02 Quantitative approach to the components of the environment.

By the end of this chapter you will be competent to...

- use measurements of volume and density to describe materials and objects in the environment.
- use measurements of speed to describe phenomena in the environment.
- use the concept of rate to describe phenomena in the environment.

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2.1 Using the measurements related to volume

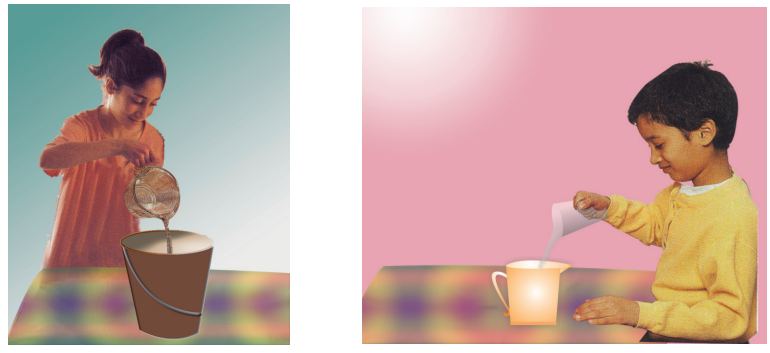

Fig 2.1 - Filling liquids from small containers to large containers

How many cups of water are needed to fill the bucket?
How many glasses of milk are needed to fill the jug?

You can answer the above questions only if you know the amount of liquid needed to fill the glass,the cup,the jug or the bucket.

Every object occupies some space.This space is called the **volume** of that object.

Feeding bottle **Blender** **Measuring cup**

Fig 2.2 - Some equipment for measuring liquids

Some equipment, such as feeding bottle, blender, measuring cup has a calibrated scale. This scale gives us the idea of volume to be used in those equipment.

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Volume of a liquid

Liquids such as water, milk, cooking oil, petrol, kerosene oil are measured according to their volumes. Like-wise liquids such as medicines, ghee, ice-cream are also sold and priced according to the volume.

In the laboratary, the volume of liquids is measured using a measuring cylinder. It is a glass cylinder with a scale, calibrated in millilitres. By using this calibrated scale,the volume can be read off. In practice, units of measuring volume are litre (*l*) and millilitre (ml).

$$1 l = 1000 \text{ ml}$$

The International Standard (IS) unit for measuring volume is m^3 (cubic meters).

Measuring the volume of a liquid using a measuring cylinder

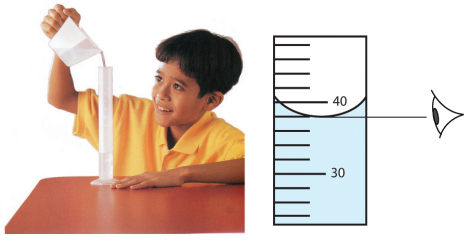

Fig 2.3-Measuring the volume of a liquid using the measuring cylinder.

Some water is poured into a measuring cylinder, as in Fig 2.3 Observe the nature of curvature at the surface of water (meniscus). When taking readings, focus your eyes directly, on the lower point of the curved line (meniscus).

Activity 2.1

Take a 1 litre measuring cylinder, get several containers, marked 100 ml, 200 ml, 250ml.Measure how many times you need to fill the measuring cylinder up to 1 litre using each of the above containers.

To fill the 1 litre, it is nessery to pour 10 times from the 100 ml container.This shows that one litre is equal to1000 millilitres.When measuring small quantities of liquid, millilitre is used and when measuring large amount of liquid litre is used.Therefore, measuring equipment have scale marked in litre (l), as well as millilitre (ml).

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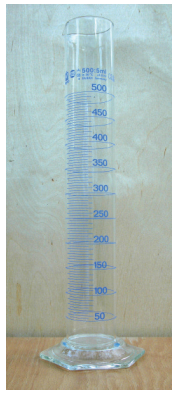

Measuring cylinder

Burette

Pipette

Measuring cup used in measuring medicines

Fig 2.4 - Various equipment used in measuring liquids

In laboratories, burettes and pipettes are used to measure liquid volumes accurately. These are calibrated in millilitres.

1 ml is the same volume as 1 cm^3(cubic centimeters)

Volume of a regular object

Objects such as cubes,cuboids,spheres,cylinders and cones are **regular objects**.Because they have a simple shape, and we can measure the height, length and width of these objects easily, thus their volumes can be found by calculation.

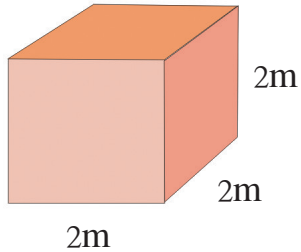

Fig 2.5-Cube

Lengths of the six sides of a cube are equal in size (Fig 2.5).

If the length of one side of the cube is 2 meters,

then its volume is = $2m \times 2m \times 2m$

= $8m^3$

Cubical objects such as bricks,box of matches,box are called cuboids.Length,width and height of cuboid are different in sizes. (Fig 2.6)

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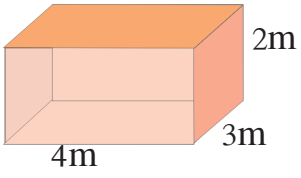
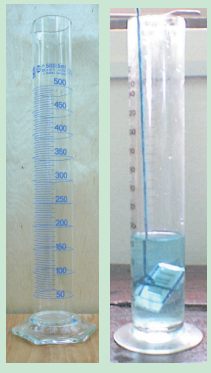


Fig 2.6-Cuboid

If length 4 m, width 3 m,
and height 2 m of a cuboid ;
Then the volume = length × width × height
= 4 m × 3 m × 2 m
= 24 m^3

Standard International unit for volume (SI units) is m^3 (Cubic meter).

Activity 2.2



- Take a cuboid shaped object (large eraser)
- Add a known amount of water into a measuring cylinder and record the reading of the water level.
- Tie the eraser to a thread and immerse it in the water in the measuring cylinder.
- Now take the reading of the water level.

Fig 2.7- Eraser immersed in water in a measuring cylinder

When the eraser is immersed in water,water level rises up.This is equal to volume of the eraser.Therefore volume of water which displaced upwards due to the eraser is equal to the volume of eraser. This is known as the displacement method for measuring volume.

Activity 2.3

- Take the eraser,which is used in Activity 2.2.
- Measure its length,width and height using a measuring ruler, marked in centimeters.
- Calculate volume of this eraser using its length,width and volume.

compare the numerical values.

According to Activites 2.2 and 2.3 it is understood that one cubic centimeter of a solid object is equal to one millilitre of water.

$1cm^3 = 1$ ml

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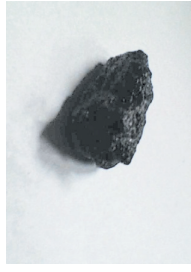
Cubic centimeter is another practical unit in measuring volume.You may find some volume measuring equipments which are calibrated in millilitre as well as cubic centimeters.

Volume of irregular objects

Objects without definite geomatric shapes are called **irregular objects**.


a stone


glass stopper


nail


small bottle

Fig 2.8 - Irregular solid objects

Water displacement method can be used to measure the volume of such irregular objects.In this method,the object is immersed in water and the volume of water displaced is measured.

Activity 2.4 Measuring the volume of a pebble using the overflow vessel

Fig - 2.9 -Measuring volume of an irregular object using the overflow vessel.

- Tie the pebble by a thread.
- Place a beaker to collect overflowing water.
- Now immerse the pebble slowly into the overflowing vessel,till it is fully immersed.
  What can you observe now?

Some water is collected in the beaker.Measure this water using a measuring cylinder. The displaced volume of water is equal to the volume of the pebble.

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2.2 Using the measurements related to density

Activity 2.5

- Take five bottles with equal volume.
- Fill these bottles with sand,flour, rice,dhal and tea powder and close them with cork stoppers.
- Weigh each bottle.
- Note down the weight and arrange them in ascending order.

According to the above activity, you can see the mass of equal volumes of different materials are different.This is because of some special property,of the substance.This special property is **density**.

Density of a substance is the amount of matter that is present in a certain volume of the substance.

Density can be used to identify the properties of various materials.

Density of liquids

Activity - 2.6

To find out whether the same volume of different liquids have the same mass.

- Take samples of water,coconut oil,kerosene oil,sea water, and a glass bottle.
- Weigh the empty bottle.
- Weigh the bottle filled with each of the above liquids,one after the other.
- Tabulate your observations.

	Density (kgm^{-3})	Liquid	Density (kgm^{-3})
Kerosene oil	790	Olive oil	920
Liquor	791	Water	1000
Petrol	800	Sea water	1025
Terpentine	870	glyserine	1262
Coconut oil	900	mercury	13600

Table 2.1 Density of different liquids

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Above activity also explains, that there is a different in mass in the same volume of different materials.

This shows that different liquids have different densities.

Density in relation to mass and volume.

From the above activities we see that density of a substance is the amount of matter present in a certain volume of that substance.

$$\text{Density} = \frac{\text{mass of substance}}{\text{volume of substance}}$$

According to International Standard (IS) units, mass is measured in kilograms and volume is in cubic meters.

$$\text{Density} = \frac{\text{mass}}{\text{volume}} = \frac{\text{kg}}{\text{m}^3}$$

Therefore International Standard (IS) units, of density is kilogram per cubic meter.

$$\text{Units of density} = \text{kg m}^{-3}$$

If mass is measured in grams and volume is measured in centimeters,then density is grams per cubic centimeter.

$$\text{Units of density} = \text{g cm}^{-3}$$

Measuring the density of liquids

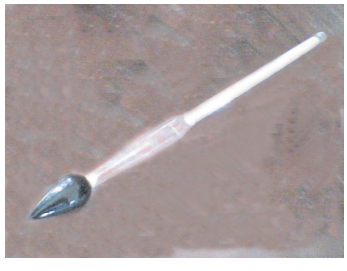

Fig -2.10- Hydrometer

The hydrometer is used to measure density of liquids in the laboratory.This equipment is used for measuring the density of milk and rubber latex.The hydrometer is immersed in the liquid in a vertical position,and density is read directly.

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Do you know?

Plimsoll line

Density of sea water is different in different oceans.Hence the amount that a ship sinks in the water is also different.This means that the amount of goods that can be loaded to the ship is also different.In order to determine this,the plimsoll line is marked on the body of ship,close to the water surface.

Fig 2.11-Plimsoll line

Assignment-2.1

1. Design a suitable equipment to measure the volume of liquids at home.
2. Construct a hydrometer using materials from your surroundings to compare the densities of different liquids.

2.3 Using the measurements related to speed


Fig 2.12

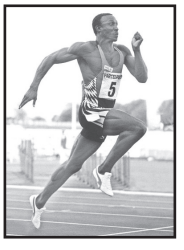
Fig 2.13

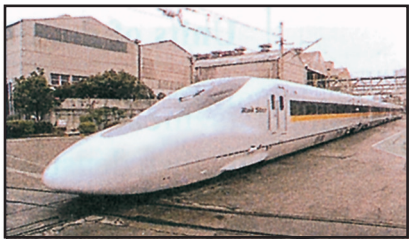
Fig 2.14

When we observe our surroundings, we can see many moving things.Humans and other animals move about.Motor vehicles, trains, aeroplanes and ships are also moving. (Fig 2.12, 2.13, 2.14)

When objects move, they move at different speeds.This speed is measurable.


Fig 2.15-Speedometers

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- Speed of motor vehicles are indicated by the speedometers, fixed to the vehicle.
- Traffic police use a special kind of speedometer to find out whether vehicles are travelling at high speeds.
- Signboards displayed at certain places along the road indicates the maximum speed that should be maintained in that area.
- Heavy vehicles have the maximum speed (40 Kmph) limit displayed at the rear of the vehicle.

Therefore, speed is measurable. Let us find out how speed is measured.

Measuring the speed

Speed is measured by the distance moved by an object in unit time.

$$\text{Speed} = \frac{\text{Distance moved}}{\text{Time}}$$

Example:- If a student takes 5 seconds to run 50 m of distance, then

$$\textbf{Speed of the student} = \frac{\textbf{50m}}{\textbf{5s}} = \textbf{10 ms}^{-1}$$

In the above example,do you think that the student ran 10 meters every second? It could not be so.His speed may have varied at different times throughout this event.Therefore we have to take the average speed of the student in the above exercise.Formula for calculating **average speed** is as follows.

$$\text{Average Speed} = \frac{\text{Distance moved}}{\text{Time taken}}$$

Speed is a **scaler quantity**, because it has no direction.It has only a magnitude.Units of average speed is derived from units of distance moved,and time taken for the movement.

Some such units are given in the table 2.2

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Units of distance moved	Unit of Time taken	Units of speed
m	s	m/s=ms^{-1}
cm	s	cm/s=cms^{-1}
km	h	km/h=kmh^{-1}

Table 2.2- units to measure speed

International Standard Unit for speed is ms^{-1}

Do you know ?

- Speed of sound through air is 332 ms^{-1}.When speed travels through liquid or solid materials,the speed increases.
- Speed of light through air is 30,000,000 ms^{-1}
- Speed of sound through steel is 4880 ms^{-1}.

Activity 2.7

Measuring the runing speed of two students.

- Measure the length of the track selected.
- Give a signal using a clapper to start the race.
- At the same time start the stop-watch.
- Stop the watch at the end of the line.
- Calculate speeds of the two students.Who ran faster ?

M. vehicle	Speed
Motor car	60kmh^{-1}
Train	100kmh^{-1}
Aeroplane	600kmh^{-1}
Rocket	1200kmh^{-1}

Table 2.3 - Speeds of several vehicles

Assignment 2.2

Can you suggest a suitable method to measure the speed of water flow in a small stream ?

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2.4 Using the concept of rate

Fig 2.16
Rotation of the earth

Fig 2.17
Watch

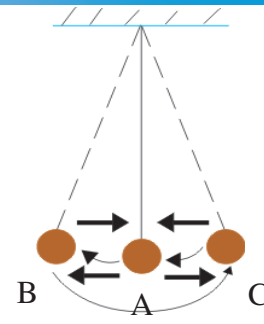

Fig 2.18
Oscillation of a pendulum bob

Several incidents in our environment occurs in a periodic pattern.

- Earth takes 24 hours to rotate round its own axis.
- School bell rings every 40 minutes to indicate the duration of a period.
- Second - hand of the clock completes one revolution every minute.
- A hanging object,oscillates in a periodic pattern.

All these incidents occur in a periodic pattern.These periods may be short or long.In order to get an idea about the rate of those incidents, we have to measure the time between two happenings (events).

Rate

Number of happenings in a unit time is called the rate.

Measuring Rate

In order to measure the rate of events in the environment,we have to measure the time difference between two successive events during this period.

A swaying bob takes 20 seconds for 20 oscillations.Then

$$\text{Oscillation rate} = \frac{\text{Number of oscillations}}{\text{Time taken}}$$

$$= 20/20$$

$$= 1 \text{ oscillation per second}$$

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Measuring the rate of rotation

To measure the rate of a wheel,we should find the number of rotations, and the mean time.
The number of rotations in a unit time is the rate of rotation of the wheel.

It can be shown by the following equation.

$$\text{Rate of rotation} = \frac{\text{Number of rotations}}{\text{Time taken}}$$

Activity 2.8

Finding the rate of rotation of a bicycle wheel.

Rotate the paddle of a bicycle for two minutes and note the number of rotations made by the paddle and the rear wheel separately. If we count the number of rotations for two minutes,we can measure the rate of rotation for the paddle and the rear wheel.

According to the above activity , you can see that the rotational speed of rear wheel is higher than that of the pedal.
Some incidents in the environment also occur on different speeds. Different rotational speeds of the hands of a clock can be cited as an example.

To fulfil our daily requirements, sometimes we should have to alter the rotational speeds of several devices.
e.g.: bicyle

In some instances we have to measure the rate of chemical reactions.

To find the rate of reaction of a chemical reaction.We can measure the

- Amount of reactants used up or
- Amount of products formed in unit time.

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Exercises

1) What is meant by 'volume' of an object ?

2) How do you find the volume of an irregular glass stopper?

3) What is meant by density of an object? What are the units of density?

4) Mass of a block of wood is 4 kg. It's volume is $2m^3$. Find it's density? State the units.

5) If a competitor completed 1500 meters in 300 seconds (5 minutes), find his average speed?

6) Following table gives the distances and the time taken by three competitors of a swimming event in the Olympic games.Calculate their speeds.

Competitor	Distance (m)	Time (s)	Speed (ms^{-1})
A	100m	60s	.....
B	200m	120s	.....
C	400m	230s	.....

7) A flight sets off from London to America at a speed of 2300 kmh^{-1}. The distance it travelled is 6900 km. Find the time taken for the journey.

8) A bicycle wheel shows 60 rotations within a time period of 3 minutes. Find the rate of rotation of the wheel.

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