PROTOTYPE

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NATIONAL CURRICULUM
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PHYSICS

TEACHER'S GUIDE

SENIOR ONE

LOWER SECONDARY
CURRICULUM

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This material has been developed as a prototype for implementation of the revised Lower Secondary Curriculum and as a support for other textbook development interests.

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Contents

Preface

This Teacher's Guide has been designed to enable the teacher to interpret the revised curriculum and use the accompanying learner textbook effectively. The Teacher's Guide provides guidance on what is required before, during and after the teaching and learning experiences.

To ease the work of the teacher, all the activities and instructions in the Learner's Book have been incorporated in this Guide but with additional information and possible responses to the activities. The guide has been designed bearing in mind the major aim of the revised curriculum which is to build in the learners the key competences that are required in the 21st century while promoting values and attitudes and effective learning and acquisition of skills, to prepare the learner for higher education and eventually the world of work.

This book has been written in line with the Revised Lower Secondary School Curriculum. The book has incorporated knowledge, skills partly required to produce a learner who has the competences that are required in the 21st century; promoting values and attitudes; effective learning and acquisition of skills in order to reduce unemployment among school graduates.

Associate Professor Betty Ezati
Chairperson, NCDC Governing Council

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The Centre is indebted to the learners and teachers who worked with the NCDC Specialist and consultants from Cambridge Education and Curriculum Foundation.

Last but not least, NCDC would like to acknowledge all those behind the scenes who formed part of the team that worked hard to finalise the work on this Learner's Book.

NCDC is committed to uphold the ethics and values of publishing. In developing this material, several sources have been referred to which we might not fully acknowledge.

We welcome any suggestions for improvement to continue making our service delivery better. Please get to us through P. O. Box 7002 Kampala or email us through admin@ncdc.go.ug.

Grace K. Baguma
Director, National Curriculum Development Centre

NOTE TO THE TEACHER

The new Physics textbook and *Teacher's Guide* follow the competency-based approach to learning as provided for in the new Physics syllabus.

So what is the competency approach?

A competence is what enables someone to correctly perform a complex task. Take note that competence should not be confused with performance or competition. Although an excellent performer is often referred to as the best having outcompeted the other learners—sometimes in unhealthy circumstances—a competent learner is one who has been prepared through the curriculum, to be able to understand how to deal with daily life problems. For the learner to be able to be competent later in life means that you, as the teacher, must provide him/her with the tools which are called **resources** and teach him/her how to use these resources to solve a problem situation/activity/task.

The competency approach requires that competences should be clearly identified at the beginning of the chapter and assessed at the end based on these competences. You need also to define what the learner needs to acquire in terms of the knowledge which becomes the objectives and activities. Then show the learner what this knowledge is good for; and finally give the learner situations so as to be able to put into practice what has been learnt. These situations should be related to their everyday lives.

This *Teachers' Guide* will be used alongside the *Learner's Book*. You should ensure that you are familiar with the contents in the *Learner's Book* for better follow-up. A number of tasks/activities are provided in the textbook. You may need to generate others to help the learner acquire the resources. At the end of each unit, a wrap-up activity which we call an **integrative activity or situation of integration**, is provided. It is called integrative because it requires an integration of the three types of resources as mentioned above. These situations are provided in order to assess the competence level of the learner.

An evaluation grid showing the different competence criteria (qualities) and descriptors has also been given in the guide to help you objectively assess the learner's work.

Below is an example of the physics aspects under the 3 types of resources (**knowledge**, **knowhow** and **know being**), which the learner will need.

a) Knowledge

i) Knowledge of terminology and specific facts
ii) Knowledge of **conventions and units** used in physics
iii) Familiarity with experiments suggested in the syllabus
iv) Knowledge of common laws/principles and generalisation identified in the syllabus
v) Ability to explain standard phenomena from laws/principles and models and to describe standard experiments met with before
vi) Ability to use standard methods to solve familiar and unfamiliar numerical types of problems

b) Know how

i) Application of knowledge/theory to practical situations
ii) Devise experiments to test hypotheses and statements of models
iii) Manipulation of the apparatus while performing experiments
iv) Making and recording observations accurately in column tables, with proper units
v) Treating data in appropriate form especially graphical, with properly labelled axes and using suitable scales
vi) Determine gradient or slope, intercept or any other required points on the graph

vii) Devise projects in which the products employ physics principles

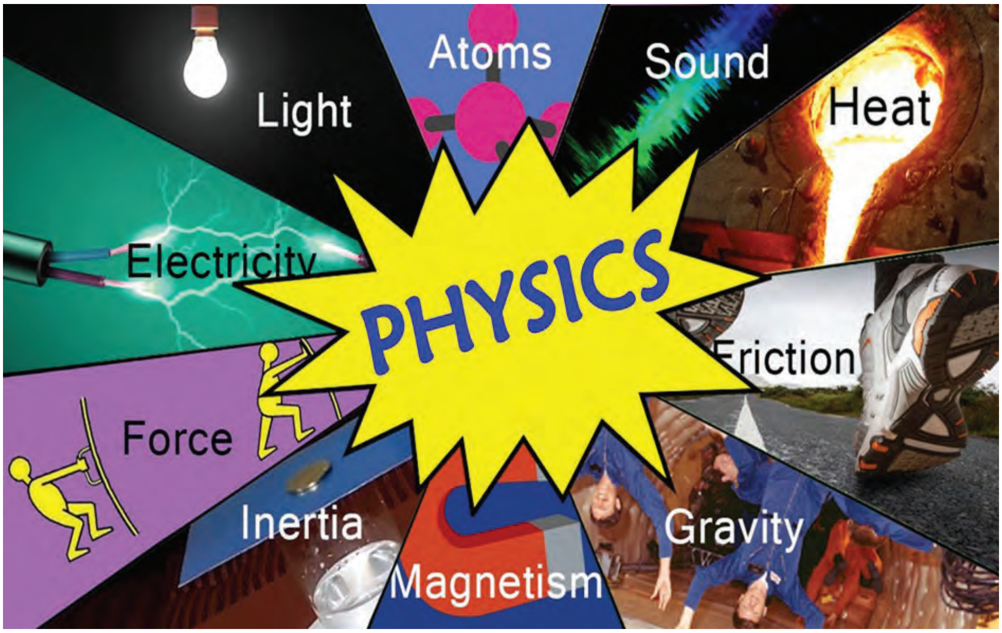
c) **Know being (the values, attitudes, behaviours)**

i) Analysing presented information and making sense out of it
ii) Drawing conclusions from experimental procedures
iii) Exercising evaluative judgment on suitability and results of scientific procedures
iv) Assessing suitability of procedure, experiment and observations made in support of the conclusion
v) Applying laws and generalisations already learnt to everyday life and new situations
vi) Ensuring safety of equipment and experimenter
vii) Ensuring integrity and honesty while studying physics
viii) Ensuring the proper use of the environment and natural resources in the study of physics

You should ensure that the learner:

i) develops skills such as communication, collaboration, safety and any others which may not be directly stated in the *Teacher's Guide* for every chapter.
ii) practices safety precautions.
iii) is provided with a variety of opportunities so that he/she develops his/her investigative skills, while recording observations and making conclusions.

Chapter 1: Introduction to Physics



Key words	***By the end of this chapter, the learner should be able to:***
▪ Science ▪ Physics ▪ Matter ▪ Energy ▪ Laboratory ▪ Apparatus	*a) understand the meaning of physics.* *b) understand why it is important to follow the laboratory rules and regulations.*

Chapter Overview

The focus of this chapter is to introduce the concept of physics to the learner and motivate him/her to be interested in the study of physics.

Introduction

Begin by initiating a discussion on some aspects of science that the learners have studied in Primary school. This should help you and the learners to develop a broader meaning of science. Ask the learners what science is and what aspects of everyday life are related to science. Some of them are indicated in **Figure 1.1** in the *Learner's Book*. Discuss with learners what is happening in each picture.

You may use other cut-outs for more illustrations.

Using the learners' responses, develop the concept of the usefulness of science to society.

From this discussion, the branches of science can be stated, based on how the learners studied science at the primary school.

Then help the learners understand physics as a branch of science. Help them to understand the concept of matter and energy as the major aspects of physics.

Branches of physics

These are stated in the *Learner's Book*. Help the learners to discover more about each of the branches in a discussion or question and answer session.

Activity 1.1

Teacher preparation

Look carefully at **Figure 1.2** in the *Learner's Book* and identify the branch of physics in each picture. Each picture is related to the applications of physics. Help the learners to identify them.

Importance of studying physics

Ask the learners to state how physics is useful to their lives, based on **Figure 1.3** in the *Learner's Book*. Let them suggest other applications that may not be indicated in the pictures.

Then lead the learners in Activity 1.2 for more applications of physics.

ICT support

Where possible, display pictures/images of some personalities such as Archimedes, Isaac Newton and others who did discoveries in physics and what they did, to motivate the learners to study physics.

Careers in physics

On a piece of paper, ask the learners to write what they want to become in future. Let them display all the stated future careers on the chalkboard or manila paper. Help them to identify some careers related to physics and what people in such careers do. You may include pictures of people practising in these careers. Let them also give reasons for their choices of such careers in physics, such as need for a job, or for prestige, solving community problems, career/professional growth, to earn a living, parents' advice, peer influence, etc. Some of their reasons may be vague, so help them to think through their reasons better.

The Physics Laboratory

Teacher preparation

Arrange the physics laboratory or science room to display the laboratory apparatus.

Cautiously take the learners to the physics laboratory or science room. Let them hold some of the apparatus but with your guidance. They should also check some fittings such as gas taps, water taps, etc., if they exist.

Ask the learners to identify some of the apparatuses and their simple uses. Try to modify the learners' answers of the (in terms of the names and uses of the apparatus) to make them scientific in nature.

Activity 1.3

After touring the laboratory, put the learners in groups of 5-10, depending on the size of the class. Let them suggest the rules they would want to follow while in the laboratory/science room.

Allow each group to present the rules they came up with. Harmonise the rules presented.

Then display the harmonized rules on the chalkboard or manila paper.

Skills developed: communication, teamwork and care for property.

In addition to the end of chapter summary indicated in the *Learner's Book*, let the learners summarise the key points.

Scoring grid for the activity of integration

OUTPUT/ PRODUCT	**C1 Accuracy**	**C2 Coherency**	**C3 Relevancy**	**C4 Excellency**
A speech delivered to S1 students during orientation period	• Learner scores 3 if he/she states five or more laboratory rules • Learner scores 2 if he/she states 3-4 laboratory rules • Learner scores 1 if he/she states 1-2 laboratory rules	• Learner scores 3 if the five rules relate to science work • Learner scores 2 for 3-4 rules relating to science work • Learner scores 1 for 1-2 rules related to science work	• Learner scores 3 for if 5 or more laboratory rules are explained • Learner scores 2 for 3-4 rules explained • Learner scores 1 for 1-2 rules explained	Learner earns an excellency score of 1 if he/she concludes the speech by giving an advisory note

Chapter 2: Measurements in Physics

Key words	By the end of this chapter, the learner should be able to:
• Estimating • Measuring • Error or uncertainty • Accuracy • Fundamental/base quantities • Derived quantities • Vectors and scalars • SI units • Significant figures ▪ Scientific method ▪ Density	*a) estimate and measure physical quantities using appropriate equipment and units.* *b) explain how to choose and use the right measuring instruments and the right units, ensuring accuracy.* *c) identify the potential sources of errors in measurements and devise strategies to minimise them.* *d) understand the various methods of presenting data.* *e) use scientific notation and significant figures in measurements and calculations.*

Key words	By the end of this chapter, the learner should be able to:
▪ Relative density ▪ Purity ▪ Floating ▪ Sinking ▪ Ocean currents	*f) understand the scientific method of investigation.* *g) understand the meaning of density and its application to floating and sinking.* *h) determine densities of different materials and relate them to purity.* i) *understand the global nature of ocean currents and how they are driven by changes in water density and temperature.*

Chapter Overview

The focus of this chapter is to estimate and measure quantities in the physical world. Measuring is a common phenomenon in everyday life e.g. buying sugar, buying paraffin, etc. Therefore, help the learners as much as possible to understand the competencies of this chapter i.e. **estimation** and **accurate measuring**. There should be many hands-on activities in this chapter. You should ensure that the learners record the readings appropriately with the correct accuracy.

Introduction

Introduce the unit by asking the learners to write on scraps of paper where measuring is done in everyday life and how it is done. Ask them to define what measuring is and how measurements are expressed.

Note to the teacher

For all the activities involving measurements, discuss with the learners the:

i) possible sources of errors and how they can be minimised.
ii) methods of representing measured data especially in form of tables.

iii) reasons for repeating measurements and why the average values are more reliable than single answers.

Estimation and measurements

Introduce the concept of metric system and also the SI unit system for the common measurable quantities to the learners. Inform them that in this section, they will measure some of the physical quantities indicated in **Table 2.1** below, and that they will use the instruments indicated in **Figure 2.1**.

Table 2.1: Physical quantities, units and instruments

Physical Quantity	Name of Unit	Abbreviation	Instrument
Mass	Kilogram	kg	Beam balance
Length	Meter	m	Metre rule
Time	Second	s	Stop clock
Temperature	Kelvin	K	thermometer
Area	Square meter	m^2	
Weight	Newton	N	Spring balance
Volume	Cubic meter	m^3	Measuring cylinder
Density	Kilogram Per Cubic Meter	kg/m^3	

Fig 2.1 Instruments used to measure some physical quantities

By referring to **Table 2.1** above, ask the learners to discuss instances in everyday life where quantities are measured.

Then ask them to identify what the instruments in **Fig 2.1** are used to measure.

Measuring length

Ask the learners how far, how long, how tall, how wide something is and asses the responses. Do this to bring out the idea of length. Then ask the learners to explain the meaning of length in their own words.

Ask them to describe what is happening in **Figure 2.2** below.

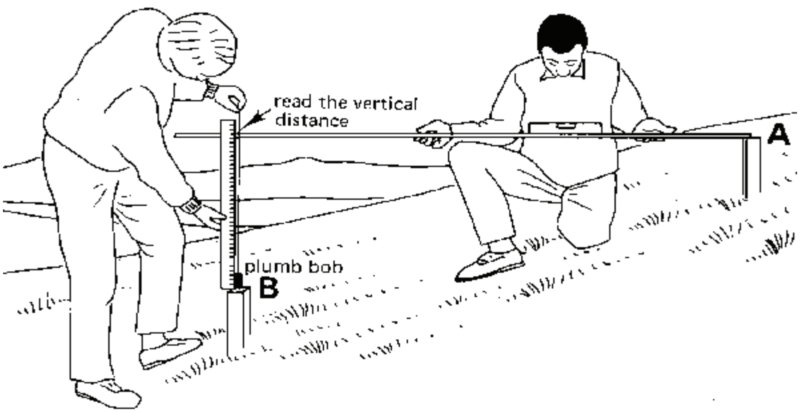


Fig. 2.2 Measuring distance between two points

Provide the learners with metre rules, if possible, and allow them to take several measurements for **fun!** Let them state their readings appropriately.

Remind the learners that the SI unit for measuring length is metres (m). However, provide them with other units of length as indicated below. Remind them that the metric system is based on units of ten, for example:

1 centimetre (cm) = 10 millimetres (mm)
1 decimetre (dm) = 10 cm
1 meter (m) = 10 dm
1 decametre (dm) = 10 m
1 hectometre (hm) = 10 dm
1 kilometre (km) = 10 hm

Help the learners through **Activity 2.1** and give them an exercise for **converting** the units of length.

Check for the correctness of their responses and assist those who are failing to get it right.

Activity 2.2: Finding the height of your friend

Put the learners in groups of 5-10 and provide them with metre rules.

Let them first estimate various lengths in the classroom, such as length of a desk, of the chalkboard and how long a stride is.

Then let them use metre rules and rulers to measure the height of their friends. Let them compare the estimated and measured values.

Note: The heights of the learners should be used for learning and not for criticism.

Ask the learners to measure the length of the playground or any other long length. Let them explain how they have done it.

Introduce a number of instruments used to measure length.
Emphasize:

- accuracy of each of the common instruments
- possible sources of errors while measuring
- inter-conversion of units

After activity 2.2, ask the learners to distinguish between estimating and measuring.

Science, Technology and Society

Sometimes lengths are too small to be measured using the instruments used in **Activity 2.2** above. For very small lengths like the thickness of an iron sheet or diameter of a wire, engineers use a special instrument called the **micrometer screw gauge**. For bigger objects like the diameter of an iron bar, engineers use the Vernier caliper. It is also used to measure **internal** and **external diameters** of tubes.

Micrometer screw gauge

Vernier calipers

Figure 2.3: Instruments for measuring small lengths

used for.

Note: Do not teach learners how to read a micrometre screw gauge and Vernier

Measuring area

Discuss with the learners the meaning of area. Use a variety of illustrations with shapes. Ask the learners to measure the area of different objects such as books, table tops, etc.

Ask them to compare the **amount of space** covered by two different figures below and predict which of them is bigger.

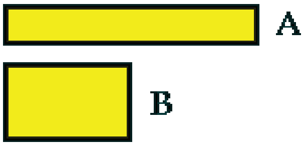


Figure 2.4: Comparing areas of different shapes

Then ask the learners to measure their length and breadth (width). Ask them to multiply the length by the breadth to find the area and compare their results to their prediction.

If they measure the sides of the rectangle in *centimetres* (cm), the area will be in *square centimetres* (cm^2). If they measure the sides of the rectangle in *metres* (m), the area will be in *square metres* (m^2).

Emphasize to the learners that areas can be measured in square metres (m^2), square centimetres (cm^2), square millimetres (mm^2), square kilometres (km^2) and square miles (mi^2) for land measurements.

Note: ***Help the learners to convert from one unit of length to another. Provide enough exercises to ensure that they have understood this concept.***

Regular shapes

Introduce the concept by asking the formula of calculating the area for common shapes like a rectangle.

Let the learners draw various rectangles and squares on the board or newsprint and then measure their sides. They should use these distances to obtain area. **You should remind them about the formulae for calculating area which they studied in their Primary school**.

Irregular shapes

Ask the learners to estimate the area of their notebook or table top. Tell them to cut a rectangular piece of plain paper and measure its length and width so as to calculate its area.

Tell them to shade an irregular shape on the paper and estimate its area in relation to the fraction the shaded area occupies.

Assignment

Ask learners to estimate the area of a table top at home or at school. Then they should measure the sides and calculate the area. How good was their estimate?

Ask learners how they would measure area of irregular shaped figures or of figures which differ in shape. For example, ask how they would measure the area of their hand. Ask them to compare their hand with that of a friend.

Assignment

A challenge

Ask learners to estimate the area of their palm and design an investigation to measure the area of the palm.

Hint: They can use a graph paper.

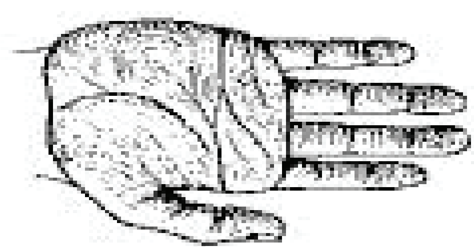


Figure 2.5: Estimating the area of palm

Lead ment of measuring the area of their palms using the grid or graph paper below.

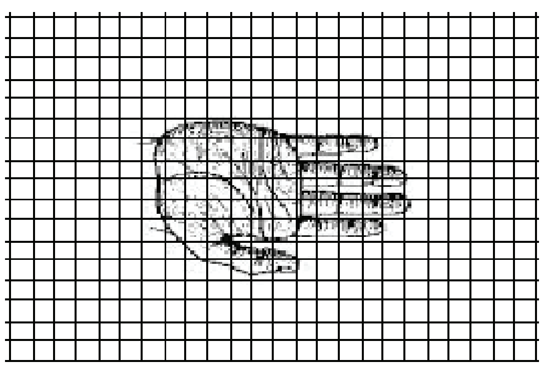


Figure 2.6: Measuring area using a graph

Measuring mass

Introduce the concept of mass by availing a number of materials to explain the idea of quantity or amount of matter.

Use this to explain the concept of mass and its units. Avail the school balances (shown in the figures below) to the learners and allow them to practise how to measure the mass of different objects.

Fig. 2.7: Different types of balances

Inform learners that the SI unit of mass is *kilograms* (*kg*) but it is also measured in grammes (g).

Activity 2.3: The activity involves measuring mass of small objects

Provide a beam balance to the groups of learners. (In case of an electronic balance, ensure that they take care not to spoil it.)

Then let learners measure the mass of a pen, ruler, and other small objects and assess how they record the masses.

Activity 2.4: The activity involves measuring mass of an empty jerry can

Put the learners in groups of 5-10 and provide the following to each group:

- Bathroom scales (or a balance reading to 1 kg)
- 1 kg mass
- 20-litre jerry can
- 100 g mass

Let them go through the activity and then record their readings. Let the groups compare their results.

Weight and mass

Note: Ensure you clarify the difference between mass and weight since they are often used interchangeably. Avail both the beam balance (Figure 2.6 and 2.8 in the *Learner's Book*) and spring balances so that the difference can be noted by making the measurements.

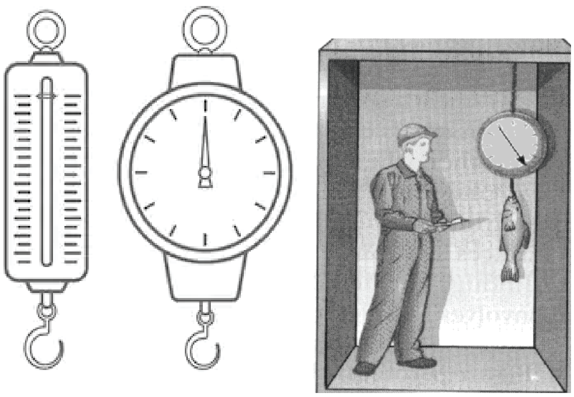


Fig 2.8: Spring balances

Measuring volume

Introduce the concept of volume by pouring water or sand in a container, such as a measuring cylinder and ask how much space is occupied. Ask the learners whether they know any formula for obtaining volume.

Measuring the volume of a rectangular object

Provide the learners with rectangular blocks of different sizes (glass or wood) and ask them to measure the dimensions. Then guide them to calculate the volume of the rectangular boxes or blocks in their exercise books. If the blocks can sink in water, help them understand how to obtain the volume by the displacement method. Let the learners compare their answers.

Activity 2.5: Interconversion of units of volume

Ask the learners to convert 1 m to cm using the following procedure:

1. Multiply 1 m by 1 m by 1 m to 1 m^3.
2. Multiply also 100 cm by 100cm by 100 cm. What do you get?
3. Compare the volume in m^3 to the volume in cm^3.

Lead the learners into a variety of exercises involving the interconversion of the units of volume, basing on stated and calculated values, and using the above procedure.

Activity 2.6: Finding the volume of a classroom

In this activity, lead the learners (in groups) to estimate and accurately measure the volume of the rectangular section of the classroom, using the model below.

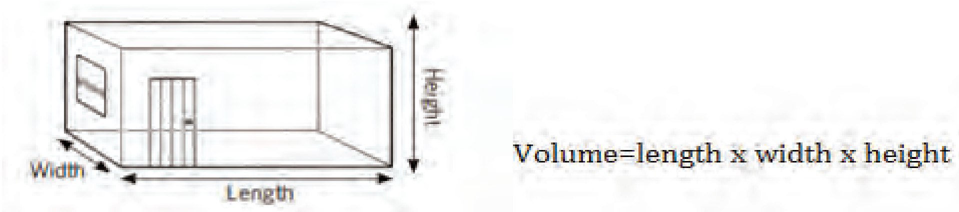
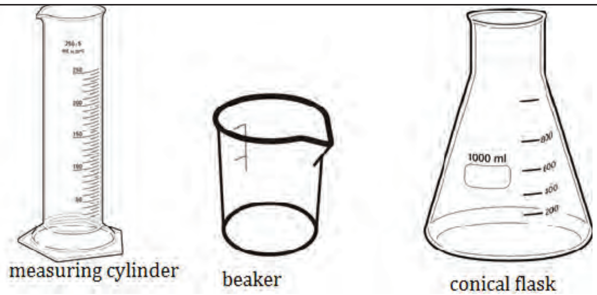


Figure 2.9: Volume of a classroom

Relate this to rectangular tanks that are used to store water in reservoirs.

NOTE: *Regular shapes such as sphere, cylinders and cones have formulae for calculating their volume. Write down the formulae for calculating the volumes of these shapes*

Measuring the volume of a liquid

It is easy to measure the volume of a rectangular object by measuring its sides. How would you measure the volume of a liquid? Another common unit of volume is the *litre* (l) or *millilitre* (ml). We often use these units when measuring the volume of liquids using the instruments shown in figure on the right hand side (**Figure 2.11** in *Learner's Book*).	 **Figure 2.10: Apparatus for measuring volume of liquids**

Avail a measuring cylinder, volumetric flask, beaker and burette to the learners and allow them to measure volumes of water several times. Introduce the **<u>litre</u>** at this point because some of the instruments are calibrated in litres and millilitres.
Emphasize how accurate readings may be obtained using a measuring cylinder i.e. the no parallax.

Did you know? 1000 cl^3 = 1 litre

Activity 2.7: Finding the volume of a liquid

Put the learners in groups and provide them with the following:

- Small bottle containing water
- Measuring cylinder

Ask different learners to read the volume for the same amount of water and compare their readings. Use this as a basis for introducing the concept of parallax.

Emphasize to the learners that for more specific and accurate measurements of volume of liquids, they can use a burette and a pipette (shown in the figures below) which you should avail to them.

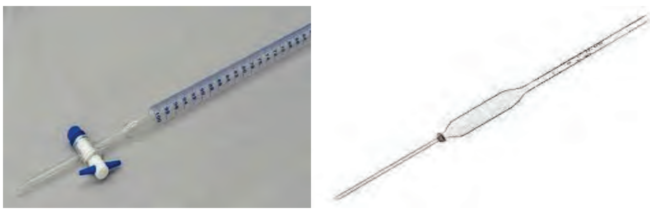


Figure 2.11: (a) Burette (b) Pipette

Allow the learners to measure volume of liquids using these instruments.

Note: Emphasize safety of these instruments since they are very fragile. Their broken parts can also cause injury to the learners.

Measuring volume of irregular objects

Ask the learners to make a difference between regular and irregular objects. Then avail shapes you think are irregular and lead them through Activity 2.8.

Provide the following to each group of learners:

- Measuring cylinder
- Overflow can, if available
- Water
- Stone (small enough to fit into the measuring cylinder)

Ask the learners to:

i) estimate the volume of the stone.

ii) put some water in the measuring cylinder and read the volume (x cm^3).

iii) put the stone in the water in the measuring cylinder and read the new volume (*y cm³*).

Let learners understand that the difference between the two volumes is the volume of the stone.

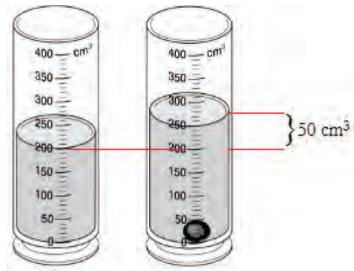


Figure 2.12: Determining the volume of irregular objects

Using the illustration above, the volume of the stone is 50 cm^3

Initiate a discussion with the learners about how they can measure the volume of an irregular object that floats in water.

Measuring time

Ask the learners what they know about time e.g. how they can tell time without watches, what measures it, how long it takes to bath, to travel a short distance, etc.

Ask them to describe the methods of measuring time indicated in the figure below.

Figure 2.13: Different ways of measuring time

Activity 2.9: Estimating time

Provide the following to each group of learners:

- Clock or watch
- 1 m pendulum
- A thread

Let the learners do the activity in groups.
After the activity, allow them to mention various daily events and how long they take to occur.

Lead the learners into a discussion on the various units in which time is expressed and how they are related.

Note: After the learners have measured and discussed the various quantities, guide them to categorize the quantities as **fundamental/base** and **derived** and **vectors** and **scalars** as indicated below:

The physical quantities that we measure and others are classified as:

a) Fundamental/base quantities such as length, mass, time, temperature i.e. quantities that are not obtained by combining any two other quantities.
b) Derived quantities such as area, volume, density, weight, speed i.e. quantities that are obtained by combining the fundamental quantities using a formula.
c) Scalar quantities e.g. mass, time, volume, etc. they have only size or magnitude but with no direction.
d) Vector quantities e.g. weight, velocity, etc. They have both size or magnitude and direction.

Remind the learners that some quantities will be met later in other classes.

Significant Figures and Scientific Notation

The following information, extracted from the *Learner's Book*, may be useful to you.

Rounding off means writing a number to a required place value. The result is less accurate, but easier to use; for example, 3.52 cm to 1 decimal place is 3.5 cm.

Decimal place is the position of a digit to the right of a decimal point. A time of 6.50 hours has two decimal places; 5 is the first and 0 the second decimal figure.

Rules for finding significant figures

Rule 1: All non-zeros digits are significant figures.

Example: Distance of 4362 m has 4 significant figures

Rule 2: All zeros occurring between non-zero digits are significant figures.

Example: Mass of 605 g has 3 significant figures

Rule 3: Zeros right of a decimal point and left of non-zero digit are not significant.

Example: Area of 0.00325 m^2 has 3 significant figures

Rule 4: All zeros right of a non-zero digit in the decimal part are significant.

Example: Height of 1.4750 cm has 5 significant figures

Now ask the learners to do the following exercise and assess the correctness of their work.

Exercise 2.1

State the number of significant figures in the following measurements:

(a) 300 cm
(b) 0.105 km
(c) 0.050 g
(d) 5.1090 m^2

Rules for rounding off significant figures

Rule 1: If the digit to be dropped is less than 5, the preceding digit is left unchanged.

Example: 1.54 is rounded off to 1.5

Rule 2: If digit to be dropped is 5 or greater than 5, the preceding digit is raised by one.

Example: 2.49 is rounded off to 2.5

Rule 3: When multiplying or dividing numbers with different significant figures, the answer takes the **lower** number of significant figures.

Rule 4: When adding or subtracting numbers with different number of decimal places, the answer takes the **lower** number of decimal places.

Now ask the learners to do the following exercise and assess the correctness of their work.

Exercise 2.2

A rectangular block of wood has a length of 5.24 cm, a height of 3.645 cm and a width of 0.63 cm.
Calculate the volume of the block of wood. Give the answer to the appropriate number of significant figures and decimal places.

Scientific Notation (Exponential or Standard Notation)

Scientific Notation is a short and convenient way of writing or expressing very large or very small numbers using powers of 10.

Examples are shown below:

i) 40 can be written as 4×10^1
ii) 2000 is written as 2×10^3
iii) 0.0003 is written as 3×10^{-4}

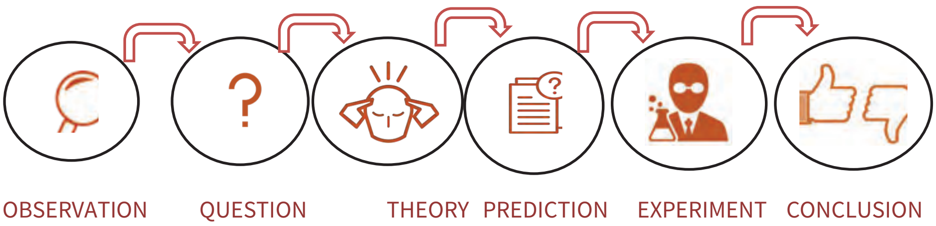
Since very large or very small numbers are written using fewer digits, Scientific Notation helps to make working with digits easier and with fewer mistakes, for example:

Provide many opportunities and a variety of activities to the learners to ensure that they comprehend how to use decimal places and rounding off, significant figures and the scientific notation. These should be used for both measured and calculated values.

Scientific method

This is a new concept. Its aim is to help young learners appreciate the steps involved in scientific investigation.

Lead the learners through each step of the scientific method shown below. Discuss with them the meaning of each of the steps and why it is important.



Provide opportunities, even those outside the *Learner's Book* for the learners to learn to think critically and scientifically while carrying out an investigation**.**

Activity 2.10: Solving a problem using the scientific method

Provide the following to each group of learners:

- Radio which does not work but with dry cells inside.
- A pair of new dry cells.

Ask the learners to:

1. copy the table below into their notebooks.
2. use the guideline provided in steps 1-6 above to carry out an investigation to identify the problem with the torch and record their results in Table 2.2 below.

Table 2.2

Observation:	
Question:	
Theory:	
Prediction:	
Experiment:	
Conclusion:	

Lead the learners through each of the steps for the above activity and check for their responses as indicated in the table.

Ask them to suggest some problems they face either at home or at school and suggest steps to solve the problems using the scientific method.

Meaning of density

Introduce the concept by asking the learners to explain briefly how they can compare objects to see which one is either heavy or larger. From their responses, introduce the idea of packing of particles in a volume. This will help you to introduce the concept of density.

Establish the idea of density by using the objects in the *Learner's Book* in **Fig. 2.19**.
Where possible, ask the learners to measure mass and volume as was seen previously and get the ratio of the mass to the volume. This should be the point at which the definition of density is established.
Use the ratio to establish the units of density from those of the two quantities i.e. mass and volume.
Lead the learners to use simple figures to calculate the density for some objects.
Then use the cubes of different materials as indicated to compare the materials. Lead the learners to appreciate the fact that mass is not the best to use to compare objects but only density should be used.

Determining density

Inform the learners that density of substances can be determined experimentally. Then prepare them for **Activity 2.11**.

Activity 2.11: Determining the density of substances
Provide the following materials to the learners in groups of 5-8.

- Water
- Sand
- Regular solids with rectangular sides (pieces of metal or wood or plastic specially cut, or objects such as a book or a brick)

- Ruler
- Measuring cylinder
- Weighing scales

Lead the learners through the procedures of the activity. After the activity, the learners can carry out a simple calculation to obtain the density of each of the objects.

Guide the learners on how to obtain the density of an irregular solid.

Then using ICT or other sources, let the learners compare their values with the quoted values of the densities of these substances.

Changes in density

Initiate a discussion with the learners about how matter can change in volume and what causes this. Then enable them to understand that the change in volume does not change the amount of substance. Then lead the learners to appreciate that a change in volume without a change in mass causes a change in density of a substance and the implication that this one has.

Density and its application to floating and sinking

Ask the learners to name some of the objects which float or sink in water, drawing from their past experiences and suggesting the reason why. Then provide the following to each group of learners:

- Pieces of metal
- Plastic
- Wood, etc.

Let the learners carry out **Activity 2.12**. Lead a discussion to establish a basic rule relating to sinking/floating to density of the objects. They can then refer to **Table 2.3** in the *Learner's Book*. Then the learners can explain why some objects floated and others did not. You should use **Table 2.3** to help them appreciate why some objects float in water while others do not.

Then let the learners discuss the application of floatation in relation to canoes, ships and ferries, using **Figures 2.20** and **2.21** in the *Learner's Book*.

Activity 2.13: Comparing how much an object sinks in seawater and fresh water

This is an activity of comparing floatation in fresh and sea (salty) water. Provide the following to each group of learners:

- Small block of wood
- Bowl
- Water
- Salt

After the activity, allow the learners to compare the floatation in both types of water.

Put the learners in groups to discuss why clouds float in air and why ice floats on water. **(This can be done experimentally where possible.)**

Does floating occur in air? Refer to clouds in **Figure 2.22** in the *Learner's Book* and initiate a discussion on its significance.

Ocean currents and water density

Discuss with the learners that an **ocean current** is a continuous, directed, horizontal movement of sea water from one region to another and that they are generated by wind, density differences in sea water caused by temperature and salinity variations in the water.

Then help the learners appreciate that currents regulate global climate, helping to counteract the uneven distribution of solar radiation reaching earth's surface. You should use the illustration in **Figure 2.23** in the *Leaner's Book*.

Density and purity

Lead the learners through a discussion on the importance of obtaining the accurate value of the density of substances. This is the basis for buying precious metals such as gold.

Density and relative density

Lead the learners in a discussion that compares the concepts of density and relative density and why it is important to know both quantities.

Wrap up the concept of density by assessing the exercise about density. Consider how the learners state the formulae, and how they substitute the quantities in the formula, and how they state the final answers.

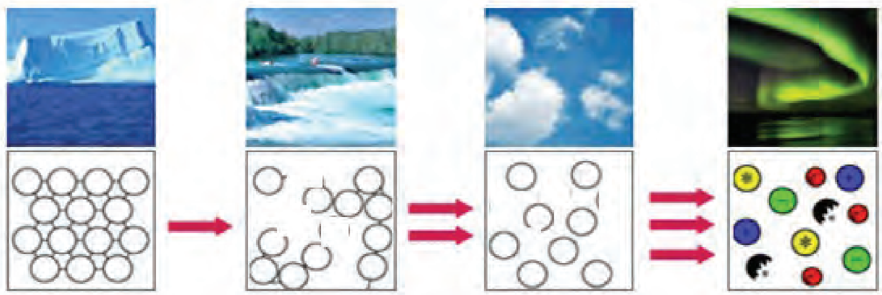
Key Points to Remember

Then finally allow the learners to state the key points from the chapter, in addition to those summarized in the *Learner's Book*. The learners should note down all key issues.

Scoring grid for the activity of integration

OUTPUT	C_1	C_2	C_3
Written explanation indicating what should be done to show that the stone is gold or not.	Scores 1 if he/she states the density should be determined without any further detail.	Scores 2 if he/she gives detailed information about determination of the density of the stone.	Scores 3 if he/she gives detailed information about determination of the density of the stone and how the obtained value should be compared with the actual density of gold in order to give the advice.

Chapter 3: States of Matter



Key words	***By the end of this chapter, learners should be able to:***
▪ Plasma ▪ Diffusion ▪ Particle theory ▪ Brownian motion ▪ Change of state	▪ *understand the meaning of matter.* ▪ *understand that atoms are the building blocks from which all matter is made.* ▪ *appreciate that the states of matter have different properties.* ▪ *apply the particle theory of matter to explain Brownian motion and diffusion and their applications.* ▪ *understand how the particle theory of matter explains the properties of solids, liquids, and gases; change of state.* ▪ *understand that a change from one state to another involves either heat gain or loss.* ▪ *understand the meaning of plasma in physics.*

Chapter Overview

This chapter examines the properties of the states of matter using simple models. It builds on the ideas that were developed in the primary school level. The inter-change of states will also be examined using experimental models. You should ensure that the learners fully participate in the activities because the required apparatus is readily available or at least can be improvised.

Introduction

Begin the lesson by asking the learners what makes a heap of sand, water in a basin and what is around them, or by asking them to breathe out. This should help introduce the concept of matter and how it exists in various forms.

Lead the learners through the assignment in the *Learner's Book* for classifying items into the states of matter.

What are properties of solids, liquids and gas?

Using tangible materials, let the learners now give the properties of common substances and materials in each of the states such as shape, movement using smell, etc. Then explain the concept of plasma using examples (**Figure 3.3**). Then let the learners do **Activity 3.1**. They should summarise their answers.

Arrangement of particles in the states of matter

This can be role-played by the learners. Arrange the learners as particles in solids, liquids and gases and let them discuss the arrangement of the particles according to the role-play. Then refer them to **Figure 3.4** to harmonise their responses.

Activity 3.2: To find out if a gas or liquid can be compressed

Provide syringes to each group of learners. Lead them through the activity and allow them to state the observations that they make.

Particle theory of matter

Introduce this section by asking the learners what they see when they look through smoke or dust, for example when sweeping.

Lead the learners to the concept of molecules and atoms briefly.

Activity 3.3: Investigating the evidence of particles using a balloon filled with air

Put the learners in groups of about 5-10 and give each group balloons. Let the learners go through the activity as they record their observations on manila paper or chalkboard. Lead a discussion on the results so that the learners can draw a conclusion.

Activity 3.4: Investigating evidence of particles using liquid

This is a learner-friendly activity. Provide the apparatus for the activity. Let the learners carry out the activity on their own. Ask them to make a report on the activity, including drawing the diagram.

Brownian motion

Introduce the concept of Brownian motion by using appropriate examples, such as dust particles after a car passing on a dusty road, or any other appropriate example. Then lead a discussion on the smoke cell experiment and its conclusions.

Diffusion

Briefly lead a discussion on diffusion based on smell and other suitable examples.

Activity 3. 5: Investigating particles in gases

Caution: Bromine vapour is poisonous and so the learners should not inhale it directly.

Lead the learners through the activity. At the end of the activity, introduce the concept of diffusion (movement of particles) as a fundamental difference between the states of matter.

Discuss the concept of force between the particles as a basis for motion of particles. You may use the learners holding one another in a small corner.

Effect of heat on states of matter

Introduce this section by allowing the learners to represent solids, liquids and gases with simple sketches.

Allow the learners to heat common substances such as wax and water. Let them explain what happened. Then lead them through the exercise in the *Learner's Book* and assess the exercise.

Change of state

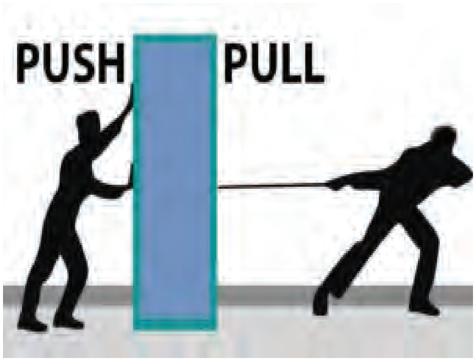
Ask the learners to state what happens when ice is left in the open or when water is heated. Ask them to name which processes occur. Let one of the learners draw up a chart that summarises the changes of state for water under different conditions. You should use **Figure 3.11** in the *Learner's Book*.

Lead a discussion on change of state in terms of what happens during the process of change of state. Then initiate a discussion on the applications of change of state such as rain formation, making ice-cream and other applications.

Then consolidate the chapter by discussing the end of chapter summary in the *Learner's Book*. Ask the learners to suggest other key points not mentioned in the summary.

OUTPUT	**C_1 Accuracy**	**C_2 Coherency**	**C_3 Relevancy**
Written explanation indicating what should be done to classify the material			

Chapter 4: Effects of Forces



Key words	By the end of this chapter, learners should be able to:
▪ Force ▪ Newton ▪ Contact forces ▪ Non-contact forces ▪ Resultant force ▪ Gravity ▪ Friction ▪ Intermolecular force ▪ Cohesion ▪ Adhesion ▪ Surface tension ▪ Capillarity ▪ Meniscus	▪ *appreciate that a force is a push or a pull, and that the unit of force is the Newton.* ▪ *appreciate the effects of balanced and unbalanced forces on objects.* ▪ *understand the importance of friction in everyday contexts.* ▪ *understand the existence of the force of gravity and distinguish between mass and weight.* ▪ *appreciate that the weight of a body depends on the size of the force of gravity acting upon it.* ▪ *understand the meaning of cohesion and adhesion* ▪ *explain surface tension and capillarity in terms of adhesion and cohesion*

Chapter overview

Forces are around us and we use them in many aspects of life. The effects of force are also widespread. The focus of this chapter is to enable the learners appreciate the various types of force and how they are useful in everyday life. The learners should also be able to recognise the instances in which forces are not desirable.

Introduction

Introduce by asking the learners to write on the board what the word **force** means, in their own words. You should accept any meaning so that you get the best meaning from their response.

Then modify their responses.
Ask the learners what is happening in **Figure 4.1** in the *Learner's Book* so that you can develop the meaning of force. Ask them to state instances where forces are applied in order to explain the types of force.
Provide spring balances, if possible, and help the learners to develop the concept of the unit of force (the **Newton**).
Lead the learners into a discussion on some applications of force such as that shown in **Figure 4.4** in the *Learner's Book*. Let them suggest other applications of force.

Types of forces

Introduce types of forces by telling learners to place a block of wood on a table and drop a small object like a piece of chalk. Ask the learners to identify the force involved in each case and then help them to categorize forces into contact and non-contact forces. Then expand this concept with other forces.

Force of gravity; weight

Initiate a discussion on weight by telling the learners to drop small objects or throw small objects into the air or to simply jump. Discuss with them what happens in each case. Help them to understand why these small bodies come back to the ground.

Activity 4.1: Investigating the relation between weight and mass

Provide slotted masses and a spring balance to groups of learners. Then lead them through this activity.

From the activity, lead the learners to:

i) develop a mathematical relation between mass and weight.
ii) calculate the weight of several masses.
iii) compare weight and mass.

Lead the learners to appreciate the concept of weight to life on earth, in the solar system, etc.

Note to the teacher:

You should ensure that the learners are able to distinguish between mass and weight since many times these terms are used to mean the same thing yet they are scientifically different.

Effects of forces

The effects of forces are many. Some of them can be stated by doing **Activity 4.2**. Lead the learners through **Activity 4.2** to identify the effects of forces.

Activity 4.3: Investigating force between charged objects

Organize the learners in groups of 5-10 and provide the following to each group:

- Two balloons
- A piece of wool
- Small pieces of tissue paper
- Cotton threads
- Two stands

The learners should go through the steps of the activity and record their results. Ensure you clarify the issues that are not clear to the learners.

- Introduce this section by using a tag-of-war i.e. two learners of the same size pulling each other and other learners observing the effect.
- Ask some learners to push a block of wood on a table or two learners push the same block in different directions.
- With this discussion, lead the learners to discover the concept of resultant force. Let them do exercises involving the resultant of **linear** and **perpendicular** forces only.

  Note: The angle at which the resultant force is inclined to the horizontal is not required at this level.

Friction between surfaces

i) Ask the learners to rub their fingers together, or to slide their fingers on a table.

ii) Also ask the learners to slide on a floor. (**This is optional because it can lead to injury.**)

iii) Then ask the learners to slide a block of wood on a table and on the ground.

Ask which of the above is easier so that you develop the concept of friction and what causes it.

Activity 4.4: Friction and weight

Organise the learners in groups of 5-10 and provide them with the following:

- A rectangular wooden block measuring 5 cm x 10 cm x 20 cm with a hook screwed into the middle of one of the smallest faces. One of the two largest faces should be smooth and the other rough.
- A force meter
- Five 100 g masses
- A flat horizontal wooden table

Let the learners carry out the activity as they record their results in the table provided in the *Learner's Book*.

Discuss the learners' results in relation to the mass/weight and the nature of surface. Use their results and lead them to discover the factors that determine solid friction. The learners should plan their activities to discover these factors.

Science, technology and society

Initiate a discussion on the applications of and problems associated with friction. Let the learners obtain the ideas using the pictures in **Figure 4.14 – 4.18** in the *Learner's Book*.
Sum up the unit by emphasizing the key issues on forces and its applications.
Check that the learners do the self-test exercise and that their answers are correct.

Intermolecular forces

Ask the learners whether they have ever noticed that while washing glass utensils water remains on the utensils, or that small insects can walk on water because their weight is not enough to penetrate the **surface**.
Then initiate a discussion on these and other phenomena that result from the forces within substances.

Ensure that the learners understand that intermolecular forces are either **cohesion force** or **adhesion force**. Use the figure below to help you explain this difference.

Figure 4.1: Effects of molecular forces

Cohesion and adhesion: Which pictures show cohesive forces?

Example:

Using the concept of cohesion and adhesion, ask the learners to explain why water in a narrow glass tube has a concave meniscus, while mercury in the same tube has a convex meniscus. You may ask them to draw sketches of the diagrams of the meniscuses.

Possible solution

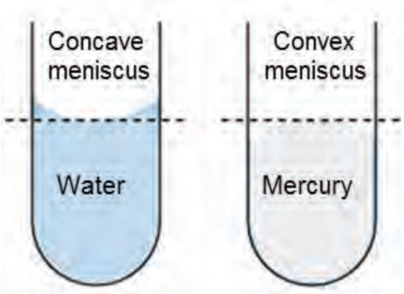


Fig 4.2: Shapes of meniscus

For water in the glass tube, the force of adhesion between the water and glass molecules is greater than the force of cohesion among the water molecules, so water clings to glass forming a concave meniscus.

On the other hand, the force of cohesion among mercury molecules is greater than that of adhesion between mercury molecules and glass molecules. Therefore, mercury molecules cling to each other forming a convex meniscus.

Assess how the learners present their solution and critique the solutions as much as possible to help them appreciate the implication of these forces on the nature of meniscus formed by liquids.

Surface tension

Initiate a discussion on surface tension by illustrating that the cohesive forces among liquid molecules at the surface hold them together, acting as if it were a stretched elastic layer. From the discussion, lead the learners to develop a statement that describes surface tension in their own words.

Note: Do not use the advanced level definition of surface tension for this level because the learners will be confused.

Now help the learners to appreciate that surface tension actually exists using some of the following examples, and any other suitable ones:

a) When water drops slowly, it breaks into a continuous stream and forms drops. The shape of the drops is caused by the surface tension of water.

b) Several insects are able to walk on water; for example, the water strider.

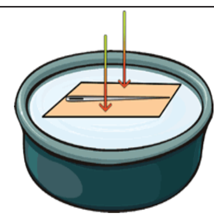
c) A pin or sewing needle, when gently put on the surface of water in a container, floats due to surface tension.

Figure 4.3: Effect of surface tension

Activity 4.5: Studying surface tension in liquids

Provide the following to each groups of learners

- Dish or beaker with cold water
- A piece of paper
- A sewing needle or metallic paper clip



Caution the learners to be careful because needles are sharp. They should handle them with care!

What to do

Let the learners go through the procedures of the activity and record their observations. You may refer to **Figure 4.4**. Then ask them the following questions.

Figure 4.4: Surface tension in liquids

Questions

1. What happened when you put the needle or paper clip on water:
   (a) directly?
   (b) using a paper?
2. Explain your answer in each of the cases above.

Assess the responses of the learners. Allow them to critique the responses of their peers.

Using the responses from the activity, ask the learners to suggest ways by which the surface tension of water can be reduced.

Capillarity

Introduce the concept of capillarity by asking the learners to dip a piece of cotton cloth, filter paper and drinking straw into a beaker of water. Ask them to explain what happens and use their responses to explain the concept of capillarity.

Activity 4.6 Studying capillarity in liquids

Provide the following to each group of learners:

Paraffin (or kerosene), a dry wick, beaker.

Lead the learners through the procedure and ask them to state their observations. Then ask them to explain their observations in a group discussion.

Assess how the learners communicate scientific ideas.

Capillary rise of liquids in tubes

Lead the learners in a brief discussion on the reasons for capillary rise and fall within liquids. This should lead to **Activity 4.7.**

Activity 4.7: Studying capillary rise in liquids

Provide the following to each group of learners:

Two capillary tubes of different sizes and a beaker of water

Allow the learners to perform the procedure for the activity.

Ask them to state what they observe. Then in a brief discussion, let them explain their observation.

The learners should draw a diagram to show the levels of the water in the different tubes. It should appear like in the figure below.

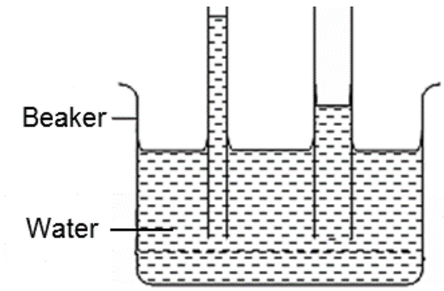


Figure 4.5: Capillarity in water

Initiate a discussion on capillary fall in mercury (since mercury is not a common substance) with the learners. Discuss why the behaviour of mercury is different from that of water.

Then let the learners represent the behaviour of mercury in tubes using a diagram. It should look like the one in the figure below.

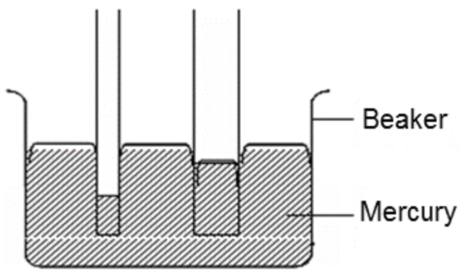


Figure 4.6: Capillarity in mercury

Note:

Emphasize to the learners that the amount of elevation, or depression of a liquid in a capillary tube depends on the internal diameter or size of the tube.

The liquid rises higher or sinks lower when the diameter is smaller.

Then discuss with the learners the examples of capillarity which include the following:

i) Water moving up a straw or glass tube
ii) Water being absorbed by a paper or cloth towel
iii) Movement of water through a plant
iv) Blotting paper to absorb liquids
v) Paraffin rise in wicks of stoves and lamps
vi) Towels and soft tissues rinsing water

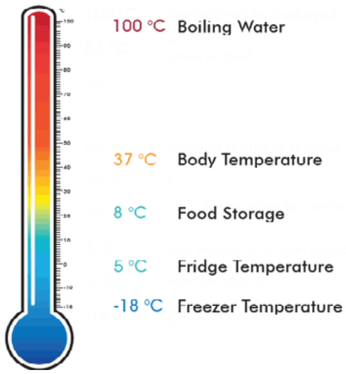
Wind up by asking the learners to identify the key points in the chapter. They should expand on those indicated in the *Learner's Book* to provide a feedback on their knowledge of the topic.

Allow for peer assessment of the learners on the end of chapter exercise, and consolidate their responses in case of any difficulty.

Scoring the activity of integration

OUTPUT	**C_1**	**C_2**	**C_3**
Written explanation indicating what should be done to construct a house where water will not move upwards on the walls.	Scores 1 if he/she states the need to use damp proof course.	Scores 2 if he/she gives detailed information about the causes of the water moving upwards on the wall.	Scores 3 if he/she gives detailed information about the causes of the water moving upwards on the wall and how this can be minimised using damp proof course and the reasons why.

Chapter 5: Temperature Measurement



Key words	*By the end of this chapter, the learners should be able to:*
▪ Temperature ▪ Temperature scales ▪ Thermometric property ▪ Upper fixed temperature ▪ Lower fixed temperature ▪ Clinical thermometer ▪ Digital thermometer	▪ understand the difference between heat and temperature. ▪ understand how temperature scales are established. ▪ calibrate a thermometer and use it to measure temperature. ▪ compare the qualities of thermometric liquids. ▪ describe causes and effects of the daily variations in atmospheric temperature.

Chapter overview

There are different sources and forms of energy in the universe. One of the forms of energy is heat. Heat has different effects on materials. One of these effects is change in temperature.

In this chapter, you will help the learners appreciate how temperature is measured and how temperature varies within the environment.

Heat and Temperature

As mentioned earlier, **heat** is a form of energy. When a body absorbs heat, it becomes hotter and when an object loses heat, it becomes colder. A measure of the degree of hotness or coldness of a body is called the **temperature** of the body. Therefore, the amount of heat in a body influences the body temperature. This clarification is important to the learners.

Ask the learners to differentiate between hotness and coldness. Can they now define temperature? They met the definition in Primary school Science.

Inquire whether the learners have heard statements like 'it is very cold today', or 'it is hot! Inquire whether such statements make sense to them.

Measuring temperature

Test whether the learners know how to estimate temperature. Ask them to state the temperature of:

1. a hot day.
2. a cup of hot tea.
3. warm bathing water.
4. normal human body temperature.

Based on the learners' responses, inform them about the following, as some of the common temperature estimates:

- A comfortable temperature for working is 25°C.
- A cold morning is about 19°C to 21°C.
- A hot day is about 29°C.

Introduce the concept of thermometers by allowing the learners to look at the thermometer scales i.e. degrees Celsius (^{0}C) or degrees Fahrenheit (^{o}F). Introduce the Kelvin (K) scale since it is not common on thermometers. Use Figure 5.1 below if a thermometer is not available.

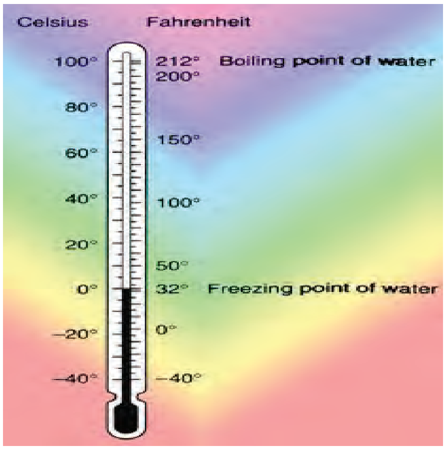


Figure 5.1: Temperature scales

Help the learners to make simple temperature conversions between Celsius and Fahrenheit scales e.g. a temperature of 100 ^{o}C is equivalent to 212 ^{o}F. From this illustration, remind them that body temperature depends on the scale used and hence the definition that temperature is the **degree of hotness on a chosen scale**.

Activity 5.1: Measuring temperature of the environment

The activity involves measuring temperature of various positions in the school compound**.**

Provide laboratory thermometers to each group of learners.

Warning: Inform the learners that thermometers are very fragile and can easily break. Therefore, they should handle them with care.

Let the learners do the activity and record their results in a table like the one below.

Table 5.1: Temperature of the environment

Place	*Temperature(°C)*	
	Estimated	*Actual*
Classroom		
Under tree		
Laboratory		

By comparing the estimated and the measured temperatures, assess whether the learners can fairly estimate temperature.

Assignment to the learners

Where possible, ask the learners to listen to the weather forecast or check for the forecast in a newspaper. Then they should:

a) state the temperature of the hottest and coldest parts in Uganda for the day recorded and then note them for a full week.
b) obtain the average temperature for each of the places.
c) discuss what causes daily variation in temperature of the environment.

Types of Thermometers

Ask the learners to identify the materials used in thermometers and why they are used. From this discussion, introduce the idea of thermometric property.

Some examples of thermometric properties are indicated below

Thermometric property	Type of thermometer
Volume expansion of a liquid	Liquid-in-glass thermometer
Volume expansion of a gas	Gas thermometer
Electrical resistance	Resistance thermometer

How a liquid-in-glass thermometer works

Provide a common liquid in glass thermometer to each group of learners in a class demonstration. Allow them to look at the thermometer carefully and identify its features, such as those listed under **Figure 5.2** below.

Figure 5.2: A laboratory thermometer

Table 5.2: Parts of a laboratory thermometer

Bulb:	It stores the liquid.
Bore:	It gives the liquid a route to travel as it expands and contracts. It is very narrow so as to make the thermometer more sensitive and accurate.
Stem:	This surrounds the bore in the thermometer. It is also a magnifying glass to enable easy reading of temperature.
Expansion Chamber:	This provides space where gases and air inside the capillary collect as liquid rises.

Note: Emphasize the concept of sensitivity of a thermometer i.e. its ability to record very small temperature changes and how it can be increased by using a large bulb and a narrow capillary tube.

Clinical thermometer

This is the thermometer doctors and nurses normally use in the hospitals to measure the temperature of the human body. It is a liquid-in-glass type of thermometer. Provide a clinical thermometer in a class demonstration and ask the learners to identify its features and how it differs from the common laboratory thermometer. If it is not available in the school, use **Figure 5.3**.

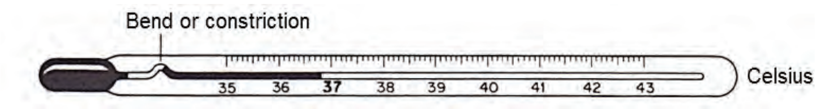


Fig. 5.3: Clinical thermometer

Ask the learners, in a class discussion, to identify the features that make these thermometers suitable for measuring body temperature. Some of the features are:

a) Mercury which is used as the liquid is very sensitive to temperature changes.
b) Scale is limited between 35 ^{0}C to 43 ^{0}C: the only range needed for medical purposes.
c) There is a constriction or bend which breaks the mercury column and prevents it from flowing back. This allows enough time for a reading to be taken.

For the learners' personal study: Based on the features of the clinical thermometer, ask the learners to suggest the best practices of the proper handling of a clinical thermometer.

Temperature scales

Now that the learners have interacted with thermometers, ask them to identify the fixed points as:

Lower fixed point:	This is the temperature of pure melting ice at standard atmospheric pressure.
Upper fixed point:	This is the temperature of steam from pure water boiling under standard atmospheric pressure.

Activity 5.2: Determining the lower fixed point

Provide the following to each group of learners:

- Cracked ice and a beaker or saucepan
- A thermometer

Caution

Thermometer is fragile. Remind the learners to handle it carefully, and that mercury vapour is poisonous.

Let the learners do the activity. They should refer to Figure 5.4 below.

Figure 5.4: Determining the lower fixed point on a thermometer

Then let the learners record their results in the table below.

Results:

1st trial	*2nd trial*	*3rd trial*	*Average*

Assess how they fill their results in the table and how they answer follow-up questions such as the following:

1. Are all the values in each of the three trials the same?
2. Is the lower fixed point of the thermometer accurate? If not, give a possible explanation for the difference.

Activity 5.3: Determining the upper fixed point

Provide the following to each group of learners:

- Beaker or saucepan, thermometer and water.
- Bunsen burner/charcoal stove.

Caution

Use gloves or cloth to avoid burns and scalds.

Let the learners do the activity by referring to the figure below.

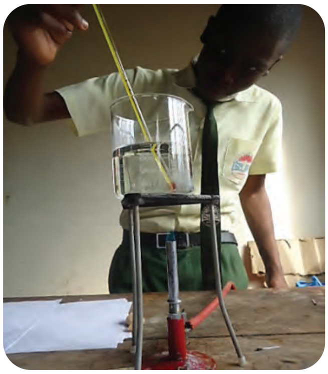


Figure 5.5: Determining the upper fixed point on a thermometer

They should then record their results in the table as shown below.

Results:

1st trial	*2nd trial*	*3rd trial*	*Average*

Assess how the learners record their results, their accuracy and how they state the units. Then they should answer follow-up questions such as:

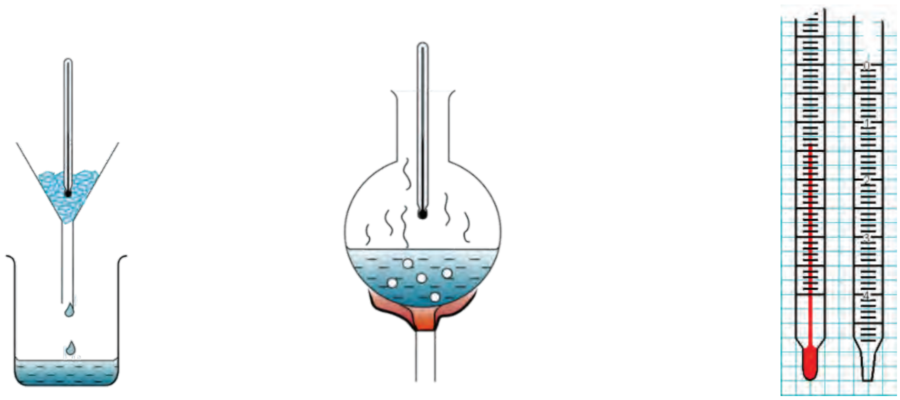
1. Are all the values in each of the three trials the same?
2. Is the upper fixed point of the thermometer accurate? If not, give a possible explanation for the difference.

Note: Ensure that when the learners are determining the upper or lower fixed point on a thermometer, water used must be pure because the presence of impurities lowers the melting point of ice and elevates (increases) the boiling point of water.

Ask the learners to suggest how pure water can be obtained.

Calibration of the thermometer

Initiate a discussion on calibration of instruments using a ruler, burette, etc. and then let the learners discuss steps in the calibration of a thermometer as indicated in **Figure 5.6** below.



Freezing point of water (0° C) Boiling point of water (100° C) Make 100 divisions

Fig. 5.6: Calibration of the thermometer

After the calibration process, in a class discussion, let the learners try out the examples and the exercise on calibration. Assess how they make the substitutions and express the final answer.

Example

A mercury thermometer is calibrated by immersing it in pure melting ice and then in steam above boiling pure water.

If the mercury columns are at 6 cm and 16 cm marks, respectively, find the temperature when the mercury column is 8 cm long.

Solution

6 cm corresponds to 0° C,

16 cm corresponds to 100° C

8 cm corresponds to θ° C

θ = ?

$$\theta = \frac{8-6}{16-6} X\ 100 = \frac{2}{10} X\ 100 = 20\ ^{0}\text{C}$$

Exercise:

The length of mercury column of a thermometer at ice point and steam point are 2.0 cm and 22.0 cm respectively. What is the reading of the thermometer when the mercury column is 9.0 cm long? What will be the mercury length in the column at 60 ^{o}C?

The following points are worth noting:

1. The Celsius scale on a common laboratory thermometer ranges from 0 °C (the freezing point of pure water) to 100 °C (the boiling point of pure water). The interval between these two points is divided into 100 equal parts and each part represents a change of 1 °C.
2. In the Kelvin or absolute scale, the freezing point of water is 273 K and the boiling point of water is 373 K. The Kelvin (K) is the S.I unit of temperature.

Relationship between Celsius scale and Kelvin scale

Note: The Kelvin scale is the universal temperature scale. Ensure that the learners understand the relation between the Kelvin and the Celsius scale.

Activity 5.4: Comparing Celsius scale and Kelvin scale

Ask the learners to do this activity by completing Table 5.2 below.

Table 5.2: Converting temperature from different scales

Temperature (^{o}C)	Temperature (K)
0	273
53	
	350
	370
100	373

Using the results in the table, in a class discussion, ask the learners to derive a general formula that relates the Celsius scale to the Kelvin scale.

Then assess them based on the exercise below.

Exercise:

1. Convert the following temperature readings to Celsius scale: (i) 1000 K (ii) 234 K (iii) 100 K (iv) 783 K
2. Convert the following temperature readings to Kelvin scale: (i) 40 ^{o}C (ii) 68 ^{o}C (iii) 34 ^{o}C (iv) 25 ^{o}C

Thermometric liquids

Liquid in glass thermometers use certain liquids due to certain qualities. In a class discussion, let the learners compare the two common liquids used in thermometers i.e. mercury and alcohol. Some of their advantages are shown in Table 5.3 below.

Table 5.3: Comparing thermometric liquids

Mercury	**Alcohol**
• It is opaque and makes reading easy.	• It is colourless and makes reading difficult. It needs colouring.
• It expands regularly.	• It has some irregular expansion.
• It has a high boiling point, 357 ^{0}C.	• It boils at 78 ^{0}C.
• Freezes at -39 ^{0}C.	• It freezes at -115^{0}C.

Using the table and any other suggestions by the learners, ask them to try out the following questions:

1. State reasons why mercury is usually preferred to alcohol as a thermometric liquid.
2. What are the advantages of alcohol over mercury as a thermometric liquid?
3. Suggest reasons why water is never used as a thermometric liquid although it is fairly abundant.

Variations in daily and atmospheric temperature

Ask the learners why it is normally colder at night than during the day. Using their responses, introduce the concept of **diurnal change** in temperature.

Introduce the concept of earth rotation as the driving force behind temperature difference between day and night.

Note: The earth receives heat during the day by solar radiation, but continually loses heat by surface radiation. Warming and cooling depend on an imbalance of solar and surface radiation. During the day, solar radiation exceeds surface radiation and the surface becomes warmer. At night, solar radiation ceases, but surface radiation continues and cools the surface. Cooling continues after sunrise until solar radiation again exceeds terrestrial radiation. Minimum temperature usually occurs after sunrise, sometimes as much as one hour after. The continued cooling after sunrise is one reason that fog sometimes forms shortly after the sun is above the horizon.

Atmospheric temperature is a measure of temperature at different levels of the earth's atmosphere. It is governed by many factors, including incoming solar radiation, humidity and altitude.

The amount of solar energy received by any region varies with seasons, latitude and time of day. These differences in solar energy create temperature variations. Temperatures also vary with differences in relief and with altitude.
The amount of ground-level atmospheric temperature ranges depends on several factors, such as:

- Average temperature
- Average humidity

- Regime of winds
- Proximity to large bodies of water, such as the sea

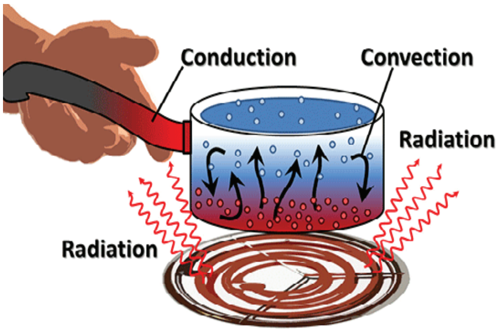
These concepts will be discussed in the next chapter.

Consolidate the chapter by discussing the end-of-chapter summary. Allow the learners to make their own summary as well.

Scoring the activity of integration

OUTPUT	C_1	C_2	C_3
A weather chart and a written explanation indicating the importance of a weather chart and how it is useful			

Chapter 6: Heat Transfer



Key words	***By the end of this chapter, the learners should be able to***:
▪ Conduction ▪ Convection ▪ Convection currents ▪ Land and sea breeze ▪ Radiation ▪ Absorbers ▪ Emitters ▪ Greenhouse ▪ Global warming	▪ *understand how heat energy is transferred and the rate at which heat transfer takes place.* ▪ *understand what is happening at particle level of conduction, convection and radiation.*

Chapter overview

Heat is a form of energy in transit. As it has been seen in the previous chapter, heat causes a temperature change in different objects. It can also be transferred from one body to another. As you teach this chapter, help the learners to appreciate the different modes of heat transfer and how they are applied.

Introduction

Ask the learners what they notice when they put a cold, metal teaspoon into a hot cup of tea, or why they feel warm when cooking or ironing, or when one sits or stands near a fire or in the sunshine. From their response, introduce the concept of heat transfer.

Methods of heat transfer

Activity 6.1: Identifying methods of heat transfer

Figure 6.1: Methods of heat transfer

Ask the learners to look at **Figure 6.1** above and answer the following questions.

1. How does heat from fire reach our bodies?
2. How does heat from the fire reach the water in a saucepan?
3. Why does a lit candle melt?

From the responses given by the learners and using **Figure 6.2**, develop the concept of heat transfer methods i.e.

a) conduction
b) convection
c) radiation

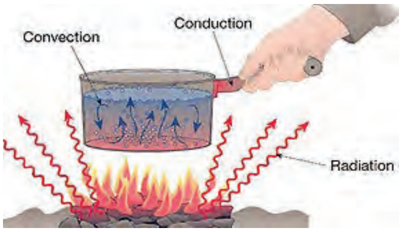


Figure 6.2: Processes of heat transfer

Conduction

Ask the learners to hold one end of a metal bar and place the other end in burning charcoal/Bunsen flame for some time. Let them state how they feel.

By using the learners' responses and **Figure 6.3** below, initiate a discussion on the process of **conduction.**

Note: During conduction, heat is transferred through a solid without movement of any part of the solid. This should be clarified to the learners.

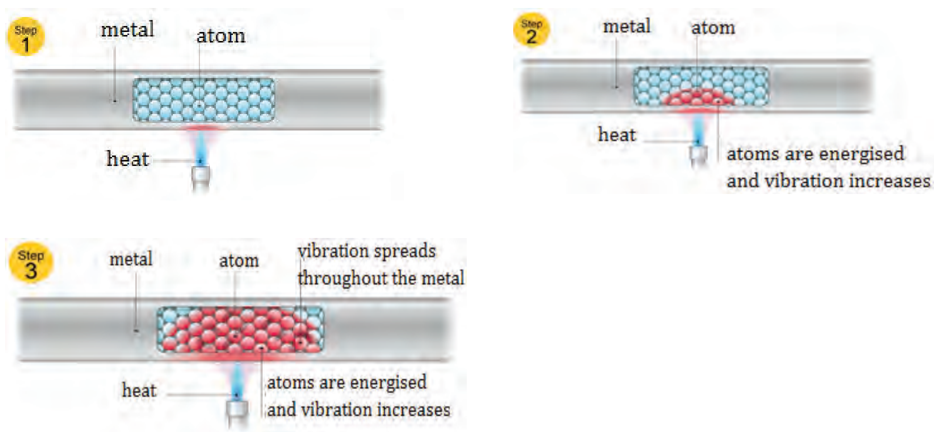


Figure 6.3: Heat transfer by conduction

Good and bad conductors of heat

A good conductor of heat is a material that easily allows heat to pass through it.

An insulator is a material that doesn't easily allow heat to pass through it. Initiate a discussion on these materials and ask the learners to suggest examples of such materials and where they are applied.

Activity 6.2: Study of heat conduction

Provide the following to each group of learners:

- Metallic, wooden and plastic spoons (or any different materials you can find around)

- Hot water, cold water, a plastic jug with a lid

Caution: The learners should handle hot water carefully to avoid burns.

What to do

Let the learners go through the procedure by referring to **Figure 6.4** below.

Figure. 6.4: Study of conduction of different materials

After the procedure, they should answer questions, such as:

1. Name the material that felt:
   a) warmest
   b) coldest
2. Replace the hot water with cold water and repeat procedures (c) and (d).
3. Explain the temperature changes of the spoons in (1) and (2) above.

Factors affecting rate of heat conduction

The rate of heat transfer in a metallic conductor depends on a number of factors. The learners should carry out the experiments below to investigate these factors.

Activity 6.3: Rate of heat conduction through different materials

Provide the following to each group of learners:

Equal lengths of copper, iron, aluminium and wood rods of the same diameter; wax and some similar coins; Bunsen flame and a triple stand.

Guide the learners to set up the apparatus as shown in Figure 8.5. Then let them carry out the procedures for (a), (b), (c) and (d), and record their observations and conclusions.
Based on their conclusions, broaden the discussion on the factors that affect the rate of conduction to take place.

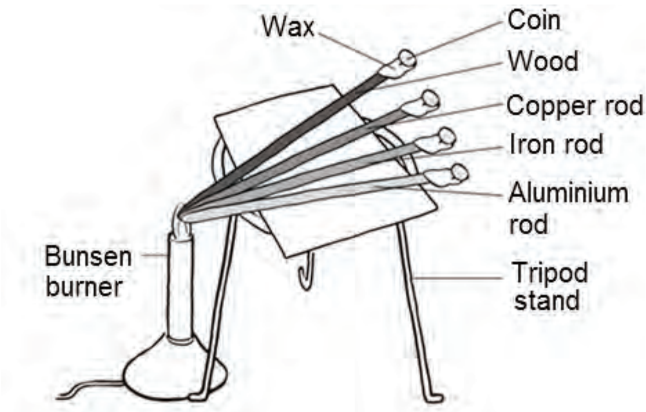


Figure 6.5: Investigating rates of conduction

Hint: You may help the learners to design alternative experiments for the above.

Application of conductors in daily life

Ask the learners to suggest applications for good conductors. They include:

i) Mercury is used in thermometers to absorb heat and show temperature.
ii) Aluminium is used for making cooking utensils to absorb heat quickly.
iii) Motor vehicle engines and radiators are made of iron to conduct away heat quickly.
iv) Refrigerators have copper pipes at the back for conducting away heat from coolant.
v) A wire gauze conducts heat quickly to the container placed on it for heating.

vi) The iron plate of an electric iron is made of steel to absorb heat quickly.

Application of insulators in daily life

Like the case with conductors, the learners should suggest applications of insulators. They may include the following:

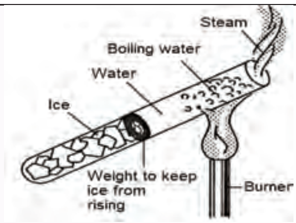
i) The handle of a frying pan is made up of wood or plastic so that it is not hot.
ii) A Styrofoam box is used for storing ice.
iii) Sawdust is used for covering ice to prevent the ice from melting quickly.
iv) Hot teapots are placed on table cloth or mat to prevent the heat from damaging the table top.
v) Wooden spoons are used to stir soup when cooking.
vi) Blankets are used for keeping our body warm.
vii) Woollen clothes are worn when cold to decrease heat loss.

Note to learners: The process of covering a good conductor with a poor conductor to prevent heat transfer is called **lagging.**

Activity 6.4: To show that water is a poor conductor of heat

Provide the following to each group of learners:

- Ice blocks
- A weight
- Long hard glass tube
- Bunsen burner
- Some water

Let the learners go through the procedure by referring to **Figure 6.6** and then should: a) state what they observe. **b)** suggest a reason for their observation.	 **Figure 6.6: Proof that water is a poor conductor**

Convection

Initiate a discussion on motion of particles in liquids and gases that was learned from Chapter 3 on 'States of Matter'. This is the basis for convection. **Convection** happens when particles with a lot of heat energy in liquid or gas move, and take up the place of particles with less heat energy as illustrated in **Figure 6.7** below.

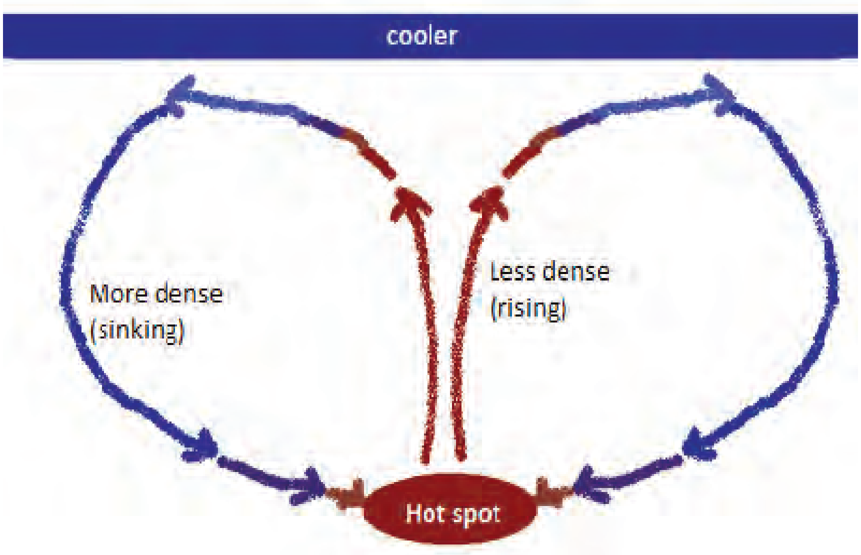


Figure 6.7: Illustration of convection

Convection in liquids

When liquid is heated, its particles closer to the heat source gain energy, expand, become less dense and rise. Meanwhile the denser, colder particles at the top move downwards to replace the rising hot particles. As a result, the heated fluid moves upwards as the cooler fluid moves downwards.
This results in a continuous movement of the water particles. The movement of the particles is called convectional currents.

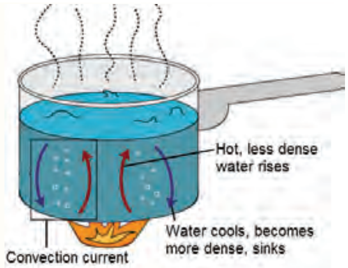


Figure 6.8: Convection in liquids

Activity 8.5: Investigating convection in liquids

Provide the following to each group of learners:

- Glass beaker or round bottomed flask and straw
- Heat source
- Potassium permanganate crystals and water

Caution the learners to be careful with heat to avoid burns

What to do

Ask the learners to follow the instructions and carry out the activity. They may refer to the **Figure 6.9** below.

Figure 6.9: Demonstration of convection in a liquid

The learners should:

1. state what they observe.
2. give an explanation for their observation in a group discussion.

Ask the learners to suggest the applications of this phenomenon.

Convection in gases

Ask the learners to compare the motion of particles in liquids and gases. From their responses, initiate a discussion on convection in gases, such as convection in air.

Activity 8. 6: Demonstrating convection in air

Provide the apparatus shown in **Figure 6.10** and let the learners carry out the activity.

Then let them state their observations.

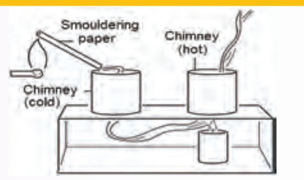


Figure 6.10: Showing convection in air

Exercise 6(a):

As a mid-chapter checkpoint, let the learners do the following brief exercise and assess their responses.

1. What is meant by convection current?
2. Briefly describe an experiment to show:
   i) convection in liquids.
   ii) convection in gases.

Application of convection

Figures 6.11, 6.12 and **6.13** show some of the applications of convection. Ask the learners to describe what is happening in each of the processes.

Fig. 6.11: Sea breeze

Fig. 6.12: Land breeze

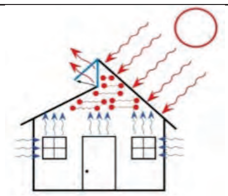


Fig. 6.13: Air convection in ventilation

Other applications of convection include:

Boiling water

The heat passes from the burner into the pot, heating the water at the bottom. Then, this hot water rises and the cooler water moves down to replace it, causing a convection current.

Hot air balloon

A hot air balloon is an aircraft consisting of a bag called an envelope full of heated air. A heater inside the balloon heats the air and so the air moves upward. This hot air gets trapped inside the balloon and causes it to rise. When the pilot wants to descend, he or she releases some of the hot air and cool air takes its place, causing the balloon to lower.	 **Figure 6.14: Convection in hot air balloon**

Cooling radiator

A radiator is a device for cooling the engine in a motor vehicle or an aircraft. It consists of many thin tubes in which circulating fluid is cooled by the surrounding air. The hot fluid coolant (air or water) from the engine rises through the radiator and is cooled by air and goes back to the engine.

Room heaters

In cold places, a heater is used to heat air which expands and rises. This heated air is replaced by the denser cold air creating a convection current that warms the room.

Refrigeration

In a fridge or freezer, air that is warmed by the things that have been put inside rises, while cold air from the freezing unit sinks due to its greater density. Hence, a cycle will go on and a convection current is produced.

Radiation

Introduce the concept of radiation by comparing conduction and convection. Initiate a discussion, such as inquiring how heat from the sun reaches us on earth. Then in a discovery session use the concept of vacuum to help the learners appreciate the concept of heat transfer without a material medium, unlike conduction and convection. You may use some of the following:

- Radiation is how we can feel the heat of the sun even though it is millions of kilometres away in space.
- Infrared cameras give images even in the dark, because they can detect heat not visible light.

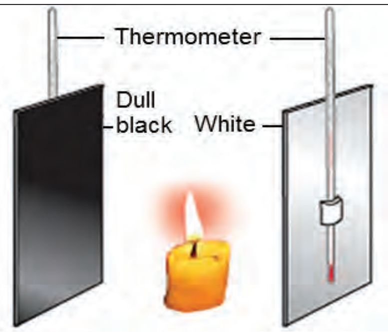
Factors that affect the emission and absorption of thermal radiation

Initiate a discussion on these factors, based on daily observations such as clothes and walls of buildings. For example, for the nature of surfaces, you may use the comparisons below.

Comparison of surfaces and their abilities to reflect and absorb thermal radiation

Colour	Finish	Ability to emit radiation	Ability to absorb radiation
Dark	Dull	Good	Good
Light	Shiny	Poor	Poor

Demonstrating absorption of radiation at different surfaces (this may be done as class demonstration because the apparatus may not be readily available to all the learners).

A heat source is placed at a point exactly between two flat surfaces made of the same material, but one surface has a dull black colour while the other surface has a white shiny surface. The thermometer behind the dull surface reads higher temperature than the one behind the white surface. What does this mean? You can also ask the learners to explain what can happen if a coin is attached with wax behind each surface and the heat source is put in the middle.	 **Figure 6.15: Study of radiation**

Demonstrating emission of radiation at different surfaces (this may be done as class demonstration because the apparatus may not be readily available to all the learners)

Leslie's cube is a metal cube with four sides prepared in different ways: shiny black, dull black, white or silver. It can be filled with hot water or heated electrically so that all four sides have the same temperature. Temperature at a fixed distance from each side of a Leslie's cube is measured using thermometer or a device called a thermocouple. It is observed that the highest temperature is recorded with the face that is dull black.	 **Figure 6.16: Leslie's cube**

Note: In a group discussion, help clarify that the better radiator is also the better absorber of heat. At the same temperature, dark dull surfaces emit (give out) more radiation than light shiny surfaces. Dark dull surfaces are better absorbers (poorer reflectors) of radiation than light shiny surfaces.

Activity 8.7: Study of absorption of radiation at different surfaces

Provide the following to each group of learners:

- Three metallic cans, cello tape or masking tape
- Scissors, paper, black polythene, thermometer

Caution:

Caution the learners to take care not to injure themselves since they are dealing with some sharp objects.

Allow the learners to go through the procedure as they record their observations in the table below the diagram.

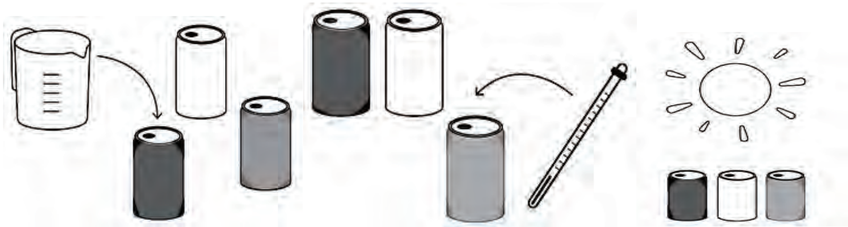


Figure 6.17: Comparing absorption of radiation at different surfaces

Results:

Surface	**Initial temperature (°C)**	**Final temperature (°C)**	**Temperature change (°C)**
Shinny			
White			
Black			

After the activity, ask learners to:

1. calculate the temperature change in each can.
2. state in which metal can there was:
   i) the highest temperature change.
   ii) lowest temperature change.
3. give an explanation for their observations in question 2 above.

Activity 8.8: Study of emission of radiation at different surfaces

You should provide the following to each group of learners:

- A metallic can, cello tape or masking tape
- Scissors, hot water at 80° C, thermometer
- A box that has a lid, stop clock
- Black polythene and white polythene (or paper)

Caution the learners to use cloth or paper towel to avoid burns and scalds.

Lead the learners to go through the procedure for this activity and let them record their observations in a table as shown below.

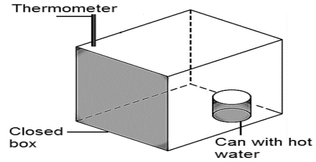


Figure 6.18: Comparing emission of radiation

Results

Time (min)	1	2	3	4	5
Temperature of black surface (°C)					
Temperature of white surface (°C)					

After the activity, the learners should answer the following follow-up questions:

1. Which surface produced higher temperatures?
2. Suggest an explanation for your answer in question 1 above.
3. Are the results of this experiment accurate?
   Suggest reasons to support your answer.

Exercise 8(b):

Assess how the learners communicate in the following mid-chapter exercise.

1. Give the difference between:
   i) convection and conduction.
   ii) conduction and radiation.
2. Briefly describe the following observations:
   (i) Ovens are black inside.
   (ii) Solar panels are matt black.
   (iii) Fridges are usually painted white.

Application of thermal radiation

In a class discussion, the learners should suggest applications of heat radiation. Some of them include:

i) Heat from the sun reaches the earth by the process of radiation. There is a vacuum in space between the sun and the earth. Heat can only be transferred through this vacuum by radiation.

ii) Heating radiators and fireplaces use the process of radiation to transfer heat to people sitting around it, or to warm the room.

iii) People in hot places like deserts wear white or light-coloured clothes because these are poor absorbers and good reflectors of heat.

iv) Cooling radiators of heat in cars, machines and air conditioners are painted black so as to have cooling effect by radiating most heat.

v) Room (electric) heaters have bright polished surfaces which act as good reflectors of heat. Such surfaces absorb very little heat and reflect most of the heat radiations. These surfaces remain cool even after continuous use of heaters.

vi) Highly polished spacecraft surface reflects most of the heat radiated from the sun.

vii) Buildings which are white-washed or painted in light colours are cooler in hot weather, since the light surfaces reflect radiant heat from the sun.

viii) Brightly polished objects retain their heat for a long period; for example, silvered kettles and teapots. Hot food is also kept in aluminium foils and flasks.

Fridge or grill Aluminium foil Car radiator Solar water heater

Figure 6.19: Ask the learners to identify these applications of thermal radiation.

The vacuum flask

This is a common device. You should obtain a flask or a used/spoiled one and open it for the learners to observe the features as shown in **Figure 8.20** below. Then in a class discussion, let them explain how these features help to minimize heat losses for the contents in a flask.

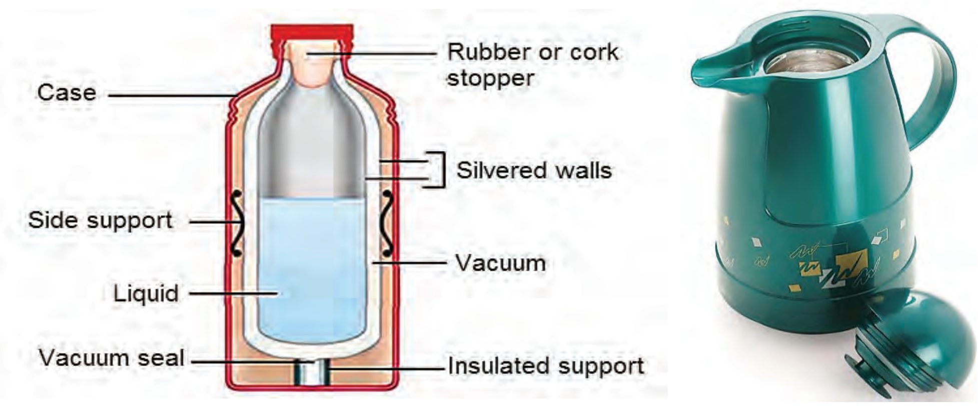


Figure 6.20: Parts of a vacuum flask

After the learners have discussed how the features of the vacuum flask help to minimize heat losses, allow for group discussions in which they suggest why the contents of the flask eventually cool down.

***Note*:** Some flasks are not vacuum flasks. Ask the learners to read and make short notes on how such flasks minimize heat loss.

A heat trap (greenhouse)

A *greenhouse* is a structure with walls and roof made of transparent material, such as glass or plastic, in which plants that require regulated climatic conditions are grown.

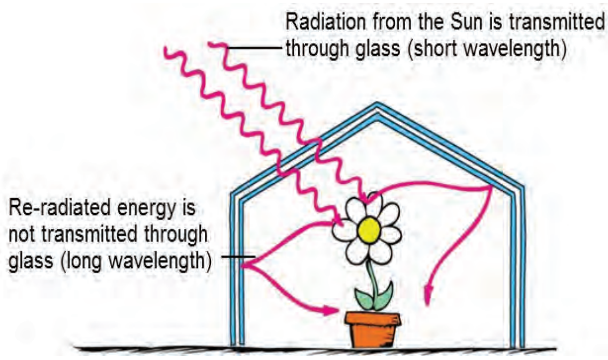


Figure 6.21: How radiation keeps a greenhouse warm

If possible, help the learners to construct a greenhouse as a class project. They should write brief notes about how the greenhouse works.

Greenhouse effect

The greenhouse effect is the process by which radiation from the atmosphere warms the surface of the planet to a temperature above what it would be without its atmosphere.

As the sun's rays enter our atmosphere, most rays continue to the surface of the planet. As they hit the soil and surface waters, these rays release much of their energy as heat. Some of the heat then radiates back out into space.

However, certain gases in our atmosphere, such as carbon dioxide, methane and water vapor, work like a blanket to retain much of that heat. This helps to warm our atmosphere. The gases do this by absorbing the heat and radiating it back to the earth surface. These gases are called "greenhouse gases" because of their heat-trapping effect.

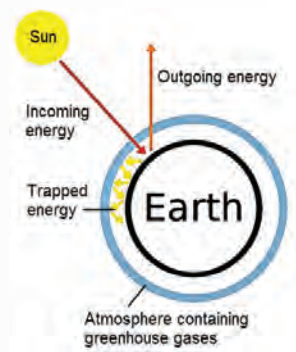


Figure 6.22: Greenhouse effect

The concept of *greenhouse effect* is a global issue. Ensure that the learners debate this issue with emphasis on how human activities lead to *greenhouse effect* and how it can be mitigated.

End of chapter summary

In addition to the key points provided in the summary in the *Learner's Book*, ask the learners to state any other important aspects which they have learnt from this chapter.

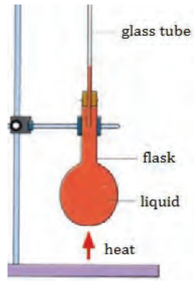
Then assess the end-of-chapter exercise. Consider how the learners communicate.

Scoring the situation of integration

OUTPUT	C_1	C_2	C_3	C_4
Written explanation and diagram of the most suitable house for a dry region.	Scores 1 if he/she states the need to use materials that do not absorb heat.	Scores 2 if he/she states the need to use materials that do not absorb, conduct or reflect heat and describes the materials.	Scores 3 if he/she gives detailed information about the use of materials that do not absorb, conduct or reflect heat and describes the materials and which part of the house should have them more than the others.	Score 1 for explaining how to stay cool inside a house during hot weather (for excellency)

Chapter 7: Expansion of Solids, Liquids and Gases





Key words	***By the end of this chapter, the learners should be able to:***
▪ Expansion ▪ Thermostat ▪ Anomalous expansion	*a) understand that substances expand on heating, and recognize some applications of expansion.* *b) understand the effects and consequences of changes in heat on volume and density of water.* c) *appreciate the anomalous expansion of water between 0 °C and 4 °C and its implications.*

Chapter overview

This chapter examines how substances change in volume/size when they are heated. When teaching this chapter, you should help the learners to appreciate the causes of the differences in expansion between solids, liquids and gases based on the particle nature of matter. The learners should also be helped to appreciate the applications of the expansion of solids, liquids and gases.

Introduction

Introduce the chapter by asking the learners the effects of heat on substances which have been discussed in the previous chapters.

If among the learners' responses there is no movement of particles, try to see how it comes out to lay a foundation for expansion. Consider also cooling down of substances that causes **contraction.**

Note: All states of matter expand when heated and contract when cooled. Gases expand most compared to solids and liquids. Initiate a mini-discussion on this issue, using the kinetic theory of matter. Therefore, use expansion to explain the evidence for particles.

Expansion of solids

Activity 7.1: To find out what happens when solids are heated

Key question

Do solids expand when we heat them?

Provide the following to each group of learners, where possible.

- Metal ball and ring
- Spirit burner

What to do

1. Ask the learners to suggest experimental procedure for the arrangement shown.
2. Let the learners do the experiment, observe what happens and describe it in their own words.

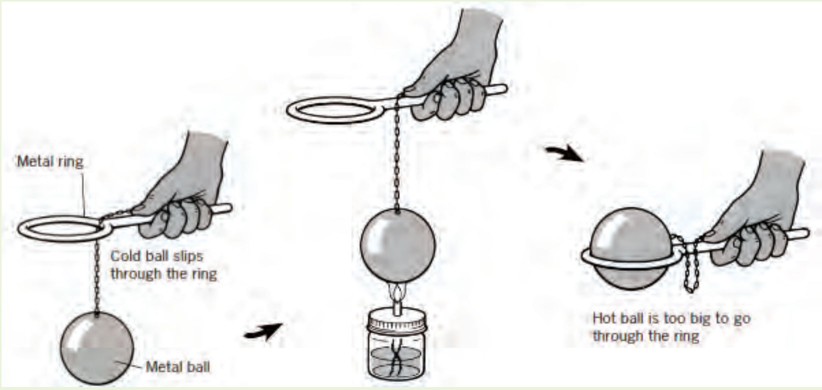
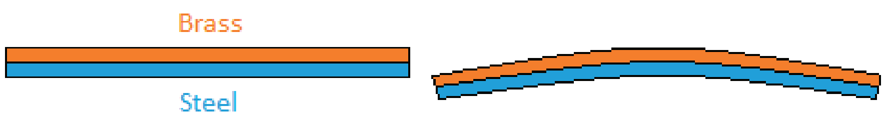


Figure 7.1: Ball and ring experiment

From the results of the experiment, in a discussion, ask the learners to explain what happens when solids are heated.

This concept can be demonstrated using a bimetallic strip. Where possible carry out a class demonstration and ask the learners to state their observations. The appearance of the strip before and after heating is indicated in **Figure 7.1** below.



(a) Before heating (b) After heating

Figure 7.2: Bimetallic strip

Initiate a discussion on the applications of the bimetallic strip experiment. Thereafter introduce devices that use a **thermostat** like the one in the lighting system below.

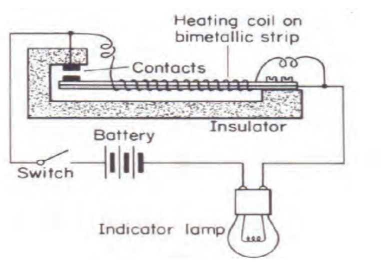


Figure 7.3: Aflasher unit that uses a thermostat

In their own words, ask the learners to describe how the above works.

Conclude this aspect by asking the learners to suggest what other devices apply the above system.

Implications of expansion of solids

This concept is of great concern in engineering. Ask the learners to look at **Figure 7.4** showing how rails are arranged. Ask them to explain the significance of the design, i.e. the gaps in the rails.

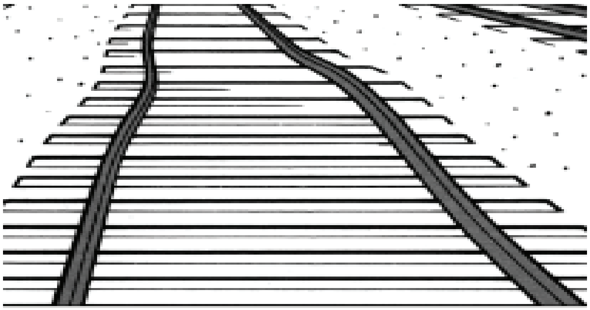


Figure 7.4: These rails have buckled in the heat because there was no expansion gap.

Expansion of liquids

Do liquids expand when we heat them?

Activity 7.2: Observing liquid expansion

Provide the following to each group of learners:

- Test tubes
- Beakers
- Stoppers
- Glass tubes
- Water
- Coloured water

What the learners should do

1. Ask the learners to set up the apparatus in the experiment as shown below.
2. Let the learners do the experiment, observe what happens and describe it in their own words.

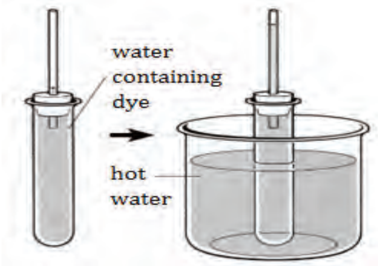


Figure 7.5: Liquid expansion

Assess how the learners communicate.
In a group discussion, let the learners suggest why it is easier to observe liquid expansion than solid expansion.
Also relate liquid expansion to instruments such as thermometers and others.

Rates of expansion of liquids

Do liquids expand by the same amount when heated through the same temperature change? The following activity will help the learners answer this question.

Activity 7.3: Comparing rates of liquid expansion

Provide the following where possible. For the liquids, you may provide alternatives provided they are not poisonous.

- Four glass flasks of the same size with narrow stems
- Bathwater maintained at the same temperature
- Equal quantities of water, ether, benzene and alcohol (Do not consume any of these liquids.)

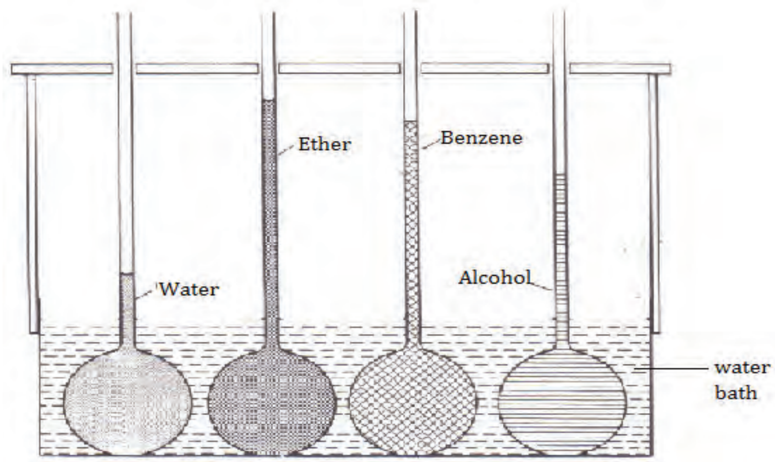


Figure 7.6: Comparing liquid expansion

Allow the learners to carry out the activity. Then they should:

- state their observations.
- make conclusions from their observations.

Anomalous expansion of water

Using the results of **Activity 7.3**, ask the learners to sketch graphs for the variation of volume and density with temperature for the different liquids. This should lead to the graph of water which shows a difference, and hence the **anomalous expansion of water.** Graphs for the anomalous behaviour of water are shown below.

In a group discussion, let the learners explain these graphs. You can intervene where necessary.

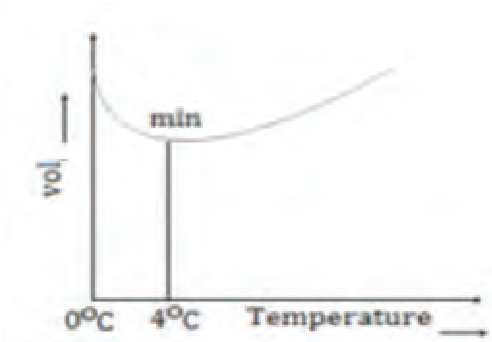


Figure 7.7: Variation of volume of water with temperature

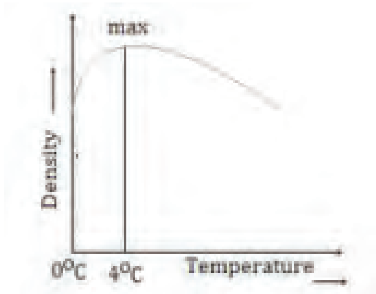


Figure 7.8: Variation of density of water with temperature

In a class discussion, help the learners appreciate the differences between the density of ice and water. Where possible, you can try to put pellets of ice in water and see whether they float. This can be used as further evidence for the anomalous expansion of water.

Using **Figure 7.9**, initiate a discussion on the significance of this behaviour and where it is likely to occur and its significance.

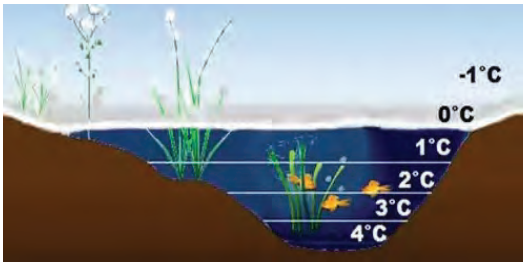


Figure 7.8: Anomalous expansion of water

Expansion of gases

Do gases expand when we heat them?

Activity 7.4: Demonstrating gas expansion

Provide the following to each group of learners:

- A bent capillary tube
- A straight capillary tube
- A test tube
- A beaker of water
- A stopper

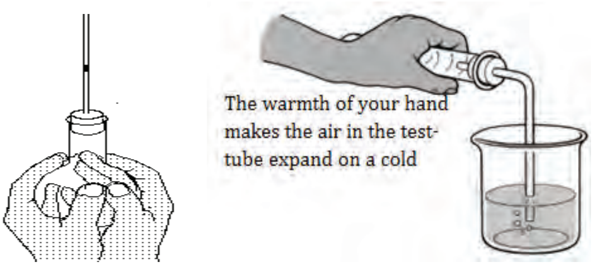


Figure 7.10: Gas expansion

What to do

1. Ask the learners to set up the apparatus in the experiments as shown above.
2. Let the learners write their own experimental procedure using the apparatus.
3. The learners should then do the experiment, observe what happens, and describe it in their own words.

In a group discussion, the learners should explain what causes the observations in the activity.

Assess how the learners communicate and how they respond to different views from their peers.

evidence to this is seen from the observable expansion with the heat just from your hand.

Note: Gases expand almost 3000 times more than solids when they are heated over the same amount of temperature.

Note: Gas expansion is manifested in many ways in everyday life. During functions, balloons used for decoration normally burst in hot weather. The learners should suggest reasons why this happens. In a class discussion, help the learners to identify other instances in which gas expansion is not desirable.

Chapter summary

- All the states of matter expand when heated and contract when they cool down.
- Expansion of solids has various applications and disadvantages.
- Expansion of liquids is applied in thermometers.
- Water does not expand uniformly like other liquids.
- Gases expand more than solids and liquids because their particles are very far apart.

In groups, ask the learners to suggest other key points learnt from this chapter, in addition to those above.

Assess the end-of-chapter exercise to see whether the learners have understood the concepts of expansion.

Scoring the activity of integration

OUTPUT	C_1	C_2	C_3	C_4
Written explanation about the effects of expansion				(for excellency)

Chapter 8: Nature of Light; Reflection at Plane Surfaces

Key words	*By the end of this chapter, learners should be able to:*
▪ Shadows ▪ Umbra ▪ Penumbra ▪ Linear propagation ▪ Eclipse ▪ Reflection ▪ Lateral inversion ▪ Periscope	*a) identify illuminated and light source objects in everyday life.* *b) understand how shadows are formed.* *c) understand how the reflection of light from plane surfaces occurs, and how we can make use of this.*

Introduction

This chapter introduces one of the commonest phenomena—light. It was partly studied in Primary Science. Light is a form of energy that we cannot easily live without. The learners will be able to investigate how light travels and the applications related to it.

Most of the activities can be done using readily available materials. In this chapter, you should encourage the learners to draw proper diagrams of light rays.

Ask the learners why they need light, and what would happen if there was no light for some days. They may refer to the introductory pictures. You may need to **assess the confidence** with which they talk about this issue.

Where does light come from?

Activity 8.1: Identifying sources of light

Begin by asking the learners to state where light comes from. Let them use the grid shown in the *Learner's Book* to identify some sources.

From the various sources of light given, task the learners to classify them as natural and artificial (in the table provided). Then for the natural sources of light, help the learners to distinguish between them in terms of self-luminous and the non-self-luminous. Help them to sort out any misconceptions of luminous and non-luminous objects.

How light travels

Ask the learners if they have seen the lights of a car at night, or you can flash a torch in a dark corner. The 'lines of light' originating from these sources are **rays.** If the learners can observe many of these lines, then you initiate the concept of the types of beams of light.
For each type of beam, ask the learners where it is found.

Activity 8.2: Investigating the path of light

Lead the learners through this brief activity. Let them use their results to identify the three types of rays i.e. convergent, divergent and parallel rays.

Activity 8.3: Investigating how light travels

In this activity, the learners will investigate how light travels. To each group of learners, provide the following:

- A long string (about 2 metres)
- A source of light e.g. a candle or a bulb
- Glue
- Three cardboard papers
- A nail
- Wooden blocks of the same dimensions

Let the learners plan this activity on their own, including a diagram to illustrate what they do during the activity.
Assess how the learners write a brief procedure for the activity and state the observation.

How shadows are formed

Activity 8.4: Identifying transparent, translucent and opaque objects

Introduce this by asking the learners to look through a glass, piece of paper and a thick book (**Activity 8.4**). Using the observations in the three cases above, initiate a discussion on transparent, translucent and opaque objects.
Discuss with the learners why shadows are formed and the regions of the shadow. Allow them to demonstrate shadows and their regions.

Activity 8.5: Demonstration of umbra and penumbra

Lead the learners through the activity that locates umbra and penumbra.
Provide the following materials to each group of learners:

- Two sources of light e.g. bulbs (one should be bigger than the other)
- Two cups of different sizes (or any other opaque objects)
- A large screen (e.g. manila paper)

Let the learners go through the steps of the activity in the *Learner's Book*. Ask them to locate and shade the regions of the shadows formed.

Then ask them how shadows occur in everyday life. This should be the best point to introduce the ideas of day and night and eclipses.

Eclipses

Ask any one learner who has seen an eclipse in recent times to tell the class what the eclipse is. Discuss with them how an eclipse is formed, and if there are any myths about it. Help them to clarify using scientific knowledge.

Using the diagrams in **Figures 8.3**, **8.4** and **8.5** in the Learner's Book, allow learners to describe how eclipses are formed. Help the learners to draw a distinction between the solar and lunar eclipse.

It is very important to assess how they draw rays showing the direction of light.

Caution: Remind the learners never to look directly into an eclipse because they may become blind.

Note: Help the learners to distinguish between partial and total eclipse and assess the diagrams of the ray.

Activity 8.6: Making a model of an eclipse in class

A model of an eclipse can be made in class. First try out this activity before you give it to the learners. Then provide the following to each group of learners.

- Bulb
- Bulb holder
- Switch
- Small ball
- Cardboard with a small hole
- Large cardboard or large ball or globe

Using the above apparatus, ask the learners to plan an activity for demonstrating the formation of an eclipse. In groups, assess how they state the steps used in carrying out the activity and how they identify what each of these materials represent in real situation.

The pinhole camera

This is a simplified form of camera that can be used to observe mages of objects and utilizes the fact that light travels in straight lines.

Let the learners sketch the pinhole camera and assess how they draw the arrows from the object to the image.
Briefly lead the learners through **Activity 8.7** and help them to identify characteristics of the images formed in a pinhole camera.
In the 'test yourself' activity, assess how the learners state the formula, how they harmonise units, how they substitute and state the final answer. (**Answer = 10 cm)**
You should provide other similar tasks to the learners.
In the project, assess how the learners assemble the materials, how they state the procedure and how they describe the images formed by their cameras.

Reflection of light by plane surfaces

Begin by asking the learners why they are able to see objects yet they do not produce light on their own. Then ask why some objects are dark or bright. This forms a basis for the discussion on reflection of light.

Using a plane mirror and other materials, ask the learners to look at themselves and why they are able to look at themselves using the mirror. Point out to them that in a plane mirror, there is maximum reflection.
Then discuss with the learners what incident ray, reflected ray, angle of incidence, angle of reflection and the normal are. Remember these are imaginary and cannot be seen physically.

Activity 8.8: To demonstrate the laws of reflection

Reflection of light is governed by two laws. Lead the learners to discover these laws by carrying out this activity.

Provide the following apparatus to each group of 5-10 learners.

- Optical pins
- Plane mirror
- Soft board
- Protractor
- White sheet of paper

Ask the learners to carry out the activity using the procedures in the *Learner's Book* as you move around checking on the progress of the work.

After the activity, assess how the learners summarise the findings of the activity. From the findings, help them to formulate the laws of reflection of light.

Images formed in plane mirror

This is an interesting sub-section which you should treat practically. We all use plane mirrors to look at ourselves, so you should use the learners' experiences.

Activity 8.9: To investigate properties of images in the lane mirror

Provide the following to each group of learners:

- Some white paint or a small piece of paper
- A plane mirror

Ask the learners to put a mark near their left eye and ask them to look at themselves. Ask on which eye the mark appears is seen in the plane mirror.

Using the learners' responses, ask them to write on manila or chalkboard the properties of images formed by a plane mirrors. Assess how they communicate.

Ask the learners to do the `test yourself' question in the learners' book.

Assess how learners draw a sketch diagram and how they apply the laws of reflection to solve this problem and how they state the answer.

(Answer= 24 cm)

Provide similar tasks to the learners

After the activity, assess how the learners summarise their findings of the activity. From the findings, help learners to formulate the laws of reflection.

Mirrors inclined to each other

Help the learners to incline two plane mirrors with an angle of 90^0 between them. Ask them to assemble **Figure 8.10**. Ask them to count the number of images formed.

Activity 8.10: Investigating images formed by inclined mirrors at various angles

Provide the learners with two plane mirrors and objects such as candles.
Lead the learners through the activity and help them to develop a formula for calculating the number of images formed by inclined plane mirrors.

Regular and diffuse reflection

Initiate a discussion on this concept. Ask the learners to draw diagrams of the ray, showing regular and diffuse reflections and assess them.

Applications of plane mirrors

Ask the learners to state as many applications of plane mirrors as possible. Some learners' responses may be repeated, so make clarifications. Some of the learners' responses will lead to the project work/situation of integration.

End of Chapter Exercise

Let individual learners try out the end-of-chapter exercise and assess their responses. A learner who scores two thirds of the maximum score will be taken as one that has achieved the outcomes of the sub-topic.

Scoring grid for the integration

OUTPUT/ PRODUCT	**Relevance of the production**	**Coherence of the narrative**	**Accuracy**	**Working product**
A designed periscope, a write up of how it works and its pictorial illustration	• Learner earns two points by designing a periscope and showing how it works without a write up • Learner earns a point by designing a periscope	• Learner earns 2 points if he/she describes the construction of a periscope in proper steps • Learner earns one point if he/she describes the construction of a periscope in any order	• Learner earns 3 points if he/she describes how a periscope works with illustration • Learner earns 2 points if he/she describes how a periscope works without illustration • Learner earns a point if he/she states that there is need to install a periscope.	Learner earns a point if he/she uses photographs/pictures to support the information in the write-up about the periscope.

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