2 GRAPHS OF MOTION

You must have travelled in a bus, train, or a bullock cart.

Answer the following questions about a trip you made.

From which place to which place did you go? (1)
What was the distance between the two places? (2)
How long did your vehicle (bus, train, or bullock cart) take to make this trip? (3)
What was the average distance your vehicle travelled in one hour? (4)

The average distance travelled in each unit time period (one hour, one minute, or one second) is called the **average speed**. That is,

$$\text{average speed} = \frac{\text{total distance travelled}}{\text{total time to cover the whole distance}}$$

If you measure the distance in kilometres and the time in hours, then the unit of speed will be kilometres/hour or km. of per hour.

If you want, you can also use other units to measure the speed, for example: cm per second, meters per second, meters per hour etc. You should remember that whatever measurement you make, you have to write the units along with it, or the measurement will be meaningless.

A journey can be described in many different ways. In this chapter we will learn how graphs can be used to represent motion and how it is useful to do so.

Exercise 1

Data related to Karima's trip is given in Table 1.

From this table calculate Karima's average speed. (5)
Did Karima travel at a constant speed? (6).

Table-1

Time (in minutes)	Distance travelled (in meters)
2	60
4	120
6	240
8	360
10	360
12	360
14	450
16	540

To find out the speed for a part of the journey, divide the distance travelled in that part by the time taken to cover that distance.

For which part of the journey did Karima travel fastest? (7)
Did she stop along the way? If so, for how long? (8)

It is a little difficult to answer these questions directly from the data, isn't it? It can be made easier by making a graph of the journey. To do so, you will have to learn a few new things. Come, let us begin!

Exercise 2

Data about Munnibai's journey from her home to school is given in Table 2. Now let us make a graph of this journey showing the time taken and the distance covered.

Table-2

Time (minutes)	Distance travelled (meters)
2	120
4	240
6	360
8	480
10	600
12	720

Last year you learned how to make graphs. To make this graph we will show time on the X-axis and distance travelled on the Y-axis.

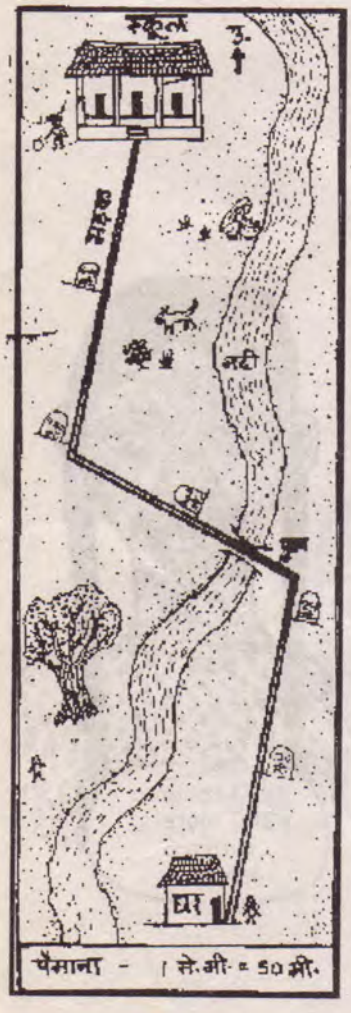
Draw X and Y axes on your graph paper and decide the scales for each of them. Write down these scales in the upper right hand corner of your graph paper.

Now, using the data, plot the first point corresponding to time 2 minutes and distance 120 meters. In this way, plot the remaining five points on the graph. Using a ruler carefully connect these points with a straight line. This is the graph of Munnibai's journey from her home to school.

A Graph is not a map

Remember that this graph and the others in this chapter are graphs of time versus distance travelled, and they are not the route maps of the journeys. Never make the mistake of thinking that they represent routes.

For example, shown below is a map showing the road Munnibai takes to go from her home to the school, as well as a graph of this journey.



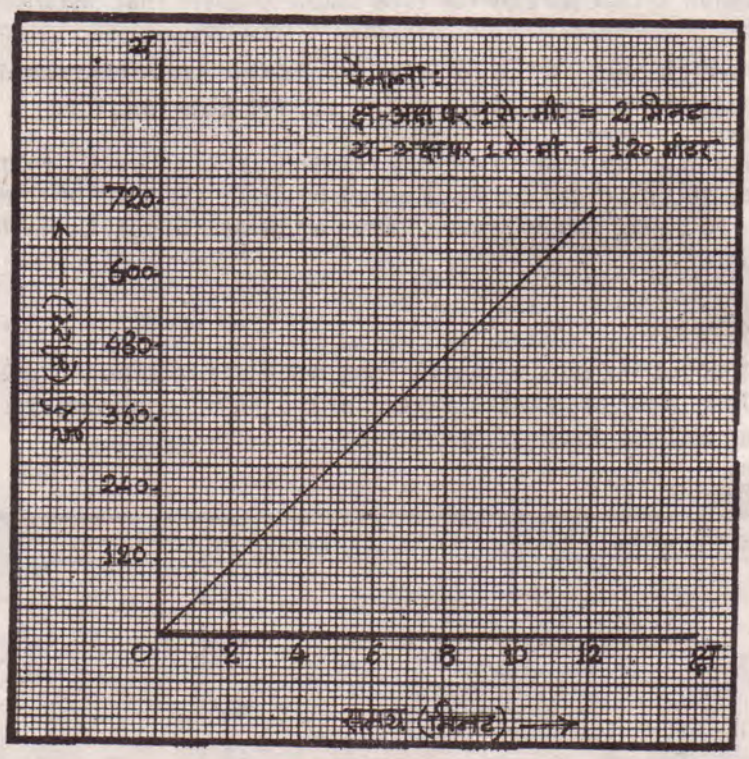


Figure-1b

Just by looking at the map (Figure 1a) can you tell how long it takes Munnibai to reach the school? (9)

By looking at the graph (Figure 1b) alone can you tell how many turns there are in the road or where the river is? (10).

While trying to answer these questions you should have realised

that the information you can get from a route map cannot be obtained from the graph. On the other hand, information about Munnibai's speed can only be obtained from the graph.

Graph of motion

Now, using the graph of Munnibai's journey, answer the following questions:

What distance did Munnibai cover in the first 2 minutes? (11).
What distance did Munnibai cover in the second 2 minutes? (12).
What distance did Munnibai cover from minute 8 to minute10? (13).
Are these distances equal? (14).

If anything covers equal distances in equal time intervals, its motion is called **uniform motion.**

How will the graph of time versus distance look for something having uniform motion?(15)

Assuming something is travelling with a uniform motion, the distance it travels in unit time is called its **speed.** Speed is measured in units of cm per second. meters per second, kilometres per hour, etc.

What was Munnibai's speed during her journey from home to school? (16)

For something travelling with uniform motion, the speed does not change. Therefore its speed and its average speed are the same.

Don't forget that you always have to write the units along with speed.

Exercise 3

Graphs of things moving at different uniform speeds.

Lacchu and Nandu had a race from their home to school. Lacchu ran at a uniform speed. Nandu also ran at a uniform speed. But their speeds were different. Their speeds are shown in the graph (Figure 2).

By looking at this graph alone and without reading the numbers, can you tell who ran at a faster speed - Lacchu or Nandu? (17).
How long did it take Lacchu to run from home to school? What distance did he cover? Calculate his speed on this basis.

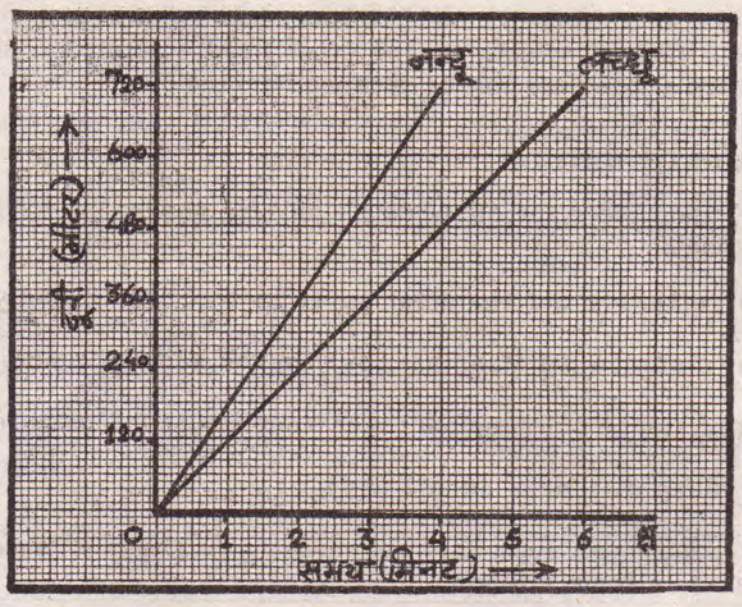


Figure-2

(18)

What was Nandu's speed? (19)

Compare your answers to questions (18) and (19). Now tell whether your answer to question (17) was right or wrong? (20)

The relation between speed and the slope of a graph

For graphs of two uniform speeds we can find out which speed is greater by just looking at the two lines.

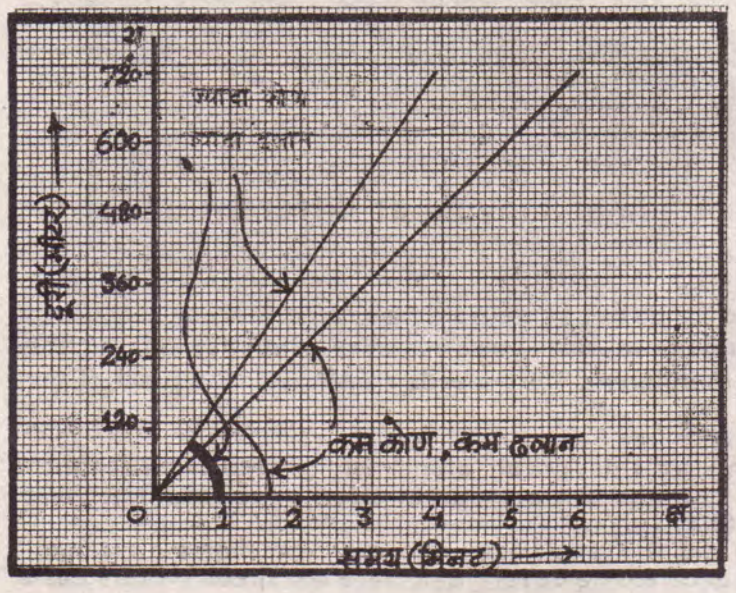


Figure-3

We just have to look at the angle between each line and the X-axis. From this angle we can estimate the slope of the line in the graph the larger the angle, the greater the slope.

Take another look at Figure 2. Whose graph has the greater slope - Lacchu's or Nandu's? (21)
Is his speed also greater? (22)

Any graph of uniform motion will consist of one straight line. The greater the speed, greater is the slope of the line. That is, the angle between the graph line and the X-axis will be greater. But be careful. Such visual comparisons of speeds can only be made provided both the graphs have the same scale. You cannot compare graphs made with different scales just by looking at them.

Exercise 4

Graphs of stationary things

Suppose after walking for 4 minutes on her way to school, Munnibai has to stop for 4 minutes for some reason. After that she continues at the same speed as before until she reaches school. The graph of her journey to school is shown in Figure 4.

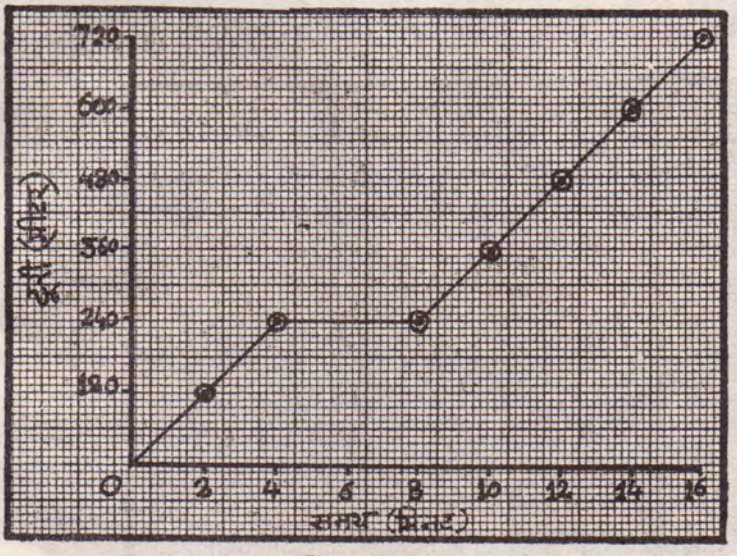


Figure-4

Now we shall try to understand how to recognise Munnibai's halt on a distance time graph. When Munnibai stopped after 4 minutes, she had already travelled a distance of 240 meters. For the next 4 minutes Munnibai did not more. So although 8 minutes had passed since the beginning of her trip she had still only gone 240 meters. That is why the next point on the graph will be plotted at 8 minutes and 240 meters.

Locate this point in the graph of Figure 4.

The straight line joining these two points is parallel to the X-axis.

Whenever anything stops at one place, although time continues to increase, the distance covered does not change. That is why, as we have just seen, the line on a distance time graph for this halt is a straight line parallel to the X-axis.

Now look at the graph in Figure 4 and tell what is Munnibai's average speed? (23)

If Munnibai had gone all the way to school without stopping in between, what would have been her average speed? Answer after looking at the graph in Figure 1b and your answer to question (16). (24)

What is the difference between these two average speeds? (25)

What is the reason for this difference ? (26)

Exercise 5

Suppose Munnibai wanted to reach school in 12 minutes in spite of stopping on the way. For this she would have had to walk faster after stopping. A graph of this journey of Munnibai is shown in Figure 5. Munnibai reached school in exactly 12 minutes.

What was her average speed on this occasion? (27)

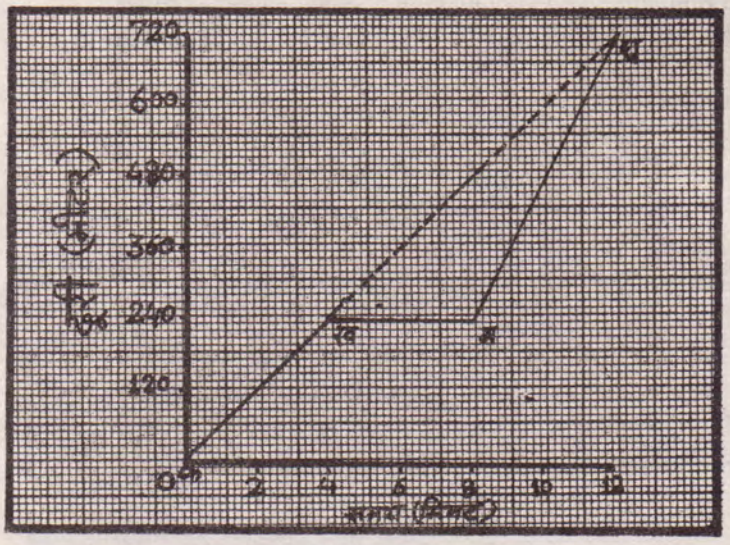


Figure-5

If Munnibai had made this journey without stopping at this speed, the graph of her journey would be a straight line joining the points a, b, and d.

What was Munnibai's speed in the first 4 minutes, and in the last 4 minutes of her journey? (28)

What is the difference between the slopes of the a to b and the c to d portions of the graph? (29)

In which part was Munnibai's speed greater? (30)

Exercise 6

We had discussed Karima's journey in Exercise1. Make a graph of Karima's journey based on the data given in Table 1. (31)

Answer questions (5) to (8) again on the basis of this graph. (32)

Exercise 7

Graphs of non-uniform motions

In the exercises so far we have talked only about uniform motion. Now we will study motion that is not uniform.

You must have seen trains arriving at and departing from a station.

When a train leaves a station does its speed remain uniform? (33)

How does the speed of a train change as it comes to a stop? (34)

Motion in which the speed increases or decreases is called changing or non-uniform motion.

One day Rashid came to Hoshangabad from Powarkheda by a passenger train. With the help of the telephone poles along the railway tracks, he noted down the distance covered by the train every two minutes. He made a graph of this data. Figure 6 shows the graph of the train's motion from the time it left Powarkheda until it stopped at Hoshangabad.

With the help of the graph, fill in the distance covered by the train every 2 minutes in table 3. (35)

Table-3

Time	Distance Covered During That Time (in Meters)
0-2 minutes	100
2-4 minutes	400
—	
—	
—	
20-22 minutes	

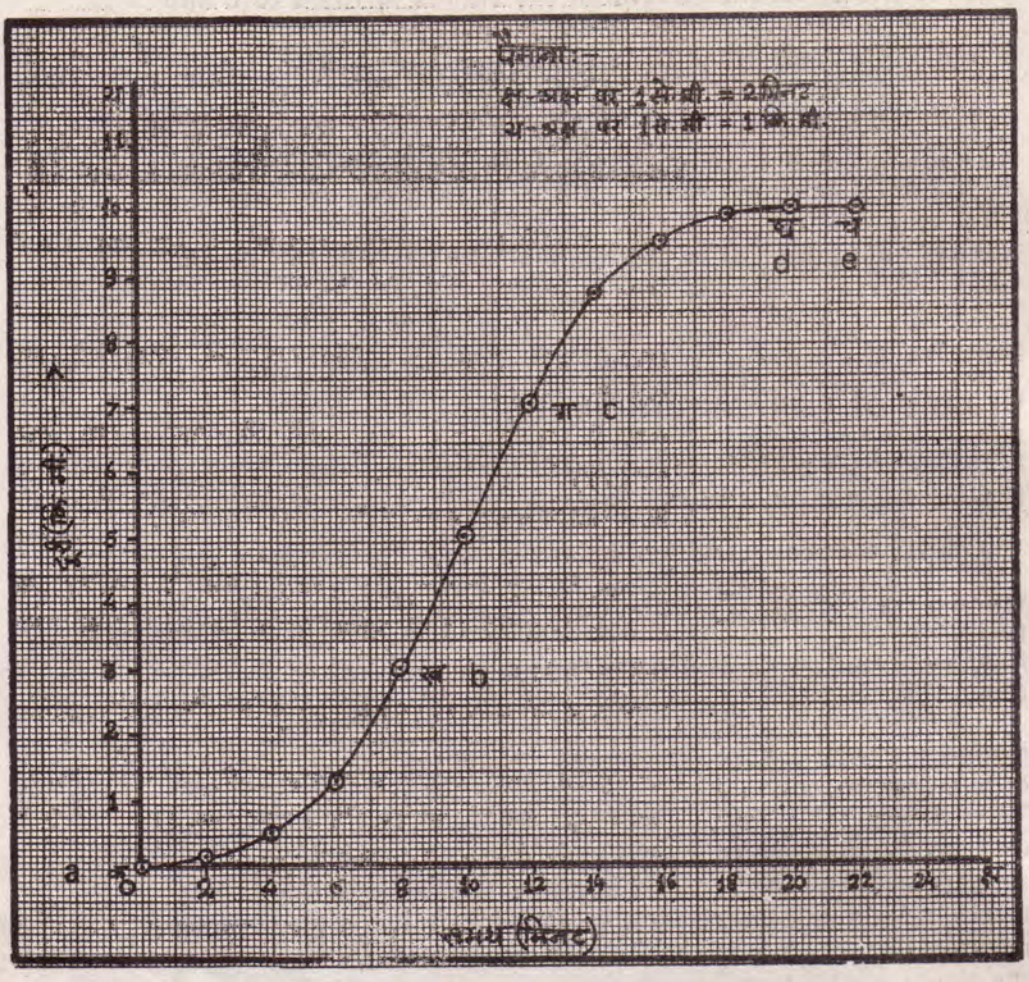


Figure-6

Did the train travel equal distances in equal intervals of time? (36)

Which part of the graph shows non-uniform motion of the train? (37)

Which part of the graph represents uniform motion? (38)

In which part of the journey was the train stationary? (39)

Look carefully at the parts of the graph showing uniform and non-uniform motion.

What is the main difference between them? (40)

A curved line in a graph of motion means that the speed is changing continuously .

Look at section 'a b' of the graph. This section shows how the train's speed gradually increased after leaving Powarkheda station.

Exercise 8

You must have heard the story about the flying turtle. The turtle gripped the middle of a stick with its mouth while two swans held the ends in their breaks as they flew. After a while they were at a height of 180 meters above a lake. Looking at the scene below, the turtle could not resist saying, "wow!" The rest of the story is given in Table 4.

Make a graph of the turtle's journey. (41)
What does this graph look like? (42)
Can you say on the basis of this graph whether the turtle's motion was uniform or non-uniform? (43)

Table-4

Time (seconds)	Distance covered by the turtle during its fall (meters)
0	0
1	5
2	20
3	45
4	80
5	125
6	180

How long did it take to fall into the lake from a height of 180 meters? (44)
What was the average speed of the turtle during the fall? (45)

Exercise 9

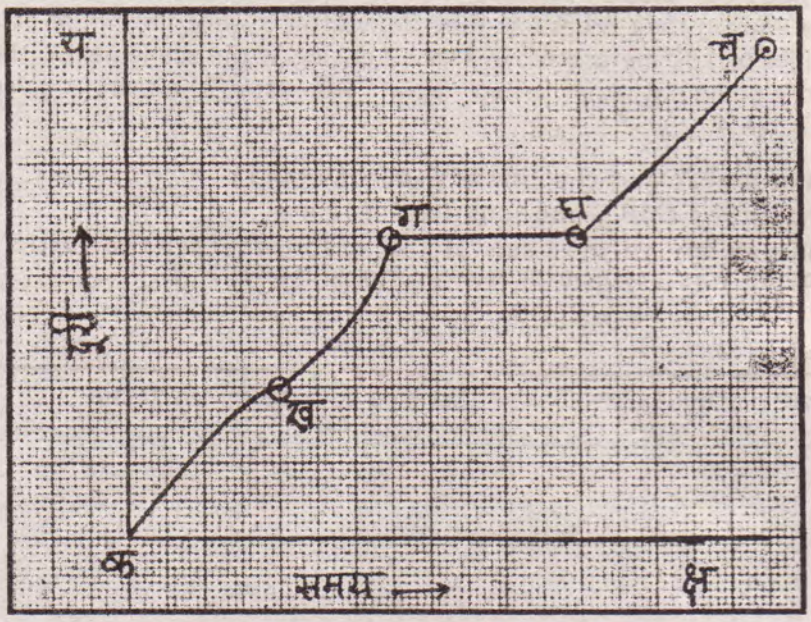
You must have had some experience riding a bicycle. You must have seen that whenever the road is level we tend to travel at a uniform speed, but if we climb uphill the speed decreases, while going downhill the speed keeps on increasing.

The graph of a person's trip on a cycle is shown in Figure 7.

Looking at the graph, can you tell which of the statements below is true:

1. **The person first climbed a hill, then went down, then stopped for rest, and then went along a level road.**
2. **The person was continuously climbing a hill.**
3. **The person first went down a hill, then went on a level road, then climbed a hill and then stopped for rest.**

4. The person first went up a hill then got tired and stopped for a while, then went on a level road, and then went down a hill. (46)



Exercise 10

Some more exercises

Ajay started walking from his village at a speed of 4 km per hour. After 2 hours he sat down under a tree to rest for a while. After an hour's rest he started off again at a speed of 3 km per hour. After another 2 hours he met his friend Suresh. They sat under a tree chatting for one and a half hours. Then Suresh carried Ajay on his bicycle at a speed of 10 km per hour. In an hour and a half they reached the city.

From this data, make a graph of Ajay's journey. Answer the following questions on the basis of this graph:

After walking how many kilometres did Ajay meet Suresh? (47)
How many hours did Ajay take to go from his village to the city? (48)
What was Ajay's average speed for the first 5 hours? (49)
How far is the village from the city? (50)
Which section of the graph has the greatest slope? (51).

Exercise 11

Mohan and Sohan wanted to go from school to Rammu's sweet shop in the bazaar. Just as they were leaving school, *guruji* stopped Sohan.

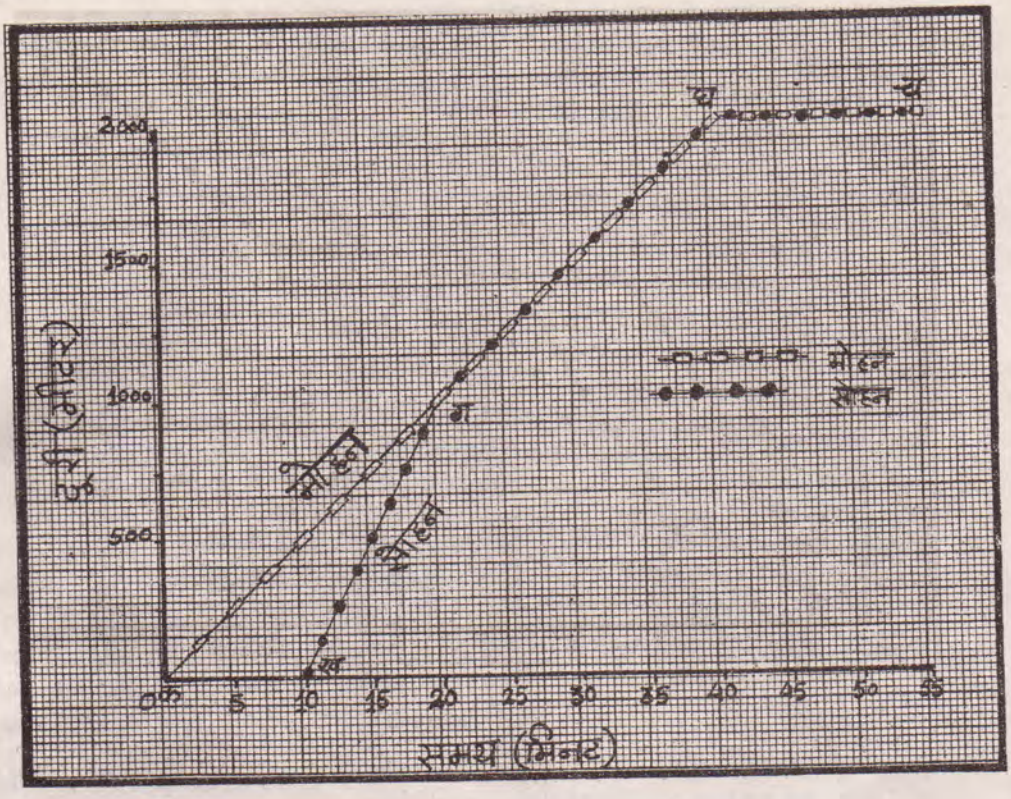


Figure-8

So, Mohan started alone. A little while later Sohan ran and caught up with Mohan. Then after going together for some time they reached the sweet shop, where they sat down and ate some sweets. All this is shown in the form of a graph. In the graph, their journeys are depicted by separate lines marked with different symbols. Look at the graph and answer the following questions:

What was Mohan's speed per minute while he was moving? (52)

For how long did *guruji* keep Sohan waiting? (53)

How long did Sohan run before he caught up with Mohan? (54)

What was Sohan's average speed per minute while he was moving? (55)

How far from the school did Sohan finally meet Mohan? (56)

What distance did the two of them cover together? (57)

For how much time did they walk together? (58)

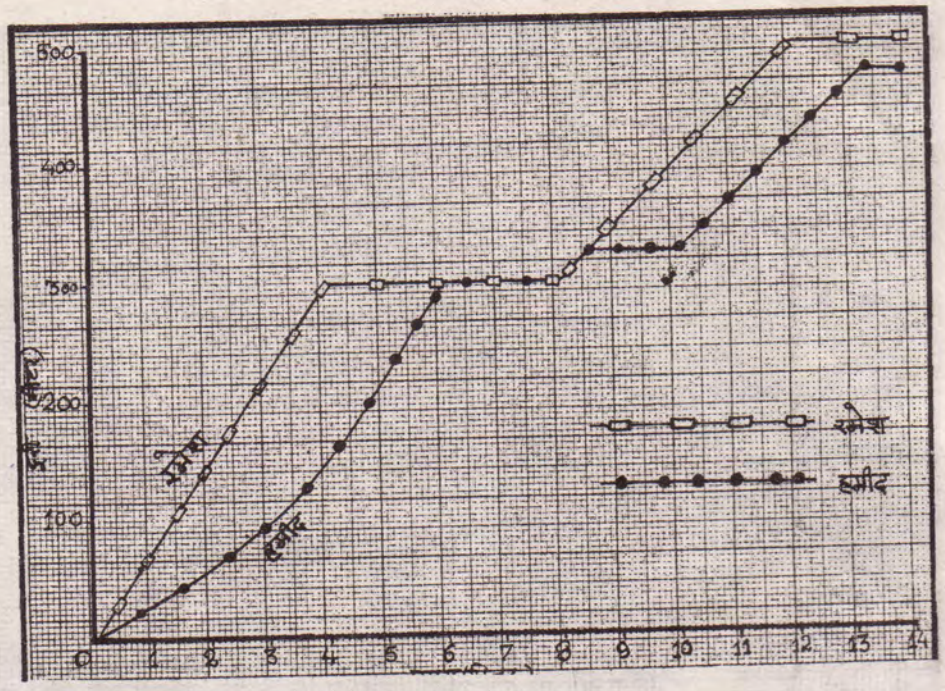


Figure-9

Exercise 12

In the beginning of the chapter you were asked to narrate a trip of your's. Make a distance-time graph of your trip and write a description of it in your note book. (59)

Graph of a story

Make a graph depicting the story of the race between the turtle and the rabbit. (60)

Brain teaser

Figure 9 shows journeys travelled by Ramesh and Hamid in the form of graphs. Look at their graphs and write a short story about the journeys. (61)

NEW WORDS:

speed	motion	slope
uniform motion	non-uniform motion	