VOLUME

Chapter 10

How is milk measured? (1)

How many cups of tea can you fill from a small jug? How can you find out? (2)

Is the weight of a glassfull of rice equal to that of a glassfull of wheat? If their weight is not equal, then what do they have in common? (3)

How do we calculate the amount of pesticide or urea solution to be sprayed on a crop? (4)

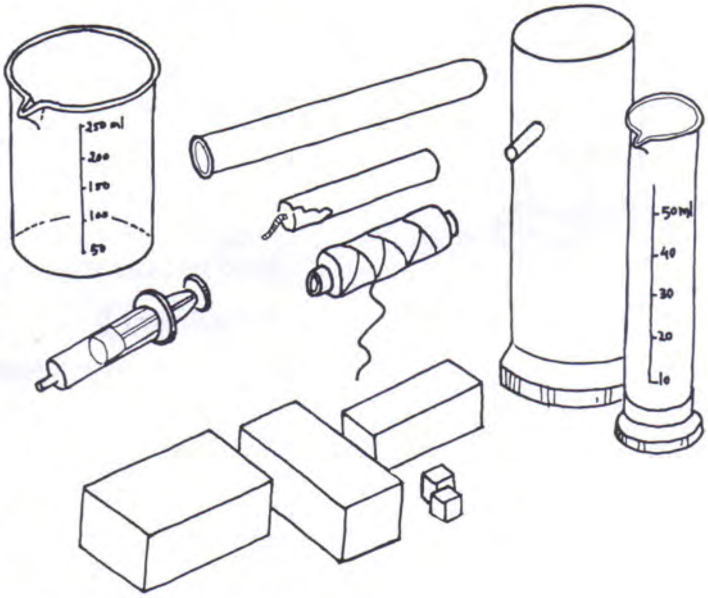
How do shopkeepers measure kerosene? (5)

How much diesel does it take to fill a jerrycan? (6)

In all these cases, you may have seen people using a vessel of a specific measure to calculate the volume of liquid. This measure is called a litre.

A litre is the standard unit to measure the volume of liquids. In this chapter you will measure the volume of several things and study their properties.

Let us begin with the volume of liquids.



Experiment 1

Your teacher will show you four containers filled with water.

Guess which container has more water and which has less? (7)

Water and other liquids assume the shape of the container they are poured into. This often makes it difficult to estimate which container has more water and which has less.

How would you check whether your estimate was right or wrong? (8)

Try your method to check which container has more water and which has less. (9)

Did you use a vessel of a fixed measure to compare the volumes of water? Since we often have to measure milk, kerosene and medical solutions at home, you have probably used this method before to measure liquids.

The Litre

Your kit has a transparent square plastic container. When filled to the brim this vessel can hold a litre of water or any other liquid. It has markings that divide the litre into ten equal parts.

Measuring (graduated) cylinders and their least count

The litre is a large unit of volume. To measure volumes less than a litre we use a unit called a millilitre, which is also written as ml. One litre equals 1,000 millilitres.

1 litre = 1,000 millilitres

Your kit has two measuring cylinders - one large and one small. The larger measuring cylinder can measure up to 250 ml of liquid at a time and the smaller one can measure up to 50 ml at one go.

Look at the markings on both the cylinders.

Can you measure 10 ml of liquid using the bigger measuring cylinder? (10)

Fill water up to any mark in this cylinder.

Find out how much more water it would take to raise the level to the next mark on the measuring cylinder. (11)

You calculated the amount of water contained between two consecutive markings of the measuring cylinder in the above question. This amount of water is the least count of the measuring cylinder (Figure 1).

The least count is the minimum amount of liquid that can be accurately measured by this measuring cylinder. If the liquid is less than this minimum amount we can only estimate its amount. Since such estimates are bound to vary from person to person they cannot be considered to be the least count.

What is the minimum amount of liquid that can be measured with the larger measuring cylinder? (12)

Find out the least count of the smaller measuring cylinder. (13)

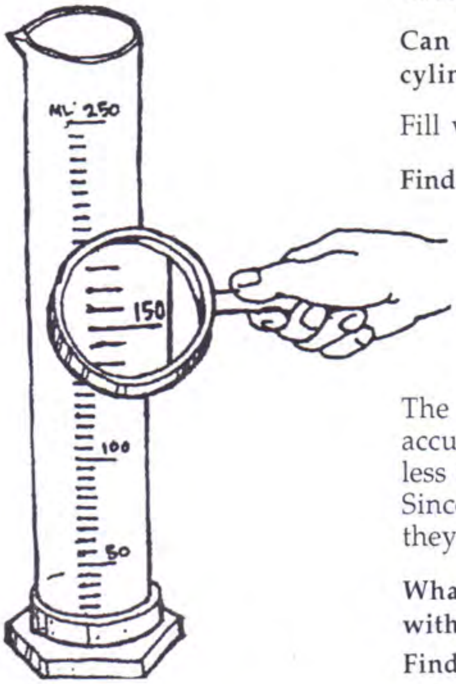


Figure 1

Experiment 2

A syringe as a measuring cylinder:

You are probably familiar with injection syringes. Try and get a syringe without a needle from somewhere and bring it to the class. This syringe can be used to measure volume. To do so, you must first seal the end where the needle is fitted by melting it over a flame (Figure 2).

Once you do so, it is ready for use as a measuring cylinder.

Find out the least count of your syringe. (14)

Experiment 3

A test tube as a measuring cylinder:

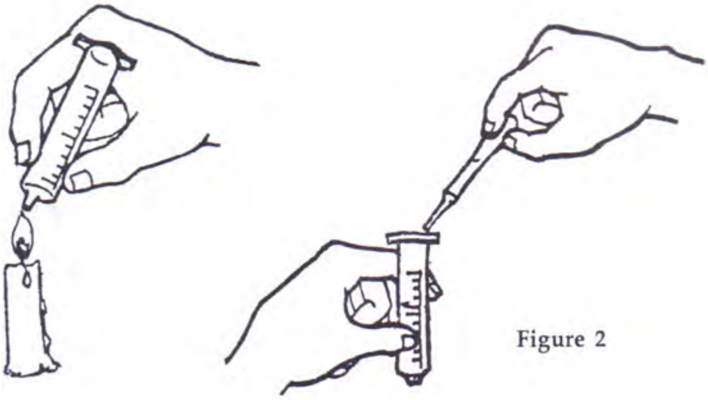


Figure 2

The test tubes in your kit can also be used as measuring cylinders. Let's make one.

Take a test tube and paste a narrow strip of paper on its side. Before pasting the paper smear it with kerosene so that it becomes **translucent**. You can then see the level of liquid through it.

Pour 1 ml water into the test tube with a syringe. Mark the water level on the strip of paper. This is the 1 ml mark of your measuring cylinder.

Pour 1 ml water at a time into the test tube and mark the water levels for each additional ml on the paper strip. Do this till the test tube has 10 ml of water. Label the water level marks 1, 2, 3 and so on up to 10. Write ml at one corner of the paper strip so that you remember the unit being used to measure volume. Your test tube measuring cylinder is ready.

What is the least count of this measuring cylinder? (15)

Household measures of volume

If you look around your home you will find many things which can be used to measure the volume of liquids. Examples include feeding bottles, mugs, buckets, medicine bottles, glucose bottles, etc. If possible, bring these things to the class and find the least count of each of them.

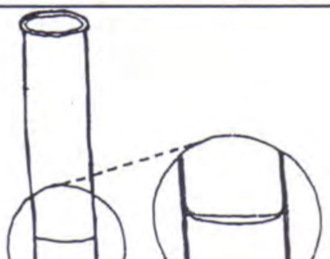


Figure 3

THE CORRECT WAY TO OBSERVE THE WATER LEVEL

How does one find the water level in a test tube?

Fill a test tube with water and hold it at eye level. Look carefully at the water level. If the test tube is clean you will notice that the surface of the water is not flat but curved slightly downwards from the edges. Such a shape is called **concave** (Figure 3).

The lowest part of the curvature is taken as the level of liquid in the test tube, as shown in the figure.

Experiment 4

Drop by Drop

Use a dropper to fill 5 ml of water, drop by drop, in a syringe or test tube. Count the number of drops.

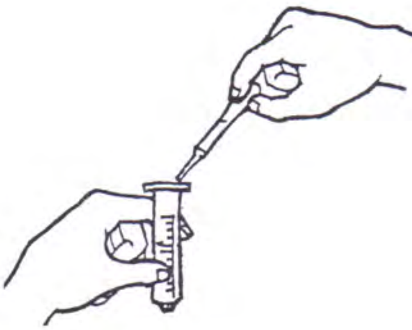


Figure 4

How many drops are there in 5 ml of water? (16)

How much water does each drop contain? Calculate the approximate volume in ml, up to the second decimal place. (17)

Did you calculate the actual volume of a drop of water or its average volume in the above question? (18)

Let's find out

You fill glass tumblers, mugs or jugs with water every day. Have you ever measured how much water each of these contains? Why not find out today? Use the measuring cylinders you made to find out how much water can be filled into different vessels at home or in the classroom.

The volume of solids

You have learnt how to measure the volume of liquids. Let us now do a few experiments to find out how we can measure the volume of solid objects.

A familiar story

You may have heard the story of the thirsty crow and the pitcher of water. The crow was thirsty but could not drink from the pitcher because the water level was too low - beyond the reach of its beak. So the clever crow began dropping pebbles into the pitcher. The level of water inside the pitcher rose and finally the crow was able to drink its fill of water.

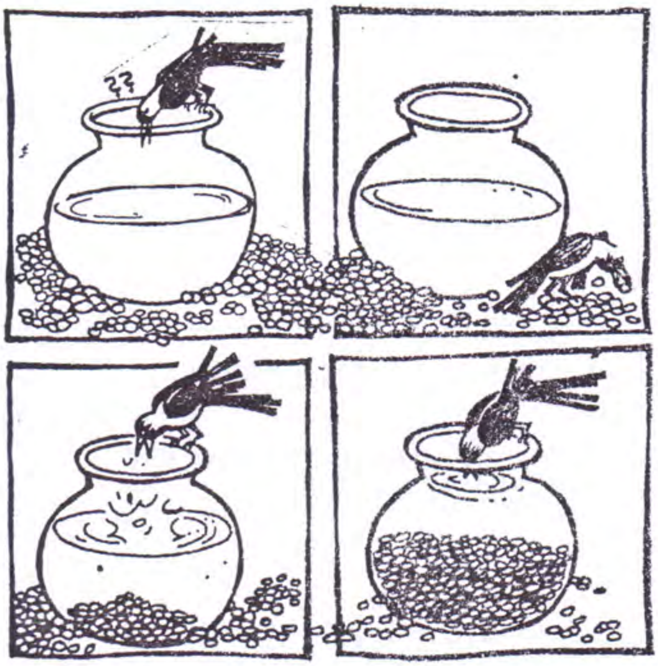


Figure 5

What do you think happened when the pebbles were dropped into the pitcher?

When a pebble is dropped in water, it occupies space by **displacing** the water. Where does the water displaced by the pebble go? This displaced water occupies a new space, but its volume does not change - the amount of water remains the same. So when pebbles are dropped in the pitcher, the water level rises.

Experiment 5

Let's do an experiment similar to what the crow did. However, unlike the crow, our aim is not to drink water but to measure the volume of solid objects.

You have three different sized blocks. Label them A, B and C. Fill a beaker half full with water and mark the water level. Tie Block A with a thread and immerse it in the water.

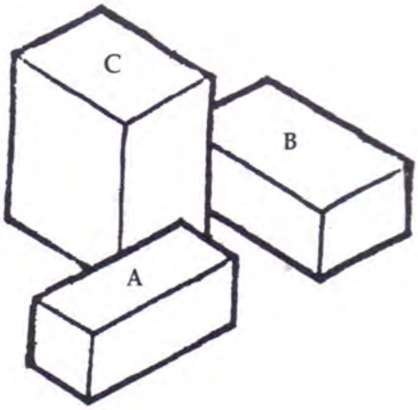
Did the water level rise? (19)

Remove the block.

Did the water level fall back to its earlier mark? (20)

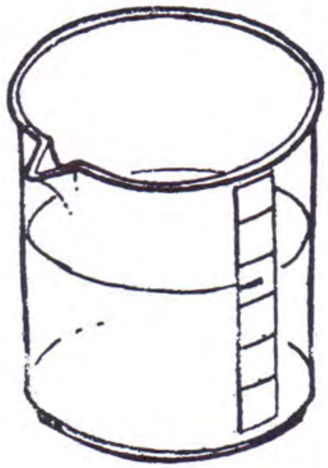
Repeat the experiment with blocks B and C.

Since you have already read the story of the crow and the pitcher, you must have figured out why the water level rose in your experiment. When the block is immersed in water, it displaces water from the space it occupies. The space occupied by an object is its volume. So a block immersed in water displaces an amount of water that is equal to its volume. You saw that on removing the block, the water returns to its original level.



Can this method be used to measure volume? Let us see.

Paste a strip of graph paper on the outer surface of the beaker. Fill the beaker half full with water. Mark the water level on the graph paper and label it X. Immerse Block A in the water like you did earlier. Mark the new water level on the paper strip with an A (Figure 6). Repeat the experiment with Blocks B and C. Mark their respective water levels B and C on the paper strip.



While doing the experiment, take one precaution. Ensure that the water level is at X before you immerse each block.

In which case did the water level rise the most - for Block A, B or C? (21)

Is this block the largest among the three? (22)

What do you think is the relationship between the volume of the block and the rise in water level? Can you explain this relationship? (23)

Before we proceed further we need to learn more about the units in which volume is measured.

Just as there are specific units to measure length and area there are also specific units to measure volume. The standard unit for measuring volume is a cube with sides equal to 1 cm. The volume of such a cube is 1 cubic centimetre. We can write this as 1 cc or 1 cm^3. Similarly, a cube with a 1 metre side has a volume of 1 cubic metre or 1 cu m or 1 m^3.

Your kit contains plastic cubes with 1 cm sides. Each cube has a volume of 1 cc or 1cm^3. So you can use these cubes as units for measuring volume.

We are now ready to measure the volume of Blocks A, B and C.

First fill the beaker with water to the point marked X. Drop the plastic cubes into the water one by one. Continue dropping cubes until the water level reaches point A.

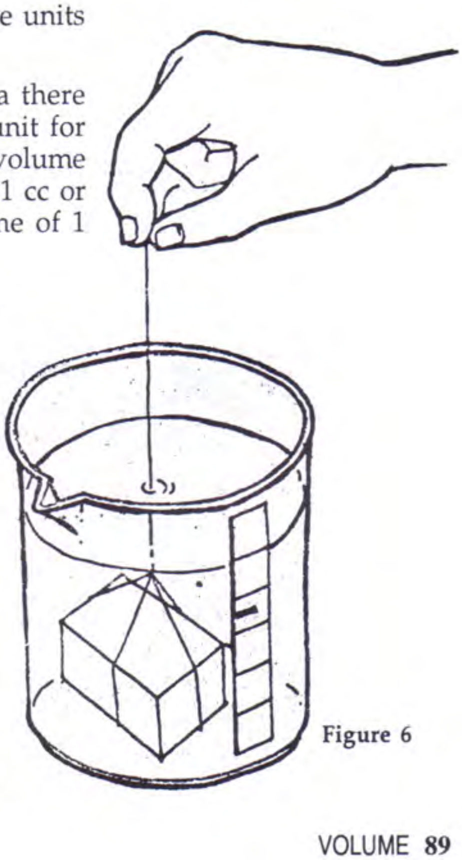


Figure 6

Count the number of cubes you have used to make the water level reach point A and note this number in your exercise book. (24)

In the same way, find out how many cubes are needed to raise the water level from point X to point B and Point

C. Note the respective number of cubes in your exercise book. (25)

What relationship do you see between the volume of the blocks and the number of cubes used to raise the water level to the respective points? Explain with reasons. (26)

What are the volumes of Blocks A, B and C in cubic centimetres? (27)

Use the same method to find the volume of other blocks in the kit in cubic centimetres. (28)

Experiment 6

Water, milk or oil - they are all the same:

You may be wondering how water, milk and oil can be the same? There are many differences between the three liquids. However, things that are different can also have similarities. This experiment is based on one similarity between water, milk and oil.

In the previous experiments you saw that when solid objects are immersed in water they displace water and occupy a space equal to their volume. That is why the water level rises. Suppose we use milk or oil instead of water. Will their level rise as much as the level of water?

Take a guess, but give reasons for your guess. (29)

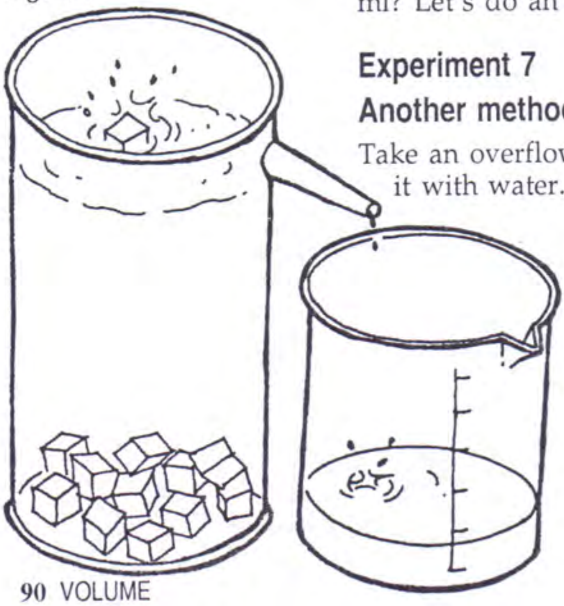
Now do an experiment to test your guess. Take the beaker used in Experiment 5 and fill it with milk or oil up to the same point marked X in the previous experiment. Repeat Experiment 5.

Each time a block was immersed did the milk or oil rise to the same level as water rose in Experiment 5? (30)

What did you learn from this experiment? Write your answer in your own words. (31)

In the above experiments you measured the volume of solid objects in cubic centimetres. You also measured the volume of liquids in millilitres earlier. What is the relationship between 1 cm^3 and 1 ml? Let's do an experiment to find out.

Figure 7



Experiment 7

Another method of measuring volume:

Take an overflow vessel (Figure 7). Place it on a level surface. Fill it with water. Wait till the water stops dripping from the spout and the level is stable. Then place an empty beaker under the spout and drop 50 plastic cubes, one by one, into the overflow vessel. Water will flow out from the spout and collect in the beaker.

How much water collected in the beaker? Use your measuring cylinder to find its volume.

You know that the volume of a plastic cube is 1 cubic cm or $1cm^3$. What is the volume of 50 cubes?

Make a table like the one given below and record your observations in it. (32)

Repeat the experiment using different numbers of cubes.

Table 1

S No	Object	Amount of water flowing out from the overflow vessel (ml)
1.	50 cubes	
2.	80 cubes	
3.	100 cubes	

Look at your table.

Do you see a relationship between the volume of a cube and the amount of water it displaces? (33)

This is another method of measuring volume. Explain this method in your own words in your exercise book. (34)

Use this method to measure the volume of some other object like a stone or a fruit.

If a 1 cm^3 solid object is dropped into the overflow vessel how many millilitres of water will be displaced? (35)

What would be the volume of a cube needed to displace 1 litre of water from the overflow vessel? (36)

The volume of liquids is also written in cubic centimetres instead of millilitres.

Do you think it is wrong to do so? If your answer to this question is yes, give reasons why you think it is wrong. (37)

A problem

When a cork is put in water, it floats on the surface.

What problem would you face in finding its volume? (38)

Suggest a way of overcoming this problem. (39)

Find the volume of the cork using your method. (40)

Experiment 8

Think first and then do

You found the average volume of a drop of water. Now find the volume of a gram (*chana*) seed.

Write your answer and explain the method you used in your exercise book. (41)

Experiment 9

A formula for measuring the volume of a block

In this experiment we shall join plastic cubes together to form a block identical to Block A. To do this, place the plastic cubes next to each other in a row equal in length to the length of Block A (Figure 8a).

How many cubes did it take to make this row? (42)

Now make similar rows of cubes and place them side by side so that a layer of cubes is formed whose length and breadth is equal to that of Block A (Figure 8b). Make several such layers of cubes and stack them one above the other till their height matches the height of Block A (Figure 8c).

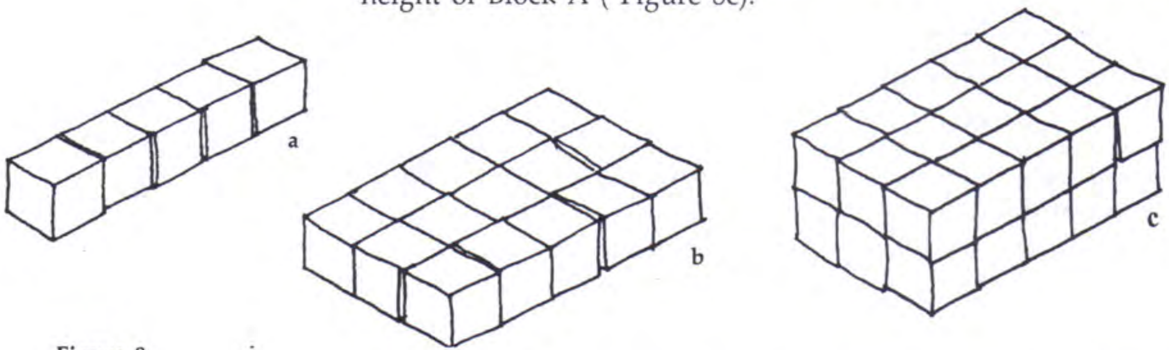


Figure 8

Does the total number of cubes used give you the volume of Block A? (43)

Measure and note the length, breadth and height of Block A in Table 2. (44)

Does the number of cubes equal the product of the length, breadth and height of Block A? (45)

What conclusions can you draw from your answers to Questions 43 and 45? Write your conclusion in the form of a formula for calculating volume. (46)

In the same way, write the relevant figures for the other two blocks in Table 2. Also note the volume of the blocks in cm³ measured in Experiment 5 or 7. (47)

Table 2

S. No. of Blocks	Length (cm)	Breadth (cm)	Height (cm)	Product (cm^3)	Volume (cm^3)
a					
b					
c					

Is your formula for volume correct for all the blocks? (48)

How much water will be displaced if all the blocks are simultaneously immersed in the overflow vessel? (49)

Experiment 10

How did the litre become a unit of volume?

Measure and note down the length, breadth and height of the inside surfaces of the one-litre plastic container provided in the kit. (50)

Calculate how many cubes fit into a litre and write your answer. (51)

Experiment 11
Size and volume

In the chapter "Area" you saw that doubling the sides of a square increases its area by four times. Similarly, if we halve the sides of a square the area is not halved but reduced to a quarter of the original area.

If the sides of a cube are doubled how many times do you think its volume would increase?

Let us find out by placing cubes having 1 cm sides together. We shall label each such cube R. You already know the volume of these cubes.

Write down the volume of Cube R in Table 3. (52)

Let's now join some of these cubes together to get a cube with a 2 cm side (Figure 9). We shall call this cube S.

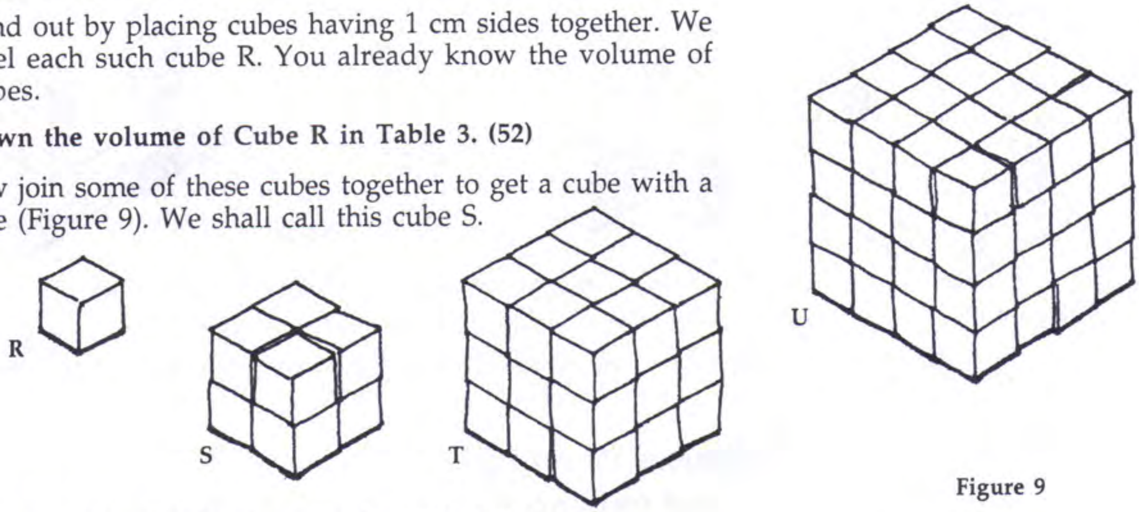


Figure 9

How many R cubes did it take to make Cube S? (53)

Note the length and volume of Cube S in the table. (54)

In the same manner, let us make cube T and Cube U. Cube T has sides measuring 3 cm and Cube U has sides 4 cm long.

Note the length of the side and volume of Cubes T and U in the table. (55)

On the basis of the table, can you explain what happens to the volume of a cube when the length of its side is doubled? (56)

If you wish to increase its volume 27 times how many times must you increase the length of its side? (57)

If each side is halved, how much smaller would its volume be? (58)

Table 3

Cube	Length of side (cm)	Volume (cm^3)	How many times larger than volume of Cube R
R			
S			
T			
U			

The relationship between the length of the side and volume is not limited to cubes alone. This relationship holds good for all shapes. For example, if the diameter of a ball is doubled, its volume does not increase two or four times. It increases eight times. Similarly, if the length of each side of a water tank is three times that of a second tank, the volume of the first tank will be 27 times that of the second tank.

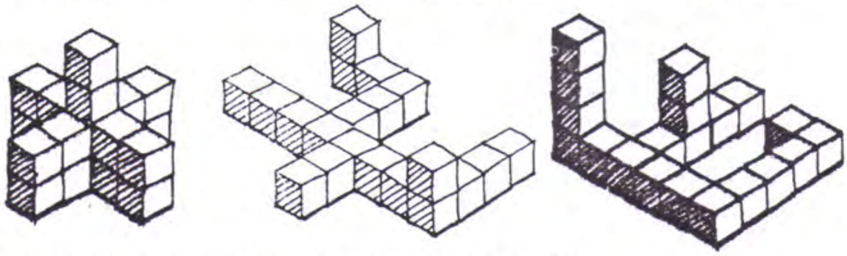
Diversity in unity

In the chapter "Area" you saw many shapes that look different but have the same area. In the same way, can objects that look different have the same volume? Let's find out.

Experiment 12

Different things, same volume:

Take twenty 1 cc cubes and make the shapes shown in Figure 10.



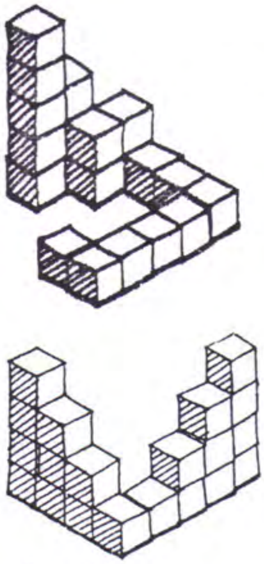


Figure 10

Do all these shapes have the same volume? (59)

Can a ball and a cube have the same volume? (60)

How can you estimate whether two objects with different shapes have the same volume or not? (61)

Questions for revision

1. **Sohail measured two litres of milk and gave Sunita three fourths of the milk. How much milk does Sohail have now? Give your answer in ml.**
2. **What is the least count of the measuring cylinder in the figure? Find the volume of water it contains.**
3. **How will you measure the volume of an iron nail? Explain your method in detail. Now measure the volume of a nail using your method. Did you face any problem in measuring the volume? If so, describe your problems.**
4. **A measuring cylinder contains 75 ml of water. Seema dropped seven 1 cc blocks into it. How high will the water level in the cylinder rise?**
5. **Estimate the volume of each of the following things and then find out their actual volume by measuring them:**
   - **A cup of tea** — **A lime, a peanut, a tamarind seed**
   - **A ball** — **Your *Bal Vaigayanik* book**
6. **A person needs to drink at least two litres of water every day. Find out how many glasses of water this would be approximately equal to.**
7. **How will you find the volume of a watermelon? Discuss this problem in class.**
8. **Can you think of a method to measure the volume of your own body?**

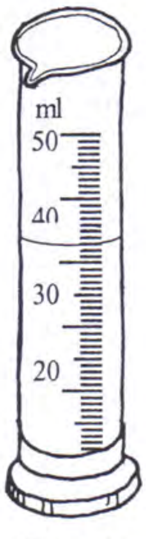


Figure 11

New words

Concave Translucent Displace