Chapter 4

Motion

You are familiar with the word 'Motion'. In our day-to-day life, we find several examples of motion, for example walking, running, movement of vehicles, falling of a fruit from a tree, flight of birds etc.

Fig. 1 : Example of Motion

We already know that all the things in our surroundings are always in motion and even we ourselves are not stationary at all times. Motion is a requirement for several activities and transitions and so its study as well as analysis provides answer to many fundamental questions. For instance, to understand seasonal changes it is important to know about the motion of earth around the sun. Knowing the time taken by a vehicle to reach from one position to another, also shows the understanding of motion.

Mostly we say that a body is in motion only if its position changes with time. But is it possible that for one person, the body seems to be in motion while for another the body is stationary? For example, if you are sitting in a moving train then, for you all other passengers and you yourself are at stationary. But for a person standing outside the train, you and the train, both are in motion.

If you are standing aside a road, for you all the trees around you seem to be stationary but while travelling by a bus, they appear to be in motion. Whether a body is in motion or is stationary depends on who is doing the observation and from which point. On this basis we can say that a body is said to be in motion when its position with respect to an observation point constantly changes with time. Any position can be considered as an observation point and its called as a reference point.

It is not easy to study the types of motion that we witness in our daily lives. When a person walks, along with the motion of his legs, different parts of his body like hands, head etc. also move. When a vehicle is in motion, all its different fittings are also in different motions. For example- while cycling, the motion of your legs, the motion of its pedal, the motion of the chain and the motion of tyres are all different.

Generally, different parts of a body are in a motion in different directions and the distance covered by the body can be very large compared to its size. In this situation, to study the linear motion of an object we consider following two simplifications-

1. A point is considered as a representative of the whole object and the motion of this point along a straight line is taken into consideration.
2. We choose this point such that the complete centre of mass of the object seems to be located at this point.

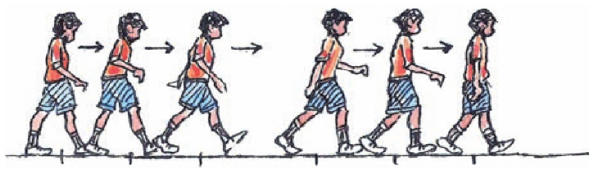


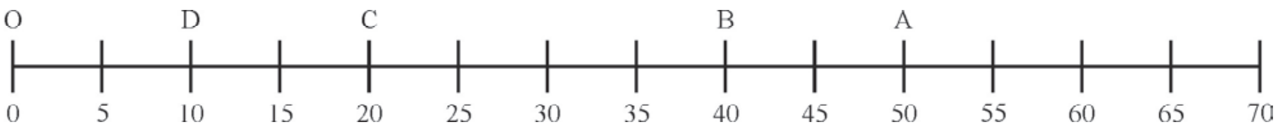
Fig. 2

The motion of a train on a straight rail track, fall of a stone from a height etc are examples of linear motion. Can you add more examples to this list?

4.1 Description of Motion

Come, let's see the changes in the position of a moving object. An object begins its motion from point O which can be considered as an initial point.

First the object moves from O to D, then D to C, and later from C to B and B to A. The length of the path from O to A covered by the object is, OA = 50 km.



Now it returns back on the same path from B to C and reaches D. The total length of the path covered by the object is

= OA + AD

= 50 + 40 = 90 km

The total length of the path covered by the object is called 'distance', which is 90 km. here. But what is the difference between the object's initial and final positions?

Initial position of object = O

Final position of object = D

Difference between initial and final positions of the object = 10 Km.

Here, the difference between the initial and final positions of an object is 10 km. This difference is called 'displacement'. Now, let's understand distance covered and displacement in more depth.

To represent the distance covered by an object we only need a numeric value. Such a quantity is called a scalar quantity. The numeric value of a quantity is its magnitude.

To represent the displacement of an object, along with magnitude we also need the direction of motion. Such a quantity is called vector quantity.

In the above example, if the object covers the distance only from O to A, then

Distance from O to A = 50 km.

Displacement from O to A = 50 km.

Thus, the magnitude of displacement and distance is equal. If the object moves from O to A and returns back to O, then the total length of the object's path is = OA + AO = 50 km. + 50 km. = 100 km. But its displacement is zero because the initial and final positions are same. Therefore, displacement can be zero, even if the distance covered is not zero. Let's understand displacement and distance through another example.

A man walks 3 m. towards east. Later, he moves 8 m. towards north and then 3 m. towards west. (Fig. 3)

It is clear that the distance covered in this case is AB + BC + CD = 3 m. + 8 m. + 3 m. = 14 m.

Magnitude of displacement = AD = 8 m. and displacement is towards north from A.

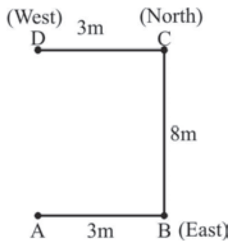


Fig. 3

4.1.1 Speed and Velocity

Activity-1

Some figures related to the motion of two buses A and B are provided in table 1:-

Table 1: Distance covered by bus A and bus B

Time	Distance covered by bus A (in km.)	Distance covered by bus B (in km.)
9.00 am	10	10
9.15 am	20	18
9.30 am	30	25
9.45 am	40	33
10.00 am	50	40
10.15 am	60	52

Observe these figures. After observation, tell-

- Is, the time interval for both the buses same?
- Which bus covers uniform distance in uniform time interval?

By observing table 1 given above we find that the time intervals for both A and B is same. Bus A covers uniform distance of 10 km. in a uniform time interval. However, bus B covers non-uniform distance in uniform time interval.

The time taken for covering a given distance (say 30 km.) is different for both the buses A and B. Bus A covers 30 km. distance in 45 minutes, while B covers the same distance in 60 minutes. Thus, we see that A moves faster while B moves slower.

To calculate the rate of motion of the bus we measure the distance travelled in a unit time by the bus. This quantity is called speed and in SI system its unit is meter/second (m/s). Another unit for speed can be kilometer/hour (km/h).

The average speed of the bus is the ratio of the total distance covered by the bus and the total time period.

$$\text{Average speed} = \frac{\text{Total distance covered}}{\text{Total Time period}}$$

Calculate the speeds of Bus A and Bus B from activity 1.

From 9:00 am to 9:15 am (in ¼ hours)

$$\text{Average speed of Bus A} = \frac{10\text{ km}}{{}^{1}\!/_{4}\text{ h}}$$

$$= 10 \times 4 \text{ km/h}$$

$$= 40 \text{ km/h}$$

Similarly,

$$\text{Average speed of Bus B} = \frac{8\text{ km}}{{}^{1}\!/_{4}\text{ h}}$$

$$= 8 \times 4 \text{ km/h}$$

$$= 32 \text{ km/h}$$

Table 2

Time Interval	**Bus A**		**Bus B**	
	Distance (km.)	**Avg. speed (km/h)**	**Distance (km.)**	**Avg. speed (km/h)**
9:00-9:15 am	10	40	8	32
9:15-9:30 am	10	?	7	28
9:30-9:45 am	10	?	8	?
9:45-10:00 am	10	?	7	?
10:00-10:15 am	10	?	12	48

The speed of Bus A is constant; therefore it is in a uniform motion. However, the speed of bus B is changing, hence it is in a non-uniform motion. Find out one example each of uniform motion and non-uniform motion from your day-to-day lives.

Lets understand speed through one example.

Example 1 : If a car covers 60 km. distance in 2 hours, what will be its speed?

Solution : Total distance = 60 km.

Time = 2 h

$$\text{Average speed} = \frac{\text{Total distance covered}}{\text{Total time period}}$$

$$= \frac{60}{2}$$

$$= 30 \text{ km/h}$$

This does not mean that the car travelled the whole journey at a constant speed of 30 km/h. It is possible that it travelled with a speed more than 30 km/h for some time and also less than 30 km/h for some other time.

Example 2 : An object covers a distance of 20 m. from A to B in 10 s. It takes 6 s to return from B to A. What is the average speed of the object?

Solution : Total distance covered by the object = 20 m + 20 m = 40 m

Total time taken = 10 s+ 6 s = 16 s

$$\text{Average speed} = \frac{\text{Total distance covered}}{\text{Total time period}}$$

$$= \frac{40\text{m}}{16\text{s}} = 2.5 \text{ m/s}$$

Average speed of the object = 2.5 m/s

4.1.2 Velocity

We can represent the direction of an object along with its speed. The distance covered by an object in the given direction in a unit time is called its velocity. The change in velocity of an object depends on the change in the speed of the object, direction of motion or change in both.

$$\text{Velocity of an object} = \frac{\text{Displacement}}{\text{Time Interval}}$$

Velocity is a vector quantity whose direction is in the direction of displacement. The units of velocity and speed are same. Average velocity and average speed represent the different motions of an object in different time intervals. They do not represent instantaneous speed or instantaneous velocity.

Example 3 : A car travels from city A to city B at a speed of 40 km/h. The same car returns back at a speed of 60 km/h. Calculate the average speed and velocity of the car.

Solution : Let the distance between city A to B is x km.

$$\left(\because \text{Speed} = \frac{\text{Distance}}{\text{Time}} \qquad \text{So time} = \frac{\text{Distance}}{\text{speed}}\right)$$

Time taken by car from city A to B is $t_1 = \frac{x}{40}$

Time taken by car from city B to A is $t_2 = \frac{x}{60}$

Total time t $= t_1 + t_2 = \frac{x}{40} + \frac{x}{60}$

$$= \frac{3x+2x}{120} = \frac{5x}{120}$$

Total distance covered by the car is $= x + x = 2x$

But, the displacement by the car is $= x - x = 0$

average speed $= \frac{\text{Total distance covered}}{\text{Total time period}} = \frac{2x}{5x/120}$

$$= \frac{2x \times 120}{5x} = \frac{240}{5} = 48 \text{ km/h}$$

Velocity of the car in this particular journey $= \frac{\text{Displacement}}{\text{Time interval}} = \frac{x-x}{5x/120}$

$$= \frac{0}{5x/120} = \frac{0 \times 120}{5x} = 0$$

4.2 Graphs of Motion

Until now we have only talked about average speed and velocity. But can we find out the instantaneous speed or velocity of an object? come, lets understand this with the help of a graph-

The figures related to Apoorva's journey from home to school is given in table number-3.

Table3 : Distance travelled and time taken from Apoorva's home to school

Time (min.)	2	4	6	8	10	12
Distance (m)	12	24	36	48	60	72

In your graph paper, put time on the x axis and distance on the y axis and decide their scales. Write the scale on the upper right corner of your graph paper. Now mark the points according to the given figures. Draw a straight line joining all these points using a scale.

This graph shows Apoorva's journey from home to school. Note that the graph drawn here and all other graphs in this chapter are the graphs of distance covered and time, and not the path of journey.

Now from this graph tell-

- How much distance did Apoorva cover in first 2 minutes?
- How much distance did she cover in next 2 minutes?
- How much distance did she cover between 10-12 minutes?
- Are all these distances same?

When an object covers uniform distance in uniform time interval, its motion is said to be a uniform motion. For such a motion the distance verses time graph is a straight line.

What was Apoorva's speed from home to school? How can we calculate this from a graph? Let's understand.

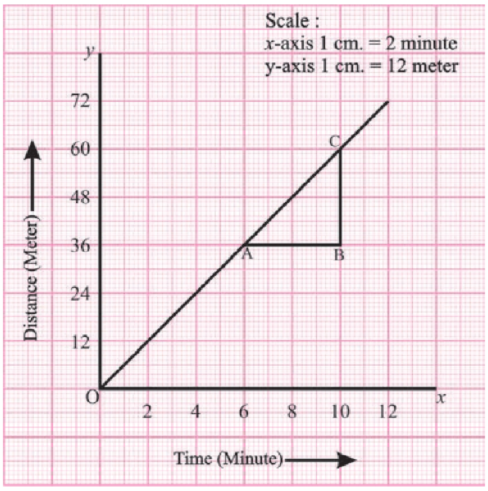


Fig. 4 : Graph for a uniform motion

To do this, choose a point A in the distance time graph (fig. 4). Draw a line AB parallel to x axis from A and from the point B draw a line parallel to y axis which meets point C and makes a triangle ABC.

Now the line AB in the graph, shows time interval (t_2-t_1) while BC, shows the distance (s_2-s_1). From the graph we can see that the object covers a distance of (s_2-s_1) from A to B in a time interval of (t_2-t_1). Thus, the speed of the object can be expressed as following:

$$v = \frac{s_2 - s_1}{t_2 - t_1}$$

If we want to know the speed of an object at an instant, then we can measure the scope of the graph at that particular point.

4.2.1 Uniform motions with different speeds

Drashti and Shrishti had a race from home to school. Both ran at a uniform motion but their speeds were different from each other. Fig. 5 shows their motions respectively.

- Do the graphs show uniform motion or non-uniform motion?
- By looking at the graph alone and without reading the numbers, can you tell whose speed was more.
- With the use of the graphs, calculate the speeds of Drashti and Shrishti.
- By comparing the speeds of Drashti and Shrishti, find out whether the answer given by you without looking at the numbers is right or wrong?

In the two uniform motion graphs, we can find out whose speed is more from the slope of the drawn lines. To find out the slope, we observe the angle made by the straight line on to the x axis at the point of origin.

If the angle is less, the slope of the straight line will be less and the speed of the person will be less. By looking at the graph (Fig. 5) say amongst Drashti and Shrishti whose slope of the motion graph is more?

Will her speed be more too?

Do remember that such a comparison of speed can be done only through graphs whose scales are same. We cannot compare graphs having different scales by just looking at them.

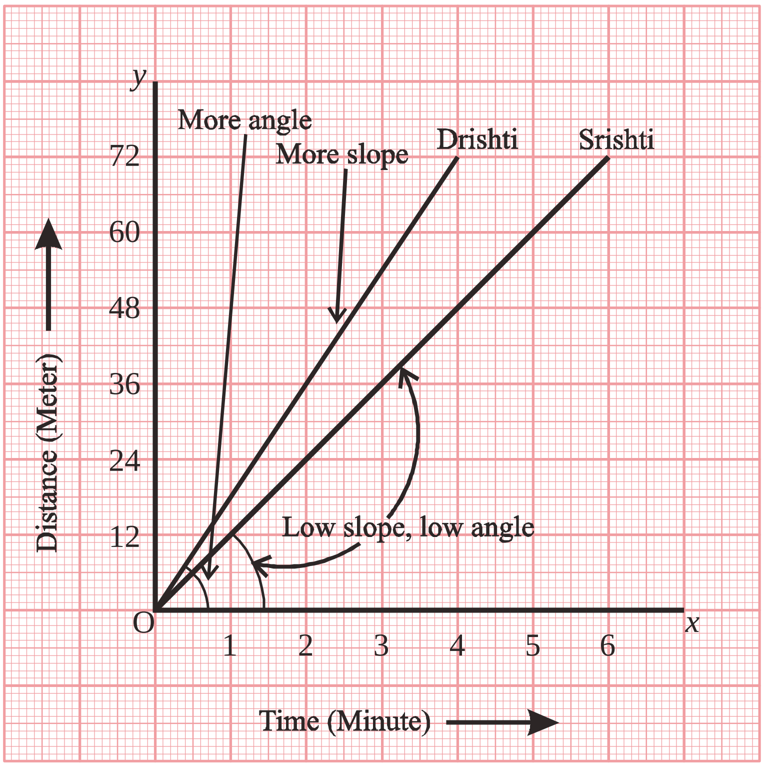


Fig. 5 : Motion of Drishti and Shrishti

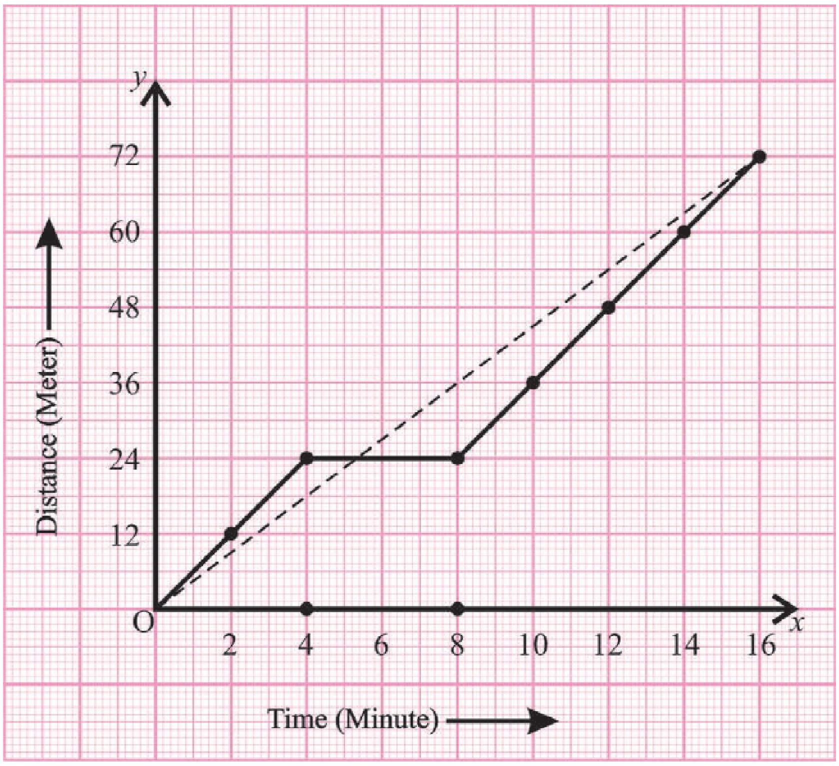
4.2.2 Graph of Halts

Suppose, on the way to school Apoorva stops for 4 minutes after walking for 4 minutes. After this she walks with a uniform motion and reaches her school. The graph showing her motion to reach school is given (Fig. 6).

When Apoorva stopped after 4 minutes, she had already covered a distance of 24 meter. Now she remained stationary for next 4 min. During this, the time increased to 8 minutes but the distance covered remained 24 m. Therefore, the next point on the graph was marked at 8 min. and 24 m.

Whenever an object stops/halts after reaching a certain position, the time passes but the distance remains the same. Therefore, as we just saw in the graph, for a stationary object, the distance time plot is parallel to the time axis.

Now, by looking at the graph in fig. 6 find out what was the average speed of Apoorva in such type of motion? What was her average speed when she reached school without a halt? (see graph in fig. 4 and table 3).



Graph fig. 6 : Graph of Apoorva's halt

- What is the difference between both these average speed.
- Give reason for this difference.

Question

The data related to Anamika's journey is given in table 4.

Table 4 : Data of Anamika's journey

Time (in min.)	2	4	6	8	10	12	14	16
Distance (m)	6	12	24	36	36	36	45	54

Based on this data draw a graph for her motion and find out her average speed.

- In which part of journey her speed will be maximum.
- Did she stop on her way? If yes then for how long?

4.2.3 Graph for non-uniform motion

Until now we have only studied about uniform motion. Now we will learn about such motions which are not uniform. You must have seen a bus starting from a station or stopping at a station. When a bus leaves from a station, is its motion uniform?

Such a motion where the speed is either increasing or decreasing is called as non-uniform motion.

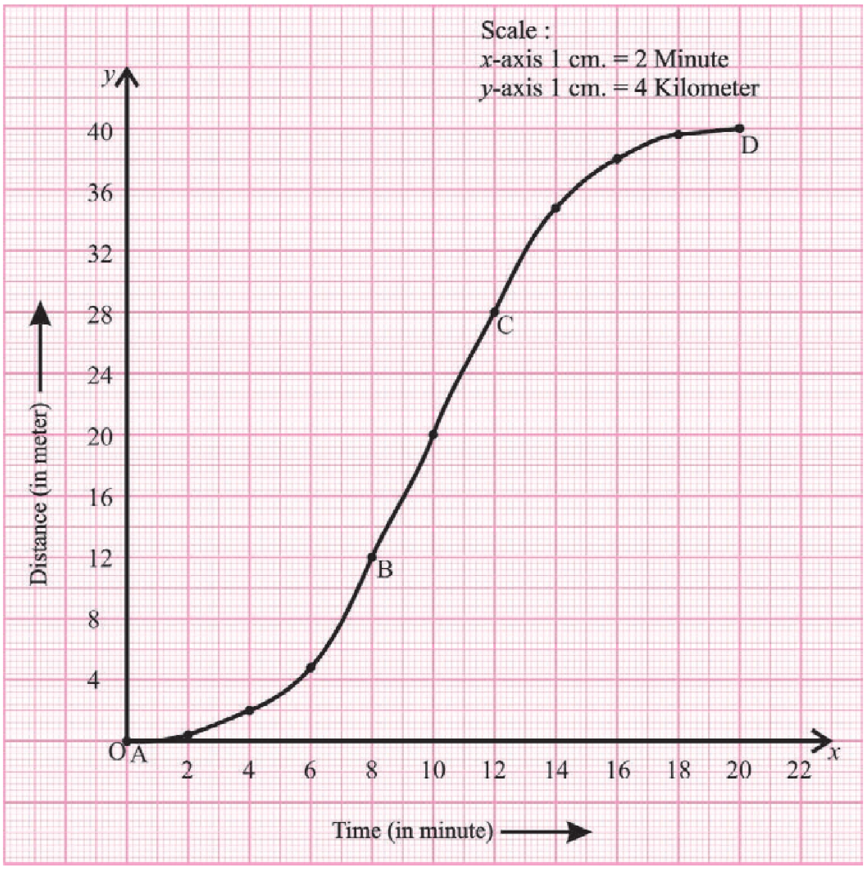


Fig. 7 : Graph of the motion of a vehicle having non-uniform speed

Table 5 : Distance travelled by Bus

Time (in min.)	Distance travelled (km.)
0 to 4	2 km
4 to 8	10 km
8 to 12	
12 to 16	
16 to 20	

See the graph given in fig.7 and fill the above table. Also, answer the following questions-

- Now tell if both the buses covered same distance in same time interval?
- Which section of the graph shows the change in motion of the bus and which part shows it's uniform motion? In which section was the bus stationary.

Look closely at the sections of uniform and non-uniform motion in the graph. Can you see any specific difference between the two?

The curve in the graph shows that the motion is continuously changing in that part. Look at the AB section of the graph. In this section, the speed of the bus is increasing after leaving from the station.

Questions

1. Write down the differences between speed and velocity.
2. In what situation will be the average velocity of an object be equal to its average speed?
3. Draw a velocity time graph for a uniform motion.

4.2.4 Acceleration

In general, what difference can you see in the cars that run on roads and a racing car that runs on a track?

One main difference is that a racing car has a very high speed.

Second difference is that a racing car has a very good pick-up. Pick-up shows how fast the speed of a car increases. For this, a technical word 'acceleration' is used.

With the help of table 1, calculate the velocity of bus A and B and complete the table 6.

(In table 1, by converting the distance in meter and time in seconds, calculate the velocity).

Table 6 : Calculation of velocities for bus A and B

Time	Velocity of bus A (m/s)	Velocity of bus B (m/s)
9.00		
9.15	$\frac{(20-10)\times1000}{(15)\times60}=\frac{10\times1000}{900}=11.11$	$\frac{(18-10)\times1000}{15\times60}=\frac{8000}{900}=8.89$
9.30	-------------- = 11.11	--------------
9.45	-------------- = 11.11	--------------
10.00	-------------- = 11.11	
10.15		$\frac{(52-40)\times1000}{15\times60}=\frac{12000}{900}=13.33$

In table 6 we see that during the motion of bus A, the change in velocity is zero and in same time intervals the velocity is constant. But in the motion of bus B, the change in velocity is different at different times. Therefore, to express the change in velocity of a bus we need to know about a new quantity. The rate of change of velocity of the bus is called acceleration.

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

If an object is moving with a velocity u, and in time t its velocity changes to v, then its acceleration

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

Acceleration is denoted by 'a'. The SI unit of acceleration is meter/second^2 (m/s^2). If acceleration is in the direction of velocity, then it is taken as positive. If it is in the opposite direction of velocity, then it is considered as negative and is called as deceleration.

When the change of velocity with respect to time is constant, then it is called as uniform accelerated motion and its acceleration is constant.

Activity-2

The distance covered by an object in a time interval of 2 seconds (s) is as follows. Calculate its velocity and acceleration and fill the table 7.

Table 7 : Velocity and acceleration of an object

Time (in sec.)	Distance (in m.)	Velocity (m/s)	acceleration (m/s^2)
0	0		
2	1	$\frac{1-0}{2-0} = \frac{1}{2} = 0.5$	$\frac{1.5-0.5}{4-2} = \frac{1}{2} = 0.5$
4	4	$\frac{4-1}{4-2} = \frac{3}{2} = 1.5$	
6	9	....	....
8	16	....	....
10	25	....	....

In table 7, you see that at every moment acceleration is same (ie. in same time interval, the change in velocity is same). Therefore, the motion of the object will be a uniformly accelerated motion.

After completing the above table draw the distance time graph, velocity time graph and acceleration time graph for a uniform accelerated motion.

In a uniform accelerated motion, acceleration is constant with time. Therefore, acceleration time graph is a straight line parallel to time axis.

Area covered by the acceleration time graph on time axis between 4-8 sec. is.

= Area for ABML

= AL × LM

= 4 m/s² × (8 – 4)s

= 4 m/s² × 4 s

= 16 m/s

In this way, we can calculate velocity through the area covered under acceleration time graph on time axis.

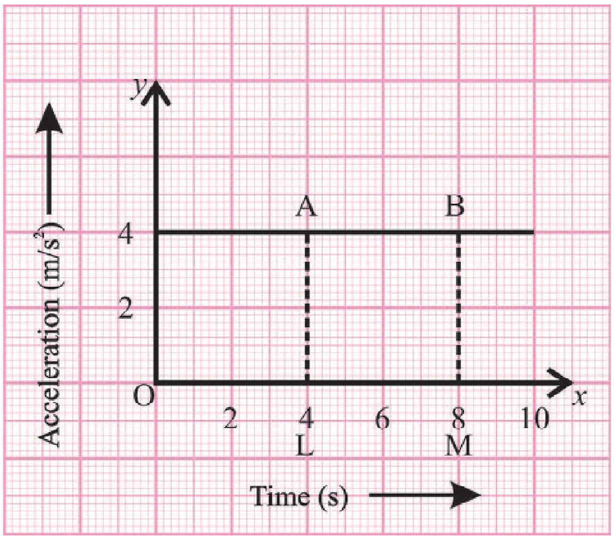


Fig. 8 : Acceleration - Time graph of uniform accelerated motion

Come, let's see a velocity time graph for a uniform accelerated motion.

From the graph, In t_1 = 2s, v = 0.5 m/s

In t_2 = 6s, v = 1.5 m/s

$$\text{acceleration} = \frac{v-u}{t_2 - t_1} = \frac{1.5-0.5}{6-2} = \frac{1}{4} = 0.25\text{m/s}^2$$

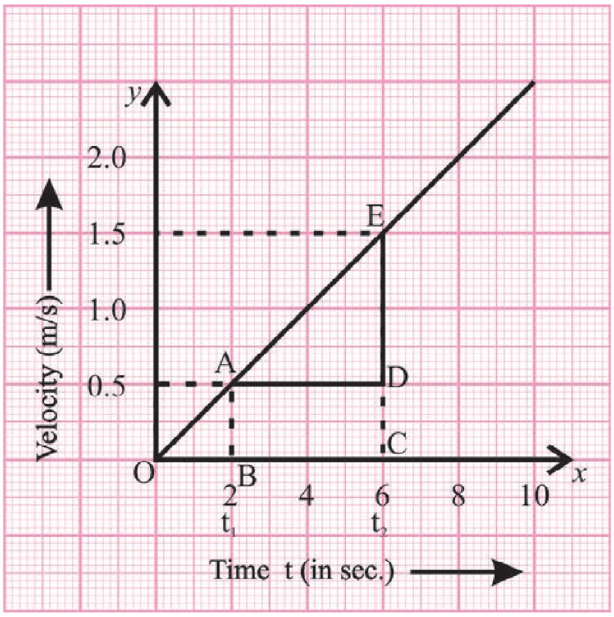


Fig. 9 : Velocity - Time graph of uniform accelerated motion

We know that for an object moving with uniform velocity, the product of its velocity and time gives displacement. In the fig. 9 the area of the field ABCDE in the given time interval shows the displacement.

that means, s = ABCDE

= area of rectangle ABCD

+ area of triangle ADE

$$= (AB \times BC) + \frac{1}{2} \times (AD \times DE)$$

$$s = (0.5 \times 4) + \frac{1}{2} \times (4 \times 1)$$

$$= 2 + \frac{1}{2} \times 4$$

= 2 + 2

= 4 m.

The area covered by velocity-time graph on the time axis shows the measurement of displacement.

4.3 Equation of Motion

When an object moves with uniform acceleration, then it is possible to establish a relation between its velocity (v), acceleration (a) and travelled distance (s) in a given time interval. These are known as the equations of motion.

In this equation-

t is time interval,

u is initial velocity of the object,

v is final velocity of the object,

a is uniform acceleration of the object in time t, and

s is the distance covered by the object in time t.

Velocity-time relation in a uniform accelerated motion

We saw a velocity-time graph for a uniform accelerated motion in fig. 9. A similar graph is shown in fig. 10.

From the graph we can see that the initial velocity of the object is u which in time t, increases to v. At the point A, the initial velocity of the object is u and at the point B its final velocity is v. (from the graph in fig. 10).

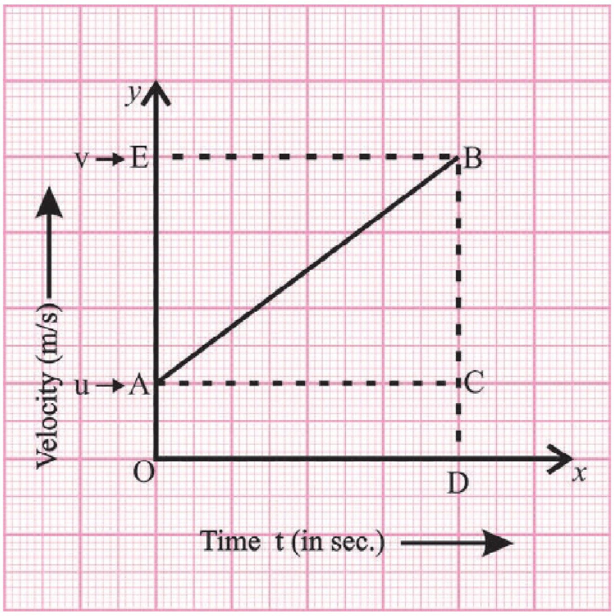


Fig. 10

BC = v – u ....(i)

We know that the acceleration, $a = \dfrac{BC}{AC} = \dfrac{BC}{OD}$

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

a t = v – u ....(ii)

v = u + at (this is the first equation of motion)

Position time relation in a uniform accelerated motion

(a) For a uniform accelerated motion let us find the area covered by velocity time graph on the time axis which is equal to the measurement of displacement (s).

From the graph, s = area of figure OABD

s = area of rectangle OACD + area of triangle ABC

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

$$= ut + \frac{1}{2}(OD \times BC) \qquad \text{from equation (i) and fig. 11}$$

$$= ut + \frac{1}{2}t\,(v - u)$$

$$= ut + \frac{1}{2}t\,(v - u)\,t$$

$$= ut + \frac{1}{2}at.t \qquad \text{from equation (ii)}$$

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

We can also find out s by one another method.

(b) (Since OABD is a parallelogram)

Therefore,

$$s = \text{area of parallelogram OABD}$$

$$s = \frac{1}{2} \times (\text{Addition of parallel sides of the parallelogram}) \times \text{height}$$

$$s = \frac{1}{2}(OA + BD) \times OD \qquad \text{(From fig. 10)}$$

$$s = \frac{1}{2}(u + v) \times t \qquad \text{Putting the value of t from equation (ii)}$$

$$s = \frac{1}{2}(v + u) \times \left(\frac{v - u}{a}\right)$$

$$s = \frac{v^2 - u^2}{2a}$$

$$v^2 - u^2 = 2as \qquad \text{This is the third equation of motion}$$

Accordingly, following are the three equations of motion.

$$v = u + at$$

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

$$v^2 - u^2 = 2as$$

Example 4 : A body is in a state of motion with a velocity of 4 m/s. If its acceleration is 2 m/s^2 then what will be its velocity after 5 s? Also find the distance covered by the body.

Solution : Given that,

velocity of body $u = 4$ m/s

acceleration $a = 2\ m/s^2$

final velocity $v = ?$ and covered distance $s = ?$

time $t = 5$ s

By the first equation of motion,

$$v = u + at$$
$$= 4 + 2 \times 5$$
$$= 4 + 10$$
$$= 14 \text{ m/s}$$

$$s = ut + \frac{1}{2}at^2$$
$$= 4 \times 5 + \frac{1}{2} \times 2 \times (5)^2$$
$$= 20 + \frac{1}{2} \times 2 \times 25$$
$$= 20 + 25$$
$$= 45 \text{ m}$$

Therefore, its velocity after 5 s of time is 14 m/s and distance covered by it is 45 m.

Example 5 : A car travels at a uniform acceleration of 4 m/s^2. So, 10 s after starting the motion, how much distance would have been covered by it?

Solution : acceleration $a = 4\ m/s^2$

initial velocity $u = 0$

time $t = 10$ s

distance $s = ?$

We know that, $s = ut + 1/2\ at^2$

$$s = (0 \times 5) + \frac{1}{2} \times (4) \times (10)^2$$
$$s = 0 + \frac{1}{2} \times 4 \times 100$$
$$s = 200 \text{ m}$$

Therefore, the distance travelled by car is 200 m.

Example 6 : A vehicle is moving at a constant speed of 36 km/h. On applying the brakes, it causes a deceleration of 0.5 m/s^2. How much distance would have been covered by the vehicle before stopping?

Solution : given that,

initial velocity of the vehicle $u = 36$ km/h

$$u = \frac{36 \times 1000}{60 \times 60} \text{ m/s}$$

$$u = 10 \text{ m/s}$$

deceleration $a = -0.5$ m/s^2 (here the -ve sign shows deceleration)

Final velocity $v = 0$

distance travelled $s = ?$

$$v^2 = u^2 + 2as$$

$$(0)^2 = (10)^2 + 2 \times (-0.5) \times s$$

$$0 = 100 - 1s$$

$$1s = 100$$

$$s = 100 \text{ m.}$$

Thus, the distance covered by the vehicle is 100 m.

Example 7 : The following speed-time graph shows the motion of a particle in a given direction.

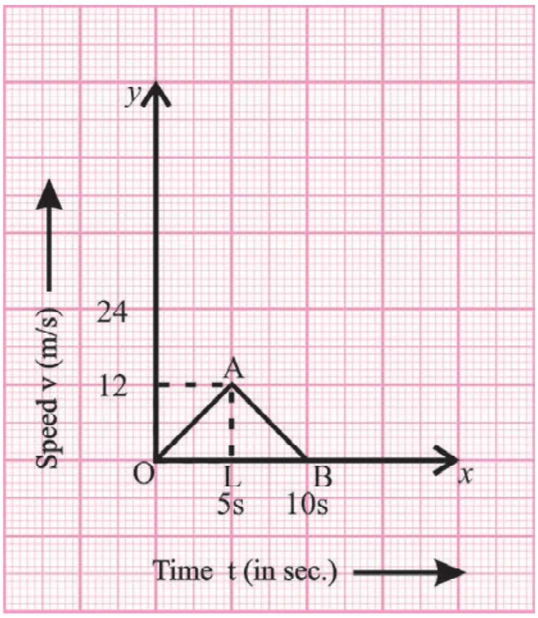


Fig. 11 : Speed-time graph

Find the distance covered between 0 to 10s and the average speed of the particle.

Solution (i) : s = distance covered between 0 to 10 s

= area covered by speed-time graph on the time axis

= area of ΔOAB

$= \frac{1}{2}$ base × height $= \frac{1}{2}$ OB × AL

$= \frac{1}{2} \times 10 \times 12$

= 60 m

(ii) Average speed of particle in 0 to 10 s.

$= \frac{\text{Distance travelled}}{\text{Total time taken}}$

$= \frac{60}{(10-0)} = \frac{60}{10} = 6$ m/s

Question

1. Draw a velocity-time graph for a uniform deceleration motion.
2. A car increases its velocity from 18 km/h to 36 km/h in 5 sec, at a constant acceleration. Find its acceleration and distance covered by it.
3. A car is moving at a constant velocity of 36 km/h. On applying brakes it stops at a distance of 10 m. Calculate deceleration and time taken by the car to stop.

4.4 Circular motion

We know that when the motion of an object is accelerated, its velocity changes. What are the ways by which a change in velocity can take place? There are three possible situations for change in velocity-

1. When there is change in the value of velocity but the direction of motion is constant.
2. When the value of velocity is constant but the direction of motion change.
3. When there is change in the value of velocity as well as the direction of motion of the object.

Now, can you think of circular motion, where in a uniform motion, the value of the velocity remains constant but there is a continuous change in the direction of motion.

Find out how the direction of the velocity and its value changes in the following examples.

(i) a runner, running on a circular track. (ii) motion of a fan.

(iii) motion of hands of a clock.

You experience circular motion also in circular................................ Find out such other examples of circular motion in your daily life.

What we have learnt

- The change in position of an object with time is called motion. It can be described by the distance covered or by displacement.
- The length of the path covered by the object is called distance. It is a scalar quantity. Its SI unit is meters (m).
- The difference in the position of the object is called displacement. It is a vector quantity. Its SI unit is meter (m).
- Displacement does not depend on the path travelled, whereas, distance depends on the path travelled.
- The distance covered in unit time is called speed. Its SI unit is meter/second (m/s).
- The rate of change of displacement is called velocity. It is known as the distance travelled in a given direction in a unit time. Its unit is meter/second (m/s).
- When an object covers uniform distance in a uniform time then its motion is called as uniform motion.
- In a uniform motion, the velocity-time graph is a straight line parallel to time axis.
- The rate of change of velocity of an object is called acceleration. It is a vector quantity. Its SI unit is meter/second^2 m/s^2.
- The acceleration time graph in a uniform accelerated motion is a straight line parallel to the time axis.
- When an object moves on a circular path, with a constant speed, then its motion is called as a uniform circular motion.

Keywords :- Distance, Displacement, Speed, Velocity, Acceleration, Retardation, Uniform circular motion.

Exercise

1. Choose the right option-

(i) If the distance covered by a body is $s = at + \frac{1}{2}bt^2$, then the acceleration of the body will be-

(a) a (b) b (c) 2 b (d) a + b

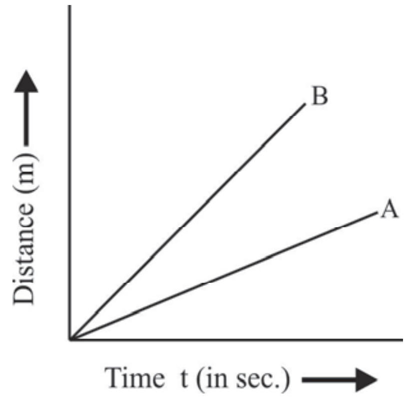
(ii) The area covered by velocity-time graph on the time axis is-

(a) m (b) m/s (c) m/s^2 (d) None of these

(iii) Below is the distance-time graph for the two bodies A and B. Say which body has more velocity.

(a) A (b) B

(c) A and B (d) None of these



(iv) Which one of the following is an example of uniform circular motion.

(a) Motion of earth around the sun.

(b) Motion of a toy train along a linear path.

(c) Motion of the second's hand of a clock.

(d) Motion of a racing car along circular track.

2. Fill in the following blanks-

(i) A body is moving at a constant velocity, its acceleration will be ....

(ii) The direction of velocity of a body depends on ....

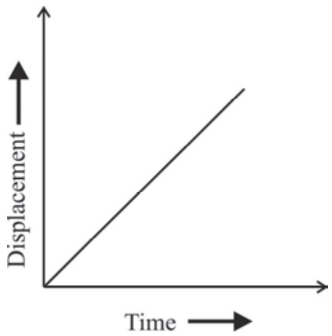
(iii) If the speed of an object is 72 km/h, its speed in m/s is ....

(iv) A person covers one round of a circular track of 2 m. radius in 2 s. What will be his displacement after 8 second.

3. What is the meaning of a uniform circular motion? Give its two examples.

4. A body moves around the sun at a constant velocity. Is its motion a uniform motion or a non-uniform motion?

5. The displacement-time graph for an object is given below. What result can you find out for its velocity?



6. The position-time graph for a given object is a straight line parallel to its time axis. What can you say about its motion?

7. Define uniform motion and a non-uniform motion also state two example of each.
8. Write all the three equations of motion and explain the symbols used in them.
9. An athlete covers one round of a circular track of 7 m. radius is 44 sec. How much distance will it cover in 1 minute? (Answer 60 m.)
10. Using the graphical method derive the second equation of motion $s = ut + ½ at^2$.
11. Neeraj reaches school in a car at an average speed of 20 km/h. While returning; his speed becomes 30 km/h due to lesser crowd. What is the average speed of Neeraj's car for the whole journey?

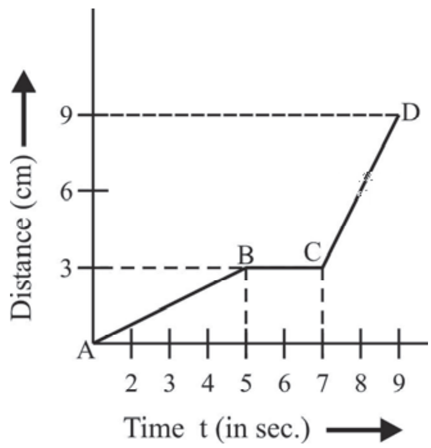
(24 km/h)

12. A ball is dropped from the top of a 20 m. high tower. If its velocity is increasing with an acceleration of 10 m/s^2 then at what speed will the ball hit the ground? How much time will it take to hit the ground? (20 m/s)
13. A car is moving on a straight road at a uniform acceleration. The velocity of the car at different times is given below. Draw its velocity-time graph and calculate its acceleration and also find out the distance covered by it in 30 seconds.

t Time (s)	0	10	20	30	40	50
v speed (m/s)	5	10	15	20	25	30

14. In the following figure, the position-time graph for an object at different times is shown. Calculate the speed of the object.

(i) A to B (ii) B to C (iii) C to B



15. A train starts moving from rest and acquires a velocity of 72 km/h in 5 minutes. If the train moves at a constant acceleration, calculate the following-
    (i) Acceleration ($0.06 m/s^2$)
    (ii) Distance travelled by the bus to acquire this velocity. (3000 m.)