

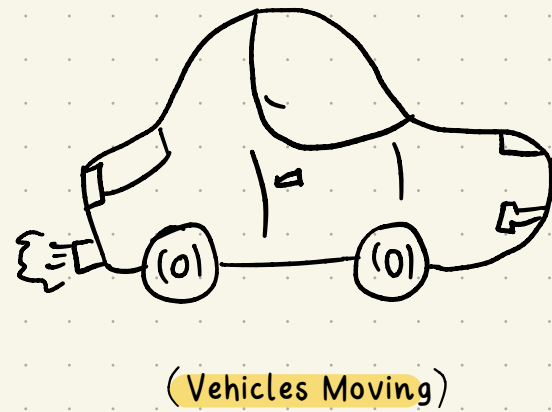
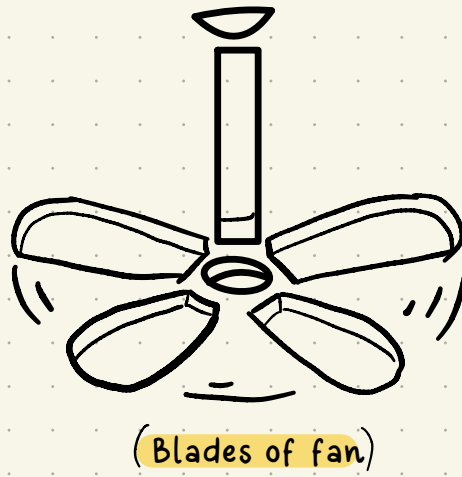
CLASS 9th

# MOTION

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Handwritten Notes





We observe these kinds of phenomena in our everyday life? Isn't it ?  
All of these are examples of types of motions.

#Kitaabi Definition: If a body changes its position with respect to time and surroundings, it is said to be in motion.

### \* Some Important Terms:

★ We describe the location of an object by specifying a reference point.

Relative: Beta tumhara school kitne dur hai?

Baccha: Mere ghar se 2km dur.

{ To yaha par bacche ne "Ghar" ko as a reference point liya. }

Therefore, to describe the position of an object we need to specify a reference point called the origin.

### ★ Scalar and Vector Quantities

Imagine you're playing a game of hide-and-seek with your friends. You want to tell your friends how far you are from the hiding spot and in which direction.

Scalar Quantity: A scalar quantity is something that tells you only the amount or size or magnitude of something, without any information about the direction.

For example, imagine you tell your friends, "I am 10 steps away from the hiding spot." Here, you're only giving them the distance, which is the scalar quantity. It doesn't matter if you went left or right or any other direction, just how far you are.

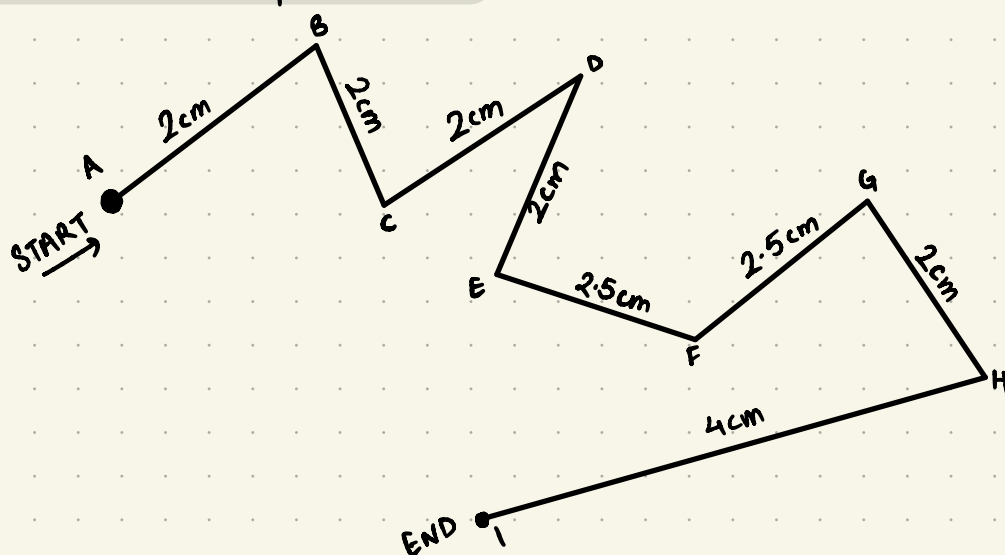
**Vector Quantity:** A vector quantity is something that tells you both the magnitude and the direction of something.

Going back to the hide-and-seek game, let's say you tell your friends, "I am 10 steps away from the hiding spot, towards the big tree." Here, you not only give them the distance but also the direction. So, the number of steps and the specific direction together make it a vector quantity.

In simple terms, scalar quantities are like giving someone a number without any specific direction, while vector quantities are like giving someone a number along with a specific direction.



### Distance and Displacement



Imagine you start moving from point 'A' to reach point 'I'

**Distance:** Distance is the total path covered from the starting point to the end point. It doesn't matter which direction you moved, distance only considers the length of the path.

Here,

$$\begin{aligned}\text{Distance} &= AB + BC + CD + DE + EF + FG + GH + HI \\ &= 2 + 2 + 2 + 2 + 2.5 + 2.5 + 2 + 4 = 19\text{cm}\end{aligned}$$

It is a scalar quantity and SI unit.

**Displacement:** Displacement is the shortest straight-line distance from the starting point to the endpoint. It takes into account both the distance and the direction.

Here, Displacement = AI

It is a vector quantity and SI unit is metre.

L.P.

[ NCERT Intext Pg100 ]

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

Ans- - Yes. an object which has moved through a distance can have zero displacement if it comes back to its initial position.

Example - If a person jogs in a circular park which is circular and completes one round. His Initial and Final Position are the same. Thus, his displacement is 0.

L.P. 2: Which of the following is true for displacement?

(a) It cannot be zero.

(b) Its magnitude is greater than the distance travelled by the object.

Ans- (a) False

(b) False

## Uniform Motion and Non-Uniform Motion

Imagine you're riding your bicycle in a park.

**Uniform Motion:** Uniform motion is when an object moves in a way that covers equal distances in equal intervals of time. It means the speed or rate at which the object is moving remains constant throughout its journey.

For example, imagine you're riding your bicycle on a straight road, and you're maintaining a steady speed of 10 km/h. In this case, you're experiencing uniform motion because you're covering the same distance every hour (10 kilometers per hour).

**Non-Uniform Motion:** Non-uniform motion is when an object moves in a way that covers unequal distances in equal intervals of time. It means the speed at which the object is moving keeps changing during its journey.

For example, imagine you're riding your bicycle on a road with hills and valleys. As you go up a steep hill, your speed decreases, and when you go downhill, your speed increases. In this case, you're experiencing non-uniform motion because the distance covered in each hour will vary depending on the ups and downs of the road.

In simple terms, uniform motion is when you're moving at a constant speed, covering the same distance in equal intervals of time. Non-uniform motion is when your speed keeps changing, and the distance covered in equal intervals of time is not the same.

## Rate of Motion

Different objects may take different amounts of time to cover a distance. Some of them move fast and some move slowly.

OR We can say the 'Rate' at which the objects move can be different. Also, different objects can move at the same rate.

→ isi 'Rate' ko find karne ke liye we'll study Speed, Velocity and acceleration.

### ★ Speed

Distance travelled by an object per unit time is called speed of an object.

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

If an object travels a distance  $s$  in time  $t$  then its speed  $v$  is,

$$V = \frac{s}{t}$$

Speed is a scalar quantity, and its SI unit is metre per second (m/s)

### ★ Speed with Direction: Velocity

Direction bhi chahiye ?? To yaad karo direction kisme padha tha humne?? - Displacement me !

So, Velocity of an object is defined as the displacement of an object per unit time.

i.e. 
$$\text{Velocity} = \frac{\text{total displacement}}{\text{total time taken}}$$

↑↑  
$$\text{Average Velocity} = \frac{\text{initial velocity} + \text{final velocity}}{2}$$

ⓀⓅⓁ Jab bhi koi object straight line me travel kar raha ho, aur uski speed variable ho tab hum average velocity nikalte hai.

If  $u$  is the initial velocity,  $v$  is the final velocity and  $v(\text{avg})$  is the average velocity then,

$$v(\text{avg}) = \frac{v + u}{2}$$

L.P.

L.P. 1- Abdul, while driving to school, computes the average speed for his trip to be 20km/hr. On his return along the same route, there is less traffic and the average speed is 30km/hr. What is the average speed for Abdul's trip.

Ans- Let the distance between school and home of Abdul be 'd'.

Time to reach school =  $t_1$

Average speed = 20km/hr

But as we know, speed = distance / time

$$20 = d/t_1$$

$$\text{So, } t_1 = d/20$$

Time to reach from school to home =  $t_2$

Average speed = 30km/hr

$$30 = d/t_2$$

$$\text{So, } t_2 = d/30$$

Now, Total distance =  $d_1 + d_2 = 2d$

Total time taken =  $t_1 + t_2$

$$\begin{aligned}\text{Therefore, Average speed} &= \text{total distance} / \text{total time} = 2d / t_1 + t_2 \\ &= 2d / (d/20) + (d/30) \\ &= 120/5 = 24\text{m/s}\end{aligned}$$

L.P. 2: Joseph jogs from one end A to the other end B of a straight 300m road in 2 minutes 30 seconds and then turns around and jogs 100m back to the 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- (A) When he jogs from A to B on straight road

Displacement = distance = 300m

$$\text{Time} = 2 \text{ min } 30 \text{ sec} = (400 \times 60) + 30 = 150 \text{ s}$$

$$\text{Hence, velocity} = \text{displacement} / \text{time} = 300 / 150 = 2 \text{ m/sec}$$

$$\text{Speed} = \text{distance} / \text{time} = 300 / 150 = 2 \text{ m/sec}$$

(B) When he jogs from A to B and turns back to C

$$\text{Displacement} = 300 - 100 = 200 \text{ m}$$

$$\text{Distance} = 300 + 100 = 400 \text{ m}$$

$$\text{Time} = 3 \text{ min } 30 \text{ sec} = (3 \times 60) + 30 = 210 \text{ sec}$$

$$\text{Velocity} = \text{Displacement} / \text{time} = 200 / 210 = 0.95 \text{ m/sec}$$

$$\text{Speed} = \text{distance} / \text{time} = 400 / 210 = 1.90 \text{ m/sec}$$

L.P.

[ NCERT Intext Pg102 ]

L.P. 1- Distinguish between speed and velocity.

Speed	Velocity
<ul style="list-style-type: none"><li>Speed is the distance travelled by an object in a given interval of time.</li><li>Speed = Distance / Time</li><li>Speed is a scalar quantity and has only magnitude.</li></ul>	<ul style="list-style-type: none"><li>Velocity is the displacement shown by an object in a given interval of time.</li><li>Velocity = Displacement / Time</li><li>Velocity is a vector quantity and has both magnitude and direction.</li></ul>

L.P. 2- Under what condition(s) is the magnitude of average velocity of an object equal to its average speed?

Ans- Avg Speed is distance/time and Avg Velocity is displacement/time. So for both of them to be equal, distance should be equal to the displacement.

Which will only happen if the object moves only in a straight line.

L.P. 3- What does the odometer of an automobile measure?

Ans- The odometer of an automobile measures the distance travelled by a vehicle.

LP- 4: What does the path of an object look like when it is in uniform motion?

Ans- In uniform motion, the path of an object can be a straight line, curved line or a circle. It can have any shape. This is because in uniform motion, speed is constant, the direction of motion may change.

LP- 5: During an experiment, a signal from a spaceship reached the ground station in five minutes. What was the distance of the spaceship from the ground station? The signal travels at the speed of light, that is,  $3 \times 10^8$  m/s.

Ans- Speed =  $3 \times 10^8$  m/s

Time = 5 min =  $5 \times 60$  sec = 300 seconds

Distance =  $3 \times 10^8$  m/s  $\times$  300 sec  
=  $9 \times 10^{10}$  m



Rate of Change of Velocity: Acceleration:

During a uniform motion, velocity remains constant through out, i.e. initial and final velocities are same.

So change in velocity in uniform motion will be zero.

But, In case of Non-Uniform motion, velocity varies with time, it has different values at different instants. Thus, the change in velocity of the object during any time interval is not zero.

Hence, to measure the rate of change of velocity we use acceleration.

$$\text{Acceleration} = \frac{\text{Change in Velocity}}{\text{total time taken}}$$

If the velocity of an object changes from an initial value 'u' to the final value 'v' in time 't', the acceleration 'a', is

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

- SI unit of acceleration is m/s
- Acceleration is +ve if it is in the direction of velocity.
- It is -ve when it is opposite to the direction of velocity.
- It is 0 when object moves with constant velocity.

**Uniform Acceleration:** If an object travels in a straight line and its velocity increases or decreases by equal amounts in equal intervals of time, then the acceleration of the object is said to be uniform.

Eg- A free falling body

**Non-Uniform Acceleration:** If velocity of an object changes non-uniformly, then the acceleration of that object is said to be non-uniform.

L.P.- Starting from a stationary position, Rahul paddles his bicycle to attain a velocity of 6m/s in 30s. Then he applies brakes such that the velocity of the bicycle comes down to 4m/s in the next 5s. Calculate the acceleration of the bicycle in the both the cases.

Ans- In the first case:

Initial velocity,  $u = 0$

Final velocity,  $v = 6\text{m/s}$

Time,  $t = 30\text{ s}$

We have,  $a = (v-u)/t$

Substituting the given values of  $u, v$  and  $t$  in the above equation, we get

$$a = (6-0)/30 = 0.2\text{ m/s}^2$$

In the second case:

Initial velocity,  $u = 6\text{m/s}$

Final velocity,  $v = 4\text{m/s}$

Time,  $t = 5\text{s}$

$$\text{Then, } a = (4-6)/5 = -0.4\text{ m/s}^2$$

The acceleration of the bicycle in the first case is  $0.2\text{ m/s}^2$  and in the second case, it is  $-0.4\text{m/s}^2$

## Graphical Representation of Motion

As graphs provide a convenient method to present basic information about a variety of events. So in order to describe the motion of an object, we can use line graphs.

We'll study Distance-Time and Velocity-Time graphs in which distance and velocity will be on Y-axis, and time on X-axis.

## ★ Distance-Time Graphs

Used to show Change in position of object with time.

Distance: y-axis

Time: x-axis

⇒ The Slope of the distance-time graph is equal to speed of the object.

(i) For object moving with Uniform Speed:

In uniform speed- Distance travelled is directly proportional to time taken. So, the speed time graph is straight line.

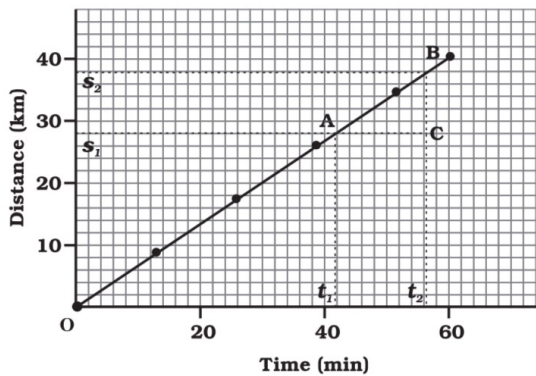


Fig. 8.3: Distance-time graph of an object moving with uniform speed

Let's say we have to calculate speed of the object from a distance time graph, choose any two points let say 'A' and 'B' as marked.

We can clearly see for A to B,

Distance travelled =  $s_2 - s_1$

time taken =  $t_2 - t_1$

Hence,  $\text{Speed} = \frac{s_2 - s_1}{t_2 - t_1}$

(ii) For object moving with Non-Uniform Speed:

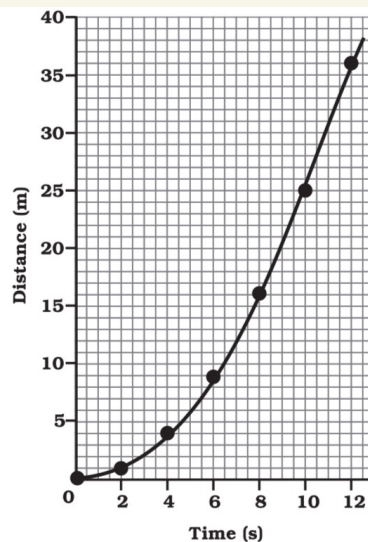


Fig. 8.4: Distance-time graph for a car moving with non-uniform speed

The nature of this graph shows non-linear variation of the distance travelled by the car with time.

## ★ Velocity-Time Graphs

Sometimes also called as speed time graph as velocity and speed are used interchangeably.

Velocity: y-axis

Time: x-axis

⇒ The area enclosed by velocity-time graph and the time axis will be equal to the magnitude of displacement.

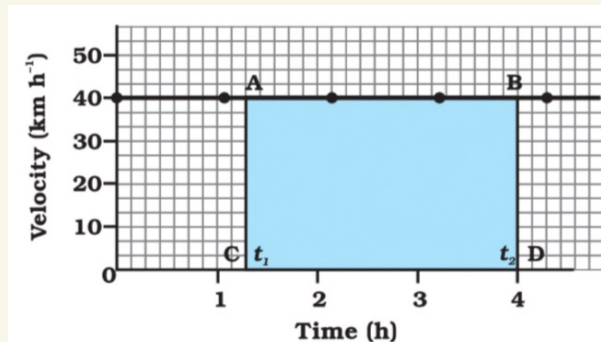
(i) For object moving with Uniform Velocity:

If the object moves at uniform velocity, the height of its velocity-time graph will not change with time. It will be straight line parallel to the x-axis.

We can find the distance moved by the car between time  $t_1$  and  $t_2$  by calculating the area under this.

So distance 's' moved by the car in the time  $(t_2 - t_1)$  can be expressed as

$$\begin{aligned} s &= \text{area of rectangle ABCD (shaded)} \\ &= AC \times CD \\ &= (40 \text{ km/hr}) \times (t_2 - t_1) \text{ hr} \\ &= 40 (t_2 - t_1) \text{ km} \end{aligned}$$



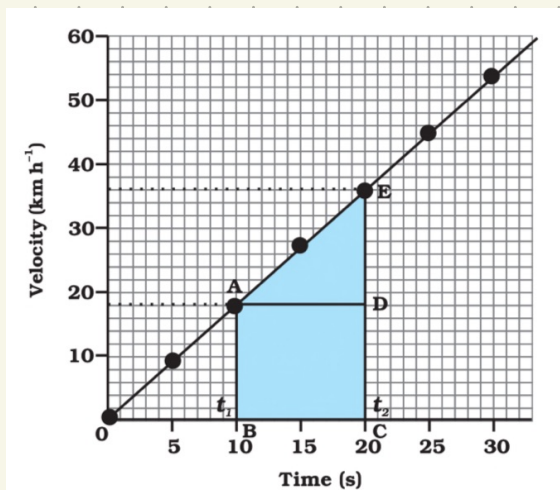
(ii) For object moving with Uniform Acceleration:

Suppose a person sitting next to the driver records its velocity after every 5 seconds by noting the reading of the speedometer of the car.

Time (s)	Velocity of the car (m s <sup>-1</sup> )      (km h <sup>-1</sup> )	
0	0	0
5	2.5	9
10	5.0	18
15	7.5	27
20	10.0	36
25	12.5	45
30	15.0	54

In this case, the velocity-time graph for the motion of the car is shown in the next page. The nature of the graph shows that velocity changes by equal amounts in equal intervals of time.

Thus, for all uniformly accelerated motion, the velocity-time graph is a straight line.



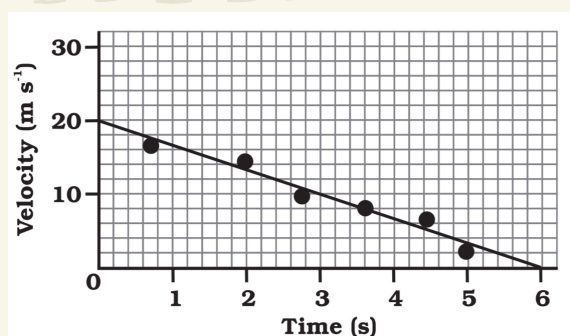
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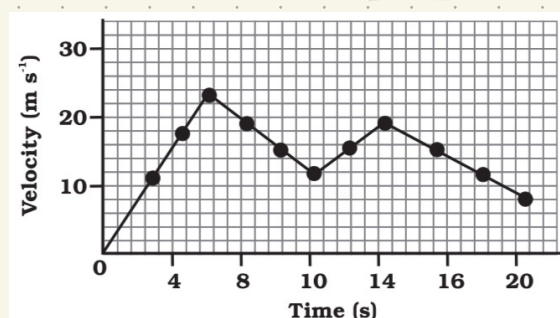
$$\begin{aligned} s &= \text{area of ABCDE (shaded)} \\ &= \text{area of rectangle ABCD} + \text{area of triangle ADE} \\ &= (AB \times BC) + \left\{ \frac{1}{2}(AD \times DE) \right\} \end{aligned}$$

(ii) For object moving with Non-Uniform Acceleration:

In case of non-uniformly accelerated motion, the velocity-time graph can have any shape.



Velocity-time graph for the motion of an object whose velocity is decreasing with time



Velocity-time graph for the non-uniform variation of velocity of the object with time

L.P. - [ NCERT Intext Pg107 ]

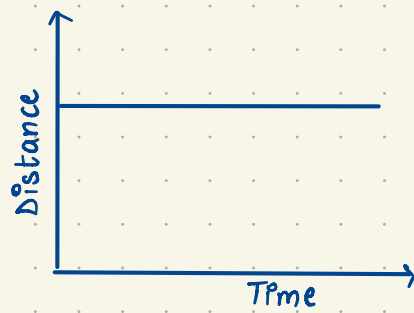
L.P. 1- What is the nature of the distance-time graphs for uniform and non-uniform motion of an object?

Ans- When the motion is uniform, the distance time graph is a straight line with a slope.

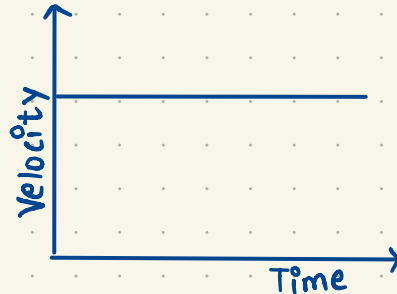
And, when the motion is non-uniform, the distance time graph is not a straight line. It can be any kind of curve.

L.P. 2- 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 the slope of the distance-time graph is a straight line parallel to the time axis, the object is at the same position as time passes. That means the object is at rest.



L.P. 3- What can you say about the motion of an object if its speedtime graph is a straight line parallel to the time axis?



Since there is no change in the velocity of the object (Y-Axis value) at any point of time (X-axis value), the object is said to be in uniform motion.

L.P. 4- What is the quantity which is measured by the area occupied below the velocity-time graph?

Ans- Displacement

### ★ Equations of Motion:

There are three equations of motion:

$$\begin{aligned} v &= u + at \\ s &= ut + \frac{1}{2} at^2 \\ 2as &= v^2 - u^2 \end{aligned}$$

Here,

$u$  = initial velocity of the object  
 $a$  = uniform acceleration of the object  
 $v$  = final velocity of the object  
 $s$  = distance travelled by the object  
 $t$  = time taken

L.P. 1- A bus starting from rest moves with a uniform acceleration of  $0.1 \text{ m/s}^2$  for 2 minutes. Find (a) the speed acquired, (b) the distance travelled.

Ans- (a) Given that the bus starts from rest, so  $u=0$

Acceleration =  $0.1 \text{ m/s}^2$

Time = 2 min = 120 sec

As we know,  $v = u + at$

$$v = 0 + (0.1) (120)$$

$$v = 12 \text{ m/s}$$

(b) We have to find 's' and we already have a, t, u and v with us.

So we can use  $s = ut + \frac{1}{2} at^2$

$$= 0 + \frac{1}{2} (0.1) (120 \times 120)$$

$$= 720 \text{ m}$$

L.P. 2- A train is travelling at a speed of  $90 \text{ km/hr}$ . Brakes are applied so as to produce a uniform acceleration of  $-0.5 \text{ m/s}^2$ . Find how far the train will go before it is brought to rest.

Ans- Given,  $u = 90 \text{ km/hr} = 25 \text{ m/s}$

As brakes are applied so it will come to rest, so  $v = 0 \text{ m/s}$

Given,  $a = 0.5 \text{ m/s}^2$

We have to find 's' and we have u, v and a with us.

So we can use,  $v^2 = u^2 + 2as$

Filling all the values, we'll get  $s = 625 \text{ m}$

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

Ans- As the trolley starts from rest, so  $u=0$

$a = 0.02 \text{ m/s}^2$

$t = 3 \text{ sec}$

We have to find 'v' and we have a, t and u.

So we can use,  $v = u + at$

$$v = 0 + (0.02)(3) = 6 \text{ cm/s}$$

L.P. 4- A racing car has a uniform acceleration of  $4 \text{ m/s}^2$ . What distance will it cover in 10 sec after the start?

Ans- Given that the car is initially at rest, so  $u=0$

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

$$t = 10 \text{ sec}$$

We have to find 's' and we have u, a and t, so using

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

Putting all the values, we'll get,  $s = 200 \text{ m}$

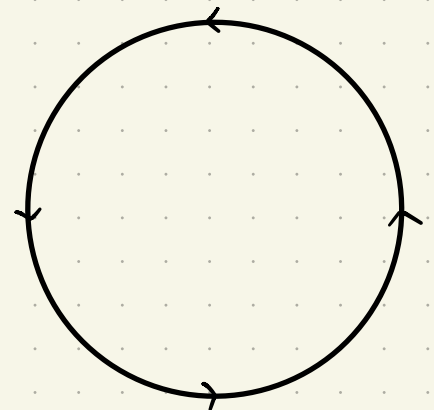
## Uniform Circular Motion

When an object moves in a circular path in uniform speed, the motion is said to be uniform circular motion.

In circular motion, the direction of motion, i.e. velocity changes every moment, thus causing acceleration.

If a body takes  $t$  seconds to go once around the circular path of radius  $r$ , then the velocity  $v$  is given by:

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



Examples of circular motion- motion of moon and earth; fan moving; cyclist on circular path; motion of a wheel; a stone tied to a string; turning of a car around curve.

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

Ans- diameter = 200m, so radius ( $r$ ) = 100m

Time for one round = 40 sec

Distance covered in 2 min 20 sec (or 140 sec) =  $140/40 = 3.5$  rounds

Distance travelled = circumference of circle  $\times 3.5$

$$= 2\pi r \times 3.5$$

$$= 2 \times \frac{22}{7} \times 100 \times 3.5 = 2200 \text{ m}$$