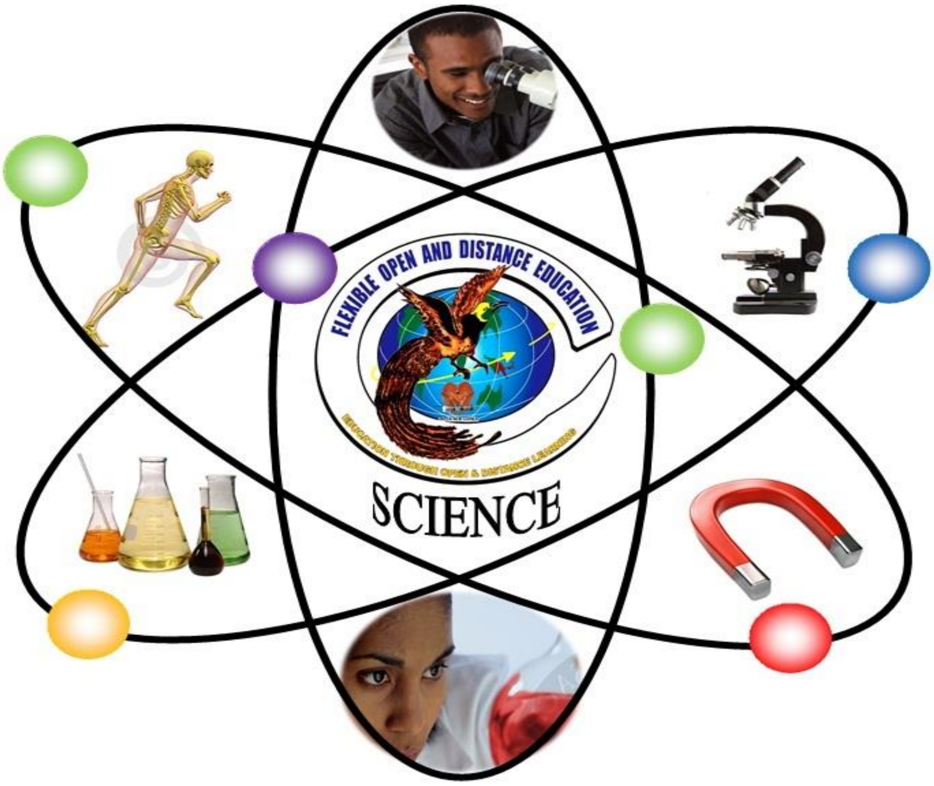
DEPARTMENT OF EDUCATION

GRADE 7

SCIENCE

STRAND 3



SCIENCE IN THE HOME

FLEXIBLE OPEN AND DISTANCE EDUCATION
PRIVATE MAIL BAG, P.O. WAIGANI, NCD
FOR DEPARTMENT OF EDUCATION
PAPUA NEW GUINEA
2017

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SCIENCE

GRADE 7

STRAND 3

SCIENCE IN THE HOME

SUB STRAND 1:	**MATTER**
SUB STRAND 2:	**PROPERTIES OF MATTER**
SUB STRAND 3:	**FORMS OF ENERGY AND SIMPLE MACHINES**
SUB STRAND 4:	**FORCE AND SIMPLE MACHINES**

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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CONTENTS

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 and parcel of the new reformed curriculum. The learning outcomes are student-centred with demonstrations and activities that can be 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. It is developed in line with the National Education Plans and addresses an increase in the number of school leavers as a result of 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 and instructional designers who have contributed towards the development of th

DR. UKE KOMBRA PhD
Secretary for Education

STRAND 3: INTRODUCTION

Dear Student,

Welcome to Strand 3 of your Grade 7 Science Course! I hope that you enjoyed studying the two earlier Strands. I also hope that this Strand, Science in the Home, will be an interesting and enjoyable subject to study too.

In this Strand, there are 20 Lessons on four Sub strands. The four Sub strands are:

- **Matter**
- **Properties of Matter**
- **Forms of Energy and Simple Machines**
- **Force and Simple Machines**

There are six Lessons in the first Sub strand. The lessons will discuss about the atoms and molecules of matter. It will also tackle the structure and behaviour of matter, the changes of states of matter and the arrangement of molecules in solids, liquids and gases. You will also learn from this Sub strand about solution and its kinds.

The second Sub strand is composed of five Lessons and will discuss about the physical properties of materials, the physical and chemical changes, chemical reactions and equations. You will also learn in this Sub strand the common elements and compounds, reactants and products and signs and symbols in word equation.

In the third Sub strand, there are five Lessons that will discuss about the forms of energy, its uses and measurement. It will also talk about the simple machines and its uses, the harmful effects of some energy, the efficiency of some energy converter and how energy is transferred from one form to another.

The last Sub strand has four Lessons. It will talk about the types of forces and its kinds, friction and magnets. You will also learn from this Sub strand the uses of forces, the advantages and disadvantages of friction and the different uses of magnets in every day life.

Remember, you have to do all the activities and carry out the Practice Exercises after each lesson. Answers to Practice Exercises are at the end of each Sub strand.

If you have any problems in understanding any of the lessons in this Strand, please don't 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 Strand now following the Study Guide on the next page.

All the Best!

STUDY GUIDE

Follow the steps given below and work through the lessons.

Step 1 Start with Sub strand 1 and work through it in order.

Step 2 When you complete Lesson 1, do Practice Exercise 1.

Step 3 After you have completed the Practice Exercise, correct your work. The answers are given at the end of each Sub strand.

Step 4 Then, revise well and correct your mistakes, if any.

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

☑ Lesson 1: States of Matter

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

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

Assignments: Sub strand Tests and Strand Tests

When you have completed all the lessons in a Sub strand, do the Sub strand Test for that Sub strand, in your Assignment Book. The Course Book tells you when to do this.

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

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

If you have any questions, write them on the Student's page. Your teachers will advise you when he/she returns your marked Assignment.

The Sub strand Tests and the Strand Test in each Assignment will be marked by your Distance Teacher. The marks you score in each 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 Assignments, your enrolment will be cancelled. So, work carefully and ensure that you pass all Assignments

SUB STRAND 1

MATTER

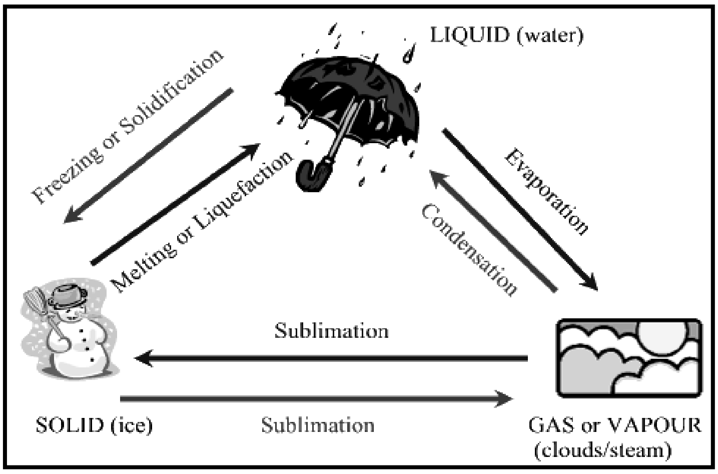
IN THIS SUB STRAND YOU WILL LEARN ABOUT:

- **MEANING OF MATTER AND ITS DIFFERENT STATES**
- **CHANGES OF STATES OF MATTER**
- **INTERNAL ARRANGEMENT OF MOLECULES IN SOLIDS**
- **INTERNAL ARRANGEMENT OF MOLECULES IN LIQUIDS**
- **INTERNAL ARRANGEMENT OF MOLECULES IN GASES**
- **MEANING OF SOLUTION AND ITS DIFFERENT CLASSIFICATION**

SUB STRAND 1: ABOUT MATTER

Introduction

Matter is everything around you. Matter is anything made of atoms and molecules. Matter is anything that has a mass. Matter is also related to light and electromagnetic radiation. Even though matter can be found all over the universe, you usually find it in just a few forms. As of 1995, scientists have identified five states of matte**r**. They may discover one more by the time you get old.



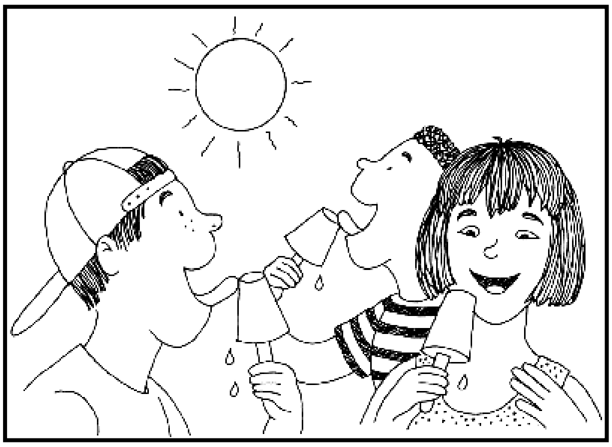
Changing States of Matter

Elements and compounds can move from one physical state to another and not change. Oxygen (O_2) as a gas still has the same properties as liquid oxygen. The liquid state is colder and denser but the molecules are still the same. Water is another example. The compound water is made up of two hydrogen (H) atoms and one oxygen (O) atom. It has the same molecular structure whether it is a gas, liquid, or solid. Although its physical state may change, its chemical state remains the same.

Changing states of matter is about changing densities, pressures, temperatures, and other physical properties. The basic chemical structure does not change.

You should know about solids, liquids and gases. So you ask,

- "What makes a state of matter"?
- "How are the molecules in solids, liquids and gases arranged"?
- "Why is matter changing states"?

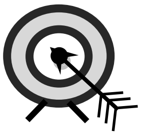


Change liquid to solid by making ice pops.

In this Sub strand you will find the answers to these questions and all other questions relating to matter.

Lesson 1: States of Matter

Welcome to Lesson 1, on states of matter. In the last strand on living things you learnt about plants and animals – from living to non-living things. These things are made of matter. Matter has different shapes, sizes and weight.

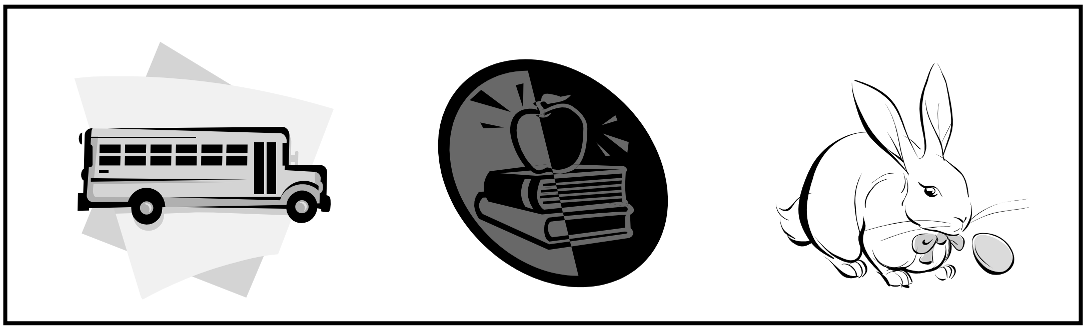


Your Aims:

- write examples for each state of matter
- describe the structure and behaviour of matter
- identify and describe the properties of three states of matter
- compare the physical properties of the three states of matter

What is Matter?

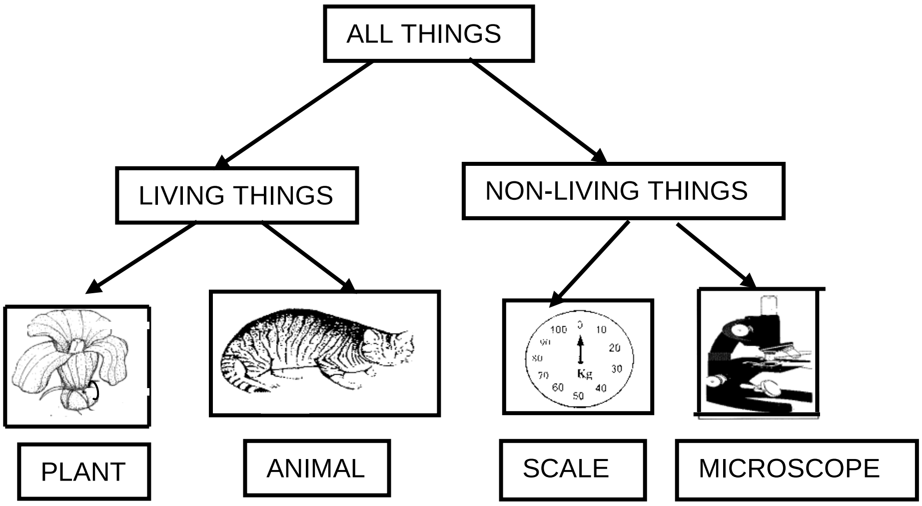
The word 'matter' can be used in many ways. Matter is what all things are made of. Everything in the universe is made of matter.
Plants and animals, rocks and soil, air and water, are all made of matter. Some matters are hard, soft, shiny, dull, and brittle while some can bend and stretch. Even the hair on your head and the air that you breathe is made of matter.
All these things can be weighed, to find how much matter is in them. This is called their **mass**. Matter also takes up space. The amount of space occupied by something is called volume**.** So, from the above discussion, we can define **matter** as anything that occupies space (has volume) and has mass (can be weighed).



Different matter

Let us look at one of the senses to see the difference between 'matter' and 'non-matter'. The sense we will look at is the feel of touch on the skin. For example, you can feel the air around your skin. Another example is the feel of water. You can tell that water feels cold and wet. The water is matter because you can feel the wetness on your body.

Now let us look at the chart below.



On this chart, where would you put a butterfly? ____________________
Where would you put a table? ____________________

However, some things do not fit into the chart.
Where on the chart do you put light? ____________________
Is light a living or non-living thing? ____________________
Where on the chart do you put anger? ____________________

You could put butterfly under living things and table under non-living things. We know that we can feel matter pressing against our skin. Light and anger are different from the things we can feel pressing against our skin. **They are not matter.** So, light, heat and sound are the things we cannot put on this chart because they are not matter.

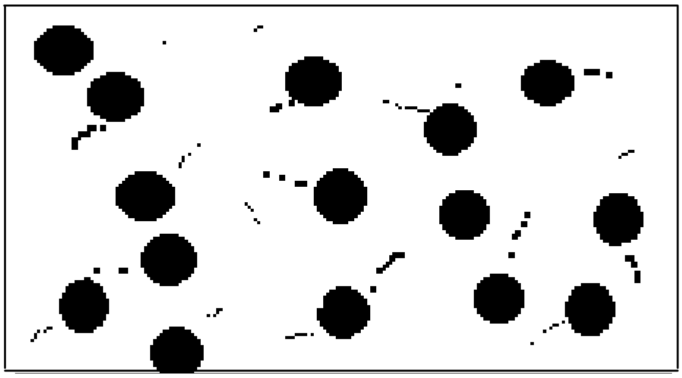
Atoms and molecules
Some substances are made up of only one type of particle. This particle is an atom. Other substances like copper are made up of copper atoms. Other substances like water or the gas like carbon dioxide are made up particles that are group of atoms. A single group of these atoms which are changed in a particular pattern is called a **MOLECULE**. Many gases and liquids are made up of molecules.

Matter is anything that has mass and takes up space. Heat, light and sound are not matter.

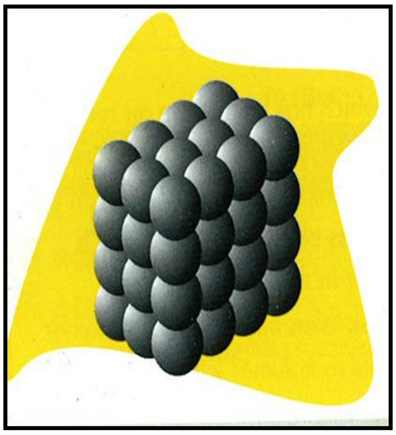
Nature of Matter
Scientists believe that matters are made up of tiny **particles**. Everything around us is made of very tiny pieces or particles. Your body is made of particles. So is your desk, your chair and this booklet. These particles are so tiny that no ordinary microscope can see them. It is impossible to pick up just one of them and look at it.

Matters – made of particles

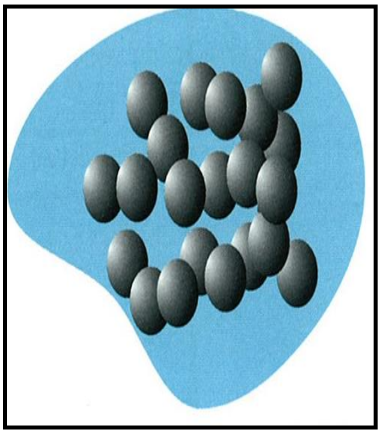
You can find evidence that things are made of particles. A good example is the dust. If you switch on a torch in a closed dark room, you will notice the particles of dust moving about randomly in all directions. The particles of dust continue moving indefinitely and their movements do not stop. They hit the dust particles from all possible directions. It is due to the impact of the molecules of the air that the dust particles move randomly.



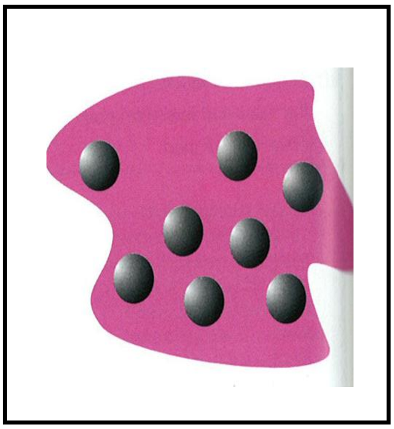
Matter will behave in different ways when it is heated, cooled or when electricity flows through it. The particles which make up matter have spaces between them. The state of matter such as solids, liquids and gases are different from each other.



Particles in solid



Particles in liquid



Particles in gas

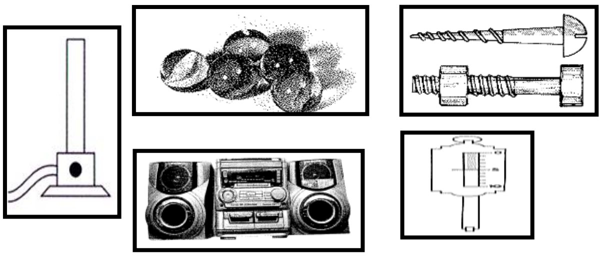
Matter is made up of tiny particles. These particles could be atoms or molecules that cannot be seen by the naked eye or by an ordinary microscope. The particles of matter behave differently when heat or

States of Matter

Matter has mass and volume; that means that it can be weighed and takes up space. Solid, liquid or gas are known as the three states of matter and are different from each other.

Solids

Solids are one of the three states of matter. Solids have a particular shape and definite volume. It takes up space, meaning their shapes will not change unless some force changes them. Solids also cannot be squashed into smaller volume. You can pick up and hold solids in your hands.

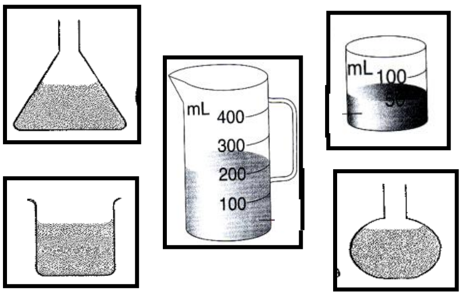


Different shapes of solids

Solids, liquids and gases are the three states of matter. All solids have definite shapes and volume.

Liquids

Liquid is another state of matter. A liquid flows easily, has a definite volume but no definite shape. Unlike solids, its shape depends on the container. You cannot pick up or hold liquids. You can pour liquid and it flows into another container. It will have the shape of that container.



Liquids take the shape of the container

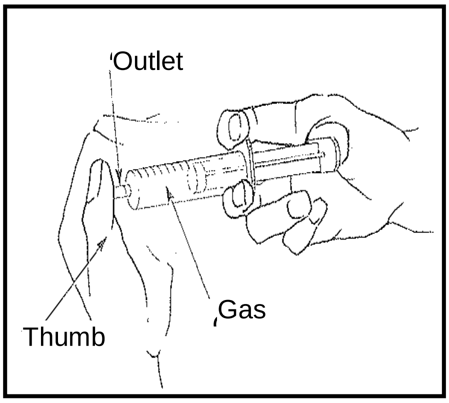
All liquids have no shape but have definite volume. Liquids are not rigid; they flow like water out of a cup or water in a stream and they take the shape of the container.

Gases

A gas has neither a definite shape nor a definite volume. It completely fills and takes the shape of its container. You cannot pick up and hold gas with your hands. It spreads out in all directions-we call that diffusion. We can weigh a gas and compress its volume; and it can go back to its original size. That’s the elastic property of gases!

Do gases have a mass?
Gases are light and have masses. If you weigh a ball that is deflated, you will get a certain mass. Now, if you pump air into it, it will be inflated. If you weigh the same ball again, you will find that the inflated ball has more mass because of the presence of air in it.


A gas helium is used here



Gases can be compressed into a smaller volume

A gas does not have a definite shape or volume. It fills up the container and takes its shape.

Activity 1: Now test yourself by doing this activity.

Part A. Complete the following sentences.

a) All matter takes up __________ and has __________.

b) The three states of matter are __________, __________ and __________.

c) A __________ can be squeezed into smaller volume, but a solid or a __________ cannot.

d) When a liquid is poured from one container to another its shape changes, but its __________ stays the same.

e) The volume and shape of a __________ stay the same, no matter what container you put it in.

Part B. State whether the given is solid, liquid or a gas.

a) Sugar __________ e) Glass __________

b) Smell of onions __________ f) Paul's milk __________

c) Sand __________ g) String __________

d) Cold ice cream __________ h) Nail polish __________

Part C. Write Yes or No to complete the table below.

States of Matter			Properties		
	Has mass	Occupy space	Fixed shape	Fixed volume	Can be compressed
Solids					
Liquids					
Gases					

Part D. Look at the table above and answer these questions.

a) Which state of matter can be weighed?

____

b) Which takes up space?

____

c) Which have fixed volume?

____

d) Which state of matter has a fixed shape?

____

e) What property do solids have that liquids do not?

____

f) What property do gases have that liquids do not?

____

Part E. Which of the following are true and which are false?

a) A solid takes the shape of its container. ____________

b) A liquid can be made to have any shape. ____________

c) All liquids are colourless. ____________

d) Gases cannot be weighed. ____________

e) Solids cannot be compressed. ____________

f) A gas will fill only part of a container. ____________

Summary

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

- matter is anything that has mass and takes up space.
- all living things and non-living things are matter.
- heat, light, sound and anger are not matter because these are different from the things we can feel pressing against our skin.
- matter is made up of tiny particles.
- particles cannot be seen by the naked eye and by an ordinary microscope. These particles can be atoms or molecules.
- solids, liquids and gases are the three states of matter.
- all solids have definite shapes and volume. They cannot be squashed into smaller volume and their shapes will not change unless some force changes them.
- liquid states have no shape but have definite volume. A gas flow like water out of a cup and they take the shape of the container.
- gases do not have a definite shape or volume. A gas fills up the container and takes its shape. It spreads in all directions and its volume can be compressed.

NOW DO PRACTICE EXERCISE 1 ON THE NEXT PAGE.

Practice Exercise 1

Answer the following questions:

1. Define matter.

   ____

2. Write down four examples of each states of matter.

   Solids: a) ____________ b) ____________ c) ____________ d) ____________

   Liquids: a) ____________ b) ____________ c) ____________ d) ____________

   Gases: a) ____________ b) ____________ c) ____________ d) ____________

3. How do you know if something is made up of matter?

   ____

   ____

4. By using the table, write the differences between the states of matter.

States	Shape	Volume	Able to be compressed
Solid			
Liquid			
Gas			

5. Classify whether the following things are matter or non-matter. Write on the table below.

salt	**push**	**nail**	**clap**
thunder	**electricity**	**natural gas**	**rock**
elastic band	**mineral water**	**laughter**	**chair**

Matter	Non-matter

6. Ice, water and steam contain the same type of particles.
Why are these states of matter so different?

____

____

CHECK YOUR WORK. ANSWERS ARE AT THE END OF SUB-STRAND 1.

Answers to Activity

Part A

a) space/ has mass
c) gas/liquid
e) solid
b) solid, liquid and gas
d) volume

Part B

a) solid
b) gas
c) solid
d) solid
e) solid
f) liquid
g) solid
h) liquid

Part C

States of Matter	Can be weighed	Occupy space	Fixed shape	Fixed volume	Can be compressed
Solids	**Yes**	**Yes**	**Yes**	**Yes**	**No**
Liquids	**Yes**	**Yes**	**No**	**Yes**	**No**
Gases	**Yes**	**Yes**	**No**	**No**	**Yes**

Part D.

a) Solids, liquids and gases

b) Solids, liquids and gases

c) Solids and liquids

d) Solids

e) Fixed shape

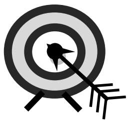
f) Cannot be compressed

Part E

a) False
c) False
e) True
b) True
d) False
f) False

Lesson 2: Changes of States of Matter

Welcome to lesson 2 of strand 3. In the last lesson you learnt about matter and what it is. You have already studied and described its structure and behavior and have learned the different states it has and the way it occupies space. You have compared its physical properties from its different states and gave examples for each. In this lesson you will learn more about matter.



Your Aims:

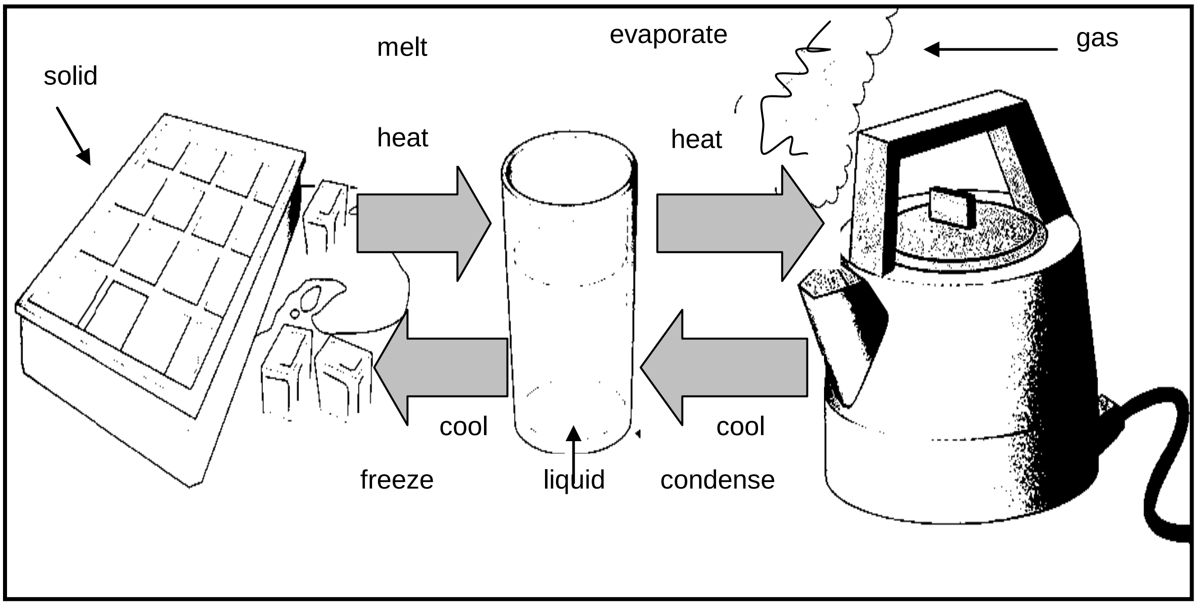
- explain changes of states of matter
- identify and describe changes of states of matter
- label the different changes of states of matter given in the diagram

What Is A Change Of State?

When a substance changes from solid to liquid, liquid to gas, gas to liquid or liquid to solid, it changes state or phase. These are called **changes of states of matter**. The type of material or substance does not alter or change; it just changes from one state to another when they are heated or cooled. As the substance is heated, the particles that make up the substance gain energy and move around faster, eventually causing the substance to change state.

The five changes of states of matter

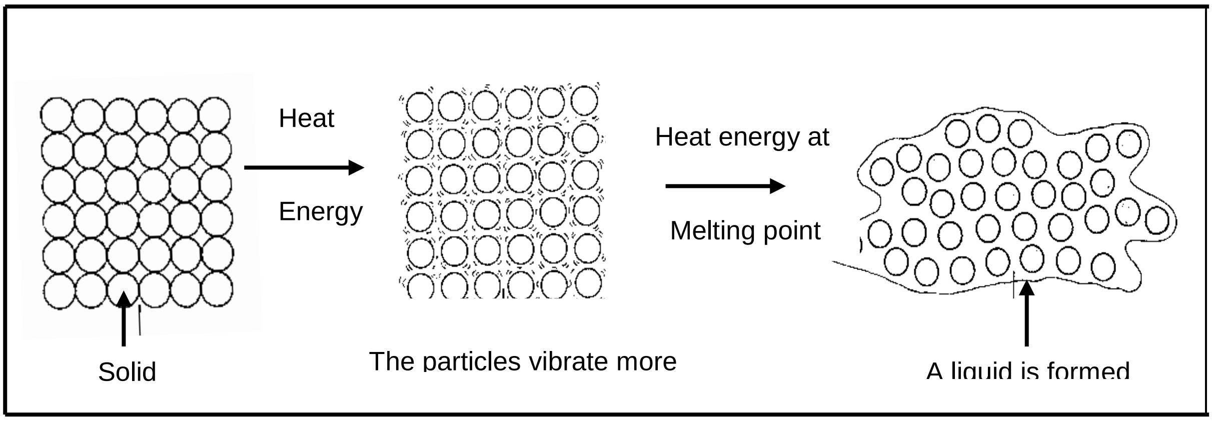
There are five changes of states of matter. These are **melting, evaporation, condensation, freezing** and **sublimation**. The diagram below illustrates these changes.



The five changes of states of matter.

Melting
Melting is a change of state where a substance changes from solid to liquid. Just like an ice block, when it melts, it changes into liquid.

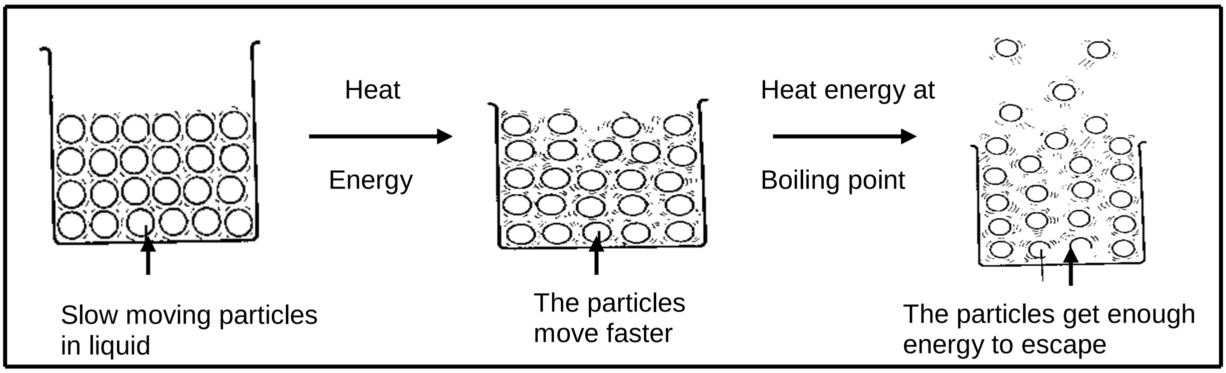
When a solid is heated, its particles get more energy and vibrate. This makes the solid expand. At the melting point, the particles vibrate so much that they break away from their positions. The solid becomes a liquid. The diagram below shows this.



Melting is a change of state where a substance changes from solid to liquid.

Evaporation
Evaporation is a change of state where a substance changes from liquid to gas. A good example is the boiling of water. The water will become gas if you continue boiling it!

When a liquid is heated, its particles get more energy and move faster. They bump into each other more often and bounce further apart. They overcome the forces holding them together and break away from the liquid and form a gas. The diagram below shows evaporation!

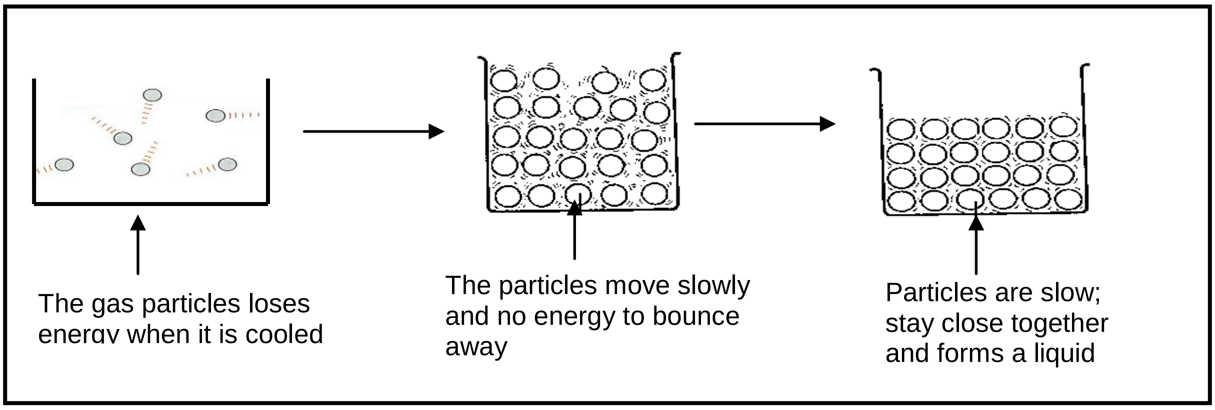


Evaporation is a change of state where a substance changes from liquid to gas.

Condensation

Condensation is a change of state where a substance changes from gas to liquid.
In evaporation, the water that turn into gas is called steam. When steam is cooled, it changes back to water. You can see it on a cold glass of water. The water gas in the air condenses outside the glass.

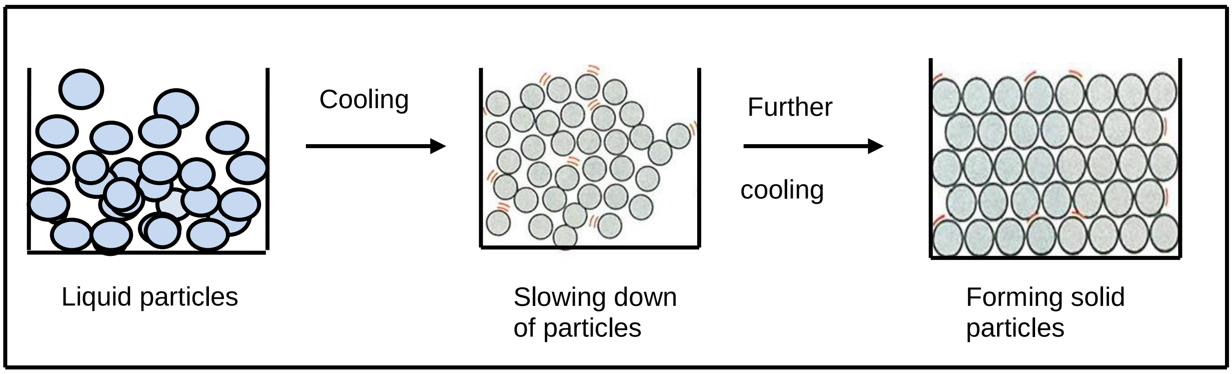
When a gas is cooled, the particles lose energy. They move more and more slowly, bump into each other but do not have enough energy to bounce away again so, they stay close together and a liquid forms. The diagram below shows this.



Condensation is a change of state where a substance changes from gas to liquid.

Freezing

Freezing is a change of state where a substance changes from liquid to solid. A good example of freezing is the water that turns into ice. When a gas is cooled, the particles lose energy and move more slowly forming a liquid. When the liquid is cooled further, the particles slow down even more; eventually stop moving except for tiny vibrations thus a solid form. Look at the diagram below; it explains this process.

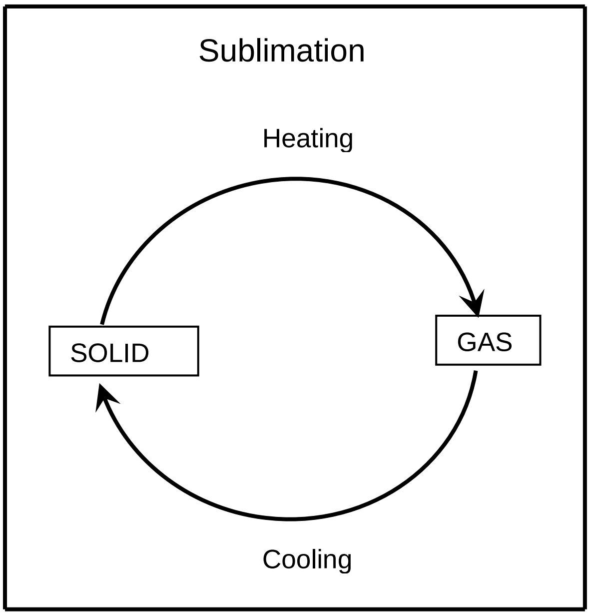


Freezing is a change of state where a substance changes from liquid to solid.

Sublimation

Some substances can change state from solid to a gas or from gas to a solid, without going through the liquid state. This is called **sublimation**.

Dry ice (solid carbon dioxide) changes directly into a gas. This is because air pressure as well as temperature affects the state of matter. Another substance which sublimes is iodine. Now to have an idea about sublimation, look at the diagram below.



Sublimation is a change of state from solid to gas or from gas to solid, without going through the liquid state.

Activity 1: **Now test yourself by doing this activity.**

Part A. **Complete the sentences.**

1. When a solid changes to a liquid, the solid is said to __________. This change is caused by __________.
2. When a liquid changes to a gas, the liquid is said to __________. This change is caused by __________.
3. When a liquid changes to a solid, the liquid is said to __________. This change is caused by __________.
4. When a gas changes to a liquid, the gas is said to __________. This change is caused by __________.
5. When a solid changes to a gas, the solid is said to __________. This change is caused by __________.

Part B. Complete the table below.

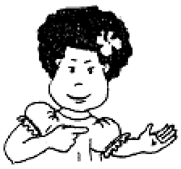
Solid to liquid	
	Freezing
	Evaporation
Gas to liquid	

Part C. Match column A with column B. Write the letters only.

	Column A			Column B
1.	Water in the solid state	__________	a)	$100^{o}C$
2.	Liquid to solid	__________	b)	$0^{o}C$
3.	To change to a gas	__________	c)	ice
4.	Boiling temperature of water	__________	d)	freezing
5.	Freezing temperature of water	__________	e)	evaporate

Part D. The table below lists five changes of state. For each change decide whether heating or cooling is needed.

Change of state	Heating/Cooling
Solid to liquid	
Liquid to gas	
Gas to liquid	
Liquid to solid	
Solid to gas	



Summary

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

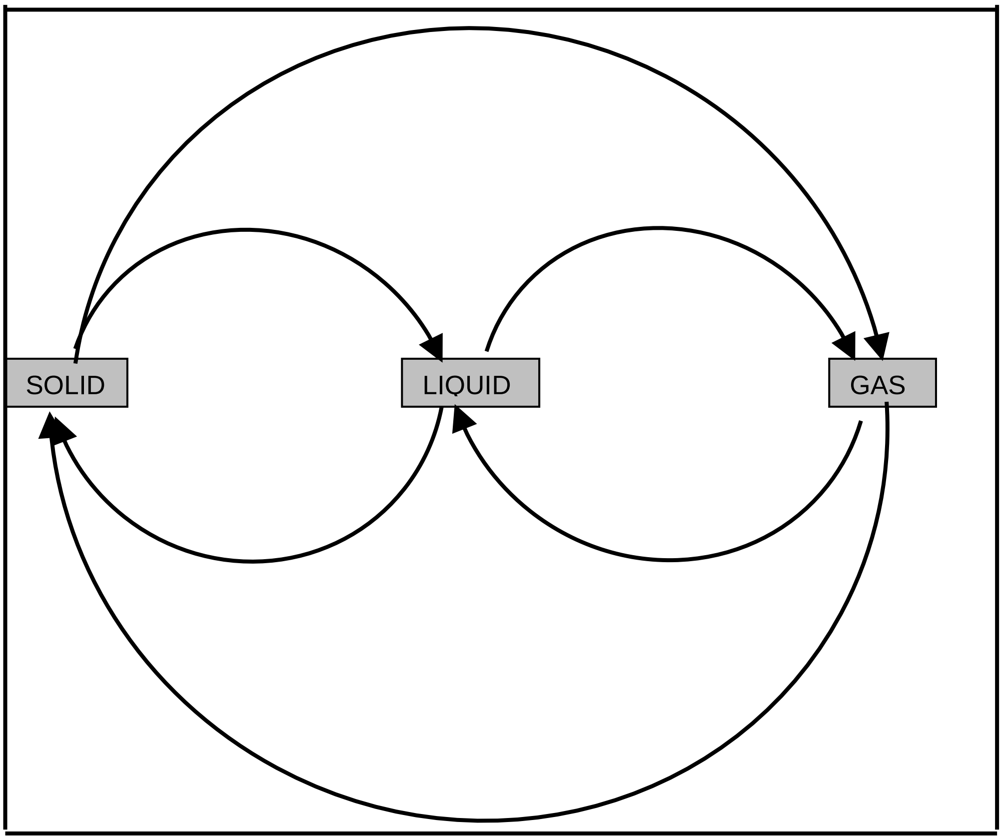
- changes of states of matter is when a substance changes from solid to liquid, liquid to gas, gas to liquid or liquid to solid.
- there are five changes of states of matter. These are melting, evaporation, condensation, freezing and sublimation
- melting is a change of state where a substance changes from solid to liquid.
- evaporation is a change of state where a substance changes from liquid to gas.
- condensation is a change of state where a substance changes from gas to liquid.
- Freezing is a change of state where a substance changes from liquid to solid.
- sublimation is a change of state where a substance changes from solid to a gas or from gas to a solid, without going through the liquid state.

NOW DO PRACTICE EXERCISE 2 ON THE NEXT PAGE.

Practice Exercise 2

Answer the following questions:

1. Write inside the box the changes of states of matter (melting, evaporation, condensation, freezing and sublimation).



2. When a solid is heated, what happens to the particles in the substance?

____

____

3. When a gas is cooled, what happens to the particles in the substance?

____

____

4. What has to be done to a substance before it changes its state?

____

____

CHECK YOUR WORK. ANSWERS ARE AT THE END OF SUB STRAND 1.

Answers to the activity

Part A

1. Melt/ heating.
2. Evaporate/heating.
3. Freeze/cooling.
4. Condense/cooling.
5. Sublime/heating

Part B

Solid to liquid	**Melting**
Liquid to solid	Freezing
Liquid to gas	Evaporation
Gas to liquid	**Condensation**

Part C

1. **C**

2. **D**

3. **E**

4. **A**

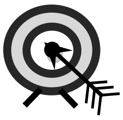
5. **B**

Part D

Change of state	Heating/Cooling
Solid to liquid	**Heating**
Liquid to gas	**Heating**
Gas to liquid	**Cooling**
Liquid to solid	**Cooling**
Solid to gas	**Heating**

Lesson 3: Solids

Welcome to lesson 3 of strand 3. In the last lesson you learnt about the changes of states of matter. In this lesson you will learn about the solid state of matter and how this state of matter behaves.

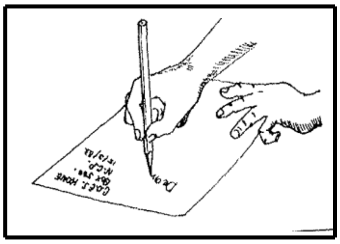


Your Aims:

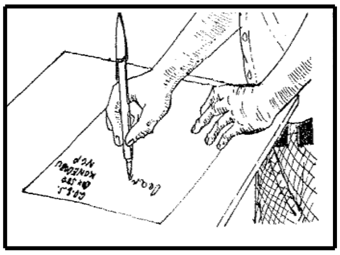
- define vibration and particles
- describe the internal arrangement of particles in solids
- draw a diagram for the particle arrangement of solids
- list the reasons why solids have fixed shape and volume

Inside The Solids

You can pick up and hold solids in your hands.

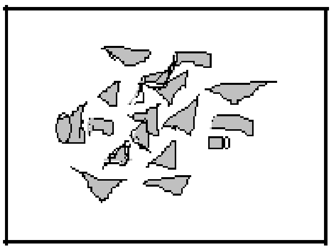


A pencil is an object and it is a solid. It is made of wood and carbon. You can pick up the pencil and hold it in your hand and write with it.



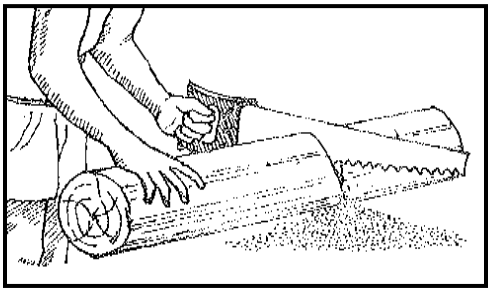
Another object is a pen. It is made of plastic and also in a solid state. You can pick up the pen, hold it in your hand and write with it.

But the examples of pencil and the pen are the physical characteristics of solid! What's really is inside the solid and what is it made of? We will now go deeper into it.

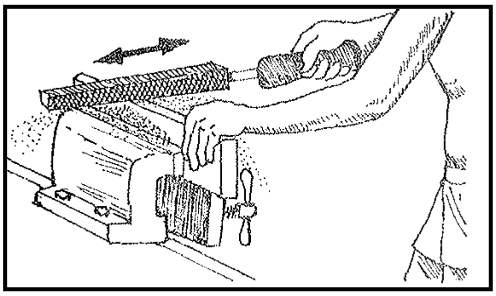


Now, let's look at the broken glass!
These small pieces are parts of the original glass. It shows what particles are!

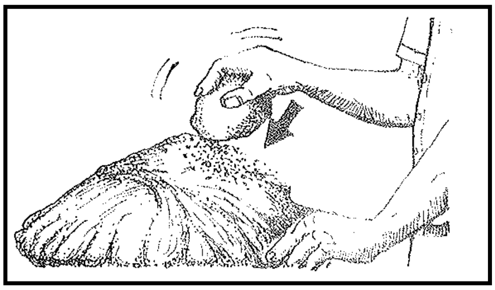
Particles are very small parts of a substance that cannot be seen by the naked eye even if you use a microscope still you cannot see it!
To better understand it, let's look at some examples given.



The sawdust is a very small part of the log.



These metal filings are very small parts of the block of metals.



A stone can be broken up into small parts called sand.

Each of these solids can be broken into small parts of the solid. These small parts can be made smaller and smaller but they are still made of the same solid. We say, they are made of tiny particles. One particle is so small that it cannot be seen by the naked eye. We only see a group of particles stuck together!

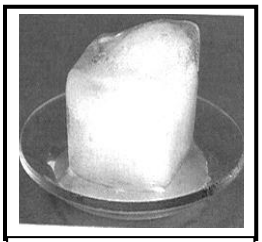
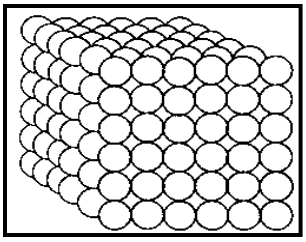
Did you know that?

- A metal is made of tiny particles of metal that stuck together?
- Paper is made of tiny particles of paper that stuck together?
- Glass is made of tiny particles of glass that stuck together?
- Flour is made of even smaller particles of flour stuck together?

How are these particles stuck together?

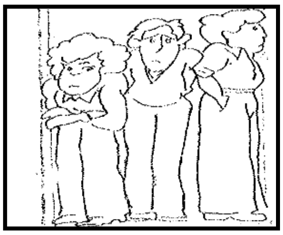
Let us look at the particle diagram. It shows how solid are closely packed together.

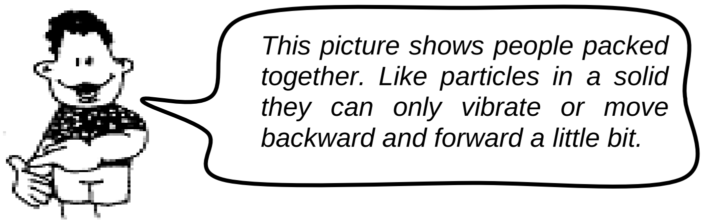
THE PARTICLE DIAGRAM OF SOLID

Solid	How the particles are arranged	Diagram of particles
 Ice	The particles in a solid are packed tightly in a fixed pattern. There are strong forces holding them together, so that they cannot leave their positions. The only movements they make are tiny **vibrations** to and fro.	

Particle arrangement of solid

In solids, particles are very tightly packed and they make little movement. The particles only vibrate. Vibration is the rapid back- and- forth motion of particles. As the spaces are very small, particles attract one another with a strong force. The force of attraction holds them at one particular place. Because of the fixed position of the particles, the solids have a **definite shape** and a **definite volume**. As the particles attract each other with a very strong force, it is therefore very difficult to tear them apart. Thus, the solids are rigid and hard.





Activity 1: Now test yourself by doing this activity.

Part A Complete the given sentences using the words below. You can use the word twice.

solid, small, shape, liquid, destroyed, gas, close, vibrate, move, seen, size

1. A particle is a very s_ _ _ _ piece of something.
2. Particles are too small to be s_ _ _ by your naked eye.
3. Particles cannot be d_ _ _ _ _ _ _ _ _.
4. Particles in every substance have their own special fixed s_ _ _ _ and s_ _ _.

5. The arrangement of particles in a substance decides whether it is a s_ _ _ _, l_ _ _ _ _ or g_ _.

6. In a s_ _ _ _ the particles are packed very c_ _ _ _ together. The particles in a solid do not m_ _ _ but can v_ _ _ _ _ _ in the same spot.

Part B. **Find the words in the puzzle. The words may be spelt across, down, backward or diagonally.**

P	M	V	I	B	R	A	T	E
E	A	I	S	O	I	M	I	B
N	T	R	E	I	G	A	S	I
G	I	F	T	E	O	D	O	R
N	L	S	F	I	X	E	D	D
O	I	D	A	D	C	L	I	R
R	Q	N	R	A	L	L	V	O
T	U	U	E	M	O	S	E	S
S	I	O	N	S	C	I	N	S
E	D	S	E	L	L	A	M	S

1. What is matter made up of?
2. The three states of matter
3. Movements of particles in solid
4. Position of particles in solid
5. Molecular force of attraction
6. Spaces between particles

Summary

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

- particles are very small parts of a substance that cannot be seen by the naked eye.
- solids have definite shape and volume because of the fixed position of particles, they are tightly packed.
- solids are rigid and hard because particles attract each other with a very strong force, they cannot leave their positions.
- the force of attraction holds the particles at one particular place.
- vibration is the rapid back- and- forth motion of particles
- the spaces between particles are very small and they attract one another with strong force.

NOW DO PRACTICE EXERCISE 3 ON THE NEXT PAGE.

Practice Exercise 3

Answer the following questions:

1. Define vibration.

____

2. What are particles?

____

____

3. Draw inside the box a diagram showing the arrangement of particles in solids.

4. Give three reasons why solids have fixed shape and volume.

a) ____

____

b) ____

____

c) ____

____

5. Describe the arrangement of particles in solids.

____

____

____

____

____

CHECK YOUR WORK. ANSWERS ARE AT THE END OF SUB STRAND 1.

Answers to Activity

Part A.

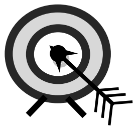
1. small
2. seen
3. destroyed
4. shape and size
5. solid, liquid or gas.
6. solid/ close. move/ vibrate

Part B.

1. particles
2. solid, liquid and gas
3. vibrate
4. fixed
5. strong
6. small

Lesson 4: Liquids

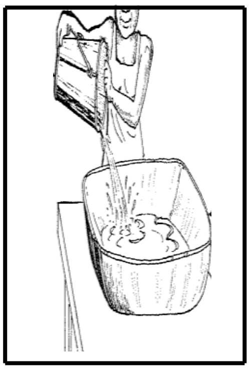
Welcome to lesson 4 of strand 3. In the last lesson you learnt that solids are tightly packed, have a definite shape and volume because of the fixed position of its particles. You also learned that solids are rigid and hard because particles attract each other with a very strong force, that they cannot leave their positions. The force of attraction holds the particles at one particular place and the only movement they make is to vibrate. Particles are very small parts of a substance that cannot be seen by the naked eye.In this lesson you will learn about the liquid state of matter.



Your Aims:

- draw the particle arrangement of liquids
- discuss the internal arrangement of particles in liquids
- differentiate the particle arrangement between solids and liquids

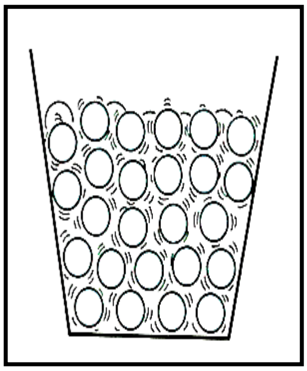
Inside The Liquids



You can pour a liquid. It flows from one container to another and will have the shape of the container. Therefore you can say that liquids have **no definite shape**. They take the shape of the container.

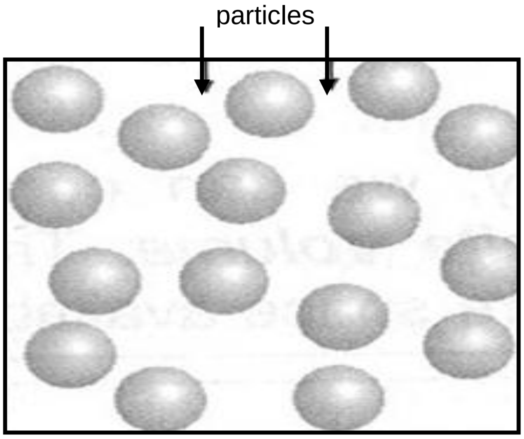
Liquids also have a definite volume and they need some container to remain in one place, otherwise they start flowing. They have only one definite free surface at the top of the container; this surface is always flat.

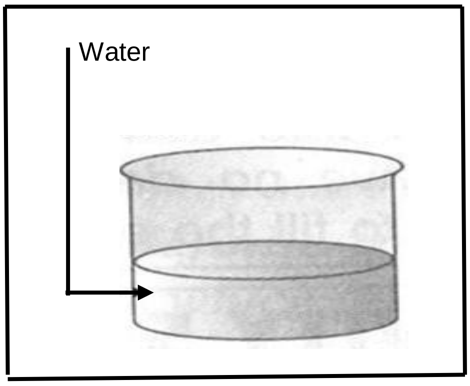
Particle arrangement of liquid
Just like in solids, inside the liquids are very small particles that cannot be seen by the naked eye even if you use the microscope. But unlike solid particles, liquid particles are **less tightly packed together** so they are able to slip and slide over each other; the distance between each particle makes it to move quite rapidly. You can see it from the diagram below.

Liquid	How the particles are arranged	Diagram of particles
	The particles in a liquid can move about and slide past each other. They are still close together but **not in a fixed pattern**. The forces that hold them together are weaker than in a solid.	

LIQUID PARTICLES

Spaces between particles





A substance can change from one state to another but the individual particles of the substance are the same in each state. It is their arrangement that is different. In liquids, particles are less tightly packed compared to solids which are tightly packed. As the spaces are large in liquids, the particles attract each other with lesser force than in solids. Because of the lesser force of attraction, the particles in liquids do not stay in one place; they interchange their positions unlike in solids which stay in place. As the position of the particles change easily, they take the shape of the container. Because the number of particles in a given liquid remains the same, they have a **definite volume** just like solids.

Activity 1: Now test yourself by doing this activity.

Aim: To show the presence of the spaces in liquids.

Materials needed: powdered sugar, spoon, water, measuring cylinder

Method: Take a measuring cylinder or any container (glass or plastic) with measurement. Fill it with water up to the 100ml mark. Add powdered sugar slowly in the cylinder. Stir well. You will notice that the water level in the cylinder remains the same.

Why has this happened?

Activity 2: Now test yourself by doing this activity.

Aim: To show that liquids take the shape of the containing vessel and have no shape of their own. They have one free surface.

Materials needed: a cup, a saucer, a coffee flask, water

Method: Take a small cup and fill it with water. Note the shape of water. It will resemble to the shape of the cup, but will have a free flat surface on the top.

Now, invert the cup in a big glass bowl.

1. What do you observe?

Pour the water from the bowl to a coffee flask.

2. What do you observe?

Pour the water from the coffee flask to the cup.

3. What do you observe?

Summary

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

- liquids have no definite shape. They take the shape of the container.
- liquids have a definite volume and only one definite free surface at the top of the vessel in which they are contained; this surface is always flat.
- just like in solids, inside the liquids are very small particles that cannot be seen by the naked eye.
- unlike solid particles, liquid particles are less tightly packed together so they are able to slip and slide over each other; the distance between each particle makes it to move quite rapidly.
- the forces that hold the liquid particles together are weaker than in a solid.

NOW DO PRACTICE EXERCISE 4 ON THE NEXT PAGE.

Practice Exercise 4

Answer the following questions:

1. Using the idea of particles, explain why it is easy to pour a liquid.

____

____

2. Write three (3) differences between the solids and the liquids.

SOLIDS	LIQUIDS
1.	1.
2.	2.
3.	3.

3. Describe the arrangement of particles in a liquid.

____

____

4. Draw inside the box a diagram showing the internal arrangement of liquids.

CHECK YOUR WORK. ANSWERS ARE AT THE END OF SUB-STRAND 1.

Answers to Activities

Activity 1

This is because the sugar particles fill in the r spaces between the molecules of water.

Activity 2

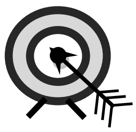
The water flows into the bowl and takes the shape of the bowl, but its top surface is free and flat.

The water flows into the flask and takes the shape of the coffee flask, with its top surface free and flat.

The cup again gets filled and water takes the shape of the cup.

Lesson 5: Gases

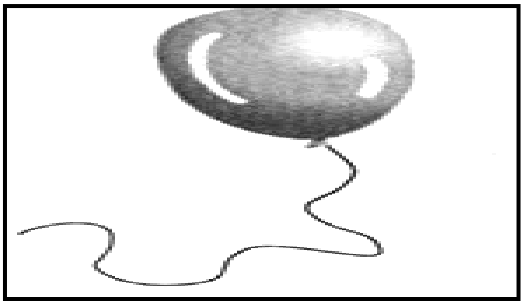
Welcome to lesson 5 of strand 3. In the last lesson you learnt about liquids. They are made of particles similar to solids but different in their arrangement. Liquid particles are less tightly packed and slide over each other compared to solids which are packed tightly. Also, the forces in the liquid particles are weaker than solids. In this lesson you will learn about gases, the third state of matter. Now, what can you predict about the particles in gas.



Your Aims:

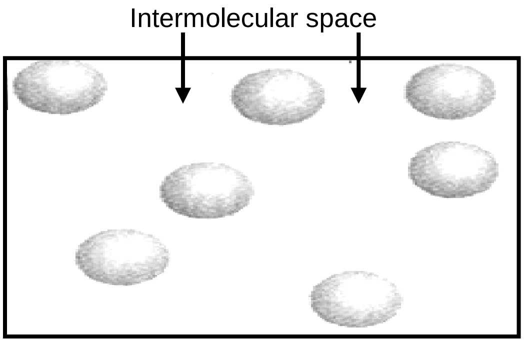
- draw the particle arrangement of gases
- discuss the internal arrangement of particles in gas
- differentiate the particle arrangement between solids, liquids and gases

Inside The Gases



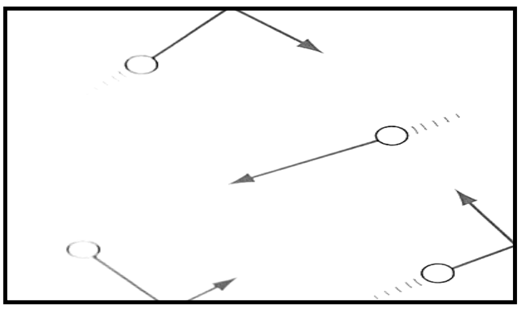
A gas has neither a definite shape nor a definite volume. It will take up the shape of any container into which it is placed and will spread out evenly within it. They are free to move anywhere within the container in which they are held.

Balloon filled with air



Gases are made of tiny particles just like solids and liquids but different in their arrangement. Gas particles are relatively far apart and move freely in all directions. They move randomly and more rapidly than those in a liquid.

Particles of gases



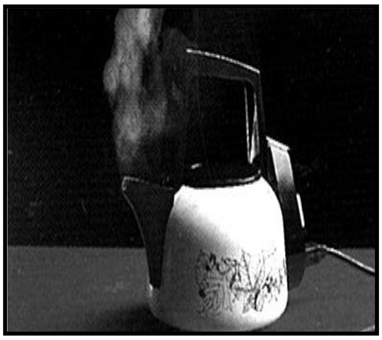
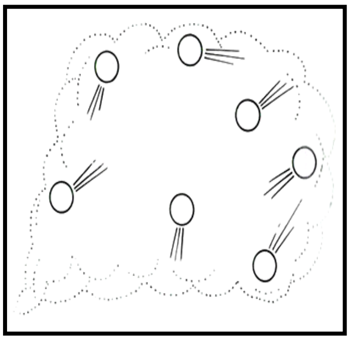
They collide with the walls of the container. They exert no forces of attraction on each other because they are relatively far apart.

Colliding particles of gases

Air particles move everywhere in all directions. The wind can blow the smell. The particles of the smelly gas move with the particles of air. There are also other good smell the particles of air carry: the smell of perfume when someone wears it; the smell of delicious food which makes you salivates, the smell of roses in the garden which makes you feel heavenly.

Particle arrangement of gases

In gases, the particles are spread far apart. They move very rapidly and freely, spreading out to take the shape of the containers they are in. These particles of gases completely fill their containers because the rapidly moving particles are colliding with each other and pushing outwards.

Gas	How the Particles are arranged	Diagram of Particles
	The particles move very quickly in all directions; as the particles bash against the walls of the container, they exert a force that causes pressure	

Differences between solids, liquids and gases

Solids	Liquids	Gases
Particles are packed tightly and cannot move out of position.	Particles are less tightly pack and slide over each other.	Particles are far apart from each other and move randomly.
Particles cannot be compressed.	Difficult to compress the particles.	Cannot compress the particles.
Forces are strong.	Forces are less than that in solids.	Forces are weak.

Brownian movement and Diffusion

If you switch on a torch in a closed dark room, you will notice the particles of dust moving about randomly in all directions in the beam of light. The particles of dust continue moving indefinitely and their movement does not stop with the passage of time.

Why does this happen?

It is because, the particles of air hit against the particles of dust at random and from all possible directions. It is due to the impact of the molecules of the air that dust particles move randomly in all possible directions. This movement of particles of substance in a fluid (liquid or gas) was discovered by Robert brown and is commonly called **Brownian movement.**

You can detect different smell such as flowers in the garden, a lighted incense stick and perfume from somebody who wears it. The smell spreads because air particles hit the particles of other substances to form a kind of uniform mixture. This process is called **diffusion.**

Anyone who has walked into a kitchen where bread was baking has experienced the fact that gases expand to fill their containers, as the air in the kitchen becomes filled with wonderful odors. Unfortunately, the same thing happens when someone breaks open a rotten egg and the characteristic odor of hydrogen sulphide gas rapidly diffuses through the room. Because gases expand to fill their containers, it is safe to say that the volume of a gas is equal to the volume of its container.

So, you could say that Brownian movement is the random movement of particles of substance in a fluid or gas while diffusion is the process of intermixing two substances (liquids or gases) so as to form a uniform mixture, without any external aid.

Always remember:

- In gases, the molecules are so much far apart, that they hardly attract each other.
- The molecules or particles move independently and therefore, gases have neither a definite shape nor a definite volume.
- They fill the entire space in which they are enclosed.

Activity 1: **Now test yourself by doing this activity.**

Aim: To prove that gases take the shape of the container.
Materials: Three (3) deflated balloons of different shapes
Methods: Take balloons of different shapes and inflate them with air.

What do you observe?

___

___

Activity 2: Now test yourself by doing this activity.

Aim: To prove that gases have no definite volume.

Materials: An empty glass bottle, small amount of scent

Methods: Take an empty glass bottle and pour a few scent into it. Smell the bottle. You will be able to smell the scent.
Now, place this bottle in your drawing room and leave it undisturbed for a few minutes. You will observe that the whole room is filled with the smell of scent.

What can you say or conclude from this activity?

____

____

Summary

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

- gases are made of tiny particles that cannot be seen by the naked eye just like in solids and liquids but different in their arrangement.
- in gases, the molecules are so much far apart, that they hardly attract each other.
- gases have neither a definite shape nor a definite volume because the particles move freely in all directions. They move randomly and more rapidly than those in a liquid.
- gases collide with the walls of the container. They exert no forces of attraction on each other.
- they can fill in the entire space in which they are enclosed.
- brownian movement is the random movement of particles of substance in a fluid or gas and was discovered by Robert brown.
- diffusion is the process of intermixing two substances (liquids or gases) so as to form a uniform mixture, without any external aid.

NOW DO PRACTICE EXERCISE 5 ON THE NEXT PAGE.

Practice Exercise 5

Answer the following questions:

1. Why do gases fill the entire space available to them?

____

____

____

2. What is Brownian movement?

____

____

3. How do you smell the perfume of a burning incense stick? Explain briefly.

____

____

____

4. Draw inside the box a diagram showing the internal arrangement of gases.

5. What do you understand by the term diffusion?

____

____

6. Differentiate solids, liquids and gases.

____

____

CHECK YOUR WORK. ANSWERS ARE AT THE END OF SUB STRAND 1.

Answers to Activities

Activity 1

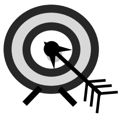
The air inside the balloon takes the shape of the balloon. It has no shape of its own.

Activity 2

I conclude that gases have no definite volume. They have a property to fill the entire space available to them.

Lesson 6: Solutions

Welcome to lesson 6 of strand 3. In the last lesson you learnt about the gas state of matter. In this lesson you will learn about solutions. Which states of matter do tea leaf, sugar and Pauls milk belong to? Of course tea leaf and sugar are solids while Pauls milk is a liquid. Oh yeah! I remember drinking a nice mixture (solution) this morning made of tea leaf, sugar, Pauls milk and hot water so what is the solution? For this lesson, you will now look at the different solutions.



Your Aims:

- define solution, solute, solvent, saturated, unsaturated, weak and strong solutions
- give examples for each types of solution
- perform a simple experiment about solution

Soluble And Insoluble Substances

Substances which dissolve in water are described as water-soluble. For example salt dissolving in water. A **soluble** substance is one that can dissolve in another substance (solids, liquids and gases). Substances which do not dissolve in water are called water-insoluble substances. For example sand do not dissolve in water. **Insoluble** substances do not dissolve. When a substance dissolves in another substance, a **solution** is formed. A solution is clear, that is no particles can be seen.

What is a solution?

When you stir sugar in a cup of tea, it seems to disappear into the water. We say the sugar **dissolves** in the water. The sugar and water have formed a **solution.** In a solution, the water particles get between the sugar particles and separate them. A solution is a special mixture in which a solid substance (the sugar) dissolves in a liquid (the water). Solutions maybe coloured, but they are always clear. You can see through them. The separate particles are too small to be seen, which is why the solution looks clear.

The solid that dissolves is called the **solute**. The liquid that does the dissolving is called the **solvent**. So the solute dissolves in the solvent, forming a solution. The solute is spread evenly through the solvent.

Solute + Solvent = Solution

Two liquids can also form a solution. For example, wine is a solution of alcohol in water. And fuel for two-stroke motor mowers and outboard engines is a solution of oil in petrol.

Solutions are not always made up of a solid dissolved in a liquid. Liquids and gases can also dissolve in solvents.

Water is a common solvent, but to dissolve some things you have to use other solvents.

Some commonly used solvents are shown in the table below.

SOLUTE	SOLVENT (dissolves the solute)
Nail polish	Nail polish remover (acetone)
Oil paint	Turpentine
Tar on car paint work	Petrol
Grease mark on clothes	Eucalyptus oil
Biro stains	Methylated spirit

Kinds of solutions
What will happen if you add one teaspoon of sugar to a glass of water?
(The sugar will dissolve immediately.)

When there is only a small amount of sugar in the water, the sugar will dissolve fast. The sugar taste in “one teaspoon solution” will be a weaker one. This is called a **weak solution.**

How about if you add three teaspoons of sugar to a glass of water?
(Well, it will dissolve but not as fast as when you add only one teaspoon of sugar.)

If you add three teaspoons of sugar to a glass of water, the sugar taste will be a lot stronger than if you only add one teaspoon. We say that the “three teaspoons solution” is strong. This is called a **strong solution.**

Strong and weak solutions are examples of **unsaturated solution**. In an unsaturated solution, all the solute added dissolves in the solvent.

What do you think will happen if you keep on adding sugar on a glass of water?
(Soon the sugar particles will stop dissolving.)

When there is enough sugar in the water, no more sugar will dissolve. The sugar will settle at the bottom of the glass. This is called a **saturated solution.**

Sugar in water solution

Activity: Now test yourself by doing this activity.

Part A. Complete the following sentences.

When one substance dissolves in another, a __________ is formed. The substance which dissolves is the __________ and substance in which it dissolves is the __________. __________ is the common solvent. Any substance which does not __________ in a solvent is said to be __________ in that solvent. When sugar is mixed with water, it __________. This shows that sugar is __________ in water. Sand is __________ in water. In salt water, the salt is the __________, and the water is the __________.

Part B. Let us do a simple experiment.

Aim: To test the solubility of various substances in water.
Materials: 6 test tubes (labeled A, B, C, D, E, and F), test tube rack, small spatula, samples of (salt, sugar, coffee, flour, sand and chalk)
Title: Which dissolves in water?

1. Use the spatula to pick up a small amount of salt-about the size of a grain of rice. Place this salt in test tube A.
2. Half fill the test tube with water. Stir the mixture by tapping the tube. As you shake each tube, hold it up to the light. Is it cloudy or does the light shine through it? Is the liquid coloured or colourless?
3. Repeat steps 1 and 2 for each of the other solids in turn.
4. Carefully observe each test tube and decide whether the substances are:
   (a) soluble (dissolves completely)
   (b) insoluble (will not dissolve)
5. Record your observations. Use the data table given below.

DATA TABLE

Test tube	Substance	Observation (cloudy/ coloured/ clear)	Soluble/Insoluble
A	Salt		
B	Flour		
C	Chalk		
D	Coffee		
E	Sand		
F	Sugar		

Part C. Write true or false in the following sentences.

1. Water dissolves everything. ___________
2. Solutions are always coloured. ___________
3. Orange juice is a solution. ___________
4. A solute can be solid, liquid or a gas. ___________
5. Gases can dissolve in water. ___________

Summary

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

- a soluble substance is one that can dissolve in another substance.
- insoluble substance is one that does not dissolve.
- a solution is formed when a substance dissolves in another substance. A solution is clear, that is no particles can be seen.
- in a solution, the solid that dissolves is called the solute. The liquid that does the dissolving is called the solvent.
- a weak solution is the one with a little solute added.
- a strong solution is the one with more solute added.
- in the unsaturated solution, all the solute added dissolves in the solvent forming a weak or strong solution.
- in a saturated solution, enough solute is added that the solvent cannot dissolve any more of it and settle at the bottom of the container.

NOW DO PRACTICE EXERCISE 6 ON THE NEXT PAGE.

Practice Exercise 6

Answer the following questions:

1. Define and give 2 examples for each types of solution.

Meaning	Examples
Solute -	
Solvent -	
Saturated -	
Unsaturated -	
Weak solution-	
Strong solution-	

2. Perform the following activity and use the table given below.

   INVESTIGATION: The effect of heat when dissolving solutes.

a) Collect a small glass bottle, teaspoon, some salt & sugar, cold and hot water.
b) Put a small amount of cold water in the bottle and mark it to show the level of the water.
c) Add salt to the water using the teaspoon and stir it.
d) Continue to add salt and stir until no more salt will dissolve. Record the number of teaspoons of salt that you have added.
e) Repeat the procedure using the same amount of hot water and record again the number of teaspoons of salt that you have added.
f) Repeat the experiment using sugar instead of salt, but again using cold and hot water.
g) Write your answers from the given table and make a conclusion based on the results.

	Teaspoon of salt	Teaspoon of sugar
Cold water		
Hot water		

Conclusion: ____

____

CHECK YOUR WORK. ANSWERS ARE AT THE END OF SUB-STRAND 1.

Answers to Activity

Part A.

Test tube	Substance	Observation (cloudy/ coloured/ clear)	Soluble/Insoluble
A	Salt	**Clear**	**Soluble**
B	Flour	**Cloudy**	**Soluble**
C	Chalk	**Cloudy**	**Insoluble**
D	Coffee	**Coloured**	**Soluble**
E	Sand	**Clear**	**Insoluble**
F	Sugar	**Clear**	**Soluble**

Part B.

When one substance dissolves in another, a **solution** is formed.
The substance which dissolves is the **solute** and substance in which it dissolves is the **solvent.** **Water** is the common solvent. Any substance which does not **dissolve** in a solvent is said to be **insoluble** in that solvent.

When sugar is mixed with water, it **dissolves**. This shows that sugar is **soluble** in water. Sand is **insoluble** in water.
In salt water, the salt is the **solute**, and the water is the **solvent**.

Part C.

1. **False**
2. **False**
3. **True**
4. **True**
5. **True**

REVIEW OF SUB STRAND 1: MATTER

Revise all the Lessons in this Sub Strand and then do **ASSIGNMENT 4.**
Here are the main points to help you revise.

Lesson 1: States of Matter

- Matter is anything that has mass and takes up space.
- Matter is made up of tiny particles and cannot be seen by the naked eye.
- Heat, light and anger are not matter because these are different from the things we can feel pressing against our skin.
- Solids, liquids and gases are the three states of matter.
- All solids have definite shapes and volume.
- Liquid states have no shape but have definite volume.
- Gases do not have a definite shape or volume

Lesson 2: Changes of States of Matter

- There are five changes of states of matter. These are melting, evaporation, condensation, freezing and sublimation
- Melting is a change of state where a substance changes from solid to liquid.
- Evaporation is a change of state where a substance changes from liquid to gas.
- Condensation is a change of state where a substance changes from gas to liquid.
- Freezing is a change of state where a substance changes from liquid to solid.
- Sublimation is a change of state where a substance changes from solid to a gas or from gas to a solid, without going through the liquid state.

Lesson 3: Solids

- Solids have definite shape and volume because of the fixed position of particles, they are tightly packed.
- Solids are rigid and hard because particles attract each other with a very strong force, they cannot leave their positions.
- The force of attraction holds the particles at one particular place in the rapid back- and- forth motion.
- The spaces between particles are very small.

Lesson 4: Liquids

- Liquids have no definite shape. They take the shape of the containing vessel.
- Liquids have a definite volume and only one definite free surface at the top of the vessel in which they are contained; this surface is always flat
- Just like in solids, inside the liquids are very small particles that cannot be seen by the naked eye.
- Unlike solid particles, liquid particles are less tightly packed together so they are able to slip and slide over each other; the distance between each particle makes it to move quite rapidly.
- The forces that hold the liquid particles together are weaker than in a solid.

Lesson 5: Gases

- Gases are made of tiny particles that cannot be seen by the naked eye
- Gas particles are far apart and exert no forces of attraction on each other.
- Gases have neither a definite shape nor a definite volume because they move freely in all directions. They can fill in the entire space in which they are enclosed.
- Brownian movement is the random movement of particles of substance in a fluid or gas and was discovered by Robert Brown.
- Diffusion is the process of intermixing two substances (liquids or gases) so as to form a uniform mixture, without any external aid.

Lesson 6: Solutions

- A solution is formed when a substance dissolves in another substance.
- A soluble substance is one that can dissolve in another substance.
- In a solution, the solid that dissolves is called the solute. The liquid that does the dissolving is called the solvent.
- A Weak solution is the one with a little solute added.
- A strong solution is the one with more solute added.
- In the unsaturated solution, all the solute added dissolves in the solvent forming a weak or strong solution.
- In a saturated solution, enough solute is added that the solvent cannot dissolve any more of it and settle at the bottom of the container.

REVISE WELL AND THEN DO SUB STRAND TEST 1 IN YOUR ASSIGNMENT 4.

Answers to Practice Exercises 1-6

Practice Exercise 1

1. Matter is anything that occupies space and has mass.

2. Solids: a) books b) tables c) chairs d) pen

   Liquids: a) water b) ocean c) cordial d) river

   Gases: a) air b) oxygen c) hydrogen d) carbon dioxide

3. I would know if something is made up of matter if that something occupies space has mass.

4.

State	Shape	Volume	Able to be compressed
Solid	Fix shape	Fix volume	Cannot be compress
Liquid	Take the shape of the container	Fix volume	Cannot be compressed
Gas	Take the shape of the container	No fix volume	Can be compressed

5 .

Matter	Non-matter
Salt	Push
Nail	Clap
Rock	Thunder
Natural gas	Electricity
Elastic band	Laughter
Mineral water	
chair	

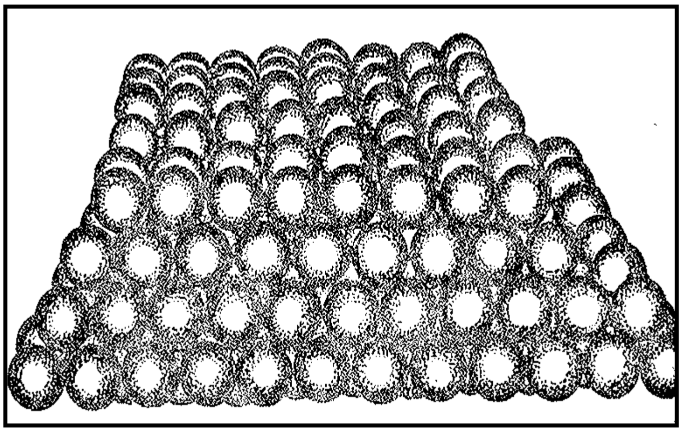
6. Ice, water and steam are different from each other because of the amount of space between the particles as well as the amount of movement of the particles in each state.

Practice Exercise 2

1. Vibration is the shaking movement to and fro rapidly and continuously.

2. Particles are very, very small parts of a substance which cannot be seen by the naked eye even if we use microscopes or magnifying glass.

3.



4. a) Particles are tightly packed.

   b) Molecules attract one another with strong force because intermolecular spaces are very small.

   c) The force of attraction holds them at one particular place.

5. The particles in a solid are packed tightly in a fixed pattern. There are strong forces holding them together, so they cannot leave their positions. The only movement they make are tiny vibrations to and from.

Practice Exercise 3

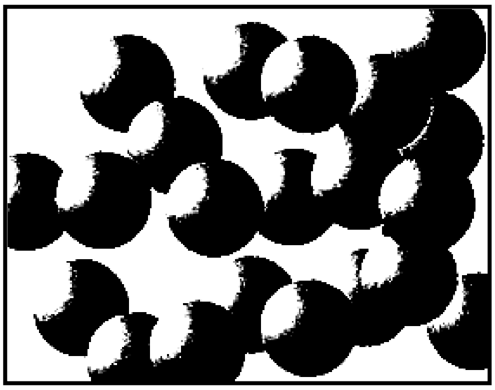
1. It is easy to pour a liquid because the particles in a liquid move about and slide each other. The particles are close but not in a fixed position and the forces that hold them together are weaker compared to the solid.

2.

SOLIDS	LIQUIDS
1. Particles are in a fixed position	1. Particles move & slide each other
2. Forces of attraction are strong	2. Weaker forces of attraction
3. Intermolecular space are small	3. Larger intermolecular space

3. The particles in a liquid can move about and slide past each other. They are still close together but are not in a fixed position. The forces that hold them together are weaker than in a solid.

4.



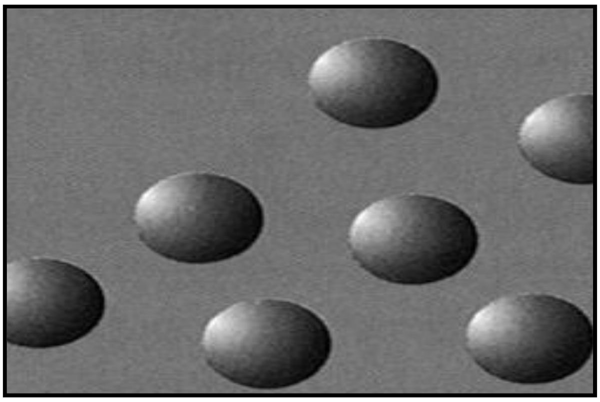
Practice Exercise 4

1. Because particles of gases are so much far apart and do not attract each other. They move independently and very quickly bouncing off in all directions thus filling the entire space available to them.

2. Brownian movement is the random movement of particles of substance in a fluid or gas.

3. The particles of air hit against the particles of the perfume in the smoke of the incense stick.

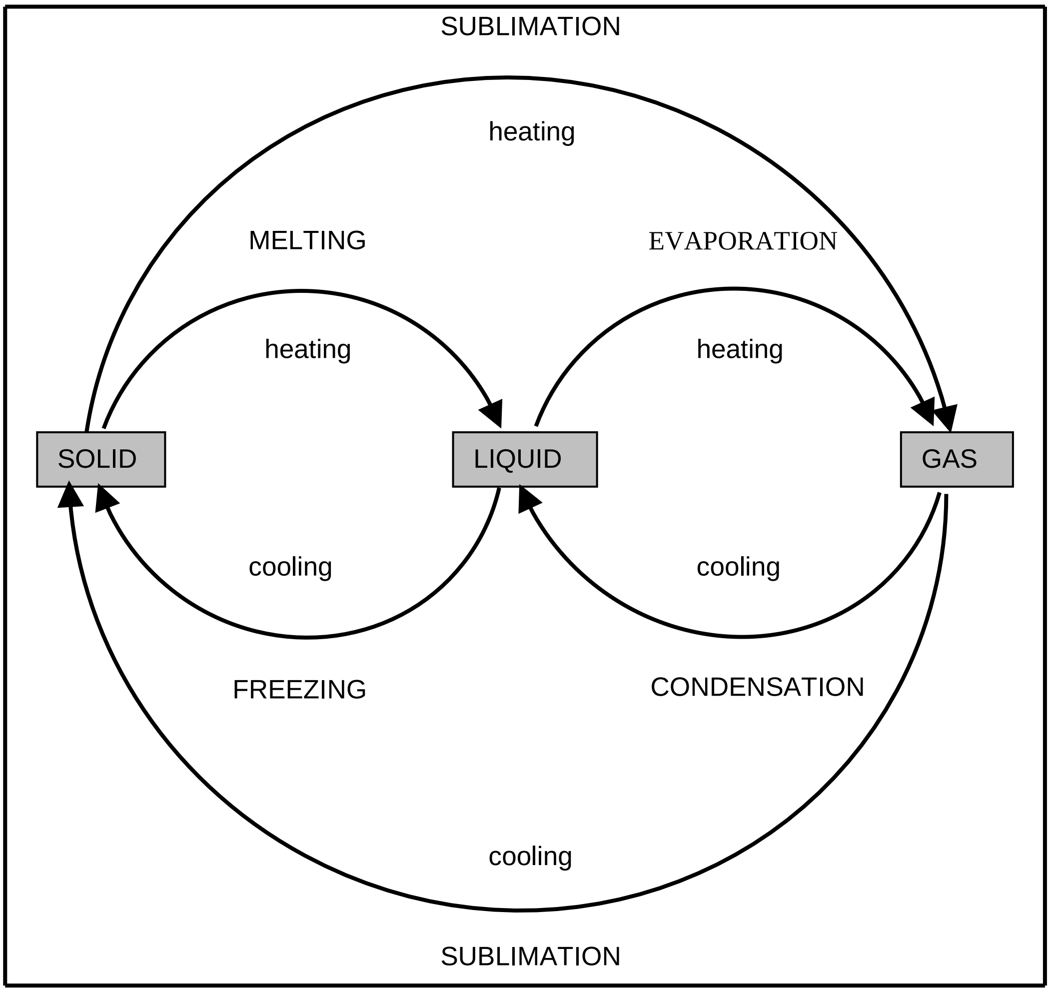
4.



5. Diffusion is a process of intermixing two substances (liquids or gases) to form a uniform mixture without external aid.

Practice Exercise 5

1.



2. When a solid is heated, the vibrations of the particles increases until finally the particles slide away from their fixed positions. The substance changes state from solid to liquid.

3. When a gas is cooled, the particles lose energy and slow down. The substance changes state from a gas to a liquid or from liquid to a solid.

4. Substances is either heated or cooled before it changes its state.

Practice Exercise 6

1.

Meaning	Examples
Solute – a substance that dissolves in a liquid.	Sugar, salt
Solvent – a liquid that can dissolve things.	Water, alcohol
Saturated – a solution in which no more solute will dissolve in the solvent.	20 teaspoons of sugar dissolved in a glass of water
Unsaturated – is a solution in which all the solute will dissolve in a solvent.	3 teaspoons of sugar dissolved in a glass of water
Weak solution – is a solution with little amount of solute added.	1/2 teaspoon of sugar dissolved in a glass of water
Strong solution – is a solution with large amount of solute added.	5 teaspoons of sugar dissolved in a glass of water

2. INVESTIGATION: The effect of heat when dissolving solutes.

	Teaspoon of salt	Teaspoon of sugar
Cold water		
Hot water		

CONCLUSION: More sugar and salt dissolves in hot water than in cold water.

SUB STRAND 2

PROPERTIES OF MATTER

In this sub strand you will learn about:

- **physical properties of materials**
- **different physical changes**
- **different chemical changes**
- **different symbols and formulae of elements and compounds**
- **signs and symbols in word equation**

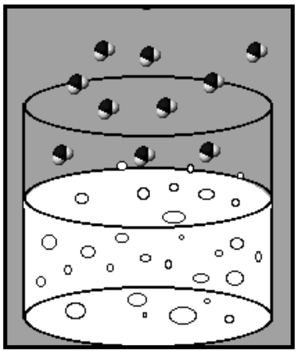
SUB STRAND 2: PROPERTIES OF MATTER

Introduction

All substances have properties that we can use to identify them. For example we can identify a person by their face, their voice, height, finger prints etc. The more of these properties that we can identify, the better we know the person. In a similar way matter has properties - and there are many of them. There are two basic types of properties that we can associate with matter. These properties are called Physical properties and Chemical properties:

Examples of physical properties are**:** colour, smell, freezing point, boiling point, melting point, attraction or repulsion to magnets and density. There are many more examples. Note that measuring each of these properties will not alter the basic nature of the substance.

Freezing water



Boiling water

Examples of chemical properties are: heat of combustion, reactivity with water, PH, and electromotive force. The more properties we can identify for a substance, the better we know the nature of that substance. These properties can then help us model the substance and thus understand how this substance will behave under various conditions.

Combustion

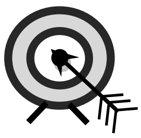
A chemical change occur

Now, how does a chemical change occur? What molecules are they? How do they interact? And what happen?

In this Sub strand, you will learn about the properties of matter and the physical and chemical changes that occur in the reaction.

Lesson 7: Physical Properties of Materials

Welcome to Sub-strand 2 of strand 3. In the last sub-strand you studied matter. In this sub strand you will study the properties of matter, the physical and chemical changes that occur during chemical reactions. From the previous lessons, you have learnt about matter, its changes of states and its internal arrangement in solids, liquids and gases. We can say that these particles in three different states are similar but are different in their arrangement. You've also learned from the previous lesson about the Brownian movement and diffusion. In this lesson you will study about the physical properties of materials.



Your Aims:

- describe the physical properties of materials
- list examples of materials and identify their properties
- write the uses of given materials based on their physical properties

What Are Physical Properties Of Materials?

In Science, we often describe the properties of a material. "Properties" means the special features or characteristics of a substance. It describe how a material behaves when heated or cooled, scratched or bent, when squashed or stretched and so on. The physical aspects or characteristics of a material and how it behaves are called its physical properties.

Properties of materials

You will have noticed that a piece of wood and a brick are different from each other. We say they are different because they feel, smell and look different. These characteristics are called the properties of materials. Properties tell the difference between one material and another.

Sometimes it is easy to determine the properties of a material, for example, cola and lemonade look, taste and smell different to each other. But sometimes special tests or experiments have to be conducted to determine properties.

A diamond and a quartz crystal may look similar, but in order to distinguish between them, special hardness tests have to be conducted. Diamond is much harder then quartz. Diamond will scratch quartz but quartz will not scratch diamond.

To describe the properties of different materials, some of the words used are shown below.

a. **Strength** is the property of a substance that allows it to retain or maintain its shape when twisted, pulled or crushed.

b. Some flexible solids will bend without breaking. We say the solid is **malleable**. A solid is called **ductile** if it can be stretched and drawn into wires. Solids which crumble and break apart if you try to bend them is said to be **brittle**.

c. Materials which allow heat and electricity to flow through them easily are called **conductors**. **Insulators** are materials which do not allow heat and electricity to flow through them.

d. **Elastic** materials can be stretched and will return to their original shape when released.

e. **Density** is the “heaviness” of the material and measures how closely particles are packed together in a material. To find the density of a sample of material you measure its mass and volume. Density is calculated by dividing the mass (in grams) by the volume (in cubic centimeters).

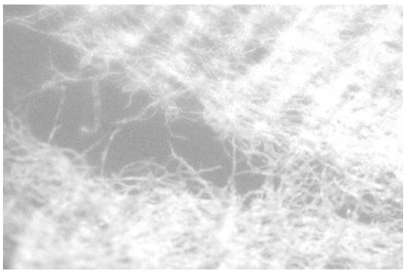
f. **Opaque** does not allow light to pass through it. **Transparent** lets light through or “see-through” it.

g. The **boiling point** of a substance is the temperature at which that substance changes state from a liquid to a gas. Different substances have different boiling points.

h. The **melting point** of a substance is the temperature at which that substance changes state from a solid to a liquid.

i. **Hardness** is the property of a substance that allows it to resist scratching. Hard materials are used to cut softer ones. The hardest substance on Earth is diamond. Diamond tipped drills is used to cut concrete; metal drills are hard enough to cut into wood.


Plastics


Fibres


Pottery


Clay


Jar


Glass

Materials used everyday

Ways of grouping solids

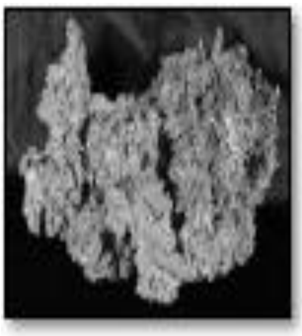
There are different ways of putting materials according to their physical properties. For example, the solid materials that are used for making things that we use in everyday life can be put into five groups.

Groups	Meaning
Pottery or ceramics	Brittle materials made by heating clay. They can usually stand high temperatures.
Glasses	Brittle materials are made partly from sand. They are transparent or opaque and are good electrical insulators.
Plastics	Made from chemicals (synthetic). Can be molded into shapes. Often flexible when cold. Melt easily. Good electrical insulators.
Metals	Metals are shiny solids that conduct heat and electricity. They are often malleable and ductile and are difficult to melt.
Fibres	Threads made from natural or synthetic materials and used to make bilums and fabrics.

Manganese

Thermometre

Zinc



Copper

Steel

Aluminium

Useful metals

Metals and their uses

There are thousands of different materials in the world. Some are natural materials and some are made by people. Objects around you are made up of many different materials. Materials such as metals are useful because of their properties.

Below are some metals and their uses.

Copper	A soft and pinkish metal. An excellent conductor of electricity and heat. Used for wiring household electrical appliances. Also used in water and gas piping.
Lead	Soft, bendable and has a dull grey appearance. Cast into all kinds of shapes and used as fishing sinkers. Also used to make waterproof joints to stop water getting into buildings.
Aluminium	A light and silvery white in colour. Used as cooking pots, aeroplanes and louvre frames. Also used as a wrapper for foods, chocolates and other articles. Can be rolled into thin sheets used in ceiling to keep houses cool.
Magnesium	A light material and white in colour. Useful in camera, flashbulbs, flares and fireworks.
Tin	Soft and can be rolled into thin sheets of tinfoil. Used for coating iron like tin plating in tin cans.
Zinc	Does not corrode easily. Used to coat iron to form galvanised iron. Used in making dry cells for radios and torches.

Most metals are hard solids that can be flattened into sheets and stretched into wires. However, most metals are not used in their **pure** state. Mixing different metals to form **alloys** can produce a metal with special properties. Some common alloys are given below.

Brass	A metal alloy of copper and zinc. It is easy to cast and does not corrode. It is used in taps and bullet cases.
Solder	A metal alloy of lead and tin. It melts easily and used to join metals in tanks, gutters and wires.
Bronze	A metal alloy of copper and tin. It is easy to cast and does not corrode. Used in boat fittings and statues.
Stainless	A metal alloy of iron, chromium, manganese and nickel. It is strong and hard and used in making knives, forks, spoons, saucepans, sinks, bolts and wire.

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

Part A. Write YES or NO to fill in the table below.

Materials	Is it hard?	Is it dense?	Is it strong?	Does it conduct electricity?
Rubber band				
Metal file				
Glass rod				
Writing pad				
Plastic cup				
5 Toea coin				

Part B. The following word maze contains mixed – up words written forwards, backwards, up, down or diagonally.
From the list below, find each word and circle it off as you find it.

A	Y	O	L	L	A	F	I	B	R	E	S
N	T	R	A	N	S	P	A	R	E	N	T
T	N	I	O	P	G	N	I	T	L	E	M
B	O	I	L	I	N	G	P	O	I	N	T
R	P	N	D	E	N	S	I	T	Y	N	E
I	A	S	C	E	L	I	T	C	U	D	A
T	Q	U	I	H	T	G	N	E	R	T	S
T	U	L	T	S	Z	L	A	A	S	A	L
L	E	A	S	D	I	A	H	N	J	C	A
E	R	T	A	A	N	S	C	L	A	Y	T
T	A	O	L	E	C	S	T	E	E	L	E
E	J	R	E	L	B	A	E	L	L	A	M

List of words

Forwards:	fibres, transparent, boiling point, density, clay, steel
Backwards:	malleable, alloy, melting point, strength, ductile,
Up:	metals, elastic, lead, jar
Down:	opaque, brittle, insulator, zinc, glass,
Diagonal:	hard, tin,

Summary

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

- physical properties mean the special features or characteristics of a substance.
- a solid is malleable if it is flexible and will bend without breaking.
- opaque does not allow light to pass through it. Transparent lets light through or "see-through" it.
- the boiling point of a substance is the temperature at which that substance changes state from a liquid to a gas. The melting point of a substance is the temperature at which that substance changes state from a solid to a liquid.
- hardness is the property of a substance that allows it to resist scratching.
- solid materials that we use in everyday life can be put into five groups such as pottery, glasses, plastics, metals and fibres.
- alloys are produced when different metals are mixed together to produce another metal with special properties.

NOW DO PRACTICE EXERCISE 7 ON THE NEXT PAGE.

Practice Exercise 7

Answer the following questions:

1. Define the physical properties of materials.

   ____

2. Describe the following physical properties.

   a) strong ______________________________
   b) brittle ______________________________
   c) density ______________________________
   d) opaque ______________________________
   e) ductile ______________________________
   f) malleable ______________________________
   g) transparent ______________________________
   h) conductor ______________________________
   i) insulator ______________________________

3. Write the uses of each materials based on their physical properties.

   a) tin ______________________________
   b) lead ______________________________
   c) zinc ______________________________
   d) copper ______________________________
   e) aluminium ______________________________
   f) Magnesium ______________________________

CHECK YOUR WORK. ANSWERS ARE AT THE END OF SUB-STRAND 2.

Answers to Activity

Part A

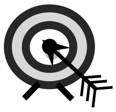
Materials	Is it hard?	Is it dense?	Is it strong?	Does it conduct electricity?
Rubber band	No	No	Yes	No
Metal file	Yes	Yes	Yes	Yes
Glass rod	Yes	Yes	No	No
Writing pad	No	No	No	No
Plastic cup	Yes	No	No	No
5 Toea coin	Yes	Yes	Yes	Yes

Part B

A	**Y**	**O**	**L**	**L**	**A**	**F**	**I**	**B**	**R**	**E**	**S**
N	**T**	**R**	**A**	**N**	**S**	**P**	**A**	**R**	**E**	**N**	**T**
T	**N**	**I**	**O**	**P**	**G**	**N**	**I**	**T**	**L**	**E**	**M**
B	**O**	**I**	**L**	**I**	**N**	**G**	**P**	**O**	**I**	**N**	**T**
R	**P**	**N**	**D**	**E**	**N**	**S**	**I**	**T**	**Y**	**N**	E
I	**A**	**S**	**C**	**E**	**L**	**I**	**T**	**C**	**U**	**D**	A
T	**Q**	**U**	**I**	**H**	**T**	**G**	**N**	**E**	**R**	**T**	**S**
T	**U**	**L**	**T**	S	**Z**	**L**	A	**A**	S	A	**L**
L	**E**	**A**	**S**	**D**	**I**	**A**	**H**	N	J	C	**A**
E	**R**	**T**	**A**	**A**	**N**	**S**	**C**	**L**	**A**	**Y**	**T**
T	**A**	**O**	**L**	**E**	**C**	**S**	**T**	**E**	**E**	**L**	**E**
E	**J**	**R**	**E**	**L**	**B**	**A**	**E**	**L**	**L**	**A**	**M**

Lesson 8: Physical Changes

Welcome to lesson 8 of strand 3. In the last lesson you learnt about the physical properties of materials and their differences and similarities. In this lesson you will learn about physical changes.



Your Aims:

- describe the physical changes of matter
- identify and explain the different physical changes
- give examples of simple physical methods and explain each

What Is A Physical Change?

Physical changes occur when objects undergo a change that does not change their chemical nature or properties. This change involves a change in physical properties. and does not produce a new substance. Changes in state or phase (melting, freezing, vaporization, condensation, sublimation) are physical changes.

An example of a physical change occurs when making a baseball bat. Wood is carefully crafted into a shape which will allow a batter to best apply force on the ball. Even though the wood has changed shape and therefore physical properties, the chemical nature of the wood has not been changed. The bat and the original piece of wood are still the same chemical substance.
Other examples of physical changes include crushing a can, melting an ice cube, breaking a bottle, sharpening pencil and grass knife, chopping of wood, tearing up a piece of paper or cloth and the erosion of soil after heavy rain.

Melting of ice cube

Broken bottle

Crushed cans

Baseball bat

Examples of physical change

The different physical changes

It is important to understand physical changes. Physical changes are about energy and states of matter. When you step on a can and crushed it, you have forced a physical change. The shape of the object has changed. It wasn't a change in the state of matter, but something changed. When you melt an ice cube you have also forced a physical change (adding energy). That example caused a change in the state of matter. You can cause physical changes with forces like motion, temperature, and pressure.

When you sharpen your bush knife, you have made a physical change. You have changed some metal into powder but you have not made any new substance.

Physical changes include changes of state, dissolving and separating mixtures. When matter changes state, a physical change takes place.

1. Changes of state

Water is a good example of a substance that can change state easily. When water is cooled, it can change to ice. This is known as **freezing** or **solidification**.

When water is heated, it can change state into a colourless gas called **steam or vapour**. This is known as **boiling**. Steam and ice are different forms of water and no new substances have been formed. Although ice and water look different, they both are made of the same water molecules and have the same formula, H_2O.

When steam or water vapour is cooled, it can change into liquid water. This change is called **condensation.** When ice is heated, it will change into liquid water. Again, no new substances are formed.

Heat must be added or removed from a substance for a change of state to take place. Heat is added to bring about melting and evaporation. Heat is removed to bring about condensation or freezing.



Freezing



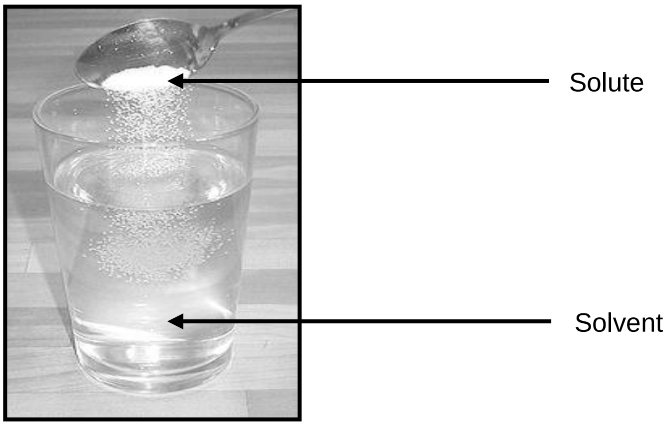
Melting Boiling Condensation

Changes of state

2. Dissolving

When we put substances such as salt and sugar into water, they dissolve and disappear. When salt dissolves in water, the large crystals of salt break up into particles. You cannot see the salt particles but you know they are there because you can taste them.

The substance that dissolves is called the **solute** and the substance that does the dissolving is called the **solvent**. Dissolving is a physical change because no new substances are formed. The particles of the solute and solvent are simply mixed together.

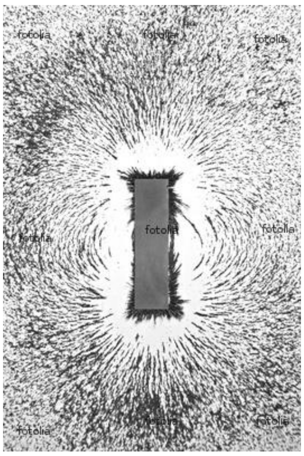


3. Mixtures

When two substances are mixed together, the particles of the two substances do not change. If we put some yellow sulphur and grey iron filings together, they mix with each other but the particles mixed together but do not join. This mixing is a physical change because no new substances are formed.

Iron nails and magnet

Horseshoe magnet and iron filings



Bar magnet and iron filings

Different mixtures

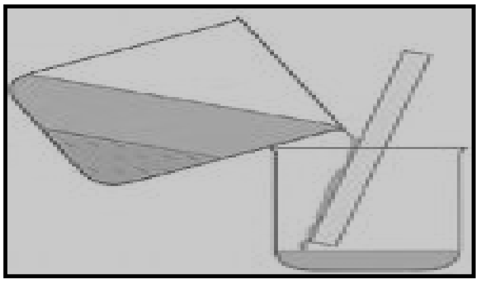
The simple physical methods

There are a lot of simple physical methods used in physical changes. Filtering, decanting, sieving, gravity separation, using separating funnel, evaporation, using magnet, and distillation are some of these.

Filtering

The process of separating a solid from a liquid, using a fine filter paper which does not allow the solid to pass through.

Decanting



The process of removing a liquid from a solid which has settled or from an immiscible heavier liquid (two liquids form two layers when mixed together) by pouring.

Sieving

The process of separating the smaller grains of substance from the bigger grains of substance by allowing it to pass through the holes of the sieve.

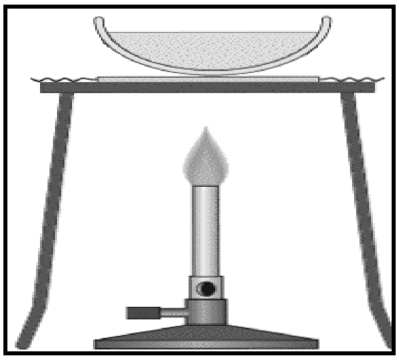
Gravity separation

Gold panning is a well-known example of gravity separation. It is the process where a stream of water is used to move the lighter particles of sand away from the heavier gold particles.

Separating funnel

If two liquids are immiscible, they can be separated with a separating funnel. For example, when a mixture of oil and water is poured into the funnel, the oil floats to the top. When the tap is opened, the water runs out. The tap is closed again when all the water has gone.

Evaporation

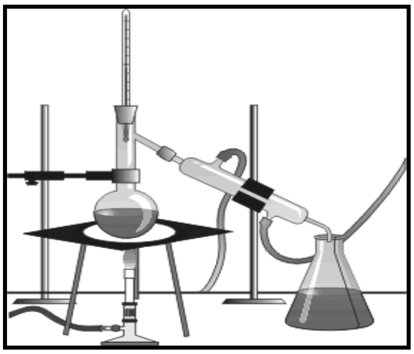


If the mixture is a solution, the solid cannot be separated by filtering because it is spread all through the solvent. Instead, the solution is heated so that the solvent evaporates, leaving the solid behind.

Magnet

The mixture of iron filings and sulphur is a good example of using a magnet. The iron can be separated from the sulphur when the iron filings are attracted to the magnet leaving the sulphur behind.

Distillation



When a solute dissolves in a solvent a mixture called a solution is formed. In the sea water, water is the solvent and the salts that are dissolved in it are the solutes. Heat energy is used to make the water evaporate leaving behind the salts. When the water vapour is cooled, it will change state again and produce distilled water, which is pure that does not contain any salt.

Activity: Now test yourself by doing this activity.

Physical changes science experiment

Physical changes can happen when two substances interact or when energy is applied to one or more of the substances. In this easy science projects we are going to see how substances change and when we are going to reverse the physical changes.

A salty work of art

In this experiment, we are going to have fun. This experiment can double up as an easy kids craft as you will be making a lovely painting.

You will be amazed at the beautiful painting you will end up with. This experiment needs a little more preparation, but is well worth the trouble.
What you need for this experiment:

- Heavy paper such as cardboard or mat board.
- Inexpensive watercolour sets, paintbrush included
- white glue (the kind you squeeze out)
- A lot of salt.
- Large pan or plastic tub for the salt
- Pencil
- Water
- Small containers for the water
- Plastic wrap and tape (optional)

How to do this experiment:

1. Provide a variety of recycled pieces of cardboard and mat board. The scraps are perfect because they come in all different shapes, sizes and colours.
2. Draw a simple design on the paper. If you want to make a pattern of swirls or geometric designs, that will work! Large designs are best.
3. Pour salt into a pan. Make sure there is enough salt for it to be "scoopable".
4. Hold your artwork over the tub and pour the salt over it with the cup. Hold the artwork flat for most of this step so the glue doesn't run too much.
5. When the glue is covered with salt, tilt the artwork to let any excess salt run back into the pan.
6. Get plenty of water on the paintbrush and then drip some water on the watercolours so they will be wet.
7. Choose a colour and then gently touch the paintbrush to the area of the painting you are starting with. It also works fine to let the colour drip onto the salty glue. The salt will absorb the water and make the colour spread. Clean the paintbrush in the container of water before changing colours.
8. Let the artwork dry for a couple of hours. Heavier glue will need to dry even longer. The glue can flake off after time, so wrap the front of the project with clear plastic wrap and tape it to the back to protect the design and help it last longer.

The rock candy experiment

In this easy experiment, we are going to do more or less the same experiment with a sugar solution.

What you need for this experiment:

- a small heatproof container such as beaker
- ½ cup of hot water
- A piece of string long enough to hang to the bottom of the beaker
- 1 cup of sugar
- A pencil

How to do this experiment:

1. Dissolve the sugar in the water in your beaker
2. Once again observe the physical change
3. Tie the string around your pencil and place the pencil over the top of the beaker so the string dangles in the water.
4. Leave your beaker in a hot dry place for a few days and observe what happens.
5. Sugar crystals start forming on the string, a physical change again.
6. There you have your rock candy!

Summary

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

- a physical change involves a change in physical properties and does not produce a new substance.
- physical changes include changes of state, dissolving and separating mixtures.
- changes in state or phase (melting, freezing, vaporization, condensation, sublimation) are all physical changes.
- melting is a physical process that results in the phase change of a substance from a solid to a liquid.
- evaporation occurs when a liquid changes its state to form a gas or vapour. Most of the evaporation that occurs on earth is the change from the liquid state of water to a water vapour.
- in physical science, freezing or solidification is the process in which a liquid turns into a solid when cold enough. The freezing point is the temperature at which this happens.
- condensation is the physical process by which a vapour becomes a liquid or solid; the opposite to evaporation.
- simple physical methods such as filtering, decanting, sieving, centrifuge, separating funnel, evaporation, magnet and distillation are used in physical changes.

NOW DO PRACTICE EXERCISE 8 ON THE NEXT PAGE.

Practice Exercise 8

Answer the following questions:

1. Describe a physical change.

2. Give 4 examples of physical changes and explain each.

   a)

   b)

   c)

   d)

3. State 7 simple physical methods used in physical changes and describe each.

   a)

   b)

   c)

   d)

   e)

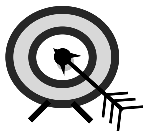
   f)

   g)

CHECK YOUR WORK. ANSWERS ARE AT THE END OF SUB STRAND 2.

Lesson 9: Chemical Changes

Welcome to lesson 9 of Strand 3. In the last lesson you learnt about the physical changes of matter. It is important to understand physical changes. Physical changes occur when objects undergo a change that does not change their chemical nature. A physical change involves a change in physical properties. A physical change does not produce a new substance but is about energy and states of matter. Physical changes include changes of state, dissolving and separating mixtures. When matter changes state, a physical change takes place. Heat must be added or removed from a substance for a change of state to take place. Heat is added to bring about melting and evaporation. Heat is removed to bring about condensation or freezing. There are a lot of simple physical methods used in physical changes. Filtering, decanting, sieving, centrifuge, using separating funnel, evaporation, using magnet, and distillation are some of these In this lesson you will learn about the chemical changes of matter.



Your Aims:

- describe the chemical changes of matter
- give examples of chemical changes and explain each
- compare and contrast physical change from chemical change

What Is A Chemical Change?

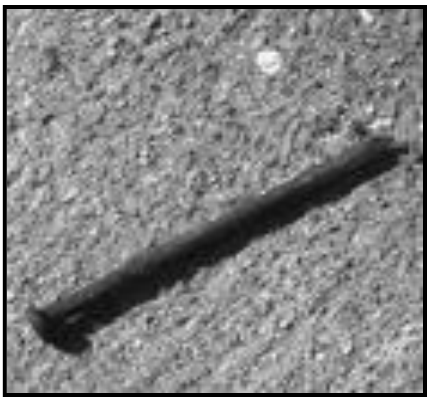
When matter changes and new substances are formed a chemical change has taken place. A chemical change produces a new substance. Examples of chemical changes include combustion (burning), cooking an egg, rusting of an iron pan, and mixing hydrochloric acid and sodium hydroxide to make salt and water.
A chemical change makes a substance that wasn't there before. There may be clues that a chemical reaction took place, such as light, heat, colour change, gas production, odour, or sound. Just like when we light a fire the wood burns to give heat, smoke and ash. When we cook our food the colour and taste is changed so that we can eat it. When living things die they will start to rot or decompose and we can smell the changes that are taking place. Chemical changes are taking place all around us and even inside us. When plants grow or animals digest food, chemical changes take place.

Firewood burning

These pipes are in the middle of chemical changes as they rust.

Examples of chemical changes

Chemical changes can be slow, such as an iron roof or a car body rusting. Or they can be fast, such as burning fuel in an engine or rocket. Burning is always a chemical change and is usually fast.

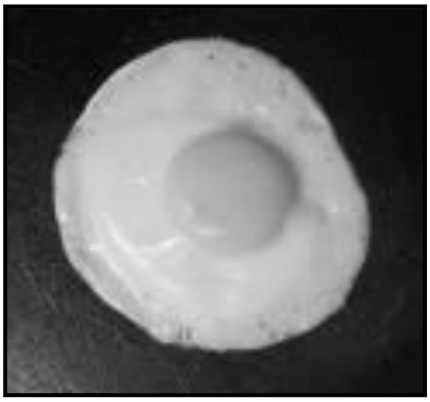

Rusting of nail


Rusting of car


Burning fuel in rocket


Heat, light and sound produced in firecrackers

Many chemical changes are useful. For example, the food that you eat is changed in your body. The chemical changes make new substances to help your body grow and give you energy.


Frying egg is a chemical change


Food makes your body grow

Other chemical changes are not useful. For example, if you keep food too long, chemical changes take place, spoiling the food. When you chew betel nut with lime, it can lead to cancer of the mouth, which is harmful.

Spoiled fruits

Spoiled vegetables

Spoiled cooking banana

Betel nut and lime causes cancer in the mouth

What are the differences between Physical and Chemical Changes?

This is a good question! One would think that a change is a change so why would there be a distinction between a physical change and a chemical change? Well, there is a big difference! If you change something physically you still have what you started with. For example, if you tear a piece of paper you still have paper. If you change something chemically you end up with something very different than what you started with. For example if you burn a piece of paper you end up with carbon and no more paper.

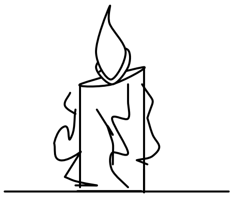
But, these are obvious examples. Is it always that simple? What if you put sugar into water? Is that a physical or a chemical change? How about if you freeze water? Is that physical or chemical? For these examples we have to examine what it would take to get the original substances back after we have made the change. With the sugar and the water we could evaporate the water and find that the sugar is left and there is no change, except in how it looks. It is still sweet and it can be remixed in water. The frozen water can be melted and we have the same water we started with. If we take that same sugar and water and mix it with flour and eggs and vanilla and chocolate chips and cook it we will have performed a chemical change making cookies. No matter what you do to the cookies you will never get the sugar and the water out of them as before.

So, in summary, there are really only two criteria for whether a change is chemical or physical: 1) After the change does it look the same and 2) can you change it back? If the answer is yes, the change is physical every time. If the answer is no, the change is chemical every time.

Activity: Now test yourself by doing this activity.

Here's what you're going to do. In letter (a) you have to write physical change or chemical change to describe each change and in letter (b) you have to give a reason for your answer. The answers are given on the next page.

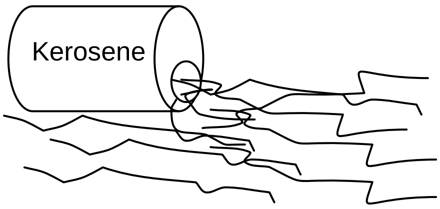
1. Some candle wax burns away.



a) ______________________

b) ______________________

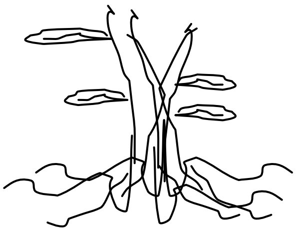
2. You can smell kerosene as it changes to gas.



a) ______________________

b) ______________________

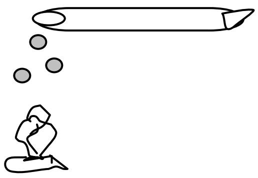
3. A plant makes new leaves and grows.



a) ______________________

b) ______________________

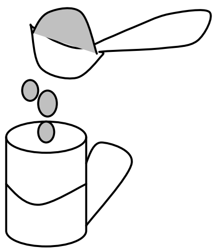
4. Candle wax melts when it is heated.



a) ______________________

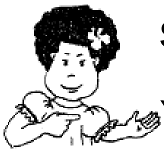
b) ______________________

5. Putting coffee into hot water



a) ______________________

b) ______________________



Summary

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

- a chemical change has taken place when matter changes and new substances are formed.
- a chemical change makes a substance that wasn't there before. There may be clues that a chemical reaction took place, such as light, heat, colour change, gas production, odour, or sound.
- chemical changes can be slow such as an iron nail rusting or they can be fast such as burning fuel in an engine.
- many chemical changes are useful such as the food that you eat that make new substances to help your body grow and give you energy.
- other chemical changes are not useful. Examples are spoiling the food and chewing betel nut with lime that can lead to cancer of the mouth.
- the change is physical, if after the change it still looks the same and you can change it back.
- the change is chemical, if after the change the looks are different and you cannot change it.

NOW DO PRACTICE EXERCISE 9 ON THE NEXT PAGE.

Practice Exercise 9

Answers the following questions:

1. Describe a chemical change.

2. Give 3 examples of chemical changes and explain each.

   a)

   b)

   c)

3. What is the difference between a physical change and a chemical change?

4. Classify the following changes as physical or chemical.

   a) ice cream melting ____________

   b) an apple rotting ____________

   c) milk going sour ____________

   d) lamp filament glowing ____________

   e) an egg frying ____________

CHECK YOUR WORK. ANSWERS ARE AT THE END OF SUB STRAND 2.

Answers to Activity

1. Some candle wax burns away.

   a) Chemical change

   b) New chemical substance was formed

2. You can smell kerosene as it changes to gas.

   a) Physical change

   b) No new chemical substance was formed

3. A plant makes new leaves and grows.

   a) Chemical change

   b) New chemical substance was formed

4. Candle wax melts when it is heated.

   a) Physical change

   b) No new chemical substance was formed

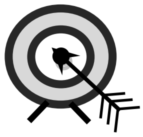
5. Putting coffee into hot water

   a) Physical change

   b) No new chemical substance was formed

Lesson 10: Simple word equation

Welcome to lesson 10 of strand 3. In the last lesson you learnt about chemical changes.



Your Aims:

- discuss chemical reactions, elements and compounds
- describe the signs of a chemical reaction
- write an observation of a given chemical reaction
- give examples of chemical reactions and explain each
- identify the symbols and formulae of some common elements
- write the formulae of some common compounds

What Is A Chemical Reaction?

Changes occur around us all the time. For example, bread goes mouldy, nails rust, milk goes sour, seeds sprout, water evaporates and so on. **Chemical reactions** take place during a chemical change.

The original substances that are used up in chemical reaction are called **reactants**. The new substances that are formed in a chemical change are called the **products**. The new substances usually look different from the original substances and have different properties.

Signs of a chemical reaction

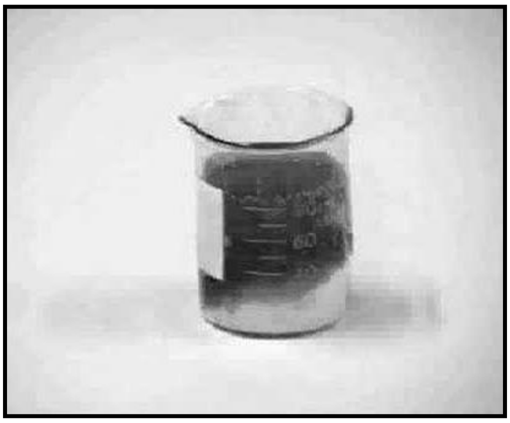
We know that chemical reactions produce new substances with new properties. It is easy to tell if a reaction has occurred, but difficult to tell at times. Some reactions occur very quickly while others are very slow. A chemical reaction occurs if one or more of the following takes place.

1. There is a permanent colour change.
2. Heat, light and sound may be produced.
3. A gas is released producing bubbles and or fizzing.
4. The temperature of the substance changes (rises or falls).
5. An insoluble solids forms (called a precipitate). The precipitate usually settles on the bottom of any container.

Examples of chemical reactions

Burning is a chemical reaction. In a bush fire, bushes and trees are burnt, producing smoke and invisible gases, and leaving ash (carbon). The smoke, gases and ash are new substances – completely different from those in the original bushes and trees. The reaction also produces heat and light.

Bush



Sugar and sulphuric acid

Sugar and concentrated sulphuric acid when added together releases a violent chemical reaction. Sugar is a white crystalline solid which we used to sweeten our food while sulphuric acid is a thick, colourless liquid that is very corrosive and will burn our skin or clothes. The products produced in this reaction which are steam, a colourless gas and carbon (a black powder) are all new substances and very different from those in the original sugar and sulphuric acid. The reaction also gives off a lot of energy.

Rusty iron

The rusting of iron is another chemical reaction which cannot be reversed. It produces a new brown substance with properties different from the original shiny iron.

Magnesium burning

Many chemical reactions give off light and heat. For example, magnesium is used in the flashlights of cameras. The bright flash you see when a picture is taken is the burning of a small amount of magnesium inside the flash bulb. Another example is that if you hold magnesium in a flame, it burns with a bright, white light and gives off a lot of energy. Magnesium metal changes to a white powder.

Couple cooking

When we cook food, the heat energy causes chemical reactions to take place in the food and the raw substances change to new substances. Chemical changes take place as energy is taken in. When wood burns, a chemical reaction takes place. The wood that we used for burning contains a lot of stored energy from the Sun. New substances such as smoke and ash are formed and a lot of heat and light energy is given out.

Iron filings and sulphur

When a mixture of iron filings and sulphur is heated, it glows red. The yellow sulphur colour disappears and replaced by a black solid. The substance is no longer a mixture of the elements sulphur and iron and a magnet cannot be used to separate the iron filings from the solid. A chemical reaction has taken place to form a new substance called iron sulphide

Couple cooking

Elements make compounds

Chemical elements are the simplest kind of matter and made up of only one kind of particle or atom. There are over 100 elements. When two or more different elements join together, a **compound** is formed.

Compounds are made up of two or more different kinds of atoms joined together. The smallest unit of a compound is called a molecule. A **molecule** is a larger particle formed by the chemical combination of two or more atoms.

When a compound is formed, the elements in it are rearranged and cannot be separated again. The compound is a completely different substance to the elements formed it. The name of a compound tells you which elements have been joined together to make it. Take the elements sodium and chlorine, these two elements combine to form the compound we call sodium chloride (NaCl).

+

→

Sodium atom (Element) + Chlorine atom (Element) → Sodium chloride (Compound)

Symbols and formulae of common elements

Sodium is made of sodium atoms only; so it is an element. We say that an element is a substance that is made of only one kind of atom. Carbon and mercury are also elements. Altogether, 105 different elements are known. Of these, 90 have been obtained from the Earth's crust and atmosphere, and 15 have been artificially made by scientists.

Every element has a name and a symbol. Here are some of them.

Element	**Symbol**
Aluminium	Al
Copper	Cu
Iron	Fe
Lead	Pb
Magnesium	Mg
Mercury	Hg
Potassium	K
Silver	Ag
Sodium	Na

Element	**Symbol**
Bromine	Br
Carbon	C
Chlorine	Cl
Hydrogen	H
Nitrogen	N
Oxygen	O
Phosphorus	P
Sulphur	S
Silicon	Si

It is easy to remember that the symbol for aluminium, Al and for carbon is C. But some symbols are harder to remember, because they are taken from Latin names for othe elements. For example, potassium has the symbol K, from its Latin name Kalium. Sodium has the symbol Na, from its Latin name Natrium. Iron has the symbol Fe, from its Latin name Ferrum. Copper has the symbol Cu, from its Latin name Cuprum. Silver has the symbol Ag, from its Latin name Argentum.

The formula of most elements is represented simply by the symbol. This system applies to all the metals and the noble gases helium, neon and argon. However, some gases consist of atoms joined up in pairs as **molecules**. The formula of the element is written as the symbol followed by a small 'number' which is written lower than the other symbols. Examples of these are given below.

Element	**Symbol**	**Formula**
Bromine	Br	Br_2
Chlorine	Cl	Cl_2
Hydrogen	H	H_2
Nitrogen	N	N_2
Oxygen	O	O_2
Phosphorus	P	P_4
Sulphur	S	S_8

Formulae of some common compounds

The formula for all compounds is the combination of two or more element symbols. For example, the formula for water is H_2O. In each water molecule there are two atoms of hydrogen joined to one oxygen atom. To read such a formula aloud we say 'H, two, O'. The two capital letters show that there are two elements in the compound, H and O. The '2' after the hydrogen shows that there are two hydrogen atoms for every one oxygen atom in a water molecule.

The chemical name for table salt is Sodium chloride. Its formula is NaCl. This shows salt molecules consist of one sodium atom for every one chlorine atom. To read such a formula aloud we say the letters in order 'N, a, C, l".

The sugar in our bodies that we need for energy is called glucose. The formula for glucose is $C_6H_{12}O_6$. To read it aloud we say 'C, six, H, twelve, O, six'. The formula shows that there are 6 atoms of carbon, 12 atoms of hydrogen and 6 atoms of oxygen in each molecule of glucose.

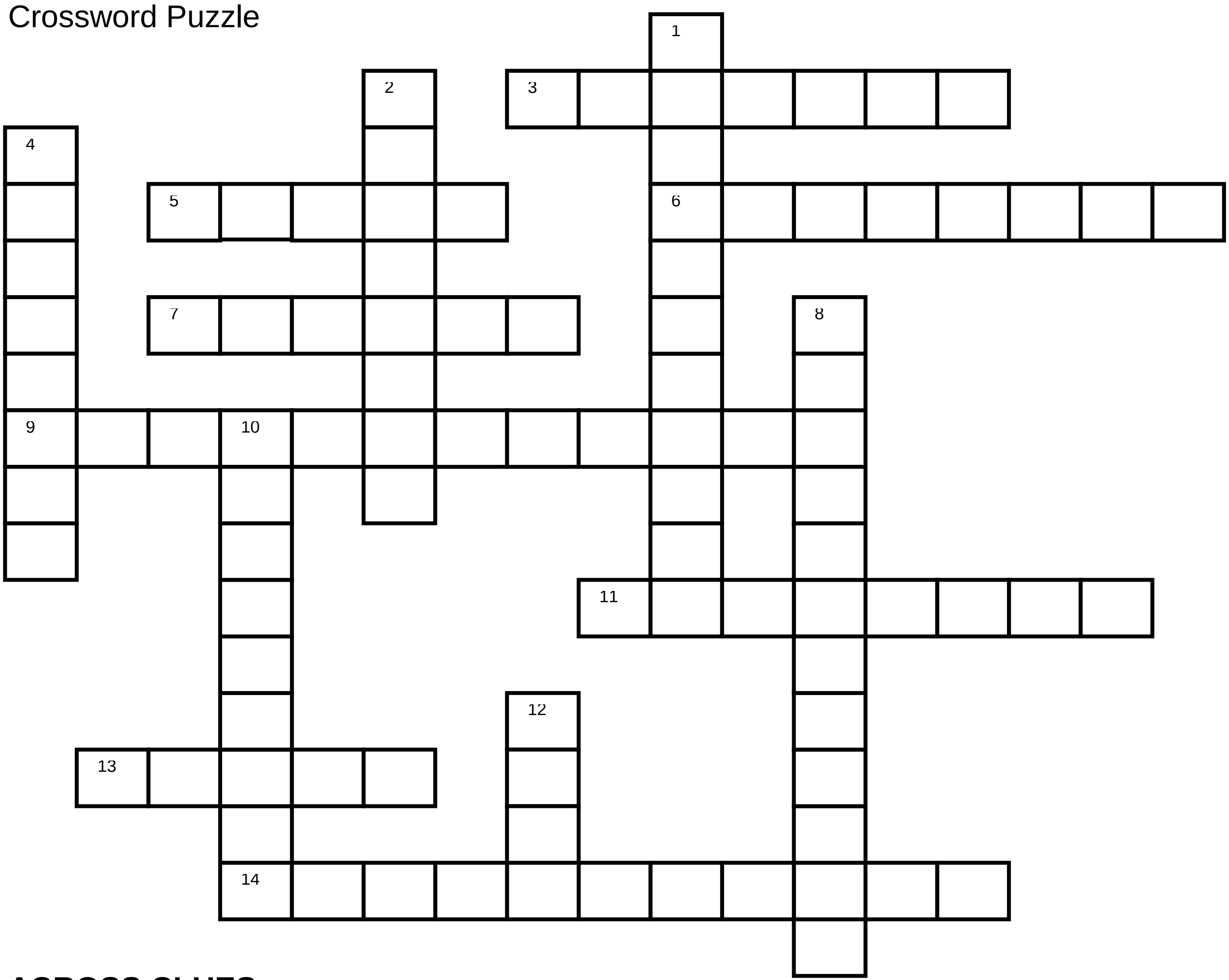
There is only one correct way to spell a word. In a similar way, each element and compound has a definite composition which is represented by one formula only.
The table below shows formulae of some common compounds.

Compound	Formula	Compound	Formula
Water	H_2O	Sodium chloride	NaCl
Carbon dioxide	CO_2	Sodium hydroxide	NaOH
Methane	CH_4	Silver chloride	AgCl
Glucose	$C_6H_{12}O_6$	Magnesium oxide	MgO
Calcium carbonate	$CaCO_3$	Sulphuric acid	H_2SO_4
Calcium oxide (lime)	CaO	Hydrochloric acid	HCl
Silica (sand)	SiO_2	Iron sulphide	FeS

Activity 1: Now test yourself by doing this activity.

For this activity, you are going to write the word that is being described in the puzzle by following the clues.

Crossword Puzzle

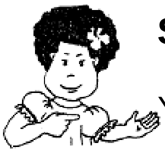


ACROSS CLUES

3 a chemical change that produces heat
5 what you need if you spill acid
6 this type of change cannot be reversed
7 baking soda does this when you add vinegar
9 opposite of ‘dilute’
11 a chemical change is also called a __________
13 liquids which can burn your skin
14 produced by the reaction in a torch battery

DOWN CLUES

1 insoluble solid formed when two liquids are mixed
2 example of physical change
4 this type of change can be reversed
8 type of acid
10 able to burn your skin
12 some reactions produce this



Summary

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

- when chemical changes take place, there has been a chemical reaction.
- the original substances used up in chemical reaction are called reactants. The new substances that are formed in a chemical change are called the products.
- some chemical reactions produce fizzing in the mixture just like baking soda and vinegar
- burning is a chemical reaction because the smoke, gases and the ash are completely new substances produced from the original materials. This reaction also produces heat and light.
- some chemical reactions produce a violent reaction such as concentrated sulphuric acid and sugar, which also gives off a lot of energy.
- elements are the simplest kind of matter and made up of only one kind of particle or atom.
- compounds are made up of two or more different kinds of atoms joined together.
- a molecule is a larger particle formed chemically by the combination of two or more atoms.
- altogether, 105 different elements are known. Of these, 90 have been obtained from the Earth's crust and atmosphere, and 15 have been artificially made by scientists.

REMEMBER
Elements are the simplest kind of matter and made up of only one kind of atom. Compounds are made up of two or more different elements joined together.

NOW DO PRACTICE EXERCISE 10 ON THE NEXT PAGE.

Practice Exercise 10

Answer the following questions:

1. Which of the following changes can be reversed (changed back)?

   a) Bread going mouldy
   b) Burning a piece of wood
   c) Adding vinegar to baking soda
   d) Heating a piece of iron until white hot

2. Which one of the following is a chemical change?

   a) Melting a block of ice
   b) Burning magnesium ribbon
   c) Air expanded when heated
   d) Magnetising a piece of ribbon

3. Ruth carried out an experiment and the results were given below.
   For each one, state a reason how she knew there was a chemical reaction.
   Choose from these reasons:

Gas produced	Permanent colour change
Precipitate formed	Heat produced

   a) Ruth mixed two clear solutions and a white solid settled to the bottom of the tube.

   ____

   b) After a while the test tube felt warm.

   ____

   c) When she added water the mixture fizzed.

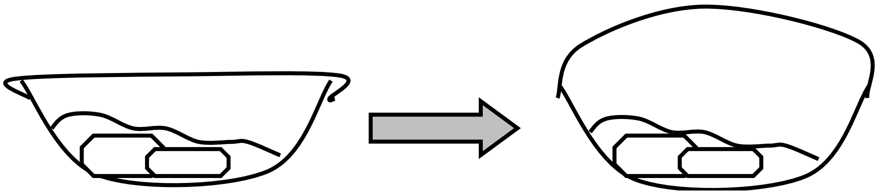
   ____

   d) When she added the acid, the mixture turned red.

   ____

4. Some food was left in a closed plastic container on the kitchen table. After two weeks, the lid started to bulge as shown. Give a reason why the container bulged.

____



BEFORE AFTER

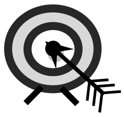
CHECK YOUR WORK. ANSWERS ARE AT THE END OF SUB STRAND 2.

Answer to Activity

									1 P							
					2 F		3 B	U	R	N	I	N	G			
4 P					R				E							
H		5 W	A	T	E	R			6 C	H	E	M	I	C	A	L
Y					E				I							
S		7 F	I	Z	Z	E	S		P		8 H					
I					I				I		Y					
9 C	O	N	10 C	E	N	T	R	A	T	E	D					
A			O		G				A		R					
L			R						T		O					
			R					11 R	E	A	C	T	I	O	N	
			O								H					
			S				12 H				L					
	13 A	C	I	D	S		E				O					
			V				A				R					
			14 E	L	E	C	T	R	I	C	I	T	Y			
											C					

Lesson 11: Chemical Equation

Welcome to lesson 11 of strand 3. In the last lesson you learnt about chemical reactions. This included common elements and common compounds and their different symbols and formula. In this lesson you will learn about chemical equations. The knowledge from your previous lessons will help you better understand word and chemical equations.



Your Aims:

- define chemical equation
- explain a simple word equation
- differentiate reactants from products

What Is A Chemical Equation?

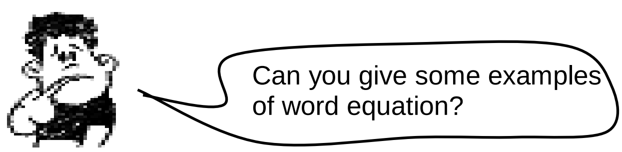
A chemical change can be represented and described by an equation. It can be written down as in a word equation or a chemical equation. An equation shows that the chemical particles before the change are equal to the chemical particles after the change. **Word equation** is an easy way to describe a reaction and a shorthand way of describing what happens in a chemical reaction. The word equation can be written once you know the names of the chemicals at the start of the reaction, and the final chemicals. The representation of a chemical reaction in the form of symbols and formulae is called **chemical equation**.

Reactants and products

You can divide the substances in any chemical reaction into two groups – **reactants** and **products**. The reactants are the substances you start with and which react with each other. The products are the new substances produced in the reaction. For example, vinegar reacted with baking soda to produce bubbles of gas that caused fizzing. So in this case the vinegar and baking soda are the reactants, and the gas (called carbon dioxide) is the product. Instead of saying baking soda reacts with vinegar to produce Carbon dioxide, you write it as word equation like:

Baking soda + vinegar ⟶ Carbon dioxide

The reactants are on the left-hand side of the equation, and the product is on the right-hand side. Sometimes there is only one reactant and sometimes there are two or more. The same goes for the products. The reactants and products can be solids, liquids or gases. Sometimes it is hard to know exactly what the reactants and products are. For example, when wood burns it reacts with oxygen (an invisible gas present in the air), and produces another invisible gas- carbon dioxide.



Here are some examples of word equation:

1. When zinc is added to copper sulphate solution, copper is formed. We say zinc and copper sulphate gives copper and zinc sulphate.

   A word equation is written with an arrow, $\longrightarrow$. The arrow means ‘gives’ or ‘changes to’. A plus sign, +, is used to mean ‘and’ or ‘added to’.

   For the above reaction, we write this equation:

   zinc + copper sulphate $\longrightarrow$ copper + zinc sulphate

2. Calcium hydroxide and copper sulphate gives calcium hydroxide and copper hydroxide.

   We can write the equation like this:

   calcium hydroxide + copper sulphate $\longrightarrow$ calcium sulphate + copper

In some reactions, the groups of chemicals that are formed may have special names. For example, water is a compound that contains hydrogen and oxygen. Water could be called ‘hydrogen hydroxide’in this reaction.

3. If hydrogen is burnt in oxygen, the equation for the reaction is this:

   hydrogen + oxygen $\longrightarrow$ water

However, in some reactions the groups of chemicals in a group can be broken. This is shown in the next example.

4. When calcium carbonate is heated, the carbonate group of chemicals splits up. Carbon dioxide and calcium are formed.

   We write:

   calcium carbonate $\longrightarrow$ calcium oxide + carbon dioxide

REMEMBER
Word equation a shorthand way of describing what happens in a chemical reaction.

Let us consider the reaction which takes place when iron is heated with sulphur. In this chemical reaction, the compound formed is Iron sulphide. This reaction can be represented in word as follows:

iron + sulphur $\longrightarrow$ iron sulphide

In the above reaction, the iron and sulphur are taking part in the chemical reaction.
Iron sulphide is formed (the product) due to the chemical reaction between (the reactants) iron and sulphur.
The above chemical reaction can be written in the form of symbols and formulae as follows:

$$Fe + S \longrightarrow FeS$$

The representation of a chemical reaction in the form of symbols and formulae is called chemical equation.

Another example of chemical equation is the reaction between sodium and oxygen. This can be represented in word equation as:

sodium + oxygen $\longrightarrow$ sodium oxide

The above chemical reaction can be written in the form of symbols and formulae as follows:

$$4Na + O_2 \longrightarrow 2Na_2O.$$

Below are the steps in writing a chemical equation.

Steps in writing a chemical equation

1. The reactants and products are written down as a word equation.
2. The formula for each reactant and product is then written underneath each word.
3. An atom check is done by counting the number of atoms of each element on each side of the equation.
4. Balance the equation. In order to balance the equation, additional molecules/atoms of reactants or products must be added until the number of atoms of each side is equal.

Take a look at this example.

1. Aluminium and oxygen react to form aluminium oxide.

   Write the word equation

   aluminium + oxygen $\longrightarrow$ aluminium oxide

2. Write the symbols and formulae for the reaction

   $Al + O_2 \longrightarrow Al_2O_3$

3. Atom check

Balancing oxygen atoms, the equation can be written as:

$Al + 3O_2 \longrightarrow 2Al_2O_3$

Balancing aluminium atoms, the equation can be written as:

$4Al + 3O_2 \longrightarrow 2Al_2O_3$

4. Balance the equation

$4Al + 3O_2 \longrightarrow 2Al_2O_3$. This equation is balanced.

Or, using an atom check:

	Reactants	Products
Al:	4(4x1)	4 (2x2)
O:	6(3x2)	6 (2x3)

Activity 1: Now test yourself by doing this activity.

Directions: Represent the following reactions in the form of a chemical equation and balance it. You may start now!

1. Sodium combines with oxygen to form sodium oxide.

a) Write the word equation

____

b) Write the symbols and formulae

____

c) Atom check

____

____

d) Balance the equation

____

2. Hydrogen combines with chlorine to form Hydrogen chloride.

a) Write the word equation

____

b) Write the symbols and formulae

____

c) Atom check

____

____

d) Balance the equation

REMEMBER
Chemical equation is the representation of a chemical reaction in the form of symbols and formulae.

Summary

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

- chemical reactions are represented by writing a chemical sentence, which is called a chemical equation. It is a way of representing what happens during a reaction using chemical formulae in place of words.

- there are four steps in writing a chemical equation:
  1. The reactants and products are written down as word equation.
  2. The formula for each reactant and product is written
  3. An atom check is done by counting the number of atoms in each element on each side of the equation.
  4. Balance the equation by adding molecules or atoms in the reactants or products.

NOW DO PRACTICE EXERCISE 11 ON THE NEXT PAGE.

Practice Exercise 11

Answer the following questions:

1. Aluminium burns in chlorine to form aluminium chloride, $AlCl_3$.
   Write a word equation and balanced chemical equation for the reaction.

   Word equation:

   Chemical equation:

   Balanced equation:

2. When hydrochloric acid is added to calcium carbonate, calcium chloride, water and carbon dioxide are produced. This reaction is used in the laboratory to make carbon dioxide gas.

   a) What are the names of the reactants?

   b) What are the names of the products?

   c) Write a word equation for this reaction.

   d) Write a chemical equation and balance it.

3. Some rescue flares contain aluminium powder. It reacts with oxygen in the air to form aluminium oxide, Al_2O_3, a white solid.

   a) Write a word equation for the reaction.

   b) Write a chemical equation and balance it.

CHECK YOUR WORK. ANSWERS ARE AT THE END OF SUB STRAND 2.

Answers to Activity

1. a) sodium + oxygen $\longrightarrow$ sodium oxide

   b) $Na + O_2 \longrightarrow Na_2O$

   c) Atom check

   Balancing oxygen atoms, the equation can be written as:

   $Na + O_2 \longrightarrow 2Na_2O$

   Balancing sodium atoms, the equation can be written as:

   $4Na + O_2 \longrightarrow 2Na_2O$

   d) Balance the equation

   $4Na + O_2 \longrightarrow 2Na_2O$ is the balanced equation.

2. a) hydrogen + chlorine $\longrightarrow$ hydrogen chloride

   b) $H_2 + Cl_2 \longrightarrow HCl$

   c) Atom check

   Balancing chlorine atoms, the equation can be written as:

   $H_2 + Cl_2 \longrightarrow 2HCl$

   Balancing hydrogen atoms, the equation can be written as:

   $H_2 + Cl_2 \longrightarrow 2HCl$

   d) Balance the equation

   $H_2 + Cl_2 \longrightarrow 2HCl$ is the balanced equation.

REVIEW OF SUB STRAND 2: PROPERTIES OF MATTER

Revise all the Lessons in this Sub Strand and then do **ASSIGNMENT 4.**
Here are the main points to help you revise.

Lesson 7: Physical Properties of Materials

- Physical properties mean the special features or characteristics of a substance.
- Strength is the property of a substance that allows it to retain its shape when twisted, pulled or crushed.
- A solid is malleable if it is flexible and will bend without breaking.
- A solid is called ductile if it can be stretched and drawn into wires.
- Solids which crumble and break apart if you try to bend them is said to be brittle.
- Conductors are materials which allow heat and electricity to flow through them.
- Insulators are materials which do not allow heat and electricity to flow through them.
- Elastic materials are those which can be stretched and will return to their original shape when released.
- Density is the “heaviness” of the material.
- Opaque does not allow light to pass through it.
- Transparent lets light through or “see-through” it.
- Hardness is the property of a substance that allows it to resist scratching.
- Alloys are metal with special properties and are produced when different metals are mixed together.

Lesson 8: Physical Changes

- A physical change involves a change in physical properties and does not produce a new substance.
- Changes in state (melting, freezing, vaporization, condensation, sublimation) are all physical changes.
- Melting is a physical process that results in the phase change of a substance from a solid to a liquid.
- Evaporation occurs when a liquid changes its state to form a gas or vapour.
- Freezing or solidification is the process in which a liquid turns into a solid when cold enough.
- Condensation is the physical process by which a vapour becomes a liquid.

Lesson 9: Chemical Changes

- A chemical change has taken place when matter changes and new substances are formed.
- In a chemical change a chemical reaction took place, such as light, heat, colour change, gas production, odour, or sound.
- Chemical changes can be slow or they can be fast.
- Many chemical changes are useful such as the food that gives you energy.
- Other chemical changes are not useful such as food spoiling.
- The change is physical, if after the change it still looks the same and you can change it back.
- The change is chemical, if after the change the looks are different and you cannot change it.

Lesson 10: Chemical Reactions

- When chemical changes take place, we say there has been a chemical reaction.
- The original substances that are used up in chemical reaction are called reactants. The new substances that are formed are called the products.
- The new substances usually look different from the original substances and have different properties.
- Elements are the simplest kind of matter and made up of only one kind of atom.
- Compounds are made up of two or more different kinds of atoms joined together.
- A molecule is a larger particle formed by the chemical combination of two or more atoms.

Lesson 11: Chemical Equations

- Chemical equation is a way of representing what happens during a reaction using chemical formulae in place of words.
- There are four steps in writing a chemical equation:
  a. The reactants and products are written down as word equation.
  b. The formula for each reactant and product is written
  c. An atom check is done by counting the number of atoms in each element on each side of the equation.
  d. Balance the equation by adding molecules or atoms in the reactants or products.

REVISE WELL AND THEN DO SUB STRAND TEST 2 IN YOUR ASSIGNMENT 4.

Answers to Practice Exercises 7- 11

Practice Exercise 7

1. The physical properties of materials are the physical aspects or characteristics of a material and how it behaves.

2. a) Resists the effects of forces

   b) Hard but breaks easily

   c) The heaviness of the material

   d) Llight passes through but scatters it

   e) Can be hammered into shape

   f) Can be pulled out into wires

   g) Light is “see-through”

   h) Heat & electricity can pass through easily

   i) Stops heat & electricity to pass through

3. a) Can be rolled into thin sheets of tinfoil. Used for coating iron like tin plating in tin cans.

   b) Used as fishing sinkers. Also used to make waterproof joints to stop water getting into building.

   c) Does not corrode easily. Used to coat iron to form galvanised iron. Used to make dry cells for radios and torches.

   d) An excellent conductor of electricity and heat. Used for wiring household electrical appliances. Also used in water and gas piping

   e) Used as cooking pots, aeroplanes and louvre frames. Also used as a wrapper for foods, chocolates and other articles. Can be rolled into thin sheets used in ceiling to keep houses cool.

   f) the light it produced is useful in camera, flashbulbs, flares and fireworks.

Practice Exercise 8

1. When matter changes but no new substance is formed, it is called a physical change. For example, when you sharpen your pencil you have made a physical change. You have changed some of the wood and graphite into shavings and powder but you have not made any new substances.

2. a. When you sharpen your bush knife, you have made a physical change. You have changed some metal into powder but you have not made any new substance.

   b. When water is cooled, it can change to ice. This is a physical change because no new substances are formed. Although ice and water look different, they both are made of the same water molecules and have the same formula, H_2O.

   c. When sugar dissolves in the water, it is called a physical change. You cannot see the sugar but you know that it is there because you can taste it. Dissolving is a physical change because no new substances are formed.

   d. When two solids are mixed together the particles are not joined, they only mixed up. This mixing is a physical change because no new substances are formed.

3. a Filtering – separating a solid from a liquid using filter paper
   b. Decanting – removing liquid from solid which has settled by pouring
   c. Sieving – separating smaller substance from bigger substance using a sieve
   d. Gravity Separation – moving lighter from heavier particles using stream of water
   e. Separating Funnel – separating two immiscible liquid just like water and oil
   f. Evaporation – separating the solution by boiling leaving the solid behind
   g. Magnet- separating iron with other solids using a magnet

Practice Exercise 9

1. When matter changes and new substances are formed a chemical change has taken place. For example, when plants grow or animals digest food, chemical changes take place. Some chemical changes can be slow or they can be fast. Many chemical changes are useful and others are not.

2. a. When we light a fire, the wood burns to give heat, smoke and ash
   b. When we cook food, the colour and taste is changed so that we can eat it.
   c. When living things die, they will start to rot or decompose and we can smell the changes that are taking place.

3. A physical change occurs when matter changes in some way, without new substances being formed. Usually physical changes is easy to reverse and useful.
   A chemical change occurs whenever matter is changed in such a way that one or more new substances are formed. The new substances from a chemical change have different properties from the original ones.

4. a) physical change

   b) chemical change

   c) chemical change

   d) physical change

   e) chemical change

Practice Exercise 10

1. D

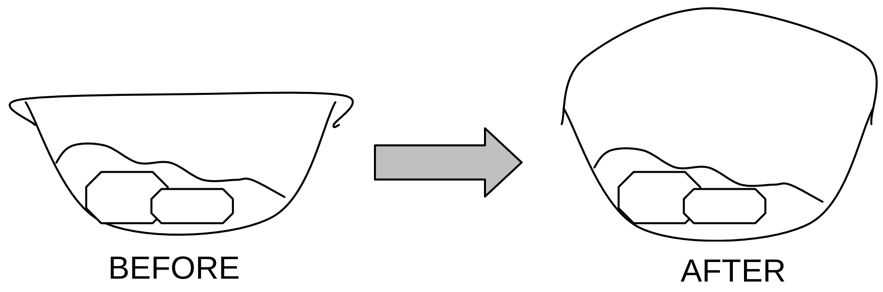
2. B

3. Ruth carried out an experiment and the results were given below.
For each one, state a reason how she knew there was a chemical reaction.
Choose from these reasons:

Gas produced	Permanent colour change
Precipitate formed	Heat produced

a) Precipitate formed
b) Heat produced
c) Gas produced
d) Colour changed

4. The food rotted. This was a chemical reaction which produced new substances. Some of these new substances were gases. It was these that caused the lid to bulge.



Practice Exercise 11

1. Word equation:

   Aluminium + Chlorine $\longrightarrow$ Aluminium chloride

   Chemical equation:

   $Al + Cl_2 \longrightarrow AlCl_3$

   Balanced equation:

   $2Al + 3Cl_2 \longrightarrow 2AlCl_3$

2. a) Calcium carbonate and hydrochloric acid

   b) Calcium chloride, water and carbon dioxide

   c) hydrochloric acid + calcium carbonate $\longrightarrow$ calcium chloride + water + carbon dioxide

   d) $2HCl + CaCO_3 \longrightarrow CaCl_2 + H_2O + CO_2$

3. a. Aluminium + Oxygen $\longrightarrow$ Aluminium oxide

   b. $4Al + 3O_2 \longrightarrow 2Al_2O_3$

SUB STRAND 3

FORMS OF ENERGY AND SIMPLE MACHINES

IN THIS SUB STRAND YOU WILL LEARN ABOUT:

- **DIFFERENT FORMS OF ENERGY**
- **USES OF ENERGY**
- **ENERGY CHANGES AND ITS MEASUREMENT**
- **DIFFERENT SIMPLE MACHINE**
- **USES OF SIMPLE MACHINE**

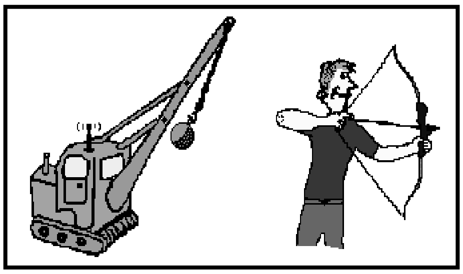
SUB STRAND 3: FORMS OF ENERGY AND SIMPLE MACHINES

Introduction

Energy makes change possible. We use it to do things for us. It moves cars along the road and boats over the water. It bakes a cake in the oven and keeps ice frozen in the freezer. It plays our favourite songs on the radio and lights our homes. Energy is needed for our bodies to work, grow and it allows our minds to think.

Scientists define energy as the ability to do work. Modern civilization is possible because we have learned how to change energy from one form to another and use it to do work for us and to live more comfortably.

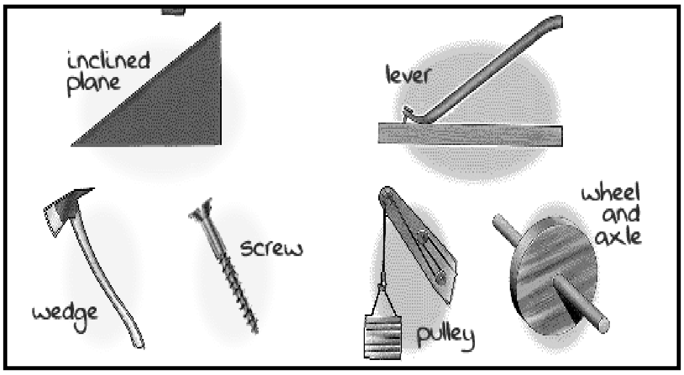
Energy is found in different forms including light, heat, chemical, and motion. There are many forms of energy, but they can all be put into two categories: potential and kinetic.



Potential energy is stored energy and the energy of position — gravitational energy. There are several forms of potential energy.

Kinetic energy is motion. Examples are moving waves, molecules, objects, substances and others.

Objects which are moving possess energy by virtue of their mass and their speed. This property is called kinetic energy.



A machine is a tool used to make work easier. Simple machines are simple tools used to make work easier. Compound machines have two or more simple machines working together to make work easier.

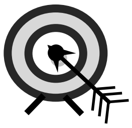
Some questions will arise such as

- What are the uses of simple machines?
- How is energy and simple machines related?
- Where can we find simple machines?

In this Sub strand, you will find the answers to these questions and other questions relating to forms of energy and simple machines.

Lesson 12: Forms of Energy

Welcome to a new sub strand. This Sub strand 3 is all about Forms of Energy and Simple Machines. It is composed of five lessons such as Forms of energy, Energy and its uses, Energy changes and its measurement, Simple machines and the last would be the Uses of simple machines. So, in this lesson, we will study the different types of Energy.



Your Aims:

- define energy and
- identify and describe the different forms of energy

What Is Energy?

Energy is needed to make things move. For example, when you walk, you can walk and move because you use the energy from the food you ate. When the truck moves, it is because it has been filled with diesel.

However, we cannot collect a piece of energy and study it. So we will not worry about what energy is, but talk about what it can do. When energy is used, work is done.

Scientists say that energy is the ability to do work. They use the word 'work' when a force moves an object a certain distance. For example, work is done when a ball is kicked because a force is needed and the ball moves. Another one is when driving a truck along a road; you need a force to move the truck, so work is done when the truck moves. If the force is not large enough to make the truck move then no work is done. Work is only done when a force causes an object to move.

Playing baseball

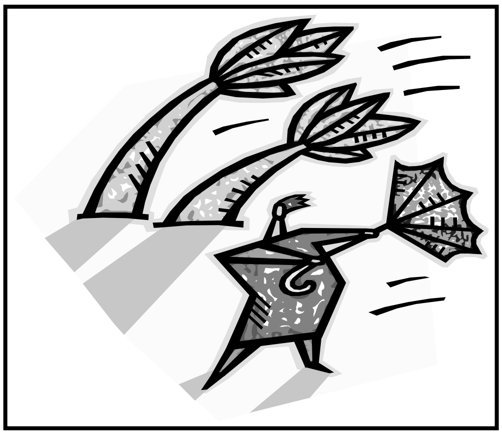
Car running

REMEMBER
Energy is a measure of the ability to do work.

Forms of energy – kinetic and potential

There are two main types of energy. These are the **kinetic** or movement energy and **potential** or stored energy.

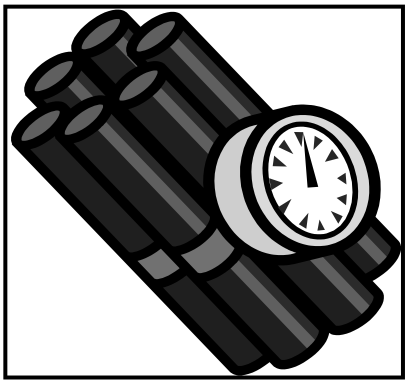
Kinetic energy is the energy an object has because of its movement. Some things have very large amounts of kinetic energy as in the case of fast moving car. Strong winds also contain large amounts of kinetic energy.



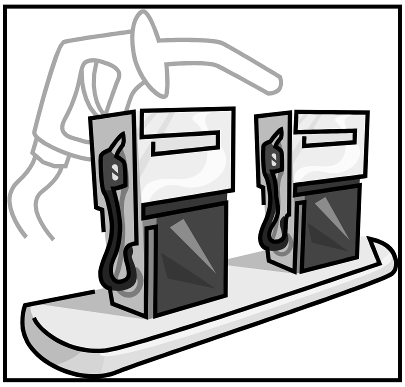
Fast car

The faster something moves the more kinetic energy it has. This is why it hurts more to be hit by a fast ball than a slow ball when you are playing sport. Kinetic energy also increases with the mass of the object. A speeding truck or car has a lot more kinetic energy than a fast-moving ball. An object that is not moving has no kinetic energy

Other things such as a car battery, a bomb, a litre of petrol and a wound-up spring all have a **potential energy**. If they are connected to something, or put where they can release this energy, then they can do some work. Potential energy is stored energy.



A time bomb



Petrol

A very important type of stored energy is gravitational potential energy. Objects are pulled towards the centre of the Earth with a large force. This is the **force of gravity**.

Water in high dams has a lot of stored gravitational potential energy

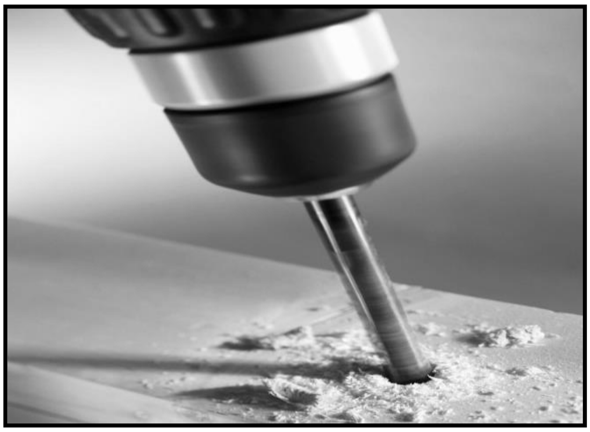
The stored gravitational potential energy of a boy climbing a pole is greatest when he is at the top of the pole

A coconut hanging from a tree and water sitting in a tank on top of a roof both have gravitational potential energy. **Anything that is able to fall because of the force of gravity has gravitational potential energy**.

REMEMBER
Two main types of energy are kinetic energy and potential energy.
Kinetic energy is the energy of movement.
Potential energy is often called stored energy.

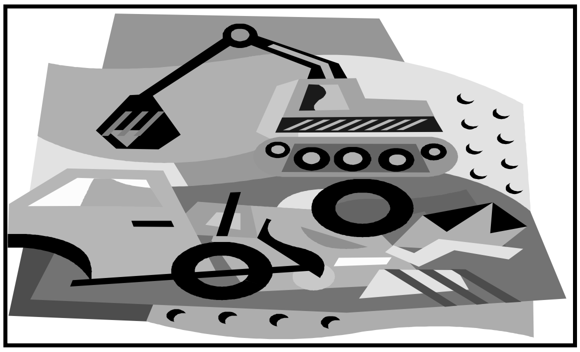
Other forms of energy
Even though kinetic and potential are the two main types of energy, there are others that should be examined. The following are really just different types of kinetic and potential energy.

Electrical energy
When electricity is stored in a car battery or made by the generators in a power station, it can be used to do some work. Some of the energy you use in your daily lives is electrical energy.



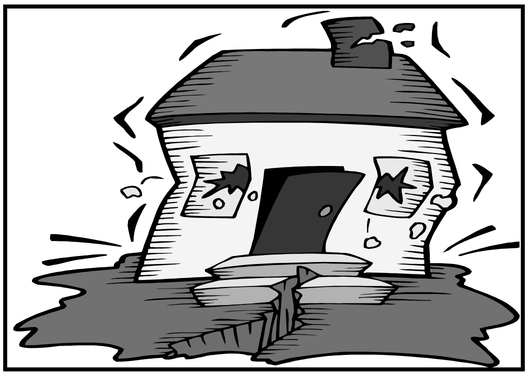
Using electrical energy to drill a hole

Magnetic energy
Strong magnets can be used to do work in scrap metal yards.



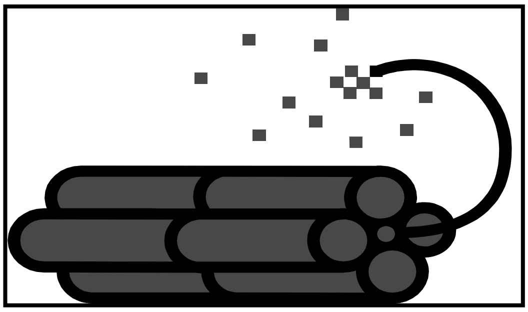
An electromagnetic crane at work in a scrap yard

Wave energy
Water waves can carry a canoe to the beach, damage wharves and change the shape of coastlines. Sound waves move our eardrums backwards and forwards so we can hear what is going on around us. Laser beams, which are very powerful light beams, can be used for welding and communications. A fourth type of wave energy is seen in earthquakes. Very few natural disasters strike with such force.



Earthquake damage

Chemical energy
Fuels, food and explosives like gunpowder have stored chemical energy, which can be released to do work. The food we eat gives us energy to move and live. The explosives used in copper mines can blast huge holes in the sides of mountains.



Dynamite sticks

Heat energy
This is a form of energy that can make substances hot. If heat energy is taken away from an object then it gets cool. This happens in refrigerators and air conditioners.

Heat radiated from a fire can warm people

Nuclear energy

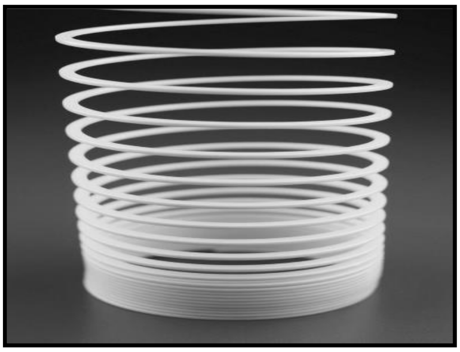
Scientists and engineers have worked out how to use nuclear energy only after it was used to destroy Nagasaki and Hiroshima in the Second World War. Since then, they know how to control nuclear reactions properly, and many nuclear power stations have been built throughout the world. Nuclear energy has also been used as a treatment for certain cancers.

Nuclear power station

Elastic energy

Springs and stretched or wound up rubber bands have elastic potential energy. An object has elastic potential energy if it is able to return to its original shape or position. The springs on a car and the rubber of the slingshot or pear gun have elastic potential energy.

Springs



REMEMBER

Other types of energy can either be kinetic, potential or a mixture of both. Some of these are electrical energy, magnetic energy, wave energy, chemical energy, heat energy, nuclear energy and elastic energy.

Activity 1: Now test yourself by doing this activity.

Answer the following questions:

1. What is energy?
   ____

2. Differentiate kinetic energy from potential energy.

   Kinetic energy ______________________________________

   Potential energy ____________________________________

3. List the seven other forms of energy.

   a) ________________ e) ________________

   b) ________________ f) ________________

   c) ________________ g) ________________

   d) ________________

4. What are the four types of wave energy?

   a) ________________ c) ________________

   b) ________________ d) ________________

Summary

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

- energy is a measure of the ability to do work.
- energy affects every part of our daily lives.
- there are two main types of energy:
  1. Kinetic energy is the energy an object has because of its movement
  2. Potential energy is the stored energy possessed by an object.
- objects are attracted to the surface of the Earth by the force of gravity.
- other types of energy can be either kinetic, potential or a mixture of both. Some of these are:
  Electrical energy, magnetic energy, wave energy, chemical energy, heat energy, nuclear energy and elastic energy.

NOW DO PRACTICE EXERCISE 12 ON THE NEXT PAGE.

Practice Exercise 12

Answer the following questions:

1. Explain energy.

____

____

2. What is kinetic energy?

____

3. What is potential energy?

____

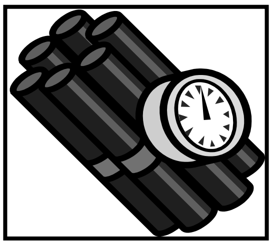
4. List the seven forms of energy and describe each.

a) ____
b) ____
c) ____
d) ____
e) ____
f) ____
g) ____

5. Name the energy being used.


____


____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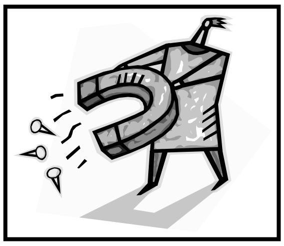
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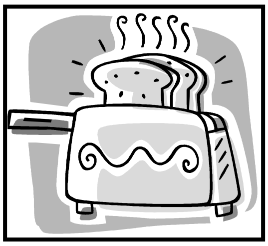
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CHECK YOUR WORK. ANSWERS ARE AT THE END OF SUB STRAND 3.

Answers to the Activity

1. Energy is a measure of the ability to do work.

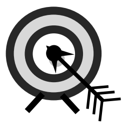
2. Kinetic energy is the energy of movement.
   Potential energy is stored energy.

3.
a)	Electrical energy	e.)	Heat energy
b)	Chemical energy	f.)	Nuclear energy
c)	Elastic energy	g.)	Wave energy
d)	Magnetic energy		

3.
a.)	Water	c.)	Laser
b.)	Sound	d.)	Earthquake

Lesson 13: Energy and its uses

Welcome to lesson 13 of Strand 3. In the last lesson you learnt about energy and its different types and forms. In this lesson you will learn about the uses of energy and its effect.



Your Aims:

- identify the uses of heat, light and sound energy and
- identify the harmful effects of heat, light and sound energy

Heat Energy

Heat is the name given to energy as it moves from a hotter object to a cooler one. The hotter object has more energy than the cooler one. The movement of the energy stops when the temperature of each object becomes the same.

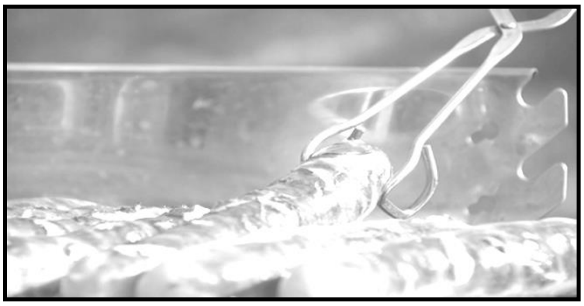
Heat reaches the earth from the sun despite the **vacuum** of space. This heat transfer method is called **radiation**. Hot objects emit radiation, also called radiant energy. Some examples of radiant energy, its uses and effects are shown in the table.

Type of radiant energy	Uses and effects
Heat	Cooking, heating the house
Light	Plants use light to make food. Many animals use light to see. People use light when they take photographs.
Radio waves	Communication
Microwaves	Cooking, communication
Infra-red rays	Heating
Ultra-violet rays	The sun gives out ultraviolet rays that burn the skin
X-rays	Looking inside the body or suitcases at airports

Heat energy cooks our food and warms our homes in cold places. Heat from burning fuel is used to run engines in cars, trucks and boat. Heat is also used to:

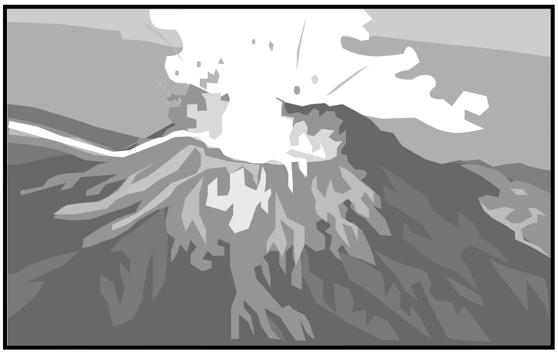
- Cut and weld metals
- Separate metals from rocks that contain minerals
- Make petrol and diesel from crude oil
- Shape metals and plastic
- Make glass, paper, textiles and many other products

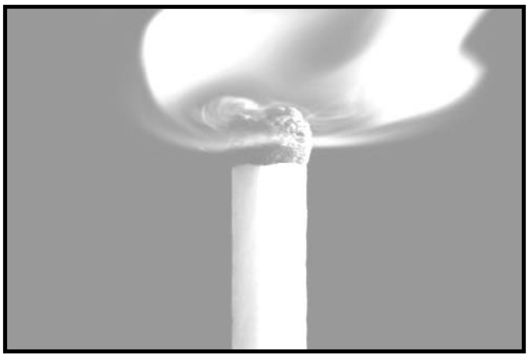

Welding metals


Cooking food

REMEMBER
Radiant energy is the energy that can travel through space and air in the form of electro-magnetic rays.

Sources of heat include the sun, fuels like firewood, electric stove, matches and candles. Heat can come from underground. The rocks deep inside the earth are very hot and they are **molten** in some places. There is still molten rock deep inside the earth because it sometimes comes to the surface when a volcano erupts.


Erupting volcano


Burning match

The hot springs at Salamo in Milne Bay are used for bathing, washing clothes and even cooking. The megapode bird lays its eggs in mounds of sand to keep them warm by heat from hot rocks. The people look after the mounds because it contains the eggs which are important source of food.

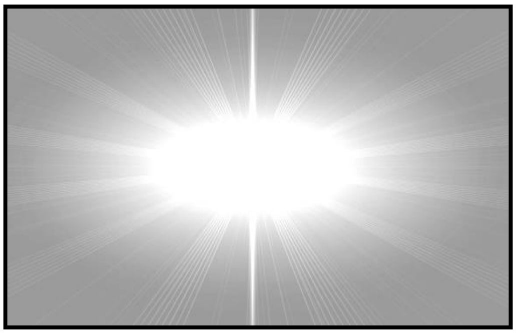
In some parts of the world, the heat is used to turn water into steam. The steam is used to make electricity.

REMEMBER
Heat energy makes us warm and cooks our food.

Light energy

Light is a form of energy. Sunlight is the most important example because it is needed to make plants grow. Light also allows us to see and helps us to take photographs and make films.


Growing plants need sunlight


The most important source of light - sunlight

When we heat things they often give off light. A wood fire gives off light, so do torches made from coconut fronds, kerosene lamps and candles. Torches give light that comes from the globe or electrical energy from the battery. Cars and trucks also have bulbs in the headlights.

Buildings that have electricity usually have lights that use bulbs or fluorescent tubes. Towns and cities have street lights and some sports ovals have floodlights to allow people to play sport at night when it is cooler.

> **REMEMBER**
> Sunlight is the most important source of light energy.

Sound energy

Sound is a form of energy. When you hear something, you are detecting the sound. Sounds are made whenever something vibrates. When you talk, vocal chords inside your throat vibrate rapidly. The vibrating chords cause particles of air to vibrate. The vibrations in the air reach a thin piece of skin inside the ear called the **ear drum**. The vibrating ear drum causes the tiny parts inside your ear to move and produce a special signal which travels along nerves to the brain. Your brain then interprets the signals as sounds.

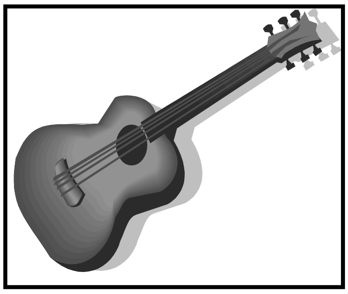

The ear

Sound produced by musical instruments
Musical instruments produce sounds because something inside the instruments vibrates. There are basically three families of musical instruments:

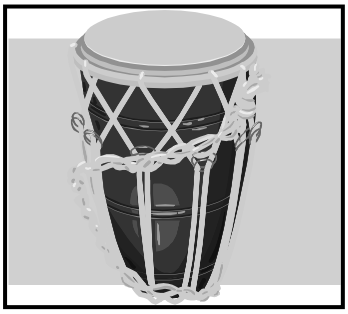
a) Stringed instruments – Stringed instruments have taut strings mounted over specially designed wooden frames, which are partially hollow from within. When the strings are plucked or struck or played with a bow they vibrate to produce a musical sound of some particular frequency.

b) Wind or reeds instruments – Wind instruments make use of vibrating air columns. In these instruments the air is blown in, either directly or through the reeds.

c) Percussion instruments – All percussion instruments have a taut skin over a hollow metal or wooden frame. When the skin is struck, it produces a musical sound.


Guitar – Stringed Instruments

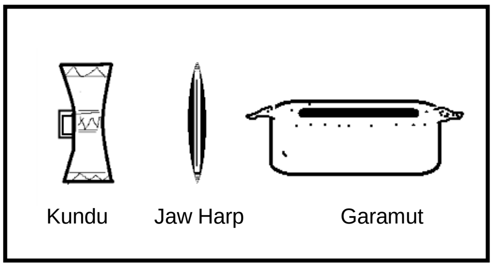

Bugle – Wind Instruments


Drum – Percussion Instruments

In Papua New Guinea, we use the traditional knowledge to make many different kinds of instruments using materials that we find in the local environment. All of these instruments use vibrations to make sound energy.
The **kundu** drum is the most common musical instrument in Papua New Guinea and is widely used for traditional dancing and singing. Kundu drum has a stretched skin that vibrates when you hit it.

The **garamut** drum is made from a log that is hollowed out. When the drum is hit with a stick it makes the air inside vibrate and the hollow shape acts as a sound box to make the sound bigger.

The **jaw harp** is made from a piece of bamboo that is cut so that one strip is free to vibrate inside a frame. Flutes and whistles may be made from a single piece of bamboo or a conch shell. Pan-pipe flutes are made by trying different lengths of bamboo together and blowing over the top of them.



REMEMBER
Sound is a form of energy and made whenever something vibrates.

Harmful effects of heat, light and sound energy

The sun and its light are not only beautiful but vital to our life and survival on this planet. Without the sun we will be frozen to death, and there will be no forms of life on earth

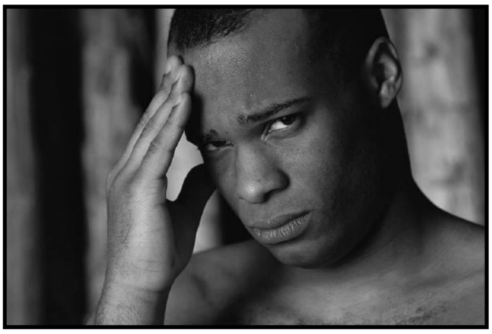
The harmful effects of sunlight come from its ultraviolet (UV) radiation which could be dangerous to our health. An overexposure to UV radiation can cause sunburn, hurt our eyes and even result in skin cancer. It can also result in making you look older by aggravating wrinkles.

Sun bathing cause sunburn

Skin cancer

Noise is not just annoying; it is dangerous, both physically and mentally. It has been described as ‘a slow agent of death.’

Sound, or noise, can lead to physical and psychological problems ranging from worries to headaches which is associated with many other problems such as stress, high blood pressure, insomnia, ulcers, digestive disorders, alcoholism, hearing loss, sleep disturbances, anxiety, and many other illnesses.



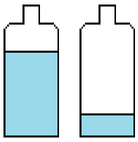
Headaches

Loud music

Activity 1: Now test yourself by doing this activity.

For this activity, you will investigate the different bottle sounds.
Let us do an experiment

You will need the following materials:
Identical glass bottles, spoon and water



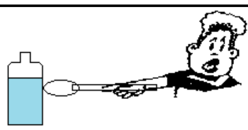
Here is what you are going to do:

Collect

- two identical glass bottles, some water and a spoon.
- Fill the bottles with different amounts of water.
- Blow across the top of each of the bottles.
  Which one makes the higher note?

  ____

- Tap each of the bottles with a spoon.
  Which one makes the higher note?



  ____

- Draw a diagram of the two bottles to show the different sounds that are made from blowing and tapping with a spoon.
  Show the different results on the same diagram.
  You may start now!

REMEMBER
The harmful effects of sunlight come from its ultraviolet (UV) radiation which could be dangerous to our health.
Sound or noise is potentially dangerous, both physically and mentally.

Summary

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

- heat, light and sound energy has its uses and effects.
- radiant energy is the energy that can travel through space and air in the form of electro-magnetic rays.
- sources of heat include the Sun, fuels like firewood, electric stove, matches and candles. Heat can also come from the underground.
- heat energy cooks our food and warms our homes in cold places. Heat from burning fuel is used to run engines in cars, trucks and boat.
- light is a form of energy and sunlight is the most important example of it.
- sound is a form of energy. When you hear something, you are detecting the sound. Sounds are made whenever something vibrates.
- the harmful effects of sunlight come from its ultraviolet (UV) radiation which could be dangerous to our health.
- a form of energy, sound or noise is caused by anything that vibrates and can lead to physical and psychological problems ranging from worries to headaches.

NOW DO PRACTICE EXERCISE 13 ON THE NEXT PAGE.

Practice Exercise 13

Answer the following questions:

1. Differentiate between heat, light and sound energy.

   Heat energy-

   Light energy-

   Sound energy-

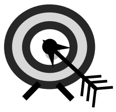
2. Explain the harmful effects of heat, light and sound energy.

3. Name and describe three 3 different traditional instruments used in Papua New Guinea.

CHECK YOUR WORK. ANSWERS ARE AT THE END OF SUB STRAND 3.

Lesson 14: Energy changes and its measurement

Welcome to lesson 14 of strand 3. In the last lesson you learnt that heat, light and sound energy have its uses and effects. In this lesson you will learn that energy can be measured and changed from one form to another.

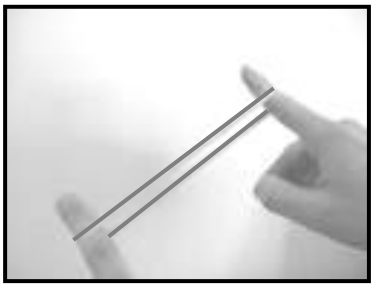


Your Aims:

- identify and explain the different energy changes
- identify the unit of measuring energy
- identify the efficiency of some energy converters

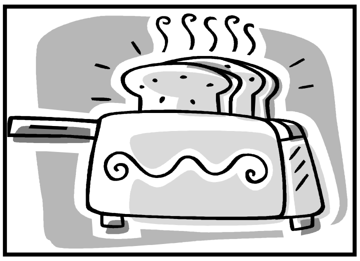
Energy changes

Energy can be changed from one form to another. Almost all the energy we use today comes from the sun. Most of it is from the energy that reached the earth millions of years ago and is now stored in coal, oil or natural gas. This stored chemical energy must be changed into other forms of energy, which can be used in factories, homes, transport and communications.



The changing of energy from one form to another is very important. An energy change occurred when you made a reel-mobile. As the wound-up elastic band unwound, potential energy stored in the band was changed into kinetic energy (energy of movement). This can be represented by

Potential energy $\longrightarrow$ Kinetic energy



When you plug an electric toaster into a power point in your home, and turn on the power, the element in the toaster heats up. Electrical energy is changed into heat energy.

Electrical energy $\longrightarrow$ Heat energy

When you rub your hands together, kinetic energy of the moving hands is changed into heat energy (your hands get warm) and sound energy (you can hear the rubbing).

Kinetic energy $\longrightarrow$ Heat energy **+** Sound energy

REMEMBER
Energy can be changed from one form to another by various means.

When television is turned on, electrical energy is changed into sound energy and light energy.

Electrical energy → Sound energy + Light energy

In hydro-electric power scheme, water stored in the dam has potential energy. When the water is released it flows down pipes and gains kinetic energy. This kinetic energy causes movement of the turbine and generator to produce electrical energy.
The electrical energy can be used to produce heat or light in our homes. This series of energy changes can be represented as an **energy chain**. In an energy chain one energy change follows another.

Potential energy → Kinetic energy → Electrical energy → Heat + Light

Energy transfer

You have known that energy can be changed from one form into another. Energy can also be transferred from one place to another.
For example, the kinetic energy of the wind can be transferred to particles of sand on a beach. The wind may move the sand particles from one place to another. In this situation kinetic energy has not been changed from one form into another, it has been transferred.

When a saucepan of soup is placed on the hotplate (element) of the stove, heat energy from the hotplate is transferred into the soup in the saucepan.
When energy changes occur some energy is turned into a form that we do not want. For example, for every 100 units of energy stored in the petrol you put in your car, only 20 units of kinetic energy is produced. The rest goes into heat and sound.

REMEMBER
Energy can also be transferred from one place to another.

Measuring energy

When work is done, energy is used. So, we need to be able to measure energy. The unit in which energy is measured is the **joule**. To do 1 joule of work you must have at least 1 joule of energy. Joule is a very small unit so it is more usual to use mega joules (MJ). One mega joule is equal to one million joules.

Look carefully at the table. This will give you some idea of how much energy is in mega joule.

The energy involved in various activities

Type of energy	**MJ**
Energy from a fluorescent light in 5 minutes	0.002
Sound energy from a radio in one hour	0.02
Food energy stored in an egg	0.3
Food energy stored in one bottle of lolly water	0.7
Movement of energy of truck travelling along	1.0
Food energy stored in a handful of peanuts	1.2
Electrical energy stored in a car battery	2.0
Food energy needed by school children every day Girls Boys	 10.4 12.0
Chemical energy stored in 20 litres of petrol	800
Electrical energy made at Yonki hydro in 1 hour	16 000

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

Let us answer these questions.
You may start now!

1. Energy is difficult to describe because

   A. it can make things hot.
   B. it can make things move.
   C. we cannot actually see it as an object.
   D. there are many different types of energy.

2. The energy change that occurs when an electric bell rings is

   A. sound to kinetic C. potential to sound

   B. kinetic to electrical D. electrical to sound

3. A device that will transform kinetic energy into electrical energy is a

   A. radio B. toaster

   C. torch battery D. bicycle dynamo

4. Which one does not involve a change from one form of energy to another?

   A. Oil is burnt to heat a room.
   B. The tyres of a moving car become hot.
   C. Hot tea poured into a cup makes the cup hot.
   D. A hydroelectric power station uses running water to generate electricity.

5. The petrol in a car is a form of chemical energy. What energy changes occur when petrol is burnt in a car engine and the car moves along the road?

Efficiency of some energy converters
When energy changes from one type to another, some energy is lost. How well a device like an electric jug or a car changes energy from one form to another is called its **efficiency.** The efficiency can be given as a percentage. An electric jug is 99 percent efficient because 99 per cent of the electrical energy that goes into the heater is changed to heat energy. The car is only 25 percent efficient because only 25 percent of the chemical energy stored in the petrol is changed to kinetic energy.

Efficiency of energy converters
The efficiency of an energy converting device or machine is calculated using this formula:

$$\text{Efficiency (\%)} = \frac{\text{useful energy output}}{\text{Total energy input}} \times 100\%$$

For example, with the light bulb, the total energy input was 120 joules. The useful energy output (light) was 80 joules. The efficiency of the light globe is therefore:

$$\text{Efficiency} = \frac{80}{120} \times 100\% = 66\%$$

If the electric motor had 100 joules of input energy and its useful output energy was 85 joules, it is therefore 85% efficient.
In reality, machines are never 100% efficient; there is always some input energy that gets changed into other less useful forms.

REMEMBER
The unit in which energy is measured is the joule (J). It is more common to use the mega joule (MJ) because the joule is a very small amount of energy.

Summary

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

- energy can be changed from one form to another by various means.
- energy can also be transferred from one place to another.
- the different energy changes are
  a) Potential energy → Kinetic energy
  b) Electrical energy → Heat energy
  c) Kinetic energy → Heat energy + Sound energy
  d) Electrical energy → Sound energy + Light energy
  e) Potential energy → Kinetic energy → Electrical energy → Heat + Light
- the common unit for energy is the joule.
- the efficiency of a device is very important in changing energy from one type to another.

NOW DO PRACTICE EXERCISE 14 ON THE NEXT PAGE.

Practice Exercise 14

Answer the following questions:

1. Match column A with column B. Write the letter of the correct answer.

Column A	**Column B**
Object	**Main energy change**
1. Lamp ( )	a. sound to electrical
2. Electric motor ( )	b. electrical to sound
3. Microphone ( )	c. electrical to kinetic
4. Solar cell ( )	d. chemical to kinetic
5. Loud speaker ( )	e. light to electrical
6. Jet engine ( )	f. electrical to light

2. Write one example of things which can change energy in the following ways:

a) Electrical energy to sound energy ______________________
b) Kinetic to heat ______________________
c) Electrical to kinetic ______________________
d) Chemical to electrical ______________________
e) Potential to electrical ______________________
f) Potential to kinetic ______________________
g) Electrical to heat (flat iron) ______________________
h) Kinetic to heat + sound ______________________
i) Electrical to sound + light ______________________

3. Refer to the table below to answer Questions a-c.

The heat values of some fuels

Fuel name	Heat energy produced
Anthracite coal	35 360
Diesel oil	41 600
Petrol	47 840
Hydrogen	143 520

a. Which fuel produces the most heat energy?

____

b. Which fuel produces only one-third as much energy as hydrogen?

____

c. Which fuel(s) produces more energy than diesel oil?

____

CHECK YOUR WORK. ANSWERS ARE AT THE END OF SUB STRAND 3.

Answers to Activity

1. C

2. D

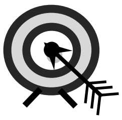
3. D

4. C

5. The stored energy of the petrol is changed into heat energy when the petrol is burnt in a car's engine. The heat energy is then changed into kinetic energy of the moving engine parts. This kinetic energy is then passed on through the gears of the wheels. Friction between the moving parts of the engine produces heat energy and sound energy.

Lesson 15: Simple Machines

Welcome to lesson 16 of strand 3. In the last lesson you learnt about that energy can be changed and transferred from one form to another. In this lesson you will learn about simple machines and the energy that it transfers.



Your Aims:

- define simple machine
- identify the different types of simple machines

What Is A Simple Machine?

A simple machine is something that helps to make work easier. For example, it is easier to carry a large load of soil if you put it in a wheelbarrow, than if you try to lift it on your shoulders. So, the wheelbarrow is a simple machine.

A tractor

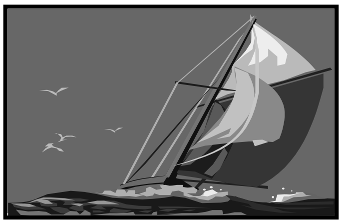
Wheelbarrow

People think that the word 'machine' means things like a tractor, bulldozer or a sewing machine. These are machines but are complicated ones because they are made up of many simple machines. Machines help you do things more easily. They do this in three different ways.

1. **Machines move heavy load with a small force.**
   When you have to remove a nail from a piece of wood it is easier to use a claw hammer than your fingers. The larger the hammer the smaller the force needed to remove the nail. Machines that increase the force you use are said to have a **force advantage**.

A hammer

2. **Machines change the direction of the force.**
   When you have to pull the sails up on your sailing boat, the pulley at the top of the mat makes it easier. You pull the rope down and the sail goes up.



A boat

> **REMEMBER**
> Simple machine allows work to be done more easily.

3. Machines make things go faster.

When you push on the pedals of a bicycle, the back wheel turns much faster than the pedals. Machines that make things go faster are said to have speed advantage or a **distance advantage.**

A bicycle

You can't get more energy out than you put in!

Some machines give you a bigger force than you apply and others make things go faster. But no machine can give you a bigger force and go faster at the same time. In other words, a machine cannot give you a force advantage as well as speed (or distance) advantage.

If this were to happen, it would mean that you are getting more energy out of the machine than you put in. Machines transfer energy from one point to another, for example, from the pedals to the back wheel of a bicycle. And because of friction, machines always lose some energy as heat and sound.

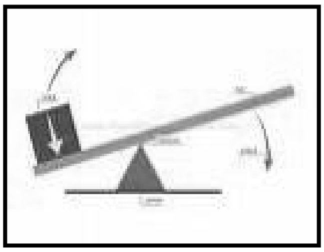
Types of simple machines

If you have used a door handle or a bottle opener today, or you have ridden a bicycle, you have been using simple machines. There are only a few types of simple machines. These are the lever, wheel and axle, inclined plane, pulley and gear wheel and hydraulic machines.

Levers

Suppose you want to move a large rock with a crowbar.

A crowbar is a type of simple machine called a **lever**. A lever moves around a fixed point called the pivot (or fulcrum), in this case a small rock. The large rock is called the **load**, and the force you apply is called the **effort.**



Lever

REMEMBER

Machines help you to
- move a heavy load with a small force
- change the direction of the force
- make things go faster

The crowbar has a force advantage. This is because the force (effort) you apply to the crowbar is less than the force used to move the rock. Sometimes you want a lever to have a distance advantage rather than a force advantage. You can use a lever to catapult a small rock into the air by placing the pivot close to the effort. Here the effort is much larger than the load, but the distance the lever moves at the load end is much greater than the distance the lever moves at the effort end.

A crowbar

REMEMBER
The lever is a simple machine, which consists of a stiff bar that turns about a fixed point called a pivot.

A steering wheel

Wheel and axle

A steering wheel is an example of a simple machine called a wheel and axle. The axle is the central rod or column and the steering wheel is attached to this axle. Without a steering wheel it would be very difficult to turn the axle. The force needed would be too great. With steering wheel, applying a small force will turn the axle. The bigger the steering wheel, the easier it is to steer.

A door knob is an example of a wheel and axle. The handle is the wheel. When you turn the handle, there is a large force applied to the axle. This opens the door. A screwdriver is another example of a wheel and axle.

A door knob

A screwdriver

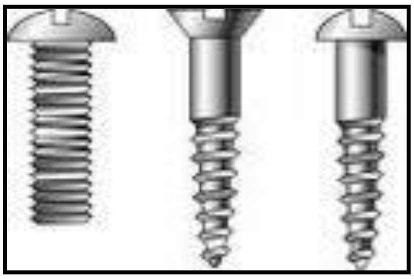
REMEMBER
A wheel and axle is a special type of lever.

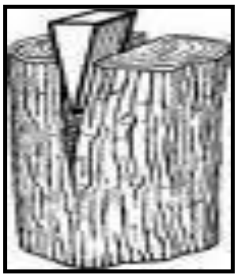
Inclined planes

Suppose you want to lift some drums onto the back of a truck. It is easier to use a ramp and roll them on than to lift them straight up. The ramp is an example of inclined plane-another simple machine. Inclined planes have a force advantage-you apply a small effort to move a heavy load. But you have to move the load over a large distance. In other words, you use less effort this way but you have to roll the drums further.

Ramp

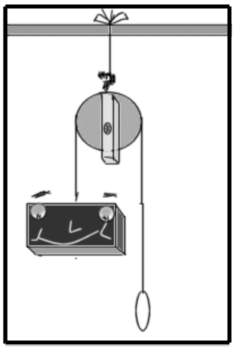
A screw is plane that turns round and round. A small force applied to the head of the screw can produce a large force to hold things together.
A wedge is a simple machine made up of two inclines placed back to back. It helps you push things apart. The head of an axe is a wedge.

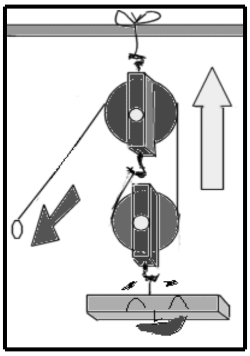

Screw


Wedge

REMEMBER
An inclined plane is a simple machine that allows heavy obiects to be raised bv smaller forces.

Pulleys and gear wheel
Lifting a bucket of sand is hard work. However, by using a pulley you can pull downwards to move the bucket upwards. This is easier than lifting the bucket upwards directly.
A pulley is wheel with a rope over it. A single pulley does not magnify your force. It simply changes the direction of the force.
To magnify your force you need to use more than one pulley. This lets you lift very heavy loads by using only a small effort. However, you need a lot of rope to lift the object only a little way.


A single pulley


More than one pulley

Gear wheels are wheels with teeth on them. The teeth of one of the gear fit into the teeth of another. Gears are used to transfer the force from one wheel to another.
In a bicycle, the large gear wheel attached to the pedals is connected to the smaller gear wheel on the back wheel by a chain. The gear wheel attached to the pedals is called the **driving gear** because it supplies the force. The gear wheel on the back wheel is called the **driven gear**.

Gears can speed things up. The large gear wheel has more teeth on it than the smaller gear wheel. This arrangement of gears makes the propeller spin faster than the motor spins. Machines that use a larger driving gear include kitchen hand beater and hand drills.

Gears can slow things down. The driving gear has fewer teeth than the driven gear and the propeller spins more slowly than the motor. Machines that have smaller driving gear than the driven gear include winches and rotating displays found in shops.

A bicycle-driven gear and driving gear

REMEMBER

Pulley wheels and belt make up a simple machine by which the energy of turning of a driving wheel can be transferred to another wheel.
In gear wheels, the connecting belt is replaced by special teeth, which mesh directly. The driven wheel will turn in the opposite direction to the driving wheel.

Hydraulics

Hydraulics allows forces to be transferred through a liquid such as oil. When a force is applied to a liquid the force is sent through the whole liquid. That is how hydraulic lifts in garages work.
The same force acts on every square centimetre of the inside of the hoist. Thus, small force acting on a small area will lift very large force acting on a large area. A small force applied many times can be used to lift something as heavy as a truck.

Hydraulic lifts

REMEMBER

Hydraulics allows work to be done more conveniently by using liquids to transfer the force from one place to another.

Activity: Now test yourself by doing this activity.

1. **Complete the sentences by choosing the words given below.**

Pivot lever effort magnify screw direction

a. A crowbar is a type of __________.
b. The __________ is the force you put into a simple machine.
c. Some machines help you by changing the __________ of the force.
d. The __________ is the fixed point around which a lever moves.
e. Some machines __________ the force you use.
f. A __________ is a type of an inclined plane.

2. The following statements are **false**. Rewrite them to make it true.

a. A simple machine can give you a bigger force and make things go faster as well.

____

b. Pliers are an example of two levers with the pivot at the end.

____

c. It is much easier to remove a tight screw with a screwdriver with a small handle than one with a large handle.

____

Summary

You have come to the end of lesson 15. In this lesson you have learnt that:

- simple machine allows work to be done more easily.
- machines help you to move a heavy load with a small force, change the direction of the force and make things go faster.
- the lever is a simple machine, which consists of a stiff bar that turns about a fixed point called a pivot.
- a wheel and axle is a special type of lever
- an inclined plane is a simple machine that allows heavy objects to be raised by smaller forces.
- Pulley wheels and belt make up a simple machine by which the energy of turning of a driving wheel can be transferred to another wheel.
- in gear wheels, the connecting belt is replaced by special teeth, which mesh directly. The driven wheel will turn in the opposite direction to the driving wheel.
- hydraulics allows work to be done more conveniently by using liquids to transfer the force from one place to another.

NOW DO PRACTICE EXERCISE 15 ON THE NEXT PAGE.

Practice Exercise 15

Answer the following questions:

1. What is a simple machine?

2. List and describe the types of simple machines.

   a.

   b.

   c.

   d.

   e.

   f.

3. What are the three ways in which machines could help you?

   i.

   ii.

   iii.

4. Give an example of each type of simple machine.

   a.

   b.

   c.

   d.

   e.

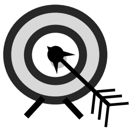
CHECK YOUR WORK. ANSWERS ARE AT THE END OF SUB STRAND 3.

Answers to Activity

1. a. lever
   b. effort
   c. direction
   d. pivot
   e. magnify
   f. crew
2. a. No machine can give you a bigger force and make things go faster at the same time.
   b. Pliers are an example of two levers with the pivot close to the load.
   c. It is much easier to remove a tight screw with a screwdriver with a large handle than one with a small handle.

Lesson 16: Uses of Simple Machines

Welcome to lesson 16 of Strand 3. In the last lesson you learnt about that simple machine transfer energy from one place to another and allow work to be done more easily or in a more convenient way. You also learnt that there are five different types of simple machines. These are the lever, wheel and axle, inclined plane, pulley and gear wheel and hydraulic machines. In this lesson you will learn about the different uses of these simple machines.



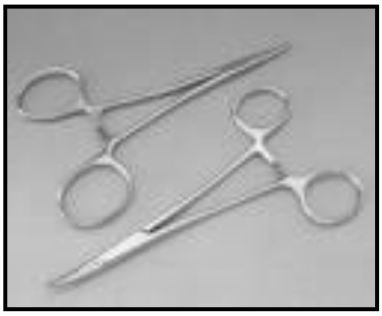
Your Aims:

- identify the different uses of simple machines
- give the importance of simple machines

What Are Levers?

Simple devices such as a see-saw, a spade, a wheelbarrow, scissors and a bottle opener are all machines. They are called levers.
A lever is usually a strong, stiff bar that can turn or pivot around a fixed point called a **fulcrum.** It is easy to see why a wheelbarrow and a forceps are called levers.

The wheelbarrow is a simple lever in which there is a force advantage



A pair of forceps- an example of a double lever

A wheelbarrow lets us lift a heavy load easily because only a small force is required. It is an example of a lever where the pivot (the wheel) is at the end of the lever and the effort is at the other end. The load is between the pivot and the effort.
The easiest way to use a wheelbarrow is to have the load close to the pivot and to have your lifting force, or effort, far from the pivot. The distance between the load and the pivot is called the **load distance** and the distance between the effort and the pivot is called the **effort distance**. When the effort distance is larger than the load distance then there is a **force advantage**. This means a **small** force is used to move a **large** load.

REMEMBER
A lever is usually a strong, stiff bar that can turn or pivot around a fixed point called a fulcrum.

You can get a measure of how useful a simple machine is by dividing the load you move by the effort you use. This measure is called the machine's **mechanical advantage**.
For example, suppose you used a crowbar and applied a 100 Newton force to move a 500N (50kg) rock.

$$\text{Mechanical advantage} = \frac{\text{load}}{\text{effort}} = \frac{500\text{N}}{100\text{N}} = 5$$

Wheel and axle
A simple machine that uses the principle of the lever is the wheel and axle. Two examples are a screwdriver and a steering wheel of a car. The wheel and axle is made of two wheels, which are joined together. The small wheel is called the axle.

To gain a force advantage, a small force is used to turn the larger wheel. This causes a large force to act on the smaller wheel or axle. In this way a small effort applied to the wheel can move a large load attached to the axle. This is because the effort distance is greater than the load distance since the wheel makes a bigger turn than the axle. This makes it easier to steer the wheels of a car and to tighten a screw using a screwdriver.

A screwdriver

Winder on clothes hoist

A doorknob

REMEMBER A wheel and axle is a machine that uses the principle of a lever.

Inclined planes
It is easier to roll a drum up a ramp on to a truck than to lift up by yourself. A sloping plank is called an inclined plane. To move something up a gentle slope requires less force than to move something up a steep slope, or to lift up vertically. Steps and stairs are the type of inclined plane and so are zigzag roads winding up a mountain.

Rolling a drum up a ramp

The advantages of inclined planes are:

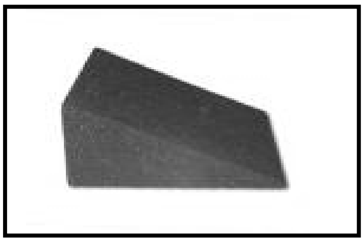
a. when an inclined plane is used to raise an object, the same amount of work is done by the smaller force moving a greater distance

b. long planes with shallow slopes give the greatest ease of lifting.

A screw is a special type of inclined plane that spirals round and round to form a thread. To drive a screw into pieces of wood, you use a small force and turn the screw many times. This is changed into a large force where the thread touches the wood, pushing it in a small distance.

To split a block of wood you need an axe, which has a wedge-shaped blade. A wedge is a pair of inclined planes that changes the direction of a force. You push the axe downwards, and the wedge-shaped blade pushes the wood apart.

Screws, nuts and bolts

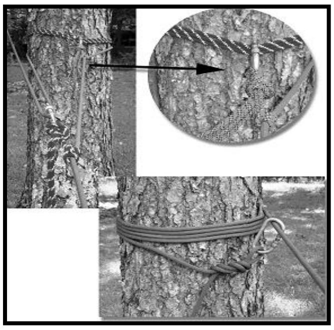


A wedge made up of two inclines placed back to back

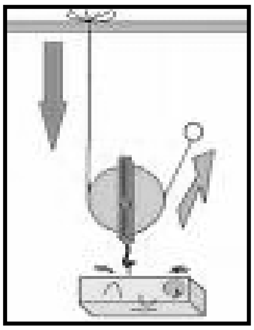
REMEMBER
An inclined plane is a simple machine that allows heavy objects to be raised by smaller forces. Wedges and screws are special cases of inclined planes.

Pulleys and gear wheels

Machines can help you by changing the direction of a force. A single fixed pulley allows you to lift an object upwards by pulling downwards on a rope. It does not magnify your force but only changes the direction of the force. To magnify your force, you need to use more than one pulley. A single movable pulley can be used to give a force advantage. You need less force to lift the load with a pulley, but you need more rope.



A tree branch used as a simple fixed pulley



A single movable pulley gives a force advantage

REMEMBER
Pulley wheels are used to change the direction of a force. They can also be used to give a force advantage, if a long string or rope is used. The more pulleys used, the longer the rope must be.

Pulley wheels and belts make up a simple machine by which the energy of the turning of a driving wheel can be transferred to another wheel. The values of pulleys are:

a. when a large wheel drives a small wheel, there is an increase in the speed of turning
b. when a small wheel drives a large wheel, there is a reduction in the speed of turning.

Many objects move by turning wheels and moving parts. Concrete mixers, sewing machines, egg beater and car engines all depend on turning to do their work. These are driven by gears, which interlock or mesh together, or by pulleys connected by chains or belts. In these machines the speed of turning can be changed.
In gear wheels, the connecting belt is replaced by special teeth, which mesh directly. The driven wheel will turn in the opposite direction to the driving wheel. The teeth of one gear fit into the teeth of another. Gears are used to transfer the force from one wheel to another.

The bike pedals provide a force advantage at the gear wheel.

The meshing cogs prevent the slipping that occurs in a belt system.

REMEMBER
Gear wheels are wheels with teeth on them which mesh directly. The driven wheel turns in the opposite direction to the driving wheel.

Hydraulics

Hydraulics allow work to be done more conveniently by using liquids to transfer the force from one place to another. When a force is applied to a liquid the force is sent through the whole liquid. This is how the hydraulic lifts in garages work. The same force acts on every square centimetre of the inside of the hoist. Thus, small force acting on a small area will lift very large force acting on a large area. In return, for the advantage of being able to lift a very heavy load with a small force, the pump that moves the small piston up and down must do this many times to force oil into the cylinder.

Hydraulic jack

REMEMBER
Hydraulics allows forces to be transferred through a liquid such as oil.

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

Directions: Complete the sentences by choosing the words given below.

gear wheels	**hydraulics**	**fulcrum**	**crowbar**
simple machine	**wheel and axle**	**wedges and screws**	
lever	**inclined plane**	**pulley wheels**	

1. __________ allow work to be done more easily or in a more convenient way.
2. The __________ is a simple machine which consists of a stiff bar that turns about a fixed point.
3. A __________ uses a principle of the lever.
4. A/An __________ is a simple machine that allows heavy objects to be raised by smaller forces.
5. __________ are special cases of inclined planes.
6. __________ are used to change the direction of a force.
7. __________ are wheels with teeth on them which mesh directly.
8. __________ allows forces to be transferred through a liquid such as oil.
9. The __________ is the fixed point around which a lever moves.
10. A _________ is a type of lever

Summary

You have come to the end of lesson 16. In this lesson you have learnt that:

- a lever is usually a strong, stiff bar that can turn or pivot around a fixed point called a fulcrum.
- a wheel and axle is a machine that uses the principle of a lever.
- an inclined plane is a simple machine that allows heavy objects to be raised by smaller forces. Wedges and screws are special cases of inclined planes.
- pulley wheels are used to change the direction of a force. They can also be used to give a force advantage, if a long string or rope is used. The more pulleys used, the longer the rope must be.
- gear wheels are wheels with teeth on them which mesh directly. The driven wheel turns in the opposite direction to the driving wheel.
- hydraulics allow forces to be transferred through a liquid such as oil.

NOW DO PRACTICE EXERCISE 16 ON THE NEXT PAGE.

Practice Exercise 16

Answer the following questions:

1. What is a lever?

____
____
____
____

2. Why is a lever useful?

____
____
____
____

3. What is an inclined plane?

____
____
____
____

4. What are the advantages of inclined planes?

____
____
____
____

5. What are the uses of pulley wheels?

____
____
____
____

CHECK YOUR WORK. ANSWERS ARE AT THE END OF SUB STRAND 3.

Answer to the Activity

1. Simple machine
2. Lever
3. Wheel and axle
4. Inclined plane
5. Wedges and screws
6. Pulley wheels
7. Gear wheels
8. Hydraulics
9. Fulcrum
10. Crowbar

REVIEW OF SUB STRAND 3: FORMS OF ENERGY AND SIMPLE MACHINES

Revise all the Lessons in this Sub Strand and then do **ASSIGNMENT 4.**
Here are the main points to help you revise.

Lesson 12: Forms of Energy

- Energy is a measure of the ability to do work
- There are two main types of energy:
  a. Kinetic energy- is the energy an object has because of its movement
  b. Potential energy- is the stored energy possessed by an object.
- Objects are attracted to the surface of the Earth by the force of gravity.
- A mixture of kinetic and potential energy is electrical energy, magnetic energy, wave energy, chemical energy, heat energy, nuclear energy and elastic energy.

Lesson 13: Energy and Its Uses

- Heat, light and sound energy has its uses and effects
- Sources of heat include the Sun, fuels like firewood, electric stove, matches and candles. Heat can also come from the underground.
- The harmful effects of sunlight come from its ultraviolet (UV) radiation which could be dangerous to our health.
- Radiant energy is the energy that can travel through space and air in the form of electro-magnetic rays.
- Light is a form of energy and sunlight is the most important example of it.
- Sound is a form of energy. Sounds are made whenever something vibrates.

Lesson 14: Energy Changes and Its Measurement

- Energy can be changed from one form to another by various means
- Energy can also be transferred from one place to another.
- The common unit for energy is the joule.
- The different energy changes are

a. Potential energy → Kinetic energy

b. Electrical energy → Heat energy

c. Kinetic energy → Heat energy + Sound energy

d. Electrical energy → Sound energy + Light energy

e. Potential energy → Kinetic energy → Electrical energy → Heat + Light

Lesson 15: Simple Machines

- Simple machine allows work to be done more easily
- Machines help you to move a heavy load with a small force, change the direction of the force and make things go faster.
- An inclined plane is a simple machine that allows heavy objects to be raised by smaller forces.
- Pulley wheels and belt make up a simple machine by which the energy of turning of a driving wheel can be transferred to another wheel.
- In gear wheels, the connecting belt is replaced by special teeth, which mesh directly. The driven wheel will turn in the opposite direction to the driving wheel.
- Hydraulics allows work to be done more conveniently by using liquids to transfer the force from one place to another.

Lesson 16: Uses of Simple Machines

- A lever is usually a strong, stiff bar that can turn or pivot around a fixed point called a fulcrum.
- A wheel and axle is a machine that uses the principle of a lever.
- Wedges and screws are special cases of inclined planes.
- Pulley wheels are used to change the direction of a force. They can also be used to give a force advantage, if a long string or rope is used. The more pulleys used, the longer the rope must be.
- Gear wheels are wheels with teeth on them which mesh directly. The driven wheel turns in the opposite direction to the driving wheel.
- Hydraulics allows forces to be transferred through a liquid such as oil.

REVISE WELL AND THEN DO SUB STRAND TEST 3 IN YOUR ASSIGNMENT 4.

Answers to Practice Exercises 12- 16

Practice Exercise 12

1. Energy is needed to make things move. For example if you move like running or walking, it is because you use the energy from the food you eat. However, you cannot collect a piece of energy and study it. Instead you can talk about what it can do. When energy is used, work is done. That's why Scientists say that energy is the ability to do work.

2. Kinetic energy is the energy of movement

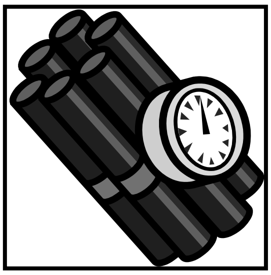
3. Potential energy is the stored energy.

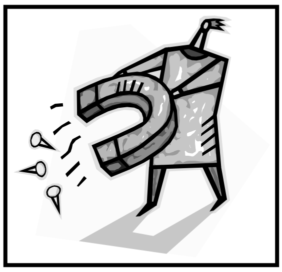
4. a. Electrical energy is the electricity that is stored in a car battery that can be used to do some work.
   b. Magnetic energy magnets can be used to do work on a scrap metal yard
   c. Wave energy has types of energies which includes water, sound, laser and earthquake
   d. Chemical energy includes fuels, food and explosives which store chemical energy that can be released to do work.
   e. Heat energy is a form of energy that can make substances hot.
   f. Nuclear energy was used during Second World War now being used to treat cancer patients.
   g. Elastic energy a stretched rubber band or coiled spring can all do work.

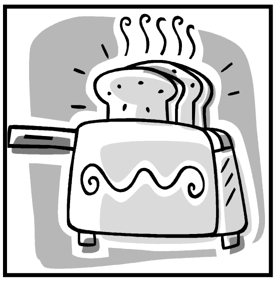
5.


Wave energy


Heat energy


Chemical energy


Magnetic energy


Electrical energy


Elastic energy

Practice Exercise 13

1. **Heat** is the name given to energy as it moves from a hotter object to a cooler one. Heat energy warms our homes in cold places and cooks our food.

   Light is a form of energy. Sunlight is the most important example because it is needed to make plants grow. When we heat things they often give off light.

   Sound is a form of energy. When you hear something, you are detecting the sound. Sounds are made whenever something vibrates.

2. The sun and its light are not only beautiful but vital to our life and survival on this planet. The harmful effects of sunlight come from its ultraviolet (UV) radiation which could be dangerous to our health. An overexposure to UV radiation can cause sunburn, hurt our eyes and even result in skin cancer. It can also result in making you look older by aggravating wrinkles.

   Sound or noise is not just annoying; it is potentially dangerous, both physically and mentally. Sound, or noise, can lead to physical and psychological problems ranging from irritability to migraine headaches. Linked with many such problems is stress, which has been found to cause high blood pressure, insomnia, ulcers, digestive disorders, alcoholism, hearing loss, sleep disturbances, anxiety, and many other ills.

3. The **kundu** drum is the most common musical instrument in Papua New Guinea and is widely used for traditional dancing and singing. Kundu drum has a stretched skin that vibrates when you hit it.

   The **garamu**t drum is made from a log that is hollowed out. When the drum is hit with a stick it makes the air inside vibrate and the hollow shape acts as a sound box to make the sound bigger.

   The **jaw harp** is made from a piece of bamboo that is cut so that one strip is free to vibrate inside a frame. Flutes and whistles may be made from a single piece of bamboo or a conch shell. Pan-pipe flutes are made by trying different lengths of bamboo together and blowing over the top of them.

Practice Exercise 14

1.

Column A	Column B
Object	**Main energy change**
1.Lamp (f)	a. sound to electrical
2. Electric motor (c)	b. electrical to sound
3. Microphone (a)	c. electrical to kinetic
4. Solar cell (e)	d. chemical to kinetic
5. Loud speaker (b)	e. light to electrical
6. Jet engine (d)	f. electrical to light

2. Electrical energy to sound energy (CD player)
Kinetic to heat (moving engine parts)
Electrical to kinetic (electric drill)
Chemical to electrical (battery being used)
Potential to electrical (hydroelectric power station)
Potential to kinetic (springs)
Electrical to heat (flat iron)
Kinetic to heat + sound (rubbing hands)
Electrical to sound + light (television)

3. a. hydrogen
b. petrol
c. petrol and hydrogen

Practice Exercise 15

1. Simple machines transfer energy from one place to another and allow work to be done more easily or in a more convenient way.

2. a. The lever is a simple machine, which consists of a stiff bar that turns about a fixed point called a pivot.
   b. A wheel and axle is a special type of lever.
   c. An inclined plane is a simple machine that allows heavy objects to be raised by smaller forces.
   d. Pulley wheels and belt make up a simple machine by which the energy of turning of a driving wheel can be transferred to another wheel.
   e. In gear wheels, the connecting belt is replaced by special teeth, which mesh directly. The driven wheel will turn in the opposite direction to the driving wheel.
   f. Hydraulics allows work to be done more conveniently by using liquids to transfer the force from one place to another.

3. Machines move a heavy load with a small force.
   Machines change the direction of the force.
   Machines make things go faster.

4. Lever – pliers, wheelbarrow, crowbar
   Wheel and axle – steering wheel, door knobs, screwdrivers
   Inclined plane – screws, axes, jacks
   Pulley wheels and gear wheels – single pulley, double pulleys, bicycle, winches, hand beater, hand drills
   Hydraulics – hydraulic lifts in garages, hydraulic jack

Practice Exercise 16

1. Simple machines transfer energy from one place to another and allow work to be done easily.

2. A lever is a simple machine which consists of a stiff bar that turns about a fixed point called a pivot.

3. Lever is useful because there is force advantage when the effort distance is greater than the load distance.

4. An inclined plane is a simple machine that allows heavy objects to be raised by smaller forces.

5. When an inclined plane is used to raise an object, the same amount of work is done by the smaller force moving a greater distance.
   Long planes with shallow slopes give the greatest ease of lifting.

6. Pulley wheels are used to change the direction of a force. They can also be used to give a force advantage, if a long string or rope is used.

SUB STRAND 4

FORCE AND SIMPLE MACHINES

IN THIS SUB STRAND YOU WILL LEARN ABOUT:

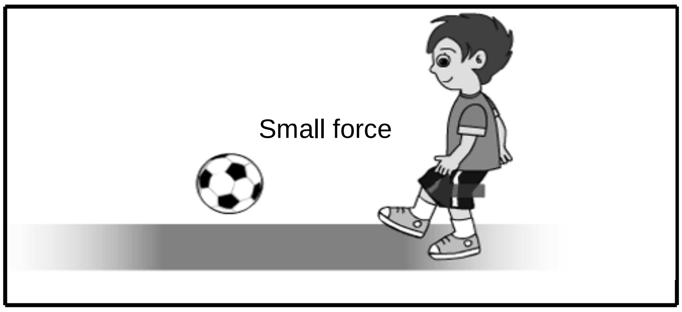
- **TYPES OF FORCES AND ITS USES.**
- **BALANCED AND UNBALANCED FORCES**
- **FRICTION AND FORCE OF FRICTION**
- **ADVANTAGES AND DISADVANTAGES OF FRICTION**
- **MAGNETS AND ITS USES**

SUB STRAND 4: FORCE AND SIMPLE MACHINES

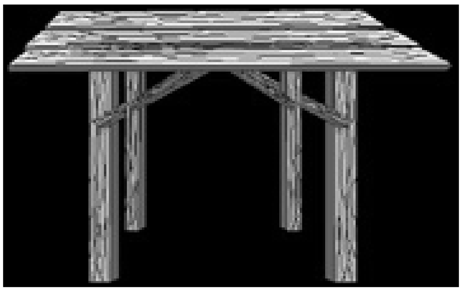
Introduction

A force is a push or pull. Forces make objects start or stop moving – like when you kick or stop a football, you need to put a force on the ball with your foot. Forces can also change an object's shape – like when you crush an empty drinks can.

You know that to make an object go faster (whether a football, a toy car, or a bicycle), the object needs a bigger push. You may not realise that you do this, but you push something harder if you want it to move faster and that is giving it more force!



Force could either be balanced or unbalanced. When things are not moving, the forces are balanced, just like the table. Gravity pulls the table down, but the table is pushed up by the ground it stands on, so the table does not move. The forces are balanced.



In tug of war, usually the weaker team is pulled by the other team, which is stronger. In this case, the forces are not equal and opposite, that is, they are not balanced and hence the weaker team is pulled by the stronger team.

Friction is the force between two surfaces rubbing together. From Sub strand 3, you know what simple machines are. So, you ask questions like

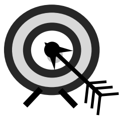
- What is a force of friction?
- How are friction and simple machines related?
- What are the effects of force of friction on simple machines?
- What are the advantages and disadvantages of force of friction?

You may want to know a lot more about force and simple machines.

In this Sub strand you will find the answers to these questions and all other questions relating to force and simple machines.

Lesson 17: Types of Forces

Welcome to Sub strand 4 of strand 3. In the last sub-strand you looked at the different forms of energy and the simple machines. In this sub strand it is all about Force and Simple Machines. It is composed of four lessons, the types of Forces, Balanced and Unbalanced Forces, Friction and Effects of Forces in the community. In this lesson you will look at force.



Your Aims:

- define force
- identify and describe the different types of forces
- discuss the different uses of forces

Forces Around You

When you change the motion or the shape of an object you are applying a force. When you push a supermarket trolley, you apply a force to make the trolley move forward. When you squeeze a blown-up balloon, the force you apply changes the shape of the balloon. When you ride a bicycle, you push the pedals with your feet and turn or twist the handlebars with your arms.

You can use a pushing force to move a trolley.

You use a push or a pull to turn the handlebars of your bike.

In a tug of war, you use a puling force.

You force the door when the door is jammed, you use more force when you are trying to get a car out of a swamp. You force yourself a little more when you have 20 metres left to swim in a 100 metre race. You have often used the word **force**. When you force something, you are usually trying to get it moving. You either push it or pull it. In other words, a **force is a push or a pull.**

Types of forces

There are four major types of forces, which can be easily identified.

1. Gravitational forces

Gravitational forces are caused by the Earth. If a bird suddenly stopped flying and folded its wings up it would fall to the ground. If a pencil is pushed off the edge of a desk it is pulled downwards and falls to the floor. The force pulling the objects down is the force of **gravity.**

2. Magnetic forces

Magnetic forces are caused by magnets. The effect of magnetic forces can be shown by rolling a steel ball-bearing past a magnet. The ball-bearing will have its path changed by the magnetic force from the magnet.

3. Electrical forces

Electrical forces are caused by charged objects. This can be observed when hair is combed with a plastic comb and hair clings to the comb. This is an example of an electrical force in action.

Electrical forces can be seen acting in a laboratory using an electrostatic generator.

4. Elastic forces

Elastic forces make objects change shape. Pieces of foam rubber, a spring or a rubber ball are all examples of situations in which elastic forces can act.

> **REMEMBER**
> A force is a push or a pull.

What do forces do to objects?

Forces can make things change shape, change direction and change speed. For example, a strong person can crush an empty soft drink can (change shape). The force of a football player’s foot can move the ball into the air (change direction). When you get on your bicycle, your foot pushes down on the pedals to get the bicycle moving (change speed).

To make an object move you need a force. Without a force the objects stays still.
Once a body is moving we need a force to stop it. To stop a moving motor car or a bicycle, you need the force of the brakes. When a motor car crashes into a brick wall, the wall exerts a force on the car to stop. Because the force is so great, the car crumbles. Passengers inside the crashed car are held in their seat by a force applied by their seat belts. Without seat belts they would be thrown out of the car.

The force produced by the brakes has slowed down the bike’s wheels.

The space shuttle needs a force from its engines to make it move off the launch pad.

To make an already moving object change direction, you need a force. We exert a force through the steering wheel of a bicycle or the rudder on an aeroplane to make these objects change direction.

To make an object change shape, you need a force. Panel beaters in car repair yards apply forces with a hammer to car panels to reshape them after they are bent in a crash.

REMEMBER
There are four major types of forces. These forces are Gravitational, Magnetic, Electrical and Elastic.

Different uses of forces

A. The pull of gravity

All bits of matter attract each other. The greater the masses of the objects, the greater the force between them. You are attracted by the earth this is why you don't fall off the Earth.

Gravitational force is a non-contact force because it exists between objects even when they are not touching. The gravitational force between the Earth and the Moon keeps the Moon in orbit. Similarly, a gravitational force keeps satellites in orbit around the Earth, and all the planets in orbit around the Sun.

Gravity on the Moon

The Moon has less mass than the Earth. This is why gravity is less on the Moon than it is on Earth. If you jumped on the moon you would not come down as quickly as you do on Earth.

B. Friction

The tyres of a car are able to push against the ground because friction makes them grip the road. The amount of friction between the tyres and road surface also determines the driver's ability to steer or stop a vehicle. Imagine a car rounding a bend. If there is not enough friction between the road and the tyres, the tyres cannot grip the road and the car cannot be turned.

Stopping a car

Skidding car

When the driver of a moving car applies the brakes hard, the wheels lock, that is they are prevented from rotating. This causes the car to skid. Skidding can be dangerous as it is very difficult to steer the car during a skid. The car is slowed down or brought to a stop by the friction between the tyres and the road surface.

C. Magnetic forces

When a magnet attracts an object it is said to be exerting a force. This force is strongest at the ends of a magnet and weakest in the middle of the magnet. The force is called a magnetic force. The closer you bring a magnetic object to a magnet the stronger the magnetic force. Magnets come in different shapes, sizes and uses. These uses include magnetic door catches, cassette tape; can openers, stickers, clips and electric motors.

REMEMBER Forces can make things change shape, change direction and change speed.

Activity 1: Now test yourself by doing this activity.

Circle the correct answer of your choice.

1. An apple false downwards from a tree branch. This motion is caused by

   A. friction B. gravity

   B. elasticity D. air pressure

2. Which situations is the best example of force causing a change in shape?

   A. Blowing up a balloon
   B. Firing an arrow from a bow
   C. Squeezing a piece of wood
   D. Applying the brakes on a car

3. Which objects is the most elastic?

   A. Soft clay
   B. Play dough
   C. Squash ball
   D. Wooden pencil

4. Choose the correct word below to complete each sentence.

pull	**direction**	**move**	**push**	**change**

   A. When you open a door, you __________.
   B. When you lift something, you __________.
   C. Forces can also __________ the shape of an object.
   D. A force can make things __________.
   E. A force can also make moving things change__________.

Summary

You have come to the end of lesson 17. In this lesson you have learnt that:

- a force is a push or a pull.
- there are four major types of forces. These forces are Gravitational, Magnetic, Electrical and Elastic.
- forces can make things change shape, change direction and change speed.

NOW DO PRACTICE EXERCISE 17 ON THE NEXT PAGE.

Practice Exercise 17

Answer the following questions:

1. What is a force?

   ____

2. List the four main types of forces and describe each.

   (i) ____

   (ii) ____

   (iii) ____

   (iv) ____

3. Say whether the following situations are examples of a force causing a change in speed, direction or shape.

   a. Stretching a spring ___________

   b. Turning the steering wheel of a car ___________

   c. Jumping on a mattress of a bed ___________

   d. Hitting a tennis ball with a racket ___________

4. Give example of push, pull, change shape, change direction and change speed.

   Push ______________________________
   Pull ______________________________
   Change of speed ______________________________
   Change of direction ______________________________
   Change of shape ______________________________

5. Complete the sentence. Choose the correct answer from the brackets.

   a. The force of gravity is a ___________ (push/pull)
   b. A force pulls the spring ___________ (up/down)
   c. The stronger the force, the ___________ (more/less) the spring stretches.

CHECK YOUR WORK. ANSWERS ARE AT THE END OF SUB STRAND 4.

An**swers to Activity**

1. B

2. A

3. C

4. a) push

   b) pull

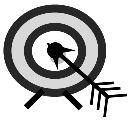
   c) change

   d) move

   e) direction

Lesson 18: Balanced and Unbalanced Forces

Welcome to lesson 18 of strand 3. In the last lesson you learnt about the different types of forces and their uses. In this lesson you will learn about balanced and unbalanced forces.



Your Aims:

- identify balanced and unbalanced forces and
- describe the different forces that changes direction, speeds things up and slow things down

Force And Movement

Imagine you are looking at a tug-of-war between two teams. Each team is pulling on a rope with equal strength but in opposite directions. As a result they are not moving. Does this mean that there is no force acting?

In a tug-of-war both teams are pulling in opposite directions. If each pulls with the same strength, then there is no overall movement.

This situation is an example of forces in **balance**. The pull in one direction is equal to the pull in the opposite direction.
If one team in a tug-of-war pulls with more force than the other, then there is movement in the direction of the greater force. In this case the forces are **unbalanced.**

Sometimes more than one force acts on an object. For example, when you sit on a chair your weight force acts downwards and there is another force, called the **reaction force**, which acts upwards.
When you sit still on a chair you are not moving. This happens because the two forces are **balanced**. They are equal but act in the opposite direction.

Balanced forces - A boy sitting

When a car moves along a straight road at a steady speed, the forces acting on it are **balanced too**. There is the force of the engine driving it forwards and the force of friction trying to slow it down.
When the breaks are applied to a moving car, the car slows down. This is because the force of friction and the force of braking are greater than the force provided by the engine. In this case forces are **unbalanced**. Unbalanced forces make things go faster or slower.

Balanced forces- A running car

REMEMBER
Balanced forces happened when the pull of forces in one direction is equal to the pull of forces in the opposite direction.
Unbalanced forces happened when the pull of force is greater in one direction than in the opposite direction.

Measuring force

A force-meter, often called a **spring balance**, consists of a spring attached to a pointer. A spring stretches when a pulling force acts on it, and is squashed or compressed when a pushing force acts on it. The bigger the force, the more it is stretched or compressed. For this reason, a spring can be used to measure the strength of forces. A pointer attached to the spring moves as the spring changes its length and the force can be read on a scale. To measure larger forces you use a stronger spring. Spring balances measure pulls and kitchen or bathroom scales measure pushes.

Kitchen scales

The unit used to measure force is the Newton (N), named after Sir Isaac Newton, the famous British scientist.
You can also use force measurers in a horizontal position. For example, you can use a spring balance to measure the force needed to pull a door open.

Spring balance

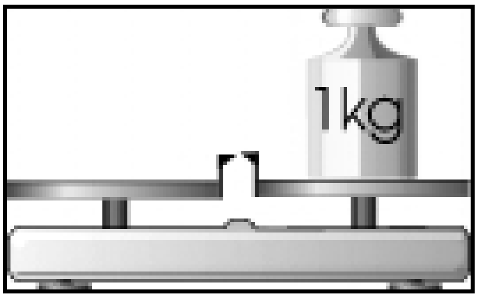
The table below gives you some idea of the approximate sizes of some forces.

Force to lift an apple	1 N
Force to lift 1kg bag of sugar	10 N
Force you exert by sitting on a chair	500 N
Force needed to launch space shuttle	33 000 000 N

What is the difference between mass and weight?
In order to avoid confusion it is very important to understand some definitions that are universally accepted by scientists; namely,

1. The **mass** (of an object) is a measure of the object's inertia and it is measured in kilograms. If matter is neither added to, nor deleted from, the object, then its mass never changes.

   Mass is measured using a balance whereby an object's mass is compared to another object whose mass has been defined.



   A used balance is for measuring mass because a balance compares an object's mass to a set of standard masses.

2. The **force** (on an object) is a measure of the amount of a push or pull exerted on an object and it is measured in newtons.

3. The **weight** (of an object) is the local force of gravity on an object and it is measured in units of newtons using a spring scale.

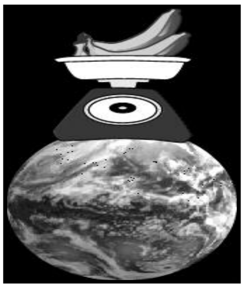
   A spring scale is used for measuring weight because it measures the force of gravity pulling objects downward.

The scales of weighing machines are usually marked in mass units (kilograms). This is why most people think mass and weight are the same, even though they aren't. When you weigh yourself, you are measuring the pull of gravity on you. And this is a force, not a mass.

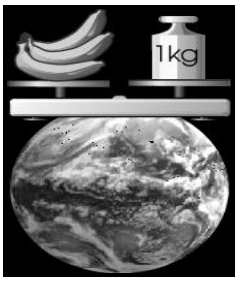
REMEMBER: Mass is measured in kilograms and weight is measured in newtons.

Mass and Weight

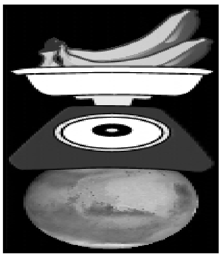
An object's mass is a universal constant or it does not change, whereas an object's weight depends upon its location. For example,



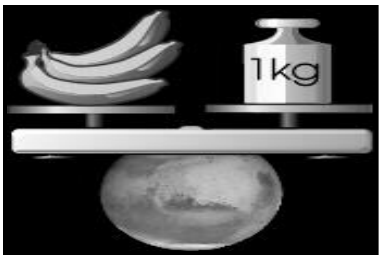
1 kg of bananas weighs 9.8 N on Earth.



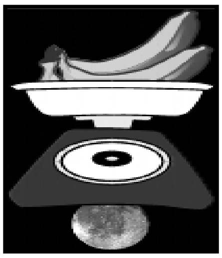
1 kg of bananas has a mass of 1.0 kg on Earth.



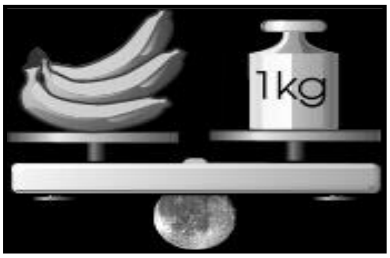
1 kg of bananas weighs 3.7 N on Mars.



1 kg of bananas has a mass of 1.0 kg on Mars (even if they're Martian bananas).

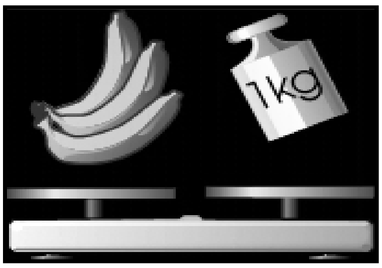


1 kg of bananas weighs 1.7 N on the Moon.



1 kg of bananas has a mass of 1.0 kg on the Moon.

1 kg of bananas weighs 0.0 N (they are weightless) on outer space.

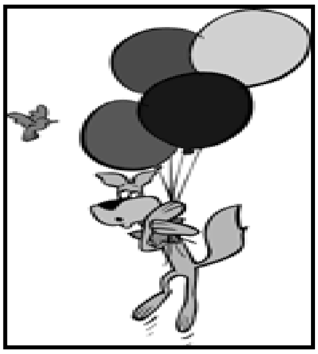


1 kg of bananas has a mass of 1.0 kg in outer space but a balance won't work here!

The moon has less mass than the Earth. So the moon would not attract you as strongly as the Earth does. This is why gravity is less on the moon than it is on Earth. Your mass does not change, but your weight does. You can jump higher on the moon, and you don't come down as quickly as you would on Earth.

Forces that changes shape, direction and speed
Forces can make things change shape, direction and speed. For instance, a strong person can produce a force big enough to stretch a chest expander or squash a can out of shape.
The force from a tennis player's racquet can change the direction in which the ball is travelling. The force produced when you push on your bike pedals makes the bike begin to move, then speed up. A force from the brakes slows it down, and then stops it.

Elastic objects
When you push on a rubber ball it changes shape. When you stop pushing on it, it returns to its original shape and size. Objects that return to their original shape and size after a force has been removed are said to be **elastic**. A rubber band is elastic, so is a blown up balloon.
Some objects do not return to their original shape or size after a force has been removed-such objects are said to be **inelastic** or plastic. Soft clay, play dough and plasticine are inelastic objects. If you pull too hard on some elastic objects they may not return to normal. When this occurs we say their elastic limit has been exceeded.



Balloon – an elastic object

Brick wall– an inelastic object

Friction
Many forces affect the speed of a moving car. For example, when you roll a ball across a carpet, friction between the ball and carpet acts against the motion or movement of the ball, slowing it down. If you are rolling along the road on a skateboard, the board eventually slows down because of friction between its wheels and the road.

Friction is a force that slows down or prevents movement. It is produced when two surfaces rub together. The rougher the two surfaces the greater the friction.
When you apply the brakes on a bicycle, the brake-block is pressed against the wheel rim and the force of friction slows the turning wheel.

Smooth surfaces=less friction

Rough surfaces=more friction

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

1. Complete these statements. Choose the words from the given below:

newton	**friction**	**pulls**	**surface**
mass	**weight**	**gravity**	

a. Forces are pushes or __________.
b. Forces are measured in __________ using spring balance and scales.
c. __________ is a force that occurs when two things rub against each other. It slows down or prevents motion.
d. Friction depends on the roughness or smoothness of the __________, and the weight of the object.
e. __________ is a force of attraction between any two objects, eg between the Sun and a planet.
f. The __________of an object is the downwards pull of gravity on it. The __________ of an object is the amount of matter in it.

2. True or False. State whether the statement is true or false.

a. Mass and weight are the same. __________

b. Weight depends on gravity. __________

c. An astronaut has the same mass on the moon as on Earth.__________

d. An astronaut weighs the same on the moon as on the Earth. __________

e. The moon's gravity is stronger than the Earth's gravity. __________

Summary

You have come to the end of lesson 18. In this lesson you have learnt that:

- balanced forces happened when the pull of forces in one direction is equal to the pull of forces in the opposite direction.
- unbalanced forces happened when the pull of force is greater in one direction than in the opposite direction.
- the unit used to measure force is the Newton (N), named after Sir Isaac Newton.
- mass and weight are not the same.
- forces can make things change shape, direction and speed.

NOW DO PRACTICE EXERCISE 18 ON THE NEXT PAGE.

Practice Exercise 18

Answer the following questions:

1. Match column A with column B. Write the correct word from column B on the space provided next to column A

	Column A		Column B
a.	Unit of force	___________	force
b.	Push or pull	___________	friction
c.	Measures force	___________	newton
d.	A pull from large body	___________	gravity
e.	Force that exists when one surface rubs on another	___________	spring balance

2. Complete these sentences.

a. Mass is the amount of __________ in an object. It is measured in ___________.

b. Weight is a downward ___________ due to gravity. It is measured in ___________.

c. The stronger the gravity, the ___________ something weighs; the weaker the gravity, the ___________ the weight.

3. Define friction.

____
____
____

4. Explain the difference between mass and weight.

____
____
____
____

5. Describe balanced from unbalanced forces.

____
____
____
____
____

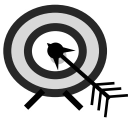
CHECK YOUR WORK. ANSWERS ARE AT THE END OF SUB STRAND 4.

Answers to Activity

1. (a) pull
   (b) Newton
   (c) Friction
   (d) surfaces
   (e) gravity
   (f) weight / mass
2. (a) False
   (b) True
   (c) True
   (d) False
   (e) False

Lesson 19: Friction

Welcome to lesson 19 of Strand 3. In the last lesson you learnt about the different forces that changes direction, speed things up and slow things down. In this lesson you will learn what friction is.

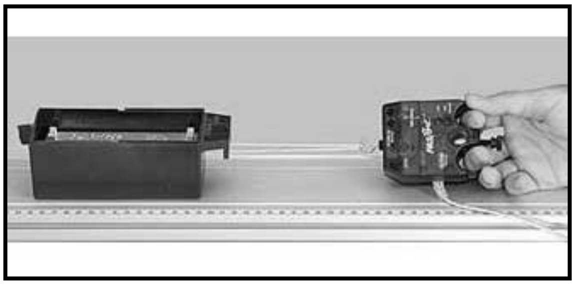


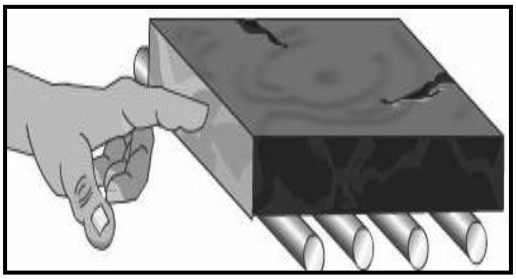
Your Aims:

- define friction and force of friction
- identify the advantages and disadvantages of friction
- identify the effects of force of friction on machines

What Is Friction?

Friction is an example of contact force. It occurs whenever two surfaces in contact move past each other. Friction always opposes motion. Suppose you try to push a bookcase full of books, and it does not move. This is because of the friction between the bookcase and the floor. This frictional force is equal to your push but in the opposite direction.



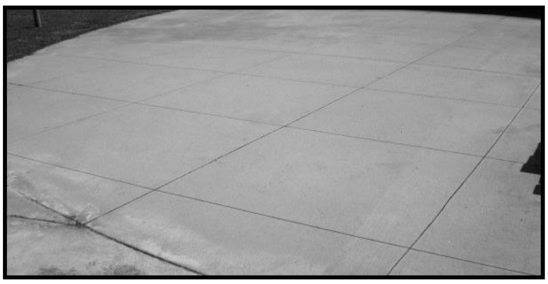


Sliding and rolling friction - slows you down

What causes friction?

If you use a powerful microscope to look at a surface which seems flat, you will find that it is not flat at all. It is full of bumps and hollows. Rough surfaces, of course, have more bumps and hollows than smooth surfaces.

When two surfaces rub together the tiny bumps and hollows lock together. This is what causes friction. The heavier the object on top, the more the bumps and hollows lock together, and the greater the friction.



Smooth surfaces

Rough surfaces

REMEMBER: Friction is a force that slows down or prevents movement.

Frictional forces occur because objects can never be completely smooth. The size of the frictional forces depends upon

1. The roughness of the two surfaces that are in contact. Rough surfaces have more points that can act to stop easy slipping. This is the reason why car tyres and climbers' boots have rough treads on them.
2. The force pushing the two surfaces together. It is much easier to slide an empty box over the floor than a full one.

Friction in everyday life

We use friction every day. Sometimes we need friction and other times we try to reduce it. When we walk, we use friction between our shoes and the ground. Imagine trying to walk if there was no friction. This would be like walking on ice or a highly polished floor. Friction also prevents knots from coming undone, and holds nails and nuts and bolts in place. Friction is often a nuisance because it makes things wear out and get hot. However it can also be of use to us. It stops the tyres of a car slipping on the road. It also acts when brakes on a car or truck are used. Friction produces heat. This can be useful when you rub a match on the side of a match box but it can cause a car engine to overheat.

Walking

Light a match

Reducing friction

By reducing friction between moving parts in a machine, less energy is needed to work the machine. Also, there is less wear of the moving parts and they do not get as hot. There are a number of ways friction can be reduced.

1. **Lubrication**
   The two contact surfaces may be lubricated. This means that an oily substance is placed between the two surfaces to allow them to slide over each other more easily. This is important in engine and other machines.
2. **Bearings**
   Ball-bearings and roller bearings are used in many types of machines. These make the surfaces roll over one another rather than slide over one another. This reduces friction by large amount.

Ball and roller bearings reduce friction greatly.

3. **Smoothing**
Surfaces in contact can be smoothed so that they slide over one another very easily. Canoes are made as smooth as possible so that they can slide through the water without the water slowing them down too much. The moving parts without the engine are always very smooth to reduce friction.

Canoe

4. **Streamlining**
Cars, aeroplanes and racing motors cycles are all shaped in a special way. They are streamlined to reduce friction with the air. When they are moving very quickly through the air or water there is very little drag on them.

5. **Air cushions**
If air is blown between the two surfaces, friction becomes very small. This is the principle on which a hovercraft works.

Air cushions

REMEMBER: The force of friction opposes the motion of one surface over another.

Increasing friction

Friction is not always a problem. Often friction needs to be increased. This can be done by:

- Making the surface rough as in the thread in the tyre
- Using a large force to hold the two surfaces together such as tying a knot tightly so it does not slip.

Sometimes friction is made larger to give a better grip. The air scoop on the roof of a racing car forces the car onto the track harder. As a result, friction is increased and the car goes around corners more quickly.

The air scoop on the back of a racing car

If friction is to be used to wear a surface away, a rough surface such as a file or sandpaper can be used. Sometimes friction is used to generate heat. This is used when a match is struck to produce a spark to light the match.

Our bodies, like machines, also have moving parts. Where bones slide each other at joints it is important to reduce friction. Because of this there is a lubricating fluid between them to make them slide more easily. If this lubricating system doesn't work properly, you get swelling and pain in your joints. This is called arthritis.

The human hip joint.

The human knee joint

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

Answer the following questions:

1. What is a friction?

2. What causes friction?

3. What two things do the size of frictional forces depends upon?

4. What are the ways to reduce friction? Describe each.

Summary

You have come to the end of lesson 19. In this lesson you have learnt that:

- the force of friction opposes the motion of one surface over another.
- the size of the frictional forces depends upon:
  a. The nature of the surface that are rubbing together
  b. The force that pushes the two surfaces together.
- friction causes resistance to motion, wear and heat
- friction has effects that have both advantages and disadvantages.
- friction can be reduced by:
  a. Using lubricants
  b. Using ball and roller bearings
  c. Smoothing the sliding surfaces
  d. Using streamlining
  e. Using air between the surfaces.
- friction can be increased by:
  a. Make the sliding surfaces rougher
  b. Using a larger force to press the surfaces together
- friction is made larger to give more grips, to wear materials away or to produce heat.

NOW DO PRACTICE EXERCISE 19 ON THE NEXT PAGE.

Practice Exercise 19

Answer the following questions:

1. Define friction.

____

____

2. The size of the frictional forces depends upon two things. What are these?

(i) ____

(ii) ____

3. What are the two things needed to increase friction?

(i) ____

(ii) ____

4. What do you need to do to reduce the friction?

____

____

5. Complete the sentence.

a. Lubrication __________ (increases/decreases) friction.

b. With lubrication, you need __________ (more/less) force to move an object.

c. When an object slides, there is __________ (more/less) resistance to movement than when it rolls.

d. Friction depends on the roughness or smoothness of the __________ and the weight of the object. (surface/matter)

e. __________ is a contact that occurs when two things rub against each other. (force/friction)

CHECK YOUR WORK. ANSWERS ARE AT THE END OF SUB STRAND 4.

Answer to Activity

1. Friction is a force that slows down or prevents movement.

2. Surfaces are full of bumps and hollows. Rough surfaces of course have more bumps and hollows than smooth surfaces. When two surfaces rub together the tiny bumps and hollows lock together. This is what causes friction.

3. a. The roughness of the two surfaces that are in contact. Rough surfaces have more points that can act to stop easy slipping.
   b. The force pushing the two surfaces together.

4. **Lubrication** is an oily substance is placed between the two surfaces to allow them to slide over each other.

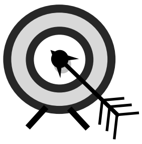
   Bearings make the surfaces roll over one another rather than slide over one another.

   Smoothing the surfaces in contact can be smoothed so that they slide over one another very easily.

   Streamlining is when cars, aeroplanes and racing motors cycles are all shaped in a special way. They are streamlined to reduce friction with the air.
   Air cushions is when air is blown between the two surfaces, friction becomes very small.

Lesson 20: Magnets

Welcome to lesson 20 of Strand 3. In the last lessons you learnt about forces. You have identified and described the different types of forces. In this lesson you will learn about one such type of force called the magnetic force. To better understand this force, we will study in more detail the magnets and how they work.



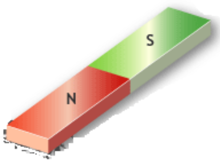
Your Aims:

- do simple activities with magnets to understand their properties
- describe what magnetic poles are, and how they behave
- give examples of the many uses of magnets and electromagnets

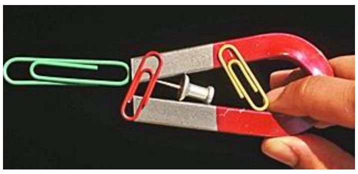
and electromagnets

What Is A Magnet?

A **magnet** is an object which is able to attract magnetic materials such as iron. Magnetic materials can be made into magnets. If you hang a magnet on a piece of string (suspend), one end will point towards the North Pole. Because of this property, magnets usually have their ends labeled as north and south **poles.** Magnets can come in all sorts of shapes. The most common shapes are bar magnets which are rectangular and horseshoe magnets, which is circular and round in shape.



Bar magnet



Horse shoe magnet

Activity 1: Now test yourself by doing this activity.

Prepare the materials and follow the method.

Part A: What things can a magnet attract?

Materials
- A bar magnet
- Samples of wood, nails, glass, plastic, pins and pot lid

Methods
1. Test each of the materials to see which are attracted to the magnet, and which are not.
2. Record your findings in the data table below. Put a tick ( ) it attracts or an (x) if it does not attract.

Data Table:

Name of Material	Attracted to magnet/ Not attracted to magnet
Wood	
Glass	
Nails	
Plastic	
Pins	
Aluminium foil	

3. What did you find out from your experiment?

____

____

____

Part B: Magnet: which part is the strongest?

Materials:

- A bar magnet and a horseshoe magnet
- A box of paperclips

Method:

1. Label one end of the magnet A and the other end B if your magnet has not been labelled.
2. Hold the bar magnet flat over the pile of paper clips
3. Lift up the magnet and observe.

(i) Which part of the magnet is holding the most paperclips?

____

____

(ii) Which part holds the least?

____

____

4. Draw a diagram of what you saw.

Box 1	Box 2

5. If you can find a horseshoe magnet repeat the steps 1-4 and draw the diagram in box 2.
6. Write a general statement about the number of paper clips held and the strength of the magnet at A and B.

____

____

____

____

Part C: Attract or Repel?

Materials

- 2 bar magnets with poles marked or labelled A and B

Methods

1. Hold 2 bar magnets (as shown in diagrams a to d below) near each other as the diagram below shows

2. Record whether the magnets attract (pull towards) each other or repel (push away) from each other.

3. Write a general statement about what you observed.

____

____

____

Magnet Position

a)	N S	N S	________
b)	S N	S N	________
c)	N S	S N	________
d)	S N	N S	________

Some fact about magnets

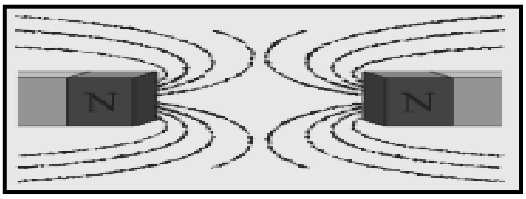
In the previous lesson, you learnt that forces are pushes or pull. From the experiments you have done with magnets, you can see that a magnet can push or pull something, without even touching it. This magnetic force is strongest near a magnet, and weakens as you get further away.

Magnetic forces affect only those materials that contain **iron, nickel** or **cobalt**. An **alloy** (is a metal made up of more than one metal mixed together). Steel and rust are examples of alloys, and can be affected by a magnet. Magnets are made of materials that contain one or more of these metals. Brass is an alloy made up of copper and zinc.

You found during the experiment that the ends of a magnet are more magnetic than the middle. These are the poles of the magnet. The magnetic field is strong near the poles of the magnet, weaker in the middle and gets weaker as you move away from the magnet. If you suspend a magnet it always points north-south. The end that points north is called the **North Pole**. The other end is called the **South Pole**.

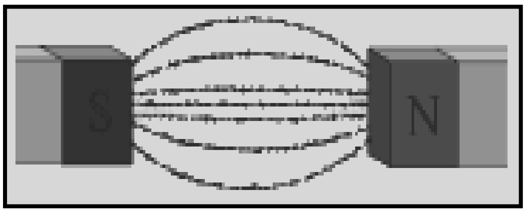
Behaviour of magnets

If the North poles of two magnets are placed near each other, they will repel each other.



Pictured here are two magnets placed on a piece of paper with their like poles facing each other, and iron filings are sprinkled around them

But if the North Pole is placed closed to the south pole of the other magnet they will attract.



The same also goes for two south poles. On the other hand, the north pole of one magnet will attract the south pole of another magnet. This can be summed up like this:

Like poles repel; unlike poles attract

Using magnets

Magnets come in many different shapes and sizes. They have many different uses. For examples in the kitchen you find magnetic door catches, can openers and knife holders. The refrigerator has a magnetic door seal, and probably has magnetic stickers and clips on it.

Audiotapes and videotapes are made of plastic with a thin coating of magnetic material. Each centimeter of tape contains millions of tiny particles, each acting like a magnet. As the tape passes through the machine, sounds are either recorded onto the tape or played from the tape. Because tapes and discs are magnetic they are affected by magnets and therefore should be kept away from them.

All electric motors have magnets in them, and so do many other modern devices such as loudspeakers.

Magnetic tape in an audiotape

Magnetic in a loud speaker

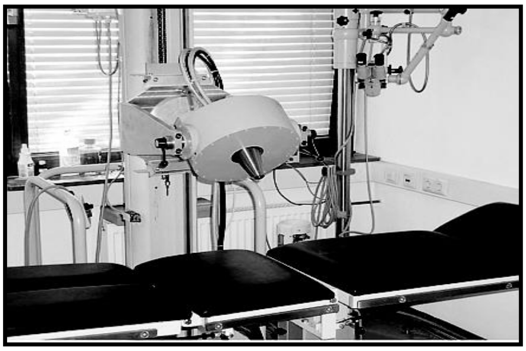
Electromagnets

Bar magnets and horseshoe magnets are called permanent magnets. Provided they are treated properly, their magnetism remains constant.

An **electromagnet** is a temporary magnet which needs electricity to make it work. To make an electromagnet, you wind a coil of wire around a piece of iron. When you pass electricity through the coil, the iron becomes a magnet.

Electromagnets are very useful because you can turn them on and off. Their magnetism is only temporary. If you use a permanent magnet to pick up some pins, you have a lot of trouble getting the pins off the magnet. However, if you use an electromagnet, you simply turn off the electricity and the pins fall off. An electromagnet is similar to a permanent magnet, but it can be turned on and off by turning the electricity on and off.

Electromagnets in scrap yard cranes



Electromagnet used in hospitals

Uses of electromagnets

Some instruments which uses electromagnets.

- Ear piece used in telephones
- Electric motor used in vehicles
- Electric bells used in schools and on doors

Activity 2: Now test yourself by doing this activity.

Part A. Complete the sentences below.

1. A substance which is attracted to a magnet is said to be a __________.
2. A magnet can exert a __________ on a piece of iron without touching it.
3. All magnets have two __________.
4. One end of a magnet is called __________. The other end is called the __________.
5. Like poles __________, and __________ poles attract.

Part B. Answer the following questions briefly.

1. Why do you use the ends of a bar magnet to pick up small iron or steel objects?
   ____
   ____

2. Flour is usually passed near a magnet before being packed. Suggest a reason for this.
   ____
   ____

Summary

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

- a magnetic force can push or pull something without touching it.
- the magnetic force is strongest at the ends of magnets. The ends are called poles.
- like poles repel each other, unlike poles attract each other.
- a magnetic field exists anywhere that the force of a magnet acts.
- magnetic forces are weaker further away from a magnet.
- an electromagnet is a temporary magnet made from a coil of wire wound round a piece of iron: the electromagnet works when electricity passes through the wire.

NOW DO PRACTICE EXERCISE 20 ON THE NEXT PAGE.

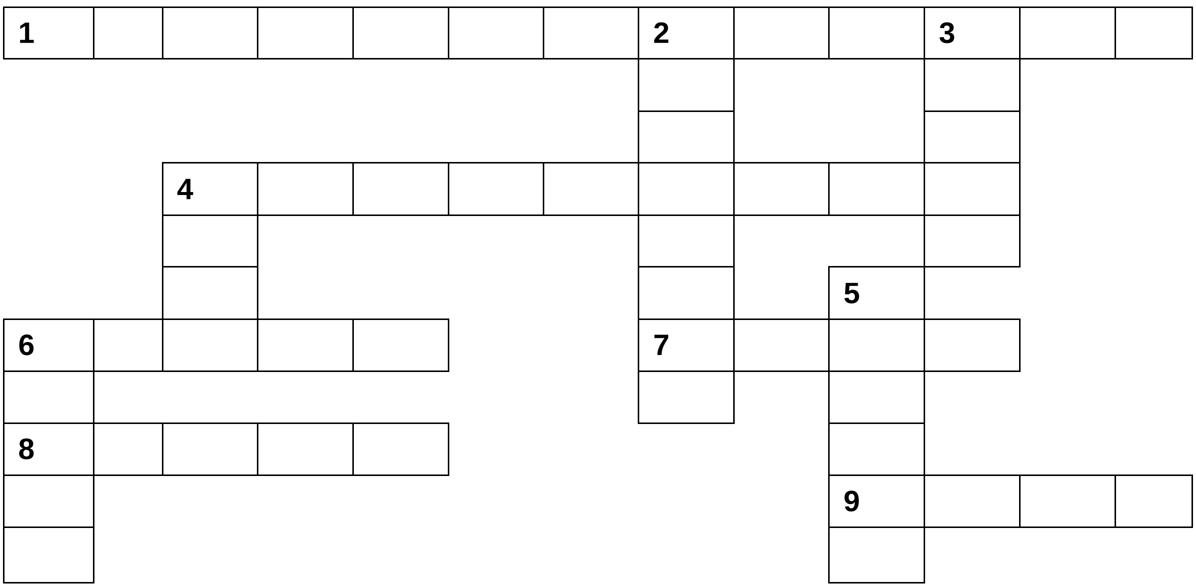
Practice Exercise 20

Part A. **Choose from the words below to complete the sentence. You can use one word twice.**

poles	**iron**	**decreases**	**repel**	**cobalt**
attract	**metals**	**push or pull**	**like poles**	**nickel**

1. Magnets can be made of __________ or __________ or __________.
2. When two magnets push each other apart, we say they __________.
3. Any __________ objects can be picked up by a magnet.
4. A north pole will __________ a south pole.
5. Like poles __________ each other.
6. As you move away from the magnet the magnetic force __________.
7. The magnet is strongest at the __________.
8. Two south poles or two north poles are called __________.
9. Magnets can __________ on something without touching it.

Part B. **Answer the crossword.**



ACROSS CLUES
1 Temporary magnet
4 Magnet that keeps its strength
6 Area around magnet
7 Attracted to magnets
8 Push away
9 These poles repel

DOWN CLUES
2 Type of force
3 Opposite of south
4 End of magnet
5 A magnetic material
6 A push or pull

CHECK YOUR WORK. ANSWERS ARE AT THE END OF SUB STRAND 4.

Answers to Activity

Activity 2

Part A

1. magnetic substance
2. force
3. poles
4. north pole/south pole
5. repel/unlike

Part B.

1. The end of the bar magnet is used to pick up small iron or steel objects because the ends of the magnet are more magnetic than the middle part.
2. Before the flour is packed it is passed near a magnet so that any small metals in the flour can be picked up by the magnets.

REVIEW OF SUB STRAND 4: FORCE AND SIMPLE MACHINES

Revise all the Lessons in this Sub Strand and then do **ASSIGNMENT 4.**
Here are the main points to help you revise.

Lesson 17: Types of Forces

- A force is a push or a pull
- There are four major types of forces. These forces are Gravitational, Magnetic, Electrical and Elastic
- Forces can make things change shape, change direction and change speed.

Lesson 18: Balanced and Unbalanced Forces

- Balanced forces happened when the pull of forces in one direction is equal to the pull of forces in the opposite direction.
- Unbalanced forces happened when the pull of force is greater in one direction than in the opposite direction.
- The unit used to measure force is the Newton (N), named after Sir Isaac Newton.
- Mass and weight are not the same.
- Forces can make things change shape, direction and speed.

Lesson 19: Friction

- The force of friction opposes the motion of one surface over another.
- The size of the frictional forces depends upon:
  a. the nature of the surface that are rubbing together and
  b. the force that pushes the two surfaces together.
- Friction causes resistance to motion, wear and heat.
- Friction can be reduced by:
  a. using lubricants
  b. using ball and roller bearings
  c. smoothing the sliding surfaces
  d. using streamlining
  e. using air between the surfaces.
- Friction can be increased by:
  a. make the sliding surfaces rougher
  b. using a larger force to press the surfaces together
- Friction is made larger to give more grips, to wear materials away or to produce heat.

Lesson 20: Magnets

- A magnetic force can push or pull something without touching it
- The magnetic force is strongest at the ends of magnets. The ends are called poles.
- Like poles repel each other, unlike poles attract each other.
- A magnetic field exists anywhere that the force of a magnet acts.
- Magnetic forces are weaker further away from a magnet.
- An electromagnet is a temporary magnet made from a coil of wire wound round a piece of iron: the electromagnet works when electricity passes through the wire.
- An electromagnet is similar to a permanent magnet, but it can be turned on and off by turning the electricity on and off.

REVISE WELL AND THEN DO SUB STRAND TEST 4 IN YOUR ASSIGNMENT 4.

Answers to Practice Exercises 17- 20

Practice Exercise 17

1. A force is a push or a pull.

2. (i) Gravitational forces are caused by the Earth.

   (ii) Magnetic forces are caused by magnets.

   (iii) Electrical forces are caused by charged objects.

   (iv) Elastic forces make objects change shape.

3. a. shape

   b. speed

   c. shape

   d. direction

4. Push - moving the trolley of grocery

   Pull - playing tug of war

   Change of speed - the force produced by the brakes has slowed down the bike's wheel.

   Change of direction - the ball has moved away from the racquet in a different direction.

   Change of shape - the springs have changed shape.

5. a. pull

   b. up

   c. more

Practice Exercise 18

1. a. Unit of force — Newton
   b. Push or pull — Force
   c Measures force — Spring balance
   d. A pull from a large body — Gravity
   e. Force that exists when one surface rubs on another — Friction

2. a. matter
   b. kilograms
   c. force
   d. Newton
   e. heavier
   f. lighter

3. Friction is a force that slows down or prevents movement. It is produced when two surfaces rub together.

4. Mass is the quantity of matter in an object. It is measured in grams or kilograms.
   Weight is a force measured with spring balance. It is the downward force of gravity

5. Balanced forces happened when the pull of forces in one direction is equal to the pull of forces in the opposite direction.
   Unbalanced forces happened when the pull of force is greater in one direction than in the opposite direction.

Practice Exercise 19

1. Friction is a force that slows down or prevents movement.

2. a. The nature of the surface that are rubbing together

   b. The force that pushes the two surfaces together.

3. a. Make the sliding surfaces rougher

   b. Using a larger force to press the surfaces together

4. a. Using lubricants

   b. Using ball and roller bearings

   c. Smoothing the sliding surfaces

   d. Using streamlining

   e. Using air between the surfaces.

5. a. decreases

   b. less

   c. more

   d. surface

   e. friction

Practice Exercise 20

1. iron or nickel or cobalt.
2. repel.
3. metal
4. attract
5. repel
6. decreases.
7. poles.
8. like poles.
9. push or pull

Part B.

1E	L	E	C	T	R	O	**2** M	A	G	**3** N	E	T
							A			O		
							G			R		
		4 P	E	R	M	A	N	E	N	T		
		O					E			H		
		L					T		**5** C			
6F	I	E	L	D			**7** I	R	O	N		
O							C		B			
8R	E	P	E	L					A			
C									**9** L	I	K	E
E									T			

GLOSSARY

Alloy	Produced when different metals are mixed together and with special properties.
Brittle	Solids which crumble and break apart if you try to bend them.
Brownian	The random movement of particles of substance in a fluid or a gas and was discovered by Robert Brown.
Chemical Change	When matter changes and new substances are formed.
Condensation	Change of state where a substance changes from gas to liquid.
Conductors	Materials which allow heat and electricity to flow through them.
Diffusion	The process of intermixing two substances (liquids or gases) so as to form a uniform mixture, without any external aid.
Ductile	Can be stretched and drawn into wires.
Elastic	Materials which can be stretched and will return to their original shape when released.
Electromagnet	A temporary magnet made from a coil of wire wound round a piece of iron: the electromagnet works when electricity passes through the wire.
Energy	A measure of the ability to do work.
Evaporation	Change of state where a substance changes from liquid to gas.
Force	Push or a pull.
Freezing	Change of state where a substance changes from liquid to solid.
Insulators	Materials which do not allow heat and electricity to flow through them.
Malleable	Flexible and will bend without breaking.
Matter	Anything that has mass and takes up space.
Melting	Change of state where a substance changes from solid to liquid.
Physical Change	A change in physical properties and does not produce a new substance.
Physical Properties	The special features or characteristics of a substance.
Radiant Energy	The energy that can travel through space and air in the form of electro-magnetic rays.
Saturated Solution	Enough solute is added that the solvent cannot dissolve any more of it and settle at the bottom of the container.
Simple Machine	Allows work to be done more easily.
Solution	When a substance dissolves in another substance.
Strength	The property of a substance that allows it to retain its shape when twisted pulled or crushed.
Sublimation	Change of state where a substance changes from solid to a gas or from gas to a solid, without going through the liquid state.
Unsaturated Solution	All the solute added dissolves in the solvent forming a weak or strong solution.

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3	CENTRAL	C/- FODE HQ	3419228	72228110	72229050
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8	KAVIENG	P. O. Box 284, Kavieng	9842183	72228136	72229069
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21	WABAG	P. O. Box 259, Wabag	5471114	72228120	72229082
22	WEWAK	P. O. Box 583, Wewak	4562231/4561114	72228122	72229062

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.

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.

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

CERTIFICATE IN MATRICULATION STUDIES		
No	**Compulsory Courses**	**Optional Courses**
1	English 1	**Science Stream:** Biology, Chemistry and 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.