DEPARTMENT OF EDUCATION

GRADE 9

SCIENCE

UNIT 1

WORKING SCIENTIFICALLY

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GRADE 9

SCIENCE

UNIT 1

WORKING SCIENTIFICALLY

IN THIS UNIT YOU WILL LEARN ABOUT:

TOPIC 1: MEASUREMENT
TOPIC 2: SCIENTIFIC APPROACH

Acknowledgement

We acknowledge the contributions of all secondary teachers who in one way or another have helped to develop this Course.

Our profound gratitude goes to the former Principal of FODE, Mr. Demas Tongogo for leading FODE team towards this great achievement.

Special thanks to the staff of the Science Department of FODE who played active roles in coordinating writing workshops, outsourcing lesson writing and the editing processes involving selected teachers of Central Province and NCD.

We also acknowledge the professional guidance provided by Curriculum and Development Assessment Division throughout the processes of writing and the services given by members of the Science Review and Academic Committees.

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DIANA TEIT AKIS

PRINCIPAL

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SECRETARY'S MESSAGE

Achieving a better future by individual students and their families, communities or the nation as a whole, depends on the kind of curriculum and the way it is delivered.

This course is part of the new Flexible, Open and Distance Education curriculum. The learning outcomes are student-centred and allows for them to be demonstrated and assessed.

It maintains the rationale, goals, aims and principles of the national curriculum and identifies the knowledge, skills, attitudes and values that students should achieve.

This is a provision by Flexible, Open and Distance Education as an alternative pathway of formal education.

The course promotes Papua New Guinea values and beliefs which are found in our Constitution and Government Policies and Reports. It is developed in line with the National Education Plan (2005 – 2014) and addresses an increase in the number of school leavers affected by the lack of access to secondary and higher educational institutions.

Flexible, Open and Distance Education curriculum is guided by the Department of Education's Mission which is fivefold:

- To facilitate and promote the integral development of every individual.
- To develop and encourage an education system that satisfies the requirements of Papua New Guinea and its people.
- To establish, preserve and improve standards of education throughout Papua New Guinea.
- To make the benefits of such education available as widely as possible to all of the people.
- To make the education accessible to the poor and physically, mentally and socially handicapped as well as to those who are educationally disadvantaged.

The college is enhanced through this course to provide alternative and comparable pathways for students and adults to complete their education through a one system, two pathways and same outcomes.

It is our vision that Papua New Guineans' harness all appropriate and affordable technologies to pursue this program.

I commend all the teachers, curriculum writers, university lecturers and many others who have contributed in developing this course.

UKE KOMBRA, PhD
Secretary for Education

COURSE INTRODUCTION

Dear Student,

Welcome to the Grade 9 Science Course with FODE. We hope that you will find this Course interesting.

About this Course
Your Grade 9 Course consists of six Unit Books, Six Assignments and an Examination.

- Units 1 to 6 have Lessons on different Topics. You will also find Practice Exercises and Answers to the Practice Exercises in each unit. You will correct your own Practice Exercises using the answers given at the end of each topic.

- Each unit has a corresponding Assignment consisting of Topic Tests on each Topic and a Unit Test on what is covered in a unit. Your Distance Teacher will mark the assignment.

The marks you score in the six assignments and the final examination will count towards your Final result.

Repeat Assignment and Cancellation
If you score less than 50% in any assignment, you will repeat that Assignment. If you fail three consecutive assignments, you will not be allowed to continue with the course. Therefore, you need to;

- revise well before doing the assignments

- answer all the questions to complete the assignments and

- check the answers carefully before sending them in for marking

Plan well, work regularly
Students at school have regular hours of study. They also have a teacher to help them with their work, but you have to work on your own. So, plan well and work regularly. It should you take you between 8 and10 weeks to complete this course.
Whenever you need help ask your;
- friends
- any high school teachers near you
- distance teachers near you or
- the Provincial coordinator

Another good idea is to study together with other students who are studying Grade 9 Science. In this way, you can successfully complete the course. We, in the Science Department at FODE, wish you well in your studies.

All the best!

UNIT INTRODUCTION

Dear Student,

Welcome to Unit 1 of your Grade 9 Science Course! I hope that you enjoyed studying the Grade 8 Units. This Unit, Working Scientifically is a skills course and requires a lot of concentration. If you study well, you will learn a lot. I hope that you will find this unit an enjoyable unit to study as well.

This Unit is based on the Lower Secondary Schools Science Curriculum.

In this Unit, there are two topics which comprises of 14 Lessons. The two topics are:

- **Measurement and**
- **Scientific Approach**

Each topic has seven Lessons. The lessons in the first topic will discuss about the different unit systems used in measurement. It will also teach on accuracy, reliability and errors in measurement. You will also learn about the measurements of different physical quantities.

The second Topic also has seven Lessons and will discuss about the rules for working safely in the science classroom. It will deal with first aid, observations and predictions as well as how to present data. You will also learn how to conduct a fair test, write parts of a science report and how to write a complete science report.

Remember, you must do all the activities and complete the Practice Exercises after each lesson. Answers to Practice Exercises are at the end of each Topic.

If you have any problems in understanding any of the lessons in this Unit, please do not hesitate to inform the Science Department at FODE Headquarters. This will help the teacher to revise the lessons for the next edition.

You may study this Unit now following the Study Guide on the next page.

All the Best!

STUDY GUIDE

Follow the steps given below to work through the lessons.

Step 1 Start with Topic 1 and work through it in order.

Step 2 When you study lesson 1, do the given Activities. When you complete the Activities, check your work. The answers are given at the end of the Lesson. (Note: Short lessons may not have an Activity.)

Step 3 You will also do a Practice Exercise at the end of each lesson. After you have completed the Practice Exercise, correct your work. The answers are given at the end of each Topic.

Step 4 Then, revise and correct any mistakes.

Step 5 When you have completed all the 4 steps, tick the check box for Lesson 1, on the Contents page, like this:

☑ Lesson 1: Unit Systems

Then, go on to the next Lesson. Repeat this process until you complete all the Lessons in the Topic. When this is done, revise using the Review Section.

Remember, as you complete each lesson, tick the box for that lesson on the Table of Contents page. This will help you check your progress.

Assignments

When you have completed all the lessons in a Topic, do the Topic Test for that Topic, in the Assignment Book. The Unit Book tells you when to do this.

When you have completed the entire Topic Tests for the Unit, revise well and do the Unit Test. The Assignment Book tells you when to do the Unit test.

When you have completed the entire Assignment Book, check and revise well before sending it to the Provincial Centre for marking.

If you have any questions, write them on the Student's page. You will receive a response and advice from your teacher when he/she returns your marked assignment.

The Topic Tests and the Unit Test in each Assignment will be marked by your Distance Teacher. The mark you score in the Assignment will count towards the final result. If you score less than 50%, you will repeat that Assignment.

Remember, if you score less than 50% in three consecutive Assignments, your enrolment will be cancelled. So, work carefully and ensure that you pass all the Assignments.

TOPIC 1

MEASUREMENT

In this topic you will learn about:

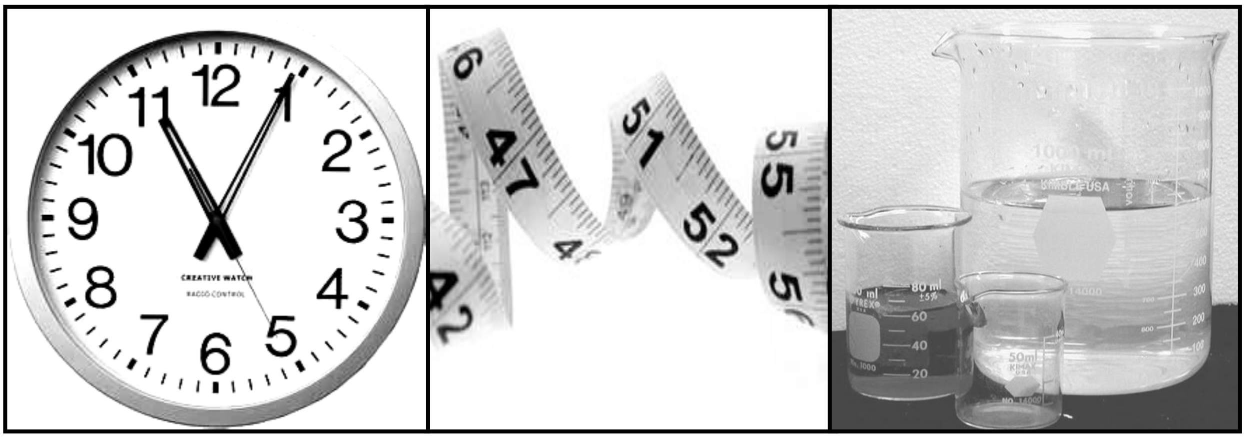
- **unit systems**
- **reliability and accuracy**
- **length**
- **time and temperature**
- **mass and weight**
- **volume**
- **density**

INTRODUCTION TO TOPIC 1: MEASUREMENT

In the past, people in different parts of the world used different units of measurement which were inconsistent and inaccurate.

Then in 1960, an internationally accepted unit of measurement was adopted commonly referred to as SI units for international use. The symbol SI comes from the French words **Système International d'Unitès.** The SI unit is the system of measurement that is most widely used around the world in everyday science and commerce.

When we study measurement we will be looking at the seven SI base units and the system of units of measurement that build around the seven base units.



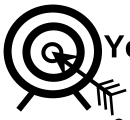
Some of the questions you may be asking yourself now are:

- What is measurement?
- How can we reduce errors and increase accuracy in measurements?
- How can we use different instruments correctly in measuring different physical quantities?

In this topic, you will find the answers to these questions as well as other questions relating to measurements.

Lesson 1: Unit Systems

Welcome to Lesson 1. Measuring is a very important part of science. Accurate measurements can help to solve scientific problems. In the past, people used several methods of measurement. The methods used were inconsistent and inaccurate. In fact, people in different parts of the world used different units of measurement. In this lesson you will learn about the two unit Systems used in measurement, the SI and arbitrary units.



Your Aims:

- recognise and list the arbitrary and SI units used in measurement
- differentiate between arbitrary and SI unit systems
- explain the disadvantages of arbitrary units to SI units

What is an Arbitrary Unit?

An arbitrary unit is used in science when you are showing information that is not checked, confirmed or proven. People make them up and then agree to use them. Arbitrary units are not standard; therefore, any information produced is unofficial but physically useful. Arbitrary unit is anything that can be used as a unit of measure.

For example; imagine you are looking at a cell under a microscope, and would like to say how big the cell is, but you do not have a scale in millimetres. So you decide to put a small object and call it a “red ball” next to the cell, so that when you say “your cell was two red balls wide”, you would be using your arbitrary unit of “red ball”.

Other examples would be: (i) you want to measure how many ice block cups of sand will fill a 1 litre coca cola carton. The volume of the ice block cup is the arbitrary unit. (ii) You may want to find out how many matchsticks long your foot is. The length of the matchstick would be the arbitrary unit.

The arbitrary units are mainly based on personal preferences or feelings, rather than on facts, reasons, system or plan and may sometimes be unfair.

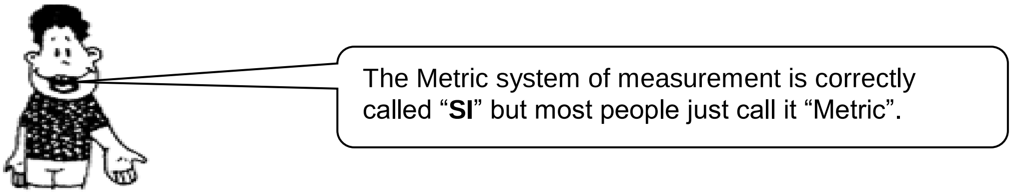
To communicate with someone in a way the other person will understand, you must use the same units as what the other person uses. For example, a child says that her paper is nine thumbs wide. Another person cannot find another piece of the same width unless the child and the thumb are there to measure it. But if she says her paper is 21 centimetres wide, another person will know exactly the width of the paper. In this case the thumb is an arbitrary unit and the centimetre is a standard unit.

The same is true for other units. Standard measuring cups and spoons must be used when cooking in order for a recipe to turn out well. If any cup or just any spoon is used when following a recipe, the measurement would be arbitrary. The chances of a successful outcome would be poor. The same can be said of building a house. If non-standard measuring tools are used, the house will not come out as planned and carpenters may be confused.

SI Units

In the past, there were many measurements used all over the world. They were used locally and not standard or commonly practiced all over the world. It created problems in global communication. So, in 1960, people from different parts of the world agreed to use a common unit which is known as the metric system of measurement called the “International System of Units” or “SI” from the French words **Système International d’Unites**. Most of the S.I units are derived from the first three basic units of: **metre** (m), **kilogram** (kg) and **second** (s).

The International System of Units is a system that is practical to use in the laboratory. The SI units are the world’s most widely used system of measurement and the easiest to use. They are used in both everyday science and commerce.



By international agreement, there are seven quantities classified as basic quantities. These include the original 3 fundamental quantities of length, mass and time plus four others that have become important with the development of more modern measuring instruments.

The appropriate units are listed in the table below:

Base Quantity	Base Unit	Unit Symbol
Length	metre	m
Mass	kilogram	kg
Time	second	s
Electrical current	ampere	A
Temperature	kelvin	K
Amount of substance	mole	mol
Luminous intensity	candela	cd

Differences Between Arbitrary and Standard Units

- Standard units have very precise or clear definitions at precise conditions. Whereas, arbitrary units do not give you very clear definitions. For example, an inch might be defined as the width of a person’s thumb but this will vary from one person to another in an arbitrary system.
- Standard unit can be used at any given time as long as the defining conditions are met.

- Standard basically means a particular set of units and arbitrary means any units. The Standard usually refers to the SI units in which lengths are measured in metres, masses in kilograms and times in seconds.
- Arbitrary units are not standard and they do not follow rules.
- SI units such as metre, kilogram and second can always follow set rules.

So arbitrary units use methods that have not been checked or proven against standard (SI) units but are physically meaningful.

Disadvantages of Arbitrary Units

- With arbitrary units you cannot check, make corrections or justification to your information or equipment. This means that you cannot confidently compare to other information.
- The arbitrary units are mainly based on personal preferences or feelings, rather than on facts.
- The information produced is often unofficial and sometimes cannot be accepted.

Summary

You have come to the end of Lesson 1. In this lesson you have learnt that:

- accurate measurements can help to solve scientific problems
- the two unit systems of measurement are SI (International System of Units) and arbitrary units.
- SI units are standard units of measurement used throughout the world.
- there are seven quantities classified as basic quantities and they are:
    - metre for distance
    - kilogram for mass
    - second for time
    - ampere for electric current
    - kelvin for temperature
    - mole for amount of substance, and
    - candela for intensity of light.
- arbitrary units are not standard units.
- the arbitrary units are mainly based on personal preferences or feelings, rather than on facts, reasons, system and may sometimes be unfair.

NOW DO PRACTICE EXERCISE 1 ON THE NEXT PAGE.

Practice Exercise 1

Answer the following questions.

1. Define measurement.

   ____

   ____

---

2. Explain what SI units are.

   ____

   ____

---

3. Name the seven SI base units and the base quantities that they measure.

	SI Base Units	Quantities they Measure
i.	__________	__________
ii.	__________	__________
iii.	__________	__________
iv.	__________	__________
v.	__________	__________
vi.	__________	__________
vii.	__________	__________

---

4. What is an arbitrary unit?

   ____

   ____

---

5. List two disadvantages of using arbitrary units.

   (i) ____

   ____

   ____

   (ii) ____

   ____

---

6. Name the scientific instrument used to measure:

   (i) electric current.

   ____

   (ii) the length of an exercise book.

   ____

CHECK YOUR WORK. ANSWERS ARE AT THE END OF TOPIC 1.

Lesson 2: Reliability and Accuracy

Welcome to Lesson 2. In your last lesson you defined Measurement and learnt about the two unit systems used in measurement. All experimental measurements are likely to have some errors, other than those caused by carelessness of a person like misreading a scale. However, reliability and accuracy are very important in scientific measurements.

Your Aims:

- explain reliability and accuracy in experimental measurements
- discuss parallax errors
- explain how parallax errors occur and how they can be

Reliability
When a scientist repeats an experiment with a different group of people and gets very similar results, those results are said to be reliable.

Let us think about the measurement process in woodwork. A tape measure is a highly reliable measuring instrument.

If you have a piece of wood that is 2.5 metres long. You measure it once with the tape measure and you get a measurement of 2.5 metres. Measure it again and you get 2.5 metres. Measure it repeatedly and you consistently get the same measurement. The tape measure gives reliable results.

Reliability refers to a condition where a measurement process gives consistent or similar results.

Accuracy
A measurement is said to be accurate if it is close to the actual or true value. Accuracy is closeness to a targeted goal.

For example, if you are playing soccer and you always hit the left goal post instead of scoring, then you are not accurate.

Another example would be, if a man is 162 cm tall, a reading of 162.3 cm would be more accurate. If you took more readings and they were all about 162 cm then your results would be reliable.

Error in Measurement
Any measurement made with a measuring device is approximate. If you measure the same object twice, the two measurements may not be exactly the same. The difference between the two measurements is called a variation.

Another word for variation or uncertainty in measurement is error. This "error" is not the same as a "mistake". It does not mean that you got the wrong answer. The error in the measurement is a mathematical way to show the uncertainty in the measurement. It is the difference between the result of the measurement and the true value of what you were measuring.

When people measure different physical quantities, there is always some error in the measured value. A measurement is only an estimation of the true value.

What is Parallax Error?

Parallax errors are sometimes called movement errors or more accurately motion parallax. It refers to the change of angular position of two measurements. A parallax error occurs when your eye is not placed directly opposite a scale when taking a reading. **Parallax** means a change in the position of an object when the person looking at the object changes position.

Imagine that we have a frog in a room with Garfield and Mickey Mouse as shown below.

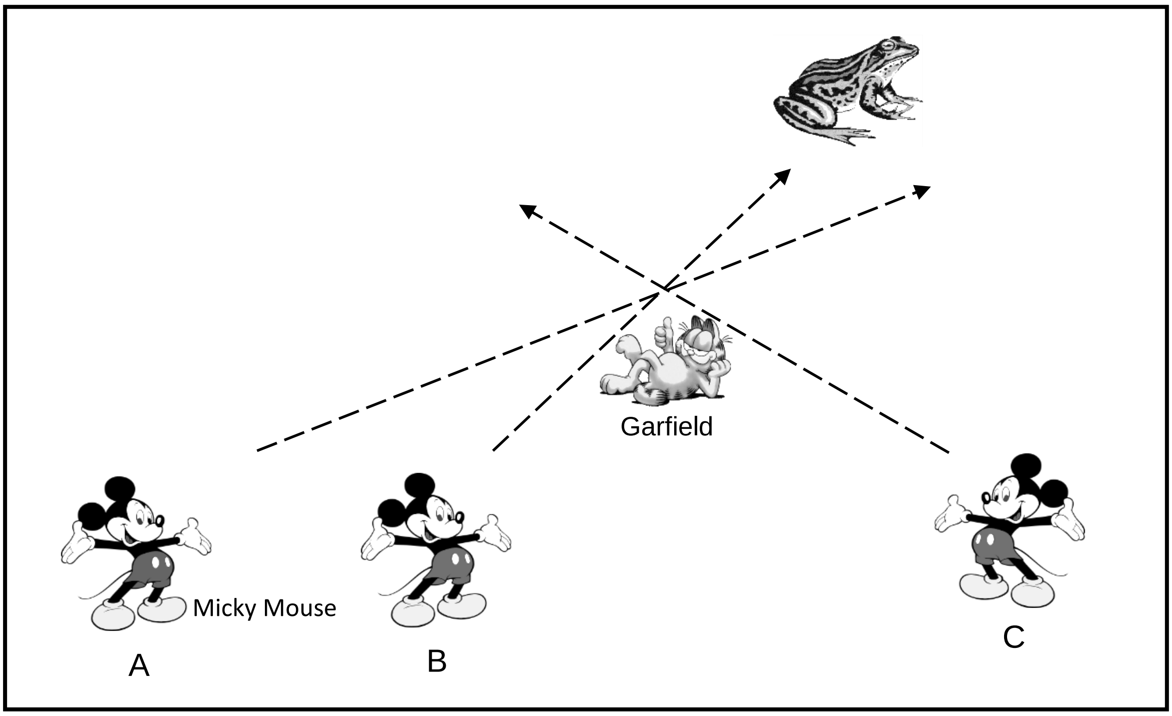


Illustration of how parallax error can occur

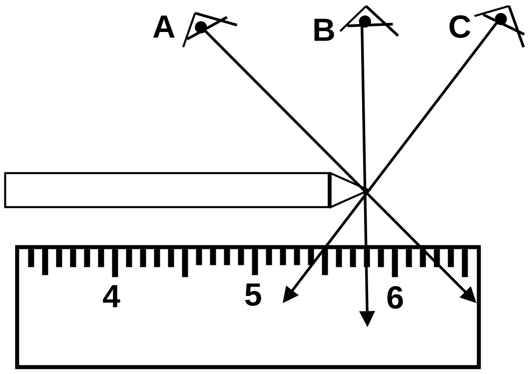
Now Mickey Mouse is moving about in the room and each time from where he is in the room, he looks at Garfield and the frog. At point A he sees the frog on the left of Garfield whereas when he is at position C he would see the frog on the right of Garfield. Only when he is at position B, would he see the frog behind Garfield.

He would discover that each time he is at a different position, he would find that the position of the frog in relation to Garfield has changed.

You can also have this effect when you are in front of a clock. If you move from side to side you would find that the time that you can read from the clock is different.

So we can understand that the parallax is the change in the apparent position of an object when the position of the observer changes.

Now let us look at the general idea of parallax error. If you have placed a pencil on a metre ruler to read the length, your eye might be looking at the pencil at different angles in relation to the ruler.



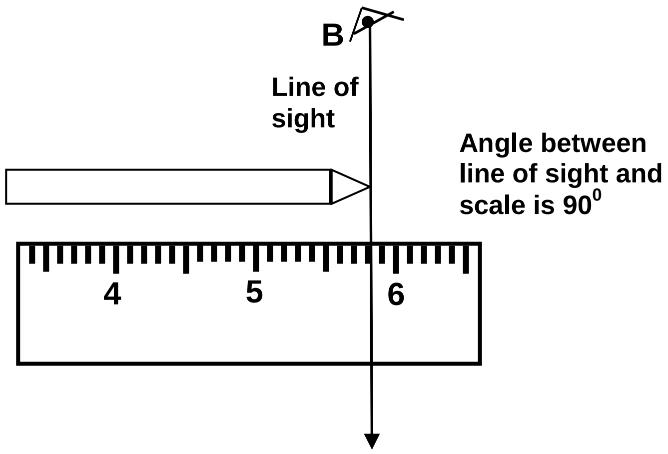
Referring to the diagram above, three positions have been chosen at which you can place your eye.

Clearly at these three positions we can have the following readings.

Reading at A = 6.2 cm Reading at B = 5.8 cm Reading at C = 5.5 cm.

What do you think is the correct reading?

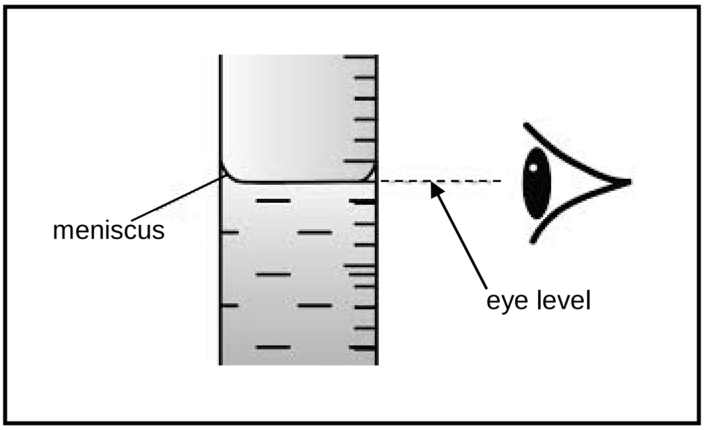
The correct reading would be obtained when the eye is placed at B which is 5.8 cm.



Now there is a line from the tip of the eye to the sharp point of the pencil that continues to the scale. This line is called the line of sight and the mark at which the line intersects the scale is the length of the pencil. This line of sight must be at right angle to the scale. This is shown in the diagram above.

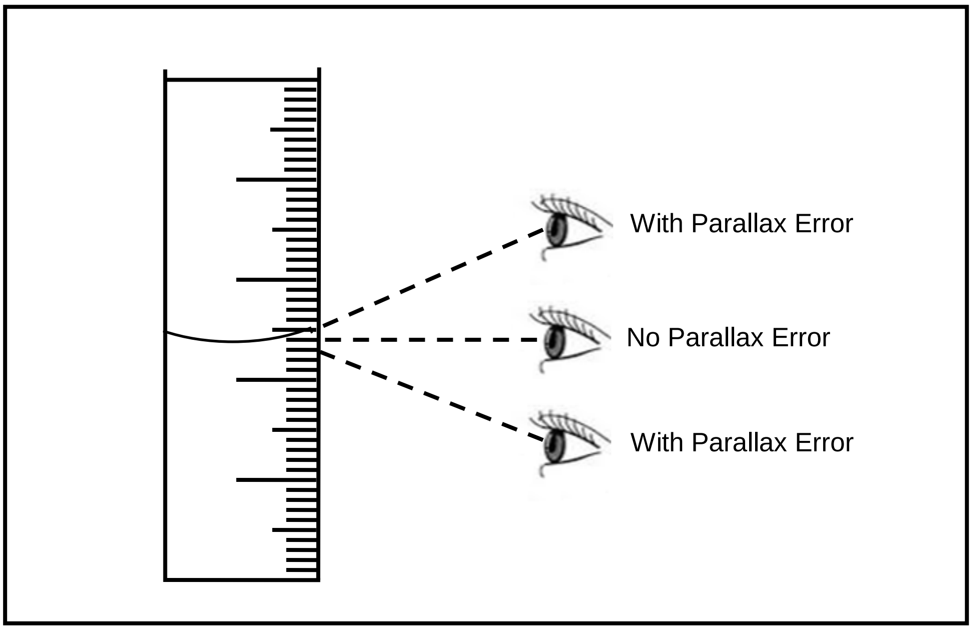
If the line of sight and the scale are not at right angle to each other, then a parallax error has occurred.

Similarly, with a measuring cylinder the line of sight from the eye to the bottom of the meniscus must be at right angle to the scale as shown in the diagram. In this case, the line of sight is horizontal and the scale is vertical.



Proper way to read a meniscus

So as you can see above, each time you are taking a reading you must ensure that the line of sight is perpendicular to the scale.



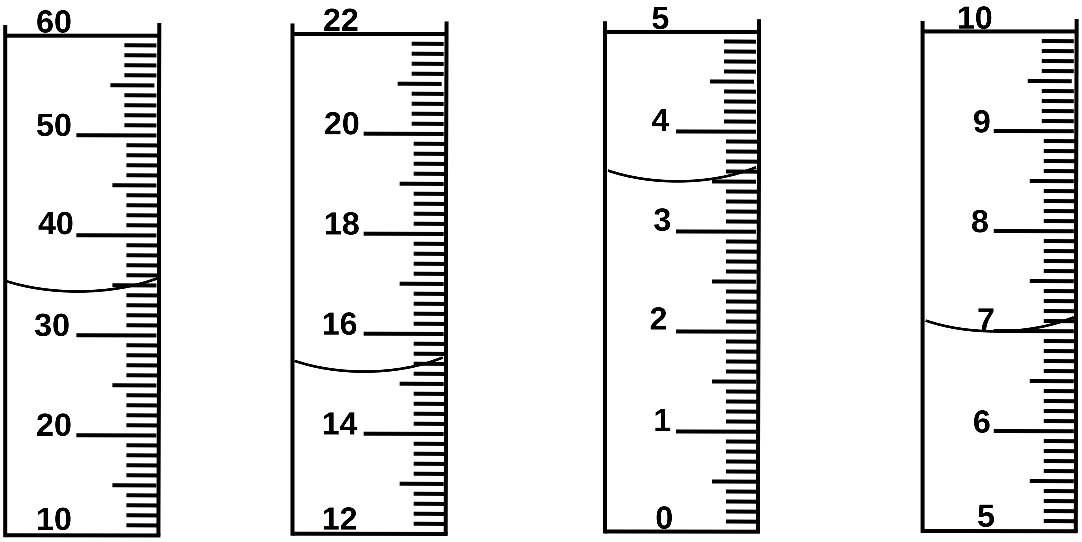
Parallax error

Activity: Now test yourself by doing this activity.

Read and answer the questions on the spaces provided.

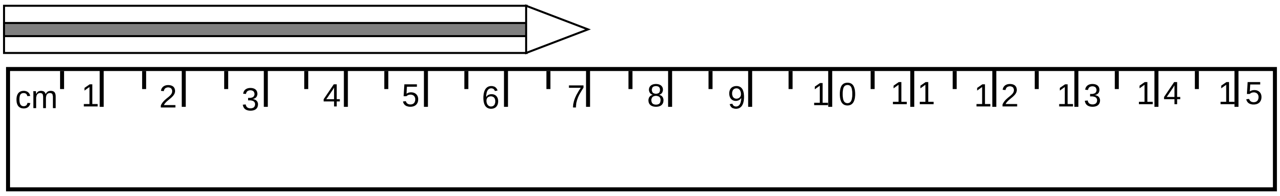
Refer to the diagrams to answer Questions A and B. Remember to read the correct measurements and include the units of measurements with your answers.

A. What is the reading in millimetres for each measuring cylinder?

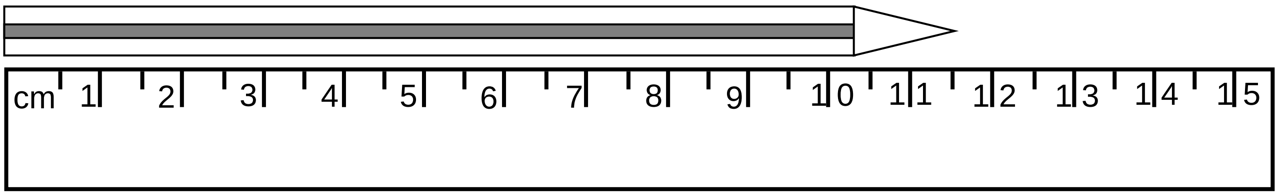


(i). ___________ (ii). ___________ (iii). ___________ (iv). ___________

B. What is the length of these pencils in centimetres?



(i) ___________



(ii) ___________

CHECK YOUR WORK. ANSWERS ARE AT THE END OF LESSON 2.

Reducing Errors
Errors cannot be removed but can be reduced. This can be done by:

1. Averaging the results of several different readings,
2. Choosing an appropriate measuring instrument for a particular task or work,
3. Carrying out the procedure carefully step by step and checking each result regularly as recorded.

How can you overcome Parallax Error?
There is no way you can overcome parallax errors, therefore you have to be careful when taking values of physical quantities on scaled scientific instruments such as measuring cylinders, beakers and rulers.

Examples of avoiding parallax errors in an experiment
You can avoid parallax errors by placing your eye vertically above the marking on the reading scale. For example, when you try to measure length of an exercise book using a ruler, you can follow these simple steps to minimise errors.

1. Place your ruler on the edges beside the object or an exercise book to be measured. This is to make sure that the scale is touching it.
2. Use a thin ruler so that the scale is touching the object to be measured. If you are measuring volume of a liquid in a measuring cylinder, for instance, make sure your eye is positioned correctly. Take the readings at the bottom of meniscus for water and top of meniscus for mercury.

Summary

You have come to the end of Lesson 2. In this lesson you have learnt that:

- reliability refers to a condition where a measurement process gives consistent or similar results over repeated measurements.
- a measurement is said to be accurate if it is close to the actual or the true value.
- an error in a measurement is a mathematical way to show the uncertainty in the measurement.
- a parallax error occurs when your eye is not placed directly opposite a scale when taking a reading. Parallax errors result in readings which are not precise.
- to avoid parallax errors, each time you are taking a reading you must ensure that the line of sight is perpendicular to the scale.
- when taking measurements it is important to:
    a. Choose the most suitable measuring instrument.
    b. Know how to use the measuring instrument.
    c. Know methods for increasing the accuracy of measurements.

NOW DO PRACTICE EXERCISE 2 ON THE NEXT PAGE.

Practice Exercise 2

Answer the following questions.

1. Define the following terms.

   a) Accuracy

   ____
   ____
   ____

   b) Reliability

   ____
   ____
   ____

2. What is a parallax error and when does it occur?

   ____
   ____
   ____
   ____

3. How can you avoid parallax errors?

   ____
   ____
   ____

4. Explain three methods that can reduce errors.

   i) ____
   ____
   ____

   ii) ____
   ____
   ____

   iii) ____
   ____
   ____

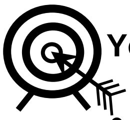
CHECK YOUR WORK. ANSWERS ARE AT THE END OF TOPIC 1.

Answers to Activity

A.	(i)	34 millimetres	(ii)	15.2 millimetres
	(iii)	3.5 millimetres	(iv)	7 millimetres
B.	(i)	7 centimetres	(ii)	11.5 centimetre

Lesson 3: Length

Welcome to Lesson 3. In your previous lesson you learnt that all experimental measurements are subject to some errors. In this lesson you will learn about length. In everyday life you deal with numbers that help to tell the time, temperature and length (distance). If the distance or length from where you live to the school is far, it would be helpful to know the distance, so that you can start walking earlier.



Your Aims:

- define length
- identify some metric and imperial units used in measuring length
- identify instruments used in measuring length
- analyse diagrams of length and read scales correctly

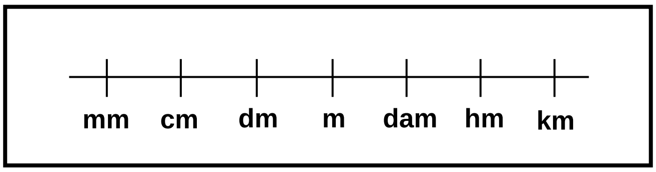
What is Length?

Length is a unit of measurement that tells you how long something is from one end point to another end point. You can measure how long things are, how tall, or how far apart they are. Those are examples of length measurements.

Example: This fork is 20 centimetres long

Metric Units Used to Express Length

The metre is the basic unit of length in the metric system. The metre is divided into ten equal parts called **decimetres**. Each of these ten parts is divided into ten smaller parts called **centimetres**. Each centimetre is further divided into ten smaller parts called **millimetres**.



Metric Units of Length

The above diagram shows the consecutive metric units of length. This is used in conversion of units of length easily as shown below.

• 10 millimetres (mm)	=	1 centimetre (cm)
• 10 centimetres (cm)	=	1 decimetre (dm)
• 10 decimetres (dm)	=	1 metre (m)
• 10 metres (m)	=	1 decametre (dam)
• 10 decametres (dam)	=	1 hectometre (hm)
• 10 hectometres (hm)	=	1 kilometre (km)

Decimetre, decametre and hectometre are rarely used. But they are still included in the list in the previous page to help us see that the metric system is based on 10, multiples of 10 or powers of 10.

Metres form the basis for larger or smaller units. The units are named using these prefixes:

Kilo = 1000
Deci = 1/10
Centi = 1/100
Milli = 1/1000
Micro = 1/1 000 000
Nano = 1/1 000 000 000

The table below shows how metres are related to five other measures of length.

Unit	Length
Kilometre (km)	1000 m (1 X 10^3 m)
Metre (m)	1 m
Centimetre (cm)	0.01 m (1X10^{-2} m)
Millimetre (mm)	0.001 m (1X10^{-3} m)
Micrometre (µm)	0.000001 m (1X10^{-6} m)
Nanometre (nm)	0.000000001 m (1X10^{-9} m)

Notice that each of the units in the table above are related to metres by a multiple of 10.

Small units of length are called millimetres.

A millimetre is about the thickness of a plastic ID card or a Westpac or BSP save card.

A millimetre is also about the thickness of 10 sheets of paper on top of each other.

A plastic ID card is about 1millimetre thick

When you have 10 millimetres, it can be called a centimetre.

10 millimetres = 1centimetre

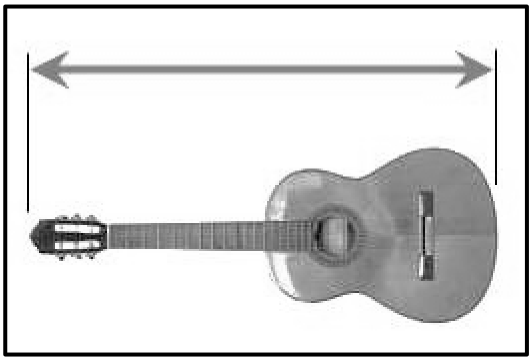
A fingernail is about one centimetre wide.

You might use millimetre or centimetres to measure how tall you are, or how wide a table is, but you would not use them to measure the length of a football field. In order to do that, you can change to metres.

A metre is equal to 100 centimetres.

1 metre = 100 centimetres

The length of this guitar is about 1 metre.



Metres might be used to measure the length of a house, or the size of a playground.

And because a centimetre is 10 millimetres:

1 metre = 1000 millimetres

When you need to go from one place to another, you measure the distance using kilometres. The distance from one city to another or how far a plane travels would be measured using kilometres.

Always remember these when measuring lengths:

10 millimetres	**=**	**1 centimetre**
100 centimetres	**=**	**1 metre**
1000 metres	**=**	**1 kilometre**

You can use the above to convert between units as well. To do this, you have to remember the basic conversion rule given below.

To convert small units to large units, you divide.

To convert large units into smaller units, you multiply

To convert a larger unit to a smaller unit, for example metres to centimetres, first check the number of smaller units needed to make 1 larger unit. This is called the conversion factor and in this case it is: 1 metre = 100 centimetres. Then, multiply the number that you are trying to convert by the number of larger units.

Worked example:

1m = 100cm

So to convert from metres to centimetres multiply by 100, and to convert from cm to m, divide by 100.

For example:

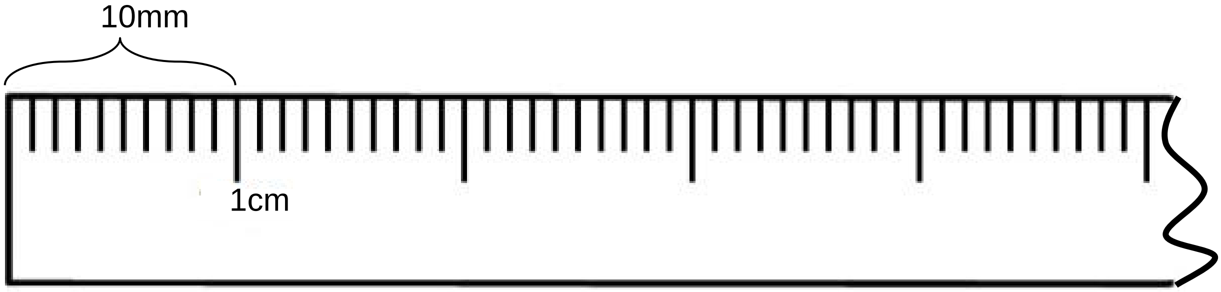
3.2m = 320cm (3.2 x 100 = 320)
400cm = 4m (400 /100 = 4)

Measuring Length

When you are measuring the length of an object, you should always make sure that you position the ruler or tape measure correctly. You should always start to measure from zero. You should line this up with the end of the item that you are measuring.

Sometimes zero is not marked on your ruler. In this case you should start measuring from the first line or end of the ruler which is zero. A metric ruler is used to measure centimetre and millimetres.

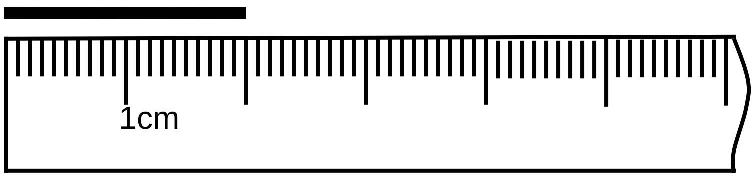
10 millimetres (mm) = 1 centimetre



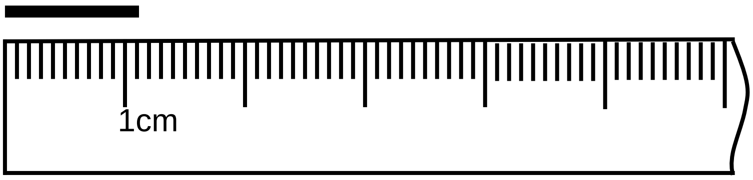
Example of a centimetre (cm) ruler (Drawing not to scale)

There are 5cm on the ruler above. There are 10 mm between each cm.

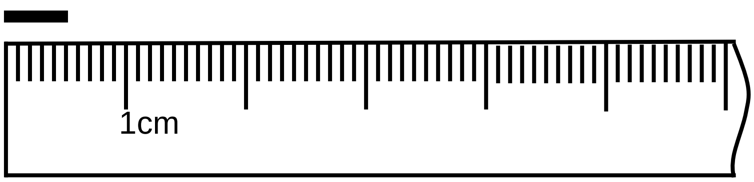
Study the examples below.



The line segment above is 2 centimetres long or 20 millimetres.



The line segment above is 1cm and 1mm. This can also be read as 1.1cm or 11mm.



The line segment above is 5mm or 0.5cm.

Remember:
To read a ruler

- Place the zero of the ruler at the beginning of the object you are measuring.
- Read the length by looking perpendicularly to the ruler in order to avoid a parallax error.
- The ruler gives lengths correct to one decimal place. That is it gives lengths in centimetres and millimetres.

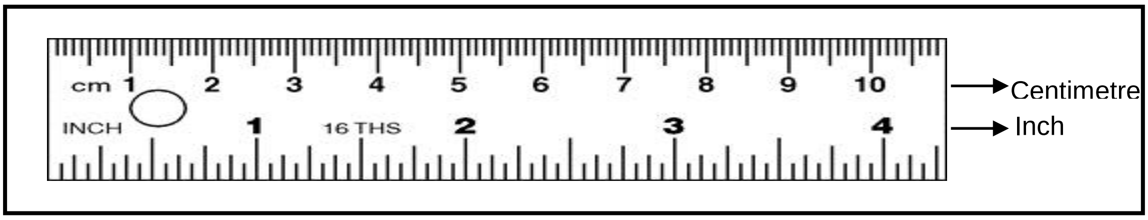
The Imperial System
The Imperial system is more complicated than the metric system because it does not work in multiples of 10 like the metric system. The Imperial system is used in England and the United States.

In the Imperial system the base unit of length commonly used are inches (in), feet (ft), yards (yd) and miles (mi).

12 inches	**=**	**1 foot**
3 feet	**=**	**1 yard**
1760 yards	**=**	**1 mile**

Conversion between Metric and Imperial Units
Given in the table below is the conversion rate for the imperial and metric measures for length.

Metric	Imperial
1 millimetre	0.0394 inch
1 centimetre (10mm)	0.3937 inch
1 decimetre (10cm)	3.937 inches
1 metre (100cm)	1.0936 yards
1 decametre (10m)	10.936 yards
1 hectometre (100m)	109.36 yards
1 kilometre (1000m)	0.6214 miles

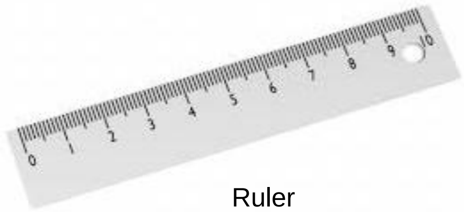


The ruler above shows both the Imperial system (inch) and metric system (centimetre)

Instruments Used to Measure Length

There are different types of instruments that you can use to measure the length, height or width of something. The equipment you choose will vary depending on what you want to measure.

The diagrams below show some examples. You might think of more.



Ruler

Dress Maker's Tape Measure

Builder's Tape Measure

Trundle Wheel

Odometer in a vehicle

Micrometer

Each instrument is marked off in units suitable to the lengths it is likely to be used to measure.

1. A standard ruler is marked in centimetres and millimetres. It measures lengths up to 30 centimetres. Some rulers also show imperial measurements – feet and inches. You can use a ruler to measure small items or lines on a page.
2. You can use a tape measure to measure things that are not straight. For example, to check your waist or neck size you can use a dress maker's tape measure. You can use a builder's tape measure to measure longer lengths like the height of a classroom. Tape measures can come in a variety of sizes but usually measures up to 150 centimetres. Many tape measures also show imperial measurements.

3. If you need to measure longer lengths, for example the length of a football field, then you could use a trundle wheel along the ground. It clicks every time it measures one metre.
4. Very small lengths can be measured using a micrometer.
5. The odometer on a car usually measures distances kilometres.

When measuring, you should be accurate. You need to choose the right measuring equipment and be able to use it correctly. You must also decide which unit of measurement is most appropriate. When measuring length, this will usually be millimetres (mm), centimetres (cm) or metres (m).

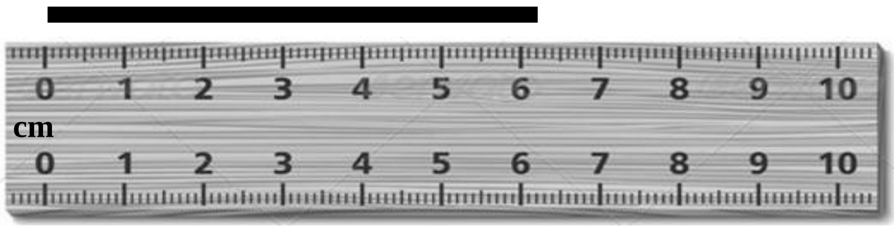
Activity: **Now test yourself by doing this activity.**

Read and answer the questions on the spaces provided.

1. A paper clip measures 30mm in length. What is this in centimetres?

Answer: __________________

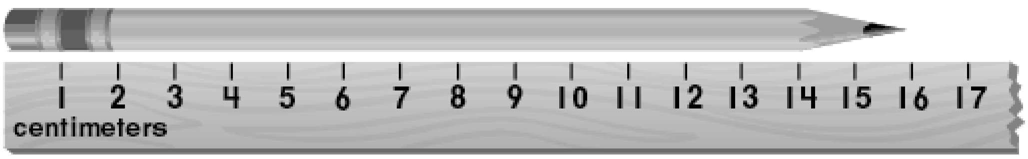
2. What is the length of this line in millimetres and centimetres?



Answer: ___________ **mm**

___________ **cm**

3. How long is this pencil?

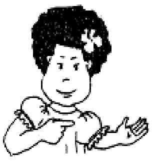


Answer: __________________

4. A plank of wood is 1.5m long. What is this in centimetres?

Answer: ___________ **centimetres**

CHECK YOUR WORK. ANSWERS ARE AT THE END OF LESSON 3.



Summary

You have come to the end of Lesson 3. In this lesson you have learnt that:

- length is distance from one end point to the other end point.
- the Imperial system uses inch, foot, yard and mile as its' standard units for measuring lengths.
- the International System (SI) uses centimetre, metre and kilometre as its' standard units for length measurements.
- the metre is the basic unit of length in the metric system.
- there are many different types of instruments that you can use to measure the length, height or width of something and the equipment you chose will vary depending on what you want to measure.
- when measuring, you should be accurate. You need to choose the right measuring equipment and be able to use it correctly. You must also decide which unit of measurement is most appropriate.

NOW DO PRACTICE EXERCISE 3 ON THE NEXT PAGE.

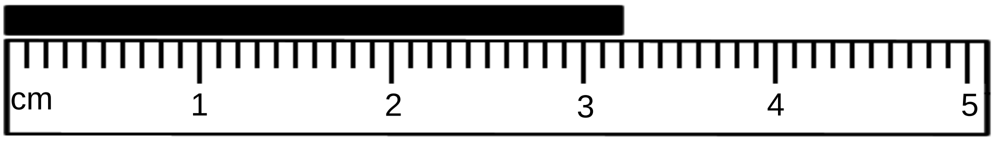
Practice Exercise 3

Answer all the questions on the spaces provided.

1. What is the basic unit of length in the metric system?

____

2. What is the length of this line in:



(i) Centimetres? __________

(ii) Millimetres? __________

(iii) Metres? __________

3. Name the instruments that are used to measure the following.

(i) Length of a soccer field ____________________

(ii) Things that are not straight ____________________

(iii) Distance that you have travelled in a vehicle ____________________

4. Convert 25cm to mm.

____

5. Convert 30km to m.

____

____

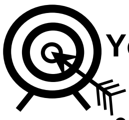
CHECK YOUR WORK. ANSWERS ARE AT THE END OF TOPIC 1.

Answers to Activity

1. 3 centimetres
2. 62mm and 6.2cm
3. 16 centimetres
4. 150 centimetres

Lesson 4: Time and Temperature

Welcome to Lesson 4. In the previous lesson you learnt about length and how it is used. In this lesson you will continue to learn numbers in relation to time and temperature. All of us deal with time every day of our lives. Time will tell us how long it takes to travel from home to school, how long a test will take and when a meeting will begin. And temperature will tell about our body, whether we are sick or not and how cold the weather is so that we can wear a sweater or a jacket.



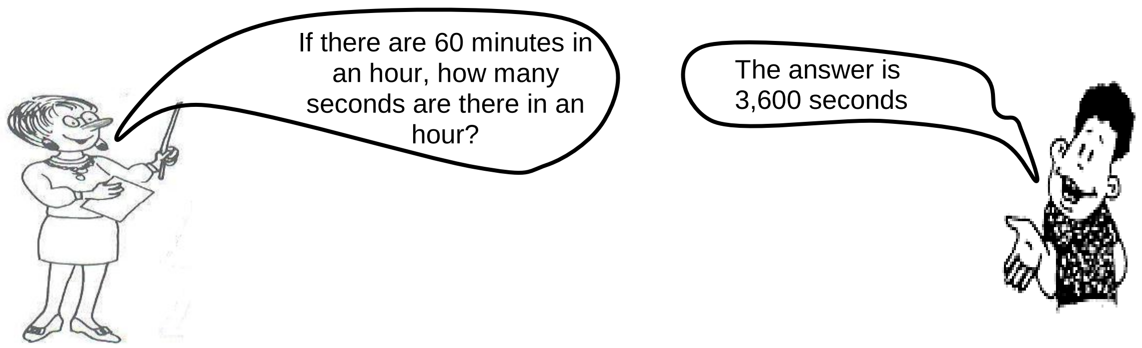
Your Aims:

- define time and temperature
- enumerate some metric and imperial units used in measuring the two quantities
- identify instruments used to measure time and temperature
- analyse diagrams of time and temperature being measured and read scales correctly

Time

Scientifically, **time** is defined as a continuous, measurable quantity wherein events occur in a succession, proceeding from the previous to the current and to the future. It may also be referred to as an interval that separates two points of a quantity, also known as **duration**. It is also the measured or measurable period during which an action, process, or condition exists or continues. Its base **SI Unit** of measurement is the **second.** Larger units can also be used, such as the minute, hour, day, week, month and year. These are considered "non-SI" units because they do not use the decimal system. However, they are still accepted in the International System. Look at the time calculation/equivalence below:

60 seconds	**= 1 minute**
60 minutes	**= 1 hour**
24 hours	**= 1 day**
7 days	**= 1 week**



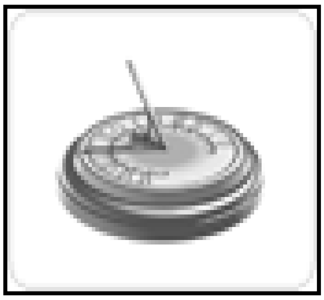
There are no fixed ratios between second and month or second and year because months and years vary significantly in length. There are months that have 31 days while some have only 30. There is also a month that has only 28 days and 29, when it is a leap year.

Measuring time

Whether time is real or not, the measuring of time has become vital to our lives. Humans have been measuring time for a relatively short period in our long history. Before that, we divided time only into daylight and night, with bright days for hunting and working and dark nights for sleeping. But as people began to feel the need to coordinate their actions, to be prompt for public gatherings and such, they needed a unified system of keeping time. The diagrams below show some methods of measuring time.

1. **Sundial**

   A sundial works by tracking the sun's movement. A blade casts a shadow that points to a marked number on the sundial's face, just like a clock with only an hour hand. At mid-day, the sundials should be turned 180 degrees to measure the afternoon hours.



2. **Hourglass**

   The hourglass is made up of two glass bulbs, one on top of the other, with a narrow opening between. Sand runs from the top bulb into the bottom when the hourglass is upended. When the top bulb empties, the time is up.

3. **Wristwatch**

   Wrist watches were used as jewelries only for women during earlier centuries. But today, wrist watches are used by both men and women.

4. **Calendars**

   Calendars are used to tally days and months based on the position of the sun and moon.

5. **Clock**

   A clock is a time-keeping mechanism which is accurately controlled by a quartz that vibrates at a fixed frequency in an oscillating electric circuit.

A clock is one of the oldest human inventions, and besides telling the exact time it often serves as an important wall-decorating accessory. Time is known to be accurate. It does not make mistakes. But no matter how accurate time is, it is not absolute. The time in the different points in space are dependent on the speed of their respective reference frames. In order to accurately measure time, timekeeping devices are used.

Clocks are classified depending on the type of time display. There are two types of display of a clock; digital and analogue.

1. **Analogue clock** has hands to show us the time. The short hand is the hour-hand while the big hand is the minute hand, so the clock on the right tells the time as five past eleven or 11:05.

2. **Digital clock** shows the time using numbers. The number on the left is the hour, at the middle is the minute and on the right is the second, so the clock tells seven hours, twenty eight minutes and nine seconds. Some digital clocks do not show the second,

There are two ways of showing the time:

- With the **12-hour** clock, there are two periods each of 12 hours' duration each day. The period from midnight and noon is called a.m. and the period between noon and midnight is called p.m.
- With a **24-hour clock** there is one period of 24 hours. This clock is used for railway and airline timetables. Times from midnight and noon are stated as 0000 hours and 1200 hours while time between noon and midnight is stated between 1200 hours and 2400 hours.

The 24 hour system continues beyond 12 noon so 1p.m. is written as 1300 hours, 2 p.m. is written as 1400 hours and so on. Midnight is written as 0000 hours and so on.

12 hour time

24 hour time

To read the 2 digital clocks, the first one is a 12 hour time and it shows 16 minutes before 6 and this can be either in the morning or in the evening. The second clock is a 24 hour time and it shows 10 minutes before 2 in the afternoon.

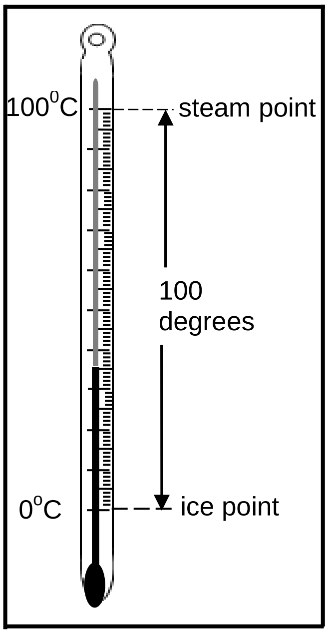
- **a.m. from ante-meridian means the time from 12 midnight up to before 12 noon. This includes the morning from 6.00 a.m. – 11.30 a.m.**
- **p.m. from post-meridian means the time from 12 noon up to 12 midnight. This includes the afternoon from 1.00 a.m. – 11.30 p.m.**

What is temperature?

Temperature is the degree of hotness or coldness of a body or environment. Temperature is measured in degrees on the **Fahrenheit (^oF)**, **Celsius (^oC)**, and **Kelvin (K)** scales. The basic unit of temperature in the International System of Units (SI) is the kelvin. The instrument used to measure temperature is the **thermometer,** from the word therm which means heat and meter which means measure.

How a Thermometer Works

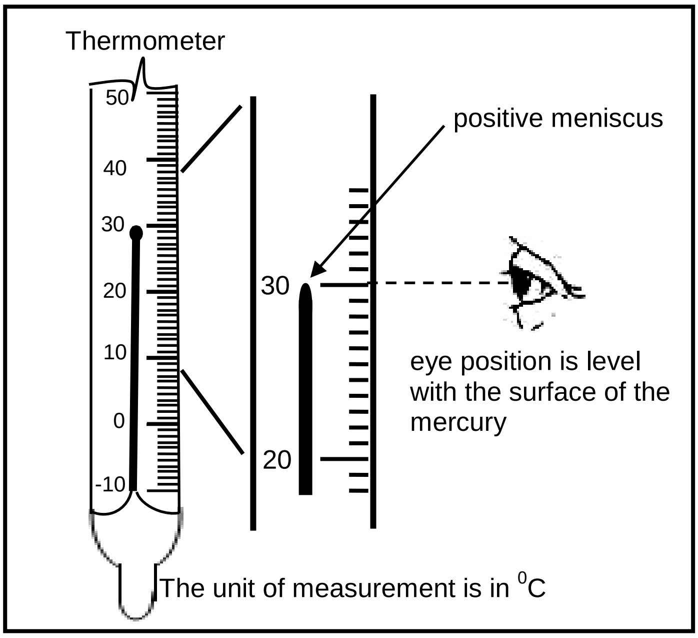
There are a variety of thermometers in use today. The type that most of us are familiar with from science class is the type that is made from a glass bulb connected to a tube of glass with a numbered scale written on the outside. Inside the glass tube is a liquid like mercury or coloured alcohol that rises and falls in the tube as the temperature around it warms or cools. When the temperature rises, the liquid in the glass tube warms up and expands, which in turn takes up more space in the tube.



How to Read a Glass Thermometer

Reading a glass thermometer is a helpful skill to learn. Below are only two tips for reading a thermometer. But there is a few which you will learn if you intend to study nursing in future.

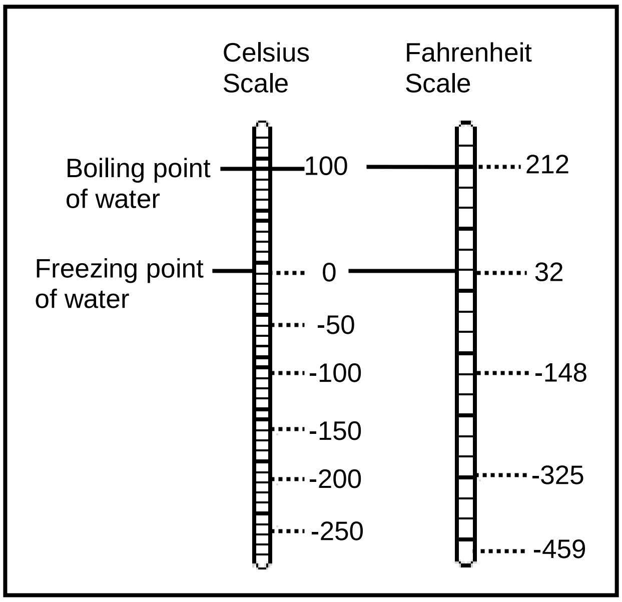
- When you read the temperature on a thermometer, it should be vertical and your eyes should be level with the top of the liquid in the glass tube.
- Avoid handling the thermometer when you take your readings. The heat from your hands will transfer to the glass causing its temperature to rise.



Proper way to read a thermometer

Scale of Temperature

To define a temperature scale, we first choose two reference temperatures called the fixed points known as **steam (boiling) point** and **ice (freezing) point**, and divide the range between them into a number of equal divisions or degrees as shown in the diagram below.



Scale of Temperature

There are two main temperature scales:
- **^{0}F**, the **Fahrenheit Scale** which is used in the US, and
- **^{0}C,** the **Celsius Scale** which is part of the metric system used in most other countries including our country

They both measure the same thing which is temperature, but use different numbers.
- Boiling water at normal pressure measures **100^0 in Celsius, but 212^0 in Fahrenheit**
- And as water freezes it measures **0^0 in Celsius, but 32^0 in Fahrenheit**

Conversion of Temperature

Look at the scale of temperature diagram above and you will notice:
1. Water freezes at 0^0C but 32^0 Fahrenheit, so we will need to add or subtract 32
2. The scales rise at a different rate from freezing point of water to the boiling point. For the Celsius scale it rises by 100 starting at 0^0C to 100^0C so we say the rate is 100 and for the Fahrenheit scale it rises by 180 starting at 32^0F to 212^0F so we will also need to multiply.

And this is how it works.
- To convert from Celsius to Fahrenheit, first multiply by 180/100, and then add 32.
- To convert from Fahrenheit to Celsius, first subtract 32, and then multiply by 100/180

Take note that 180/100 can be simplified to 9/5, and likewise100/180 = 5/9, so this is the easiest way.

^{0}C to ^{0}F	Multiply by 9, then divide by 5, then add 32**.**
^{0}F to ^{0}C	Subtract 32, then multiply by 5, and then divide by 9

We can write that as a formula like this:

Celsius to Fahrenheit	$(^0C \text{ X } 9/5) + 32 = {}^0F$
Fahrenheit to Celsius	$(^0F – 32) \text{ X } 5/9 = {}^0C$

Example: Convert 26^0 Celsius (a nice warm day) to Fahrenheit.

First:	26^0C X 9 = 234/5	= 46.8
Then:	46.8 + 32	= **78.8^0F**

Time and temperature, are also related. As time continues temperature increases. For example, when you place a plate of food into a microwave and as you press the start the button and time continues the food inside become warmer. The opposite is also true, when time continues temperature decreases. For example, at night after 6 pm, as time continues the temperature generally decreases.

Activity: **Now test yourself by doing this activity.**

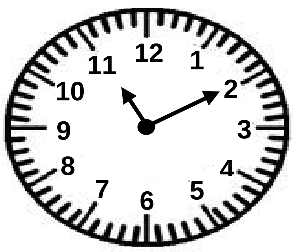
Answer all questions according to the given instructions.

1. Define these terms.
   a. Time: ____

   b. Temperature: ____

2. Name the three units to measure time.
   a) ____________ b) ____________ c) ___________

3. What time is it?



Answer ____________

Summary

You have come to the end of Lesson 4. In this lesson you have learnt that:

- time is scientifically defined as a continuous, measurable quantity wherein events occur in a succession proceeding from the previous through the current to the future.
- time is measured in units called second(s), minute(m), and hour(h)
- temperature is the degree of hotness or coldness of a body or environment.
- temperature is measured in units called degrees Celsius, degrees Fahrenheit and Kelvin.

NOW DO PRACTICE EXERCISE 4 ON THE NEXT PAGE

Practice Exercise 4

PART A: Multiple Choice.

Circle the best answer.

1. What is the basic unit of time?

A. Day B. Hour

C. Minute D. Second

2. How many seconds are there in an hour?

A. 3,600 B. 360

C. 72 D. 36

3. Thermometer is an instrument used to measure __________.

A. time B. density

C. pressure D. temperature

4. What chemical element is present in a thermometer?

A. Helium B. Oxygen

C. Mercury D. Hydrogen

5. ‘Therm’ in thermometer means__________.

A. hot B. heat

C. cold D. warm

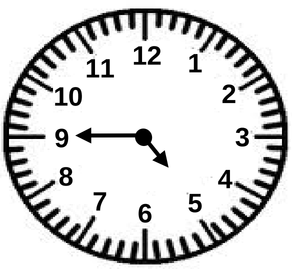
PART B: Short Answer Questions.

Answer the following questions

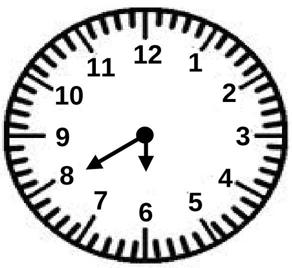
1. Describe a.m. and p.m.

2. What are the two types of clock displays? How are they different from each other?

3. What is the correct time for each clock?



a. __________



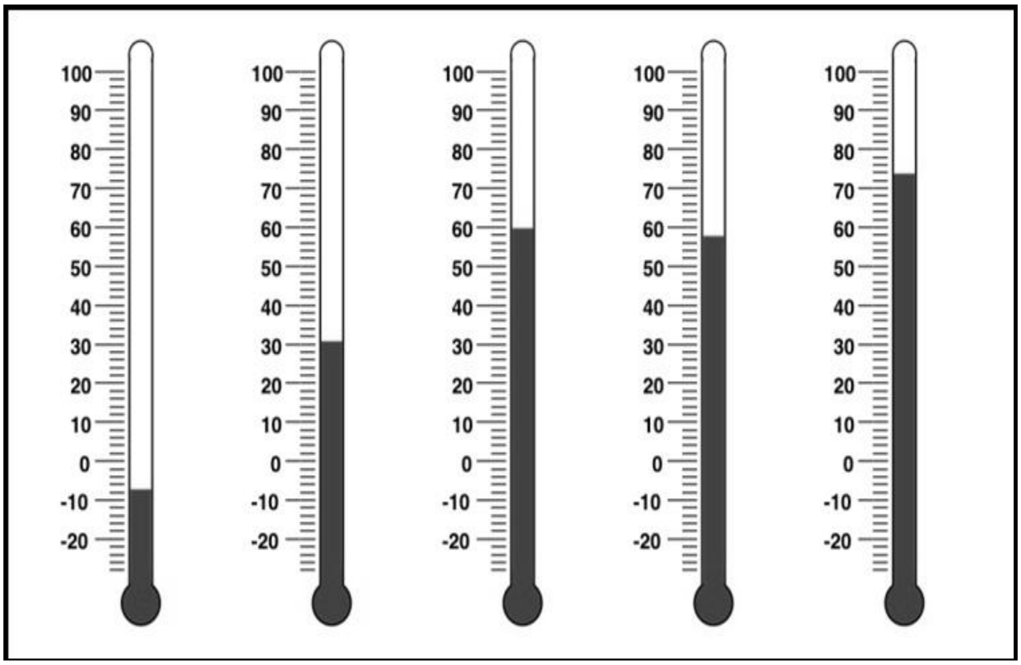
b. ____________

c. ____________

d. ____________

---

4. What is the correct temperature in Fahrenheit scale (^{o}**F**) in each thermometer?



A **B** **C** **D** **E**

CHECK YOUR WORK. ANSWERS ARE AT THE END OF TOPIC 1.

Answers to the Activity

1. a) Time is scientifically defined as a continuous, measurable quantity wherein events occur in a succession proceeding from the previous through the current to the future.

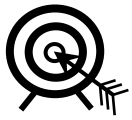
   b) Temperature is the degree of hotness or coldness of a body or environment.

2**.** a) second b) minute c) hour

3. 11:10 or ten minutes past 11:00

Lesson 5: Mass and Weight

Welcome to Lesson 5. In this lesson, you will study about Mass and Weight which often used in confusion. You will be able to easily tell the difference between the two as you learn more about them.



Your Aims:

- define mass and weight
- identify metric and imperial units used in measuring mass
- differentiate mass from weight
- name instruments used to measure mass and weight

Defining Mass and Weight

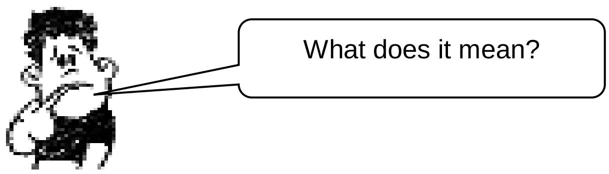
Mass is the amount of matter in an object. It is also known as inertia (pronounced *i-n-er-sh-i-a)* and is considered as constant. The usual symbol for mass is **m**. **Weight** is the force of gravity acting on the object and can be defined or calculated by getting the product of mass and acceleration due to gravity. The symbol for weight is **w.**

Metric Units of Mass Measurement		
1000 milligrams	=	1 gram (g)
1000 grams	=	1 kilogram (kg)
1000 kilograms	=	1 tonne (t)

Imperial Units of Mass Measurement		
437.5 grains	=	1 ounce (oz.)
16 ounces (oz.)	=	1 pound (lb.)
112 pounds (lb.)	=	1 hundredweight (cwt.)
20 hundredweight	=	1 ton (t)

What Is The Difference Between Weight and Mass?

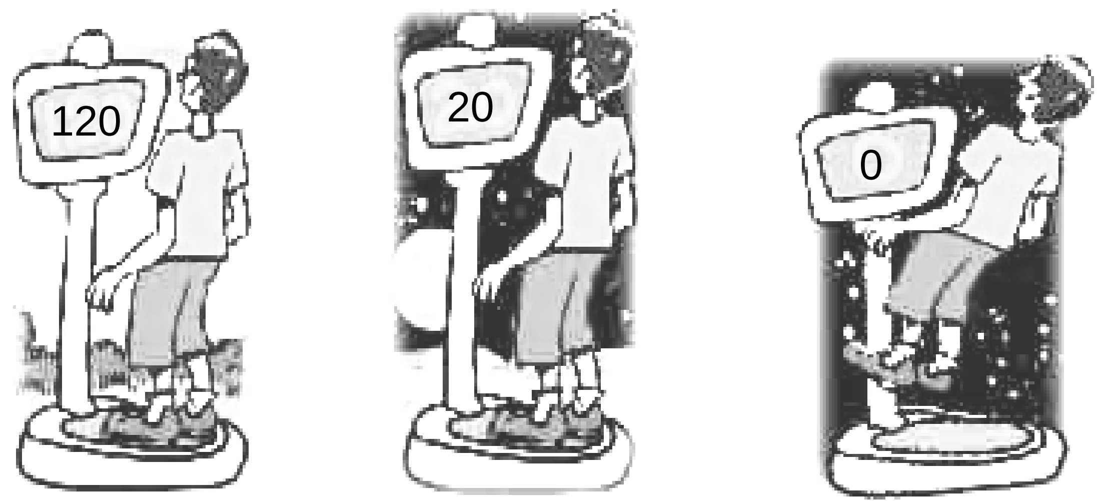
As long as you stay on Earth, the difference is more real than practical.



Well, **mass** is a measurement of how much matter is in an object while weight is a measurement of how hard gravity is pulling on that object. Your mass is the same wherever you are on Earth, on the moon or floating in space because the amount of matter you are made of does not change. But if you stay on Earth, gravity is always the same, so it really does not matter whether you talk about weight or mass. **Gravity** is the force that attracts a body towards the centre of the earth, or towards any other physical body having mass. Gravity has no effect on the mass of an object. Whether it is placed in outer space or in the moon, the object's mass remains constant. For example, an object has a mass of 120kg here on earth. When put in outer space, its mass is still 120kg.

An object's weight is how hard gravity is pulling on it. We think that the weight is the same everywhere because we all live on the surface of the planet Earth. But the truth is, there is a difference in the weight depending on the intensity of gravity on particular locations on Earth. The difference is very little that sometimes it is not even noticed. But your weight depends on how much gravity is acting on you.

You weigh less on the moon where gravity is only 1/6 of the Earth's gravity. But when an object is placed in a different place, like in outer space, there is a big difference between its weight on Earth and the weight in outer space. It can even become weightless. It is therefore safe to remember that an object's **mass does not change** but its **weight can change**, as shown in the diagrams below.



Weight on earth — Weight on moon — Weight on floating space

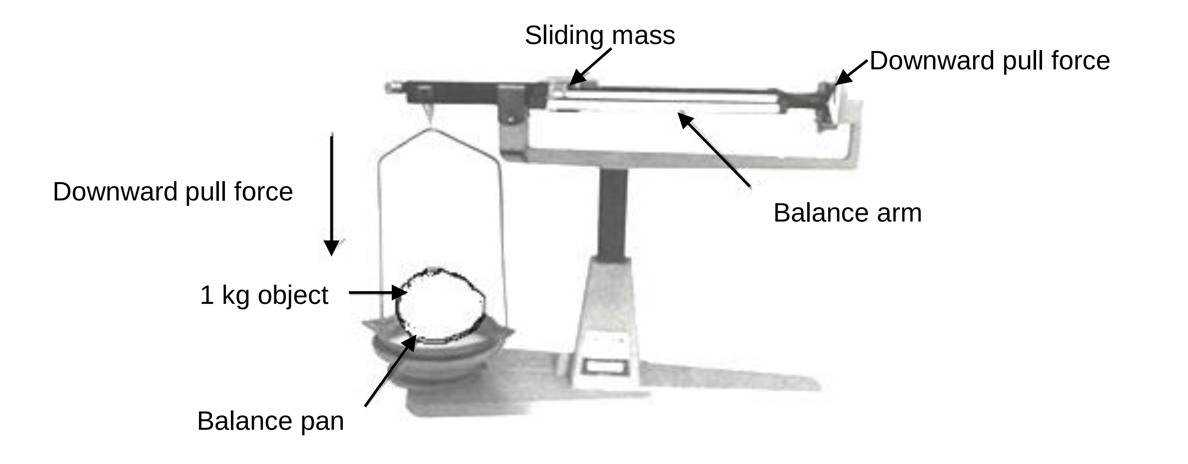
A lot of people are confused with the difference between mass and weight. Often, they use mass to mean weight, or weight to mean mass. To understand the differences, we need to consider and compare some vital points.

Mass vs. Weight Comparison Table

MASS	WEIGHT
It is the measurement of the amount of matter an object contains also known as inertia.	It is the measurement of the pull of gravity on an object.
It is measured by using a Balance, comparing a known amount of matter to an unknown amount of matter.	It is measured using a Scale.
It does not change even if the location of the object changes.	It changes as the location of the object changes

As we have said, weight is a force caused by gravity. The weight of an object is the gravitational force between the object and the earth. The more mass the object has,

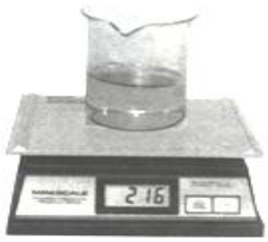
the greater its weight will be. Weight is a force so it is measured in Newtons, **N**. On the surface of the earth an object with a mass of 1kg has a weight of about 10N
When a 1 kilogram object is placed on the balance, the gravitational or downward pull force acting upon the object makes the balance to give the reading as 1 kilogram. The 1 kilogram mass is said to have 10 Newtons of downward pull force acting upon the object. So, you can say that an object with a mass of 1 kilogram has 10 newtons of weight acting upon it.



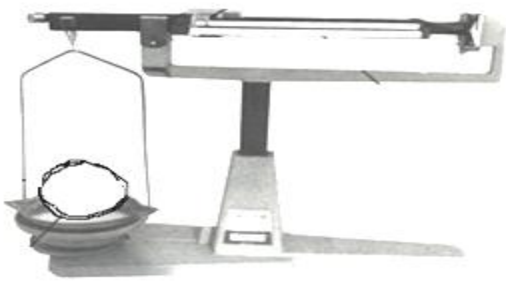
The diagram above illustrates the balance measuring the mass of a 1 kg object

The downward pull or gravitational force acting on the 1kg object has placed 10 newtons of force on the scale to move the scale reading to 1kg on the balance.

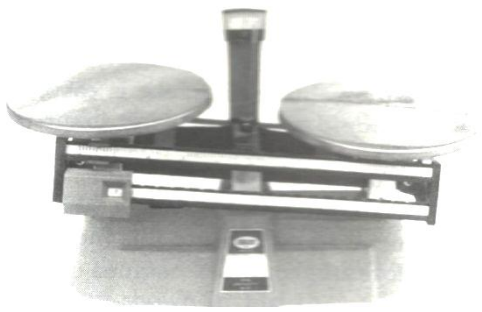
Measuring mass of objects
There are different types of balances used to measure the mass/weight of an object. The diagrams below are some of the examples.



An electronic balance

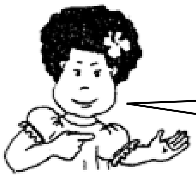


Suspended-pan balance



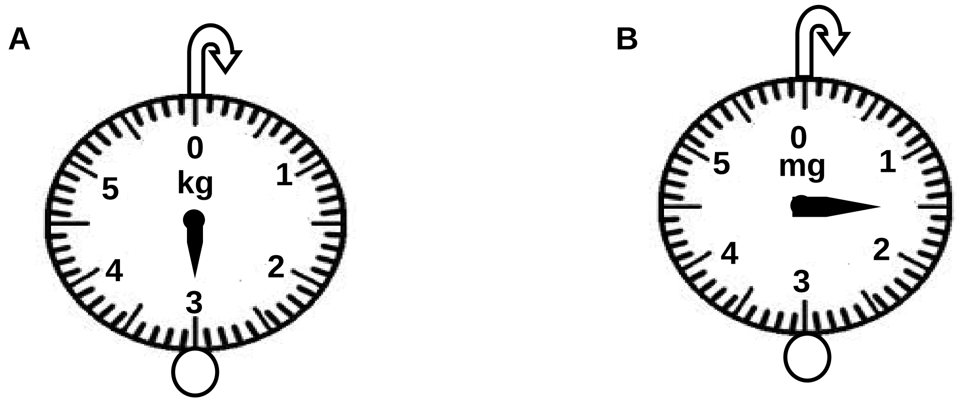
Top-loading balance

Weighing scale



To read scales correctly, look carefully where the pointer is located. Take note of the number it is pointed at and the unit of measurement used.

For example, in the scales below, A reads 3kg and B reads 1.5mg



Activity: Now test yourself by doing this activity.

Circle the letter of the best correct answer from the given choices.

1. Which instrument listed below is **not** used for measuring the mass of objects?

   A. Thermometer

   B. Bathroom scale

   C. Top-loading balance

   D. Triple beam balance

---

2. Which of the list below contains the units of measurement for mass?

   A. Newtons, Grams, Kilojoules

   B. Grams, Kilograms, Milligrams

   C. Grams, Degree Celsius, Newtons

   D. Centimetres, Millimetres, Kilometres

---

3. Weight is the

   A. mass of an object.

   B. force of an object.

   C. upward force acting on the object.

   D. downward force acting on the object.

4. Which of the following affects the weight of an object?

A. Height B. Gravity

C. Weight D. Newton

5. Mass is the

A. force of an object.
B. weight of an object.
C. amount of matter in an object.
D. upward force acting on the object.

Summary

You have come to the end of Lesson 5. In this lesson you have learnt that:

- mass is the amount of matter in an object and is also known as inertia. It can be measured using a balance, while weight is the amount of force of gravity on the object.
- the mass of an object is constant but the weight does change depending on the intensity of gravity in particular places.
- mass is measured in grams or kilograms. The results are usually given in grams where 1 kilogram is equal to 1000 grams.
- weight is the gravitational force that is acting on an object.
- the unit of weight is the Newton (N).
- the gravitational or downward pull force of the earth is about 10 newtons per kilogram.

NOW DO PRACTICE EXERCISE 5 ON THE NEXT PAGE.

Practice Exercise 5

Answer the following questions on the spaces provided.

1. Define the following terms:

   a) mass ____

   b) weight ____

---

2. List the names of the instruments used for measuring mass mentioned in the lesson.

   a. ____________________ b. ____________________
   c. ____________________ d. ____________________

---

3. Write the names and symbols of the units of measurement for mass.

Name	Symbol
a. ________________________	________________
b. ________________________	________________
c.________________________	________________

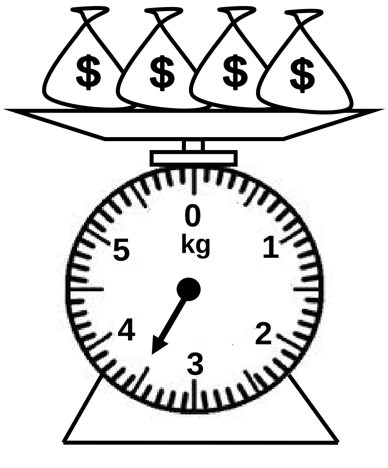
---

4. Write the name and symbol of the unit of measurement for weight.

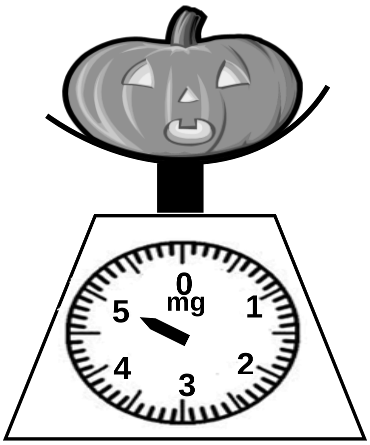
Name	Symbol
________________________	________________

---

5. Read the following scales and answer the questions below.
   What is the weight shown in diagrams a and b?



a) ___________

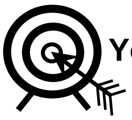


b) ___________

CHECK YOUR WORK. ANSWERS ARE AT THE END OF TOPIC 1.

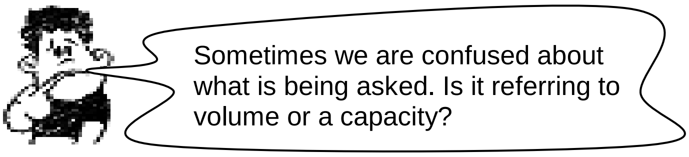
Lesson 6: Volume

Welcome to Lesson 6. In the previous lesson you learnt about mass and weight. In this lesson, you will learn how to measure volumes of liquid and regular and irregular shapes of solid.



Your Aims:

- define volume
- identify metric and imperial units used in measuring volume
- identify instruments used to measure volume



What is Volume?

Volume is the measure of how much space a given amount of substance occupies. Some of the common units to use are cubic metre, cubic millimetre, cubic centimetre, litre, millilitre, cubic inch, cubic feet, and cubic yard. **Capacity** is used to measure the volume of something that can be poured into a container or the amount a container can hold. The units of capacity are gallons, quarts, pints, cups, fluid ounces, litres, and millilitres.

Different containers with different capacities

CONVERSION TABLE OF UNITS FROM METRIC TO IMPERIAL

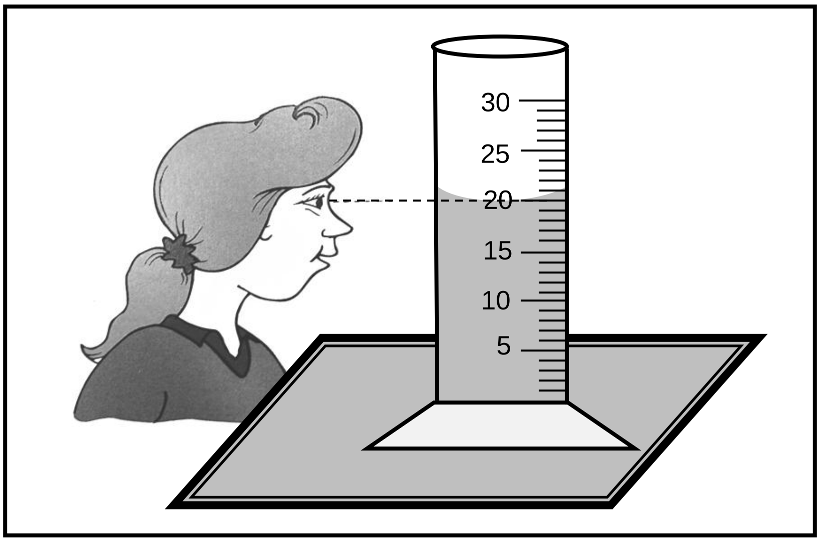
Metric	Imperial
1 cubic centimetre (cm^3)	0.0610 cubic inch (in^3)
1 cubic decimetre (dm^3)	0.0353 cubic feet (ft^3)
1000 cubic centimetre (cm^3)	0.0353 cubic feet (ft^3)
1 cubic metre (m^3)	1.3080 yard (yd^3)
1000 cubic decimetre (dm^3)	1.3080 yard (yd^3)
1 litre (l)	1.7598 pint (pt)
1 cubic decimetre (dm^3)	1.7598 pint (pt)
1 hectolitre(hl)	21.997 gallon (gal)
100 litre (l)	21.997 gallon (gal)

CONVERSION TABLE OF UNITS FROM IMPERIAL TO METRIC

Imperial	Metric
1 cubic inch (in^3)	16.39 cubic centimetre (cm^3)
1 cubic feet (ft^3)	0.0283 cubic metre (m^3)
1.728 cubic inch (in^3)	0.0283 cubic metre (m^3)
1 fluid ounce (fl oz)	28.413 millilitre (ml)
1 pint (pt)	0.5683 litre (l)
20 fluid ounce (fl oz)	0.5683 litre (l)
1 gallon (gal)	4.561 litre (l)
8 pint (pt)	4.561 litre (l)

Sometimes we ask, how do we measure the volume of liquid including regular and irregular solids? As we continue with our topic, we will find answers the question.

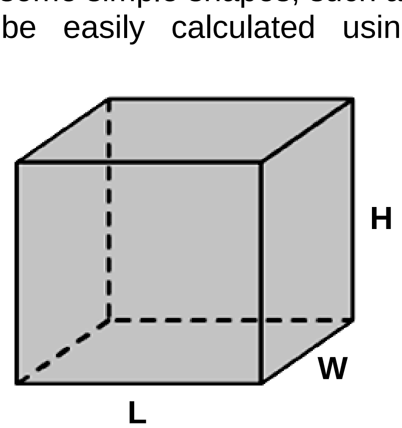
Liquid substances can be poured into a **measuring cylinder**. To measure the volume of the liquid accurately, you read the scale at the eye level at the lowest part of the meniscus. **Meniscus** is the concave curved upper surface of a liquid in a container or tube. The liquid surface usually curves downwards to form a meniscus. The diagram below shows the proper reading of the meniscus on a measuring cylinder.



Proper reading of the meniscus on a measuring cylinder

For solid objects; if a substance is a regular shaped solid, then the volume can be determined using **mathematical formulas**. Volumes of some simple shapes, such as regular, straight-edged, and circular shapes can be easily calculated using mathematical formulas.

The volume of a rectangular block is found by multiplying together the lengths of the sides.

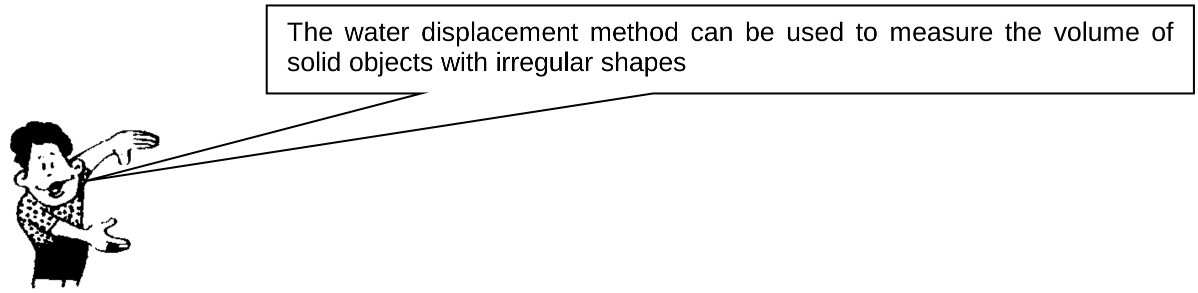


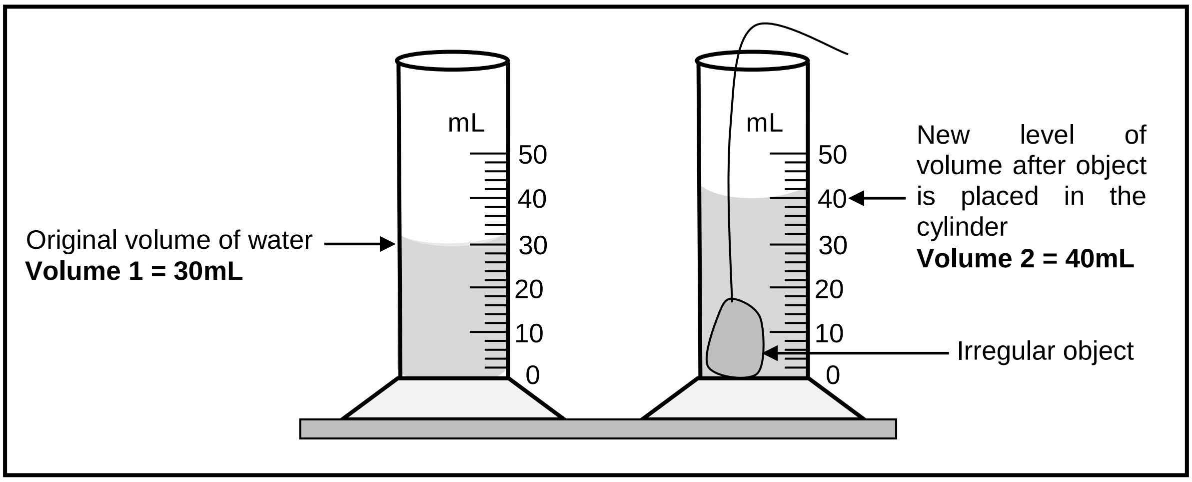
V= L x W x H

A cube 6cm on each side, for example, has a volume of 6cm x 6.00cm x 6cm = 216cm^3. Notice that the unit of volume is centimetre cubed (cm^3).

The volume of irregular shaped solid objects such as a ring, a spoon or a stone can be determined by **water** or **fluid displacement method**. This process is a simple use of addition and subtraction. You can do this by filling the beaker or measuring cylinder with enough water that allows the irregularly shaped object to fit inside it. Note the level of water at this point and record the water level without the object.

Place the object down into the water. Look at the level of the water again and notice that it has risen. Mark down the new number of units that you measured in the beaker. This is the level including the object. Subtract the level without the object from the level including the object to reach the volume of the irregularly shaped object. The result may be in millimetres if you used a standard beaker or measuring cylinder. This gives the volume of the irregularly shaped object.





Liquid or water displacement method

You will now learn how to calculate the volume of an irregular shaped object. You will use the displacement method illustrated above as an example and the steps listed below to do this.

To calculate the volume of an irregular shaped solid,

1. Take the original volume of the water. This is volume 1. In the example above it is 30 millilitres.
2. Tie a rope around an irregular shaped object and lower it into the measuring cylinder until it rests firmly at the base.
3. Take the reading of the new volume. This is volume 2. In our example it is 40 millilitres.
4. Now subtract volume 1 from volume 2. Your answer

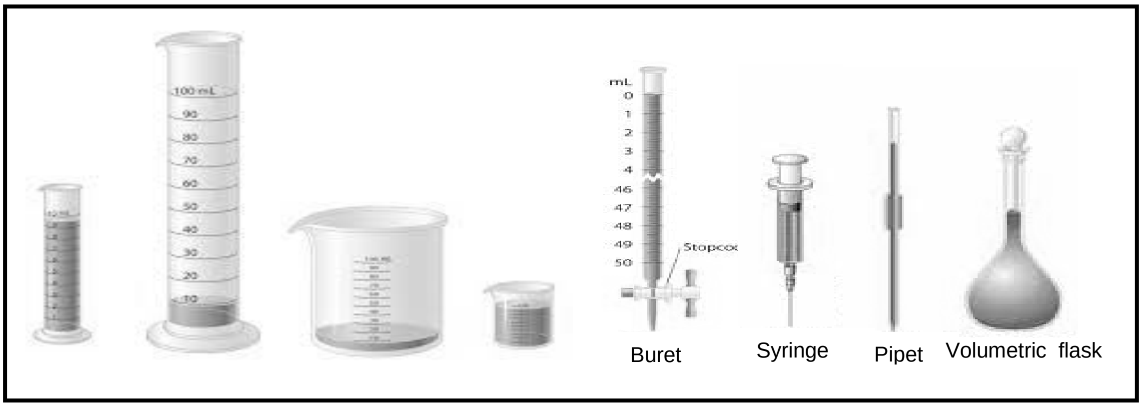
Volume of stone	=	Volume 2 - Volume 1
	=	40ml - 30ml
Volume of stone	**=**	**10ml**

To summarize on how to determine the object's volume

- If the object is solid with regular dimensions, measure its length, width and height (or length and diameter if cylindrical) and calculate its volume mathematically depending on the shape of the object.
- If the object is solid and non-porous with no regular dimensions, such as a jagged rock, you can determine its volume by immersing it in water and measuring the volume of water it displaces
- If the object is a liquid or powder, place it in a graduated cylinder and read the mark to which the substance fills the container. (If the substance is a liquid, read the mark at the lowest point of the curve the top of the liquid forms.)

Volume is commonly measured in cubic centimetres (cm^3), cubic metre (m^3), litres (l), millilitres (ml) or millimetres (mm).

Common instruments used to measure the volume of liquids are: measuring cylinders, beakers, and flasks.



Different instruments used to measure volume

Activity: Now test yourself by doing this activity.

Multiple Choice.

Circle the best answer.

1. Which of the instruments listed below is used to measure volume?

   A. Measuring cylinder B. Tape Measure

   C. Thermometer D. Bathroom scale

---

2. Which of the list below contains units of measurements for volume?

   A. Newtons, Grams, Kilojoules

   B. Grams, Kilograms, Milligrams

   C. Grams, Degree Celsius, Newtons

   D. Litres, Cubic centimetres, Millilitres

3. Volume is the

   A. force of an object.
   B. mass of an object.
   C. upward force acting on the object.
   D. the amount of space something takes.

---

4. Which of the following methods is used to measure the volume of solids of irregular shape?

   A. Meniscus method
   B. Fluid displacement method
   C. Water replacement method
   D. Measuring cylinder method

---

5. What is the volume of a solid object when the original volume is 10 mL and the final volume 15 mL after the object is placed in the cylinder?

   A. 2mL B. 3mL

   C. 4mL D. 5mL

Summary

You have come to the end of Lesson 6. In this lesson you have learnt that:

- the amount of space taken up by a substance is called its volume.
- the volume of a container is generally understood to be the capacity of the container, that is the amount of fluid (gas or liquid) that the container can hold, rather than the amount of space the container takes.
- the volumes can be measured using a measuring cylinder.
- if a substance is a regular shaped solid, then the volume can be determined mathematically using arithmetic formulas.
- the volume of a solid (whether regular or irregular shaped) can be determined by fluid displacement.
- meniscus is the concave curved upper surface of a liquid in a container or tube.
- volume is commonly measured in cubic centimetres (cm^3), cubic meter (m^3), litres (l), millilitres (ml) or millimetres (mm).

NOW DO PRACTICE EXERCISE 6 ON THE NEXT PAGE.

Practice Exercise 6

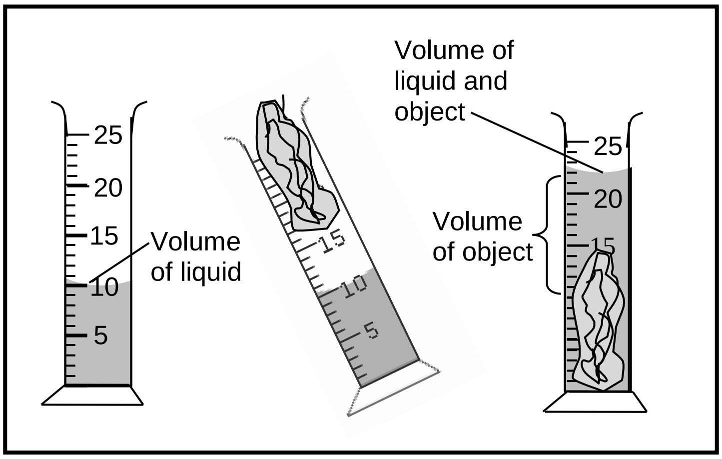
Answer the following questions.

1. Define volume.

   ____

---

2. For questions i to iv, refer to the diagram below and express your answers in ml.



   (i) What is the original volume of the liquid? __________

   (ii) What is the new volume after dropping the stone into the cylinder? __________

   (iii) What is the name of the measuring instrument used in the above experiment?

   ____

   (iv) Calculate the volume of the stone. Show the working out.

   Answer: ____________________

---

3. What is the curved upper surface of a liquid in a container called?

   ____

4. Write the names and symbols of the unit of measurements for liquid volume.

Name	Symbol
i. ______________________	____________
ii. ______________________	____________

---

5. Write the name and symbol of the unit of measurement for solid objects.

Name	Symbol
i. ______________________	____________
ii. ______________________	____________

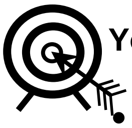
CHECK YOUR WORK. ANSWERS ARE AT THE END OF TOPIC 1.

Answers to Activity

1. A 2. D 3. D 4. B 5. D

Lesson 7: Density

Welcome to Lesson 7. In your last lesson, you learnt how to measure the volume of a substance. You defined mass as how much matter is inside of an object and volume as how much space an object occupies. In this lesson, you will study the relationship of mass, volume, and density. From a density calculation, we may tell whether a substance will float or sink in another liquid.



Your aims:

- define and explain density using correct units
- identify instruments used to measure density
- state how density is derived
- measure density of solids, liquids and gases

How Dense Are You and Why Objects Float or Sink

In diagram 1, which is heavier? Which would sink and which would float, a kilogram of feathers or gold?

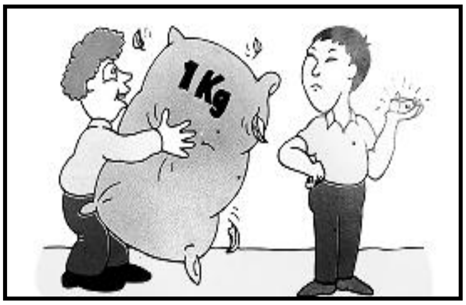


Diagram 1

The answer is neither; they both have the same mass. Gold sinks and feathers float. Why? The difference is that the mass of gold is packed into a much smaller volume than the feathers. We say that gold is much denser than the feathers.

In diagram 2, why does a light copper coin sink when it is put in water? Why does a much heavier oak log float?

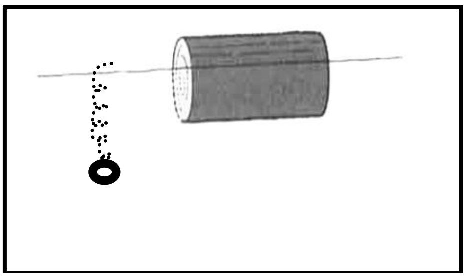


Diagram 2

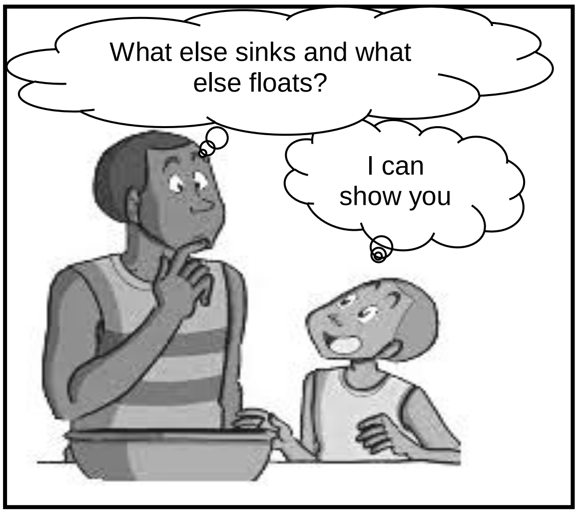
In both diagrams, you will realize straight away that it cannot be the mass of the object which makes it float or sink. Copper is more dense than water, so the coin sinks and oak wood is less dense than water and so the wood floats. In fact, it is the object's **density** which matters. It is how much mass is packed into a measured volume. Gold and copper are made up of heavy **atoms** (basic unit of matter) closely packed together and so it has a high density.

Density can be defined in this way:

The density of a substance is the mass of 1 cubic centimeter (cm^3) of it.

The unit of density is usually measured in grams per cubic centimetre **(g/cm^3)**.

Suppose you have a $1cm^3$ of iron and a $1cm^3$ of wood. Both cubes take up the same amount of space, so they both have the same volume, $1cm^3$. However their masses are very different. The iron cube has more mass packed into $1cm^3$. The density of iron is therefore greater than the density of wood. In the table, iron has a density of $7.8g/cm^3$. This means that each cubic centimetre of iron has a mass of 7.8 grams.



The table on the right shows the densities of some common substances. Notice that the density of **water is 1 g/cm^3**, and gases are much less dense than solids and liquids.

Table of densities (g/cm3)

Helium gas	0.00018	**Float on water**
Air	0.0013	
Carbon dioxide gas	0.002	
Polystyrene foam	0.1	
Cork	0.2	
Pine wood	0.4	
Petrol	0.7	
Polythene plastic	0.9	
Ice	0.9	
Water	**1.0**	
Sea water	1.03	**Sink in water**
Aluminium	2.7	
Granite	2.7	
Iron	7.8	
Nickel	8.9	
Lead	11.3	
Gold	19.3	
Osmium	22.5	

You can find the density of any object if you know its mass and its volume.

The formula is:

$$\textbf{density} = \frac{\textbf{mass}}{\textbf{volume}}$$

or in short form:

$$\mathbf{d} = \frac{\mathbf{m}}{\mathbf{v}}$$

Example 1

If 96.5 grams of gold has a volume of $5cm^3$, what is the density of gold?

$$d = \frac{m}{v}$$

Substitute values into formula

Solve:

$d = 96.5g / 5cm^3$ **$d = 19.3g/cm^3$**

Example 2

Finding Mass from Volume and Density

If the density of a diamond is 3.5g/cm^3, what would be the mass of a diamond with the volume 0.5cm^3?

Since mass is unknown, we have to derive the formula; $d = \frac{m}{v}$ by multiplying d and v to get, **m = d x v**

Substitute number and units

Solve:

Determining mass

m = 3.5g/c$\cancel{m^3}$ x .5c$\cancel{m^3}$ (cancel the unit cm^3 to get **g** as the unit)

m = 1.8g

Example 3

Finding Volume from Density and Mass

If a 96.5g piece of aluminium has a density of 2.7g/cm^3, what is its volume?

Since volume is unknown, we have to derive the formula; $d = \frac{m}{v}$ by dividing m per d to get, $v = \frac{m}{d}$

Substitute numbers and units

Solve:

Finding Volume from Density and Mass

$$v = \frac{m}{d}$$

$$v = \frac{96.5\cancel{g}}{2.7\cancel{g}/cm^3}$$ (cancel the unit g to get **cm^3** as the unit)

V = 35.7cm^3

From a density calculation, we may tell whether a substance will float or sink in another liquid. The density of a substance depends on two things:

- the mass of its atoms.
- how closely these atoms are packed together.

Objects with a density less than water will float while objects with a density more than water will sink.

Instruments Used to Measure Density and How Density is Derived

There is no real "instrument" to measure density, but there is a way to find out. Density is a mass of a volume unit. A unit of density is defined as a unit of mass divided by unit of volume. In its turn a unit of volume is a third degree of a unit of length. Mass and length units are main units. So density is a derived unit as derived from main units.

Measure density of solid, liquid and gas
The density is the ratio of the mass of a solid object to its volume. The mass is easy to get by weighing the object on a scale. However, the calculation of the volume could be challenging if the object has an irregular shape. Fortunately, the volume can be accurately measured by placing the object into water. Volume is easy if your object is regular, in which case you use the standard equations available for most regular shapes, example, cylinder, cube, and sphere but if it is irregular in shape the easiest technique is water displacement as discussed and learned from Lesson 6.

With liquids, it's fairly easy to measure both of those. Measure the mass of the container, measure the mass of the liquid and container, subtract the mass of the container and you have the mass of the liquid. Then measure the volume. Then calculate the density of the liquid.

There are several ways to measure the density of gas. One way is to take a certain amount of gas and weigh it. Yes, you really can weigh a volume of gas. One way to do this is by filling a container with the gas and weighing it, then using a vacuum pump to empty the container out completely and weighing it again. If you know how much the gas weighs and how much space it takes up, you can work out the density. Gases have very low densities. Gas molecules spread out to occupy a large volume with lots of empty space. This is the result why gases are very light.

Activity: Now test yourself by doing this activity.

Read and answer all these questions on the spaces provided.

1. Calculate the density of petrol with 8000kg mass and a volume of $10m^3$.

---

2. Water has a density of $1000kg/m^3$.
   a) What does this tell you about the water?

   b) What would be the mass of $5m^3$ of water?

   c) What would be the volume of 10 000kg of water?

Summary

You have come to the end of Lesson 7. In this lesson you have learnt that:

- the density of an object is its mass per unit volume
- the density of a substance is the mass of $1cm^3$ of it
- different materials usually have different densities
- density measures how much matter is packed into a given space
- the density of an object depends on two things; the mass of its atoms and how closely these atoms are packed together.
- objects with a density less than water will float while objects with a density more than water will sink.

NOW DO PRACTICE EXERCISE 7 ON THE NEXT PAGE.

Practice Exercise 7

Answer the following questions.

1. The mass of $10.0m^3$ of carbon tetrachloride was measured to be 15.94kg.

   What is the density of carbon tetrachloride?

2. Calculate the density of the block to two decimal places.

   Mass = 79.4 kilograms Volume=29.8 cubic metre

3. What is the density of a substance?

4. Petrol has a density of $1kg/m^3$ (kgm^{-3}). What does this mean?

5. Why does the copper coin sink when put in the water?

CHECK YOUR WORK. ANSWERS ARE AT THE END OF TOPIC 1.

Answers to Activity

1. $800kg/m^3$.
2. a) This tells that 1 m^3 of water has a mass of 1000kg.

   b) 5000kg

   c) $10m^3$

Answers to Practice Exercises 1 – 7

Practice Exercise 1

1. Measurement is a skill required in collecting data in a scientific investigation.

2. SI units mean International System of Units. It is the world's most widely used system of measurement.

3.

	SI Base Units	Quantities they Measure
i.	metre (m)	distance
ii.	kilogram (kg)	mass
iii.	second (s)	time
iv.	ampere (A)	electric current
v.	Kelvin (K)	temperature
vi.	mole (mol)	amount of substance
vii.	candela (cd)	light intensity

4. Arbitrary unit is anything that can be used as a unit of measure that cannot be checked, corrected or justified.

5. i. The arbitrary units are mainly based on personal wishes or feelings, rather than on facts.

   ii. Equipment and collected information cannot be corrected or compared accurately.

6. (i) Ammeter

   (ii) Ruler

Practice Exercise 2

1. A measurement is said to be accurate if it is close to the actual or true value. Accuracy is closeness to a targeted goal.

2. Reliability refers to a condition where a measurement process gives consistent or similar results over repeat measurements.

3. Parallax errors are sometimes called movement errors or more accurately motion parallax. It refers to the change of angular position of two measurements. A parallax error occurs when your eye is not placed directly opposite a scale when taking a reading.

4. To avoid parallax errors, each time you are taking a reading, you must ensure that the line of sight is perpendicular to the scale.

5. i) Averaging the results of several different readings.

ii) Choosing an appropriate measuring instrument for that particular task or work.

iii) Carrying out the procedure or steps carefully step by step and checking each result regularly as recorded.

Practice Exercise 3

1. Metre

2. (i) 3.2 centimetres

   (ii) 32 millimetres

   (iii) 0.032 metres

3. (i) Tape measures

   (ii) Trundle wheel

   (iii) Odometer

4. 25cm = 250mm

5. 30km = 30000m

Practice Exercise 4

Part A

1. D. Second

2. A. 3600

3. D. temperature

4. C. Mercury

5. B. heat

Part B

1. a.m from ante-meridian means the time from 12 midnight up to before 12 noon.
   p.m from post-meridian means the time from 12 noon up to 12 midnight.

2. Digital and analogue clocks. Digital clocks show the time using numbers while analogue clocks have hands to show the time.

3. a. Quarter to 5 (15 minutes before 5 or 15 minutes to 5)

   b. 20 minutes before 6 (or 20 minutes to 6 or 40 minutes past 5)

   c. 42 minutes past 4 in the afternoon (or 18 minutes before 5 in the afternoon)

   d. 2 minutes before 9 in the morning (or 2 minutes to 9 in the morning or 58 minutes past 8 in the morning)

4. A. -12^0F
   B. 30^0F
   C. 60^0F
   D. 58^0F
   E. 74^0F

Practice Exercise 5

1. a) Mass is the amount of matter in an object.

   b) The weight of an object is how hard gravity is pulling on it.

2. a. electronic balance

   b. suspended-pan balance

   c. top-loading balance

   d. weighing scale

3.

Kilogram	kg	All three answers can be accepted
Gram	g	
Milligram	mg	

4. Newton N

5. a) 3.5kg b) 5mg

Practice Exercise 6

1. Volume is the amount of space taken up by a substance.

2. i. 10ml
   ii. 22ml
   iii. Measuring cylinder

   iv. Volume of liquid = 10ml
   Volume of liquid and stone = 22ml
   therefore:
   Volume of stone = volume of liquid and stone – volume of liquid
   = 22ml – 10ml
   Volume of stone = 12ml

3. Meniscus

4. i. cubic litre (l^3)
   ii. cubic millilitre (ml^3)

5. i. cubic centimetre (cm^3)
   ii. cubic decimetre (dm^3)

Practice Exercise 7

1. $1.594 kg/m^3$

2. $2.66 kg/m^3$

3. The density of a substance is the mass of $1cm^3$ of it.

4. It means that each cubic metre of petrol has a mass of 1kg.

5. Copper sinks in water because it is more dense than water.

REVISE TOPIC 1 USING THE MAIN POINTS ON THE NEXT PAGE.

REVIEW OF TOPIC 1: Measurement

Now, revise all the lessons in this Topic and then do **ASSIGNMENT 1**.
Here are the main points to help you revise.

Lesson 1: Unit Systems

- Accurate measurements can help to solve scientific problems
- The two unit systems of measurement are SI (International System of Units) and arbitrary units.
- SI units are standard units of measurement used throughout the world.
- There are seven quantities classified as basic quantities and they are:
    - metre for distance
    - kilogram for mass
    - second for time
    - ampere for electric current
    - kelvin for temperature
    - mole for amount of substance, and
    - candela for intensity of light.
- Arbitrary units are not standard units.
- The arbitrary units are mainly based on personal preferences or feelings, rather than on facts, reasons, system and may sometimes be unfair.

Lesson 2: Reliability and Accuracy

- Reliability refers to a condition where a measurement process gives consistent or similar results over repeated measurements.
- A measurement is said to be accurate if it is close to the actual or the true value.
- An error in a measurement is a mathematical way to show the uncertainty in the measurement.
- A parallax error occurs when your eye is not placed directly opposite a scale when taking a reading. Parallax errors result in readings which are not precise.
- To avoid parallax errors, each time you are taking a reading you must ensure that the line of sight is perpendicular to the scale.
- When taking measurements it is important to:
    a. Choose the most suitable measuring instrument.
    b. Know how to use the measuring instrument.
    c. Know methods for increasing the accuracy of measurements.

Lesson 3: Length

- Length is distance from one end point to the other end point.
- The Imperial system uses inch, foot, yard and mile as its' standard units for measuring lengths.
- The International System (SI) uses centimetre, metre and kilometre as its' standard units for length measurements.
- The metre is the basic unit of length in the metric system.
- There are many different types of instruments that you can use to measure the length, height or width of something and the equipment you choose will vary depending on what you want to measure.
- When measuring, you should be accurate. You need to choose the right measuring equipment and be able to use it correctly. You must also decide which unit of measurement is most appropriate.

Lesson 4: Time and Temperature

- Time is scientifically defined as a continuous, measurable quantity wherein events occur in a succession proceeding from the previous through the current to the future.
- Time is measured in units called second(s), minute(m), and hour(h)
- Temperature is the degree of hotness or coldness of a body or environment.
- Temperature is measured in units called degrees Celsius, degrees Fahrenheit and Kelvin.

Lesson 5: Mass and Weight

- Mass is the amount of matter in an object and is also known as inertia. It can be measured using a balance, while weight is the amount of force of gravity on the object.
- The mass of an object is constant but the weight does change depending on the intensity of gravity in particular places.
- Mass is measured in grams or kilograms. The results are usually given in grams where 1 kilogram is equal to 1000 grams.
- Weight is the gravitational force that is acting on an object.
- The unit of weight is the Newton (N).
- The gravitational or downward pull force of the earth is about 10 newtons per kilogram.

Lesson 6: Volume

- The amount of space taken up by a substance is called its volume.
- The volume of a container is generally understood to be the capacity of the container, that is the amount of fluid (gas or liquid) that the container can hold, rather than the amount of space the container takes.
- The volumes can be measured using a measuring cylinder.
- If a substance is a regular shaped solid, then the volume can be determined mathematically using arithmetic formulas.
- The volume of a solid (whether regular or irregular shaped) can be determined by fluid displacement.
- Meniscus is the concave curved upper surface of a liquid in a container or tube.
- Volume is commonly measured in cubic centimetres (cm^3), cubic meter (m^3), litres (l), millilitres (ml) or millimetres (mm).

Lesson 7: Density

- The density of an object is its mass per unit volume
- The density of a substance is the mass of $1cm^3$ of it
- Different materials usually have different densities
- Density measures how much matter is packed into a given space
- The density of an object depends on two things; the mass of its atoms and how closely these atoms are packed together.
- Objects with a density less than water will float while objects with a density more than water will sink.

NOW DO TOPIC TEST 1 IN YOUR ASSIGNMENT 1

TOPIC 2

SCIENTIFIC APPROACH

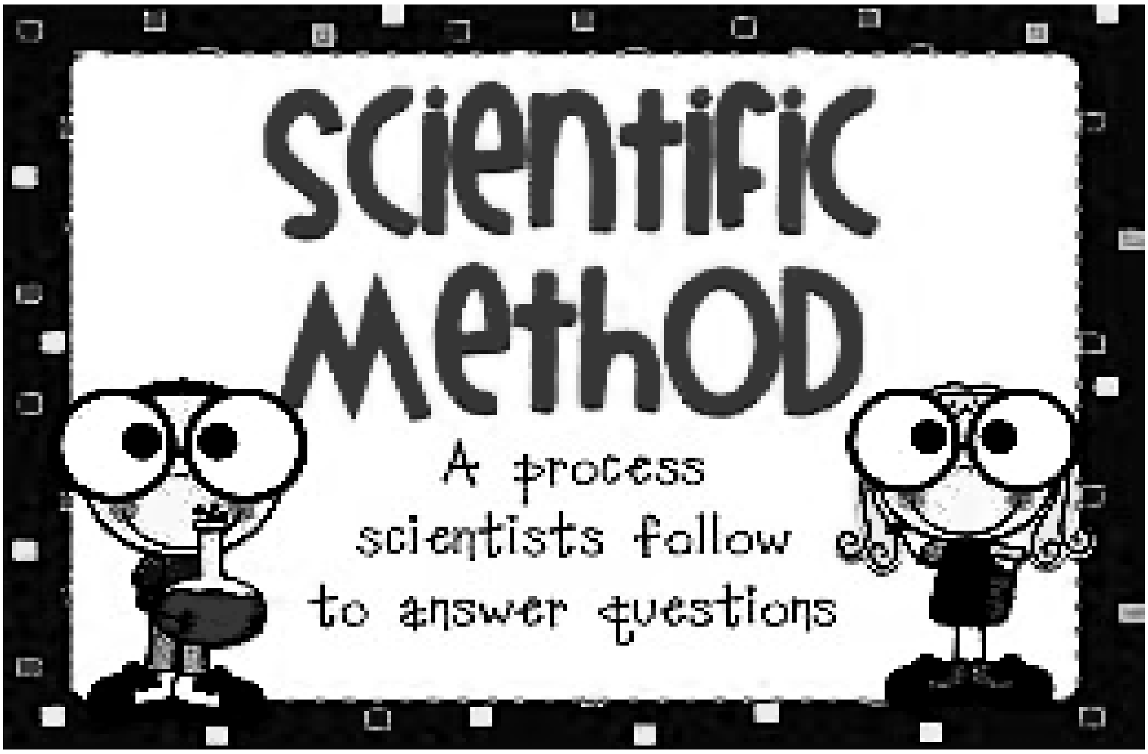
In this topic you will learn about:

- **use of apparatus and instrument**
- **first aid**
- **prediction and inference**
- **how to present data**
- **control, variable and hypothesis**
- **parts of a science report**
- **writing a science report**

INTRODUCTION TO TOPIC 2: SCIENTIFIC APPROACH

The scientific method is one way that people can try to find the answers to the problems. It is a series of steps followed by scientific investigators to answer specific questions about the natural world. This includes observing, testing and doing experiments.

The scientific method is essential in every science experiment. Understanding how to work with it is critical for the success of your science fair experiment.



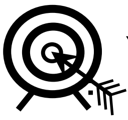
You should know all about the scientific method and the list of steps that you need to follow when you are solving a problem. Some of the questions you may be asking yourself now are:

- How do we solve scientific problems?
- Do we carry out experiments to solve scientific problems?
- If we carry out experiments to solve problems in science, what are some important things that we should know about?

In this topic, you will find answers to these questions and all other questions relating to the scientific approach

Lesson 8: Use of Apparatus and Instruments

Welcome to Lesson 8. As you enter a science laboratory, you will find that it is not the same as the normal classrooms that you find in schools. In the Science laboratory, you will find many different pieces of equipment that are used to perform science experiments. In this lesson you will learn about some of the common equipment that you can find in a science laboratory.



Your Aims

- identify equipment used in the science laboratory
- enumerate correct and safe ways to use different science equipment

Equipment Used in a School Science Laboratory

At school you will do most of your scientific work in the science laboratory. A school science laboratory has similar settings to any laboratory that a scientist works in. There will be special taps and sinks for washing and cleaning. There may be fume cardboards to remove dangerous or unwanted smells. There will be gas taps placed around the room and gas burners that can be used for heating chemicals. There will be different shaped pieces of glassware in which to do experiments.

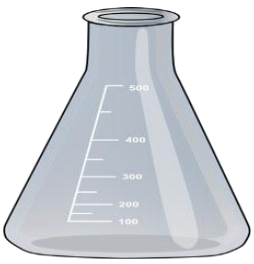
All the equipment that you find in a science laboratory is called **apparatus**. It is very important to know which equipment to use and how to use it safely. All equipment should be clean and dry before and after use.

Before you can begin experimenting you need to be able to identify these items and know what they are used for. You also need to be able to spell their names correctly and draw them when you write up reports of experiments. By now, you would have some ideas on how to draw scientific diagrams as you have learnt in Grade 7 and 8.

Some of the laboratory equipment is listed below.

A. Containers and Other Useful Items

Beaker



Conical Flask


Test Tube


Measuring Cylinder


Evaporating Basin


Watch Glass


Spatula


Filter Funnel


Dropper

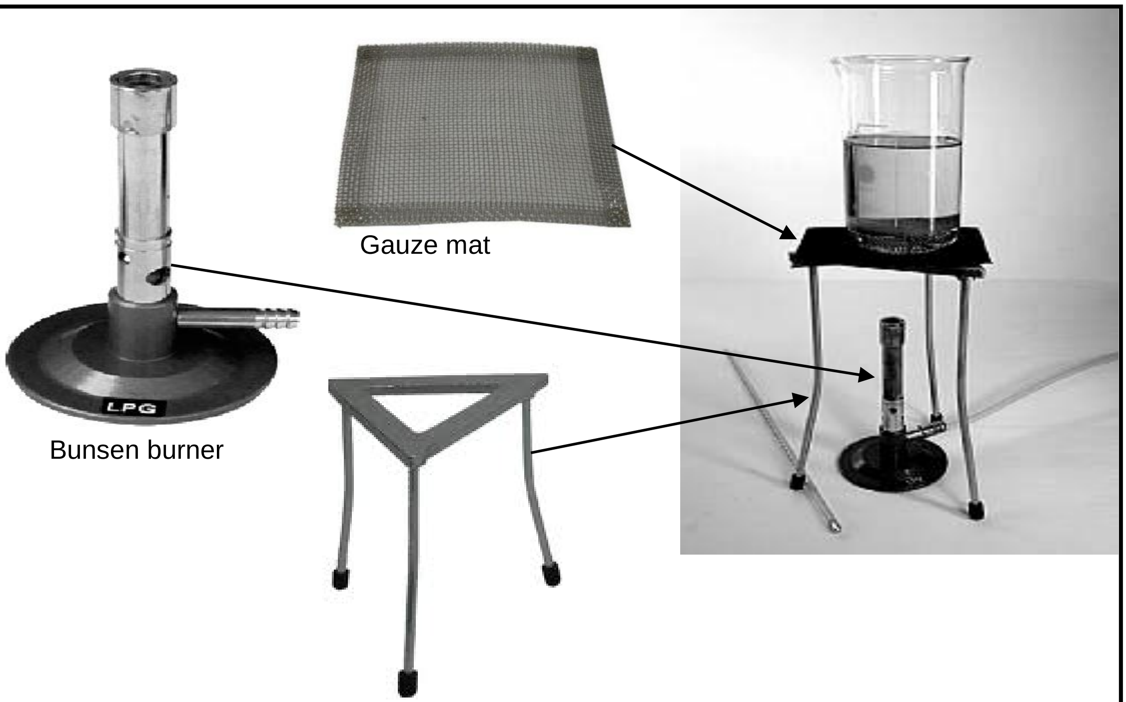

Crucible with lid


Petri Dish


Gas


Test tube brush

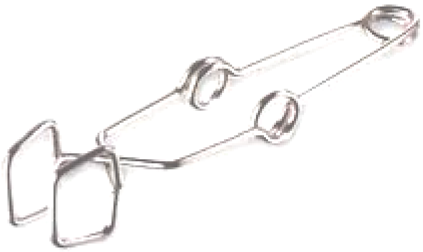
B. Heating Apparatus



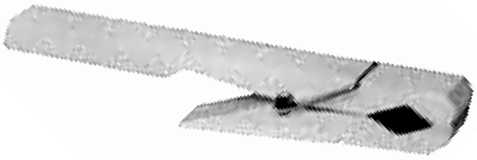
Tripod

C. Holding Things

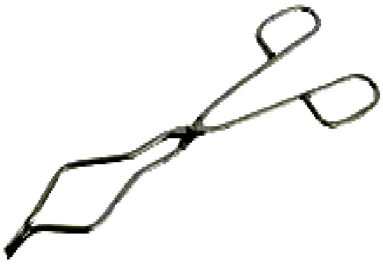
Test tube rack with test tubes



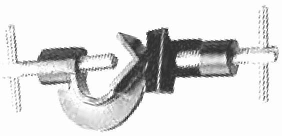
Test tube holder (metal)



Test tube holder (wooden)



Metal tong



bosshead

Metal retort stand

Clamp

Stand and clamp

List below are the uses of the different apparatus learnt in this lesson.

Equipment	Use
Beaker	Used to hold and heat liquids. Multipurpose and essential in the laboratory.
Conical flask	Used for mixing and storing different chemicals for reactions.
Test tube	Open tube used to hold liquids.
Measuring cylinder	Used to make accurate measurements of liquid volumes.
Evaporating basin	Used to heat and evaporate liquids over a Bunsen burner.
Watch glass	Used to hold solids when being weighed or transported. It can also be used as a cover for a beaker. Watch glasses should never be heated.
Spatula	Used to transfer powder and crystal chemicals.
Filter funnel	Used to transfer liquids into any container so they will not be lost or spilled.
Dropper	Used to dispense small amounts of liquid. It is especially useful when the amount to be added is very small and needs to be measured accurately.
Crucible and lid	Used as a container when heating small amounts of chemicals to very high temperatures.
Petri dish	Glass or plastic equipment mostly found in the lab and it has a variety of uses though it is mainly used to grow bacteria. The dish can also be used for viewing seed germination or small animals. Because petri dishes are relatively small, they can fit under a dissection scope and be used for viewing small objects under the microscope.
Test tube brush	Used to easily clean the inside of a test tube.
Bunsen burner	Used for heating and exposing items to flame.
Gauze mat	Supports containers over a Bunsen burner while they are heated; spreads heat evenly under the container.
Tripod	Supports gauze mats over Bunsen burners.
Test tube rack	Used to hold test tubes while reactions happen in them or while they are not needed.
Test tube holder	Holds test tubes when they are hot and untouchable.
Metal tongs	Used to hold many different things such as flasks, crucibles, and evaporating dishes when they are hot.

Metal retort stand	Used with clamps and boss heads to hold substances at a required height.
Boss head	Used to hold a clamp to a retort stand in a science lab.
Clamp	Used with a retort stand to hold a glass container above the lab table.
Stand and clamp	Used to hold items being heated. Clamps can be used so that items may be placed above the lab table for heating by Bunsen burners or other items.

Science Laboratory Safety Rules

Experimenting in the science laboratory is safe if you are careful! You must take responsibility for the safety of yourself and those around you. Following the safety rules below will help you avoid unnecessary accidents and you will make your laboratory a safe place to work in.

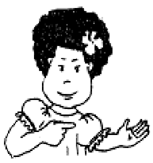
1. The science lab is used for serious work only. No playing around will be permitted.
2. Do not perform unauthorized experiments. Always obtain your teacher's permission before doing any experiments.
3. Study your lab experiment carefully. If you are in doubt about any procedure, ask your teacher.
4. Use the safety equipment provided for you. Know their location and proper use.
5. Safety glasses must be worn whenever any substance is being heated or when mixing or pouring chemicals.
6. Report all accidents, injuries or incorrect procedures to your teacher at once.
7. If clothing accidently catches fire, smother it with a blanket or coat. NEVER RUN!!
8. If you spill acid or other chemical, wash with water or ask your teacher for help.
9. Never taste any chemical or transfer chemicals by mouth pipette.
10. Never eat or drink in the lab.
11. Never try to smell or inhale chemicals.
12. Keep combustible materials away from open flames.
13. Do not throw paper or other solid material into the sink.
14. If glass is broken, call your teacher for help.

Activity: Now test yourself by doing this activity.

Answer all questions according to the given instructions.

Write the name of the apparatus that correctly matches the description of their use in the table below.

Apparatus	Use
	Used to pick up or hold hot objects
	Placed on top of a tripod to spread the heat
	You stand equipment on this when heating things
	Used to dispense a very small amount of a liquid
	A small glass container used to view chemical reactions or to heat small amounts of a substance
	Used to measure volume very precisely
	Used for heating and exposing items to flames
	Used to easily clean the inside of a test tube
	Used to heat small amounts of chemicals to very high temperatures



Summary

You have come to the end of Lesson 8. In this lesson you have learnt that:

- at school most of the scientific work is done in the science laboratory.
- all the equipment that you find in a science classroom is called apparatus.
- there are various apparatus used to carry out experiments in a science laboratory.
- it is very important to know which equipment to use and how to use it safely.
- when carrying out experiments, care must always be taken to avoid accidents
- rules of a science laboratory must be followed closely to avoid any accidents.

NOW DO PRACTICE EXERCISE 8 ON THE NEXT PAGE.

Practice Exercise 8

Multiple Choice Questions

Circle the letter of the correct answer.

1. What should a student do if equipment is not working properly in a science classroom?

   a) Continue to try to use it
   b) Tell the science teacher
   c) Tell your lab partner to fix it
   d) Find another piece of equipment

---

2. Which of the following would you *least* expect to do in a science laboratory?

   a) Conduct tests
   b) Solve problems
   c) Taste chemicals
   d) Take measurements

---

3. Which of the following piece of apparatus is **not** used to store water?

   a) Crucible
   b) Test tube
   c) Filter funnel
   d) Evaporating basin

---

4. We must be careful when smelling substances in science because

   a) our nose might be blocked.
   b) not all substances have a smell.
   c) some substances have a terrible smell.
   d) some substances give off poisonous fumes.

---

5. You are heating a piece of glass and now want to pick it up. You should

   a) use a tong.
   b) pour cold water on it.
   c) use a rag or paper towels.
   d) pick up the end that looks cooler.

6. What equipment would you use to take a small amount of powder from a bottle and dissolve it in water?

a) Tong b) Crucible
c) Spatula d) Clamp

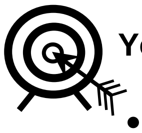
CHECK YOUR WORK. ANSWERS ARE AT THE END OF TOPIC 2.

Answers to Activity

Apparatus	Use
Tong	Used to pick up or hold hot objects
Gauze mat	Placed on top of a tripod to spread the heat
Tripod	You stand equipment on this when heating things
Dropper	Used to dispense a very small amount of a liquid
Test tube	A small glass container used to view chemical reactions or to heat small amounts of a substance
Measuring cylinder	Used to measure volume very precisely
Bunsen burner	Used for heating and exposing items to flames
Test tube brush	Used to easily clean the inside of a test tube
Crucible	Used to heat small amounts of chemicals to very high temperatures

Lesson 9: First Aid

Welcome to Lesson 9. In your last lesson you learnt about the different science equipment that you can find in a school science laboratory. Working in a science laboratory involves some risks. To prevent injuries to yourself and others, you should be aware that there are laboratory safety rules you must follow. Some safety rules are designed to prevent accidents while others give advice on what to do if accidents occurred. This lesson will help you recognise some of the rules and how you can help those who might have accidents.



Your Aims:

- discuss First Aid and its importance

Safety Rules

You may be required to wear **Personal Protective Equipment** (**PPE)** such as safety glasses and laboratory aprons. While this will reduce the effects of laboratory accidents, they will not stop an accident from occurring. When carrying out experiments you need to follow safety rules and act in a responsible manner.

A student working safely in a laboratory

Some basic safety equipment

Chemicals are delivered to schools with information such as risk, safety procedures and first aid information attached to the chemical label. It is a legal requirement that the chemical suppliers provide a **Material Safety Data Sheet (MSDS)** with each chemical they sell. During your science classes you must learn to handle apparatus and the equipment carefully and learn the safety tips.

In order to prevent accidents in the science classroom you must obey these two important rules.

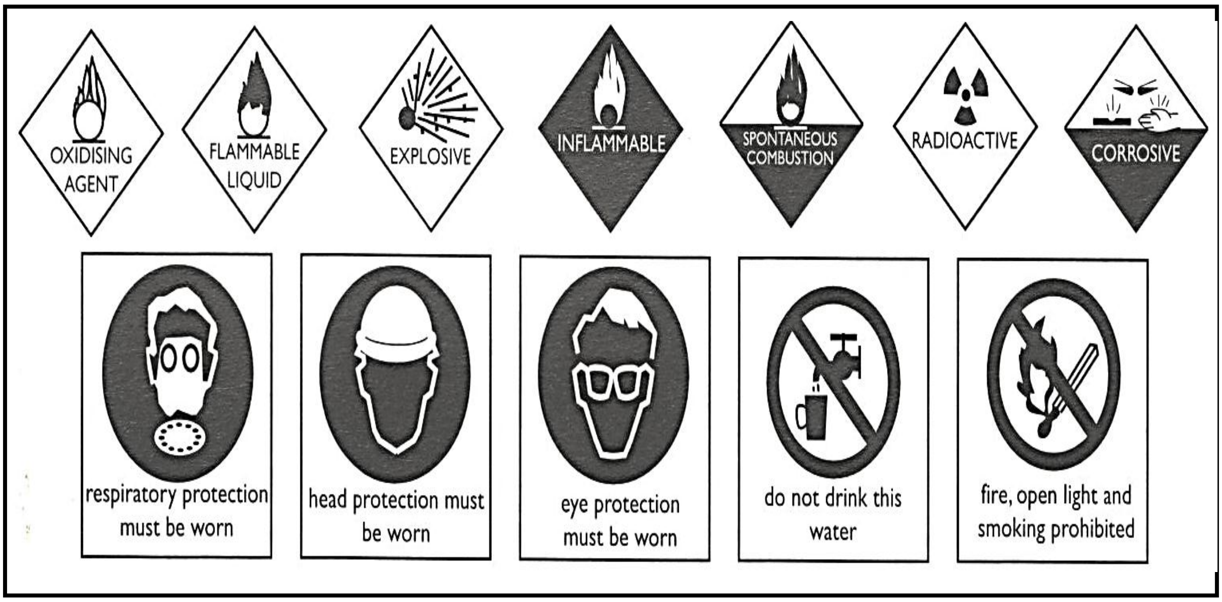
1. Know what you are doing in the laboratory and read the instructions carefully before you start.
2. Always think of others and behave sensibly

Always remember to have your apparatus and workplace clean to prevent accidents.

Warning Signs and Labels

Throughout life, you will be faced with injuries of every kind; whether it is a simple cut or a severe chemical burn. Accidents can happen in school or at home. Every accident must be dealt with in the right way. Not only rules warn us of danger, symbols are also used to remind people of what not to do.

Manufacturers of chemicals put warning signs or labels to warn users of their chemicals. The text and symbols are internationally known. The warning signs indicate danger, demanding care and proper use. Some chemicals are corrosive this means they eat away other materials. Some chemicals are poisonous which means they can be damaging to a person’s health. Some labels you might find on chemicals and symbols that warn you of danger are shown below.



Examples of labels

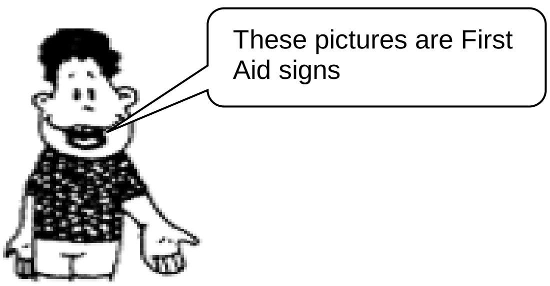
First Aid and its Importance

Many deaths and impact of injuries can be prevented with First Aid if the **casualty** is treated immediately. A casualty refers to a person badly affected or injured in an accident. It can also refer to a person that is killed during an accident. **First Aid** is the initial care given to an injured person. In other words it is a timely and quick care given to the injured person prior to the arrival of the trained medical personnel.

It must start immediately when the injury or illness occurs and continue until medical help arrives or the casualty recovers.

The basic aims of first aid are to:

- save life
- protect the casualty from getting more harm
- reduce pain and priorities of casualty treatment



Let us now discuss what poisoning is and the first aid procedure used when poisoning occurs.

First Aid for Poisoning
Poisoning is caused by swallowing, injecting, breathing in, or otherwise being exposed to a harmful substance. Most poisonings occur by accident.

Immediate first aid is very important in a poisoning emergency. The first aid you give before getting medical help can save a person’s life. If you have been experimenting with chemicals, you should consider poisoning if someone suddenly becomes sick for no apparent reason, or if the person is found in an area that is not well ventilated.

Symptoms of poisoning may take time to develop. However, if you think someone has been poisoned, do not wait for symptoms to develop before getting that person medical help.

First Aid
Seek immediate medical help for:

1. Poisoning by swallowing:

- Check and monitor the person’s airway, breathing and pulse. If necessary, begin rescue breathing and **CPR**. CPR stands for cardiopulmonary resuscitation. It is an emergency lifesaving procedure that is done when someone’s breathing or heartbeat has stopped. CPR allows oxygenated blood to circulate to vital organs such as the brain and heart and can keep a person alive until more professional medical help arrives.

- Try to make sure that the person has indeed been poisoned. It may be hard to tell. Some signs include chemical-smelling breath, burns around the mouth, difficulty breathing, vomiting, or unusual odours on the person. If possible, identify the poison.

- Do NOT make a person throw up unless told to do so by poison control or a health care professional.

- If the person vomits, clear the person’s airway. Wrap a cloth around your fingers before cleaning out the mouth and throat. If the person has been sick from a plant part, save the vomit. It may help experts identify what medicine can be used to help reverse the poisoning.

- Keep the person comfortable. The person should be rolled onto the left side, and remain there while getting or waiting for help.

- If the poison has spilled on the person’s clothes, remove the clothing and flush the skin with water.

Calling for emergency help

Poisoning by inhaling:

- Call for emergency help. Never attempt to rescue a person without notifying others first.
- If it is safe to do so, rescue the person from the danger of the gas, fumes, or smoke. Open windows and doors to remove the fumes.
- Take several deep breaths of fresh air, and then hold your breath as you go in. Hold a wet cloth over your nose and mouth.
- Do not light a match or use a lighter because some gases can catch fire. After rescuing the person from danger, check and monitor the person's airway, breathing, and pulse. If necessary, begin rescue breathing and CPR.
- If the person vomits, clear the person's airway. Wrap a cloth around your fingers before cleaning out the mouth and throat.
- Even if the person seems perfectly fine, get medical help.

First Aid Kit
It is important to have a first aid kit available at all schools. It should include a first-aid guide. A first aid kit is a collection of supplies and equipment for use in giving first aid and can be put together for the purpose by an individual organization or your school.

Laboratory First Aid
Accidents can also happen in a science laboratory and it must be dealt with in the right way. Listed below are some laboratory first aid that you can follow.

1. Report all accidents, injuries, or incorrect procedures at once.
2. In case of severe bleeding contact your teacher immediately.
3. If any substance is spilled on you or gets into your eyes, wash with plenty of water and notify your teacher.
4. Minor burns should be immersed in cold water at once. For severe burns, notify your teacher immediately.
5. In case of fainting or collapse, give the person fresh air and recline him so that the head is lower than the body.

A poster reminding us to report accidents

A safety first sign


Immersing a minor burn in cold water


A person in a reclined position

Activity: Now test yourself by doing this activity.

How well do you know how to deal with emergencies? Could you give life- saving first aid to those who need it?

You have 3 lives in your hands. If you answer correctly, you save a life if not you lose a life. See how many lives you can save by giving first aid to those who need it. All you have to do is circle the correct first aid. When you have finished with the activity, check your answer and see how many lives you saved.

Problems:

1. You are having lunch with your friend and he begins to choke on some food. He cannot speak or cough it up. How can you help?

   a) Get him to lay down flat.

   b) Leave him alone and go and look for help.

   c) Put your fingers down his throat to try to dislodge the obstruction

   d) Give at least strong five taps between his shoulders using the palm of your hands.

2. One of your friends has cut his arm and is bleeding severely. How do you treat his injury?

   a) Give him an aspirin.

   b) Apply direct pressure over the wound.

   c) Put the injured limb in some cold water.

   d) Put him on a stretcher and take him to the nearest clinic.

3. You are standing in line waiting to pick up your study materials and the person in front of you suddenly collapses. What do you do?

   a) Roll them into the recovery position

   b) Immediately call St John's ambulance

   c) Get them into a sitting position and offer a glass of water

   d) Try to get a response out of them before checking their airway

---

Summary

You have come to the end of Lesson 9. In this lesson you have learnt that:

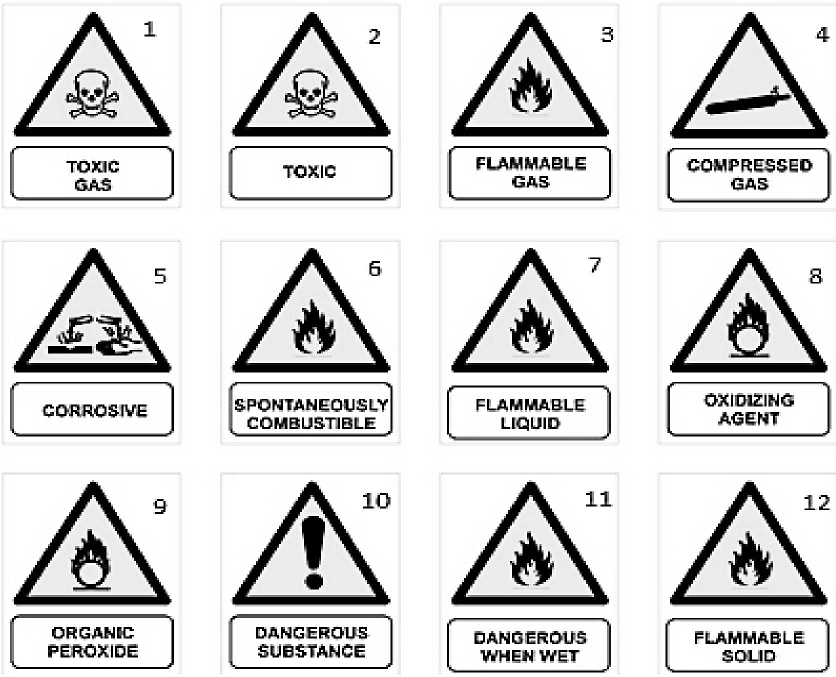
- safety rules must be strictly followed when you are using a science laboratory.
- you must always wear personal protective equipment such as safety glasses and laboratory aprons to prevent accidents.
- remember to have your apparatus or your work place clean.

- chemicals delivered to your school must have first aid and safety procedures attached to the chemical labelled.
- it is a legal requirement that the chemical suppliers provide a material safety data sheet for every chemical they sell
- first aid is the providing of first care for an illness or injury. It is usually performed by a non-expert, but trained personnel to a sick or injured person until proper medical treatment arrives.
- first aid is applied for three main reasons: to save a person ,to prevent further harm and to help the person to recover.

NOW DO PRACTICE EXERCISE 9 ON THE NEXT PAGE.

Practice Exercise 9

Refer to the diagrams to answer the following questions. There could be two or more possible answers to a question.



1. Which of these labels would be dangerous when using a lighter?

2. Potassium and sodium are dangerous when in contact with water. Which label would be placed on potassium and sodium?

3. Which labels would be placed on acids?

4. Which label would be placed on petrol and kerosene?

5. What does the word toxic on label 2 mean?

CHECK YOUR WORK. ANSWERS ARE AT THE END OF TOPIC 2.

Answers to Activity

1. d Give at least strong five taps between his shoulders using the palm of your hands.

2. c Put the injured limb in some cold water

3. d Try to get a response out of them before checking their airway

Lesson 10: Prediction and Inference

Welcome to Lesson 10. In your previous lesson you learnt about first aid and its importance. In this lesson you will learn about prediction and inference. In science when an experiment is being carried out, careful observations are made. When we observe we take note of what is around us by using our five senses. We record what is seen, smelled, tasted, heard and touched. In an observation you simply describe something as it appears. From your observation you can be able to guess what might happen next or in the future.

Your Aims:

- defines inferences and predictions
- makes inferences in given situation
- make prediction in given situations

Inferring

When you suggest a possible explanation for an observation, you are making an inference. Inferences cannot be directly observed. For example, you get up in the morning, look up at the sky and observe dark clouds, observe the air is cool and humid, and observe puddles on the ground, you might infer that it has recently rained.

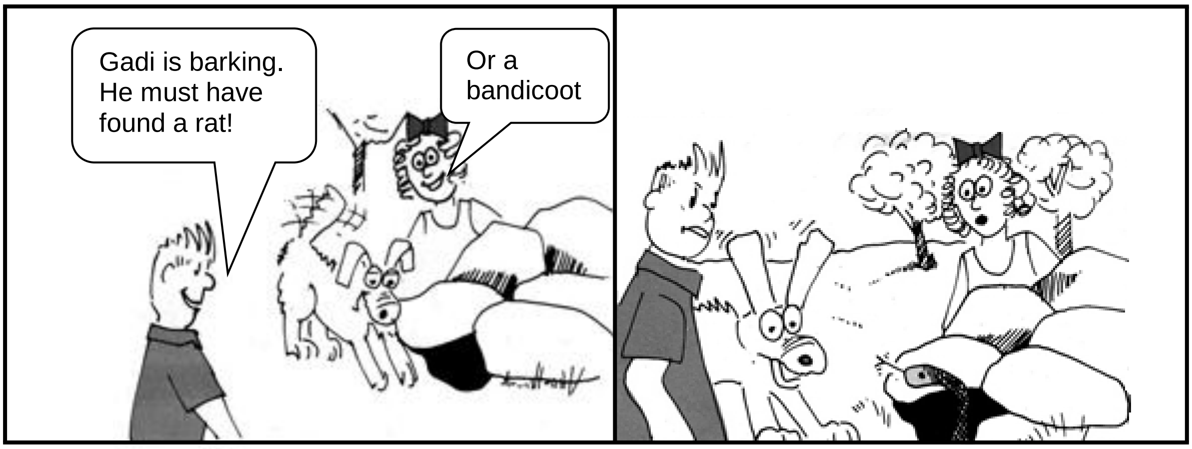
Take note of this: You did not **see** rain; you **decided** that it rained based on your observations.

An inference is a statement based on your interpretation of the facts

Inferring is an important skill in science. There are three things you must remember when making inferences;

1. Make several different inferences from the same observation.

In figure (a) below, Ingian made an observation. ***The dog is barking.*** He also made an inference. ***He must have found a rat.*** Adelle has made another possible inference: ***or a bandicoot.***

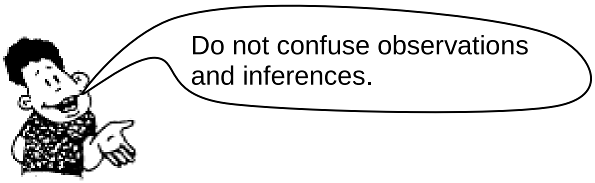


a) Different inferences from the same observation b) Inferences can be wrong

2. Make correct observations, provided that you have been careful and honest in reporting the observations. However, inferences often turn out to be wrong as shown in figure (b) in the previous page. They can be tested by further observations.

3. It is important not to confuse observations and inferences. Otherwise you may think that something is a fact when it is just a possible explanation. Look at the figure below. What was Bella's observation? What was her inference? Was her inference correct?

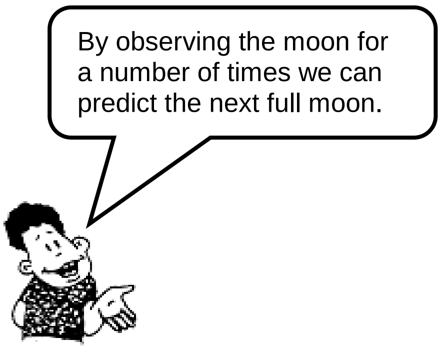
Inferences can be wrong



Bella observed the dog wagging its tail and walking towards her. She inferred that the dog was friendly and reached out to touch the dog. Her inference was wrong as the dog was aggressive. As soon as she touched the dog it ripped her dress.

Predicting

Another important skill is predicting. If you make a statement of what you think may happen in the future, then you are making a prediction. Predictions are usually based on past observations and experiences. For example if you observe the moon for a number of nights you can confidently predict whether there will be a full moon tonight. Otherwise you will only guess and you will probably be wrong.



A crescent moon A full moon

A prediction is a statement of what will happen in the future

Activity: **Now test yourself by doing this activity.**

Answer the following questions.

1. Which of the following are observations and which are inferences?

   a) The leaves of the plant are dropping.

   ____

   b) I think this is a sugar solution.

   ____

   c) The inside of the earth is molten rock.

   ____

   d) The temperature of the water is 23 ^{0}C.

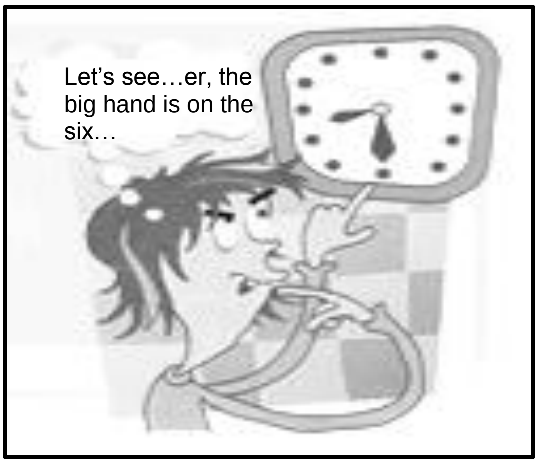
   ____

   e) This toy must have a magnet.

   ____

---

2. For the situation below decide which statement is an observation, which is an inference, and which is a prediction.



   a) The minute hand is on the six and the hour hand is between 8 and 9.

   ____

   b) The time is 8.30 am.

   ____

   c) In half an hour the bell will ring.

   ____

Summary

You have come to the end of Lesson 10. In this lesson you have learnt that:

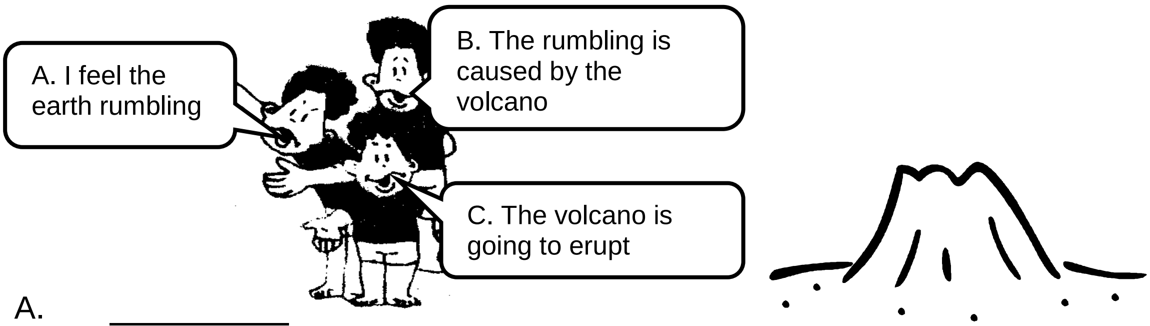
- observation can be done with the use of senses.
- the five senses are hearing seeing, smelling, touching and tasting.
- inference is where a student tries to explain what happened in an observation.
- when making inferences there are three things that one must note They are:
    - Many inferences should be made from the same observation.
    - You must be careful when observing and honest in your report.
    - You must not confuse inferences and observations.
- predicting is simply the forecast of the future based on your observations.
- a number of observations can help you predict the future.

NOW DO PRACTICE EXERCISE 10 ON THE NEXT PAGE.

Practice Exercise 10

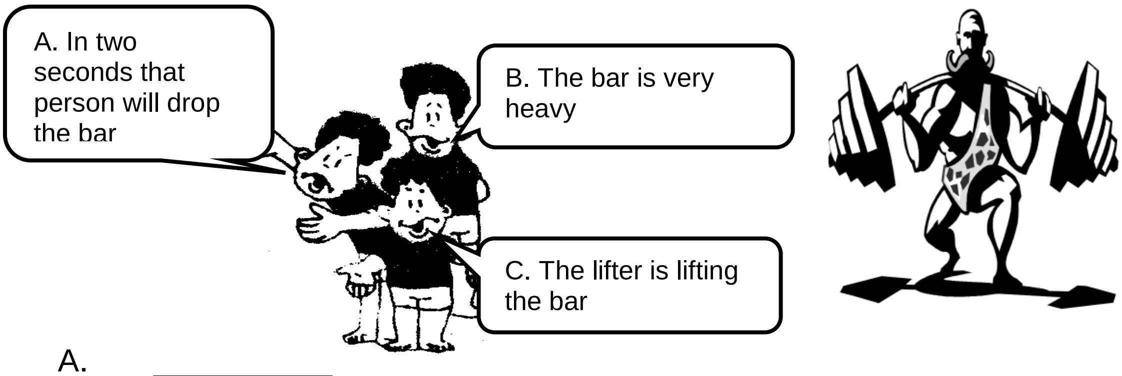
1. Look at the picture at the right and decide which statement by cartoons is an observation, which is an inference and which is a prediction.

i.



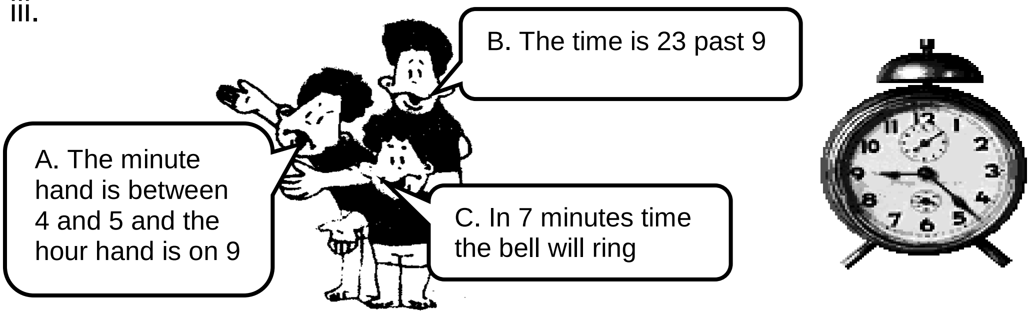
A. ____________
B. ____________
C. ____________

ii.



A. ____________
B. ____________
C. ____________

iii.



A. ____________
B. ____________
C. ____________

CHECK YOUR WORK. ANSWERS ARE AT THE END OF TOPIC 2.

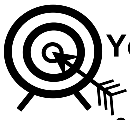
Answers to Activity

1. a) Inference
   b) Prediction
   c) Inference
   d) Inference
   e) Prediction

2. a) Observation
   b) Inference
   c) Prediction

Lesson 11: How to Present Data

Welcome to Lesson 11. In your previous lesson you learnt about inferring and predicting. In this lesson you will learn about how to present data. When you record a set of measurements you end up with a list of numbers. These numbers are called **data** and can be presented in a table. Such a table is called a **table of data.**

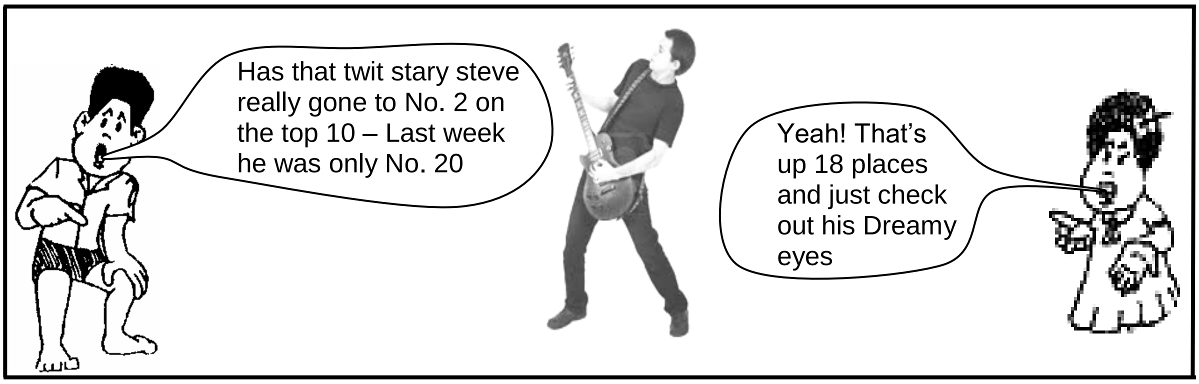


Your Aims:

- use information in a given situation to tabulate data on graphs and table
- write conclusion from the tables and graphs drawn using given guidelines

Handling Data

When data is collected, it is good to sort it out so that it makes sense like we do in everyday life. Here are some ways to handle data.



From the above conversation, Aiya presented some data and Grace has done something with the data.

Suppose that ten students in a class measure their heights, as shown in the table below.

Data Table

Student	Height in cm	Student	Height in cm
Bathsheba	133	Stephanie	136
Lloyd	138	Ellie	142
Eddie	157	Robert	156
Nigel	160	Marcellus	135
Adelaide	140	Gabriella	139

We handle the data as follows:

1. Sorting the data

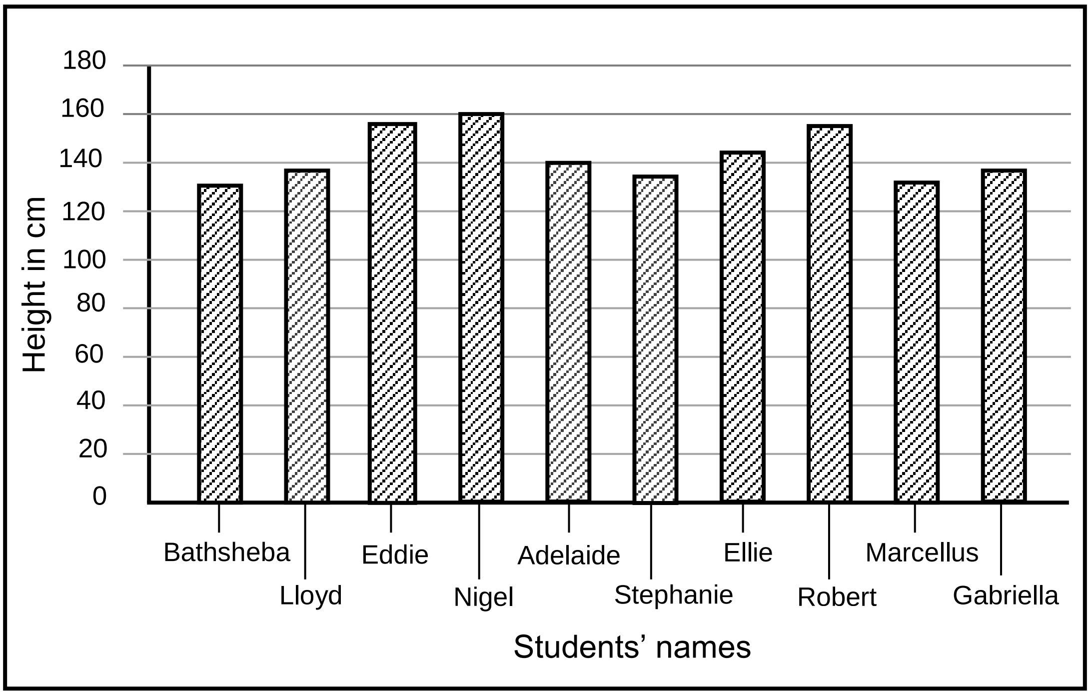
This means putting it in order so it is easier to use. For example, you may want to sort the heights from the shortest to the tallest. Or you may separate the boys and the girls. Computers can help you sort data quickly.

2. Displaying the data

You can display the data in a graph, diagram or chart. In the diagram below the students' heights have been sorted from shortest to tallest. They have been displayed in a **bar graph.** Bar graphs are used when comparing data.

To find Bathsheba's height, you go to the top of her bar, and then over to the vertical axis. The number on the vertical axis is Bathsheba's height – 133 centimetres. From the graph you can see at a glance who is the tallest, and who is the shortest.

BAR GRAPH OF STUDENT HEIGHTS



3. Looking for a pattern

Now look to see if one part of the data seems to have links to other parts. This is the **pattern**. In this case there does not seem to be a pattern. In other cases you might find that the girls tended to be taller than the boys, or, if you knew the students 'masses, you would probably find that the taller students tended to be heavier than the shorter students. In this case there is a link between height and mass. Once again, computers can be used to find these sorts of patterns quickly.

4. Using the data

The heights of the students vary – from 133cm up to 160cm. You can get a general idea of how tall this group of students is from the **average** height. You find the average by adding up all the heights, and then dividing by the number of students.

$$\text{Average} = \frac{\text{sum of all the heights}}{\text{number of students}}$$

$$= \frac{133 + 138 + 157 + 160 + 140 + 136 + 142 + 156 + 135 + 139}{10}$$

$$= \frac{1436}{10} = 143.6\text{cm}$$

Notice that none of the students is 143.6cm tall. Some are taller than 143.6cm and some are shorter.

Another way to describe the data would be to give the **range**. For instance, if you were making student chairs, it would be useful to know that students' heights range from 133cm to 160cm.

You may want to measure the students' heights each year. In this case, you will need to store the data for later use.

Activity: Now test yourself by doing this activity.

Answer all questions according to the given instructions.

1. Look at the bar graph of students' height on the previous page. If the average height is 144cm, which students are taller than the average?

   ____

   ____

---

2. The table below shows the times of high tide at a beach.

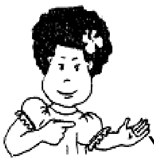
	Monday	**Tuesday**	**Wednesday**	**Thursday**	**Friday**
Morning	6.10a.m.	7.00a.m.	7.50a.m.	8.40a.m.	
Afternoon	6.35p.m.	7.25p.m.	8.15p.m.	9.05p.m.	

(a) What patterns can you see linking the times of the high tides?

____

____

(b) Predict the times of the two high tides on Friday. (Write them in the table)



Summary

You have come to the end of Lesson 11. In this lesson you have learnt that:

- data can be handled in a number of ways and they are:
  - sorting the data,
  - displaying the data,
  - looking for a pattern and
  - using the data
- to make data more useful it needs to be sorted and displayed, example, in a bar graph

---

NOW DO PRACTICE EXERCISE 11 ON THE NEXT PAGE

Practice Exercise 11

Complete the following activities.

1. Six students each measured how long it takes a disprin tablet to dissolve in water at different temperatures. The table below shows their results.

Temperature of water (^oC)	**Dissolving time (second)**
30	22
25	24
35	20
40	18
20	27
45	16

(i) Sort out this data in the following table and see if you can see a pattern in it.

Temperature of water (^oC)	**Dissolving time (second)**

(ii) Describe the pattern.

2. A farmer found that he had four types of grubs eating his crops – brown ones, white ones, green ones, and speckled ones. One day he counted the grubs on one plant and found 25 brown ones, 10 white ones, 30 green ones, and only two speckled ones. Draw a bar graph showing his results.

CHECK YOUR WORK. ANSWERS ARE AT THE END OF TOPIC 2.

Answers to Activity

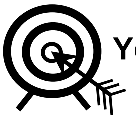
1. Three students are taller than the average height and they are Eddie, Nigel and Robert.

2. (a) For every day after Monday the time increase by 50 minutes in the mornings and by an hour and 50 minutes in the afternoons.

   (b) Friday morning: 9.30a.m.
   Friday afternoon: 10.00p.m.

Lesson 12: Control, Variable and Hypothesis

Welcome to Lesson 12. Science is all about experiments, but do you know what an experiment is? An experiment is a test of a possible solution or answer to a problem. The possible solution to a problem is called a **hypothesis**. A hypothesis is based on some prior knowledge. For example, based on experience with various brands of mosquito coil, a student made the following hypothesis. 'Mortein will repel mosquitoes from landing on bare skin longer than Good Knight and Frangipani. In this lesson, you will set up a good experiment to test hypothesis.



Your Aims:

- discuss variables, control and hypothesis
- state the difference between a control and a variable
- examine an experiment to identify control and variable

Designing Experiments

Scientists plan an experiment to test a hypothesis. You explore or find out about the world around you through experimenting. Experiments can take place in laboratories or anywhere at any time.

Scientists often investigate things by first thinking of a hypothesis, and then testing it by doing experiments. This procedure is sometimes called the scientific method.

It is important that an experiment must be designed to be a **fair test** of the hypothesis. You conduct a fair test by making sure that you change one factor at a time while keeping all other conditions the same.

For example, let us imagine that we want to find out which is the best sugar that taste well in a cup of tea. We have Ramu sugar and an unknown sugar. If we use the same cups, the same amount of water and the same teaspoon to measure the amount of sugar, but added more of the unknown sugar, did we do a fair test of which is the best sugar? The answer is no because we gave the unknown sugar an unfair advantage by adding more of it to the cup. That is not a fair test. The only thing that we should change is the type of sugar.

The amount of water, the cups and the amount of sugar must be the same. It is only the type of sugar that must be changed.

Scientists call the changing factors in an experiment, **variables**.

Variables are things that you can change or control in an experiment. For a fair test, you choose just one variable to change. Keep all other variables the same.

Types of Variables

Variables are anything that might change or be changed in an experiment. Some variables you will change yourself. Other variables are the ones you are interested in measuring. An experiment usually has three kinds of variables: controlled, independent and dependent.

1. **Controlled variables**, sometimes called **constant variables** are variables that are kept constant or unchanging. For example, if you are doing an experiment measuring the fizz released from different types of soda, you might control the size of the container so that all brands of soda would be in 375mL cans. If you are performing an experiment on the effects of spraying plants with different chemicals, you would try to maintain the same pressure and maybe the same volume when spraying your plants.

2. The **independent variable** is the one factor that you are changing. Usually in an experiment you try to change one thing at a time and that should be the only thing that should change. This makes interpretation of the data much easier. If you are trying to determine whether heating water allows you to dissolve more sugar in the water then your independent variable is the temperature of the water. This is the variable you are purposely controlling.

3. The **dependent variable** is the variable you observe, to see whether it is affected by your independent variable**.** In the example where you are heating water to see if this affects the amount of sugar you can dissolve, the mass or volume of sugar (whichever you choose to measure) would be your dependent variable.

Doing an Experiment

An experiment can be made up of two nearly identical parts. Suppose we want to test the hypothesis that bright light is needed to produce bigger tomatoes.

We get two trays of tomatoes. We increase the brightness of light in the first tray which we will call Tray 1 and the tomatoes get bigger. Tray 1 is called the **experimental group**. However, we are not finished. There is something more that we must do. We must get a second tray which we will call Tray 2 which is an identical set up to Tray 1 but is kept in its natural unchanged state. Tray 2 is called a "**control group**". The Tray 2 is needed because it provides a standard to compare the first tray (Tray 1). Tray 2 is called the **control**.

In carrying out this experiment it is essential that the two plants should be kept in exactly the same conditions, except for the light they receive. To put it in a general way: **we must keep all the variables constant except for the one whose effect we want to investigate**.

An experiment of this kind, in which an experimenter controls the conditions, is called a **controlled experiment**.

In a controlled experiment, you compare an experimental group with a control group. Ideally, these two groups are identical except for one variable, the independent variable.

Let us look again at the three kinds of variables in our tomato plant experiment.

The Independent Variable: This is a variable that you purposely change. In the case of our tomato plant experiment, it would be the brightness of the light in Tray 1.

The Dependent Variable: This is the difference between the two parts of the experiment that happens when the independent variable is changed. In this case, it would be the size of the tomatoes in Tray 1. So you turn up the lights in Tray 1(the independent variable) and the tomatoes get bigger (dependent variable).

The Controlled Variable: These are the variables that are kept the same in Tray 2. In other words, when you turn the lights up in Tray 1, the lights in Tray 2 stay the same. So when the tomatoes in Tray 1 get bigger, you can say that the difference in size between the tomatoes in Tray 1 and Tray 2 is the result of the independent variable, or the light that you made brighter.

Tray 2 is called a "**control group**". This is an identical set up to Tray 1, but it is kept in its natural, unchanged state. Tray 1 is called the "**experimental group**". So when you change something in the experimental group (like the brightness of the light), the control group stays the same so that you can measure changes in your dependent variable (the size of the tomatoes).

It is important that you have to think about how best to set up your science fair experiment to give you accurate and reliable results. You should keep in mind both the Scientific Method and the question you are trying to answer.

Activity: Now test yourself by doing this activity.

You are asked to design an experiment to find out if an expensive brand of battery lasts longer than a cheap brand.

a) Which variable should be changed?

b) Which variable should be measured?

c) List two variables which should be controlled if this is to be a fair experiment.

CHECK YOUR WORK. ANSWERS ARE AT THE END OF LESSON 12.

Summary

You have come to the end of Lesson 12. In this lesson you have learnt that:

- an experiment is a test of a possible solution or answer to a problem.
- the possible solution to a problem is called a hypothesis.
- scientists often investigate things by first thinking of a hypothesis, and then testing it by doing experiments. This procedure is sometimes called the scientific method.
- that an experiment must be designed to be a fair test of the hypothesis.
- a fair test is conducted by making sure to change one factor at a time while keeping all other conditions the same.
- variables are things that you can change or control in an experiment.
- an experiment usually has three kinds of variables: controlled, independent and dependent.

NOW DO PRACTICE EXERCISE 12 ON THE NEXT PAGE.

Practice Exercise 12

1. Write the word that best fits the description on the space provided.

   a) These are things that you can change in an experiment.

   ____

   b) The possible solution to a problem.

   ____

   c) Something that you change when you do your experiment.

   ____

   d) A test of a possible solution to a problem.

   ____

   e) These are things that are kept the same.

   ____

2. Identify the control, independent and dependent variable in this experiment.

   Dale was told that a certain muscle cream was the newest on the market and claims to double a person's muscle power when lathered on the muscles. Interested in this product, he buys the special muscle cream and asks Clive and Moses to help him with an experiment. Dale develops a special weight-lifting program for Clive and Moses. He meets with them once everyday for a period of 2 weeks and keeps track of their results. Before each session Clive's arms and back are lathered in the new muscle cream, while Moses' arms and back are lathered with the normal regular lotion.

   (a) Which person is in the control group?

   ____

   (b) What is the independent variable?

   ____

   (c) What is the dependent variable?

   ____

Time	**Clive**	**Moses**
Initial Amount	18	5
After 1 week	24	9
After 2 weeks	33	17

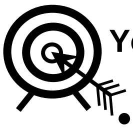
CHECK YOUR WORK. ANSWERS ARE AT THE END OF TOPIC 2.

Answers to Activity

a) The type of battery
b) The strength of the batteries
c) The size of the battery and the number of the batteries

Lesson 13: Parts of a Science Report

Welcome to Lesson 13. Scientists have a special way of solving problems. Scientists write up **reports** of experiments so that other people can read what they did and discovered. A report is a record of what you did in an experiment. A similar method is often used in schools.



Your Aims:

- list the parts of writing a report
- read a sample of a science report
- describe the different parts of a science report

Writing a Report

A practical report is a bit like a recipe. It gives a list of the chemicals and equipment needed as well as a set of step by step instructions.

A report is also neatly written. It is easy to read, and not too long. Labelled diagrams are drawn with a ruler and pencil and are quite large.

He also went on to say that a well organised report uses various headings. And he listed them as:

1. The **aim** states the problem or purpose of the experiment. In the aim you say *why* you did the experiment. Sometimes this is a question.

2. The **apparatus** indicates the equipment used in the experiment.

3. The **method** is the set of instructions that are used to carry out the experiment. In the method you say *what* you did in the experiment. Whenever possible you should include a diagram of the apparatus.

4. The **results** section records the **data** that were obtained. Data includes qualitative observations (words) or measurements (numbers). The results or data are often given in tables or graphs. Sometimes a **discussion** of the results is included.

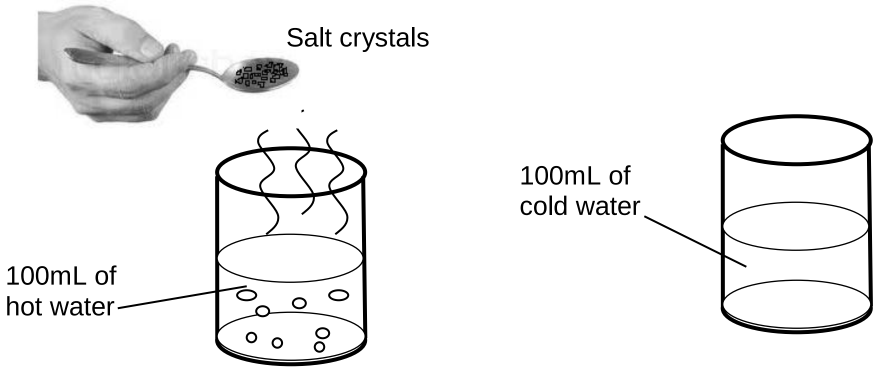
5. The **conclusion** is the answer to the aim or problem being investigated. In the conclusion you try to explain your results, and answer the question asked in the aim. Sometimes you can write a general statement or **generalisation**- one that seems true in most cases. For example, a student investigating the height of bounce of balls dropped from a certain height concluded: *The heavier the ball is, the lower the bouncing height.*

   You will not always be able to make a generalisation like this, and in some cases it may not be possible to make a conclusion at all. If the experiments gave strange results then it may be necessary to say something like this: *No valid conclusion can be made from the results obtained.*

A sample practical report is shown below.

Aim: To find out if salt crystals dissolve faster in hot or cold water.

Apparatus: Salt crystals, teaspoon, two beakers, hot and cold water.



Method:

1. Add 100mL of hot water to the first beaker and 100mL of cold water to the second beaker.
2. Add a teaspoon of salt crystals to each beaker and measure the time it takes for the crystals to fully dissolve (disappear).

Results: Salt in the hot water took 20 seconds to dissolve.
Salt in the cold water took 40 seconds to dissolve.

Conclusion: Salt crystals dissolve faster in hot water.

Summary

You have come to the end of Lesson 13. In this lesson you have learnt that:

- scientists have an organised way of writing up their experiments and this is called a science report
- a well organised report uses five headings and they are: Aim, Apparatus, Method, Results and Conclusion.
- a report is neatly written. It is easy to read, and not too long. Labelled diagrams are big and easy to see and drawn with a ruler and a pencil.

NOW DO PRACTICE EXERCISE 13 ON THE NEXT PAGE

Practice Exercise 13

Answer the following questions.

1. Arrange the following steps in their correct order.

   Conclusion Method Aim Results Apparatus

2. The results of an experiment are shown in the data table below.

Solid	**Melting point ^{o}C**
ice	0
mothballs	80
wax	44
Hypo (photographic fixer)	48

   i) Write down the aim for the experiment.

   ii) State how you think the experiment was done.

   iii) Write the conclusion for the experiment.

3. Gabriella wrote this in her science notebook:

   We measured the mass of five frogs. The first frog had a mass of 155 grams. The second frog measured 163 grams. The third frog measured 180 grams; the fourth 135 grams; and the fifth mouse had a mass of 149 grams.

   Record this information in a data table. (Choose your own vertical and horizontal scale.)

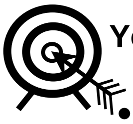
4. Ingian and Pieng observed the cars passing the school in one hour. They saw 10 Toyotas, 8 Nissans, 5 Mitsubishis, 9 Isuzus and 2 which they could not identify.

   Draw a column graph of this data.

CHECK YOUR WORK. ANSWERS ARE AT THE END OF TOPIC 2.

Lesson 14: Writing a Science Report

Welcome to Lesson 14. In our last lesson we discussed the various parts of a science report. We learnt that a well organised report uses the following headings: Aim, Apparatus, Method, Results and Conclusion. In this lesson we will learn to write a science report.



Your Aims:

- plan and carry out an experiment from a given topic
- write a report on the experiment using the headings discussed in Lesson 13

Writing a Report
From your last lesson you should now know how scientists write up reports of experiments so that other people can read what they did and what they discovered.

Some grade 9 students planned and performed an experiment on bouncing balls. Read carefully how it was carried out.

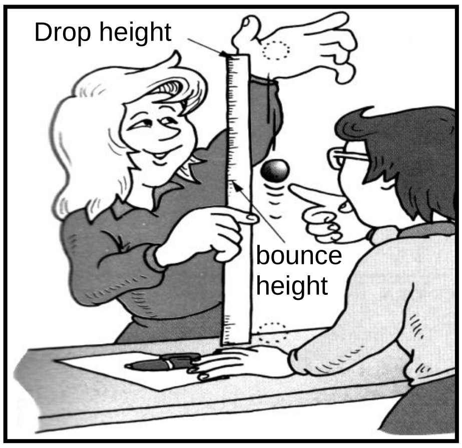
EXPERIMENT 3: BOUNCING BALLS

Aim:
To find out which type of ball bounces the highest.

Materials:
- Balls of different types, e.g. golf, cricket, tennis, table-tennis, basketball, super ball
- Metre rule

PLANNNING AND SAFETY CHECK
- Read through the method and design a data table for your results
- From your own experience with balls, predict which will bounce the highest
  - List them from highest to lowest

Method:
1. Fasten the metre rule in an upright position, with zero at the bottom. Drop the first ball onto a hard surface from a fixed height. (Hint: Line up the bottom of the ball with the mark on the metre rule.)
   - Record the bounce height
2. Do this three times and calculate the *average* bounce height.
3. Repeat steps 1 and 2 for the other balls.
4. Display your data as a column graph.



Their teacher then asked them to write a full report of the experiment using the four headings that we learnt in our last lesson. The teacher also gave them the notes below. You are also one of those students and these notes are for you as well.

Teacher's Notes

In this case the **aim** has been written for you, but when you design your own experiment you will need to write an aim.

Under the **method** heading you should describe any changes you made to the method given here. Also note details such as the type of floor and the height from which you dropped the balls.

Under **results** put your data table and bar graph, and under **conclusion** write down an answer to the question in the aim.

From this lesson, you can now practice writing your own reports.

Activity: Now test yourself by doing this activity.

Find a piece of paper and write a full report of the experiment.

Summary

You have come to the end of Lesson 14. In this lesson you have learnt that:

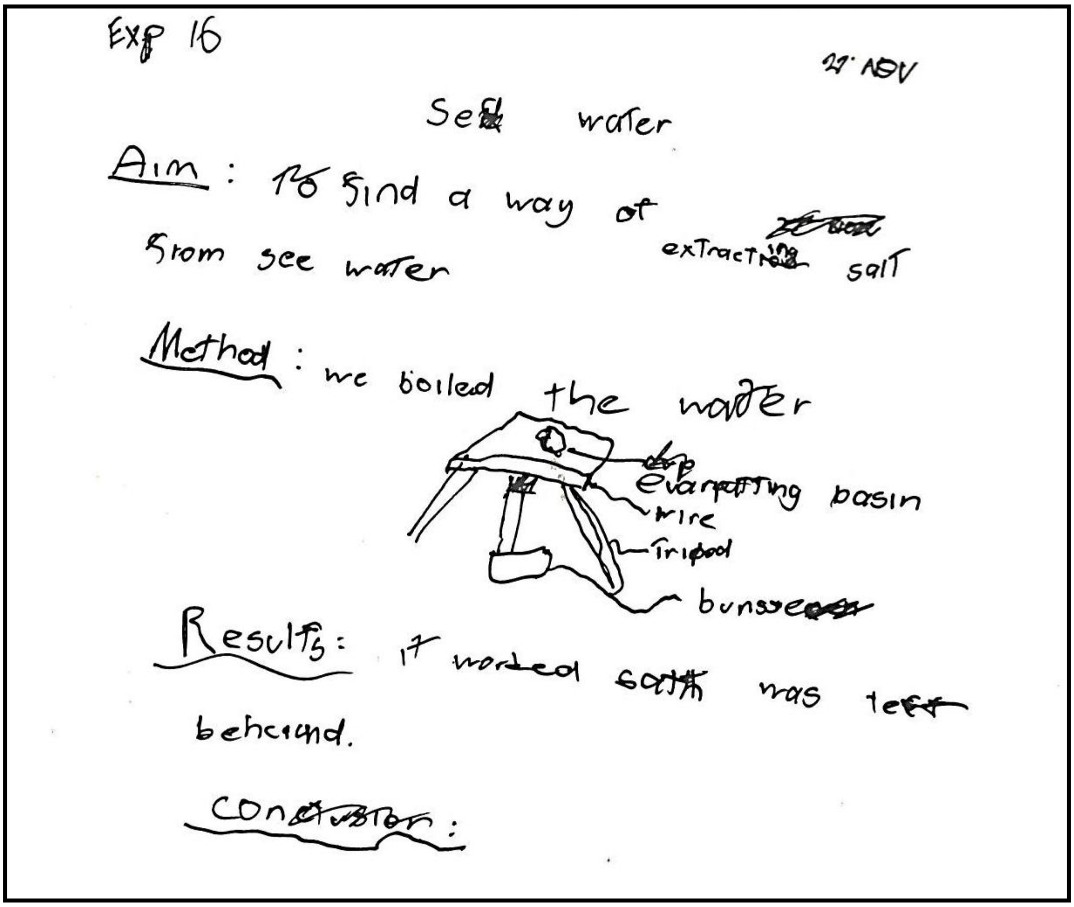
- experiments are tests that are well thought out and are designed to answer questions.
- we use experiments in science to find out how things happen.
- in science it is important to record things in a way that other people can understand.
- a good report has the following headings: aim, method, results and conclusion.

NOW DO PRACTICE EXERCISE 14 ON THE NEXT PAGE.

Practice Exercise 14

Look at this report written by a Year 9 student. What is wrong with it?

Rewrite the report, correcting all the faults in it.


Exp 16

22 NOV

Sea water

Aim: To find a way of extracting salt from see water

Method: we boiled the water

Results: it worked salt was left behind.

Conclusion:

CHECK YOUR WORK. ANSWERS ARE AT THE END OF TOPIC 2.

Answers to Activity

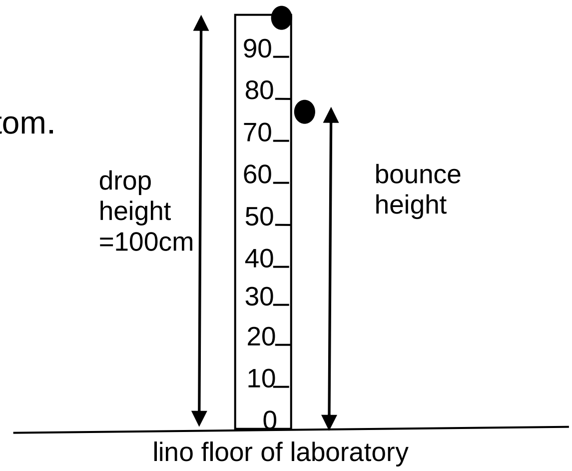
Experiment 3 6 April

BOUNCING BALLS

Aim: To find out which type of ball bounces the highest.

Method:

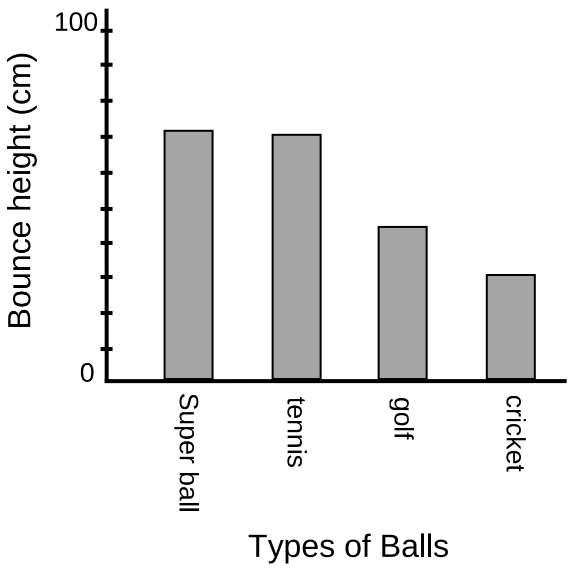
1. We decided to test four different balls and we made this prediction.
   Super ball (highest bounce)
   Golf ball
   Tennis ball
   Cricket ball (lowest bounce)
2. We set up a metre rule with the zero at the bottom.
3. We measured the bounce height for the super ball three times and then calculated the average.
4. We did the same for the other three balls.



Results

	Bounce height 1	2	3	Average
Super ball	73	72	70	72
Golf ball	71	70	68	70
Tennis ball	46	44	46	45
Cricket ball	21	19	22	21

GRAPH SHOWING THE BOUNCE HEIGHT



Conclusion:
Our prediction was correct, although we expected a greater difference between the super ball and the golf ball.

Answers to Practice Exercises 8 - 14

Practice Exercise 8

1. b Tell the science teacher
2. c Taste chemicals
3. c Filter funnel
4. d some substances give off poisonous fumes.
5. a use a tong.
6. c Spatula

Practice Exercise 9

1. Label 3, label 4, label 6, label 7, label 12
2. Label 11
3. Label 2, Label 5, label 10
4. Label 7
5. The word toxic means poisonous

Practice Exercise 10

1. i. A. Observation
   B. Inference
   C. Prediction

   ii. A. Prediction
   B. Inference
   C. Observation

   iii. A. Observation
   B. Inference
   C. Prediction

Practice Exercise 11

1. (i) One way to find a pattern is to rearrange the temperatures from lowest to highest as shown.

Temperature of water (^oC)	**Dissolving time (second)**
20	22
25	24
30	20
35	18
40	27
45	16

(ii) As the temperature of the water increases, the dissolving times decreases. (When you increase the temperature by 5^0C the dissolving time decreases by about 2 seconds.) So the tablet dissolves faster in hot water than in cold water.

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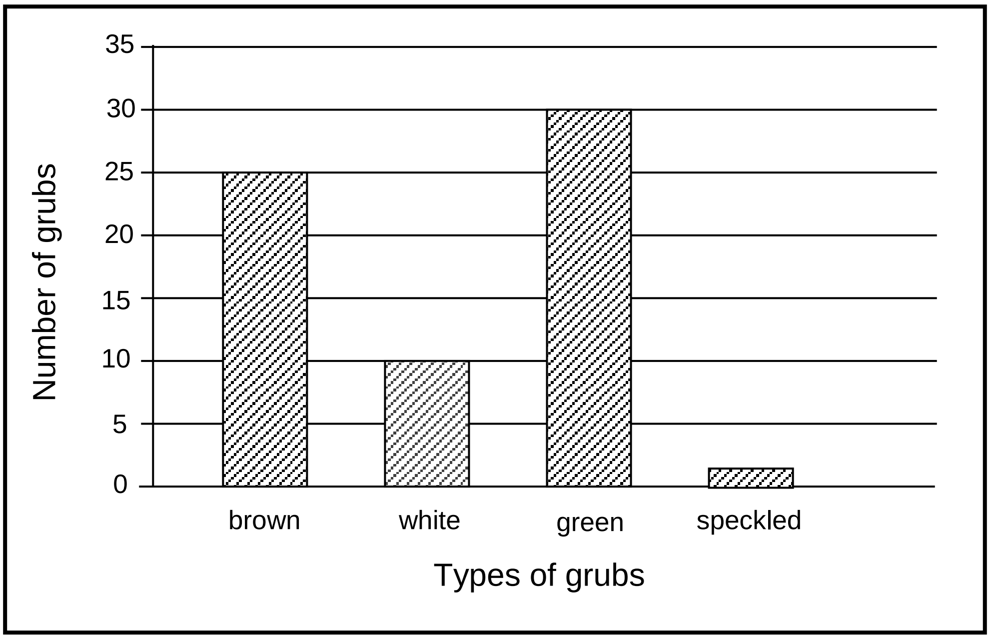
2. **TYPES OF GRUBS EATING A FARMER'S CROPS**



Practice Exercise 12

1. (a) Variables

(b) Hypothesis

(c) Independent Variables

(d) An experiment

(e) Controlled Variables

2. (a) Moses

   (b) Muscle cream

   (c) Amount of marshmallows lifted (strength)

Practice Exercise 13

1. Aim Apparatus Method Results Conclusion

2. (i) To find out the melting points of different solids

   (ii) The solids were heated to the point where they melted and the temperature taken at that point determined their melting point.

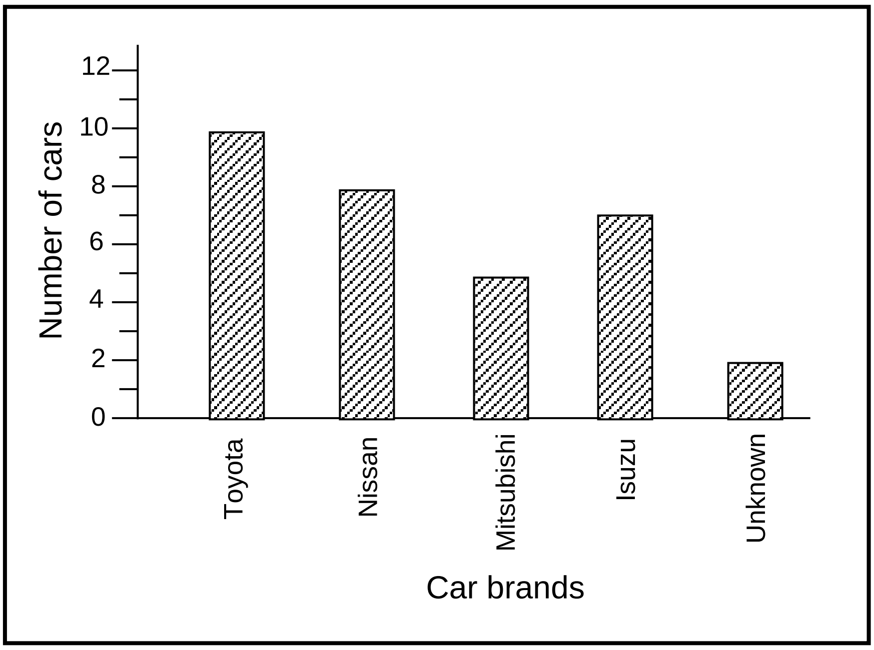
   (iii) The more complex the solid is, the higher the melting point.

3.

Frog	**Mass in grams**
First frog	155
Second frog	163
Third frog	180
Fourth frog	135
Fifth frog	149

4.

CARS PASSING THROUGH THE SCHOOL IN AN HOUR



Practice Exercise 14

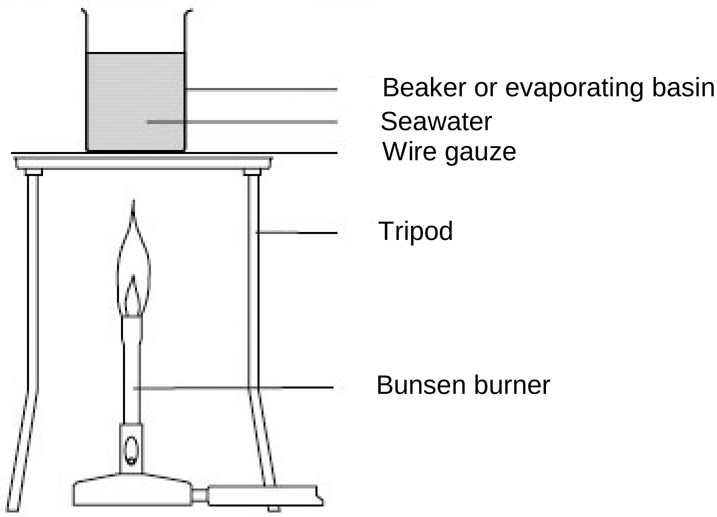
Experiment 16 21 November

EXTRACTING SALT

Aim: To find a way of extracting salt from seawater

Method:

We boiled the seawater into steam until almost none was left. Then we let it cool.



Result: It worked. Only salt was left behind

Conclusion: Seawater can be evaporated to extract salt.

REVISE TOPIC 2 USING THE MAIN POINTS ON THE NEXT PAGE.

REVIEW OF TOPIC 2: Scientific Approach

Now, revise all lessons in this Topic and then do **ASSIGNMENT 1**.
Here are the main points to help you revise.

Lesson 8: Use of Apparatus and Instruments

- At school most of the scientific work is done in the science laboratory.
- All the equipment that you find in a science classroom is called apparatus.
- There are various apparatus used to carry out experiments in a science laboratory.
- It is very important to know which equipment to use and how to use it safely.
- When carrying out experiments, care must always be taken to avoid accidents
- Rules of a science laboratory must be followed closely to avoid any accidents.

Lesson 9: First Aid

- Safety rules must be strictly followed when you are using a science laboratory.
- Always wear personal protective equipment such as safety glasses and laboratory aprons to prevent accidents.
- Remember to have your apparatus or your work place clean.
- Chemicals delivered to schools must have first aid and safety procedures attached to the chemical labelled.
- It is a legal requirement that the chemical suppliers provide a material safety data sheet for every chemical they sell
- First aid is the providing of first care for an illness or injury. It is usually performed by a non-expert, but trained personnel to a sick or injured person until proper medical treatment arrives.
- First aid is applied for three main reasons: to save a person, to prevent further harm and to help the person to recover.

Lesson 10: Prediction and Inference

- Observation can be done with the use of senses.
- The five senses are hearing seeing, smelling, touching and tasting.
- Inference is where a student tries to explain what happened in an observation.
- When making inferences there are three things that one must note They are:
  - Many inferences should be made from the same observation.
  - You must be careful when observing and honest in your report.
  - You must not confuse inferences and observations.
- Predicting is simply the forecast of the future based on your observations.
- A number of observations can help you predict the future.

Lesson 11: How to Present Data

- Data can be handled in a number of ways and they are:
  - sorting the data,
  - displaying the data,
  - looking for a pattern and
  - using the data
- To make data more useful it needs to be sorted and displayed, example, in a bar graph

Lesson 12: Control, Variable and Hypothesis

- An experiment is a test of a possible solution or answer to a problem.
- The possible solution to a problem is called a hypothesis.
- Scientists often investigate things by first thinking of a hypothesis, and then testing it by doing experiments. This procedure is sometimes called the scientific method.
- It is important that an experiment must be designed to be a fair test of the hypothesis. You conduct a fair test by making sure that you change one factor at a time while keeping all other conditions the same.
- Variables are things that you can change or control in an experiment.
- An experiment usually has three kinds of variables: controlled, independent and dependent.

Lesson 13: Parts of a Science Report

- Scientists have an organised way of writing up their experiments and this is called a science report
- A well organised report uses five headings and they are: Aim, Apparatus, Method, Results and Conclusion.
- A report is neatly written. It is easy to read, and not too long. Labelled diagrams are big and easy to see and drawn with a ruler and a pencil.

Lesson 14: Writing a Science Report

- Experiments are tests that are well thought out and are designed to answer questions.
- We use experiments in science to find out how things happen.
- In science it is important to record things in a way that other people can understand.
- A good report has the following headings: aim, method, results and conclusion.

NOW DO TOPIC TEST 2 IN YOUR ASSIGNMENT 1.

NOW YOU MUST COMPLETE ASSIGNMENT 1.
RETURN IT TO THE PROVINCIAL CO-ORDINATOR.

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FODE PROVINCIAL CENTRES CONTACTS

PC NO.	FODE PROVINCIAL CENTRE	ADDRESS	PHONE/FAX	CUG PHONES	CONTACT PERSON		CUG PHONE
1	DARU	P. O. Box 68, Daru	6459033	72228146	The Coordinator	Senior Clerk	72229047
2	KEREMA	P. O. Box 86, Kerema	6481303	72228124	The Coordinator	Senior Clerk	72229049
3	CENTRAL	C/- FODE HQ	3419228	72228110	The Coordinator	Senior Clerk	72229050
4	ALOTAU	P. O. Box 822, Alotau	6411343 / 6419195	72228130	The Coordinator	Senior Clerk	72229051
5	POPONDETTA	P. O. Box 71, Popondetta	6297160 / 6297678	72228138	The Coordinator	Senior Clerk	72229052
6	MENDI	P. O. Box 237, Mendi	5491264 / 72895095	72228142	The Coordinator	Senior Clerk	72229053
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9	MT HAGEN	P. O. Box 418, Mt. Hagen	5421194 / 5423332	72228148	The Coordinator	Senior Clerk	72229057
10	VANIMO	P. O. Box 38, Vanimo	4571175 / 4571438	72228140	The Coordinator	Senior Clerk	72229060
11	WEWAK	P. O. Box 583, Wewak	4562231/ 4561114	72228122	The Coordinator	Senior Clerk	72229062
12	MADANG	P. O. Box 2071, Madang	4222418	72228126	The Coordinator	Senior Clerk	72229063
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22	JIWAKA	c/- FODE Hagen		72228143	The Coordinator	Senior Clerk	72229085

FODE SUBJECTS AND COURSE PROGRAMMES

GRADE LEVELS	SUBJECTS/COURSES
Grades 7 and 8	1. English
	2. Mathematics
	3. Personal Development
	4. Social Science
	5. Science
	6. Making a Living
Grades 9 and 10	1. English
	2. Mathematics
	3. Personal Development
	4. Science
	5. Social Science
	6. Business Studies
	7. Design and Technology- Computing
Grades 11 and 12	1. English – Applied English/Language& Literature
	2. Mathematics - Mathematics A / Mathematics B
	3. Science – Biology/Chemistry/Physics
	4. Social Science – History/Geography/Economics
	5. Personal Development
	6. Business Studies
	7. Information & Communication Technology

REMEMBER:

- For Grades 7 and 8, you are required to do all six (6) subjects.
- For Grades 9 and 10, you must complete five (5) subjects and one (1) optional to be certified. Business Studies and Design & Technology – Computing are optional.
- For Grades 11 and 12, you are required to complete seven (7) out of thirteen (13) subjects to be certified.

Your Provincial Coordinator or Supervisor will give you more information regarding each subject and course.

GRADES 11 & 12 COURSE PROGRAMMES

No	Science	Humanities	Business
1	Applied English	Language & Literature	Language & Literature/Applied English
2	Mathematics A/B	Mathematics A/B	Mathematics A/B
3	Personal Development	Personal Development	Personal Development
4	Biology	Biology/Physics/Chemistry	Biology/Physics/Chemistry
5	Chemistry/ Physics	Geography	Economics/Geography/History
6	Geography/History/Economics	History / Economics	Business Studies
7	ICT	ICT	ICT

Notes: You must seek advice from your Provincial Coordinator regarding the recommended courses in each stream. Options should be discussed carefully before choosing the stream when enrolling into Grade 11. FODE will certify for the successful completion of seven subjects in Grade 12.

CERTIFICATE IN MATRICULATION STUDIES		
No	**Compulsory Courses**	**Optional Courses**
1	English 1	**Science Stream:** Biology, Chemistry, Physics
2	English 2	**Social Science Stream:** Geography, Intro to Economics and Asia and the Modern World
3	Mathematics 1	
4	Mathematics 2	
5	History of Science & Technology	

REMEMBER:
You must successfully complete 8 courses: 5 compulsory and 3 optional.