Chapter

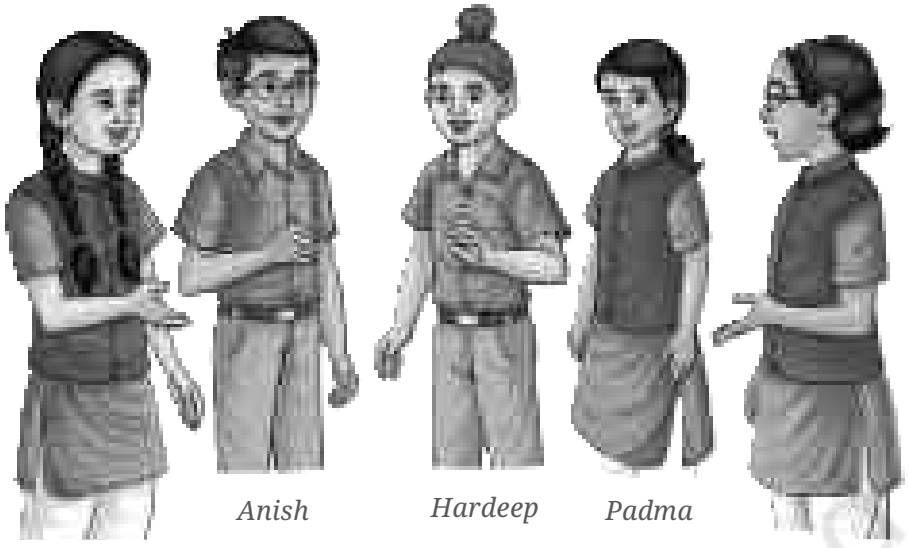
5 Measurement of Length and Motion

Deepa, a curious eleven-year old girl, lives in a town in the state of Haryana. The new school year has started. Deepa needs a new uniform since she has grown taller. Her mother takes her to a cloth shop. She asks for a two-metre cloth piece. The shopkeeper measures the cloth using a metal measuring rod.

Then, the tailor takes her measurements using a flexible measuring tape. Her mother instructs the tailor to increase the length of her uniform by *char angula* (four fingers width).

Are the tape and rod similar to the scale that the elder sister has in her geometry box? What did mother mean by *char angula*?

Deepa shares her experience with her school friends Anish, Hardeep, Padma, Tasneem and this leads to a discussion amongst them.



5.1 How do we Measure?

Hardeep says, "I have seen my grandmother measuring cloth by the length of her arm."

"Have you ever seen how a farmer measures length to divide his field into beds? He walks and counts the number of his strides," says Padma.

"Oh, not just the length of the strides—sometimes they also use the length of their feet to measure," adds Anish.

Deepa says excitedly, "Measuring length using body parts must be so much fun! Let us also measure something using a body part."

"What should we measure? Okay, let us measure the length of the table in our classroom," says Tasneem.

Padma adds, "And which body part should we use to measure it?"

Deepa says, "Let us use our handspan. I will show you how to use it. I have seen my mother using it. She calls it *balisht*."

Hardeep adds, "Okay. Let us also note down our measurements."

Fig. 5.1: Use of handspan for measuring

Table 5.1: Measuring the length of the table

Name of the Student	Number of Handspans
Anish	Slightly more than 13
Padma	13
Tasneem	Slightly less than 13
Deepa	Between 13 and 14
Hardeep	14

Padma says, “Oh, the number of handspans is different for all of us. So, what can we say about the length of the table?”

“But why should the number be different?” Hardeep asked thoughtfully.

Tasneem says, “I can guess. Our handspans are of different sizes.”

Anish gives an idea, “Let us check this.”

So, all five of them put their handspans along each other and arrive at the conclusion that the lengths of their handspans are different.

Deepa says thoughtfully, “No wonder people use scales and measuring tapes.”

Deepa and her friends compare the length of the table with the length of their handspans. The length of the table is expressed in terms of their handspans. Here, the handspan used for measurement is an example of a unit. And the length is expressed in two parts, a number and a unit. For example, if the length of the table is found to be 13 handspans, then 13 is the number and ‘handspan’ is the unit selected for the measurement.

However, handspans and other similar units, such as length of hand, foot, fist or fingers, differ from person to person. Thus, there is a need for such a unit for which measurements of the same length made by different people do not differ.

More to know!

India has a rich history of measurement systems dating back to ancient times. *Angula* (finger width), multiples of *angula*, *dhanusa,* and *yojana* are some of the units mentioned in ancient Indian literature, and used in measuring artefacts, architecture, and town planning. The *angula* is still used by traditional craftspeople like carpenters and tailors. Several objects with ruled markings which could be scales have been excavated from sites of the Harappan Civilisation.

5.2 Standard Units

Several systems of units evolved with time in different parts of the world. However, when people started travelling from one place to another, it created a lot of confusion. This led to the different countries coming together and adopting a set of standard units of measurement. The system of units now used is known as the 'International System of Units' or SI units.

The **SI unit of length** is **metre**. Its symbol is **m**. A metre scale is shown in Fig. 5.2. One metre (m) is divided into 100 equal divisions. Each division is called a **centimetre** (**cm**). You may be familiar with a smaller part of the metre scale, typically 15 cm long, shown in Fig. 5.3.

Look carefully at the 15-cm scale. It has markings (in cm) from 0 to 15. The length of any section between two consecutive big marks, such as between 1 and 2 or between 5 and 6, is 1 cm. Observe that these sections

Fig. 5.2: A metre scale

Fig. 5.3: A 15-cm scale

of 1 cm length are further divided into 10 equal parts. The length of one of these smaller parts is called a **millimetre** (**mm**). 1 mm is the smallest value of length that you can measure using this scale. 1 mm is equal to one-tenth of a centimeter (1 mm = 0.1 cm).

For measuring larger lengths, we use a larger unit called a **kilometre** (**km**) which is equal to 1000 metres. And for measuring smaller lengths, we use units such as centimetre or millimetre.

Would it be convenient to use the unit metre to measure larger lengths, such as the length of a railway track between two cities, or to measure smaller lengths, such as the thickness of a page of a book?

1 km = 1000 m	1 m = 100 cm	1 cm = 10 mm

In some scales, you might have noticed another scale marking. This scale marking is in inches, where 1 inch = 2.54 cm. In earlier days, units, such as inch and foot, were used to measure length. These units are still used by some people.

Do you know?

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5.3 Correct Way of Measuring Length

For measuring any length, we need an appropriate scale. For example, if you want to measure the length of your pencil, you may use a 15-cm scale. Similarly, if the height of a room is to be measured, you may need a metre scale or a measuring tape. You cannot directly measure the girth of a tree or the size of your chest using a metre scale. For such measurements, flexible measuring tape, such as a tailor's tape is more suitable.

While measuring lengths, we need to take care of some points.

What is the correct way to place the scale?

Place the scale in contact with the object along its length as shown in Fig. 5.4.

(a) Correct *(b) Incorrect*

Fig. 5.4: Method of placing the scale

What is the correct position of the eye while reading the scale?

For example, if you are trying to measure the length of a pencil by aligning it with a scale, the position of your eye should be directly above the tip of the pencil (Fig. 5.5).

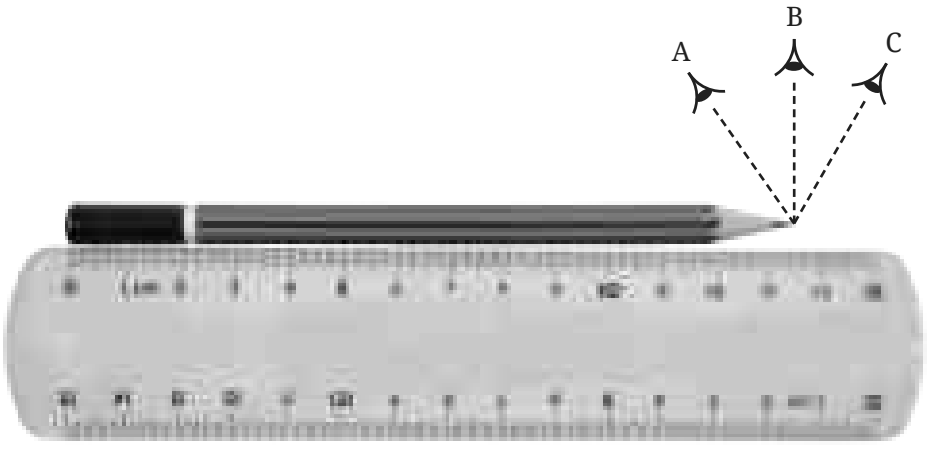

Fig. 5.5: Correct position of the eye is 'B'

How to measure the length if the ends of the scale are broken?

If the ends of the scale are broken or the zero marking is not clear, it can still be used for measurement. With such a scale, use any other full mark of the scale, say, 1.0 cm (Fig. 5.6). Then you must subtract the reading of this mark from the reading at the other end. For example, in Fig. 5.6, the reading at one end is 1.0 cm and at the other end, it is 10.4 cm. Therefore, the length of the object is 10.4 cm–1.0 cm = 9.4 cm.

Fig. 5.6: Correct method of placing the scale with broken end

Do you know?

How do visually challenged students measure lengths? They use scales with raised markings that can be felt by touching them.

Activity 5.1: Let us measure

- Select some objects around you, such as a comb, a pen, a pencil, and an eraser to measure their lengths.
- Measure their lengths one by one using a metre scale and note down the measurements in Table 5.2.

Table 5.2: Measuring lengths

Object	Length of the object

While writing the length, do not forget to write the unit also. Thus, your result will consist of two parts—one part is a number and the other part is the unit of measurement.

Some of your friends in the class would have measured the length of the same objects. Compare the lengths measured by you with that of your friends. Are the measured lengths the same or slightly different? If not the same, discuss the possible reasons for the differences.

Do you know?

Units of length, such as kilometre, metre, centimetre and millimetre, begin with a lowercase letter, except at the beginning of a sentence. Their symbols km, m, cm and mm are also written in lowercase letters, and are never followed by 's' for the plural. Note that a full stop is not written after the symbol, except at the end of a sentence. While writing the length, always leave a space between the number and the unit.

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5.4 Measuring the Length of a Curved Line

Anish and his parents fixed electric string lights on the arches of the verandah of their house, as shown in Fig. 5.7, for a celebration at home. How would they have measured the required length of string lights?

In the case of a curved line, measurements can be made with the help of a flexible measuring tape or by using a thread as shown in Fig. 5.8.

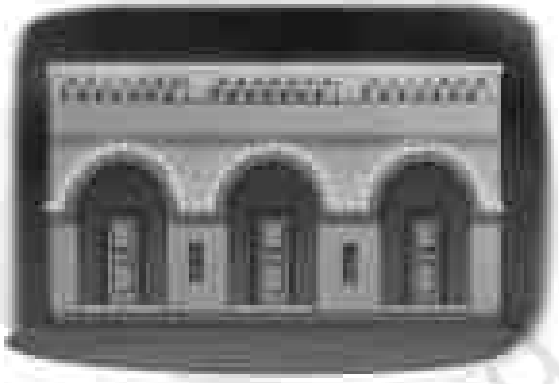
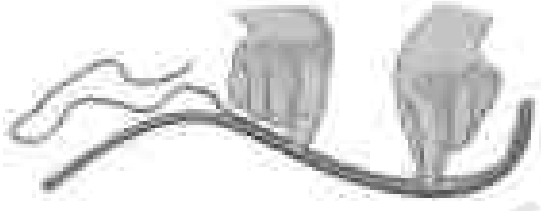


Fig. 5.7: House decorated with string lights



The thread can then be straightened and its length can be measured using a metre scale.

Fig. 5.8: Measuring the length of a curved line

5.5 Describing Position

One day the teacher informs her students that she has planned an educational visit to a nearby garden. She asks the students to reach there directly in the morning. Deepa and her friends start discussing whether the garden would be closer than their school or farther. Tasneem and Padma say that the garden would be closer, while Deepa and Anish feel that the school would be closer, Hardeep thinks that both would be almost at an equal **distance** (Fig. 5.9).

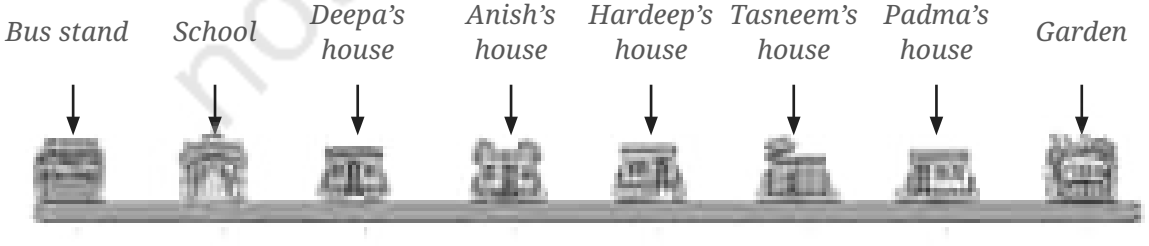


Fig. 5.9: Location of bus stand, school, garden and houses of Deepa and her friends

Who do you think is correct? All of them are correct (Fig. 5.9). Then, why are their observations different? They are locating the distances of the school and garden from their houses. If, instead, each of them had thought of distances from a same object or point, say, the bus stand, then their observations would have been the same.

When distance is stated with respect to a fixed object or point, then this point is called a **reference point.**

A few days later, Hardeep tells his friends excitedly, "Let us all go to the playground. The sports teacher wants us to help her to draw lines with *chuna* powder (limestone powder) for making the Kabaddi court for the sports day."

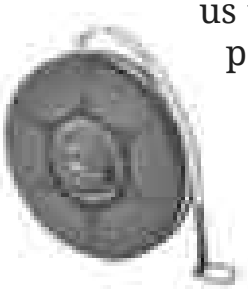


Fig. 5.10: A measuring tape

Padma: "We will need a longer measuring tape. Let us take it from the sports room." (Fig. 5.10)

Deepa: "Let us first decide the point on the ground from which we will measure the distances to start drawing the lines. Let us call this our reference point." (Fig. 5.11)

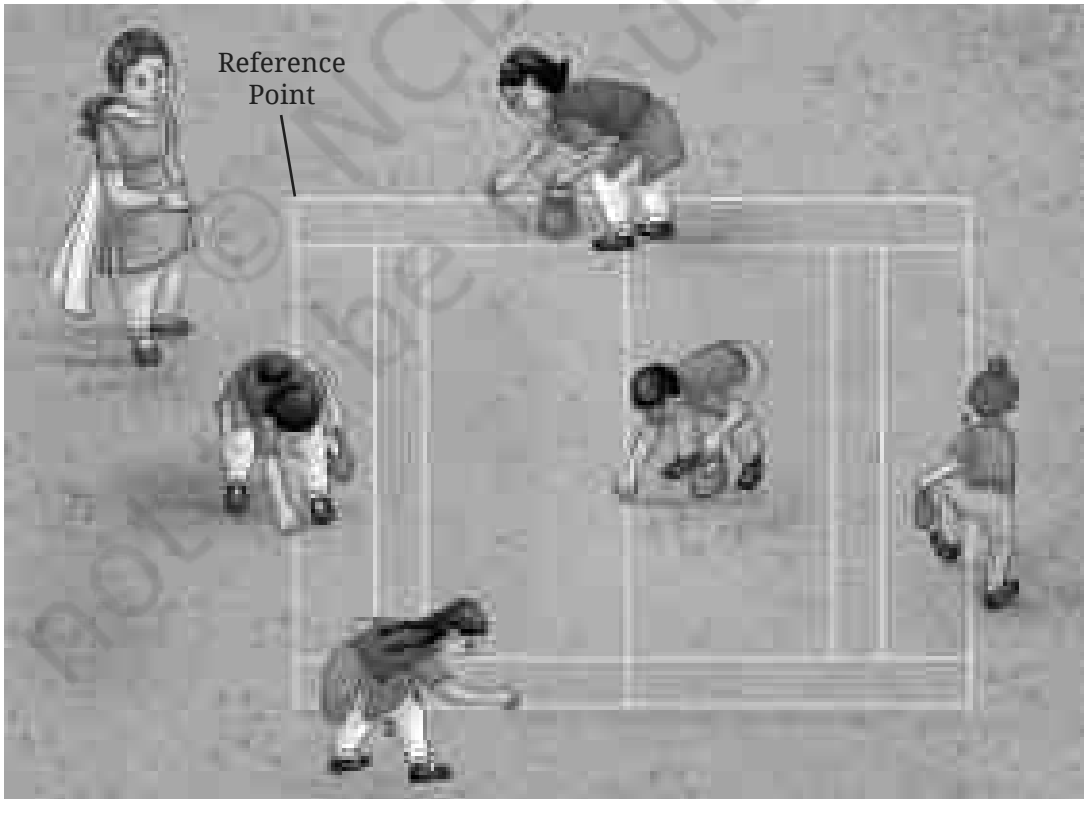


Fig. 5.11: Drawing lines for Kabaddi court

Fig. 5.12: A kilometre stone

After a few days, Padma was travelling by bus to visit her grandparents in Delhi. She was eager to reach Delhi and was reading the kilometre stones on the side of the road. On one of the kilometre stones, it was written 'Delhi 70 km' (Fig. 5.12).

Further on, the next kilometre stone read 'Delhi 60 km'. Each kilometre stone indicated that she was getting closer to her grandparents' house.

These kilometre stones indicated her distance from Delhi. So, Delhi is the reference point in this situation.

What do such kilometre stones indicate? How could Padma conclude that she was getting closer to her destination?

Fig. 5.13: Positions of kilometre stones with respect to Delhi as a reference point

If the kilometre stone reads 'Delhi 70 km' as shown in Fig. 5.13, we can say that the position of Padma is 70 km from Delhi. When the kilometre stone reads 'Delhi 60 km', the position of Padma is 60 km from Delhi.

Does this mean that the position of Padma, with respect to the reference point, is changing with time? When does the position of an object change with respect to a reference point? Does it change when an object is moving?

5.6 Moving Things

Activity 5.2: Let us explore

- Look around and prepare a list of five objects that are in motion and five objects that are at rest.
- Record your observations in Table 5.3.
- Think about how you decided whether an object was in motion or at rest. Write your explanation (**justification**) in Table 5.3.

Table 5.3: Observing things around you

Objects in motion	Justification	Objects at rest	Justification
Cow grazing in the field		Tree	

Compare and analyse your justifications. How can one decide if an object is in motion or at rest?

An object is said to be in **motion** if its position changes with respect to the reference point with time. If an object is not changing its position with respect to the reference point with time, it is said to be at rest.

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Deepa looked around her in the bus and noticed that all the passengers were seated. She looked around again after a minute and found them still occupying their seats. She wondered, 'Are they moving?' She concluded that the position of the passengers was not changing with time. Therefore, they were certainly at rest. However, when she looked outside, she felt they were in motion as their positions were changing with respect to things outside.

The reference point is important in deciding whether an object is at rest or in motion. If Deepa considered herself (or the bus) as the reference point, then the passengers were at rest. However, if she considered any object outside the bus (say a building) as the reference point, then the passengers (and the bus) were in motion.

More to know!

Think it over!

Suppose you are travelling on a ship which is moving at a constant speed along a straight line on a calm sea. Suppose there is no window on the ship. Is there any way that you can determine whether the ship is moving or is stationary?

5.7 Types of Motion

Activity 5.3: Let us explore

- Take an eraser and drop it from a certain height.
- Observe its motion.

Does it move along a straight line? When an orange drops from the tree, does it move in a straight line? Have you seen the Republic Day parade? Recall the march-past of students during the parade. Do they move on a straight-line path? When a heavy box is pushed, it may also move along a straight line (Fig. 5.14).

When an object moves along a straight line, its motion is called **linear motion**. **Identify** such linear motion in your surroundings.

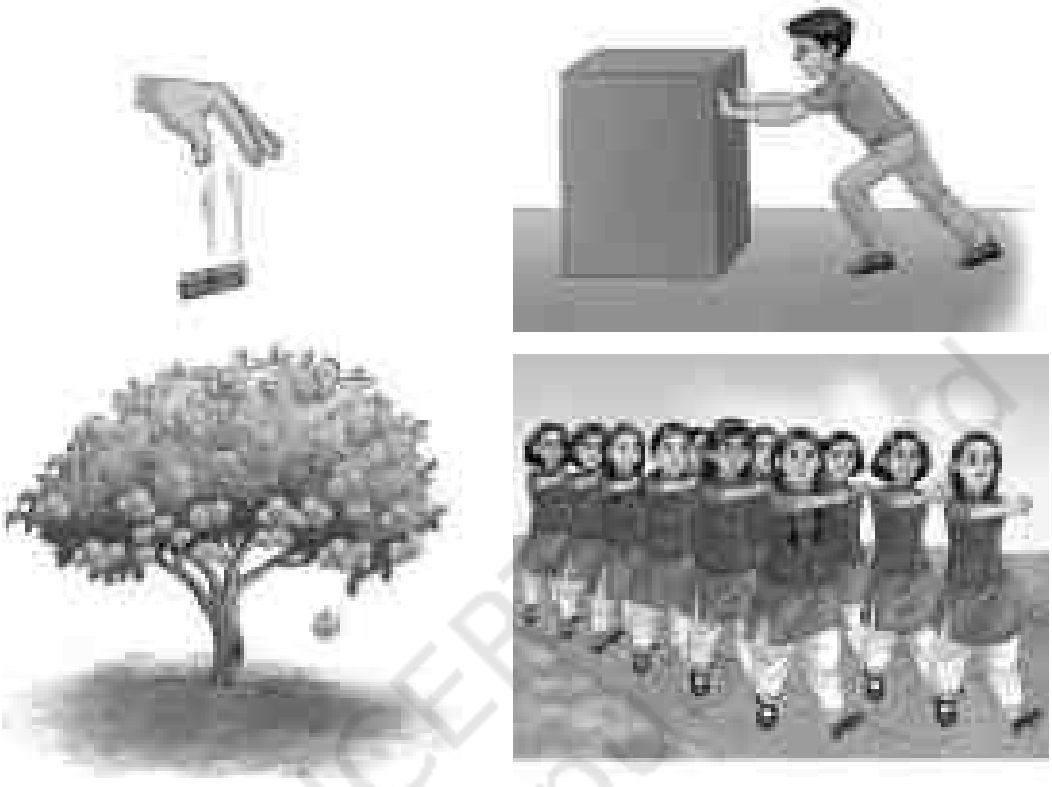

Fig. 5.14: Linear motion

But do things always move along a straight line? You might have enjoyed playing on swings and merry-go-rounds. Are these types of motion also linear motion?

Activity 5.4: Let us investigate

- Tie an eraser (or a potato) to one end of a thread.
- Hold the other end of the thread with your hand and whirl it (Fig. 5.15).
- Observe its motion.

Is the motion of the eraser the same as that of a merry-go-round?

When an object moves along a circular path, its motion is called **circular motion.**

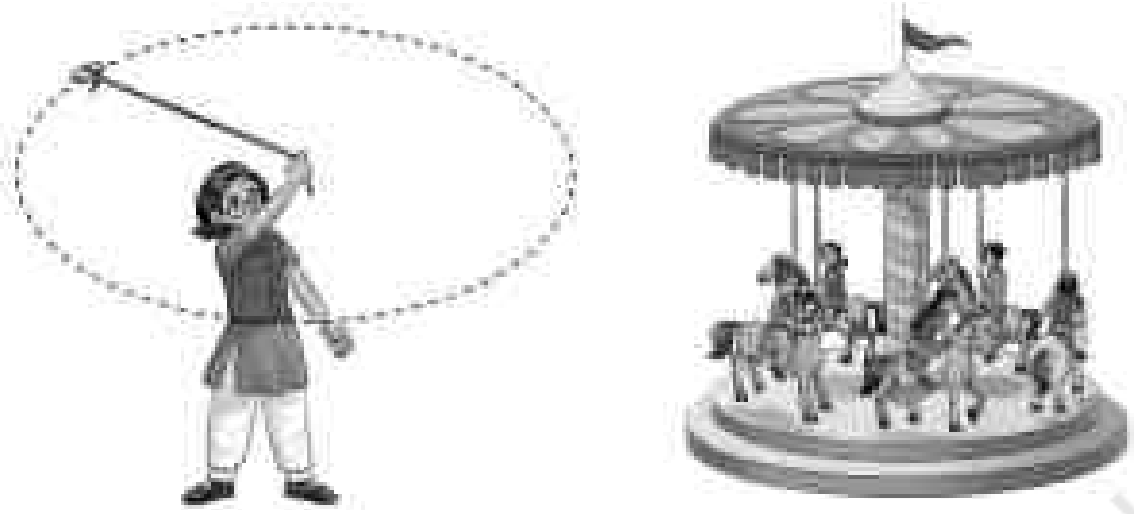

Fig. 5.15: Circular motion

Activity 5.5: Let us investigate

- Tie an eraser (or a potato) to one end of a thread.
- Hang the eraser by holding the other end of the thread (Fig. 5.16). Keep your hand steady.
- Using the other hand, take the eraser slightly to one side and then release (Fig. 5.16).

Does it start moving to and fro? Is its motion similar to the motion of a swing?

When an object moves to and fro about some fixed position, its motion is called **oscillatory motion.**

Fig. 5.16: Oscillatory motion

Activity 5.6: Let us investigate

- Take a thin metal strip of about 50 cm long.
- Hold its one end pressed to a table. You may use a few books or a brick to hold it (Fig. 5.17).
- Press the free end of the strip slightly and let it go.
- Observe the motion of this end of the strip.

Does it move up and down? This is also an example of oscillatory motion.

Fig. 5.17: Oscillatory motion of a metal strip

More to know!

If an object repeats its path after a fixed interval of time, its motion is said to be periodic. When an object is in circular motion, it moves along the circular path again and again. An object in oscillatory motion also repeats its motion while moving to and fro. Both circular and oscillatory motion are periodic in nature.

Activity 5.7: Let us identify

- Look at the picture of a children's park (Fig. 5.18) or visit a children's park.
- Observe different kinds of motions. **Classify** them as linear, circular or oscillatory motion.

List them in Table 5.4. Give your justification for why you put each in a certain category.

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Fig. 5.18: Types of motion observed in a children's park

Table 5.4: Types of Motion

Object	Linear motion	Circular motion	Oscillatory motion
Swing			Moving to and fro

Keywords

centimetre	Measurement	Classify
Circular motion	metre	Explore
Distance	millimetre	Identify
kilometre	Motion	Investigate
Length	Oscillatory motion	Justification
Linear motion	Reference point	Observe
	SI Unit of Length	

Summary

- The International System of Units (SI units) has been adopted by countries as standard units of measurement.
- The SI unit of length is metre. Its symbol is m.
- 1 km = 1000 m, 1 m = 100 cm, 1 cm = 10 mm.
- When distance is stated with respect to a fixed object or point, then this point is called a reference point.
- An object is said to be in motion if its position changes with respect to a reference point with time.
- When an object moves along a straight line, its motion is called linear motion.
- When an object moves along a circular path, its motion is called circular motion.
- When any object moves to and fro about any fixed position, its motion is called oscillatory motion.

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Let us enhance our learning

1. Some lengths are given in Column I of Table 5.5. Some units are given in Column II. Match the lengths with the units suitable for measuring those lengths.

Table 5.5

Column I	Column II
Distance between Delhi and Lucknow	centimetre
Thickness of a coin	kilometre
Length of an eraser	metre
Length of school ground	millimetre

2. Read the following statements and mark True (T) or False (F) against each.
   (i) The motion of a car moving on a straight road is an example of linear motion. [ ]
   (ii) Any object which is changing its position with respect to a reference point with time is said to be in motion. [ ]
   (iii) 1 km = 100 cm [ ]
3. Which of the following is not a standard unit of measuring length?
   (i) millimetre (ii) centimetre (iii) kilometre (iv) handspan
4. Search for the different scales or measuring tapes at your home and school. Find out the smallest value that can be measured using each of these scales. Record your observations in a tabular form.
5. Suppose the distance between your school and home is 1.5 km. Express it in metres.

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6. Take a tumbler or a bottle. Measure the length of the curved part of the base of glass or bottle and record it.

7. Measure the height of your friend and express it in (i) metres (ii) centimetres and (iii) millimetres.

8. You are given a coin. Estimate how many coins are required to be placed one after the other lengthwise, without leaving any gap between them, to cover the whole length of the chosen side of a notebook. Verify your estimate by measuring the same side of the notebook and the size of the coin using a 15-cm scale.

9. Give two examples each for linear, circular and oscillatory motion.

10. Observe different objects around you. It is easier to express the lengths of some objects in mm, some in cm and some in m. Make a list of three objects in each category and enter them in the Table 5.6.

Table 5.6: Sizes of objects around us

Size	Objects
mm	
cm	
m	

11. A rollercoaster track is made in the shape shown in Fig. 5.19. A ball starts from point A and escapes through point F. Identify the types of motion of the ball on the rollercoaster and corresponding portions of the track.

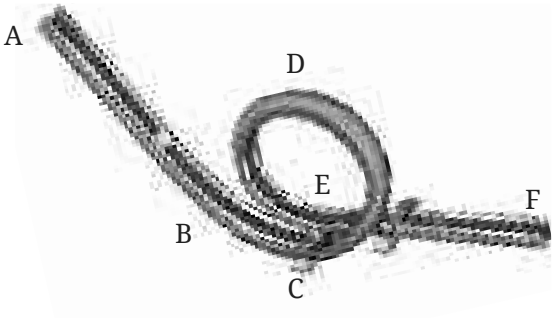

Fig. 5.19: Rollercoaster track

12. Tasneem wants to make a metre scale by herself. She considers the following materials for it—plywood, paper, cloth, stretchable rubber and steel. Which of these should she not use and why?

13. Think, design and develop a card game on conversion of units of length to play with your friends.

Learning further

- Can you find the thickness of a single page of your notebook or textbook using a scale? Think of a way and write it. Carry out the activity and report your result.
- Collect fallen leaves from the same tree. Identify the name of the tree whose leaves you have taken. Measure length and breadth of all these leaves using a 15-cm scale, as shown in Fig. 5.20. Record your observations in the Table 5.7.

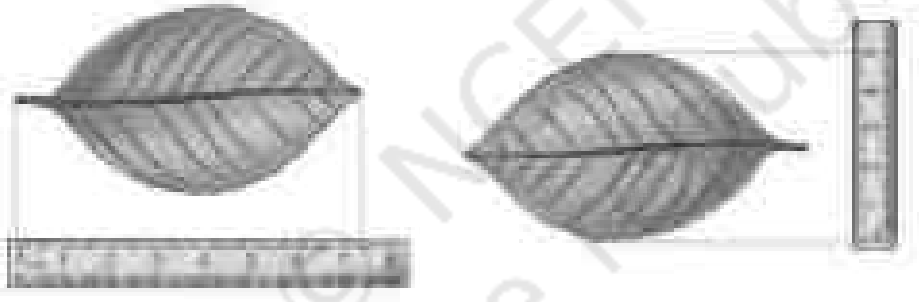

Fig. 5.20: Measuring a leaf

Table 5.7: Length and breadth of leaves

S. no.	Name of tree	Length of leaf	Breadth of leaf
1.			

Discuss why the leaves of the same tree vary in length and breadth.

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- Discuss with elders in your community what units were used for measurement of length in the olden days. Also, using the internet, try to find out about the length scales found in excavations of archaeological sites in India.

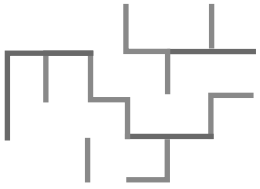

Fig. 5.21: A maze

- Create a maze using lines of 1 cm, 2 cm and their combination. Part of it has been made for you in Fig. 5.21. Now use your imagination and expand it to a size as big as you want.
- How tall am I? Stand along a wall and with the help of an adult, mark your height (Fig. 5.22). Repeat it every three months to maintain a height record for yourself and your siblings.

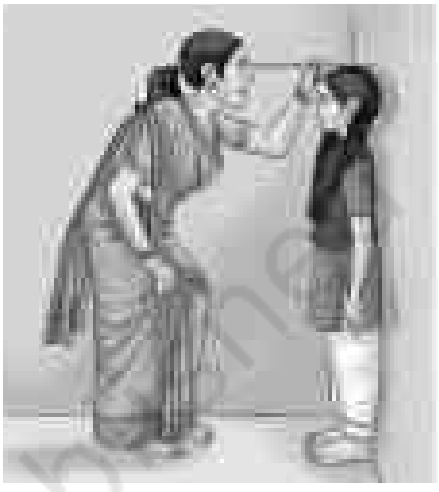

Fig. 5.22: Measuring height

- Let us design a fun method for measuring the distance between two places by using a bicycle. Attach a flexible metal strip to the spoke of the front wheel in such a manner that it hits the frame of the bicycle holding the wheel, every time it crosses it and produces a sound (Fig. 5.23).

Now ride the bicycle slowly and count the number of times in which sound occurred. The number will give you the number of turns of your wheel made. Now measure the length of the outer boundary of the wheel using a string as done in Fig. 5.8. Multiply this length by the number of turns of the wheel. This is the distance you travelled.

Fig. 5.23: Measuring distance

Such methods are actually used to measure the distance for road-running races. Try to find out about a 'Jones Counter' which is attached to a bicycle wheel and is used for measuring distances.