Chapter 8

# MEASUREMENT OF PHYSICAL QUANTITIES


## STUDENTS' LEARNING OUTCOMES

**After studying this chapter, students will be able to:**

- ☑ Define a physical quantity with examples.
- ☑ Apply the prefixes milli, kilo, centi, and interpret the units.
- ☑ Interconvert smaller units and bigger units.
- ☑ Select and use measuring instruments.
- ☑ Interpret SI units in daily life.
- ☑ Investigate why it is desirable for a scientist to use the SI units in their work.
- ☑ Measure the volume of liquid by reading correct meniscus.

How far is your school from your home? How much is the table heavier than the chair? How much more water can be filled in a jug than that in a glass? How long is the duration of a day? Such questions can be answered only when you are able to measure the physical quantities like length, mass, time, volume, etc. In this chapter, we will learn about these physical quantities and their measurements. Measuring instruments and units of measurements will also be discussed.

## 8.1 Physical Quantities

The quantities which can be measured are called physical quantities. Length, mass, time, volume, etc., are the examples of physical quantities. Physical quantities have at least two things in common. One is the size or magnitude and the other is the unit in which the quantity is measured. For example, to describe a brick, its length, width, height and mass are measured. These are called physical quantities.

## 8.2 International System of Units

In our daily life, we often need to measure various physical quantities. To measure a physical quantity, we compare it with some standard quantity. For example, if we purchase some sugar, we must know how much quantity of sugar we are talking about. Thus, there is a need of some standard quantity for measuring unknown quantity. This standard quantity is called unit.

Various standard units have been in use at different times in different parts of the world. With the passage of time, these units were made more precise and acceptable. People especially business communities and scientists of different countries faced problems of converting the units into one another. This problem was solved in a conference of the scientists from all over the world held in Paris.

In 1960, the eleventh general conference of International Committee on Weights and Measures recommended that all countries of the world should adopt a system of same kind of standard units. This conference recommended the use of International System of units. It is abbreviated as SI. According to this system, the units of length, mass, time and volume are given in the following table.

**For your information**

The standard kilogram kept in Paris

| Physical Quantity | Symbol | Unit | Symbol |
|---|---|---|---|
| **Length** | $l$ | metre | m |
| **Mass** | $m$ | kilogram | kg |
| **Time** | $t$ | second | s |
| **Volume** | $V$ | cubic metre | $m^3$ |

A practical unit of volume is litre (L). Mostly the litre is used for measuring volume of liquids such as milk, petrol, cooking oil, etc. It is 1/1000th part of a cubic metre ($m^3$).

Therefore $1\ m^3 = 1000\ L$

Also $1\ L = 1000$ millilitre $= 1000$ cubic centimetre (cc)

## Prefixes

The main advantage of SI units is that their multiples and sub-multiples can be conveniently expressed using prefixes. Prefixes are based on multiplying and dividing the units by powers of 10. The words or letters added before SI units such as milli (m), centi (c) and kilo (k) are known as prefixes.

- Milli means $1000^{th}$ part. For example, millimetre (mm) is $1000^{th}$ part of a metre, i.e., 1/1000 m. It means, 1 m = 1000 mm.
- Centi means $100^{th}$ part. For example, centimetre (cm) is $100^{th}$ part of a metre, i.e., 1 cm = 1/100 m. It means 1 m = 100 cm.
- Kilo means 1000 times. For example, kilometre (km) is 1000 times of a metre, i.e., 1 km = 1000 m.

Thus, diameter of a thin wire can be written in smaller units of centimetre (cm) or millimetre (mm) instead of metre. Similarly, the longer distance between two cities may be expressed better in a bigger unit of distance, i.e., kilometre (km).

## Examples

**1. Convert 5 m into mm.**

$$5\text{ m} = 5 \times 1{,}000\text{ mm}$$
$$= 5{,}000\text{ mm} = 5 \times 10^3\text{ mm}$$

**2. Convert 50 m into cm.**

$$50\text{ m} = 50 \times 100\text{ cm}$$
$$= 5{,}000\text{ cm} = 5 \times 10^3\text{ cm}$$

**3. Convert 20,000 g into kg.**

$$20{,}000\text{ g} = 20{,}000 \div 1{,}000\text{ kg}$$
$$= 20\text{ kg}$$

**Multiples and sub-multiples of length**

| | |
|---|---|
| 1 m<br>1 cm<br>1 km | 100 cm<br>10 mm<br>1000 m |
| 1 mm<br>1 cm<br>1 m | $10^{-3}$ m<br>$10^{-2}$ m<br>$10^{-3}$ km |

**Multiples and Sub-multiples of mass**

| | |
|---|---|
| 1 kg<br>1 g | 1000 g<br>1000 mg |
| 1 mg<br>1 g | $10^{-3}$ g<br>$10^{-3}$ kg |

**Sub-multiples of time**

| | |
|---|---|
| 1 ms<br>1 μs | $10^{-3}$ s<br>$10^{-6}$ s |

### Mini Exercise

**1. Complete the following:**

1 km = _____ m , 1 cm = _____ m

1 mm = _____ m , 1 cm = _____ mm

**2. The height of a student is 150 cm. What is his height in metres?**

**Mini Exercise**

1. Complete the following:
   (i) 1 kg = _____ g = _____ mg
   (ii) 1 mg = _____ g = _____ kg
2. The mass of a bag of flour is 10 kg. What is the mass in grams?
3. Convert the following in grams:
   (a) $75.5 \times 10^{3}$ mg
   (b) $1.58 \times 10^{-2}$ kg
   (c) 440 mg

## 8.3 Measuring Instruments

Measuring instruments are used to measure various physical quantities such as length, mass, time and volume etc. We shall now describe some measuring instruments used in the laboratory.

### 8.3.1 Metre Rule

A metre rule is one metre long graduated stick. It is usually used to measure length of an object or distance between two points. A metre rule is divided into 100 equal parts, each part is equal to one centimetre (Figure 8.1). Each centimetre is further divided into 10 millimetres. Thus, a metre rule can measure the length of an object correct upto one millimetre.

**For your information**

It is better to measure from 1cm mark of the metre rule or measuring tape and then subtract 1 cm from the final reading. This is because of the wears and tears of zero edge of the scale.

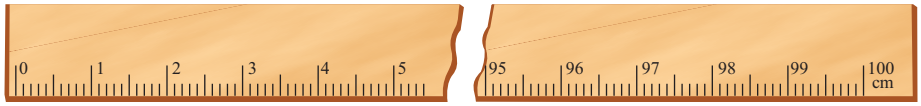
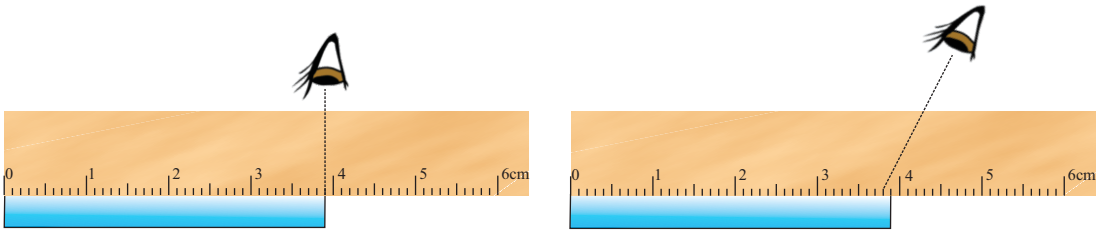



Figure 8.1: Metre rule

While measuring length or distance between two points, eye must be kept vertically above the reading point as shown in Figure 8.2(a). If the eye is positioned either left or right to the measuring point (Figure 8.2-b), the reading will become doubtful.

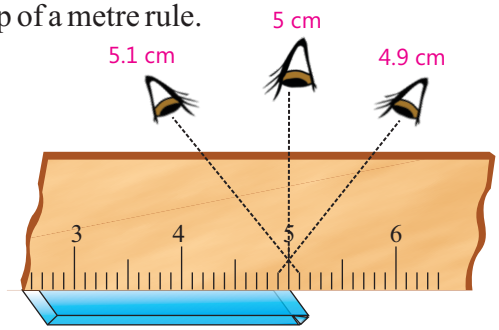



**(a)** Correct reading **(b)** Incorrect reading

**Figure 8.2**

## Activity 8.1

- Measure the length of a plate with the help of a metre rule.
- Position your eye vertically above the reading mark on the scale. In this way you would get accurate measurement.
- Now measure the same length from wrong positions of the eye as shown in the figure.




- Wrong position of the eye will give you an incorrect reading.
- Such an error (due to wrong position of eye) is called parallax error.

## Mini Exercise

Measure the following lengths with the help of a measuring tape and convert them into larger or smaller units:

1. The length of your science textbook

   = _____ cm = _____ m

2. The height of the boundary wall of your school

   = _____ m = _____ cm = _____ mm

3. The distance of your classroom from the Principal office

   = _____ cm = _____ m = _____ km

4. Length of your classroom

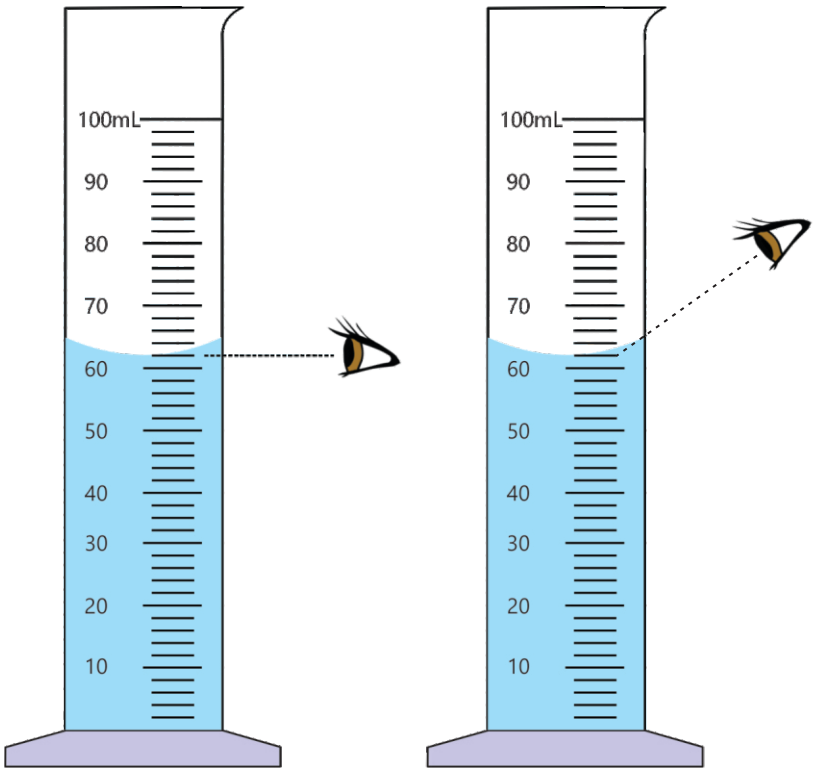
   = _____ cm = _____ m

5. Height of your friend

   = _____ cm = _____ mm

## 8.3.2 Measuring Cylinder

A measuring cylinder is used to measure the volume of a liquid. It is made of glass or transparent plastic. It has a scale in millilitre (mL) or cubic centimetre ($cm^3$) along its length. That is why, it is also called graduated cylinder. Measuring cylinders of different capacities (from 5 mL to 500 mL) are available in the school laboratory. To measure the correct volume of a liquid, cylinder must be placed on horizontal surface and the eye should be kept on the level with the bottom of the meniscus (curved surface) as shown in Figure 8.3 (a).




**(a)** Correct reading **(b)** Incorrect reading

**Figure 8.3: Measuring cylinder**

**? Do you know?**

Meniscus of all liquids is curved downward whereas meniscus of mercury is curved upward when they are put in a cylindrical container.

**i Interesting information**

| | | | | |
|---|---|---|---|---|
| 1 $dm^3$ | = | 1 L | = | 1000 mL |
| 1000 mL | = | 1000 $cm^3$ | | |
| 1 mL | = | 1 $cm^3$ | | |

**Mini Exercise**

**Convert the following into $dm^3$.**

(i) 5 $m^3$

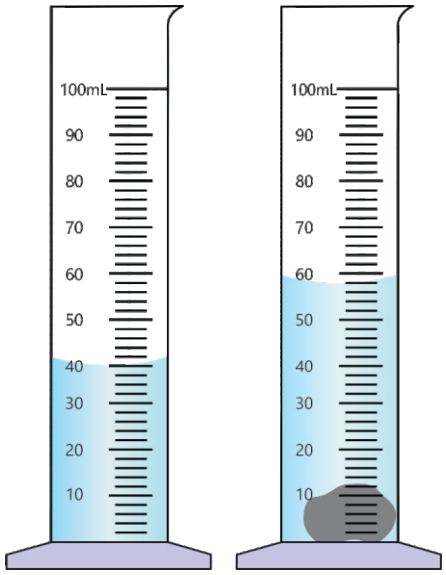
(ii) 1000 $cm^3$

**Activity 8.2 - Measurement of volume of an irregular shaped object**

- Fill 1/3rd of a graduated cylinder with water and note the volume of water $V_1$.
- Take a small irregular shaped object and drop it gently in the measuring cylinder by rolling down along the inner wall of the cylinder.
- The level of water in the cylinder will rise up.
- Note the new volume $V_2$ as shown by the cylinder.
- Increase in volume is in fact the volume ($V$) of the small irregular shaped object dropped in the cylinder.

**Calculate the volume V of an irregular shaped object as follows:**

$$V = V_2 - V_1$$




Measuring volume of a small irregular shaped object

## 8.3.3 Flasks

Flasks are laboratory vessels (containers). They are made of glass or plastic. Flasks are available in many shapes and sizes (Figure 8.4). Their sizes are specified by the volume they can hold. In school laboratory, these are usually available in the sizes of 50 mL, 100 mL, 250 mL, 500 mL and 1000 mL. These are graduated in the units of cubic centimetre (cc) or millilitres (mL). Flasks are used for making solutions.

Figure 8.4: Measuring flasks

### 8.3.4 Pipette

Pipettes are commonly used in chemistry and biology laboratory to measure the volume of a liquid in a smaller quantity. Pipettes have several shapes and sizes (Figure 8.5). These are graduated to a specific mark. These are commonly available in the sizes of 10 mL to 25 mL. Pipettes are made of glass or plastic.

Figure 8.5: Pipettes

## KEY POINTS

- The quantity that can be measured is called a physical quantity. Length, mass, time, volume, etc. are the examples of physical quantities.
- The system of units recommended by the scientists in an international conference held in 1960 near Paris is known as System International units, abbreviated as SI.
- SI units of length, mass, time and volume are metre (m), kilogram (kg), second (s) and cubic metre ($m^3$) respectively.
- Metre rule, measuring tape, etc. are the instruments which are used for the measurement of length.
- Measuring cylinder, measuring flask and pipette etc. are the instruments used for the measurement of volume.
- The liquid in a measuring cylinder has its surface curved. This curved surface of the liquid level is called meniscus.
- The meniscus of the most of the liquids curves downwards whereas meniscus of mercury curves upwards.
- The correct way to read meniscus is to position the eye at the same level as the meniscus.

# QUESTIONS

**8.1 Encircle the correct option.**

(i) An electronic balance is used to measure:

a. electric current b. length
c. mass d. volume

(ii) SI unit of mass is:

a. kilogram b. kilometre
c. pound d. ounce

(iii) Which of the following liquids makes the meniscus opposite to the others?

a. Mercury b. Water
c. Alcohol d. Petrol

(iv) Which of the following is SI unit of volume?

a. m b. $m^2$
c. $m^3$ d. kg

(v) A mass of 2 kg is equal to:

a. 1,000 g b. 2,000 g
c. 2,500 g d. 3,000 g

(vi) Which of the following relation is correct relation?

a. 1 min = 60 h b. 1m = 1,000 cm
c. 1mL = 1 $cm^3$ d. 1min = 30 s

(vii) A length of 50 mm is equal to:

a. 0.5 m b. 0.05 m
c. 0.005 m d. 0.0005 m

(viii) 25 $cm^3$ is equal to:

a. 25 mL b. 2.5 mL
c. 0.25 mL d. 250 mL

(ix) One kilometre is equal to:

a. 100 m b. 500 m
c. 1,000 m d. 10,000 m

(x) Pipettes are commonly used for:

a. making solutions

b. measuring the volume

c. transferring a measured volume

d. measuring mass

## 8.2 Match the Words of column A with those of column B.

| A | B |
|---|---|
| Mass | Metre rule |
| Length | Flask |
| Volume | Digital watch |
| Time | Standard quantity |
| Unit | Balance |

## 8.3 Short answer questions.

(i) Define a physical quantity.

(ii) Define the term prefix.

(iii) What is a metre rule?

(iv) How many millilitres are there in one $dm^3$?

(v) How many seconds are there in one solar day?

## 8.4 Descriptive questions.

(i) What are SI units? Explain.

(ii) Describe the importance of SI units.

(iii) The length of a wooden rod is 25.5 cm. What is this length in:

(a) millimetres? (b) metres?

(iv) The mass of an iron plate is 1,950 g. What is this mass in kilograms?

(v) Convert in minutes.

(a) 3,600 s (b) 2 h

(vi) Describe the use of measuring cylinder.

(vii) Write short notes on measuring flask and pipette.