocity is defined as the ratio of the displacement to the time taken.

21. What do you understand by a uniform velocity ?
Ans. Velocity of an object is uniform if it travels equal displacement in equal intervals of time.

22. What do you understand by a non-uniform velocity?
Ans. Velocity of an object is non-uniform if it travels unequal displacements in equal intervals of time.

23. Define average velocity.
Ans. Average velocity is the ratio of the total displacement to the total time taken.

24. Is velocity a scalar or a vector quantity?
Ans. Velocity is a vector quantity.

26. Define acceleration of a body.
Ans. Acceleration is denned as the change in velocity per unit time.

26. State SI unit of acceleration.
Ans. S.I. unit of acceleration is metre/second^2 (ms^{-2})

27. Name the physical quantity that corresponds to the rate of change of velocity.

Ans. Acceleration.

28. What do you mean by positive acceleration?

Ans. When the change in velocity of a body takes place in the direction of motion of the body, then the acceleration is positive.

29. Give one example of positive acceleration.
Ans. When the velocity of a train increases after leaving the platform.

30. What do you mean by negative acceleration?
Ans. When the change in velocity of a body takes place in a direction opposite to the direction of motion of the body, then the acceleration is negative.

31. Give one example of retardation or negative acceleration.
Ans. When the velocity of a train decreases before entering the platform?

32. When do you say that a body is in uniform acceleration?
Ans. When the velocity of a body changes by an equal amount in equal intervals of time, then the body is in uniform acceleration.

33. When do you say that a body has non-uniform acceleration?
Ans. When the velocity of a body changes by unequal amount in equal intervals of time, then the body is in non-uniform acceleration.

34. Give one example of a uniform motion in a straight line in which velocity is changing at uniform rate.
Ans. The motion of a freely falling body.

35. Give one example of a non-uniform motion in which acceleration is not constant.
Ans. The motion of a car over a straight road in a crowded market.

36. Give an example of a motion in which the acceleration is in the direction of motion.
Ans. When a body (say a ball) falls from the roof of a house, then the acceleration of the body is in the direction of motion.

37. Give an example of a motion in which the acceleration is against the direction of motion?
Ans. When a ball rolling over a horizontal surface slows down due to the force of friction between the ball and the horizontal surface, then acceleration is against the direction of motion. Or
When a body is thrown upward, then the acceleration is against the direction of motion.

38. What will you say about the motion of a body if its distance-time graph is a straight line parallel to time axis?
Ans. When distance-time graph is a straight line parallel to time axis, then the distance of the body remains the same for all times. It means the given body is at rest (i.e. stationary).
[Refer Figure 18]

39. What will you say about the motion of a body if its distance-time graph is a straight line having a constant angle with time axis?
Ans. If distance-time graph is a straight line having a constant angle with time axis, then the distance travelled by the body increases in equal amount in equal intervals of time. It means, the motion of the body is a uniform motion. ' [Refer Figure 19]

40. State the nature of distance-time graph for uniform motion of an object.
Ans. Distance-time graph for uniform motion of an object is a straight line having a constant slope or gradient. [Refer Figure 19]

41. State the nature of distance-time graph for non-uniform motion of an object.
Ans. Distance-time graph for non-uniform motion of an object is a curve having increasing slope or decreasing slope with time axis. [Refer Figures 20 and 21]

42. What can you say about the motion of a body if its velocity-time graph is a straight line parallel to time axis ?

Ans. When velocity-time graph of the motion of a body is a straight line parallel to time axis, then the velocity of the body does not change with time. So the body is said to move with constant velocity. [Refer figure 22]

43. Name the physical quantity measured by the area under velocity-time graph.
Ans. Area under velocity-time graph is equal to the magnitude of the displacement of the body. Thus, magnitude of the displacement of the body is measured by the area under velocity-time graph.

44. What can you say about the motion of a body if its speed-time graph is a straight line parallel to time axis?
Ans. When speed-time graph is a straight line parallel to time-axis, then speed of the body does not change with time. So the body is said to move with constant speed.

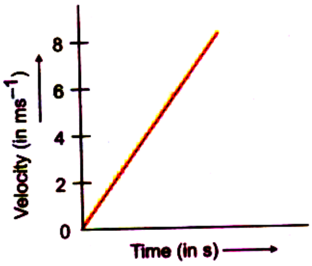
45. Name the physical quantity measured by the area under speed-time graph.
Ans. The distance travelled by a body is measured by the area under speed-time graph.

46. Name the physical quantity measured by the slope of the velocity-time graph for uniform motion.
Ans. Acceleration.

47. Plot velocity-time graph of a body moving with constant velocity.
Ans. Refer Figure 22

48. Slope of velocity-time graph = ... of the body.
Ans. Acceleration.

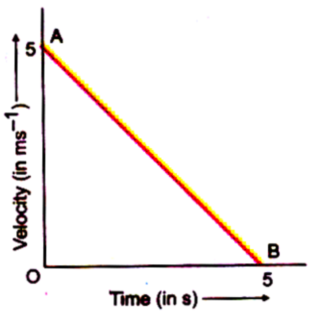
49. Velocity-time graph of a body is shown in figure. What is the initial velocity of the body ?



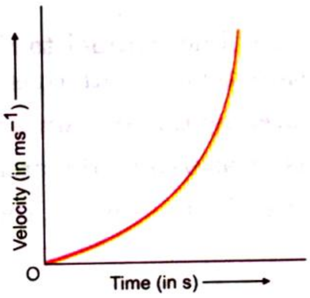
Ans. Zero
50. Area under velocity-time graph = ... of the particle.
Ans. Magnitude of acceleration.

51. Area under speed-time graph = ... travelled by the particle.
Ans. Distance.

52. Velocity-time graph of a body is shown in figure. What are the initial and final velocities of the body?
Ans. Initial velocity = $5ms^{-1}$; Final velocity = 0



53. Velocity-time graph of the motion of a body is shown in figure. State whether the acceleration body is increasing or decreasing.
Ans. Acceleration = slope of velocity-time graph. Since slope of the given curve is increasing with passage of time, so acceleration of the body is increasing.



54. A physical quantity measured is 10 ms^{-1}. Is it a speed or velocity?

Ans. It is velocity because velocity can be positive or negative. On the other hand, speed is always positive

55. Define circular motion.
Ans. The motion of a body moving around fixed point in a circular path.

56. What do you mean by uniform circular motion?
Ans. The circular motion of a body having constant speed.

57. A body moves around the sun with the constant speed in circular path. Is the motion of is uniform or accelerated ?
Ans. Motion of the body is accelerated because its direction of motion is changing continuously around the sun.

58. Name the physical quantity which remains constant during uniform circular motion.
Ans. Linear speed.

59. Name the physical quantity which changes during uniform circular motion.
Ans. Linear velocity.

60. A satellite revolves around the earth with uniform speed. Is the motion of the satellite uniform or accelerated?
Ans. Accelerated.

Short Answer Type Questions

1. Distinguish between distance and displacement.

2. An object (say a car) has moved through a certain distance. Can it have zero displacement? If yes, support your answer with an example.
Ans. Yes. consider an object moves through a distance 1 km from the origin and then returns back along the same path to the origin. In this case, the total distance travelled by the object = 1km + 1 km = 2 km. However, its displacement is zero because its initial (i.e., beginning) and final positions are same.

3. Distinguish between speed and velocity.

4.Name the two physical quantities which can be obtained from velocity-time graph.
Ang. (i) Acceleration and (ii) Displacement.
Acceleration = slope of velocity-time graph
Displacement = area under velocity-time graph.

5. What type of motion, an object has if its velocity-time graph is (i) parallel to the time-axis (ii) a straight line passing through the origin and having constant slope?
Ans. (i) The motion of the object is uniform-motion i.e., it moves with a constant velocity.
(ii) The motion of the object is uniformly accelerated motion i.e., it moves with a constant acceleration.

6. Distinguish between linear motion and circular motion,

Long Answer Type Questions

1. Using velocity-time graph, derive v = u + at.

2. Using velocity-time graph, derive $S = ut + \frac{1}{2}at^2$

3. Using velocity-time graph, derive υ^2 **- u² = 2aS.**

Questions Based on Text Book

In Text Questions

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

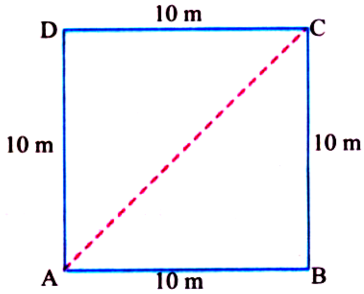
Ans. Refer Short Answer Type Question 2.

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

Ans. ABCD is a square field of side 10m.

The farmer moves along the boundary of the field from the corner A via the corners B, C and D. After every 40s, the fanner is again at the corner A, so his displacement after every 40 s is zero. At the end of 2 minutes 20 seconds = (2 x 60 + 20) = 140 s, the farmer will be at the corner C.

Therefore, the magnitude of his displacement = AC



3. Distinguish between speed and velocity.

Ans Refer. 1.2.2.

4. Under what condition(s) is the magnitude of the average velocity of an object equal to its average speed?

Ans. When an object moves in a straight line in a particular direction.

5. What does the odometer of an automobile measure.

Ans. Refer Very Short Answer Type Question 4.

6. What does the path of an object look like when it is in uniform motion/

Ans. Straight path

7. 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, $3\times10^8\ ms^{-1}$

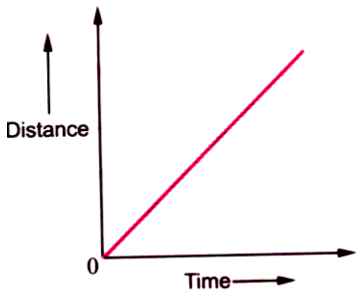
Ans. Here, $t = 5\,\text{minutes} = 5\times60s$

= 300 s $\upsilon = 3\times10^8\ ms^{-1}$

Using $S = \upsilon t,$ we get $S = 3\times10^8\ ms^{-1}\times300s$

= $9\times10^{11}m$ = $9\times10^8\ km$

$\therefore$ the distance of the spaceship from the ground was $9\times10^8 km$



8. When will you say a body is in (i) uniform acceleration?

Ans. (i) A boyd is in uniform acceleration if its velocity changes by an equal amount in equal intervals of time.

(ii) A body is in non-uniform acceleration if its velocity changes by unequal amount in equal intervals of time.

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

Ans. Here, $u = 80\,km\,h^{-1} = 80\times\frac{5}{18}ms^{-1}$ = $22.22\,ms^{-1}$

$\upsilon = 60\,kmh^{-1} = 60\times\frac{5}{18}ms^{-1}$ = $16.67\,ms^{-1}$ $t = 5s$

$\therefore$ acceleration, $a = \frac{\upsilon - u}{t} = \frac{(16.67 - 22.22)\,ms^{-1}}{5s} = \frac{-5.55\,ms^{-1}}{5s} = -1.11 ms^{-2}$

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

Ans. Here, $u = 0$ $\quad \upsilon = 40\,km\ h^{-1} = 40 \times \frac{5}{18}$ $= 11.11\ ms^{-1}$

$t = 10\,\text{min}\,utes = 600s$ $\quad \therefore$ acceleration $a = \frac{\upsilon - u}{t} = \frac{(11.11)\,ms^{-1}}{600s}$ $= 0.0185\,ms^{-2}$

11. What is the nature of the distance-time for uniform and non-uniform motion of an object?
Ans.(i) For uniform motion. Distance time graph is a straight line having constant gradient as shown in figure.
(ii) For non-uniform motion, distance-time graph is a curve having increasing gradient or decreasing gradient as shown in figure.

12. What can you say about the motion of an object whose distance-time graph is a straight line parallel to the time axis?
Ans. When distance-time graph is a straight line parallel to the time axis, it means, the distance of the object is not changing with time. Thus, the object is stationary.

13. What is the quantity which is measured by the area occupied below the velocity-time graph?
Ans. Magnitude of the displacement of a body is measured by the area under the velocity-time graph.

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

Ans. Here $u = 0$ $\quad a = 0.1\ ms^{-2},\ t = 2\,\text{min}\,utes = 120s$

(a) Using, $\upsilon = u + at$, we get $\quad \upsilon = 0 + 0.1 \times 120 = 12\,ms^{-1}$

$\therefore$ speed acquired $= 12\,ms^{-1}$

(b) Using, $S = ut + \frac{1}{2}at^2$, we get $\quad S = 0 + \frac{1}{2} \times 0.1 \times 120 \times 120 = 720m$

$\therefore$ Distance traveled = 720 m

15. A train is traveling at a speed of $90\,km\,h^{-1}$. 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.

Ans. Here, $u = 90\,km\ h^{-1} = 90 \times \frac{5}{18} = 25\,ms^{-1}$ $\quad a = -0.5\,ms^{-2}$ $\quad \upsilon = 0$

Using, $\upsilon^2 - u^2 = 2aS$, we get $\quad S = \frac{\upsilon^2 - u^2}{2a} = \frac{0 - 625}{-2 \times 0.5} = 625m$

16. A trolley, while going down an inclined plane has an acceleration of $2\,cms^{-2}$. What will be its velocity 3s after the start?

Ans. Here, $u = 0,\ \upsilon = ?$ $\quad a = 2\ cm\ s^{-2},\ t = 3s$

Using, $\upsilon = u + at$, we get $\quad \upsilon = 0 + 2 \times 3 = 6\,cm\,s^{-1}$

17. A racing car has a uniform acceleration of $4\,ms^{-2}$. What distance will it cover in 10 s after start?

Ans. Here, $a = 4\,ms^{-2},\ t = 10s$ u = 0

Using $S = ut + \frac{1}{2}at^2,$ we get $S = 0 + \frac{1}{2} \times 4 \times 100 = 200\,m$

$\therefore$ Distance covered in 10s = 200 m

18. 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 be the height attained by the stone and how much time will it take to reach there?

Ans. Here, $u = 5\ ms^{-1}$ $a = -10\,ms^{-2}$

$\upsilon = 0$ at the maximum height $S = ?,\ t = ?$

(i) Using $2aS = \upsilon^2 - u^2,$ we get $S = \frac{\upsilon^2 - u^2}{2a} = \frac{0-25}{-2\times 10} = 1.25\,m$

$\therefore$ Height attained = 1.25 m

(ii) Using, $\upsilon = u + at,$ we get $t = \frac{\upsilon - u}{a} = \frac{0-5}{-10} = 0.5\,s$

Chapter & Exercise

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

Ans. Length of circular track = $2\pi r = \pi(2r) = \pi D = \frac{22}{7} \times 200m$ ($\because$ D = 200m) $= \frac{4400}{7}m$

(i) Distance traveled in 40s = $= \frac{4400}{7}m$ Distance traveled in 1s = $\frac{4400}{7\times 40} = \frac{110}{7}m$

Distance traveled in 2 minutes and 20 s(i.e, 140s) = $\frac{110}{7} \times 140 = 2200\,m = 2.200\,km$

(ii) After every 40s, athlete reaches his starting point, so after 40s, his displacement is zero. It means, the athlete completes the circular track 3 times in 120 s and in the next 20s. he is just opposite to his starting point. Therefore, the magnitude of the displacement of the athlete at the end of the 140 s (or 2 minutes 20s)
= Diameter of the circular track = 200 m

2. Joseph Jogs from one end A to the other end B of a straight 300 m road in 2 minutes 50 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 (a) from A to B and (b) from A to C?

Ans. Distance form A to B = 300 m Displacement from A to B = 300 m
Time taken to go from A to B = 2 minutes 50 s = 170 s

(a) Average speed in jogging from A to B = $\frac{Distance}{Time} = \frac{300\,m}{170s} = 1.76\ m\ s^{-1}$

Average velocity in jogging from A to B = $\frac{Displacement}{Time} = \frac{300m}{170s} = 1.76\ ms^{-1}$

(b) Distance covered from A to C = 300m + 100m = 400m
Displacement from A to C = 300-100 =200m
Time taken to go from A to C = 170s +60s =230s

$\therefore$ Average speed from A to C = $\frac{Distance}{Time} = \frac{400\,m}{230\,s} = 1.74\ ms^{-1}$

Average velocity = $\dfrac{Displacement}{Time} = \dfrac{200m}{230s} = 0.87\,ms^{-1}$

3. Abdul, while driving to school, computes the average speed for his trip to be 20 $km\,h^{-1}$. On his return trip along the same route, there is less traffic and the average speed is $40\,km\,h^{-1}$. What is the average speed for Abdul's trip?

Ans. Let S = distance between Abdul's home to his school

Time taken to reach the school, $t_1 = \dfrac{S}{\upsilon_{av}} = \dfrac{S}{20}h$

$\therefore$ Total time to complete the trip , $t = t_1 + t_2$ $= \dfrac{S}{20} + \dfrac{S}{40} = \dfrac{3S}{40}h$

Total distance traveled during the trip = 2S km $\therefore$ Average speed for Abdul's trip = $\dfrac{2S}{3S} \times 40 = 26.67\,km\,h^{-1}$

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

Ans. Here u = 0 $a = 3.0\,ms^{-2},\ t = 8.0\,s$ Using $S = ut + \dfrac{1}{2}at^2$, we get

$S = 0 + \dfrac{1}{2} \times 3 \times 64 = 96\,m$ $\therefore$ Distance traveled by boat in $8.0\,s = 96\,m$

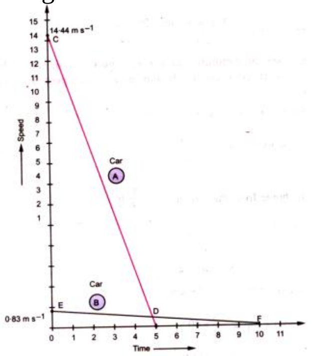
5. A driver of a car traveling at 52 $km\ h^{-1}$ applies the brakes and accelerates uniformly in the opposite direction. The car stops in 5s. Another driver going at $3\,km\ h^{-1}$ in another car applies his breaks slowly and stops in 10s. On the same graph paper plot the speed versus time graphs for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

Ans Intial speed of car, A, $u = 52\,km\ h^{-1} = 52 \times \dfrac{5}{18}ms^{-1} = 14.44\,ms^{-1}$ Final speed of car A, $\upsilon = 0$

Time taken, t = 5s Initial speed of car B, u = $3\,km\,h^{-1} = 3 \times \dfrac{5}{18} = 0.83\,ms^{-1}$

Final speed of car B, $\upsilon = 0$ Time taken, t = 10s

Speed time graphs for cars A and B are shown in figure



Distance traveled by car A = Area under curve CD

= Area of $\Delta COD = \dfrac{1}{2} \times base \times height$ $= \dfrac{1}{2} \times 5 \times 14.44 = 36.1m$

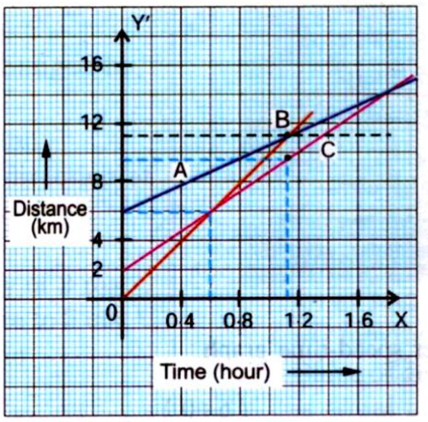
Distance traveled by car B = Area under curve EF

= Area of $\Delta EOF = \dfrac{1}{2} \times base \times height = \dfrac{1}{2} \times 10 \times 0.83 = 4.15\,m$

$\therefore$ Car A traveled more distance than car B after the brakes were applied.

6. Fig. Shows the distance-time graph of three objects A,B and C. Study the graph and answer the following questions:

Scale :
Along Distance axis :
1 div = 0·4 km



(a) Which of the three is traveling the fastest?

(b) Are all three ever at the same point on the road?

(c) How far has C traveled when B passes A?

(d) How far has B traveled by the time it passes C?

Ans. (a) Speed = Slope of distance-time graph
Since slope of distance-time graph for object B is the greatest, so object B is traveling the fastest
(b) All the three objects will be at the same point on the road if these objects are at the same distance from the origin O. They are never at the same point on the road.
(c) When B passes A, distance traveled by C = 9.4 -2 = 7.4 km
(d) Distance traveled by B by the time it passes C = 6 m

7. A ball is gently dropped form 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?

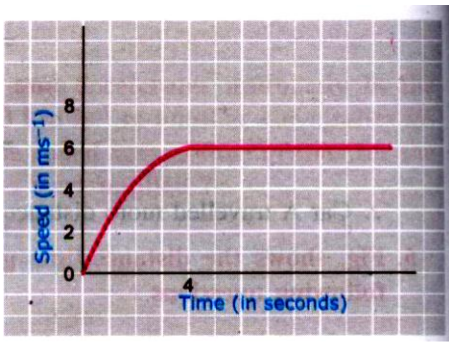
Ans. Here, u = 0, S = 20 m a = 10 ms^{-2}

(i) Using $\upsilon^2 - u^2 = 2as,$ we get $\upsilon^2 - 0 = 2\times10\times20 = 400 \quad \therefore\ \upsilon = \sqrt{400}\ 20\,ms^{-1}$

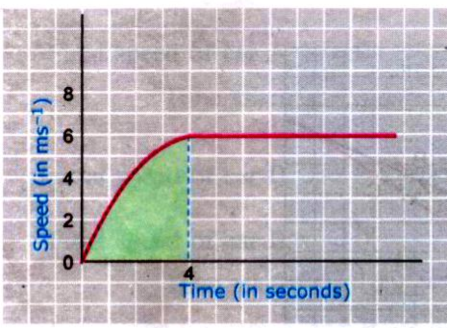
$\therefore$ the ball strikes the ground with a velocity of $20\,ms^{-1}$

(ii) Using $S = ut + \frac{1}{2}at^2$ we get $20 = 0 + \frac{1}{2}\times10t^2 = 5t^2$ or $t = \sqrt{4} = 2s$

8. The speed-time graph for a car is shown in figure
(a) Find how far does the car travel in the first four seconds. Shade the area on the graph that represents the distance traveled by the car during the period.
(b) Which part of the graph represents uniform motion of the car?



Ans. (a)



Distance = Area under speed –time graph = average speed × time = $\left(\frac{6+0}{2}\right)\times 4 = 12\,m$

(b) The straight part of the curve parallel to time axis represents the uniform motion of the car.

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 zero velocity.
(b) an object moving in a certain direction with an acceleration in the perpendicular direction.

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.

Ans. Radius = R = 42250 km

Length of orbit = Circumference of the orbit

$2\pi R = 2 \times \frac{22}{7} \times 42250\, km = 265571.43\, km$ Time t = 24 h

$\therefore$ Speed = $\frac{Length\ of\ \ orbit}{Time} = \frac{2\pi R}{t} = \frac{265571.43km}{24h} = 11065.48\, km\ h^{-1}$

= $\frac{11065.48}{3600} km\ s^{-1} = 3.07\, km\ s^{-1}$

Chooce the correct option :

1. If the distance travelled by an object is zero, then the displacement of the object is
(a) zero (b) not zero (c) negative (d) may or may not be zero.

2. If the displacement of an object is zero, then the distance travelled by the object is
(a) zero (b) not zero (c) negative (d) may or may not be zero.

3. Speedometer measures
(a) speed (b) average speed (c) instantaneous speed (d) instantaneous velocity.

4. The velocity of an object can be changed by
(a) changing the speed (b) changing the direction of motion
(c) changing both the speed and direction of motion (d) all (a), (b) and (c) are true.

5. An object is moving with a velocity of 2 ms^{-1}. Its velocity changes at a uniform rate to 5 ms^{-1} The average velocity of the object is
(a) 3 ms^{-1} (6) 3.5 ms^{-1} (c) 4 ms^{-1} (d) 5.5 ms^{-1}

'6. A boy running at an average speed of 4 km h^{-1} reaches school from his home in $\frac{1}{2}$ hour. The distance of the school from his home is
(a) 2 km (0)8 km (c)4km (d) 6 km.

7. A device used-to measure the distance is known as
(a) speedometer (b) sonometer (c) odometer (d)galvanometer.

8. A girl swims in a swimming pool of length 100 m. She swims from one end to another end and reaches the starting point again in 2 minutes. The average velocity of the swimmer is
(a) 100 ms^{-1} (b) 0.83 ms^{-1} (c) 1.67 ms^{-1} (d) zero.

9. A car is moving with a uniform velocity of 40 km h^{-1}. Its acceleration after 1 hour is
(a) 40 km h^{-1} (fc) 20 km h^{-1} (c) 30 km h^{-1} (d) zero.

10. A body will have uniform acceleration if its
(a) speed changes at uniform rate (b) velocity changes at uniform rate
(c) speed changes at non-uniform rate (d) velocity remains constant.

11. Distance-time graph of a body is a straight line parallel to time axis. The body is
(a) moving with constant speed (b) moving with constant velocity
(c) at rest (d) moving in a straight line.

12. Slope of distance-time graph of a moving body is equal to
(a) velocity of the body (6) speed of the body (c) acceleration of the body (d) none of these.

13. The speed of a body is 1 ms~[1]. The angle between the distance-time graph of the body and the time axis is
(a) 0° (b) 30° (c) 45° (d) 60°.

14. Area under velocity-time graph is equal to the
(a) speed of the body (b) distance travelled by the body
(c) magnitude of the displacement of the body (d) none of these.

15. Area under speed time graph is equal to the
(a) velocity of the body (b) magnitude of the displacement (c) distance traveled by the body (d) none of these

16. The acceleration of an object moving with speed v in a circle of radius r is
(a) $\upsilon^2 r$ (b) r/υ^2 (c) υ^2/r (d) υ^2/r^2

17. the direction of acceleration of an object moving in a circular path is
(a) directed away from the centre of the circle (b) directed towards the centre of the circle
(c) directed upward in the plane of the circle (d) none of these

Answer

1.(a) 2.(d) 3.(c) 4.(d) 5.(d) 6.(a) 7.(c) 8.(d) 9.(d) 10.(b) 11.(c) 12.(b) 13.(c)
14.(c) 15.(c) 16.(c) 17.(b)

Hints

5. $\vec{\upsilon}_{av} = \frac{\vec{u}+\vec{\upsilon}}{2} = 3.5\ ms^{-1}$

6. Distance = average speed × times = $4 \times \frac{1}{2} = 2km$

7. $\vec{\upsilon}_{av} = 0$ because net displacement is zero **9.** $a = 0$ because velocity is not changing

13. slope = $\tan\theta = speed\ = 1 \quad \therefore\ \theta = 45^0$

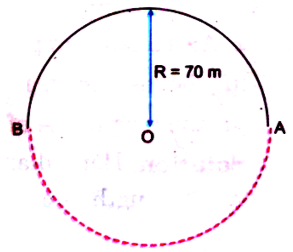
Higher order Thinking Questions

1. Explain, whether the walls of a classroom are at rest or in motion.
Ans. The walls of a classroom are at rest with respect to the students sitting in a classroom because the walls of the classroom do not change their positions with respect to the students in the classroom.
However, the walls of a classroom are in motion for a person sitting in a bus moving on a road
outside the classroom because the positions of the walls are changing with reapect to the person sitting in the moving bus.

2. A standing train in which we are sitting appears to move. Explain why.
Ans. A standing train in which we are sitting appears to move if we look at another train moving parallel to our train.

3. A student runs over a circular track of diameter 70 m. He starts from point A and stops at point B as shown in figure. What is the
(i) distance travelled by the student.
(ii) displacement of the student?
Ans. (i) Distance travelled = length of semicircular track

= $\frac{1}{2} \times circumference\ of\ \ the\ circular\ track\ \ AB$



$= \frac{1}{2} \times 2\pi R = \pi R = \frac{22}{7} \times 70\ m$ = 220 m

4. The school of a boy from his home is 1 km to the east. When he reaches back his home, he says that he had travelled 2 km distance but his displacement is zero. State whether the statement made by the boy is correct or incorrect. Justify your answer

Ans. His statement is correct.
Distance travelled by the boy = Distance between his home and school
+ Distance between his school and home
= 1 km + 1 km = 2 km
Displacement of the boy = Final position of boy – Initial position of boy.
Since, boy started his journey form his home and finishes his journey again at his home, so his initial position = final position. Therefore, displacement of the boy is zero

5. On a cloudy day, lightning is seen before the thunder is heard. Explain, why ?

Ans. This is because speed of light (3 x 10^8 ms"[1]!]-! air) is much more than the speed of sound (346 ms^{-1}). It means, light travels faster than the sound. Therefore, lightning is seen before the thunder is heard.

6. Under what condition, the average speed is equal to the magnitude ofthe average velocity.

Ans. Average speed= $\frac{Total\ dis\tan ce\ travelled}{Total\ time\ taken}$ and magnitude of average velocity =

$$\frac{Magnitude\ of\ the\ displacement}{Total\ time\ taken}$$

Now, the average speed = magnitude of average velocity if the total distance travelled by an object in a given time interval is equal to the magnitude of the displacement of the object in the same time interval. This is possible, when an object moves in one direction along a straight line.
Thus, average speed is equal to the magnitude of the average velocity if an object moves in one direction along a straight line.

7. Can the average speed of a moving body be zero ?

Ans. Average speed = $\frac{Total\ dis\tan ce\ travelled\ by\ the\ body}{Total\ time\ taken}$

Since, the total distance travelled by a moving body increases with the time, so average speed of a moving body can not be zero.

8. Can the average velocity of a moving body be zero ? State examples.

Ans. Average velocity = $\frac{Total\ displacement\ of\ the\ body}{Total\ time\ taken}$

since total displacement of a moving body can be zero, so the average velocity of a moving body can be zero.
Examples. (i) When an athlete completes one round in a circular track in the given time interval, then his total displacement is zero. Hence, his average velocity is zero.
(ii) When a boy runs from one corner of a lawn to another and runs back to his starting point, then the total displacement of the boy is zero. Hence, his average velocity is zero.

9. Give one example of a uniform motion in a etraight line in which velocity is constant.

Ans. Light in vacuum/air travels in a straight line with constant velocity (3 x 10^8 ms^{-1} **).**

10. An object P is moving with a constant velocity for 5 minutes. Another object Q is moving with changing velocity for 5 minutes. Out of these two objects, which one has acceleration. Exaplain.

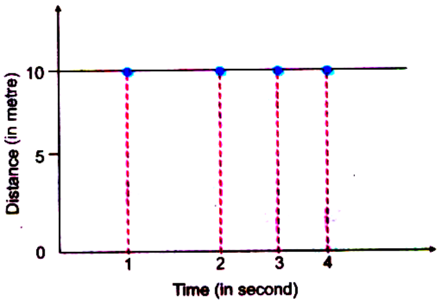
Ans. Acceleration = $\frac{\textit{Change in velocity}}{\textit{Time taken}}$

Since, the velocity of object P is not changing or change in velocity of the object is zero, therefore, object P has no acceleration. On the other hand, there is change in velocity of the object Q, so it has acceleration.

11. Can an object be accelerated if it is moving with constant speed? If yes, give example.
Ans. An object moving with constnat speed can be accelerated if its direction of motion changes. For example, an object moving with a constant speed in a circular path has an acceleration because its direction of motion changes continously.

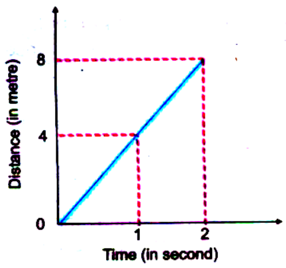
12. (i) When do you say that an object has positive acceleration? (ii) When do you say that an object has negative acceleration?
Ans. (i) An object has positive acceleration if the direction of acceleration of the object is same as that of the direction of motion of the object. (ii) An object has negative acceleration if the direction of acceleration of the object is opposite to the direction of motion of the object.

13. A graph between distance travelled and time taken by an object is shown in figure (i) State, whether the object is moving or stationary (ii) The distance of the object from a fixed point at t = 0 (iii) Speed of the object at 4 seconds.



Ans. (i) Since the distnace of the object remains the same (=10m) with the passage of time, so the object is stationary. If the object would be moving, then its distance should have increased with the passage of time.
(ii) Distance of the object from a fixed pont at t = 0, = 10 m
(ii) Since the object is stationary, so its speed is zero at 4 seconds.

14. Distance-time graph for the motion of an object is shown in figure.
(i) State whether the motion of the object is uniform motion or non uniform motion.
(ii) Calculate the speed of the object at t =2 seconds.



Ans. (i) Since the object travels equal distnaces in equal intervals of time, so the object has uniform motion.
(ii) Speed of the object = Slope of distance-time graph

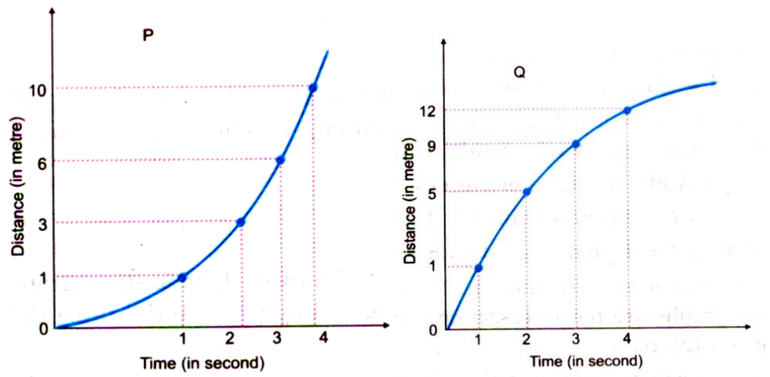
$$=\frac{(8-0)m}{(2-0)s}=\frac{8m}{2s}=\mathbf{4}ms^{-1}$$

15. Two trains A and B start moving at the same time. The distances travelled by them in given intervals of time are show below. State which train has uniform motion and which train has non-uniform motion.

Time	Distnace travelled by train A (in km)	Distance travelled by train B (in km)
6.00 pm	0	0
6.15 pm	10	15
6.30 pm	20	24
6.45 pm	30	32
7.00 pm	40	38
7.15 pm	50	42
7.30 pm	60	47

Ans. Since train A travel equal distances in equal itnervals of time (i.e., in every 15 minutes), so the motion of train A is uniforom motion. On the other hand, train B travels unequal distances in equal intervals of time (i.e. in every 15 minutes), s the motion of train B is non-uniform motion.

16. The distance-time graph for the motion of two objects P and Q are shown in figure I and figure II respectively.



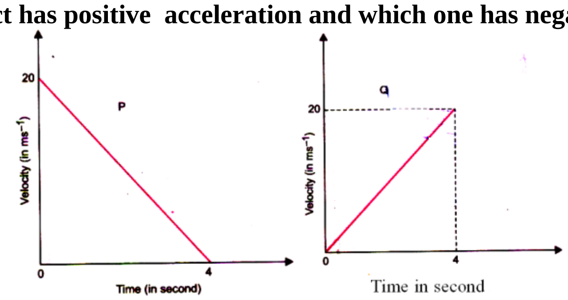
I II

(i) State whether the motion of objects P and Q is uniform motion or non-uniform motion.
(ii) A student comments that the speed of object P is decreasing and the speed of object Q is increasing State whether the comment is correct or incorrect. Justify you answer.

Ans. (i) Since both the object P and Q are travelling unequal distnaces in equal intervals of time, so the motion of both the objects is non-uniform motion.

(iii) The comment is incorrect. Since spped of an object = slope of distance-time graph. The speed of the object will increase if the slope of distance-time graph increases and vice-versa. As the slope of distance-time graph of the motion of the object P is increasing, so the speed of P increases. On the other hand, slope of distance-time graph of the motion of the object Q is decreasing, so the speed of Q decreases.

17. The velocity-time graph for the motion of two objects P and Q are shown in figure I and II respectively. Which of the object has positive acceleration and which one has negative acceleration?

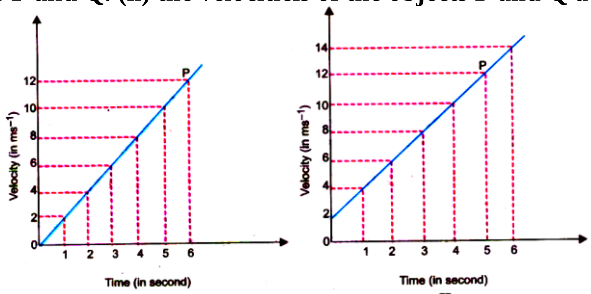


Ans. Acceleration of an object = $\dfrac{\text{Final velocity - Initial velocity}}{\text{Time interval}}$

Since, for object P, initial velocity ($20\,\text{ms}^{-1}$) is greater than the initial velocity, so object P has **negative acceleration.**

For object Q, final velocity $(20\ ms^{-1})$ is greater than the initial velocity (0), so object Q has positive acceleration.

18. Velocity-time graph for the uniform motions of two objects P and Q are shown in figures I and II respectively. State (i) the initial velocities of objects P and Q. (ii) the velocitieis of the objects P and Q at the instant t = 6 second.



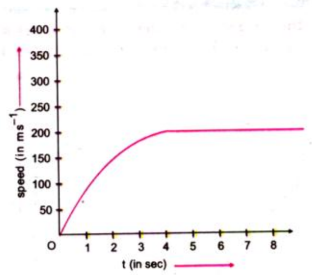
I II

Ans. (i) For object P, velocity = 0 at t = 0. Therefore, initial velocity of object P = 0.

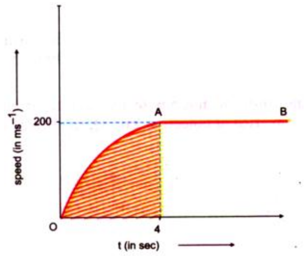
For object Q, velocity = $2ms^{-1}$ at $t = 0$ Therefore, initial velocity of object Q = $2ms^{-1}$

(ii) Velocity of object P at t = 6s = 12 ms^{-1} Velocity of object Q at t = 6s = 14 ms^{-1}

19. A bus is moving on a straight road. The speed-time graph for the motion of the bus is shown in figure. Calculate the distance travelled by the bus in 4 seconds. Also state, what does the straight part of the graph represent.



Solution. The distance travelled by the bus in 4s = Average speed × Time $= \left(\frac{200+0}{2}\right)\times 4 = 400\,m$



The striaght part AB of the graph represents that the bus is moving with constant speed after 4 seconds. In other words, straight part AB represents the uniform motion of the bus.

20. State which of the following situations are possible and give an example of each of these:
(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 a n accelerated motion.
Ans. (a) This situation is possible.
Example : When a body (say a ball) is thrown vertically upward, then the body comed to rest momentarily at the highest position fromwhere it starts falling downwards. At the highest position velocity of the body is zero but its acceleration is equal to acceleration due to gravity (i.e., $98\,ms^{-2}$) in the downward direction.
(b) This situation is possible
Example: Aeroplane flying horizontally with constant velocity. In this case, acceleration equal to acceleration due to gravity is acting on the aeroplane in the vertical direction.
(c) This situation is possible.
Example: A body moving in a circular path. In this case, the body moves with constant speed but it has an acceleration towards the centre of the circular path (centripetal acceleration) due to continuous change in the direction of motion.

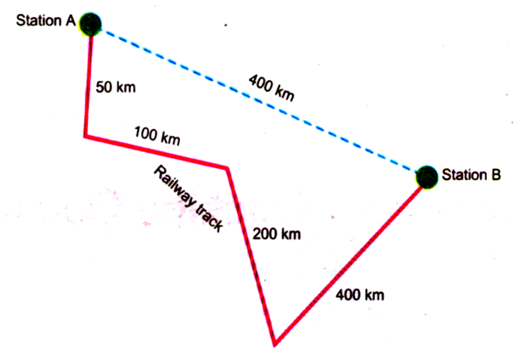
21. An artificial satellite is moving in a circular orbit of radius 36,000 km. If it takes 24 hours to complete one orbit around the earth, find its linear velocitys.
Solution. Radius of orbit, $r = 36,000\,km$ Distance travelled by satellite to complete one orbit

= Circumference of the orbit = $2\pi r$ $= 2\times\frac{22}{7}\times 36,000 = 226285.7\ km$ Time, $t = 24\,hr$

$\therefore$ Linear velocity of satellite = $\frac{Dis\tan ce}{Time}$ = $\frac{22685.7\,km}{24h} = 9428.57\ km\ h^{-1}$ = $\frac{9428.57}{3600} = \mathbf{2}.62\,km\ s^{-1}$

MODEL NUMERICAL PROBLEMS

1. A train goes from station A to station B as shown in figure. Calculate (i) the distance travelled by train and (ii) the magnitude of the displacement of the train on reaching station B.



Solution. (i) Distance travelled by the train

= 50+100 +200 +400 =**750 km**

(ii) Magnitude of the displacement in going from station A to station B = **400 km**

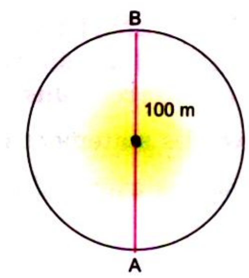
2. An athlete completes a round of a circular track of diameter 200 m in 20s. Calculate
(i) the distance travelled by the athlete and
(ii) the magnitude of the displacement of the athlete at the end of 1 minutes and 10 seconds.

Solution. Here, diameter of circular track, D = 200m

$\therefore$ Length of circular track = circumference of the circular track

$= 2\pi r = \pi(2r) = \pi D \qquad (\because 2r = D)$

$= \frac{22}{7} \times 200 = 628.57\ m$



(i) Distance travelled in 20 s = length of circular track = 628.57 m

Distance travelled in 1s = $\frac{628.57}{20} m$

$\therefore$ Distance travelled in 1 minutte and 10 s (or 70s)

$\frac{628.57}{20} m \times 70 = 2199.99 \ = 2200 m$

(ii) Number of rounds completed in 20 s = 1 Number of rounds completed in 70 s = $\frac{1}{20} \times 70 = 3\frac{1}{2}$

When athlete completes 3 rounds, his displacement = zero

The position of the athlete at the end of 1 minute and 10 s = diameter of the circular track = 200 m

Formula used, $a = \frac{\upsilon - u}{t}$ or $\upsilon = u + at$

Units, υ and u are measured in $km\ h^{-1}$ or ms^{-1}, a is measured in $km\ h^{-2}$ or ms^{-2}

3. A driver applies the brakes and slows down the velocity of the bus from $80 km\ h^{-1}$ to $60 km\ h^{-1}$ in 5s. Calculate the acceleration of the bus.

Solution. Initial velocity, $u = 80 km h^{-1} = 80 \times \frac{5}{18} ms^{-1} = 22.22 ms^{-1}$ Final velocity, $\upsilon = 60\ km\ h^{-1}$

$= 60 \times \frac{5}{18} ms^{-1} = 16.67 ms^{-1}$ Time, t = 5s Acceleration, $a = ?$

Using, $a = \frac{\upsilon - u}{t}$, we get $a = \frac{(16.67 - 22.22) ms^{-1}}{5s} = \frac{-5.55\ ms^{-1}}{5s} = -1.11\ ms^{-2}$

4. A bus starts from rest and attains a speed of $36 km\ h^{-1}$ in 10 minutes while moving with uniform acceleration. Calculate the acceleration of the bus.

Solution. Here, initial velocity, $u = 0$ Final velocity, $\upsilon = 36\ km h^{-1}$

$= 36 \times \frac{5}{18}\ ms^{-1}$ $= 10\ ms^{-1}$

Time, t = 10 minutes $= 10 \times 60\,s$

$= 600s$

Acceleration a =?

Using, $a = \frac{\upsilon - u}{t}$, we get $a = \frac{(10-0)\ ms^{-1}}{600\,s} = \frac{1}{60} ms^{-2}$

Thus, acceleration of the bus = $\frac{1}{60} ms^{-2}$

5. A car starts from rest and attains a velocity of $10\,ms^{-1}$ in 40 s. The driver applies brakes and slow down the car to $5\,m\,s^{-1}$ in 10s. Find the acceleration of the car in both the cases.

Solution. First case

Initial velocity, u =0

Final velocity, $\upsilon = 10\,ms^{-1}$

Time, $t = 40\,s$

$a = ?$

Using, $a = \frac{\upsilon - u}{t}$, we get $a = \frac{(10-0)\,ms^{-1}}{40s} = \mathbf{0}.25\,ms^{-2}$

Second case

Intial velocity, $u = 10\ ms^{-1}$

Final velocity, $u = 5\ ms^{-1}$

Time, t = 10s

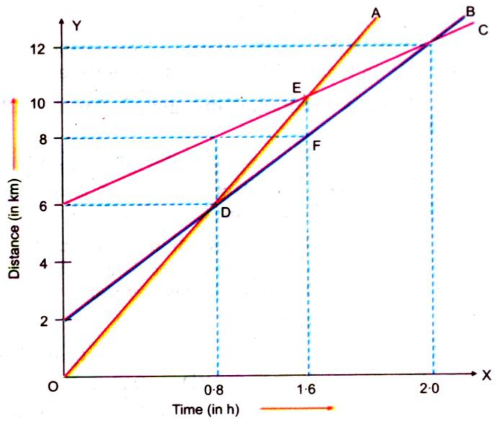
a = ?

Using, $a = \frac{\upsilon - u}{t}$, we get

$$a = \frac{(5-10)\,ms^{-1}}{10s} = -\frac{5}{10} ms^{-2} = -0.5\,ms^{-2}$$

In first case, car is accelerated and in the second case, the car is retarded.

6. Figure shows the distance-time graph of three children A,B and C



Answer the following questions:

(i) Which child has the highest speed and which has the lowest speed?

(ii) What is the distance of each child from the origin at t = 0 ?

(iii) Are the three children ever at the same point on the road?

(iv) When B passes A, where is child C?

(v) How much distnace child B travels when he passes child C?

Solution. (i) Speed = slope of distance-time graph.

Since slope of distance-time graph of child A is maximum so child A has the highest speed. On the other hand, slope of distance-time graph of child C is minimum, so child C has the lowest speed.

(ii) Distnace of child A at t = 0 from origin O = 0.

Distance of child B at t = 0 from origin O = 2 km.

Distance of child C at t = 0 from origin O = 6 km.

(iii) Three children will meet each other on the road if all the three distance-time graphs intersect each other. Since the three graphs are not intersecting each other at any time, so the three children will never be at the same point on the road.

(iv) Child B meets or passes child A at D. So draw perpendicular form D on time axis. From figure, it is clear that child B passes child A after 0.8 hours. At this time, child C is at 8 km

(v) Distance travelled by child B = (12-2) = 10 km

Formulae Used: (i) $\upsilon = u + at$ (ii) $S = ut + \frac{1}{2}at^2$ (iii) $\upsilon^2 - u^2 = 2aS$

Units: u and υ are measured in ms^{-1} or kmh^{-1}; S in **m** or km; a in ms^{-2} or $km\ h^{-2}$; t in **s or h**

Conversion Factor: $1km\ h^{-1} = \frac{5}{18}ms^{-1}$ Technique: If body starts from rest, take u = 0

If body finally stops, take $\upsilon = 0$ If velocity of the body increases, take 'a' as **positive**

If velocity of the body decreases, take $'a'$ as **negative**

7. A bus starting form rest accelerates in a straight line at a constant rate of $3ms^{-2}$ for 8 seconds. Calculate the distance travelled by the bus

Solution. Here, $u = 0;\ a = 3ms^{-2};\ t = 8s;\ S = ?$ **Using,** $S = ut + \frac{1}{2}at^2,$ we get

We have $S = 0 + \frac{1}{2} \times 3ms^{-2} \times 64\,s^{-2} = 96\,m$

8. A car starts from rest and acqures a velocity o f $54\,km\,h^{-1}$ in 2 minutes. Find (i) the acceleration and (ii) distance travelled by the car during this time. Assume, motion of the car is uniform

Solution. Here, initial velocity, u = 0

Final velocity, $\upsilon = 54\,km\ h^{-1} = 54 \times \frac{5}{18}ms^{-1} = 15\,ms^{-1}$

Time, t = 2 minutes = $2 \times 60 = 120\,s$ $a = ?,\ S = ?$

(i) Using, $\upsilon = ut + \frac{1}{2}at^2$ we get

(ii) $S = 0 + \frac{1}{2} \times \frac{1}{8}ms^{-2} \times (120s)^2$ $= \frac{1}{16} \times 120 \times 120\,m = 900m$

9. A bus starts from rest and moves with a uniform acceleration of $1ms^{-2}$ of 2 minutes. Calculate (i) the speed acquired and (ii) the distance travelld by the bus.

Solution. Here, $u = 0$; $a = 1ms^{-2}$; $t = 5$ minutes = $5 \times 60 = 300\,s$ $\upsilon = ?;\ S = ?$

(i) Using, $\upsilon = u + at,$ we get $\upsilon = 0 + (1ms^{-2}) \times 300\,s = 300\,ms^{-1}$

(iii) Using $S = ut + \frac{1}{2}at^2,$ we get $S = 0 + \frac{1}{2} \times 1ms^{-2} \times (300\,s)^2$ = $45{,}000\,m = \mathbf{4}5\,km$

10. A car is travelling with a speed o f $36\,km\,h^{-1}$. The driver applies the brakes and retards the car uni formly. The car is stopped in 5 seconds. Find (i) the retardation of the car and (ii) distance travelled before it is stopped after applying the brakes

Solution. Here, $u = 36\,km\,h^{-1} = 36 \times \frac{5}{18}ms^{-1} = 10\,ms^{-1}$ $\upsilon = 0;\ t = 5s$ $a = ?;\ S = ?$

(i) Using $\upsilon = u + at,$ we get $a = \frac{\upsilon - u}{t} = \frac{(0-10)ms^{-1}}{5s} = -2\,ms^{-2}$

(ii) Using, $S = ut + \frac{1}{2}at^2,$ we get $S = 10\,ms^{-1} \times 5s + \frac{1}{2}(-2\,ms^{-2})(25\,s^2)$ = $50\,m - 25m = 25\,m$

11. A train is travelling at a speed of $72\,km\,h^{-1}$. The driver applies brakes so that a uniform acceleration of $-0.2\ ms^{-2}$ in produced. Find the distance travelled by the train before it comes to rest.

Solution. Here $u = 72\,km\,h^{-1} = 72 \times \frac{5}{18} ms^{-1} = 20\,ms^{-1}$ $\quad a = -0.2\,ms^{-2}$ $\quad \upsilon = 0$

$S = ?$ $\quad (\because train\ \ finally\ comes\ to\ rest)$ $\quad$ Using, $2aS = \upsilon^2 - u^2$, we get

$S = \frac{\upsilon^2 - u^2}{2a} = \frac{0-(20\ ms^{-1})^2}{-2\times 0.2\,ms^{-2}}$ $= \frac{400\,m^2 s^{-2}}{0.4\,ms^{-2}} = 1000\,m = \mathbf{1}km$

12. A box going down an inclined plane has an acceleration of $0.9\,ms^{-2}$. Calculate the distance of the box 6 seconds after the start.

Solution. Here, $a = 0.9\,ms^{-2},\ t = 6s,\ u = 0,\ S = ?$ $\quad$ Using, $S = ut + \frac{1}{2}at^2, we\ \ get$

$S = 0 + \frac{1}{2} \times 0.9\,ms^{-2} \times 36\,s^2 = 16.2\,m$

13. A child drops a ball from a height of 10m. Assume that its velocity increases uniformly at the rate of $10\,ms^{-2}$. Find (i) the velocity with which the ball strikes the ground and (ii) the time taken by the ball to reach the ground.

Solution. Here, S = 10 m , $a = 10\,ms^{-2}$ $\quad u = 0\ (\because ball\ \ was\ \ simply\ \ dropped)$ $\quad \upsilon = ?,\ t = ?$

(i) Using, $\upsilon^2 - u^2 = 2aS$, we get $\quad \upsilon^2 - 0 = 2\times 10\,ms^{-2} \times 10m$

Or $\quad \upsilon^2 = 200\,m^2 s^{-2}$

Or $\quad \upsilon = \sqrt{200\,m^2\ s^{-2}} = 14.14\ ms^{-1}$

(ii) Using, $\quad \upsilon = u + at$, we get $\quad 14.14 = 0 + 10t$ $\quad$ or $t = \frac{14.14}{10} = 1.414\,s$

14. The driver of train A travelling at a speed of $54\,km\,h^{-1}$ applies brakes and retards the train uniformly. The train stops in 5seconds. Another train B is travelling on the parallel track with a speed of 36 $km\ h^{-1}$. His driver applies the brakes and the train retards uniformly. The train B stops in 10 seconds. Plot speed-time graphs for both the trains on the same graph paper. Also calculate the distance travelled by each train after the brakes were applied.

Solution. For train A $u = 54\,km\ h^{-1} = 54 \times \frac{5}{18} = 15\,ms^{-1}$ $\quad \upsilon = 0;\ t = 5s$

For train B $\quad u = 36\,km\ h^{-1} = 36 \times \frac{5}{18} = 10\,ms^{-1}$ $\quad \upsilon = 0;\ t = 10s$

Distance travelled by train A = Area under curve EF = Area of ΔOEF

$= \frac{1}{2} \times Base \times Height = \frac{1}{2} \times OF \times OE$ $\quad = \frac{1}{2} \times 15\,ms^{-1} \times 5s = 37.5\,m$

Distance travelled by train B = Area under curve CD $\quad = Area\ of\ \ \Delta OCD$

$= \frac{1}{2} \times Base \times Height = \frac{1}{2} \times OD \times OC$ $\quad = \frac{1}{2} \times 10ms^{-1} \times 10s = 50\,m$

UNSOLVED NUMERICALS (Try Yourself)

1. Ram travels on a straight road. He goes from position A to position B. The distance between A and B is 4 km. Now from position B he truns back and travels a distance of 2 km to reach the position C. Find (i) the total distance travelled by Ram during the whole journey and (ii) magnitude position C. Find (i) the total distance travelled by Ram during the whole journey and (ii) magnitude of his displacement.

Ans. Distance = 6 km ; displacement = 2 km

2. An athlete completes one round of a circular track of diameter 200 m in 30 s. Find (i) the distance travelled by the athlete and (ii) the magnitude of the displacement of the athlete at the end of 30s.

Ans. Distance = 628.57 m; displacement = 0

3. An athlete completes one round of a circular track of diameter 200 m in 40s. Find (i) the distance travelled by him and (ii) the magnitude of the displacement at the end of 3 minutes 20 seconds.
Ans. Distance = 3142.85 m; displacement = 0

Formulae used. (i) Speed $(\upsilon) = \frac{Distance}{time}$ (ii) Average speed $(\upsilon_{av}) = \frac{Total\ distance}{Total\ time\ taken}$

(iii) Velocity $(\vec{\upsilon}) = \frac{Displacement}{Time}$ (iv) Average velocity $(\vec{\upsilon}_{av}) = \frac{Total\ displacement}{Total\ time\ taken}$

S.I. Units. Speed and velocity are measured in ms^{-1}. Time in s.

Non-SI.Units Speed velocity can also be measured in **km** h^{-1} time in **h.**

Conversion factor. $1\ km\ h^{-1} = \frac{5}{18}\ ms^{-1}$

4. A taxi driver noted the reading on the odometer fitted in the vehicle as 1052 km when he started the journey. After 30 minutes drive, he noted that the odometer reading was 1088 km.. Find the average speed of the taxi.
Solution. Distance travelled by the taxi = 1088 – 1052 = 36 km

Time taken = 30 min = $\frac{1}{2}h$

$\therefore$ Average speed of taxi = $\frac{Distance}{time} = \frac{36\,km}{\frac{1}{2}h} = 72\ km\ h^{-1} = 72 \times \frac{5}{18} ms^{-1}$ = $\mathbf{20}\ ms^{-1}$

5. A boy is running on a straight road. He runs 500m towards north in 2.10 minutes and then turns back and runs 200m in 1.00 minute. Calculate
(i) his average speed and magnitude of average velocity during first 2.10 minutes, and
(ii) his average speed and magnitude of average velocity during the whole journey.
Solution. (i) Totla distance = 500 m Total time = 2.10 minutes = 130 s

Magnitude of displacement = 500 m Average speed = $\frac{Distance}{Time} = \frac{500\,m}{130s} = 3.85\,ms^{-1}$

Magnitude of average velocity = $\frac{Magnitude\ of\ displacement}{Time} = \frac{500\,m}{130\,s} = 3.85\ ms^{-1}$

Note- This example shows that the average speed = average velocity if the motion is in one direction.
(ii) Total distance = 500 m + 200m = 700 m Total time = 2.10 +1.00 = 3.10 minutes = 190s
Magnitude of total displacement = 500m – 200m = 300m

$\therefore$ Average speed = $\frac{Total\ displacement}{Total\ time} = \frac{700\,m}{190s} = 3.68\ ms^{-1}$

Magnitude of average velocity = $\frac{Total\ displacement}{Total\ time} = \frac{300\,m}{190\,s} = 1.58\ ms^{-1}$

Note: This example shows that average speed is greater than the magnitude of average velocity if the direction of motion changes.

6. It has been estimated that the radio signal takes 1.27 seconds to reach the earth from the surface of the moon. Calculate the distance of the moon from the earth. Speed of radio signal = $3\times10^{8}\ ms^{-1}$ (speed of light in air)
Solution. Here, time = 1.27 s
Speed = $3\times10^{8}\ ms^{-1}$
Distance = ?
Using, distance = speed × time, we get
Distance = $3\times10^{8}\,ms^{-1}\times1.27s = 3.81\times10^{8}\,m = \mathbf{3}.81\times10^{5}\,km$

7. A wireless signal is sent to earth from a spacecraft. This signal reaches the earth in 300 seconds. Calculate the distance of the spacecraft from the earth. Given, speed of the signal = $3 \times 10^8 \ ms^{-1}$

Solution. Here, t = 300s

Speed, $\upsilon = 3 \times 10^8 \ ms^{-1}$

Distance = ?

Using, distance = speed × time, we get

$= 3 \times 10^8 \, ms^{-1} \times 300 \ s = 9 \times 10^{10} \ m = \mathbf{9} \times 10^7 km$

Thus, distance of spacecraft from earth = $9 \times 10^7 \ km$

8. A sound is heard 5 seconds later than the lightning is seen in the sky on a rainy day. Find the distance of the location of lightning. Give speed of sound = 346 ms^{-1}

Solution. Here, $t = 5s$

Speed, $\upsilon = 346 \ ms^{-1}$

Distance =?

Using, distance = speed × time, we get

Distance = $346 \ ms^{-1} \times 5s = 1730 \, m$

Thus, the distance of the locaiton of lightning = **1730 m.**

9. Akshil drove his car with an average speed of $20 \, km \, h^{-1}$ **while going to his college. When he returned to his home along the same route, the average speed of the car is** $30 \ kmh^{-1}$**. Calculate the average speed of the car during the entire journey**

Solution. Let $s =$ distance between the college and home

Time taken to travel distance s with the average speed of 20 kmh^{-1}, $t_1 = \frac{Distance}{Average\,speed} = \frac{s}{20} h$

Time taken to travel distance s with the average speed of $30 \ kmh^{-1}$, $t_2 = \frac{s}{30} h$

∴ Total distance travelled during the entire journey = $s + s = 2s$

Total time taken to complete the entire journey, $t = t_1 + t_2 = \frac{s}{20} + \frac{s}{30} = \frac{s}{12} h$

∴ Average speed of the car during the entire journey, $\upsilon_{av} = \frac{Total\ distance}{Total\ \ time} = \frac{2s}{s} \times 12 = 24 \ km \ h^{-1}$

10. A 200m long train crosses a 400 m long bridge with a speed of $36 \, km \, h^{-1}$**. Calculate the time taken by the train to cross the bridge.**

Ans. 1 minute

11. A non-stop bus goes from one station to another station with a speed of 54 $km \, h^{-1}$ **. The same bus returns from the second station to thefirst station with a speed of** $36 \ km \ h^{-1}$**. Find the average speed of the bus for the entire journey.**

Ans. 43.2 $km \, h^{-1}$

12. A train travels 20km at a uniform speed of $60 \, km \ h^{-1}$ **and the next 20 km at a uniform speed of** $80 \ km \, h^{-1}$**. Calculate its verage speed**

Ans. $68.57 \, km \, h^{-1}$

13.A scooter travels from station A to station B at a uniform speed of $60\ km\ h^{-1}$. It returns immediately after reaching station B back to station A and travels at a uniform speed of $70\ kmh^{-1}$. Find the average speed of the scooter.

Ans. $64.6\ km\ h^{-1}$

14. Sound is heard after 2s, the lightning is seen in the sky during a cloudy day. Find the distance of the locaiton of lightning, if speed of sound is $346\ ms^{-1}$

Ans. 692 m

Unsolved Numericals Try Your self

1. A bus starts from rest and attains $40 km h^{-1}$ velocity after 10 seconds. Calculate the acceleration of the bus in (i) $km\ h^{-2}$ and (ii) $m s^{-2}$

Ans. 14400 $km\ h^{-2}$ (ii) $1.11\ m s^{-2}$

2. A bus moving with a velocity of $60 km\ h^{-1}$ is brought to rest in 20 second by applying brakes. Find its acceleration.

Ans. $-0.83\ ms^{-2}$

3. A car is retarded by applying brakes at the rate of $2 ms^{-2}$. It is finally stopped in 10s. Find its initial velocity.

Ans. $20 m s^{-1}$

4. A train moving with velocity of $54 km\ h^{-1}$ is accelerated so that its velocity becomes $72\ km\ h^{-1}$ in 15 seconds. Find the acceleration of the train.

Ans. $0.33\ m s^{-2}$

5. A car starts from rest and accelerates uniformly at $2 ms^{-2}$ for 10s. What is its velocity at the end of 10s.

Ans. $20 ms^{-1}$

6. A train starts from rest and acceleration uniformly at $10 ms^{-2}$ for 1 minute. Find the (i) velocity and (ii) distnace travelled by the train at the ende of 1 minute.

Ans. (i) $600 ms^{-1}$ (ii) 18 km

7. A stone is dropped down a deep well from rest. The well is 50 metre deep. How long will it take to reach the bottom of the well? Give $a = 9.8 ms^{-2}$

Ans. 3.2 s

8. A car is moving with a uniforml velocity of $10 ms^{-1}$. The drive of the car decided to overtake a bus moving ahead of the car. So the driver of the car accelerates at $1ms^{-2}$ for 10 seconds. Find the velocity of the car at the end of 10 seconds. Also find the distance travelled by the car while accelerating.

Ans. $20 ms^{-1}; 150 m$

5. A car starts from rest and accelerates uniformly at the rate of $1ms^{-2}$ for 5s. It then maintains a constant velocity for 30s. Then brakes are applied and the car is uniformly retarded to rest in 10s. Find the maximum velocity attained by the car and the total distance travelled by it. Also plot velocity-time graph for the motion of the car.

Ans. $5 ms^{-1};\ 187.5 m$

6. A train is travelling with a velocity of $72 km\ h^{-1}$. The brakes are applied to retard the motion of the train uniformly. If the train is stopped after 50 metres away from the place where brakes were applied, find the retardation of the train.

Ans. $-4.0 ms^{-2}$

7. A bullet moving with velocity of $10\,ms^{-1}$ is brought to rest after penetrating the wooden plank of 4 cm thickness. Calculate the retardation of the bullet.

Ans. $-1250\,ms^{-2}$
