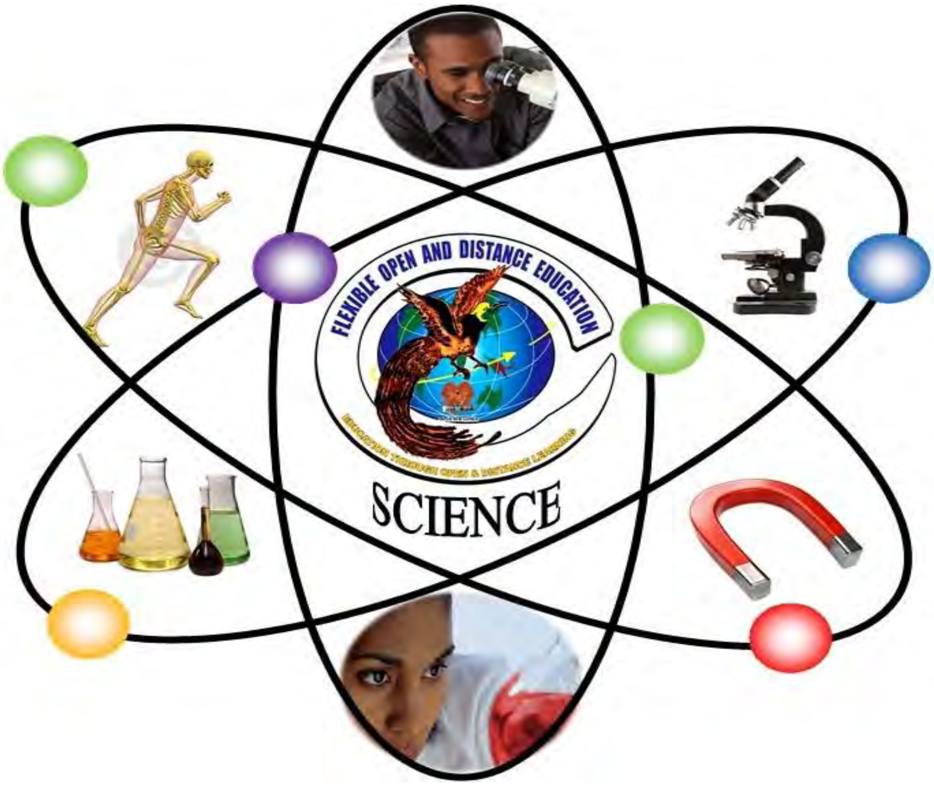
DEPARTMENT OF EDUCATION

GRADE 8

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
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GRADE 8

SCIENCE

STRAND 3

SCIENCE IN THE HOME

SUB STRAND 1: PHYSICAL PROPERTIES OF MATTER

SUB STRAND 2: ACIDS AND BASES

SUB STRAND 3: HEAT AND ELECTRICAL ENERGY

SUB STRAND 4: 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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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 this course.

DR. UKE KOMBRA PhD
Secretary for Education

STRAND 3: INTRODUCTION

Dear Student,

Welcome to Strand 3 of your Grade 8 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:

- **Physical Properties of Matter**
- **Acids and Bases**
- **Heat and Electrical Energy**
- **Simple Machines**

There are five Lessons in the first Sub strand. The lessons will discuss about the physical properties of matter. It will also tackle the structure and behaviour of matter in solids, liquids and gases. You will also learn from this Sub strand about the properties of metals.

The second Sub strand is composed of five Lessons and will discuss about heat and electrical energy. You will also learn in this Sub strand the common sources of heat, movement of heat, electrical circuits, uses of heat and how electricity is being produced.

In the third Sub strand, there are five Lessons that will discuss about acids and bases. It will also talk about the acidic and basic substances and its uses, the common laboratory acids and bases, the importance of indicators and neutralisation process.

The last Sub strand has also five Lessons. It will talk about the simple machines. You will also learn from this Sub strand the uses of simple machines, types of forces, the advantages and disadvantages of simple machines, how energy and work are measured and the efficiency of simple machines.

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 do not hesitate to inform the Science Department at FODE Headquarters. This will help the teacher to revise the lessons for the next edition.

You may study this 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: Properties 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 advice 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

PHYSICAL PROPERTIES OF MATTER

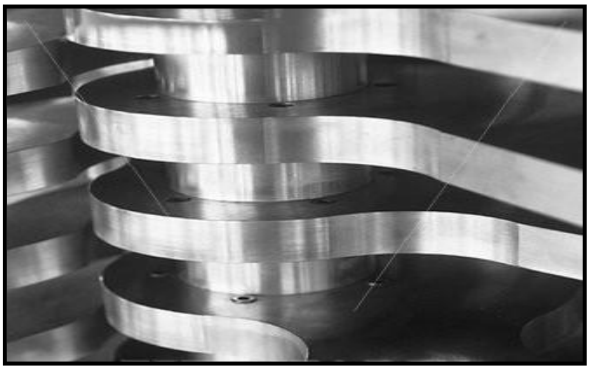
In this sub strand you will learn about:

- **properties of matter**
- **properties of solids**
- **properties of metals**
- **properties of liquids**
- **properties of gases**

SUB STRAND 1: PHYSICAL PROPERTIES OF MATTER

Introduction
All substances have properties that we can use to identify. For example, we can identify a person by their face, voice, height, finger prints and DNA. The more of these properties that we can identify, the better we know the person is. In a similar way matter has properties.

The properties of a substance are characteristics that are used to identify or describe it. When we say that water is "wet", or that silver is "shiny", we are describing materials in terms of their properties. There are two basic types of properties that we can associate with matter. These properties are called Physical properties and Chemical properties. This Sub strand we will only focus physical properties.



Shiny metals

Physical properties can be observed or measured without changing the composition of matter. Physical properties are used to observe and describe matter. Examples of physical properties are: colour, smell, freezing point, boiling point, melting point, infra-red spectrum, attraction (paramagnetic) or repulsion (diamagnetic) to magnets, opacity, viscosity and density. Note that measuring each of these properties will not alter the basic nature of the substance.

The smell of fresh fruits

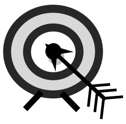
The density of oil and water

Some questions such as the following maybe be raised:
- How the particle arrangements of matter affect its states?
- What are the different properties of solids, liquids and gases?
- How are metals related to the different properties of solid matter?

In this Sub strand, you will find the answers to these questions and other questions relating to the physical properties of matter.

Lesson 1: Properties of Matter

Welcome to Lesson 1 of Strand 3, Properties of Matter. In Grade 7 you studied matter; its composition, structure and behaviour. You also learnt that matter has three different states. In Grade 8 you, will continue to study matter in detail and see how they are made and what they do. In this lesson you will learn about the different states of matter and their properties.



Your Aims:

- discuss and draw the particle arrangement of matter
- describe the physical properties of matter

What Is Matter?

Matter is anything that has mass and takes up space. Everything around you is made up of matter. Your shirt is made up of matter; you are made of matter too.

Is a book matter? What do you think? Does it have mass and occupies space? Of course! The book is heavy therefore it has mass. And yes! It does occupy a space on your table. So a book is definitely a matter. Matter behaves differently in its different states.

States of Matter

Gases, liquids and solids are all made up of microscopic particles, but the behaviors of these particles differ in the three phases.

Note that:

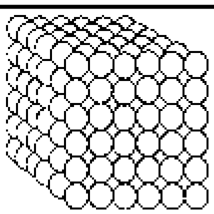
- Particles in a:
    - gas are well separated with no regular arrangement.
    - liquid are close together with no regular arrangement.
    - solid are tightly packed, usually in a regular pattern.
- Particles in a:
    - gas vibrate and move freely at high speeds.
    - liquid vibrate, move about, and slide past each other.
    - solid vibrate (jiggle) but generally do not move from place to place.

Liquids and solids are often referred to as **condensed phases** because the particles are very close together.

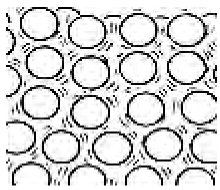
The following table summarizes properties of gases, liquids, and solids and identifies the microscopic behavior responsible for each property.

Some Characteristics of Gases, Liquids and Solids and the Microscopic Explanation for the Behavior		
gas	liquid	solid
Assumes the shape and volume of its container particles can move past one another.	Assumes the shape of the part of the container which it occupies particles can move/slide past one another.	Retains a fixed volume and shape rigid - particles locked into place.
Compressible lots of free space between particles.	Not easily compressible little free space between particles.	Not easily compressible little free space between particles.
Flows easily particles can move past one another.	Flows easily particles can move/slide past one another.	Does not flow easily rigid - particles cannot move/slide past one another.

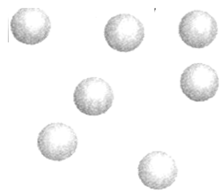
The particle arrangement of matter in solid, liquid and gas.



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.

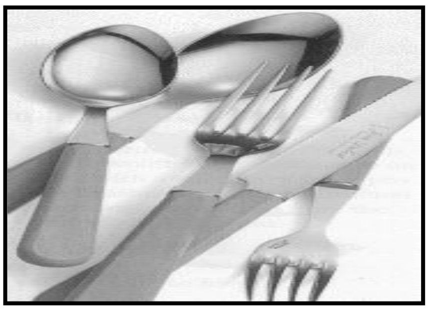


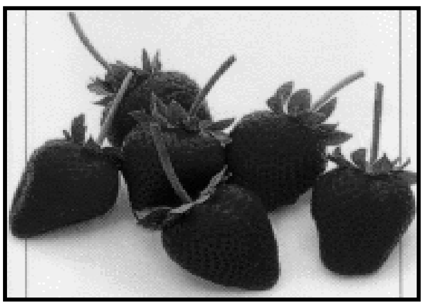
The particles in a liquid can move about and slide past each other. They are still close together but not in a fixed patter. The forces that hold them together are weaker than in a solid.



The gas particles are relatively far apart. These particles move freely and rapidly in all directions. They collide with the walls of the container.

Properties of Matter

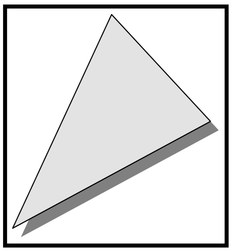




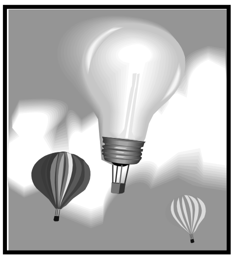
Study the pictures above? How can you describe them if you do not know what they are? From the pictures above, you use your sense of touch, taste and smell to tell the difference between the spoon, fork and strawberry.

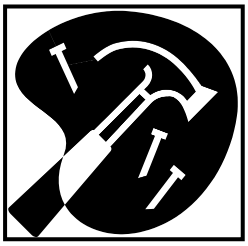
Remember, all objects take up space and have mass. The measurement of mass and other characteristics that can be seen without changing how that object looks are its **physical properties**. When you look at strawberries, you know that they are strawberries because of their colour, shape, and smell.

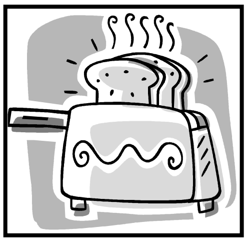
People describe objects in many ways. A property describes how an object looks, feels, and behaves. The objects shown on the next page have different kinds of properties:

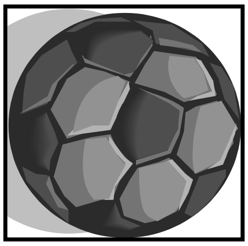

Size


Shape


Colours


Hardness


Smell


Texture

The table below it shows some common properties of matter.

Physical Property	Description
Strength	retains shape when twisted, pulled or crushed.
Malleable	bend without breaking
Ductile	can be stretched and drawn into wires
Brittle	easily breaks
Elastic	can be stretched and returned to original shape
Opaque	does not allow all light to pass through it
Transparent	allows light to pass through
Boiling point	temperature at which a liquid boils
Melting point	temperature at which solids melt
Hardness	does not stretch

Activity: Now test yourself by doing this activity.

Part A. Write solid, liquid or gas beside each of the substances given.

1. Apple ___________
2. Wind ___________
3. River ___________
4. Inside of a blown balloon ___________
5. Coke ___________
6. Ice ___________
7. Rock ___________
8. Saliva in your mouth ___________
9. Air in a soccer ball ___________
10. Chewing gum ___________

Part B. Describe the properties of the following substance.

Substance	Properties
Glass	
Kerosene	
Marble	
Diamond	
Plastic	
Rubber band	

Part C. Complete the following sentences.

1. Matter takes up ___________ and has ___________.
2. The three states of matter are ___________, ___________ and ___________.
3. A gas can be squeezed into a smaller volume, but a solid or ___________ cannot.
4. When a liquid is poured from one container to another its shape changes, but its ___________ stays the same.
5. The volume and shape of a ___________ stays the same, no matter what container you put it in.

Summary

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

- matter can be classified into three main groups: solids, liquids and gases. These are the three states of matter.
- solids include most of the objects around you. They occupy space and can be weighed. The volume of a solid cannot easily be changed, nor can the shape. The particles in a solid are packed tightly in a fixed pattern.
- liquids flow easily. It has a definite volume but no definite shape. The particles in a liquid can move about and slide past each other. They are still close together but not in a fixed pattern.
- a gas has neither a definite shape nor a definite volume. It completely fills and takes the shape of its container. Gas particles are relatively far apart. These particles move freely and rapidly in all directions.
- physical properties of matter are the characteristics that are used in describing objects that can be seen without changing how the object looks. When you describe objects using size, shape, colour, texture, smell, ductile, malleable, brittle and etc. you use the physical property of the object.

NOW DO PRACTICE EXERCISE 1 ON THE NEXT PAGE.

Practice Exercise 1

Answer the following questions:

1. Define matter.

 ____

2. What are the three states of matter?

 ____

3. For each of the following, state whether it is a solid, liquid or gas.

 a. Sugar
 b. Air
 c. Water
 d. Rice
 e. Ice

4. Describe physical properties of matter.

 ____

5. Draw and describe the particle arrangement of matter in solid, liquid and gas.

Draw here- Solid	___________________________
Draw here- Liquid	___________________________
Draw here- Gas	___________________________

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

Answers to Activity

Part A.

1. **Solid**
2. **Gas**
3. **Liquid**
4. **Gas**
5. **Liquid**
6. **Solid**
7. **Solid**
8. **Liquid**
9. **Gas**
10. **Solid**

Part B.

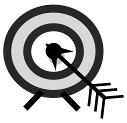
Substance	Properties
Glass	**Transparent**
kerosene	**Smell**
Marble	**Smooth, hard**
Diamond	**Hard, heavy**
Plastic	**Strong, brittle**
Rubber band	**Elastic**

Part C.

1. All matter takes up space and has weight.
2. The three states of matter are solid, liquid and gas.
3. A gas can be squeezed into a smaller volume, but a solid or a liquid cannot.
4. When a liquid is poured from one container to another its shape changes, but its volume stays the same.
5. The volume and shape of a solid stays the same, no matter what container you put it in.

Lesson 2: Properties of Solids

Welcome to Lesson 2 of Strand 3. In the last lesson, you have learnt about the properties of matter. You have studied and described matter and its states. You also have learned the different particle arrangement of matter and how it occupies space in solid, liquid and gas. You also learnt the different physical properties of matter. For this lesson, you will study the properties of solids.

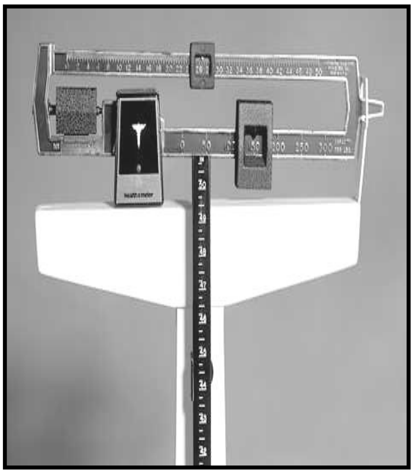


Your Aims:

- define weight, density, mass, volume and buoyancy
- describe the different properties of solids
- solve simple problems about density

What Are The Different Properties Of Solids?

Some solids are hard and strong. Others are soft and stretchy. Some conduct electricity while others don't. Below are some words used to describe the properties of solid.



Weight is a measure of the pull of gravity on an object. Spring scales measure an object's weight. When measuring with a spring scale, a spring is stretched or compressed by an object. The amount that the spring's lengths change indicates the object's weight. If an object is too large to hang from a scale, you can add up the weights of all the objects parts. The total weight of the parts always equals the weight of the whole object.
Weight changes when the pull of gravity changes. Gravity is not the same everywhere on Earth. For example, the pull of gravity decreases slightly as an object is lifted to the top of a mountain. Therefore the object's weight becomes a little less.

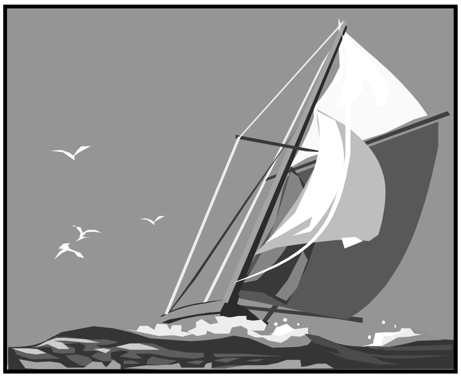
Mass is the amount of matter in an object. The amount of mass affects the weight of an object, but mass is not the same as weight. Moving an object to the top of the mountain does not change the amount of matter in an object. Its mass stays the same. Mass is measured by using a balance, often using units of grams, milligrams or kilograms. To find mass, an object is placed on one side of the balance. Known masses are placed on the other side. When the two sides balance each other, the total mass of all the known masses equals the object's mass.

Volume is the amount of space that an object takes up. Cubic units are used for volume. You can find the volume of a regular box by measuring and multiplying its length, width and height.

You can use a graduated cylinder to find the volume of a liquid. You can also use a graduated cylinder to measure the volume of a solid object that fits in the cylinder and sinks in water. First, put a measured amount of water in the cylinder. Then, put the object onto the water. Read the new volume. The difference between the two volumes is the volume of the object.

Regular boxes

Mass and Volume



A ship

Even though iron is denser than water, it can still be used to build a ship that floats. This is because a ship is not a solid metal. It has lots of rooms and hallways. Most of its volume is filled with air. Because of all these air, the ship has much lower mass than you would find in a solid piece of metal the size of the ship. This makes the ship's density less than water's density.

Density is a measure of the amount of matter in a given volume. To find an object's density, divide the object's mass by its volume. Density is a physical property of a substance. Density is the same for a substance no matter how much of the substance is measured. For example, iron will always have a density of about 7.9 grams per cubic centimeter; no matter how large a piece of iron is measured. Because the density of a material is always the same, it can be used to help identify a material. You can work out the density of a substance using the formula given below.

Iron Block			
Mass	7.9 g	15.8 g	23.7 g
Volume	1 cm^3	2 cm3	3 cm^3
Density	7.9 g/cm^3	7.9 g/cm3	7.9 g/cm^3

$$\text{Density} = \frac{\text{Mass}}{\text{Volume}}$$

Buoyancy

An object is buoyant if it floats. Buoyancy is an important property for use in some objects such as boats or balloons. For example, you want a life jacket to float and an anchor to sink. You would use different materials for each.

Whether a certain material floats in a liquid depends on the densities of both the material and liquid. If the object's density is less than the liquid's density, it will float. If the object's density is greater than the liquid's density, it will sink. From the table, materials that you expect to sink in water, such as cement and iron, are denser than water. Materials that float in water such as pinewood and cork

Material	Approximate Density (g/cm^3)
Fresh water	1.00
Cork	0.25
Pinewood	0.50
Olive oil	0.92
Bess wax	0.96
Sugar	1.60
Cement	2.70
Iron	7.90

have a density less than 1 gram per cubic centimeter. Ocean water has dissolved salt and other materials. Because of this, ocean water is denser than fresh water. Its density depends on how much material is dissolved in it.

Sinking and Floating

Anything will float in water if its density is equal to or less than the density of water, that is $1g/cm^3$. For example, cork (density $0.25g/cm^3$) floats in water, but a piece of cement (density $2.70g/cm^3$) sinks.

Vegetables and fruits are mostly water, and they usually float. The lower their density, the more they stick out above the water. You can try this at home with a bowl of water.

Anything will float in water if its density is less than the density of water.

Animals are made also mostly of water. But they have a layer of fat under their skin, and this has a density less than water. There are also spaces, such as lungs, inside their bodies. So most animals float in water. Sharks are denser than water. If they don't keep swimming they sink to the bottom.

Activity: Now test yourself by doing this activity.

Part A. Solve the following simple problem.

A block of wood is 8cm long, 5cm wide and 3cm deep.

1. What is the volume of the block?

The block has a mass of 144 grams. What is its density?

Part B. Answer the questions briefly.

1. Why do ships made of iron, float even though the density of iron is $7.8g/cm^3$?

____

____

____

____

2. People float better in ocean-water than in fresh water. Explain this in terms of density.

____
____
____
____

Summary

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

- weight is a measure of the pull of gravity on an object.
- mass is the amount of matter in an object. The amount of mass affects the weight of an object. Mass is measured by using a balance, often using units of grams, milligrams or kilograms.
- volume is the amount of space that an object takes up. Cubic units are used for volume.
- density is a measure of the amount of matter in a given volume. To find an object's density, divide the object's mass by its volume.

NOW DO PRACTICE EXERCISE 2 ON THE NEXT PAGE.

.

Practice Exercise 2

Answer the following questions:

1. Write the meaning of the following words.

   Weight ______________________________

   Mass ______________________________

   Volume ______________________________

   Density ______________________________

2. Look at the table below.

	Mass (g)	Volume (cm^3)	Density (g/cm^3)
Object A	39	6	
Object B	54	20	
Object C	6	5	

   a. Which object has the greatest mass? ___________

   b. Which object has the greatest density? ___________
   (Compute the density of Object A, B and C)

3. Solve the following simple problem.

   a. A piece of copper has a mass of 50g and a volume of $5.6cm^3$. What is its density?

   Density= mass/volume

   b. Another piece of copper has a volume of $17cm^3$. What is its mass?

   Density= mass÷volume
   Mass= density x volume

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

Answers to Activity

Part A.

1. A block of wood is 8cm long, 5cm wide and 3cm deep.

   a. What is the volume of the block?

      Volume=8x5x3
      $=120cm^3$

   b. The block has a mass of 144 grams. What is its density?

      Density=mass ÷ volume
      =144÷120
      $=1.2g/cm^3$

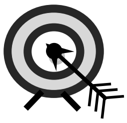
Part B. .

1. Even though iron is denser than water, it can still be used to build a ship that floats. This is because a ship is not a solid metal. It has lots of rooms and hallways. Most of its volume is filled with air. Because of all these air, the ship has much lower mass than you would find in a solid piece of metal the size of the ship. This makes the ship's density less than water's density.

2. Ocean water has dissolved salt and other materials. Because of this, ocean water is denser than fresh water. Its density depends on how much material is dissolved in it.

Lesson 3: Properties of Metals

Welcome to Lesson 3 of Strand 3. In the last lesson, you learnt about the properties of solids. You defined and described density, weight, mass, volume and buoyancy of solids. In this lesson, you will be studying the properties of substances known as metals.



Your Aims:

- define metal
- explain the different properties of metals

What Is A Metal?

A metal is a group of chemical elements which are shiny solids and good conductors of heat and electricity. Mercury is a metal but is in liquid form. Some of the metals are listed below with their symbols.

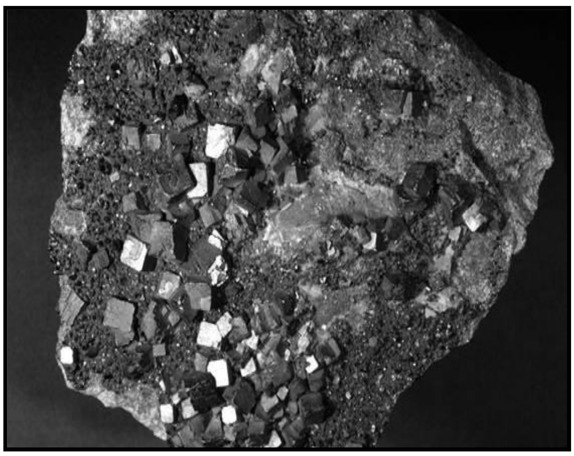
Name	Symbols
Aluminium	Al
Calcium	Ca
Copper	Cu
Gold	Au
Iron	Fe
Lead	Pb

Name	Symbols
Magnesium	Mg
Potassium	K
Silver	Ag
Sodium	Na
Tin	Sn
Zinc	Zn

Uses of pure metals

Metals are used in different ways according to their properties. Pure aluminium can be rolled into very thin sheets, which are quite strong but easily cut. So it is used for milk bottle tops and cooking foil.

Pure lead is soft and bends easily without being heated. It also resists corrosion. So it is used to seal off brickwork around chimneys.



Pure Lead

Pure Aluminium

The table below summarises some uses of pure metals.

Metal	Uses	Properties that make it suitable
Sodium	A coolant in nuclear reactors	Conducts heat well
Aluminium	Overhead electricity cables/ Saucepans	Good conductor of electricity (not as good as copper but cheaper and lighter) Conducts heat well and is non-poisonous
Zinc	Coating iron, to give galvanised iron	Protects iron from rusting
Tin	Coating steel cans or 'tins'	Non-reactive. Protects steel from rusting
Mercury	Thermometers	Liquid at room temperature. Expands on heating. Easy to see. Does not wet the sides of tubes.

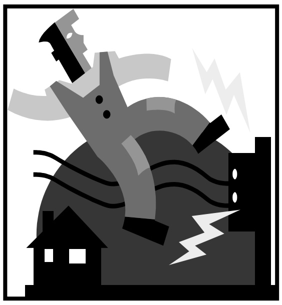
Sometimes a metal is most useful when it is pure. For example, copper is not nearly such a good conductor when it contains impurities.
But many metals are more useful when they are not pure. Iron is the most widely used metal of all and it is almost never used pure because it is too soft, easily stretches and rusts.

What are the different properties of metals?
Metals are important in our lives. Over three quarters of elements are metals. All the properties shown below are the physical properties of metals. They describe the metal itself, not its chemical reactions.

A. Strong and Hard

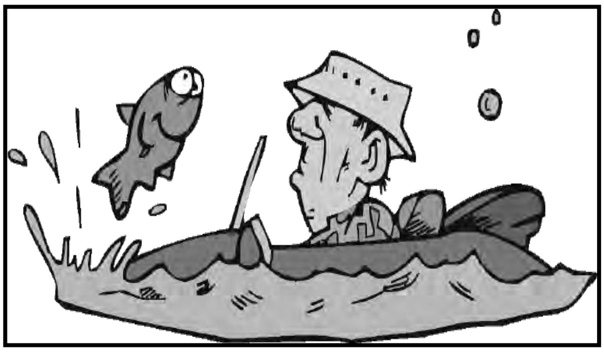

- Most metals are generally strong and hard.
- They are difficult to break down into smaller pieces and changing their shape usually involves a lot of effort.

B. Conductors

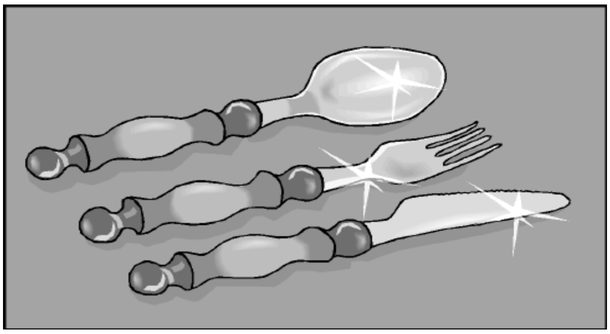
- They are very good conductors of heat and electricity.
- This is why they are used for pots and pans and an electrical circuit to carry the current.

C. Dense



- Most metals have high density.
- This is why they feel heavy and sink when placed in water.

D. Shiny



- Most metals are silvery in colour, except copper and gold.
- Some go dull over time.
- All metals are shiny when freshly cut.

E. High Melting and Boiling Point

- Most metals have very high melting and boiling points.
- They need to be heated to a very high temperature before they melt to become liquids.

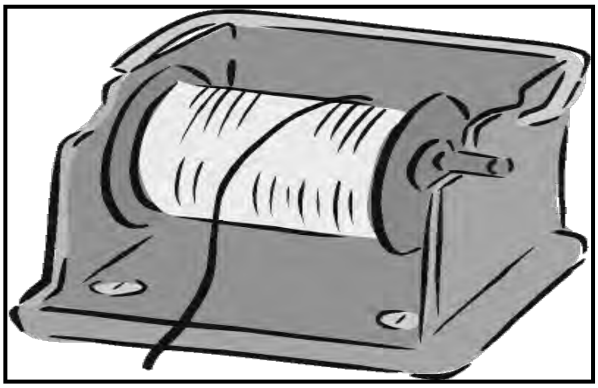
F. Solids

- All metals are solids at room temperature.
- The only exception is mercury.
- Mercury is the only liquid under normal conditions.
- Mercury is used in a thermometer.

G. Malleable

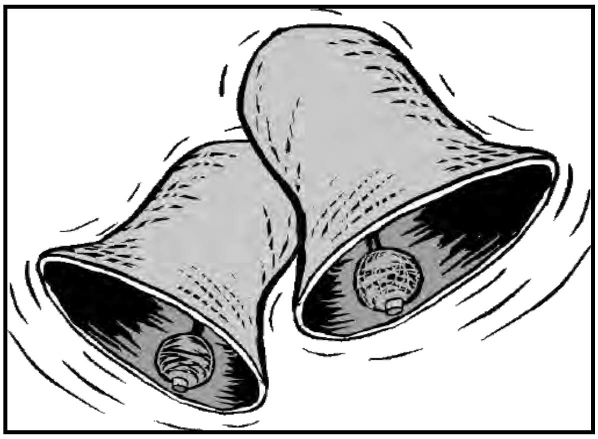
- This property means that metals can be hit without shattering.
- They can be hammered into different shapes, even when cold and not break into lots of small pieces.

H. Ductile



- This property means that metals can stretch very thinly without them breaking.
- This is why they can be drawn out into wires.

I. Sonorous



- This property refers to the sound that metals make when they are hit.
- Metals make a ringing sound when they are struck.

Activity: Now test yourself by doing this activity.

Answer the following briefly.

1. Why is iron more useful when it is mixed rather than pure?

2. Explain why tin is used to coat food tins.

3. Write three reasons why mercury is used in thermometers.

   a. ______________________________

   b. ______________________________

   c. ______________________________

4. Give two reasons why aluminium is used as sauce pans.

   a. ______________________________

   b. ______________________________

5. Metals have high melting and boiling points. What does this mean?

6. Explain why metals are used in an electrical circuit, pots and saucepans.

Summary

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

- a metal is a substance having a ‘metallic’ luster and being malleable, ductile, of high relative density and a good conductor of heat and electricity.
- most metals are strong and hard- meaning they are difficult to break down into smaller pieces.
- metals are conductors- they are very good conductors of heat and electricity- this is why they are used for pots and pans and in electrical circuit to carry current.
- metals have high density- this is why they feel heavy and sink when placed in water.
- metals have silvery colour, except copper and gold.
- metals have very high melting and boiling points. They are solids at room temperature, the only exception is mercury.
- metals are Malleable- this property means that metals can be hit without shattering.
- metals are ductile- this property means that metals can stretch very thinly without breaking.
- metals are sonorous-this property means metals make a ringing sound when they are struck.

NOW DO PRACTICE EXERCISE 3 ON THE NEXT PAGE.

Practice Exercise 3

Answer the following questions:

1. What is a metal?

   ____

2. List and explain the properties of metals.

   a. ____
   ____

   b. ____
   ____

   c. ____
   ____

   d. ____
   ____

   e. ____
   ____

   f. ____
   ____

   g. ____
   ____

3. Write the uses of the following metals.

Metals	Uses
Zinc	
Tin	

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

Answers to Activity

1. Iron is the most widely used metal of all and it is almost never used pure because it is too soft, easily stretches and rusts too.

2. Tin is used to coat food tins because it is non-reactive. It also protects the steel from rusting.

3. a. Easy to see.
   b. Expands on heating.
   c. Liquid at room temperature
   d. Does not wet the sides of tubes.

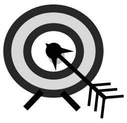
4. a. Aluminium conducts heat well.
   b. It is non-poisonous.

5. Most metals have very high melting and boiling points. They need to be heated to a very high temperature before they melt to become liquids.

6. Metals are used for pots and pans and an electrical circuit to carry the current because they are very good conductors of heat and electricity.

Lesson 4: Properties of Liquids

Welcome to Lesson 4 of Strand 3. In the last lesson you learnt about metals and their properties and uses. Now you will learn about the properties of liquids.



Your Aims:

- explain the nature and temperature of liquids
- explain the different properties of liquids

Getting To Know Liquids

This is the state of matter in which the substance is in the form of a runny fluid. The liquid sinks to the bottom of the container, and maintains its volume and has a flat surface. The particles in a liquid are closely packed but are able to move freely pass each other.

Water is a unique liquid, in that it reacts differently from most other liquids. Water has an extremely high boiling point and a high specific heat. It takes much more heat to raise the temperature of water than any other liquid. The density of water in its solid form (ice) is much less than in its liquid form.

Temperature of liquids

The vapour pressure of a liquid increases with increasing temperature. As the temperature increases, the number of molecules increases. As a result, more molecules (particles) escape from the surface of the liquid and concentration of molecules in the vapour increase. Hence, vapour pressure of the liquid increases.

Properties of liquids

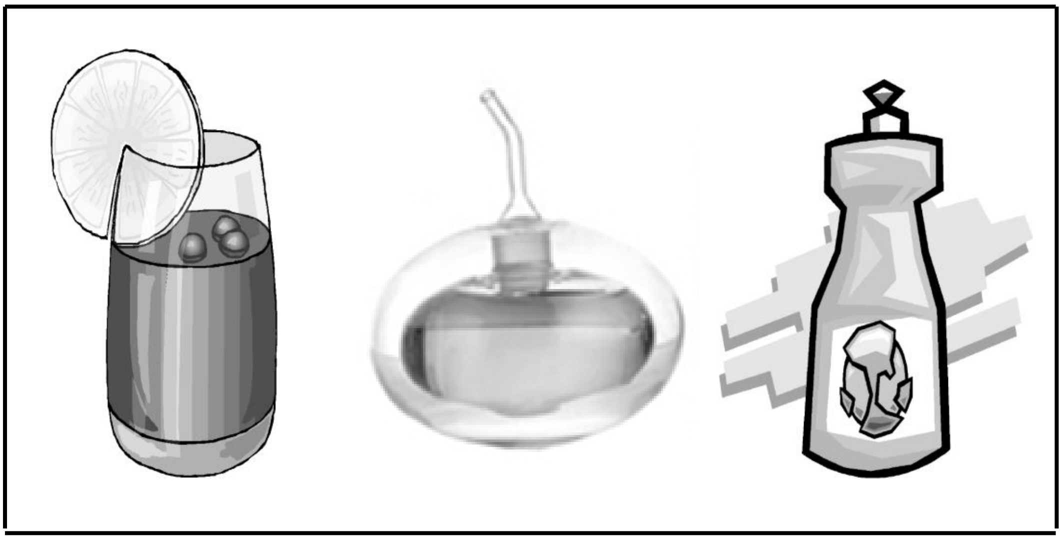
1. **Expansion and Contraction**
   In general, liquids show expansion on heating, contraction on cooling. A liquid changes at its boiling point to a gas and at its freezing point or melting point to a solid. The boiling point of a liquid is important since a mixture of liquids can be separated by raising its temperature and changes to vapour.

2. **Density**
   In general, the density of liquids is higher than gases and it decreases with increase in temperature. The higher density of liquids compared to gases is due to the fact that molecules of liquids are more closely packed than gases.

3. **Compressibility**
   Liquids are 10 times less compressible than gases but are about 10 times more compressible than solids. This is due to the fact that the molecules in liquid state are not closely packed as in solids but are closer to each other as compared to gases.

4. Volume

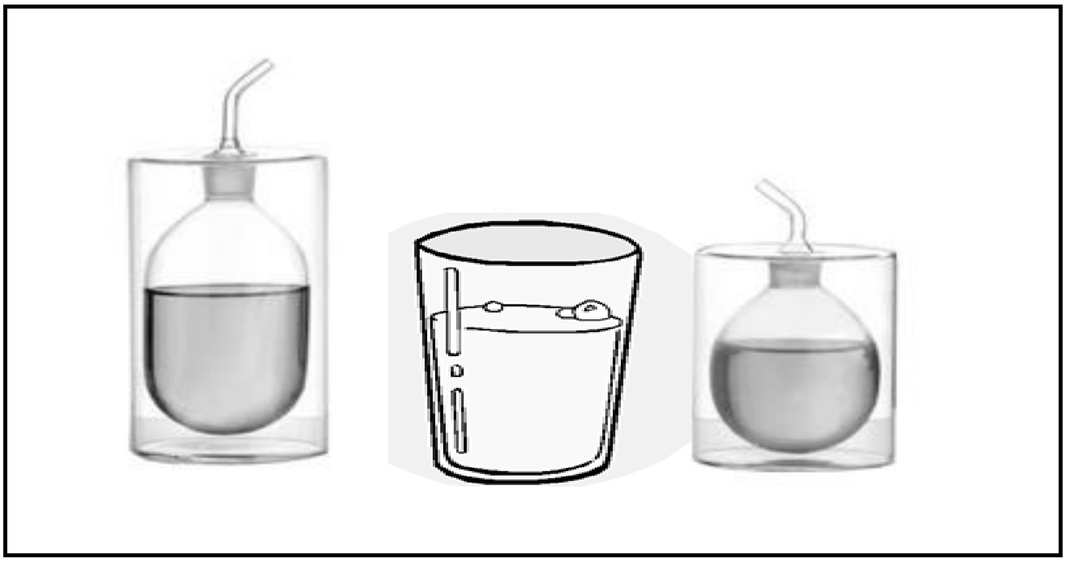
Liquids have a definite volume under given temperature and pressure conditions. Though they take the shape of the container, they maintain their volume. The intermolecular (forces between particles) forces in liquids are strong and therefore, they do not expand to occupy all the space available –as gases do. A given mass of liquid has a fixed volume whether it is placed indifferent containers.



Fixed volume even in different containers

5. Shape

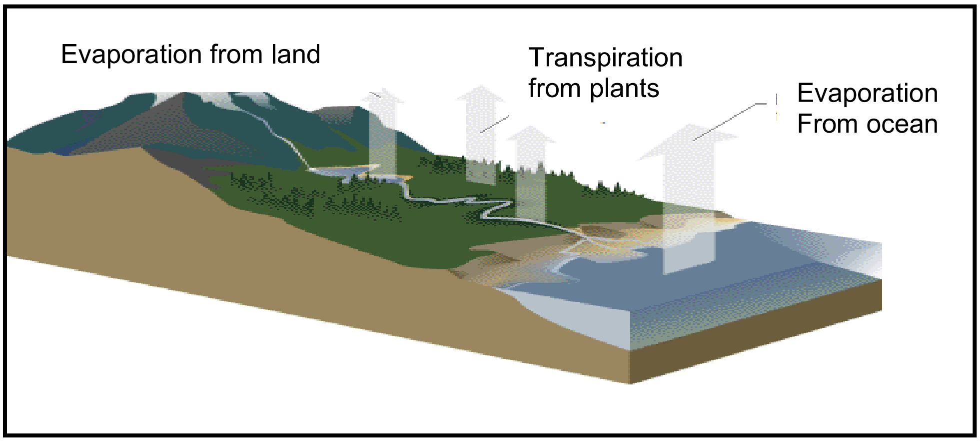
Liquids have no shape of their own. The molecules in the liquid state are not rigidly fixed to their own and take up the shape of the container in which they are placed.



Different shapes

6. Evaporation

Evaporation is the process by which water in the ocean and on land changes to water vapour and enters the atmosphere as a gas. A liquid heated to a high temperature will vaporise and turn into a gas.



Activity: Now test yourself by doing this activity.

You can calculate density of a liquid using the formula:

$$\textbf{Density} = \frac{\textbf{Mass}}{\textbf{Volume}}$$

Remember, mass is how much matter in an object. Volume is the amount of space that an object occupies. Density can be calculated by taking the mass (usually measured in grams) and dividing it by the volume (usually measured in cm^3).

Materials you will need: Drinking glass, water, cooking oil

Method:
Pour some water into a drinking glass. Then carefully pour some cooking oil on top of the water.

1. a. What can you observe?

____

b. Why did this happens?

____

c. Draw a diagram of what happened in the box.

2. The density of many common substances is known. For example, the density of water is 1.00 g/cm^3. The density of a substance determines whether that substance will sink or float if placed in a liquid like water. Substances that are less dense than water will float on its surface and substances that are denser will sink. Gold has a density of 19.3 g/cm^3, which means it, is much denser than water.

Would gold sink or float if placed in water? __________

3. What is the density of water? __________

4. Would a liquid with a density of 2 g/cm^3 sink or float when added to water? __________

5. As water freezes it becomes __________ dense.

6. Ice __________ in water.

Summary

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

- liquid is one of the three commonly recognised states in which matter occurs.
- the vapour pressure of a liquid increases with increasing temperature.
- liquids expand when heated and contracts when cooled.
- liquids have a definite volume under given temperature and pressure conditions. Though they take the shape of the container, they maintain their volume.
- liquids have no fixed shape, but take the shape of the container it is placed in.
- the density of liquids is higher than gases and it decreases with increase in temperature.
- liquids are less compressible than gases but are more compressible than solids.
- evaporation is the process by which water in the ocean and on land changes to water vapour and enters the atmosphere as a gas.
- water is a unique liquid, in that it reacts differently from most other liquids.

NOW DO PRACTICE EXERCISE 4 ON THE NEXT PAGE.

Practice Exercise 4

Answer the following questions:

1. Define liquid.

   ____

2. Explain the different properties of liquids.

Property	Explanation

3. Use one of these words to complete each statement:

liquids, heat, shape, cool, melts, volume, solid, freezing

a. To turn a liquid into a solid, you need to __________ it.
b. To turn a solid into a liquid, you need to __________ it.
c. When a solid __________ it turns into a liquid.
d. Pouring a liquid from one container to another does not change its __________.
e. Liquids always take the __________ of their container.
f. If you freeze water, it will become a __________.
g. You can pour __________ but not solids.
h. To stop ice from melting, you need to keep it below __________ point.

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

Answers to Activity

1. a. The cooking oil floats on top of the water.
   b. It happens because oil is less dense than water, so it is able to float on top of it.
   c.
   

2. If you answered sink, you are correct!

3. 1 gm/cm^3

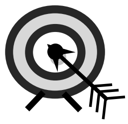
4. sink

5. less

6. floats

Lesson 5: Properties of Gases

Welcome to Lesson 5 of Strand 3. In the last lesson you learnt about the properties of liquids. In this lesson you will learn about the properties of gases. Do you sometimes wonder why a balloon happens to float in air and what causes fire to light? This is because it has something to do with the air around us. What does air have that makes these things happen?



Your Aims:

- identify and describe the properties of gases
- list and describe the uses of gases
- give the uses of some common gases

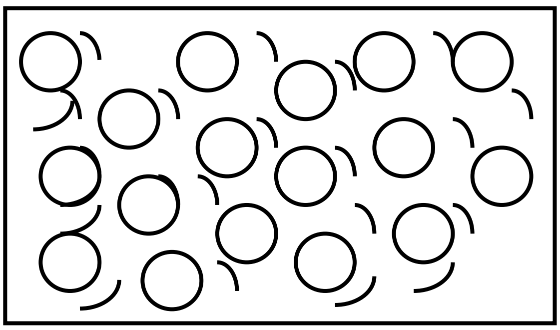
Knowing About Gases

In gas, the particles are spread out and they move very quickly in different directions. The particles are not arranged in any pattern because they are changing places all the time. The forces holding the particles together are very small. They behave the same way in response to temperature and pressure unlike liquids or solids.

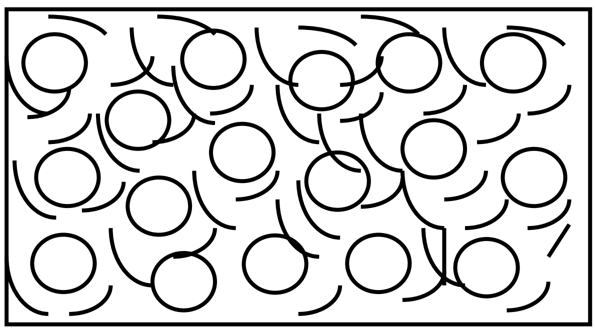
Balloon

When you blow up a balloon, you will fill it with air particles moving at high speed. The particles knock against the sides of the balloon and exert pressure on it. The pressure is what keeps the balloon inflated. In the same way, all gases exert pressure. The pressure depends on the temperature of the gas and volume it fills.

Let us look at the diagram below.



If the gas is heated, the particles move at high speed. They hit the walls of the container and exert pressure on them.



When the gas is heated, the particles take in heat energy and move even faster. They hit the walls more often and with more force. So, the gas pressure increases.

Properties of Gases

1. Gases take up the volume and shape of the container. They do not keep their shape; they completely fill the container that they are in.

2. Gases are compressible. This means that they can be squeezed into a much smaller volume (compressed). This is because the particles are so far apart. Gases spring back when you stop compressing (squashing) them. As soon as you stop squeezing, they fly apart again.

3. Gases flow easily. They spread out quickly from where they are to start with (this is called diffusion). This is because the particles are always changing places with each other. It will mix evenly and completely when confined to the same container.

4. Gases spread out to fill the container. This is because they are moving very fast and there are no forces to stop them flying apart. They will be stopped by the solid walls of the container.

5. Gases have much lower densities than liquids and solids.

Uses of Gases

The uses of natural gas are many and varied. Consumers, industries, and commerce can all benefit from its use. Here are just some examples of its many uses.

This table shows the names and uses of some common gases.

Name of Gas	Some Useful Facts	Uses
Air	Air is the gas all around us. It is a mixture of several different gases, mainly nitrogen and oxygen.	Without air we can not breathe and fires will not light. It supports balloons and aeroplanes.
Oxygen	About 1/5 of the air is oxygen. Without oxygen we cannot breathe and fires won't burn. Oxygen is produced by plants during photosynthesis.	Oxygen is used in hospitals to help us breathe. It is also used in welding and as rocket fuel.
Carbon dioxide	Carbon dioxide is needed by plants when they make food during photosynthesis. All living organisms breathe out carbon dioxide when they make energy from food.	Carbon dioxide is the gas in fizzy drinks. It is also used in fire extinguishers.
Nitrogen	Nitrogen is the main gas in the air. It is composed of about 80%.	Nitrogen is used to make plant food (fertilizer) and is also in explosives.
Water vapour	Water vapour is formed when water evaporates. There is lots of water vapour in the air we breathe out.	When water vapour in the air cools down it forms clouds.
Helium	There is small amount of helium in the air. It is a very light gas and is used in balloons to help them float.	In balloons to help them float.
Argon	There is a small amount of argon in the air.	Argon is the gas inside electric light bulbs.

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

Part A. Can you match the different gases and their uses?

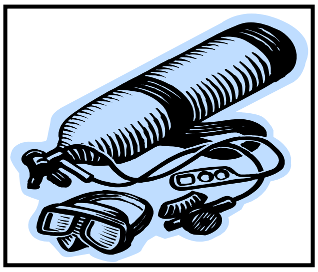
Choose the correct answer from the list given below.

Nitrogen, helium, carbon dioxide, argon, oxygen

Write your answer on the space provided.

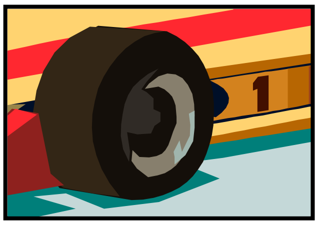
1. The gas that makes balloons float. ____________________
2. This gas is used in some light bulbs. ____________________
3. This gas is used in fire extinguishers. ____________________
4. A gas that is used in explosives. ____________________
5. A gas that is used for welding. ____________________

Part B. From the diagrams below, name the gas and give its use.



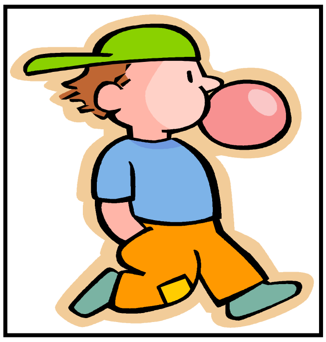
1. Gas ____________________________________

   Use ____________________________________



2. Gas ____________________________________

   Use ____________________________________



3. Gas ____________________________________

   Use ____________________________________

4. Gas ________________________________

Use ________________________________

5. Gas ________________________________

Use ________________________________

Summary

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

- in a gas, the particles are spread out and are moving very quickly in different directions.
- gases take up the volume and shape of the container.
- gases can be compressed or squashed into a much smaller volume.
- gases spread out to fill the container.
- gases have much lower densities than liquids and solids.
- the most common gas is called air.
- air is a mixture of different gases mainly nitrogen and oxygen.
- oxygen is about 1/5 of the air and used in the hospital, welding and rocket fuel.
- carbon dioxide is needed by plants to make food and used in fire extinguishers and fizzy drinks.
- nitrogen is about 80% gas in the air and used as fertilizer and in explosives.
- helium is a light gas and used in balloons to help them float.
- argon is the gas inside the electric bulbs.

NOW DO PRACTICE EXERCISE 5 ON THE NEXT PAGE.

Practice Exercise 5

Answer the following questions:

1. Identify and describe the five properties of gases.

   a. ______________________________

   b. ______________________________

   c. ______________________________

   d. ______________________________

   e. ______________________________

2. List and describe the four uses of natural gas.

   a. ______________________________

   b. ______________________________

   c. ______________________________

   d. ______________________________

3. Give the uses of the following.

   a. Oxygen

   ____

   b. Helium

   ____

   c. Carbon dioxide

   ____

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

Answers to Activity

Part A.

1. Helium
2. Argon
3. Carbon dioxide
4. Nitrogen
5. Oxygen

Part B.

1. Oxygen – for breathing
2. Methane – for cooking
3. Carbon dioxide – for blowing bubble gum
4. Argon – for lighting
5. Helium – for balloons to float

REVIEW OF SUB STRAND 1: PHYSICAL PROPERTIES OF MATTER

Revise all the Lessons in this Sub Strand and then do **ASSIGNMENT 3.**
Here are the main points to help you revise.

Lesson 1: Properties of Matter

- Everything around you is made of matter.
- Matter can be classified into three main groups: solids, liquids and gases. These are the three states of matter.
- Solids include most of the objects around you. They occupy space and can be weighed. The volume of a solid cannot easily be changed, nor can the shape. The particles in a solid are packed tightly in a fixed pattern.
- Liquids flow easily. It has a definite volume but no definite shape. The particles in a liquid can move about and slide past each other. They are still close together but not in a fixed pattern.
- A gas has neither a definite shape nor a definite volume. It completely fills and takes the shape of its container. Gas particles are relatively far apart. These particles move freely and rapidly in all directions.
- Physical properties of matter are the characteristics that are used in describing objects that can be seen without changing how the object looks. When you describe objects using size, shape, colour, texture, smell, ductile, malleable, and brittle you use the physical property of the object.

Lesson 2: Properties of Solids

- Weight is a measure of the pull of gravity on an object.
- Mass is the amount of matter in an object. The amount of mass affects the weight of an object. Mass is measured by using a balance, often using units of grams, milligrams or kilograms.
- Volume is the amount of space that an object takes up. Cubic units are used for volume.
- Density is a measure of the amount of matter in a given volume. To find an object's density, divide the object's mass by its volume.

Lesson 3: Properties of Metals

- A metal is a substance having a 'metallic' luster and being malleable, ductile, of high relative density and a good conductor of heat and electricity.
- Sometimes a metal is most useful when it is pure; just like copper. But some metals are more useful when they are not pure. Iron is the most widely used metal of all and it is almost never used pure because it is too soft, easily stretches and rusts.
- Most metals are strong and hard- meaning they are difficult to break down into smaller pieces.
- Metals are conductors- they are very good conductors of heat and electricity- this is why they are used for pots and pans and in electrical circuit to carry the current.
- Metals have high density- this is why they feel heavy and sink when placed in water.

- Metals have very high melting and boiling points. They are solids at room temperature, the only exception is mercury.
- Metals are malleable- this property means that metals can be hit without shattering.
- Metals are ductile- this property means that metals can stretch very thinly without them breaking.
- Metals are sonorous-this property means metals make a ringing sound when they are struck.

Lesson 4: Properties of Liquids

- Liquid is one of the three commonly recognised states in which matter occurs.
- The vapour pressure of a liquid increases with increasing temperature.
- In general, liquids show expansion on heating and contraction on cooling.
- Liquids have a definite volume under given temperature and pressure conditions. Though they take the shape of the container, they maintain their volume.
- The liquid state is not rigidly fixed to their own sites and takes the shape of the container in which they are placed.
- The density of liquids is higher than gases and it decreases with increase in temperature.
- Liquids are less compressible than gases but are more compressible than solids.
- Liquids also diffuse but they diffuse slowly than gases.
- Evaporation is the process of conversion of a liquid into its vapours at room temperature.
- Water is a unique liquid, in that it reacts differently from most other liquids.

Lesson 5: Properties of Gases

- In a gas, the particles are spread out and are moving very quickly in different directions.
- Gases take up the volume and shape of the container.
- They can be compressed or squashed into a much smaller volume.
- Gases flow easily.
- Gases spread out to fill the container.
- Gases have much lower densities than liquids and solids.
- The most common gas is called air.
- Residential applications are the most commonly known use of natural gas. It can be used for cooking, washing and drying, etc.
- Natural gas is used in the manufacture of anti-freeze, plastic, pulp and paper, metals, chemicals, stone, clay, glass and to process certain foods.
- Commercial users of natural gas are food service providers, hotels, healthcare facilities or office buildings.
- Uses of natural gas in transportation cover everything from cars and trucks to heavy-duty service vehicles.
- Air is a mixture of different gases mainly nitrogen and oxygen.
- Oxygen is about 1/5 of the air and used in the hospital, welding and rocket fuel.

- Nitrogen is about 80% gas in the air and used as fertilizer and in explosives.
- Water vapour is formed when water evaporates.
- Helium is a light gas and used in balloons to help them float.
- Argon is the gas inside the electric bulbs.

REVISE WELL AND THEN DO SUB STRAND TEST 1 IN YOUR ASSIGNMENT 3.

Answers to Practice Exercises 1- 5

Practice Exercise 1

1. Matter has mass and takes up space

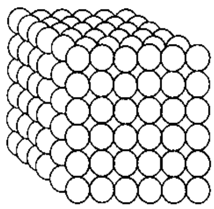
2. The three states of matter are solid, liquid and gas.

3.
   a. Sugar **solid**
   b. Air **gas**
   c. Water **liquid**
   d. Rice **solid**
   e. Ice **solid**

4. Physical properties of matter are the characteristics that are used in describing objects that can be seen without changing how the object looks. When you describe objects using size, shape, colour, texture, smell, ductile, malleable and brittle, you use the physical property of the object.

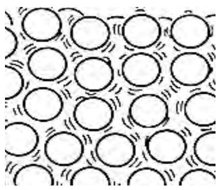
5.

Draw here- Solid



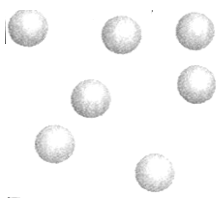
The particles in a solid are packed tightly in a fixed pattern. There are strong forces holding them together, so that they cannot leave their positions. The only movements they make are tiny vibrations to and fro.

Draw here- Liquid



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.

Draw here- Gas



Gas particles are relatively far apart. These particles move freely and rapidly in all directions. They collide with the walls of the container.

Practice Exercise 2

1. Weight is a measure of the pull of gravity on an object.
Mass is the amount of matter in an object.
Volume is the amount of space that an object takes up.
Density is a measure of the amount of matter in a given volume.

2.

	Mass (g)	Volume (cm^3)	Density (g/cm^3)
Object A	39	6	6.5
Object B	54	20	2.7
Object C	6	5	1.2

a. Object B
b. Object A

3. a. Density= mass/volume
= 50/5.6
= $8.9 g/cm^3$

b. Density= mass/volume
Mass = density x volume
= $8.9 g/cm^3 \times 17 cm^3$
= 151.3g

Practice Exercise 3

1. Metal- A metal is a substance having a 'metallic' luster and being malleable, ductile, of high relative density and a good conductor of heat and electricity.

2.
a. Most metals are strong and hard- meaning they are difficult to break down into smaller pieces.
b. Metals are conductors- they are very good conductors of heat and electricity- this is why they are used for pots and pans and in electrical circuits to carry the current.
c. Metals have high density- this is why they feel heavy and sink when placed in water.
d. Metals have silvery colour, except copper and gold.
e. Metals have very high melting and boiling points. They are solids at room temperature, the only exception is mercury.
f. Metals are malleable- this property means that metals can be hit without shattering.
g. Metals are ductile- this property means that metals can stretch very thinly without them breaking.
h. Metals are sonorous-this property means metals make a ringing sound when they are struck.

3. Give the uses and properties of the following.

Metals	Uses	Property
Zinc	Coating iron, to give galvanized iron	Protects the iron from rusting.
Tin	Coating steel cans or ‘tins. Non reactive.	Protects the steel from rusting.

Practice Exercise 4

1. Liquid is one of the three commonly recognised states in which matter occurs.
2. a. Liquids show expansion on heating, contraction on cooling.
   b. Liquids have a definite volume under given temperature and pressure conditions.
   c. The liquid state is not rigidly fixed to their own sites and takes the shape of the container in which they are placed.
   d. The density of liquids is higher than gases and it decreases with increase in temperature.
   e. Liquids are less compressible than gases but are more compressible than solids.
   f. Liquids also diffuse but they diffuse slowly than gases.
   g. The ease of flow of liquids depends on the strength of the intermolecular attractive forces.
   h. Liquids surface tension causes water to form spherical drops.
   i. When a liquid is placed in an open vessel, it gradually evaporates and is converted into its vapours

3. a. cool
   b. heat
   c. melts
   d. volume
   e. shape
   f. solid
   g. liquids
   h. freezing

Practice Exercise 5

1. a. Gases take up the volume and shape of the container. They do not keep their shape; they completely fill the container that they are in.
   b. Gases are the most compressible states of matter. They can be compressed (squashed into a much smaller volume).
   c. Gases flow easily. They spread out quickly from where they are to start with (this is called diffusion).
   d. Gases spread out to fill the container. This is because they are moving very fast and there are no forces to stop them flying apart.
   e. Gases have much lower densities than liquids and solids.

2. a. Residential applications are the most commonly known use of natural gas. It can be used for cooking, washing and drying, water warming, pool and spa heaters, fire pits, barbecues, heating and air conditioning.
   b. Industrial Sector-Natural gas is used in the manufacture of anti-freeze, plastic, pulp and paper, metals, chemicals, stone, clay, glass and to process certain foods.
   c. Main commercial users of natural gas are food service providers, hotels, healthcare facilities or office buildings. Commercial applications include cooling (space conditioning and refrigeration), cooking or heating.
   d. Uses of natural gas in transportation cover everything from cars and trucks to heavy-duty service vehicles

3. a. Oxygen - is used in hospitals to help us breathe. It also used in welding and as rocket fuel.
   b. Helium - it is a very light gas and is used in balloons to help them float .
   c. Carbon dioxide - is the gas in fizzy drinks. It is also used in fire extinguishers.

SUB STRAND 2

ACIDS AND BASES

In this sub strand you will learn about:

- **what are acids?**
- **what are bases?**
- **common laboratory acids and bases**
- **indicators**
- **neutralisation process**

SUB STRAND 2: ACIDS AND BASES

Introduction

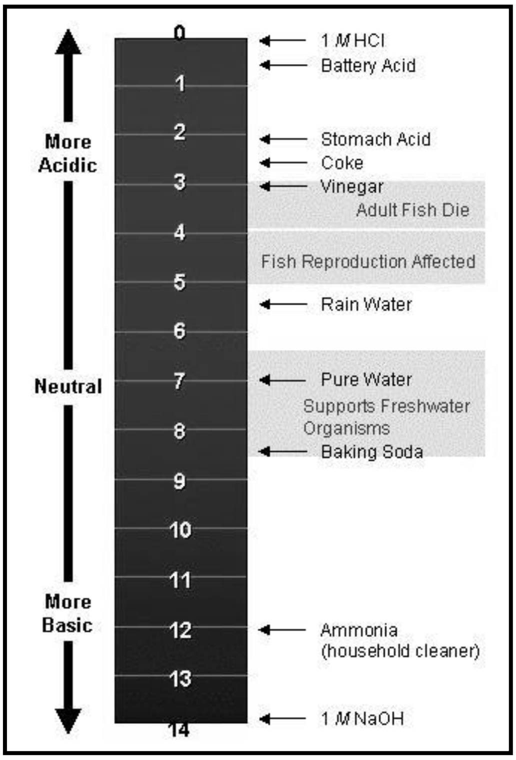
Acids and bases are two related types of chemicals. Each type has a number of common properties when dissolved in a solvent, usually water. Acids in water solutions usually taste sour, turn litmus paper red and they react with certain metals. Solutions of bases exhibit these common properties; taste bitter, turn litmus paper blue and feel slippery. When an acid solution is mixed with an alkaline solution, they neutralise each other forming water and salt.

Lime - acidic fruit

Baking soda – basic substance

Every liquid you see will probably have either acidic or basic traits. Most water you drink has ions in it. Those ions in solution make something acidic or basic. In your body there are small compounds called amino acids. Those are acids. In fruits there is something called citric acid. That's an acid, too. But what about baking soda? When you put that in water, it creates a basic solution.

Scientists use something called the **pH scale** to measure how acidic or basic a liquid is. The scale goes from values very close to 0 through 14. Distilled water is 7 (right in the middle). Acids are found between a number very close to 0 and 7. Bases are from 7 to 14. Most of the liquids you find every day have a pH near 7. They are either a little below or a little above that mark.



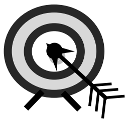
Now, you may want to know

- Why does dishwashing liquid have a high pH?
- Why do acids corrode or attack metals?
- What are the common uses of acids and bases in everyday life?

In this Sub strand, you will learn about the properties of acids and bases and the answers to these questions.

Lesson 6: What Are Acids?

Welcome to Sub Strand 2, Acids and Bases! In everyday life we deal with many substances that chemists classify as acids. For example, orange juice and grapefruit juice contain citric acid. These juice, and others, also contain ascorbic acid, a substance more commonly known as Vitamin C. So for this lesson you will be studying about different acidic substances.



Your Aims:

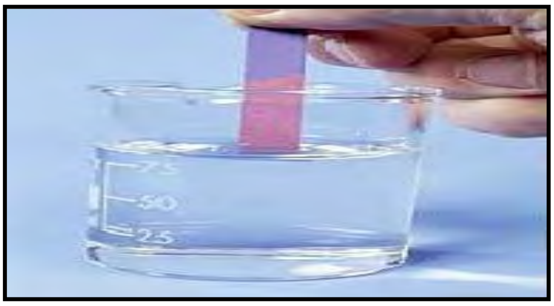
- define acids
- state the different properties of acids
- give the uses of acids
- identify and describe the different acidic substances at home

What are Acids?

For thousands of years people have known that vinegar, lemon juice and many other foods taste sour. However, it was not until a few hundred years ago that it was discovered why these things taste sour. This is because they contain acids. The term acid, in fact, comes from the Latin term acere, or acidus which means "sour".

Acids are substances that are soluble in water, they contain hydrogen and can neutralise a base.

Acids are chemicals that turn blue litmus paper red. Litmus is a coloured substance that change colour when they are added to acidic solution.



Acids turn blue litmus paper red

Types of acids

1. Natural acids
   Acids can be found in many substances, including food. Fruits contain an acid called citric acid and salads are often flavoured with vinegar, which contains dilute acetic acid. These acids like many others are everyday acids.

Source: Lemons
Acid: Citric acid

Vinegar contains acetic acid

2. Household or Synthetic acids
Their bottles are labelled with the warning symbol for **'**irritant**'**. This means that if any of them makes contact with your skin, it will become red or blistered. You must wash off any spills with plenty of water; otherwise your skin will soon feel as if it is burning. Acids have a sour taste, like vinegar, which contains acetic acid**,** and lemons, which contain citric acid. These are safe to use in food, but they can still hurt if they get into a cut or into your eyes. Other acids you will find at home are carbonic acid in fizzy drinks, tannic acid in tea and ascorbic acid which is vitamin C, found in fruit and vegetables.

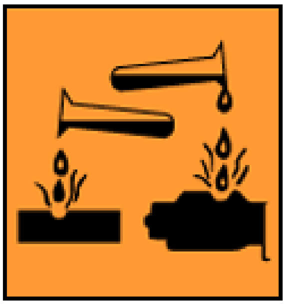
Source: Fizzy drinks
Acid: Carbonic acid

Source: Tea
Acid: Tannic acid

Source: Orange fruit
Acid: Ascorbic acid

3. Laboratory acids.
Apart from these, there are also laboratory acids such as hydrochloric acid, sulphuric acid and nitric acid.

Properties of Acids
Acids have a number of properties. These properties make acidic substances easy to distinguish.



Symbol for corrosive

i. Acids are corrosive. They can attack metals and burn skin if spilled.
ii. Acids have sour taste. Citric acid is responsible for the sour taste of lemons, limes, grapefruits and oranges. Acetic acid is responsible for the sour taste of vinegar.
iii. Acids change litmus (a dye extracted from lichens) red. When a sample of an acid is placed on blue litmus paper, the colour of the litmus changes from blue to red.
iv. Acids have a pH less than 7.
v. Acids can conduct electricity.
vi. Acids react with bases to form a salt (neutral) and water.
vii. Acids react with carbonates to form carbon dioxide gas, water and a salt (neutral).
viii. Acids react with metals (the more reactive metals) to form hydrogen gas and a salt (neutral).

Uses of acids

Common uses of acids are the following.

i. Steel used in construction is acid treated before painting. Dilute sulphuric or hydrochloric acid will remove any surface rust which would otherwise spread under the painted surface. 'Rust remover' used to repair cars is dilute phosphoric acid - H_3PO_4.

ii. Acids may be used as an electrolyte in a wet cell battery, such as sulphuric acid in a car battery.

iii. Nitric acid, another important industrial acid, is used in the manufacture of fertilizers, plastics, photographic film, and dyes. Nitric acid is also used in the preparation of such explosives as dynamite and TNT.

iv. Hydrochloric acid like sulphuric acid is used to clean metals, brick and tile. It is also used in the manufacture of sugar and glue.

v. In humans and many other animals, hydrochloric acid is a part of the gastric acid secreted within the stomach to help digest foods.

vi. Baking powder contains tartaric acid.

7. ‘Lime scale’ removers contain dilute (weak) acids. Lime scale is Calcium carbonate (also called furring).

viii. Boric acid is a weak acidic substance that is sometimes used to wash the eyes. It is used as fire retardant, antiseptic, manufacture of heat-resistant glass and ceramics. Its formula is H_3BO_3.

ix. A wasp sting is alkali. It may be neutralised with a weak acid such as lemon juice or vinegar.

Activity: Now test yourself by doing this activity.

Multiple Choice Questions.

Circle the letter of the correct answer.

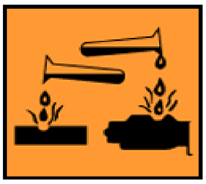
1. Different lotion was tested in the laboratory.

   Which would be described as the most acidic? Lotion pH __________.

   A. 10.5 B. 7.9

   C. 6.9 D. 5.4

2. Look at the diagram.



   What does the symbol represent?

   A. Toxic B. Irritant

   C. Harmful D. Corrosive

3. Use the information in the table below to answer the following
(Hint: Refer to the information in the pH scale on page 54)

Bleach	pH 12
Calamine lotion	pH 8
Fizzy citrus drink	pH 4.5
Common salt	pH 7
Baking soda	pH 7.5
Vinegar	pH 3
Toothpaste	pH 9
Wine	pH 6
Ammonia	pH 11
Washing soda	pH 11.5

Which is the weakest acid?

A. Wine
B. Vinegar
C. Limewater
D. Baking soda

4. Refer to the diagram below.

Which pH is a strong acid?

A. pH 14
B. pH 9
C. pH 5
D. pH 1

Summary

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

- acids are chemicals which will turn blue litmus paper red.
- acids can be found in many substances, including food.
- there are also laboratory acids such as hydrochloric acid, sulphuric acid and nitric acid.
- acids may be used as an electrolyte in a wet cell battery.
- nitric acid, another important industrial acid, is used in the manufacture of fertilizers, plastics, photographic film, and dyes.
- in humans and many other animals, hydrochloric acid is a part of the gastric acid secreted within the stomach to help digest foods.
- baking powder contains tartaric acid.
- ‘lime scale’ removers contain dilute (weak) acids.
- boric acid is a weak acidic substance that is sometimes used to wash the eyes. It is also used as fire retardant.
- acids are corrosive. They can attack metals and destroy skin if spilled.
- acids have a sour taste, like vinegar, which contains acetic acid**,** and lemons, which contain citric acid.
- other acids you will find at home are carbonic acid in fizzy drinks, tannic acid in tea and ascorbic acid which is vitamin C, found in fruit and vegetables.
- acids change litmus (a dye extracted from lichens) red.
- acids have a pH less than 7.
- acids can conduct electricity.

NOW DO PRACTICE EXERCISE 6 ON THE NEXT PAGE.

Practice Exercise 6

Answer the following questions:

1. What is an acid?

   ____

2. List at least five uses of acids.

   a. ____
   b. ____
   c. ____
   d. ____
   e. ____

3. Write down the eight different properties of acids.

   a. ____
   b. ____
   c. ____
   d. ____
   e. ____
   f. ____
   g. ____
   h. ____

4. Identify and describe the different acidic substances at home.

   a. ____
   b. ____
   c. ____
   d. ____
   e. ____

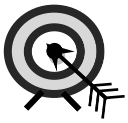
CHECK YOUR WORK. ANSWERS ARE AT THE END OF SUB STRAND 2.

Answers to Activity

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

Lesson 7: What are Bases?

Welcome to Lesson 7 of Strand 3. From the previous lesson, you studied and described acids and its properties. In this lesson, you will learn about the opposite of acidic substances; that is the basic substances. These substances we use can be found at home like toothpaste, detergents and milk are called bases.



Your Aims:

- define base
- give the uses of bases
- state the different properties of bases
- compare properties of acids and bases

What Are Bases?

These are the opposite of acids. It is a substance which forms hydroxide (**OH^-**) ions in a solution. **It is these OH^{1-} ions that are responsible for the properties of bases.** A base is a substance that can neutralise an acid. Bases which are soluble in water are called alkalis. Alkalis turn red litmus paper blue. Bases normally taste bitter and feel soapy. Most of washing powders are bases. Some bases are often found in household cleaners, they help clean grease from windows and floors and are found in the soap we use everyday. Some other examples of basic substances are toothpaste, egg whites, dishwashing liquids and household ammonia.

Alkalis turn red litmus paper blue

(WARNING: Do not taste these!)

Different bases found at home

Uses of Bases

Bases can be found in soap, toothpaste, human saliva, blood plasma and baking powder. Here are some of the uses of bases.

Ammonium hydroxide or frequently called ammonia water is used in the preparation of important related compounds such as nitric acid and ammonium chloride. It is very irritating to the nose and the eyes. This substance called a hydroxide, or a base, is often used in the home for cleaning agent because bases generally dissolve grease. Milk of magnesia (magnesium hydroxide), which is used as an antacid, is a base.

Ammonia water

Sodium hydroxide is another familiar example of a base. It is one of the most used bases in industrial processes. Also called "lye", it is used as a drain cleaner, in the manufacture of soap, rayon, paper and to neutralise acids. Strong solutions of this base are very caustic; that is, they are extremely harmful to the skin.


Sodium hydroxide pellets

Sodium hydroxide solution

Calcium hydroxide, commonly known as slaked lime, is used in the preparation of plaster and mortar. Water solutions of calcium hydroxide, called limewater, can be used in the lab as a test for the presence of carbon dioxide.


Calcium hydroxide

Calcium hydroxide solution

Baking soda, the proper chemical name for sodium bicarbonate is Sodium hydrogen carbonate. Sodium bicarbonate is a white powder which is commonly used as an antacid and in cooking as a leavening agent as it reacts with acidic ingredients such as buttermilk and yogurt. It is also used for cleaning and as a deodorizer. It is a very weak base and may be used as an ingredient in toothpaste.

Oven cleaners, egg whites and milk are among the other many basic substances.

Look at table below for the uses and formula of some common bases.

Substances	Formula	Examples
Sodium hydroxide	NaOH	Lye, Caustic; make soap and textiles, oven cleaner, liquid plumber
Potassium hydroxide	KOH	Lye, Caustic; make soap and textiles
Magnesium hydroxide	$Mg(OH)_2$	Milk of magnesia; laxative and antacid
Calcium hydroxide	$Ca(OH)_2$	Lime water; astringent-causes contraction of skin pores
Ammonium hydroxide	NH_4OH	Ammonia in water; window cleaner, other cleaning solutions
Ammonia	NH_3	Gas; inhalant to revive an unconscious person, anhydrous or liquid ammonis is injected into soil as a fertiliser
Sodium carbonate	Na_2CO_3	Soda ash; detergents
Sodium phosphate	Na_3PO_4	Sodium triphosphate; detergents

Properties of Bases

Here are the properties of bases in water solutions.

1. Bases taste bitter. A bitter taste is characteristic of all bases. It is the presence of a base that gives unflavoured milk of magnesia its bitter taste.
2. Bases feel slippery. If you rub a drop or two of household ammonia between your fingers, you experience the slippery feeling of a base. Wet soap is also slippery because of the presence of a base.
3. Bases turn red litmus blue. A common indicator, used to detect the presence of a base, is phenolphthalein which, when mixed with a base, turns pink.
4. Bases have a pH value greater than 7.
5. Concentrated or strong bases are caustic (corrosive) on organic matter and react violently with acidic substances.
6. Bases conduct electricity due to the presence of mobile ions in solution.

Comparison of Acids and Bases

Test	Acids	Bases
Taste	Sour • Household vinegar (acetic acid) • Lemon juice, orange juice or citrus juices (citric acid) • Vitamin c (ascorbic acid) • Soft drinks (Phosphoric acid)	Bitter • Milk of magnesia (magnesium hydroxide) • Maalox antacid (Magnesium hydroxide and aluminium, hydroxide)
Feel	Concentrated acid can cause skin burn, care should be taken when handling acids	Concentrated bases can cause skin burn, care should be taken when handling bases; bases often feel slippery or soapy
Reaction to Litmus Paper	turn litmus paper red	turn litmus paper blue
Reactions	• React with bases to form salt and water (neutralization reaction) • React with metals such as magnesium, zinc, iron to reduce hydrogen gas, H_2 (g).	• React with acids to form salt and water (neutralization reaction)
Examples	• Car battery (sulphuric acid) • Stomach acid (hydrochloric acid)	• Drain cleaner, oven cleaner (sodium hydroxide) • Cleaning products (ammonia solution)

Activity: Now test yourself by doing this activity.

Multiple Choice Questions.

Circle the letter of the correct answer.

1. Which solution will change red litmus to blue?

   A. HCl B. NaCl

   C. NaOH D. CH_3OH

2. A basic solution could have a pH of __________.

   A. 3 B. 5

   C. 7 D. 9

3. When litmus is added to a solution of borax, it turns __________.

   A. red B. pink

   C. blue D. colourless

4. Which of the following is a weak base?

   A. KOH B. NaOH

   C. NH_4OH D. $Ca(OH)_2$

5. When water solutions of an acid and base are mixed

   A. no reaction occurs.
   B. a salt and water are formed.
   C. an acid and a salt are formed.
   D. a new acid and a new base are formed.

6. The characteristic properties of a base is due to the presence of

   A. oxide ions.
   B. hydride ions.
   C. hydroxyl ions.
   D. hydroxide ions.

7. The pH of toothpaste is __________.

A. equal to 7

B. less than 7

C. more than 7

D. approximately 6.9

Summary

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

- a base is a substance which forms hydroxide (OH^-) ions in a solution. It turns red litmus paper blue. It is the opposite of acids, gases take up the volume and shape of the container.
- bases which are soluble in water are called alkalis.
- bases normally taste bitter and feel soapy.
- some examples of basic substances are washing powders, toothpaste, soap, human saliva, blood plasma, baking powder, egg whites, dishwashing liquids and household ammonia.
- ammonium hydroxide or frequently called ammonia water is used in the preparation of nitric acid and ammonium chloride. It is very irritating to the nose and the eyes.
- sodium hydroxide (lye) is one of the most used bases in industrial processes. It is used as a drain cleaner, in the manufacture of soap, rayon, paper and to neutralize acids. Strong solutions of this base are very caustic; that is, they are extremely harmful to the skin.
- calcium hydroxide (slaked lime) is used in the preparation of plaster and mortar. Water solutions of calcium hydroxide, called limewater, can be used in the lab as a test for the presence of carbon dioxide.
- baking soda (Sodium bicarbonate or Sodium hydrogen carbonate) is a white powder used as an antacid and in cooking as a leavening agent as it reacts with acidic ingredients such as buttermilk and yoghurt. It is also used for cleaning and as a deodorizer.
- comparison between acids and bases are the following
  - Acids have a sour taste while bases have a bitter taste.
  - Acids turn litmus paper red while bases turn litmus paper blue.
  - Bases have a soapy feel while acids do not feel slippery.

NOW DO PRACTICE EXERCISE 7 ON THE NEXT PAGE.

Practice Exercise 7

Answer the following questions:

1. Define base.

____

____

2. Give at least five properties of bases.

A. ______________________________

B. ______________________________

C. ______________________________

D. ______________________________

E. ______________________________

3. State at least five different uses of bases.

A. ______________________________

B. ______________________________

C. ______________________________

D. ______________________________

E. ______________________________

4. Identify at least five different basic substances at home.

A. ______________________________

B. ______________________________

C. ______________________________

D. ______________________________

E. ______________________________

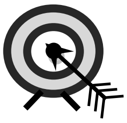
CHECK YOUR WORK. ANSWERS ARE AT THE END OF SUB STRAND 2.

Answers to Activity

1. **C**
2. **D**
3. **C**
4. **C**
5. **B**
6. **D**
7. **C**

Lesson 8: Common Laboratory Acids and Bases

Welcome to Lesson 8 of Strand 3. In lessons 6 and 7, you learnt about acidic and basic substances, their properties and uses. Laboratory acids and bases are those that scientists use in a conventional science laboratory to carry out science experiments or solve other problems that require the use of acids and bases. So for this lesson you will learn about the common laboratory acids and bases.



Your Aims:

- identify common laboratory acids and bases
- compare and give examples of strong and weak laboratory acids and bases
- identify the uses of common laboratory acids and bases

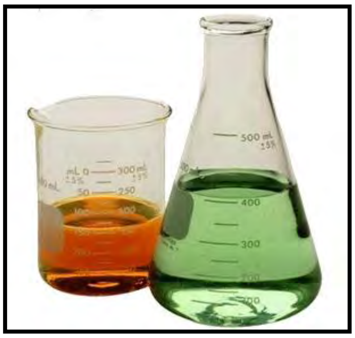
Strong and Weak Acids

One important group of chemicals is called acids. Acids may be solids, liquids or gases. We usually see them dissolved in water as solutions. Some of the food that we eat contains weak acids which are harmless but useful in our body by breaking down food that we eat.

Strong acids

Acids used in the laboratory are strong acids.

Hydrochloric acid



Sulphuric acid

Nitric acid

The table below shows the three common types of laboratory acids and their uses.

Name of Acid	Uses
Hydrochloric acid	Used to clean metals before soldering or plating with other metals. Dilute hydrochloric acid in the stomach helps to break down food and also kills germs.
Nitric acid	Used to make explosives and dyes.
Sulphuric Acid	Used in car batteries and to make fertilisers.

They are all liquids- meaning they are solutions of pure compounds in water. If you get any acid on your skin or clothes, wash it away immediately with plenty of water. Strong acids must be handled carefully, for they are corrosive and can cause serious burns to the skin and damage the cloth. They can also corrode metals.

Weak acids
The sour taste of an unripe fruit is an example of a weak acid. Examples of these include fruits like oranges, lemons, pomelos, apples and limes. Other examples are sour milk and vinegar. All of these foods contain weak acids and are quite harmless.


Different fruits and vinegar are all weak acids

The table below shows some common types of weak acids and their uses.

Name of weak acid	Uses
Acetic acid	Found in vinegar and is used for cooking
Citric acid	Found in lemon
Tartaric acid	Found in grapes
Lactic acid	Found in yoghurt
Carbonic acid	Found in soft drinks

Strong and weak bases
Like acids, bases can also be strong or weak. Bases which are soluble in water are called **alkalis.** Bases have a bitter taste and a soapy feel. Just like strong acids, strong bases are also corrosive. It is dangerous to touch the laboratory alkalis and some kitchen cleaners because they can burn flesh and damage the clothes if not washed off immediately with water. Great care must be taken when using these bases. One drop of Sodium hydroxide in the eye can cause blindness.

Ammonium hydroxide- weak base

Calcium hydroxide- strong base

Sodium hydroxide- strong base

Potassium hydroxide- strong base

Strong bases

All laboratory bases are dangerous. Sodium hydroxide, Potassium hydroxide and Calcium hydroxide are strong alkalis.

Below are the three common laboratory alkalis (solution) which are strong.

- Calcium hydroxide
- Sodium hydroxide
- Potassium hydroxide

The table below shows the three common types of laboratory bases and their uses.

Name of Base	Uses
Ammonium hydroxide	Used as a cleaning agent that dissolves grease and dirt in many household cleaning fluids
Calcium hydroxide	Used to remove the hair of skins in the manufacture of leather and is used to convert wood chips to pulp in the making of paper. It is also mix with sand and water to make mortar and plaster.
Sodium hydroxide	It is also known as caustic soda. It is used to clean stoves and clean drains blocked with fat and grease. It is used to react with fats to produce soap.

Weak basses

Ammonium hydroxide is a weak laboratory base. All the substances below are alkaline. Notice that all of them can be found at home. Many kitchen cleaners are bases because they contain ammonia or Sodium hydroxide, which attack grease.

Kitchen cleaner

Metal polish

Ammonia solution

Toilet cleaner

Activity: Now test yourself by doing this activity.

Answer the following questions:

1. Name three common acids used in the laboratory.

   a. ________________________________

   b. ________________________________

   c. ________________________________

2. Name three common bases used in the laboratory.

   a. ________________________________

   b. ________________________________

   c ________________________________

3. Give one example of a:

   a. strong acid _____________________

   b. weak acid _____________________

   c. weak base _____________________

   d. strong base _____________________

Summary

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

- acids may be solids, liquids or gases. We usually see them dissolved in water as solutions.
- fruits and other substances like lime, sour milk and vinegar all contain weak acid, taste sour and are quite harmless.
- the three common laboratory acids which are strong are hydrochloric acid, sulphuric acid and nitric acid.
- strong acids must be handled carefully, for they are corrosive and can cause serious burns to the skin and damage clothes.
- bases which are soluble in water are called alkalis.
- just like strong acids, strong bases are also corrosive. They can burn flesh and can cause blindness.
- the three common laboratory bases which are strong are sodium hydroxide, calcium hydroxide and potassium hydroxide.
- ammonia is a weak alkali.
- ammonium hydroxide is used as a cleaning agent that dissolves grease and dirt in many household cleaning fluids.
- calcium hydroxide is used to remove the hair of skins in the manufacture of leather and is used to convert wood chips to pulp in the making of paper.
- sodium hydroxide (also known as caustic soda) is used to clean stoves and clean drains blocked with fat and grease.

NOW DO PRACTICE EXERCISE 8 ON THE NEXT PAGE.

Practice Exercise 8

Answer the following questions:

A. **Matching Type.**

Study the properties of acids and bases in **column A** and then draw a line to match their uses in **column B**

Column A	Column B
A. Hydrochloric Acid	(i) Used to make explosives and dyes.
B. Calcium hydroxide	(ii) Used as a cleaning agent that dissolves grease and dirt in many household cleaning fluids.
C. Sodium hydroxide	(iii) Used to clean metals before soldering or platting with other metals.
D. Nitric Acid	(iv)Used to remove the hair of skins in the manufacture of leather and is used to convert wood chips to pulp in the making of paper.
E. Ammonium hydroxide	(vi) It is also known as caustic soda. It is used to clean stoves and clean drains blocked with fat and grease.
F. Sulphuric Acid	(vi) Used in car batteries and to make fertiliser.

B. Name three examples of strong and weak acids.

Strong acids
a.
b.
c.

Weak acids
a.
b.
c.

C. Word maze. The words may be written forwards, backwards, up, down or diagonally. Find each word and cross it off as you find it.

sulphuric	**base**	**vinegar**	**lemon**	**ammonia**	**soap**
weak	**water**	**acid**	**strong**	**alkali**	**hydrochloric**

E	I	L	A	K	L	A	M	A	C	I	D
N	I	K	L	E	M	O	N	I	B	Y	E
B	E	A	T	S	S	T	R	O	N	G	N
A	R	E	T	A	W	U	P	T	E	M	S
S	A	W	E	R	H	E	R	U	G	A	N
E	P	Q	U	P	R	A	G	E	N	I	V
D	A	S	L	I	M	E	Y	A	C	T	H
E	O	U	A	M	M	O	N	I	A	E	I
A	S	R	O	L	H	C	O	R	D	Y	H
C	I	R	O	L	H	C	O	R	D	Y	H

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

Answers to Activity

1. a. Hydrochloric acid

   b. Nitric acid

   c. Sulphuric acid

2. a. Ammonium hydroxide

   b. Calcium hydroxide

   c. Sodium hydroxide

3. a. hydrochloric, nitric, sulphuric (any of these)

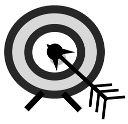
   b. sour milk, vinegar, fruits (any of these)

   c. ammonia

   d. ammonium, calcium, sodium hydroxides (any of these)

Lesson 9: Indicators

Welcome to Lesson 9 of Strand 3. In lessons 6, 7 and 8, you learnt about acids, bases and the common laboratory acids and bases. You also learnt that some acids and bases are strong and dangerous and some are weak and even useful to us. Therefore, to find out if acids and bases are strong or weak, we need to test these using indicators. So for this lesson, you will learn about indicators.



Your Aims:

- define and give examples of indicators
- explain what a pH scale is when looking at the strength of acids and bases
- identify the different colours of indicators in acids and bases

What are Indicators?

We have read that all acids taste sour. However, we cannot taste every substance to see if it is an acid or not. Scientists use chemical dyes called indicators to test the presence of an acid. An indicator is a substance that will change colour when added to an acid or base.

Laboratory indicators

Litmus is a common indicator that is either red or blue. However, litmus is only one of a number of useful indicators. In acids, litmus turns red and blue in bases. Some indicators are made by scientists. The table below shows some of these indicators.

Name of indicator	Colour in acid	Colour in base
Litmus	Red	Blue
Phenolphthalein	Colourless	Pink
Bromothymol blue	Yellow	Blue
Methyl orange	Red	Yellow

Solutions which are neither acidic nor basic are said to be **neutral**. Pure water is an example of a neutral solution. Sometimes when you add an indicator to a solution, there is no colour change. To be sure that a substance is an acid or a base, you must observe a change in the colour of an indicator. Sometimes two indicators may be needed to check a substance.

Natural indicators

Hibiscus petal

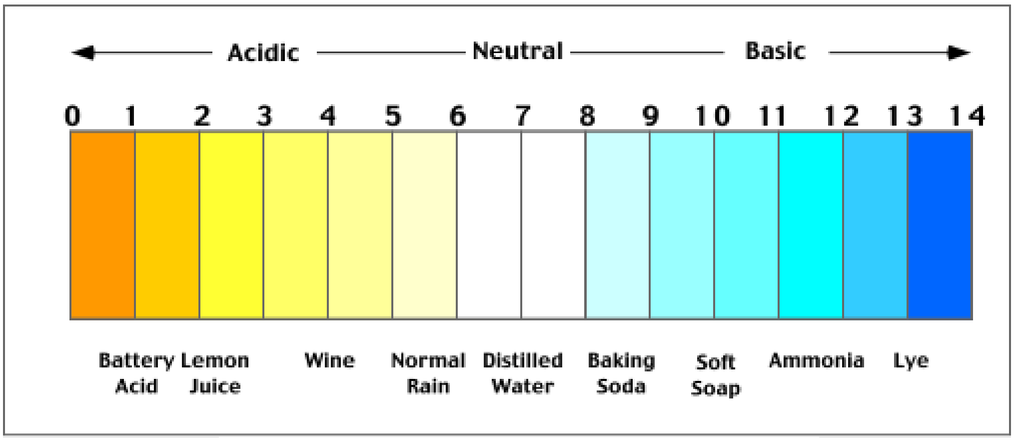
Cabbage leaves

Many of the coloured dyes in plants, vegetables and flowers are also good indicators. The red colouring in hibiscus flowers can be extracted by boiling the petals in water for a few minutes. The red solution can then be used as an indicator. Hibiscus flower indicator is red in acids and green in bases.

When betel nut and mustard are chewed with lime, the nut turns red. Betel nut and mustard contain a substance that changes colour in a similar way to phenolphthalein indicator. In acids this substance is colourless, but in bases it turns red.

The pH Scale

Most of the indicators listed so far have two colours. Litmus, for example, is either red or blue. **Universal indicator** is a mixture of several different indicators. Because of this, universal indicator can turn into many different colours depending on how acidic or basic a solution is. Each of the colours can be matched to numbers which form a scale called the pH scale. The **pH scale** indicates the **power of hydrogen (pH)** in acidic and basic substances. It shows numbers ranging from 0 to 14. Acidic solutions have pH between 0 and 6. Basic solutions have pH between 8 and 14. The pH number 7 shows a neutral solution which is pure water. An example of a pH scale is shown below with some common substances.



The pH of some common substances.

Range of pH	Colour of Universal Indicator	Strong/Weak/Acid/Base
0	Red	
1	Red	Strong acids, for example hydrochloric acid
2	Red	
3	Pink	
4	Pink	Weak acids, for example citric acid
5	Orange	
6	Yellow	
7	Green	Neutral solutions, for example pure water and salt solution
8	Blue-green	
9	Blue	Weak bases, for example lime water
10	Blue	
11	Purple	
12	Purple	Strong bases, for example sodium hydroxide
13	Purple	
14	Purple	

Colours of universal indicator and the pH scale

Importance of pH in our life

pH is also important to our life. For example, gardeners and farmers talk of the pH of soils and hairdressers talk of the pH of shampoos. Bananas, sugar and coconuts grow best in slightly basic soil of pH 7 to 8, whereas peanuts, kaukau and coffee prefer a fairly acidic soil of around pH 5 to 6. The pH of soil is important for the growth of plants. If the soil is too acidic or too alkaline, plants usually do not grow. Gardeners and farmers add lime to neutralise the acid and raise the pH of the soil. Most plants require a pH of 7 to 8 in order to grow well.

Even in the human body, the pH varies from one part to another. The liquids in our stomachs are strongly acidic due to the presence of hydrochloric acid. Acidic conditions are needed for the digestion of proteins. Alkaline fluids are in our small intestine for the digestion of carbohydrates. Blood is almost neutral.

The pH of food is also important. To make jam, the pH must be kept at about 5. Lemon juice is often added when jam is being made to keep it acidic. Meat, fruits and vegetables contain either acidic or alkaline substances.

Activity: Now test yourself by doing this activity.

Answer the following questions:

1. Use the pH chart from the previous page. Arrange the following substances from the most acidic to the most basic:

Substances: **limewater, distilled water, milk, lemon juice, ammonia, hydrochloric acid, vinegar, soft drinks, sodium hydroxide, toothpaste**

Arrange from the most acidic to the most basic
1.
2
3.
4.
5.
6.
7.
8.
9.
10.

2. The words in the following sentences have been jumbled up. Unjumble the words then rewrite the sentences correctly.

a. an solution a pH than 7 acidic less has

____

b. a pH basic has a solution than 7 more

____

c. solution has a pH of 7 a neutral

____

d. an water example of a neutral is solution

____

Summary

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

- an indicator is a dye that will change colour when mixed with an acid or a base.
- pH scale is a scale of numbers from 0 to 14 that is used to measure the strength of an acid or a base.
- acidic solutions have a pH between 0 and 6. Basic solutions have a pH between 8 and 14. The pH number 7 corresponds to a neutral solution.
- many of the coloured dyes in plants, vegetables and flowers are also good indicators.
- litmus turns red in acid and blue in base.
- phenolphthalein turns colourless in acid and pink in base.
- bromothymol blue turns yellow in acid and blue in base.
- methyl orange turns red in acid and yellow in base.
- a universal indicator is a mixture of several different indicators. Because of this, universal indicator can turn many different colours depending on how acidic or basic a solution is.
- pH is important for the growth of plants, for the body and for food.

NOW DO PRACTICE EXERCISE 9 ON THE NEXT PAGE.

Practice Exercise 9

Answer the following questions:

1. Explain the meanings of these words.

   a. Indicator ______________________________

   ____

   b. pH scale ______________________________

   ____

2. Fill in the tables below.

Table A:

Name of solution	pH colour	pH number	Acid/base/neutral
Lemon juice			
Coke			
Vinegar			
Hydrochloric acid			
Sodium hydroxide			
Household ammonia			
Pure water			
Lime water			
Toothpaste			
Distilled water			

Table B:

Indicator name	Colour in acid	Colour in base
Litmus		
Phenolphthalein		
Bromothymol blue		
Methyl orange		

3. Some phenolphthalein is added to a solution of household ammonia. What colour would you expect the indicator to be?

____

4. Some bromothymol blue is added to some vinegar. What colour would you expect the indicator to be?

____

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

Answers to Activity

1.

Arrange from the most acidic to the most basic
1. Hydrochloric acid
2. Lemon juice
3. Vinegar
4. Soft drinks
5. Distilled water
6. Milk
7. Toothpaste
8. Ammonia
9. Limewater
10. Sodium hydroxide

2. a. An acidic solution has a pH less than 7.

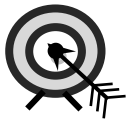
b. A basic solution has a pH more than 7.

c. A neutral solution has a pH of 7.

d. Water is an example of a neutral solution

Lesson 10: Neutralisation Process

Welcome to Lesson 10 of Strand 3. You have learnt so much about acids and bases in this sub strand. As you already know acids are the opposites of bases and some acids can be quite dangerous. What do you think will happen if you were to mix an acid and a base together? Will it explode? Something does happen and it's called **neutralisation** which you will about in this lesson.



Your Aims:

- define neutralisation and salt
- describe neutralisation in everyday life

Neutralisation and Salt

Acids and alkalis are chemical opposites. They react together and cancel each other out. If we mix just the right amount of acid and alkali together, we get a neutral solution. The reaction between an acid and an alkali is called a **neutralisation** reaction. And heat energy is produced with salt and water.

The neutralisation reaction can be shown by the general equation below.

acid + base ⟶ salt + water

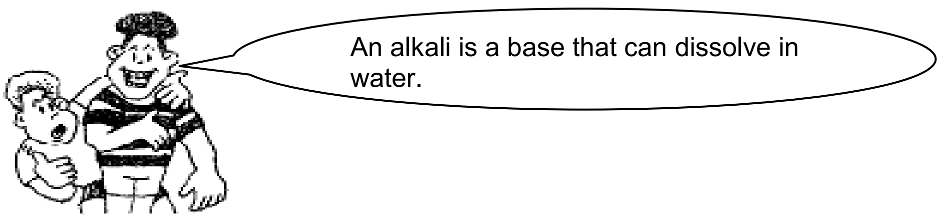
Hydrochloric acid + Sodium hydroxide ⟶ Sodium chloride + water

A table salt, sodium hydroxide

Neutralisation always produces a salt. But what is a salt? Salt is used to describe any metal compounds that are made from acids. All acids contain hydrogen so, when we replace the hydrogen in an acid with a metal, we get a salt. Each acid has its own salts.

Let us look at some of the salt of acids.

Acid		Salt
Hydro**chlo**ric acid	⟶	chlorides
Sulphuric acid	⟶	sulphates
Nitric acid	⟶	nitrates



Neutralisation in everyday life

Neutralising acid is important in everyday life. Here are some neutralisations in our day to day living.

A. **Preventing tooth decay** – the sugar in your mouth produces acids that rot your teeth. Toothpaste is base and neutralises these acids so it helps to clean your teeth soon after eating.

Toothpaste

Calamine lotion

B. **Insect stings** – When a bee stings, it injects an acidic liquid into the skin. The sting can be neutralised by rubbing a calamine lotion, which contains zinc carbonate or baking soda, which is sodium hydrogen carbonate. Wasp stings are alkaline, and can be neutralised with vinegar.

C. **Soil treatment** – Most plants grow best when the pH of the soil is close to 7. If the soil is too acidic or too alkaline, the plants grow badly or not at all.
Chemicals can be added to soil to adjust its pH. Most often soil is too acidic so it is treated with quicklime (calcium oxide), slaked lime (calcium hydroxide) or chalk (calcium carbonate). These are all bases and are quite cheap.

Slaked lime

D. **Acid rain** – Most power stations burn fossil fuels. This gives off acidic sulphur dioxide gas which causes acid rain. Power stations can use lime or limestone to neutralise the gas before it leaves the chimneys.

E. **Factory waste** – Liquid waste from factories often contains acid. If it reaches the river, the acid will kill the fish and other river life. This can be prevented by adding slaked lime to the waste, to neutralise it.

Liquid wastes from factories

Activity: Now test yourself by doing this activity.

Complete the following:

Acid + base ⟶ salt + __________

When an acid and alkali react to cancel each other out, we call it a __________ reaction.

A salt is made when the __________ in an acid is replaced by a __________.

Acid		Salt
Hydrochloric acid	⟶	__________
__________ acid	⟶	sulphates
Nitric acid	⟶	__________

Summary

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

- the reaction between an acid and an alkali is called neutralisation and heat energy is also produced.
- heat, salt and water are products of neutralization.
- any metal compounds that can be made from acids are called acids.
- the salt of hydrochloric acid are chlorides.
- the salt of sulphuric acid are sulphates.
- the salt of nitric acid are nitrates.
- neutralisation plays an important role in everyday life.
- the general equation for neutralisation reactions are:
    - Acid + base ⟶ salt + water + heat

NOW DO PRACTICE EXERCISE 10 ON THE NEXT PAGE.

Practice Exercise 10

Answer the following questions:

1. Define

   a. Neutralisation

   ____

   b. Salt

   ____

2. Describe the neutralisations in everyday life.

   a. Acid rain

   ____

   ____

   b. Insect stings

   ____

   ____

   c. Soil treatment

   ____

   ____

   d. Factory waste

   ____

   ____

   e. Preventing tooth decay

   ____

   ____

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

Answers to Activity

Acid + base $\longrightarrow$ salt + **water**

When an acid and alkali react to cancel each other out, we call it a **neutralisation** reaction.

A salt is made when the **hydrogen** in an acid is replaced by a **metal**.

Acid		Salt
Hydrochloric acid	$\longrightarrow$	**chlorides**
Sulphuric acid	$\longrightarrow$	sulphates
Nitric acid	$\longrightarrow$	**nitrates**

REVIEW OF SUB STRAND 2: ACIDS AND BASES

Revise all the Lessons in this Sub Strand and then do **ASSIGNMENT 3.**
Here are the main points to help you revise.

Lesson 6: Acidic Substances

- Acids are chemicals which will turn blue litmus paper red.
- Dilute sulphuric or hydrochloric acid will remove any surface rust which would otherwise spread under the painted surface.
- Nitric acid, another important industrial acid, is used in the manufacture of fertilizers, plastics, photographic film, and dyes.
- In humans and many other animals, hydrochloric acid is a part of the gastric acid secreted within the stomach to help digest foods.
- Boric acid is a weak acidic substance that is sometimes used to wash the eyes. It is also used as fire retardant.
- Acids are corrosive. They can attack metals and destroy skin if spilled.
- Acids have a sour taste, like vinegar, which contains ethanoic acid**,** and lemons, which contain citric acid.
- Other acids you will find at home are carbonic acid in fizzy drinks, tannic acid in tea and ascorbic acid which is vitamin C, found in fruit and vegetables.
- Acids have a pH less than 7.
- Acids can conduct electricity.

Lesson 7: Basic Substances

- A base is a substance which forms hydroxide (**OH^-**) ions in a solution. It turns red litmus paper blue. It is the opposite of acids.
- Bases which are soluble in water are called alkalis. Bases normally taste bitter and feel soapy.
- Ammonium hydroxide or frequently called ammonia water is used in the preparation of nitric acid and ammonium chloride. It is very irritating to the nose and the eyes.
- Sodium hydroxide (lye) is one of the most used bases in industrial processes. It is used as a drain cleaner, in the manufacture of soap, rayon, paper and to neutralize acids. Strong solutions of this base are very caustic; that is, they are extremely harmful to the skin.
- Calcium hydroxide (slaked lime) is used in the preparation of plaster and mortar. Water solutions of calcium hydroxide, called limewater, can be used in the lab as a test for the presence of carbon dioxide.
- Baking soda (Sodium bicarbonate or Sodium hydrogen carbonate) is a white powder used as an antacid and in cooking as a leavening agent as it reacts with acidic ingredients such as buttermilk and yogurt. It is also used for cleaning and as a deodorizer.
- Comparison between acids and bases are the following.
  - Acids have a sour taste while bases have a bitter taste.
  - Acids turn litmus paper red while bases turn litmus paper blue.
  - Bases have a soapy feel while an acid does not feel slippery.

Lesson 8: Common Laboratory Acids and Bases

- Acids in the laboratory are strong. The three common acids used in the laboratory are hydrochloric acid, sulphuric acid and nitric acid.
- Strong acids must be handled carefully, for they are corrosive and can cause serious burns to the skin and damage clothes.
- Hydrochloric Acid- is used to clean metals before soldering or plating with other metals.
- Nitric Acid- is used to make explosives and dyes.
- Sulphuric Acid- is used in car batteries and to make fertiliser.
- Bases have a bitter taste and a soapy feel. Bases which are soluble in water are called alkalis.
- Just like strong acids, strong bases are also corrosive. They can burn flesh and can cause blindness.
- Sodium hydroxide, Potassium hydroxide and Calcium hydroxide are strong alkalis but ammonia is a weak alkali.
- The three common bases used in the laboratory are ammonium hydroxide, calcium hydroxide and sodium hydroxide.
- Ammonium hydroxide is used as a cleaning agent that dissolves grease and dirt in many household cleaning fluids.
- Calcium hydroxide is used to remove the hair of skins in the manufacture of leather and is used to convert wood chips to pulp in the making of paper.
- Sodium hydroxide (caustic soda) is used to clean stoves and clean drains blocked with fat and grease.

Lesson 9: Indicators

- Indicator is a dye that will change colour when mixed with an acid or a base.
- pH scale is a scale of numbers from 0 to 14 that is used to measure the strength of an acid or a base.
- Acidic solutions have a pH between 0 and 6. Basic solutions have a pH between 8 and 14. The pH number 7 corresponds to a neutral solution.
- Litmus turns red for acid and blue for base.
- Phenolphthalein turns colourless for acid and pink for base.
- Bromothymol blue turns yellow for acid and blue for base.
- Methyl orange turns red for acid and yellow for base. Universal indicator is a mixture of different indicators.

Lesson 10: Neutralisation Process

- The reaction between an acid and an alkali is called neutralisation and heat energy is also produced.
- Neutralisation always produces a salt. Chemists use the word salt to describe any metal compounds that can be made from acids.
- All acids contain hydrogen so, when we replace the hydrogen in an acid by a metal, we get salt.
- The salt gets its first name from the metal, and its surname from the acid. Each acid has its own salts.
- The salt of hydrochloric acid are chlorides.
- The salt of sulphuric acid are sulphates.
- The salt of nitric acid are nitrates.

- Neutralising acid is important in our everyday life. It prevents tooth decay, cures insect stings, treats soil in the right pH, neutralises acid rain from power stations, helps cake-mix to rise, and neutralises liquid wastes from factories.
- The general equation for neutralisation reactions are:
    - Acid + metal ⟶ salt + hydrogen
    - Acid + base ⟶ salt + water
    - Acid + carbonate ⟶ salt + water + carbon dioxide

REVISE WELL AND THEN DO SUB STRAND TEST 2 IN YOUR ASSIGNMENT 3.

Answers to Practice Exercises 6- 10

Practice Exercise 6

1. Acids are chemicals which will turn blue litmus paper red.

2. a. 'Rust remover' used to repair cars.

   b. Acids may be used as an electrolyte in a wet cell battery.

   c. Used in the manufacture of fertilizers, plastics, photographic film, and dyes.

   d. In humans and many other animals, acid is a part of the gastric acid secreted within the stomach to help digest foods.

   e. Baking powder contains tartaric acid.

   f. ‘Lime scale’ removers contain dilute (weak) acids.

   g. Boric acid is a weak acidic substance that is sometimes used to wash the eyes. It is also used as fire retardant.

3. a. Acids are corrosive.

   b. Acids have sour taste

   c. Acids change litmus (a dye extracted from lichens) red.

   d. Acids have a pH less than 7.

   e. Acids can conduct electricity.

   f. Acids react with bases to form a salt (neutral) and water.

   g. Acids react with carbonates to form carbon dioxide gas, water and a salt

   h. Acids react with metals (the more reactive metals) to form hydrogen gas and a salt.

4. a. Vinegar – contains acetic acid

   b. Lemons – contain citric acid

   c. Fizzy drinks – carbonic acid

   d. Tea – tannic acid

   e. Vitamin C (fruits and vegetables) – ascorbic acid

Practice Exercise 7

1. A base is a substance which forms hydroxide (OH^-) ions in a solution. It turns red litmus paper blue.

2. A. Bases taste bitter.

   B. Bases feel slippery and soapy.

   C. Bases turn red litmus blue.

   D. Bases have a pH value greater than 7

   E. Concentrated or strong bases are caustic (corrosive) on organic matter and react violently with acidic substances.

   F. Bases conduct electricity due to the presence of mobile ions in solution.

3. A. Used to neutralise acids.

   B. It is used as a drain cleaner.

   C. In the preparation of plaster and mortar.

   D. In the manufacture of soap, rayon, paper.

   E. It is also used for cleaning and as a deodorizer.

   F. It is used as an antacid and in cooking as a leavening agent.

4. A. Washing powders

   B. Toothpaste

   C. Soap

   D. Human saliva

   E. Blood plasma

   F. Baking powder

   G. Egg whites

   H. Dishwashing liquids

   I. Household ammonia

Practice Exercise 8

1. (i) D

   (ii) E

   (iii) A

   (iv) B

   (v) C

   (vi) F

2.

Strong acids
a. HYDROCHLORIC
b. SUPHURIC
c. NITRIC

Weak acids
a. SOUR MILK
b. VINEGAR
c. FRUITS

3.

E	**I**	**L**	**A**	**K**	**L**	**A**	M	**A**	**C**	**I**	**D**
N	I	**K**	**L**	**E**	**M**	**O**	**N**	**I**	B	Y	E
B	E	**A**	T	S	**S**	**T**	**R**	**O**	**N**	**G**	N
A	**R**	**E**	**T**	**A**	**W**	**U**	P	T	E	M	S
S	A	**W**	E	R	**H**	E	R	U	G	A	N
E	**P**	Q	U	**P**	**R**	**A**	**G**	**E**	**N**	**I**	**V**
D	**A**	S	**L**	I	M	E	Y	A	C	T	H
E	**O**	**U**	**A**	**M**	**M**	**O**	**N**	**I**	**A**	E	I
A	**S**	R	O	L	H	C	O	R	D	Y	H
C	**I**	**R**	**O**	**L**	**H**	**C**	**O**	**R**	**D**	**Y**	**H**

Practice Exercise 9

1. a. Indicator – a dye that will change colour when mixed with an acid or a base.

   b. pH scale – a scale of numbers from 0 to 14 that is used to measure the strength of an acid or a base.

2. a.

Name of solution	pH colour	pH number	Acid/base/neutral
Lemon juice	Red	2	Acid
Coke	Orange	5	Acid
Vinegar	Pink	3	Acid
Hydrochloric acid	Red	1	Acid
Sodium hydroxide	Purple	14	Base
Household ammonia	Blue-green	8	Base
Pure water	Green	7	Neutral
Lime water	Purple	12	Base
Toothpaste	Blue	10	Base
Distilled water	Yellow	6	Acid

b.

Indicator name	Colour in acid	Colour in base
Litmus	Red	Blue
Phenolphthalein	Colourless	Pink
Bromothymol blue	Yellow	Blue
Methyl orange	Red	Yellow

3. The colour would be pink

4. The colour would be yellow

Practice Exercise 10

1. a. **Neutralisation** – the reaction between an acid and an alkali to form neutral solution. Heat energy is also produced.

   b. **Salt** – is the product when we replace the hydrogen in an acid by a metal.

2. a. **Acid rain** – Most power stations burn fossil fuels. This gives off acidic sulphur dioxide gas which causes acid rain. Power stations can use lime or limestone to neutralise the gas before it leaves the chimneys.

   b. **Insect stings** – When a bee stings, it injects an acidic liquid into the skin. The sting can be neutralised by rubbing a calamine lotion, which contains zinc carbonate or baking soda, which is sodium hydrogen carbonate. Wasp stings are alkaline, and can be neutralised with vinegar.

c. **Soil treatment** – Most plants grow best when the pH of the soil is close to 7. If the soil is too acidic or too alkaline, the plants grow badly or not at all. Chemicals can be added to soil to adjust its pH. Most often soil is too acidic so it is treated with quicklime (calcium oxide), slaked lime (calcium hydroxide) or chalk (calcium carbonate).

d. **Factory waste** – Liquid waste from factories often contains acid. If it reaches the river, the acid will kill the fish and other river life. This can be prevented by adding slaked lime to the waste, to neutralise it.

e. **Preventing tooth decay** – the sugar in your mouth produces acids that rot your teeth. Toothpaste is basic and neutralises these acids so it helps to clean your teeth soon after eating.

SUB STRAND 3

HEAT AND ELECTRICAL ENERGY

In this sub strand you will learn about:

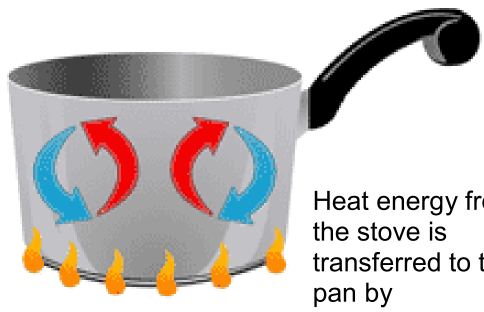
- **sources of heat**
- **movement of heat**
- **electrical circuits**
- **uses of electricity**
- **producing electricity**

SUB STRAND 3: HEAT AND ELECTRICAL ENERGY

Introduction

The Universe is made up of matter and energy. Matter is made up of atoms and molecules (groupings of atoms) and energy causes the atoms and molecules to always be in motion. The motion of atoms and molecules creates a form of energy called heat energy.

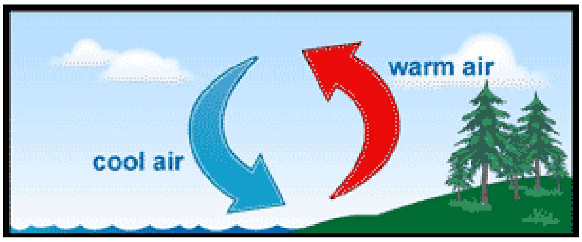
Heat is the energy an object has because of the movement of its atoms and molecules which are continuously jiggling and moving around, hitting each other and other objects. When we add energy to an object, its atoms and molecules move faster increasing its energy of motion or heat. Even objects which are very cold have some heat energy because their atoms are still moving.



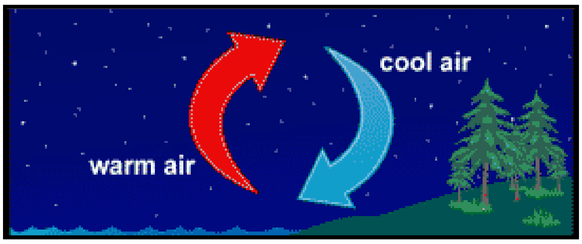
Heat energy from the stove is transferred to the pan by conduction.

Heat energy moves in through conduction, convection and radiation. Conduction occurs when energy is passed directly from one item to another.

Convection is the movement of gases or liquids from a cooler spot to a warmer spot. During daytime, cool air over water moves to replace the air rising up as the land warms the air over it. During night time, the directions change, the surface of the water is sometimes warmer and the land is cooler.



Day time



Night time

Electrical energy is the presence and flow of an electric charge. The energy portion of electricity is found in a variety of forms such as static electricity, electromagnetic fields and lightning. Electrical energy is converted into heat energy when you use objects such as heating pads, electrical stove elements, toasters, hair dryers, or light bulbs.

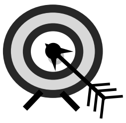
Some questions will arise such as

- What are the sources of heat?
- What are the uses of electricity in our everyday life?
- How are electricity produced?

In this Sub strand, you will find the answers to these questions and learn more about heat and electrical energy.

Lesson 11: Heat Energy

Welcome to Lesson 11 of Strand 3. Do you know what heat is? Well, heat is a form of energy transferred between objects with different temperatures. When you touch an ice cube your hand feels cold because heat energy from your body is being lost to the ice.
Temperature sensors in your body send messages to your brain. When your body loses heat energy, the message is decoded by the brains that you have touched something cold. When you pick up a cup of hot coffee, the cup feels hot because heat energy from the cup is being lost to your body. When your body gains heat energy, the message decode by your brain is that you have touched something hot. For this lesson you will be studying about heat energy.



Your Aims:

- define heat energy
- identify and describe the different sources of heat
- list the advantages and disadvantages of heat

What is Heat Energy?

When you touch an object, your hand tells you that the object is either hot or cold. If heat flows into your hand, the object is hotter than your hand. If heat is removed from an object, it usually gets cooler. Heat is a form of energy that can make things hot.
The heat of a fire has energy. You can see that heat energy does work in the way that it can make smoke and ashes.
When heat energy is given to an object it usually gets hotter. Heat energy is the type of energy that moves from places of higher temperature to those of lower temperature. Heat energy can be measured with units called **Joules (J).**

Trucks burn fuel to make heat energy

Heat energy can be used to move things like. Many machines like trucks, boats, aeroplanes and rockets burn fuel in their engines to make heat energy. The heat energy is then used to drive the machine. Heat and temperature are different but are related to each other. Temperature is a measure of the degree of hotness or coldness of something. It is measured in degrees Celsius (^{o}C) using a thermometer.

What are the sources of heat?
All forms of energy can be changed into heat energy. The following outlined the various sources of energy that can be converted into heat energy.

1. **Chemical energy** – the burning of fuels, such as natural gas, oil, wood, coal, kerosene and petrol releases the chemical energy stored inside these substances and produces heat.
2. **Electrical energy** – electricity can be changed into heat by passing through a suitable thin wire. This process is used in electric jug, stoves and irons.

Burning of wood produces heat

Electric stove produces heat

3. **Mechanical energy** – energy of motion can also be changed into heat. For example, friction changes mechanical energy into heat. This is used in traditional methods of making fire. It also occurs in dentists' drills and metal drills, which must be water or oil cooled to work effectively.
4. **Nuclear energy** – energy obtained from the changes that take place within the centre of atoms. Nuclear explosions show that very large amounts of heat are produced by these changes. The heat from nuclear reactions can be produced in a slow and controlled manner, which can be used to produce steam to drive turbines, which in turn produce electricity.
5. **Solar energy** – energy obtained from the Sun. Solar energy is produced as heat and light energy and is used by plants to make food. Solar cells can be used to give electricity in the bush and also as solar hot-water systems in many parts in Papua New Guinea.

Traditional way of making fire

Nuclear energy produces electricity

House water is heated by solar energy

Uses of heat

Apart from the use of heat in engines to make machines work; there are many other uses of heat. In all of these examples, the heat must be controlled to make sure that the right amount of heat is used for:

1. Cooking –fires and stoves supply heat.
2. Keeping us warm – sitting by the fire warm us.
3. Drying things – like copra and coffee beans.
4. Cleaning things – hot water is used for washing.
5. Sterilising – a lot of heat kills germs.
6. Moulding and bending – heated metals and plastics can be moulded and shaped.
7. Treating injuries – heat treatment helps injured muscles.
8. Melting and casting – liquid metals can be poured into moulds to get different shapes.
9. Producing light – light globe filaments are heated by electricity to give light.
10. Making different substances – heat is used to cut and make glass.

Problems of heat

Although heat can be very useful, it can also have disadvantages. Some of these problems are:

1. Too much heat can make people feel uncomfortable and may make them sick or die.
2. Heat can cause serious burns to the skin and muscles.
3. Too much heat can start a fire which can do a lot of damage.
4. Heat caused by friction is a problem in many machines. Lubricants like oil and grease can help to reduce the friction and moving air or moving water is often used to cool the machine.
5. Some industries pump a lot of heated water into rivers and sea that affects the plants and animals living in the water.

Activity: Now test yourself by doing this activity.

Complete the following sentences by filling in the missing word.

Heat is a form of __________ that can make things __________.The heat of a fire has __________. Heat energy does __________ in the way that it can make smoke and ashes move up into the sky. When __________ is given to an object it usually gets __________. Heat energy is the type of energy that moves from places of __________ temperature to those of __________temperature. Heat energy is measured in ___________.

Summary

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

- heat is a form of energy that can make things hot.
- heat energy moves from areas with high temperatures to places of low temperatures
- heat energy is measured in joules (J).
- temperature is a measure of the degree of hotness or coldness of something. It is measured in degrees Celsius (^{o}C) using a thermometer.
- all forms of energy can be changed into heat energy. Examples are:
    a. Chemical energy – the burning of fuels releases the chemical energy stored inside these substances and produces heat.
    b. Electrical energy – electricity can be changed into heat by passing through a suitable thin wire. This process is used in electric jug, stoves and irons.
    c. Mechanical energy – energy of motion can also be changed into heat. Friction changes mechanical energy into heat.
    d. Nuclear energy – energy obtained from the changes that take place within the centre of atoms. The heat from nuclear reactions can be used to produce steam to drive turbines, which in turn produce electricity.
    e. Solar energy – energy obtained from the Sun. Solar energy is produced as heat and light energy and is used by plants to make food. Solar cells can be used to give electricity in the bush and also as solar hot-water systems in many parts in Papua New Guinea.

NOW DO PRACTICE EXERCISE 11 ON THE NEXT PAGE.

Practice Exercise 11

Answer the following questions:

1. What is heat energy?

2. Name the sources of heat energy and describe each one of them.

   a.

   b.

   c.

   d.

   e.

3. List the advantages and disadvantages of heat.

   a. Advantages

   b. Disadvantages

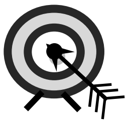
CHECK YOUR WORK. ANSWERS ARE AT THE END OF SUB STRAND 3.

Answers to Activity

energy, hot, energy, work, heat energy, hotter, higher, lower, Joules (J)

Lesson 12: Movement of Heat

Welcome to Lesson 12 of Strand 3. Read about my little incident and think about the questions asked.
Ouch! I quickly pulled off my fingers off a very red hot stone almost the size of a fist. At the same time I also moved 30 centimetres away from the warm surrounding. Why did I move my fingers away from the hot stone? And why was its surrounding warm too? I wondered why and how this happened. Therefore in this lesson you are going to learn about the movement of heat.



Your Aims:

- define conduction, convection and radiation
- describe the different movement of heat

Transfer of Heat

What happens to a hot drink when left in a cold room? Of course, the drink will get cooler because heat moves from hot objects to its surroundings. Heat energy is always difficult to keep in or to keep out. Therefore hot objects eventually cool down until they have the same temperature as their surroundings. This transfer or movement of heat can occur in three ways. These methods are known as **conduction, convection** and **radiation**.

A saucepan being heated on a stove.

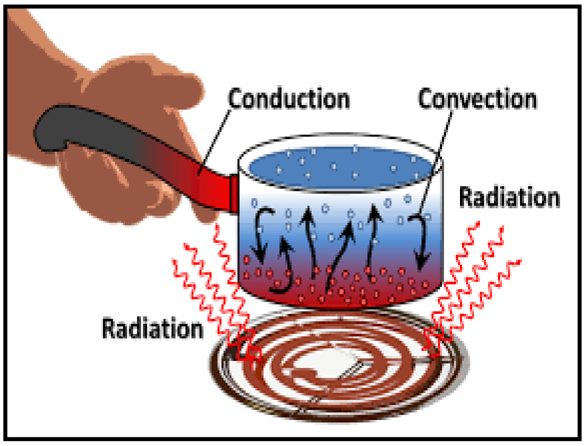
An 'Esky' being used to keep ice-blocks cold.

Conduction of heat
Conduction is the main way by which heat moves through a solid. The heat gradually spreads out through the solid from a hot part to a cold part. Some solids conduct heat better than others as heat moves quickly through them. Substances which conduct heat well are called good conductors. Most metals such as steel, iron, aluminium are good conductors of heat. Silver is the best conductor of heat but it is so expensive to use. Copper is the next best and not so expensive. Copper pipes are used in solar hot water systems to collect the heat from the Sun. Some saucepans have copper bases to help conduct from the stove to the food being cooked.

Substances which are not good conductors of heat are called poor conductors or **insulators**, as heat moves slowly through these substances. Most plastics are poor conductors of heat. Those plastics that do not melt easily can be used as the handles of saucepans, kettles, frying pans and clothes iron. Other good insulation materials are cork, wood and glass. Thick woollen clothing and blankets are also good insulators and help to keep us warm.

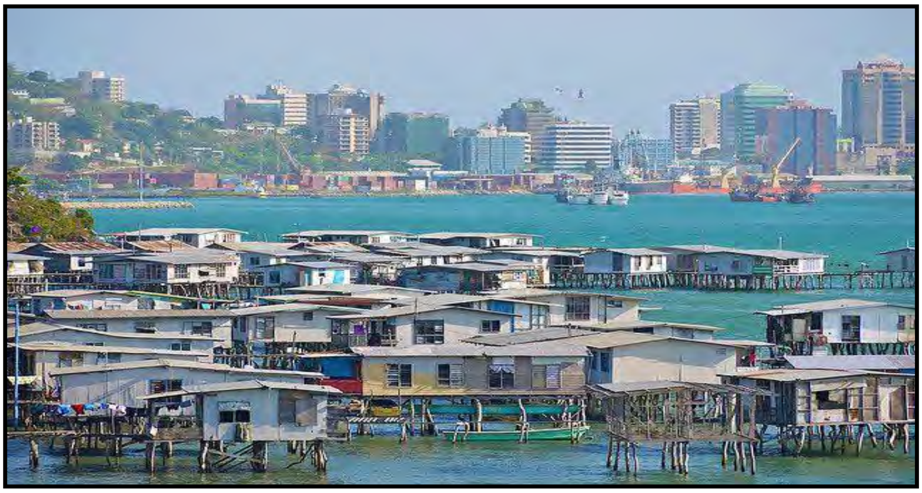
Conduction and the particle theory

The particle model of matter can be used to explain how heat conduction occurs. When a solid substance is heated, the particles being heated absorb the heat energy and vibrate more quickly. These particles then pass this energy onto the particles next to them, which in turn, pass it on, until the whole object is hot. This is how the heat energy is transferred through the solid from the hot end to the cold end. A solid conducts better than a liquid or a gas because the solid's particles are closest together.



Convection of heat

Liquids and gases transfer heat by convection. This is because hot air rises. Why does hot air rise? Because as air is heated, the particles move further and further apart. As a consequence, the air weighs less; the density of the air has decreased. Because this air is now lighter, it rises, while the surrounding cooler air falls. Convection of heat occurs in liquids and gases. Examples of convection currents in the atmosphere are land and sea breezes, in chimneys and in house ventilation. It is used in many circulation systems such as in solar hot-water systems, and some engine cooling systems.



Convection currents help keep coastal village house cool

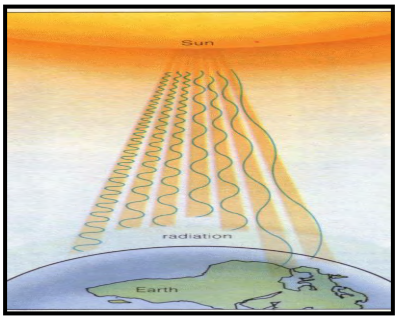
Radiation

The heat from the Sun cannot reach us by either conduction or convection because the space between the earth and the Sun is almost a vacuum. Both of these methods of heat transfer need particles which can vibrate to carry the heat. In a vacuum there are no particles, yet when the Sun is shining, you can feel the heat.

The Sun gives out large amounts of radiation, such as light and infra-red radiation. These radiations themselves are not hot, but when they are absorbed by an object, that object gets hot. The hotter they are the more they radiate. The radiation causes the particles in the object to vibrate more quickly. Most of the radiation from the Sun which heats the earth is in the form of infra-red radiation.

Dark-coloured surfaces absorb more radiation than light-coloured surfaces. This is because light-coloured surfaces reflect most of the radiation which falls on them. They are good reflectors of radiation. Shiny surfaces are very bad absorbers and also very good reflectors of radiation. This is why sheets of aluminium are place under the roofs of the schools and other buildings. They reflect radiation and help stop the building getting too hot.

Solar hot-water systems are painted black so that the copper pipes inside can absorb as much of the Sun's radiation as possible. You get hotter wearing dark-coloured clothes in the sunlight than wearing light-coloured clothes. Black cars get hotter in the sun than white cars.



Radiation from the Sun

Aluminium is a good reflector of radiation

Activity: Now test yourself by doing this activity.

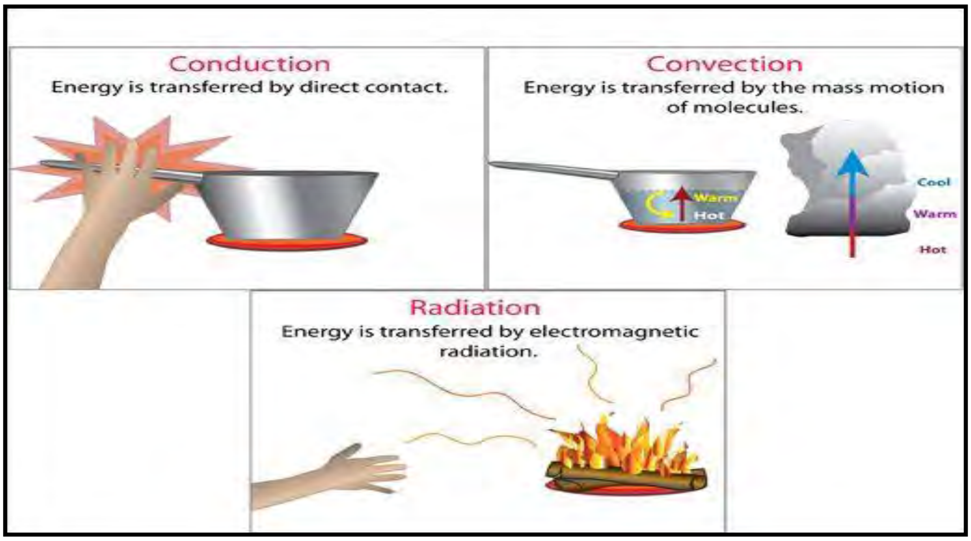
Complete the following sentences. You may start now!

The transfer or movement of heat can occur in __________ ways. These methods are known as conduction, convection and radiation. __________ is the main way by which heat moves through a solid. The heat gradually spreads out through the solid from a __________ part to a __________ part. Substances which conduct heat well are called __________ conductors.__________ is the best conductor of heat but it is so expensive to use. __________ is the next best and not so expensive. Substances which are not good conductors of heat are called __________ conductors or__________. Liquids and gases transfer heat by __________. The heat from the __________ cannot reach us by either conduction or convection because the space between the earth and the Sun is almost a __________. The Sun gives out large amounts of radiation, such as __________ and __________ radiation.

Summary

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

- heat moves from hot objects to cooler ones.
- the transfer or movement of heat can occur in three ways, known as conduction, convection and radiation.
- conduction is the main way by which heat moves through a solid. The heat gradually spreads out through the solid from a hot part to a cold part.
- substances which conduct heat well are called good conductors.
- most metals such as steel, iron, aluminium are good conductors of heat. Silver is the best conductor of heat but expensive to use. Copper is the next best and not expensive.
- substances which are not good conductors of heat are called poor conductors or insulators.
- most plastics are poor conductors of heat. Those plastics that do not melt easily can be used as handles of saucepans, kettles, frying pans and clothes iron.
- liquids and gases transfer heat by convection. Examples of convection currents in the atmosphere are land and sea breezes, in chimneys and in house ventilation.
- the heat from the Sun cannot reach us by either conduction or convection because the space between the earth and the Sun is a vacuum.
- the Sun gives out large amounts of radiation, such as light and infra-red radiation.
- dark-coloured surfaces absorb more radiation than light-coloured surfaces.
- shiny surfaces are very good reflectors of radiation.
- solar hot-water systems are painted black so that the copper pipes inside can absorb as much of the Sun's radiation as possible.



NOW DO PRACTICE EXERCISE 12 ON THE NEXT PAGE.

Practice Exercise 12

Answer the following questions:

1. Define the following terms.

   a. Conduction

   ____

   b. Convection

   ____

   c. Radiation

   ____

2. Describe the different movement of heat

   a. Conduction

   ____
   ____
   ____
   ____
   ____

   b. Convection

   ____
   ____
   ____
   ____
   ____

   c. Radiation

   ____
   ____
   ____
   ____
   ____

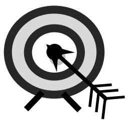
CHECK YOUR WORK. ANSWERS ARE AT THE END OF SUB STRAND 3.

Answers to Activity

three, conduction, hot, cold, good, silver, copper, poor, insulators, convection, Sun, vacuum, light, infra-red

Lesson 13: Electrical Circuits

Welcome to Lesson 13 of Strand 3. The first method of transferring heat as known in the last lesson is conduction. As learned, heat is conducted through conductors to colder parts of the surroundings; heat can also be conducted around conductors in an electric circuit. Likewise, electric current can be conducted around an electric circuit. You will learn more about electrical circuits in this lesson.



Your Aims:

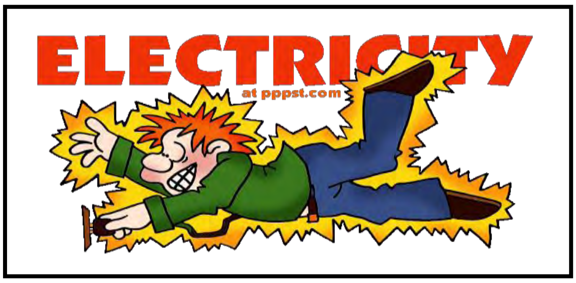
- define electricity, circuit, series and parallel circuits
- describe the different sources of electricity
- draw different electrical symbols
- differentiate series from parallel circuits

What Is Electricity?

Imagine a normal day in your life. You get up when your alarm starts playing your least favourite music. You go to the bathroom, turn on the light and take a shower. In the kitchen, you open the refrigerator. You grab some bread and put it in the toaster. Your brother gets on the computer and checks his email, while listening to a CD. After school, you do laundry and help cook dinner. Then you go to bed, turn your lamp on and read. After a while, you turn off your light and go to sleep. Almost everything we use now is powered by electricity. But, what really is electricity?

Electricity is a form of energy produced by the movement of electrons. There are two kinds of electricity: static electricity and current electricity. Static electricity stays in one place and doesn't move like current electricity. Lightning is the most common example of static electricity. Current electricity is the flow of electric charge through a substance that conducts electricity such as copper wire. A battery is a good example of a device that uses current electricity.

Lightning



Electricity from a power point

What are the sources of electricity?
Electricity comes from many sources. Some of the sources, such as fossil fuels, are disappearing because there is such a big demand for them. Scientists are researching new ways of generating electricity, so that if fossil fuel run out, there will be other sources. None of these alternative sources is ideal, but all have advantages and disadvantages. Here are some of the most popular sources of electricity

Solar energy

Solar energy that comes from the sun is captured through solar panels does not produce pollution. This might sound like the perfect energy but it is costly and besides, you can't be sure that the sun will shine brightly without cloud cover everywhere in the country every day.

Solar Panels

Solar Powered Calculator

Fossil fuel

Fossil fuel is a material that can be burned and comes from the fossil remains of animals and plants, such as dinosaurs. Some examples of fossil fuels are coal, natural gas and petroleum. This source is currently available and it is not dependent upon the weather. Some of the problems of fossil fuel use are that it causes pollution, it is a non-renewable resource and it needs to be mined from the earth. In addition, it causes acid precipitation which destroys life in lakes.

Coal

Oil Drilling

Hydro- electric power

Hydroelectric energy is produced when water falls from a high place to a low place. A hydroelectric power station contains a turbine driven by falling water from a dam. The turbine drives the generator. This form of energy produces little pollution; in addition, it does not ruin the water. The water still can be used for other purposes. Hydroelectric power does not cost any more than fossil fuels. Another advantage is that there are a lot of lakes or rivers where a dam can be built to produce energy. One disadvantage is that fish, such as salmon, cannot climb over the dam, so the dam changes the environment. Another disadvantage is that when a dam is built, a huge area is flooded to make a lake, so the water displaces people and animals living there.

Dam

Nuclear Power

Nuclear power

When atoms split, they give off energy. This energy is called nuclear power. It is produced in the reactor of a nuclear power station. The energy turns water into steam, which drives a turbine that powers a generator. Nuclear power produces lots of energy and can be made to power major cities. This energy, unlike other sources, produces lots of radioactive waste. If that waste gets released, it could cause devastation to a large area. In addition, it warms its waste water, so fish in the nearby lake might lay their eggs at any time of the year in the warm spot. Some fish, such as trout, cannot live in warm water.

Wind power

Wind power is produced by the wind turning a turbine. Wind power, through using windmills, has been known for many centuries. This source of energy produces almost no pollution. Some people think that the fields of windmills ruin the beauty of the land, and some other people are bothered by the noise generated by the windmills. Also, in order to be effective, the wind speed at a power site has to be over 12 kilometres per hour. Finally, this source of power is costly and requires special equipment.

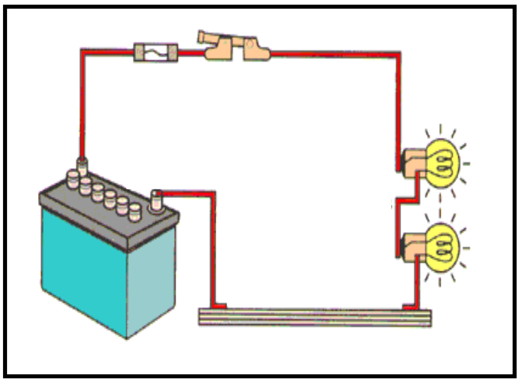
Water-Powered Mill

What is an electrical circuit?

An electrical circuit is an electrical device that provides a path for electrical current to flow. A circuit is a path that electricity follows, from a source through a connection to an output device. A circuit has three basic parts: (1) a source, such as a battery, (2) an output device, such as a motor or light bulb, and (3) a connection, such as a wire, between the source and the output device.

If any part of the circuit is removed, such as a wire, the current cannot flow. The circuit is then considered broken or open. When the connection is made again, the circuit is considered made or closed. A light switch opens and closes a circuit to turn lights on and off. At ordinary frequencies the beginning and the end of the circuit must be connected. This means that if you attach one end of a wire to a battery and the other end of the wire to a light bulb nothing would happen, because there is no connection from the bulb to the other end of the battery. In very high frequencies, electricity can flow when there is no visible connection. The gases in the air complete high-frequency circuits.

The circuit shown on the right has a power source, fuse, switch, two lamps and wires connecting each into a loop or circle. If the connection is complete, current flows from the positive terminal of the battery through the wire, the fuse, the switch, another wire, the lamps, a wire and to the negative terminal of the battery. The route or part along which the electricity flows is called an **electrical circuit**.

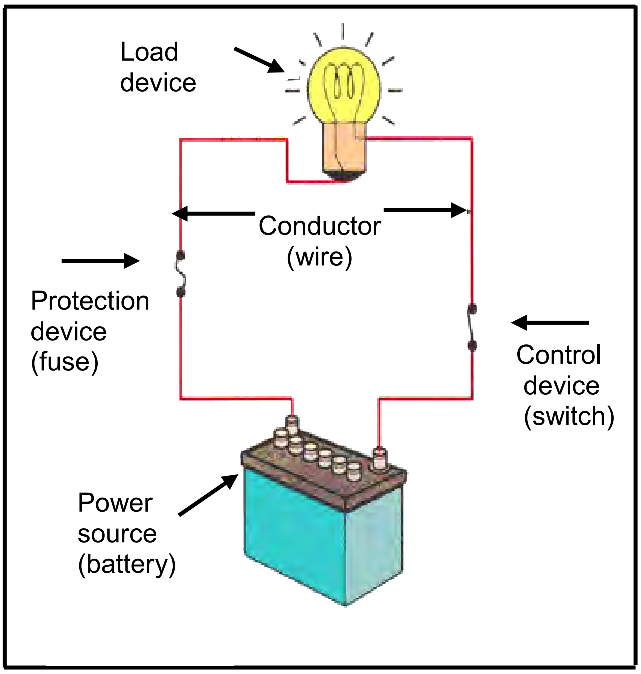


An electrical circuit

What are circuit components?

A complete electrical circuit is required in order to make electricity practical. **Electrons** must flow from and return to the power source. Different circuit types require all the same components.

1. Power source (battery, alternator and generator) is needed to supply the flow of electrons (electricity).
2. Protection device (fuse, fusible link, circuit breaker) prevents damage to the circuit in the event of short circuit.
3. Load device (lamp, motor, winding and resistor) converts the electricity into work.
4. Control Device (switch, relay and transistor) allows the user control to turn the circuit on or off.
5. Conductors (a return path, and wiring to ground) provide an electrical path to and from the power source.



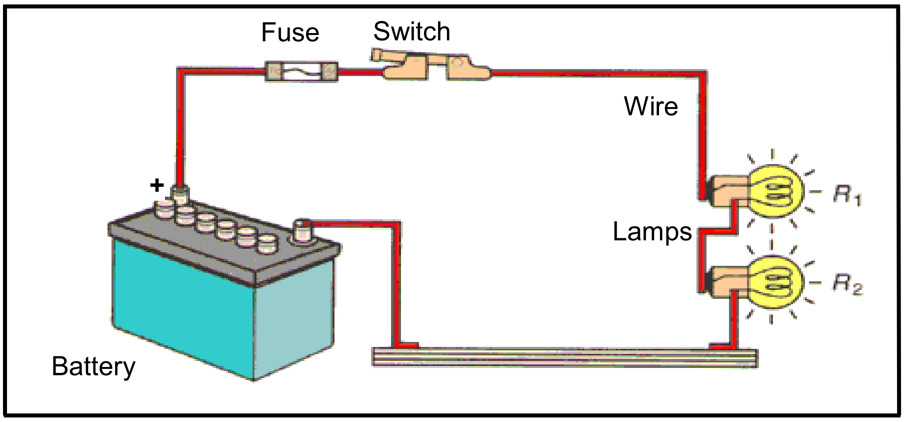
Circuit Components

Circuit Types

Individual electrical circuits normally combine one or more resistance or load devices. The design of the electrical circuit will determine which type of circuit is used. There are two basic types of circuits, the series circuit and parallel circuit.

Series Circuit

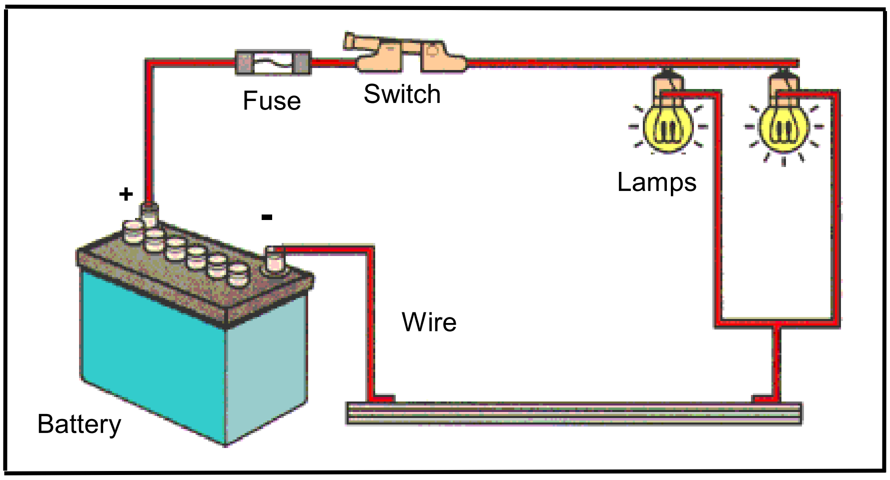
A series circuit is the simplest circuit. The conductors, control and protection devices, loads, and power source are connected with only one path to ground for current flow. The resistance of each device can be different. The same amount of current will flow throughout the circuit. The voltage divides (shared) between the loads. If the path is broken, no current flows and no part of the circuit work. An open in the circuit will disable the entire circuit. Christmas tree lights are a good example; when one light goes out the entire string stops working.



A series circuit

Parallel Circuit

A parallel circuit has more than one path for current flow. In the event of an open in the circuit in one of the branches, current will continue to flow through the remaining other branches. The same voltage is applied across each branch. The current flow through each branch can be different and the resistance of each branch can also be different.



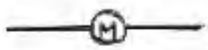
A parallel circuit

The table below gives us the advantages and disadvantages of series and parallel circuits.

Circuits	Advantages	Disadvantages
Series	You can add more power devices, such as more batteries, and increase the force of the output. This will give you more power.	One disadvantage is that as you add output devices, such as light bulbs, you increase the resistance and the bulbs do not shine as brightly. Another important disadvantage is that if one output device stops working, all the other output devices will stop working, too. This is because all of the power and output devices are connected in a straight line.
Parallel	The advantage of a parallel circuit is that if one of the output devices burns out, then only that device stops working.	The disadvantage is that if you have multiple power sources, the power stays at the same voltage as that of the single power source. In parallel circuits, increasing the number of output devices does not increase the resistance the way it does in series circuits.

The table below gives us the description and picture of some electrical symbols.

Some Electrical Symbols

Description	Picture	Symbol
Connecting wire		
Bulb		
Switch		
Battery		
Motor		
Buzzer		

Activity: Now test yourself by doing this activity.

Multiple Choice Questions

Circle the letter of the correct answer.

1. Which one is a fossil fuel?

    A. A green rock
    B. A hard fossil
    C. Natural gas
    D. Produced in the reactor

2. What is an advantage of nuclear power?

   A. Produces water falls
   B. Produces wind turning
   C. Produces a lot of waste
   D. Produces a lot of energy

3. Which is an example of alternative energy?

   A. Oil B. Coal
   C. Corn D. Natural gas

4. Which energy can be mined?

   A. Wind B. Solar
   C. Fossil D. Nuclear

5. Wind power, as a source of energy, is

   A. clean and expensive.
   B. clean and inexpensive.
   C. polluting and expensive.
   D. polluting and inexpensive.

6. An advantage of parallel circuit versus series circuit is that

   A. you add output devices, you increase the resistance.
   B. if one of the output burns, then only that device stops working.
   C. you can add more power devices to increase the force of the output.
   D. the power stays at the same voltage as that of the single power source.

Summary

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

- electricity is a form of energy produced by the movement of electrons.
- there are two kinds of electricity: static electricity and current electricity.
- static electricity stays in one place and doesn't move. Lightning is an example.
- current electricity is the flow of electric charge through a substance that conducts electricity. A battery is a good example.
- some of the most popular sources of electricity are solar energy, fossil, hydroelectric power, nuclear and wind.
- an electrical circuit is an electrical device that provides a path for electrical current to flow.
- a circuit is a path that electricity follows, from a source through a connection to an output device.
- a circuit has three basic parts: (1) a source, such as a battery, (2) an output device, such as a motor or light bulb, and (3) a connection, such as a wire, between the source and the output device.
- a series circuit is the simplest circuit. The conductors, control and protection devices, loads, and power source are connected with only one path to ground for current flow.
- a parallel circuit has more than one path for current flow. In the event of an open in the circuit in one of the branches, current will continue to flow through the other branches.

NOW DO PRACTICE EXERCISE 13 ON THE NEXT PAGE.

Practice Exercise 13

Answer the following questions:

1. Define

   a. Electricity

   b. Circuit

2. Describe the different sources of electricity.

   a. Solar energy

   b. Fossil fuel

   c. Hydroelectric energy

   d. Nuclear power

   e. Wind power

3. Draw the following electrical symbols:

Description	**Symbols**
Connecting wire	
Switch	
Battery	
Bulb	

4. Differentiate series from parallel circuit.

   a. Series circuit

   ____
   ____

   b. Parallel circuit

   ____
   ____

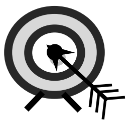
CHECK YOUR WORK. ANSWERS ARE AT THE END OF SUB STRAND 3.

Answers to Activity

1. **C**
2. **D**
3. **C**
4. **C**
5. **A**
6. **B**

Lesson 14: Uses of Electricity

Welcome to Lesson 14 of Strand 3. In the last lesson, you studied electricity and learnt that electrical current flow through a part called an electrical circuit. Does electricity benefit you? As we go along this lesson you will learn about the uses and the different effects of electricity.



Your Aims:

- explain the different uses of electricity
- identify and give examples of the four effects of electricity

What are the Uses of Electricity?

Electricity is the most widely used type of energy in the world. We use it for work and play, in the home and at school. The role it plays in our lives enhances our productivity, comfort, safety and health. We live with the benefits of electricity every day. In the past it mainly provided us with light and heat. Over the years the number of electrically powered items has hugely increased. We now use it almost continually every day. We use it so much that we take it for granted. However, when there is a black out we begin to realise just how much we need it and how dependent we have become on it.

Transport like trains, buses, trams and cars all use electricity. Many use it as the motive power, meaning that electricity drives the wheels to make the vehicle move. Even gas and diesel powered vehicles use electricity to start engines, control the engine and power the ancillary devices.

Home heating, lighting, television, radio, computer, telephones all rely on electricity. Even wireless lights such as solar powered lamps will convert light to electricity.
Electricity is used as the medium for the transmission of signals of communication as well as providing power for computers, cell phones, fixed phones. Even high speed optical fibres rely on an electrical signal at each end of the line. Without electricity, communication would be reduced to letters, flag waving and lighting fires and shouting at each other. None of the electricity free methods are as flexible as any that we are used to using today.

Industry manufacturing relies on electricity to drive virtually every moving part in a factory. Saws, cutters, conveyor belts, furnaces, chillers - whatever the process, electricity are involved somewhere.

In entertainment, the MP3 player, the portable battery powered radio, memory stick are all accepted as part of our everyday lives. All rely on electricity to operate. Whether connected to a main supply or battery, they all use electricity. Take a look around you: if it moves, lights up or makes a noise, it probably uses electricity.

Effects of electricity
Electric current has four effects: **heating**, **lighting**, **chemical** and **magnetic**.

The Heating Effect
Heating effect of electricity is one of the widely used effects in the world. Whenever electric current is passed through a conductor (any substance that allows electricity to pass through), it produces heat due to the resistance (preventing the flow of electric current) offered by the conductor.

Electric

All wires have resistance to the flow of electric current. The lesser the resistance in a wire, a good conductor it is. The greater the resistance the more heat is produced.

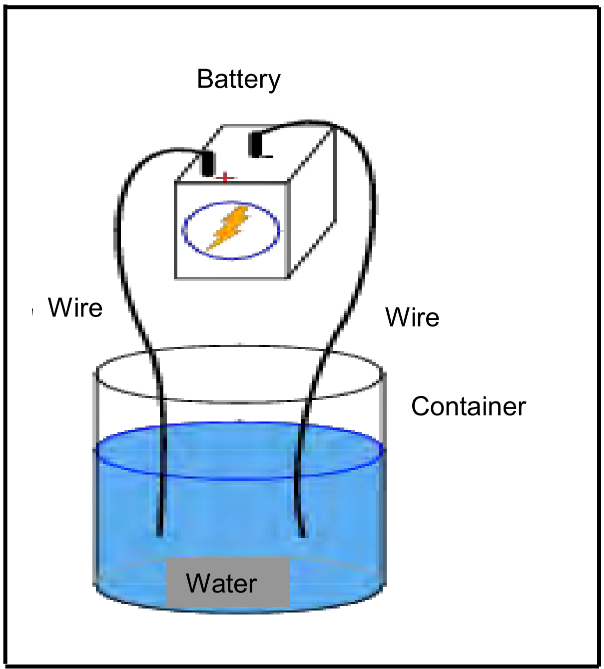
Therefore electrical appliances such as toasters, jugs and stoves have resistant wires wounded in a coil called an element.
Heating elements are generally made of special alloys (a metal made by two or more metals).

Electric

Appliances such as immersion water heater, electric iron box, electric cookers, kettles, and toasters. All of these have a heating element in it. Appliances that get hot must be used carefully so as not to burn out the element and start a fire.

For example:
- Electric jugs and urns must have water completely covering the element before they are switched on.
- An electric shower heater must have water flowing over the element before the power is switched on.

The Chemical effect
Passing an electric current through a liquid causes chemical changes. Electroplating is a good example; it is when a layer of one metal is coated on top of another metal. That is done when electric current is passed into a chemical solution and the chemical than coats the new metal onto the old one. The knives spoons and forks are good examples of electroplating. They are made of a mixture of metals which are than coated with silver to look shiny and to prevent rust.



Electrolysis

The Lighting Effect

Electrical energy can be converted into light energy in two main ways:

Light bulbs

- Light bulbs contain a coil of very thin, high resistance wire called a filament.
- The filament is made of metal called tungsten that has a melting point of 3500^0C. When electricity passes through the filament it becomes very hot and gives off light.
- Most bulbs are filled with the gases nitrogen and argon that help prevent the element from melting or burning.

Fluorescent tubes

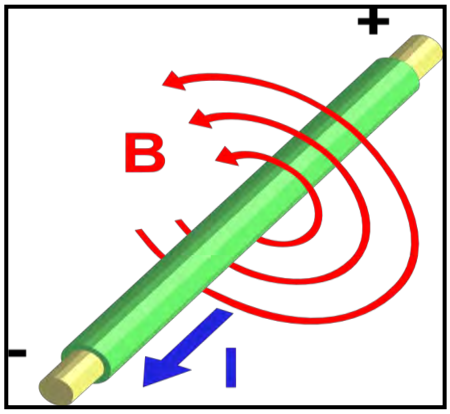
- Fluorescent tubes contain a special chemical powder coating on the inside of the glass.
- The electric current produces ultraviolet radiation which causes the chemical to produce light.
- Fluorescent tubes are about three times as efficient as light bulbs and they cast little shadow because they are long.

Fluorescent tubes

Light bulb

The magnetic effect

Electric current passing through a wire generates a magnetic field around the wire. This effect is used in all sorts of ways. Examples include electric motors and electromagnets. An iron bar inside the coil of wire is called an electromagnet and only works while the current is flowing. In a car, for example, the central locking uses electromagnets called solenoids to operate the lock mechanism. Another widespread example is the loudspeaker, where variations in the magnetic effect of an electric current are translated into sound waves that we can hear.



Electromagnetic field

The magnetic effect can be increased by using a coil of wire instead of a straight piece of wire. If an iron bar is put inside the coil the effect is even greater. Large electromagnets are used to lift iron and steel in scrap metal yards. Electric bells, buzzers and car signal lights also use small electromagnets to make them work.

Electric motors combine electricity and magnetism to produce movement. Examples include radio cassette players, fans, washing machines, power tools and starter motors in cars and trucks. An electric motor consists of a rotating electromagnet called the armature and two fixed magnetic poles which may be permanent magnets or electromagnets. When a current is passed through the armature it becomes an electromagnet and interacts with the fixed magnetic poles. This causes the armature to rotate. Each time the armature rotates 180 degrees a device called a commutator reverses the direction of the current in the armature so that the armature continues to rotate in one direction.

The working of an electric motor can be summarised as follows:

Coil + Current + Magnet ⟶ Movement

The electric motor converts electrical energy to kinetic energy without producing pollution.

Electric motor

Electric bell

A lift used in scrap

Activity: Now test yourself by doing this activity.

Multiple choice Questions

Circle the letter of the correct answers.

1. When there is an electric current passing through a wire, the particles moving are __________.

   A. ions B. atoms

   C. protons D. electrons

2. The magnetic field lines due to a straight wire carrying a current are __________.

   A. circular B. straight

   C. parabolic D. elliptical

3. In an electric motor, the energy transformation is from

   A. chemical to light.
   B. electrical to chemical.
   C. mechanical to electrical.
   D. electrical to mechanical.

4. An electric generator actually acts as

   A. an electromagnet.
   B. a converter of energy.
   C. source of heat energy.
   D. source of electric charge.

5. A magnetic field line is used to find the direction of

   A. south-north.
   B. a bar magnet.
   C. magnetic field.
   D. a compass needle.

6. For making a strong electromagnet, the material of the core should be __________.

A. steel B. brass

C. soft iron D. copper

Summary

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

- electricity is the most widely used type of energy in the world. We use it for work and play, in the home and at school.
- electricity is used for transport, home, and industry.
- electric current has four effects: heating, lighting, chemical and magnetic.
- heating elements are generally made of specific alloys like, nichrome, manganin and constantan (a copper–nickel alloy used in electrical work for its high resistance). A good heating element has high resistance and high melting point.
- electrolysis is a process of passing an electric current through a liquid which causes chemical changes.
- electroplating uses electrolysis to put a layer of one metal on top of another. Examples include silver plating of cutlery and jewellery.
- electrical energy can be converted into light energy in two main ways: light bulbs and fluorescent tubes.
- light bulbs contain a coil of very thin, high resistance wire called a filament.
- fluorescent tubes contain a special chemical powder coating on the inside of the glass. The electric current produces ultraviolet radiation which causes the chemical to produce light.
- electric current passing through a wire generates a magnetic field around the wire. Examples include electric motors and electromagnets.
- an iron bar inside the coil of wire is called an electromagnet and only works while the current is flowing.
- electric motors combine electricity and magnetism to produce movement. Examples include radio cassette players, fans, and washing machines.
- an electric motor consists of a rotating electromagnet called the armature and two fixed magnetic poles which may be permanent magnets or electromagnets.
- the electric motor converts electrical energy to kinetic energy without

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NOW DO PRACTICE EXERCISE 14 ON THE NEXT PAGE.

Practice Exercise 14

Answer the following questions:

1. Identify the four effects of electricity and give examples.

   A.

   B.

   C.

   D.

2. Explain the uses of electricity in vehicles, at home and industry.

   For vehicle

   At home

   In industry

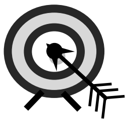
CHECK YOUR WORK. ANSWERS ARE AT THE END OF SUB STRAND 3.

Answers to Activity

1. **D**
2. **A**
3. **D**
4. **B**
5. **C**
6. **C**

Lesson 15: Producing Electricity

Lesson 14 discussed about the uses of electricity. You have learnt many uses of electricity at home, industry and in vehicles. You also learnt the different effects of electricity. Just as electricity produces certain effects, so the effects of electricity can be reversed to produce electricity. For this lesson you will learn about how electricity is being produced.



Your Aims:

- discuss the methods of producing electricity
- list safety rules in using electricity

What are the Methods of Producing Electricity?

Generally there are six basic sources of producing electricity. These are: heat, light, friction, pressure, magnetism and chemical action. Of these, magnetism is the most important, contributing by far the largest portion of electrical production worldwide. Power generators, whether hydroelectric or fuelled by coal, oil, gas or nuclear power, use magnetism as the actual means of electricity generation. Light, acting upon solar panels, is slowly gaining importance, but has yet to increase in commercial electricity production because of its cost. Electricity generated directly by heat, pressure and friction tend to be very small. Chemical action in the form of batteries is both the oldest means of producing electrical current, and has had a great impact on our modern way of life.

Magnetic method
When a magnet is moved inside a coil of wire, electricity will be produced in the coil. The kinetic or moving energy is changed to electrical energy. If there is no movement then the current will not flow. We can describe what happens simply in the following way:

Coil + magnet + Movement ⟶ Electricity

This is the way that a generator or dynamo works. A magnet is made to spin inside a coil of wire. The spinning can be caused in different ways.

- A bicycle dynamo is turned by one of the wheels which are turned by a person's leg muscles.
- A car generator is turned by the engine that burns petrol or diesel.
- Bigger generators like those in power stations are driven by diesel engines or turbines.

A bicycle dynamo

- A turbine is a special wheel that has blades that can be turned by a liquid or a gas. The turbines are then used to turn the generator. When water is used to turn the generator then hydro-electricity is produced.

- The bigger hydro-electric power stations are at Rouna, outside of Port Moresby, at Yonki in the Eastern Highland and Warangoi in East New Britain, although there are also many smaller ones in other provinces.

Wind turbines

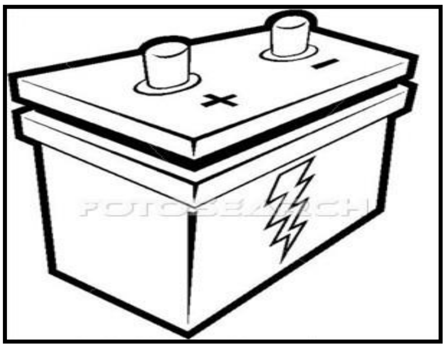
Hydro-electric power station

Chemical Methods

Cells use chemical reactions to make electricity. The most common type of cell is the dry cell which is used in torches and radios. The outside metal case of this cell is made of zinc and is known as the negative electrode. The zinc case is usually covered with the label. The carbon rod in the middle of the cell is the positive electrode. There is a paste containing different chemicals between two electrodes so that a chemical reaction takes place which produces electricity. During chemical reaction, one electrode is used up and said to be 'flat'. It is usually thrown away.

Dry cell

Another type of cell is the lead accumulator which is used in car batteries. This type of cell has a series of lead and lead-coated electrodes that are covered with dilute sulphuric acid. When the battery is being used a chemical reaction occurs between the electrodes and the acid that produces electricity. An advantage of this type of battery is that it can be recharged. Recharging produces some hydrogen and oxygen gas, filled with distilled water occasionally.



Car battery

Light Method

Solar cells are special cells that convert sunlight directly into electrical energy. Solar cells are used to provide electricity for communication repeater stations in the bush and for navigational aids for shipping.

Solar cells

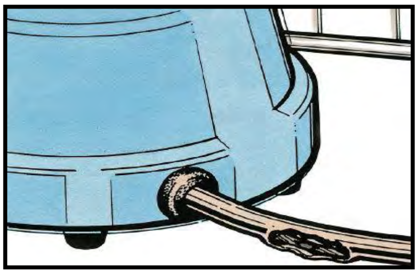
What are the safety rules for using mains electricity?

Mains electricity (main switches) can be used in many ways that are helpful, but it can also be very dangerous. It can cause fire and electric shock, so it is best to use it carefully.

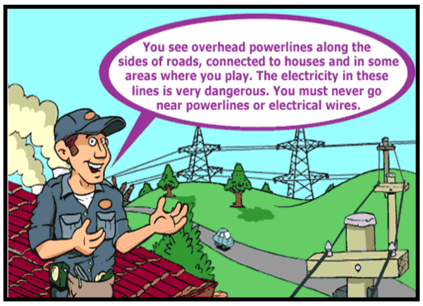
These safety rules should always be followed.

1. Make sure that the switch is turned off before plugging an appliance into a power point.
2. Switch off the power before you remove a plug from an appliance or power point.
3. Do not pull a plug out by the cord. Hold on to the plug itself.
4. Do not fill the electric jug or pour from it while the power is on.
5. Do not let wires or electrical appliances get wet.
   Do not touch switches or electrical appliances if you have wet hands or wet feet.
6. Do not have long extension cords lying about in the house. Somebody could easily trip and knock the appliance over.
7. Do not use adaptors to run more than two appliances from a single power point.
8. Do not try to clean an appliance until you have switched it off and removed the plug.
9. Do not poke your fingers or push other objects into electrical appliance, power points or fuse boxes.
10. Do not use appliances with worn or damaged cords.
11. Keep well away from overhead wires when you are working or playing. Do not throw anything over the wires or fly kites near them.
12. Do not climb electricity poles or pylons.

Do not let wires get wet



Do not use damaged cords



Do not climb electricity poles

Activity: Now test yourself by doing this activity.

Multiple Choice Questions: Circle the letter of the correct answer.

1. A type of battery that can be used many times is called __________ battery.

   A. reusable B. renewable

   C. returnable D. rechargeable

2. Which of the following is **not** an example of static electricity at work?

   A. A magnet picking up iron filings
   B. A bolt of lightning striking the Earth
   C. Toner in a photocopier being attracted to paper
   D. Getting a shock after walking across a rug on a dry day

3. When batteries are placed in a flashlight, the positive terminal of one is connected to the negative terminal of the next, so that the

   A. electricity can flow from one to the next.
   B. electromagnetic interference is reduced.
   C. current is slowed as it enters the next battery.
   D. voltage is decreased as it enters the next battery.

4. In a circuit, what particle flow from the negative terminal to the positive terminal?

   A. Proton B. Neutron

   C. Electron D. Positron

5. Which of the following is **false** about electric motor?

   A. A device that converts electricity to mechanical work.
   B. An engine for doing work using electricity.
   C. A device used to measure current and voltage in ammeters and voltmeters.
   D. A device that involves rotating coils of wires which are driven by the magnetic force exerted by a magnetic field on an electric current.

6. What function does a circuit serve in your home?

   A. It protects your home against lighting strikes.
   B. It provides a barrier against electromagnetic radiation.
   C. It provides a complete path through which electricity can flow.
   D. It increases the voltage from the power lines outside your house.

7. Which of the following would **not** give you a shock?

   A. Staying away from power lines
   B. Dropping a radio into a bathtub
   C. Hitting a power lines with a kite
   D. Sticking a fork into an electrical outlet

8. What is an electric charge?

   A. An imbalance of electrons and protons
   B. A material that transfers a charge easily
   C. A material that does not transfer a charge easily
   D. The force of attraction or repulsion between objects due to charge

9. Which of the following is a solution that conducts electricity in a cell?

   A. Current B. Resistor

   C. Grounding D. Electrolyte

Summary

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

- generally there are six basic sources of producing electricity. These are: heat, light, friction, pressure, magnetism and chemical action.
- when a magnet is moved inside a coil of wire, electricity will be produced in the coil. The kinetic or moving energy is changed to electrical energy. If there is no movement then the current will not flow. This is the magnetic method.
- cells use chemical reactions to make electricity. The most common type of cell is the dry cell which is used in torches and radios.
- another type of cell is the lead accumulator which is used in car batteries. An advantage of this type of battery is that it can be recharged by passing an electric current back into the battery which reverses the chemical reaction.
- solar cells are special cells that convert sunlight directly into electrical energy.

NOW DO PRACTICE EXERCISE 15 ON THE NEXT PAGE.

Practice Exercise 15

Answer the following questions:

1. Discuss the following methods of producing electricity.

   a. Magnetic method

   ____
   ____
   ____

   b. Chemical method

   ____
   ____
   ____

   c. Light Method

   ____
   ____
   ____

2. List safety rules in using electricity.

   a. ______________________________
   b. ______________________________
   c. ______________________________
   d. ______________________________
   e. ______________________________
   f. ______________________________
   g. ______________________________
   h. ______________________________
   i. ______________________________
   j. ______________________________
   k. ______________________________
   l. ______________________________

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

Answers to Activity

1. **D**
2. **A**
3. **A**
4. **C**
5. **C**
6. **C**
7. **A**
8. **D**
9. **D**

REVIEW OF SUB STRAND 3: ACIDS AND BASES

Revise all the Lessons in this Sub Strand and then do **ASSIGNMENT 3.**
Here are the main points to help you revise.

Lesson 11: Sources of Heat

- Heat is a form of energy that can make things hot.
- Heat energy is the type of energy that moves from places of higher temperature to those of lower temperature.
- Temperature is a measure of the degree of hotness or coldness of something.
- All forms of energy can be changed into heat energy. Examples are chemical energy, electrical energy, mechanical energy, nuclear energy and solar energy.
- There are some cases where heat is a disadvantage. Too much heat can make people feel uncomfortable and may make them sick or even die. Heat can cause serious burns to the skin and muscles. Too much heat can start a fire which can do a lot of damage. Heat caused by friction is a problem in many machines. Lubricants like oil and grease can help to reduce the friction.

Lesson 12: Movement of Heat

- Heat moves from hot objects to cooler ones.
- The transfer or movement of heat can occur in three ways such as conduction, convection and radiation.
- Conduction is the main way by which heat moves through a solid. The heat gradually spreads out through the solid from a hot part to a cold part.
- Substances which conduct heat well are called good conductors. Substances which are not good conductors of heat are called poor conductors or insulators.
- Liquids and gases transfer heat by convection. Examples of convection currents in the atmosphere are land and sea breezes, in chimneys and in house ventilation.
- The heat from the Sun cannot reach us by either conduction or convection because the space between the earth and the Sun is a vacuum.
- Dark-coloured surfaces absorb more radiation than light-coloured surfaces.
- Shiny surfaces are very good reflectors of radiation.

Lesson 13: Electrical Circuits

- Electricity is a form of energy produced by the movement of electrons.
- There are two kinds of electricity: static electricity and current electricity.
- Static electricity stays in one place and doesn't move. Lightning is an example.
- Current electricity is the flow of electric charge through a substance that conducts electricity. A battery is a good example.
- Fossil fuel is a material that can be burned and that comes from the fossil remains of animals and plants.
- Hydroelectric energy is produced when water falls from a high place to a low place. A hydroelectric power station contains a turbine driven by falling water from a dam. The turbine drives the generator.
- When atoms split, they give off energy. This energy is called nuclear power. It is produced in the reactor of a nuclear power station. The energy turns water into steam, which drives a turbine that powers a generator.
- Wind power is produced by the wind turning a turbine. This source of energy produces almost no pollution, and it is used in different countries.
- An electrical circuit is an electrical device that provides a path for electrical current to flow.
- A circuit is a path that electricity follows, from a source through a connection to an output device.
- A circuit has three basic parts: (1) a source, such as a battery, (2) an output device, such as a motor or light bulb, and (3) a connection, such as a wire, between the source and the output device.
- A series circuit is the simplest circuit. The conductors, control and protection devices, loads, and power source are connected with only one path to ground for current flow.
- A parallel circuit has more than one path for current flow. In the event of an open in the circuit in one of the branches, current will continue to flow through the remaining other branches.

Lesson 14: Uses of Electricity

- Electric current has four effects: heating, lighting, chemical and magnetic.
- Electrolysis is a process of passing an electric current through a liquid which causes chemical changes.
- Electrical energy can be converted into light energy in two main ways: light bulbs and fluorescent tubes.
- Light bulbs contain a coil of very thin, high resistance wire called a filament.
- Fluorescent tubes contain a special chemical powder coating on the inside of the glass. The electric current produces ultraviolet radiation which causes the chemical to produce light.
- Electric current passing through a wire generates a magnetic field around the wire. Examples include electric motors and electromagnets.
- An iron bar inside the coil of wire is called an electromagnet and only works while the current is flowing.

- An electric motor consists of a rotating electromagnet called the armature and two fixed magnetic poles which may be permanent magnets or electromagnets.
- The electric motor converts electrical energy to kinetic energy without producing pollution.

Lesson 15: Producing Electricity

- Generally there are six basic sources of producing electricity. These are: heat, light, friction, pressure, magnetism and chemical action.
- When a magnet is moved inside a coil of wire, electricity will be produced in the coil.
- Cells used chemical reactions to make electricity. The most common type of cell is the dry cell which is used in torches and radios.
- Another type of cell is the lead accumulator which is used in car batteries. An advantage of this type of battery is that it can be recharged by passing an electric current back into the battery which reverses the chemical reaction.
- Solar cells are special cells that convert sunlight directly into electrical energy.
- Mains electricity can be used in many ways that are helpful but it can also be very dangerous. Safety rules should always be followed.

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

Answers to Practice Exercises 11- 15

Practice Exercise 11

1. Heat energy is the type of energy that moves from places of higher temperature to those of lower temperature.

2. a. Chemical energy – the burning of fuels releases the chemical energy stored inside these substances and produces heat.

   b. Electrical energy – electricity can be changed into heat by passing through a suitable thin wire. This process is used in electric jug, stoves and irons.

   c. Mechanical energy – energy of motion can also be changed into heat. Friction changes mechanical energy into heat.

   d. Nuclear energy – energy obtained from the changes that take place within the centre of atoms. The heat from nuclear reactions can be used to produce steam to drive turbines, which in turn produce electricity.

   e. Solar energy – energy obtained from the Sun. Solar energy is produced as heat and light energy and is used by plants to make food. Solar cells can be used to give electricity in the bush and also as solar hot-water systems in many parts in Papua New Guinea

3. a. Advantages - Apart from the use of heat in engines to make machines work it is also used for cooking, for keeping us warm, for drying things, for cleaning things, for sterilising, for moulding and bending, for treating injuries, for melting and casting, for producing light and for making different substances.

   b. Disadvantages - There are some cases where heat is a disadvantage. Too much heat can make people feel uncomfortable and may make them sick or die. Heat can cause serious burns to the skin and muscles. Too much heat can start a fire which can do a lot of damage. Heat caused by friction is a problem in many machines. Lubricants like oil and grease can help to reduce the friction.

Practice Exercise 12

1. a. Conduction – is where heat is passed through a substance. It occurs mostly in solids.

   b. Convection – is where heat is carried by moving materials. It occurs in liquids and gases.

   c. Radiation – is where heat is transferred by radiation, such as infra-red radiation. It occurs in a vacuum.

2. a. Conduction - is the main way by which heat moves through a solid. The heat gradually spreads out through the solid from a hot part to a cold part. Some solids conduct heat better than others as heat moves quickly through them. Substances which conduct heat well are called good conductors. Most metals such as steel, iron, aluminium are good conductors of heat. Substances which are not good conductors of heat are called poor conductors or insulators; as heat moves slowly through these substances. Most plastics are poor conductors of heat.

   b. Convection - Liquids and gases transfer heat by convection. In convection, hot air rises because when air is heated, the particles move further and further apart. As a consequence, the air weighs less; the density of the air has decreased. Because this air is now lighter, it rises, while the surrounding cooler air falls. Examples of convection currents in the atmosphere are land and sea breezes, chimneys and in house ventilation. It is also used in many circulation systems such as in solar hot-water systems, and some engine cooling systems.

   c. Radiation - The Sun gives out large amounts of radiation, such as light and infra-red radiation. These radiations themselves are not hot, but when they are absorbed by an object, that object gets hot. The hotter they are the more they radiate. The radiation causes the particles in the object to vibrate more quickly. Most of the radiation from the Sun which heats the earth is in the form of infra-red radiation
   The heat from the Sun cannot reach us by either conduction or convection because the space between the earth and the Sun is a vacuum. Both of these methods of heat transfer need particles which can vibrate to carry the heat. In a vacuum there no particles, yet when the Sun is shining, you can feel the heat.

Practice Exercise 13

1. a. Electricity - is a form of energy produced by the movement of electrons.

   b. Circuit - is a path that electricity follows, from a source through a connection to an output device.

2. a. Solar energy - is the energy that comes from the sun. We capture solar energy through solar panels.

   b. Fossil fuel - is a material that can be burned and that comes from the fossil remains of animals and plants. Some examples of fossil fuels are coal, natural gas and petroleum.

   c. Hydroelectric energy- is produced when water falls from a high place to a low place. A hydroelectric power station contains a turbine driven by falling water from a dam. The turbine drives the generator.

   d. Nuclear power - when atoms split, they give off energy. This energy is called nuclear power. It is produced in the reactor of a nuclear power station. The energy turns water into steam, which drives a turbine that powers a generator.

e. Wind power - is produced by the wind turning a turbine. This source of energy produces almost no pollution, and it is used in different countries.

3. Draw the following electrical symbols:

Description	Symbols
Connecting wire	
Switch	
Battery	
Bulb	

4. a. Series circuit - is the simplest circuit. The entire devices are connected with only one path to ground for current flow. If the path is broken, no current flows and no part of the circuit work. An open in the circuit will disable the entire circuit.

   b. Parallel - has more than one path for current flow. In the event of an open in the circuit in one of the branches, current will continue to flow through the other branches.

Practice Exercise 14

1. Heating effects – electric cookers, toasters, flat iron, kettles, water heater.

   Lighting effects – light bulbs and fluorescent tubes.

   Magnetic effects – electric motors and electromagnets.

   Chemical effects - silver plating of cutlery and jewellery, plating of bathroom and car parts chillers.

2. For vehicle - electricity drives the wheels to make the car move. Even gas and diesel powered vehicles use electricity to start the engines, control the engine and power the ancillary devices.

   At home – electricity provides power for heating, lighting, television, radio, computer, telephones and cell phones.

   In industry - Industry manufacturing relies on electricity to drive virtually every moving part in a factory such as saws, cutters, conveyor belts, furnaces and chillers.

Practice Exercise 15

1. A. Magnetic method - When a magnet is moved inside a coil of wire electricity will be produced in the coil. The kinetic or moving energy is changed to electrical energy. If there is no movement then the current will not flow. We can describe what happens simply in the following way:

   Coil + magnet + Movement $\longrightarrow$ Electricity

   B. Chemical method - Cells used chemical reactions to make electricity. The most common type of cell is the dry cell which is used in torches and radios. During chemical reaction, one electrode is used up and said to be 'flat'. It is usually thrown away. Another type of cell is the lead accumulator which is used in car batteries. An advantage of this type of battery is that it can be recharged by passing an electric current back into the battery which reverses the chemical reaction.

   C. Light Method - Solar cells are special cells that convert sunlight directly into electrical energy. Solar cells are used to provide electricity for communication repeater stations in the bush and for navigational aids for shipping.

2. A. Make sure that the switch is turned off before plugging an appliance into a power point.
   B. Switch off the power before you remove a plug from appliance or power point.
   C. Do not pull a plug out by the cord. Take hold of the plug itself.
   D. Do not fill the electric jug or pour from it while the power is on.
   E. Do not let wires or electrical appliances get wet. Do not touch switches or electrical appliances if you have wet hands or wet feet.
   F. Do not have long extension leads in and around the house. Somebody could easily trip and knock the appliance over.
   G. Do not use adaptors to run more than two appliances from a single power point.
   H. Do not try to clean an appliance until you have switched it off and removed the plug.
   I. Do not poke your fingers or push other objects into electrical appliance, power points and fuse boxes.
   J. Do not use appliances with worn or damaged cords.
   K. Keep well away from overhead wires when you are working or playing. Do not throw anything over the wires or fly kites near them.
   L. Do not climb electricity poles or pylons.

SUB STRAND 4

SIMPLE MACHINES

In this sub strand you will learn about:

- **simple machines**
- **measuring force**
- **measuring work and energy**
- **mechanical advantages of simple machines**
- **efficiency of simple machines**

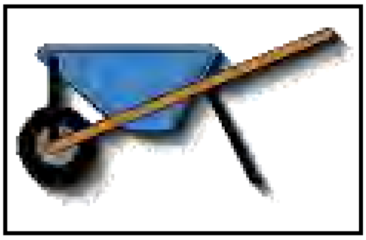
SUB STRAND 4: SIMPLE MACHINES

Introduction

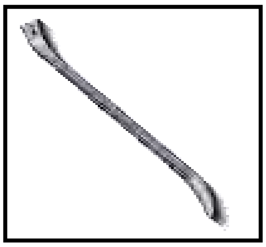
Simple machines are "simple" because most have only one moving part. Some are so simple; they don't have any moving parts. When you put simple machines together, you get a complex machine, like a lawn mower, a car, even an electric nose hair trimmer. Remember, a machine is any device that makes work easier. In science, "work" means making something move.

It's important to know that when you use a simple machine, you're actually doing the same amount of work; it just seems easier. A simple machine reduces the amount of effort needed to move something, but you wind up moving it a greater distance to accomplish the same amount of work. So remember, there's a trade-off of energy when using simple machines.

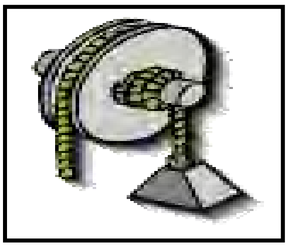
From day to day, you find yourself using any of the six simple machines; wedge, lever, inclined plane, pulley, wheel and axle, or screw and each can be used in many different ways.



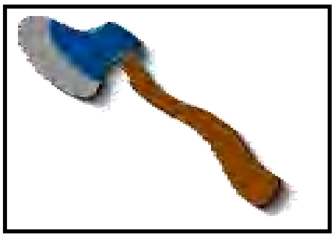
The wheel and axle is a simple machine made of a large wheel attached to a post or axle.



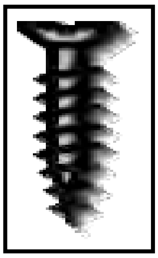
The lever is simple machine made up of a stiff arm or arms that pivots or turns.



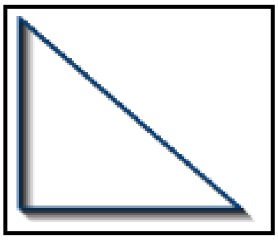
The pulley is a simple machine made of a rope or chain wrapped around the wheel.



The wedge is a double-inclined that moves to exert a force along the lengths of the sides.



The screw is an inclined plane wrapped around a post.



The inclined plane is a kind of simple machine with a slanted surface.

Simple machines give us an advantage by changing the amount, speed, or direction of forces. We are dependent on simple machines in many aspects of our lives.

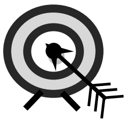
So, you might be asking

- How do we measure work, force and energy in simple machines?
- What are the mechanical advantages and efficiency of simple machines?

In this Sub strand, you will find the answers to these questions and learn more about simple machines.

Lesson 16: Simple Machines

Welcome to Lesson 16 of Strand 3. In our everyday life we experience that if we use less energy less work is done, more energy more work is done. When we want to do more work how can we do this without using less energy. It is possible with the use of simple machines.



Your Aims:

- identify and describe the types of simple machines
- list the uses of simple machines

Simple Machines

These are tools that make work easier. They have few or no moving parts. These machines use energy to work. There are six simple machines, that is, the lever, pulley, screw, inclined plane, wedge and the wheel and axle.

The Lever

Levers are simple machines used to lift weights. First let us learn some terms you will need to know. A **load** is the thing you're lifting. A **fulcrum** is the thing that makes the load lighter. An **effort** is the person pushing to make the objects move. In its simplest form, a lever is a stick that is free to pivot or move back and forth at a certain point. Levers are probably the most common simple machine because just about anything that has a handle on it has a lever attached. The point on which the lever moves is called the fulcrum. By changing the position of the fulcrum, you can gain extra power with less effort. A good example of a lever is a see-saw. Let's say that you're really light, and you want to lift a really heavy person on the opposite side. If you put the fulcrum in the middle, you won't have a chance. But if you slide the fulcrum closer to the heavy person, it will be easier to lift because your side of the see-saw is much longer (and higher off the ground), so you have to move it a much greater distance to get to lift. Baseball bats, wheelbarrows and crowbars are types of levers.

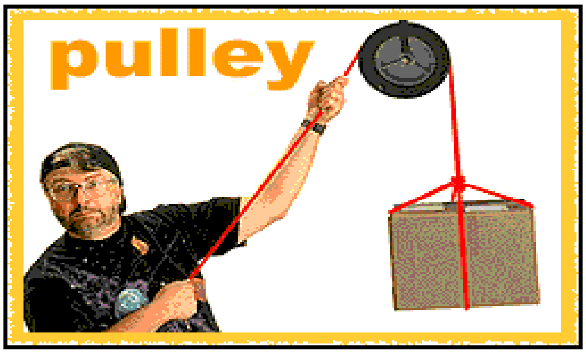
See-saw

Crowbar

The Pulley

Pulley is a simple machine used for lifting objects. Most machines used for lifting, such as cranes, have sets of pulleys that reduce the effort of lifting. We will use the words effort to mean the force needed or applied and load to mean the weight that needs to be lifted.

Effort = force applied
Load = weight



Pulleys make work easier because it changes the direction of motion to work with gravity. The more pulleys that are used, the less effort required to lift the load and the slower the load is lifted off the ground. A pulley really saves effort when you have more than one pulley working together.

By looping a rope around two, three, or even four pulleys, you can really cut down on the effort needed to lift something because, as you increase the number of pulleys, you also increase the distance you have to pull the rope.

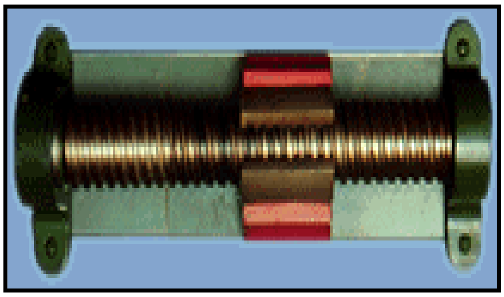
Lifting cargo into the haul of the ship was heavy work made increasingly lighter by the use of pulleys.

Cranes

Pulleys used in ships

The Screw

A screw is like the ramp it is used in many different places to hold things together. The screw has threads that spirals down to its pointed end. The wider the thread of a screw, the harder it is to turn it. If you've ever had to put in a screw with really narrow threads, you've probably found that you have to turn it a really long time to get it to go anywhere. Just like in a ramp, the easier the effort, the longer the distance you have to move something.



Screw

The Inclined Plane

The inclined plane is the simplest of simple machines because to make it work, nothing moves. Another name for an inclined plane is a ramp. A ramp works by helping you lift things more easily up to a higher level. It can be really difficult to carry a box of stuff up a ladder. But carrying that same box up a staircase is an easier job, and carrying it up a smooth ramp is even easier.

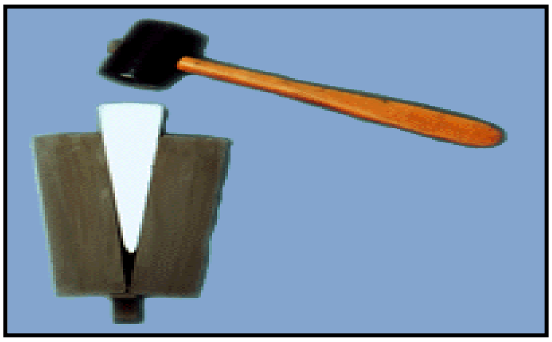
The way an inclined plane works is to save effort, but you must move things a greater distance. If you compare the length of a ladder to that of a staircase going to the same height, you'll find the ladder is much shorter. But it takes a lot more effort to climb a ladder than to simply walk up a flight of stairs.

The Wedge

A wedge is a double-inclined plane (both sides are inclined) that moves to exert a force along the lengths of the sides. The force is perpendicular to the inclined surfaces, so it pushes two objects (or portions of a single object) apart. Axes, knives, and chisels are all wedges. The common "door wedge" uses the force on the surfaces to provide friction, rather than separate things, but it's still fundamentally a wedge.

A wedge is really an inclined plane turned on its side. But instead of helping you move things to a higher level, a wedge helps you push things apart. Axes, knives, and chisels are all wedges. Basically, the wedge works just like a ramp: The sharper the point of a wedge, the easier it is to drive in and push things apart.

Axe



A wedge of wood

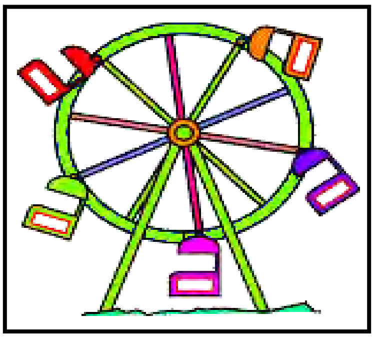
Wheel and axle

A wheel and axle is really two machines in one because you can use each part in different ways. Wheels help you move an object across the ground because they cut down on the amount of friction between what you're trying to move and the surface you're pulling it against. (The axle is the object that attaches the wheel to the object it's moving.) Since only the very bottom of the wheel touches the ground, there is less surface area to rub — and less friction. Imagine pulling a little red wagon without any wheels! Generally speaking, the bigger the wheel, the easier it is to make something roll.

The other way of using a wheel is like a lever in the round. A door knob or a faucet on a sink is really round levers, and the "fulcrum" is in the middle where the axle turns. Imagine if a door knob was replaced with a little rod. It would be much harder to open the door. But there's a trade-off - the larger the diameter of the wheel, the less effort you need to turn it, but you have to move the wheel a greater distance to get the same work done.

Bicycle

Electric fan



Ferris Wheels

Activity: Now test yourself by doing this activity.

Multiple Choice Questions. Circle the letter of the correct answer.

1. A seesaw on the playground is a/an __________.

   A. lever B. wedge
   C. pulley D. inclined plane

2. A roller skate is an example of a ___________.

   A. lever B. wedge
   C. wheel and axle D. inclined plane

3. The bottom of a light bulb would be considered a ___________.

   A. screw B. lever
   C. wedge D. inclined plane

4. A straight slanted surface.

   A. Screw B. Inclined plane
   C. Pulley D. Wheel and axle

5. A stiff rod that rotates around a pivot point.

   A. Screw B. Lever
   C. Pulley D. Inclined plane

6. A ramp is an example of a/an __________.

   A. screw B. pulley
   C. wheel and axle D. inclined plane

7. Made of two inclined planes put together.

   A. Wedge B. Pulley
   C. Wheel and axle D. Screw

8. Uses grooved wheels and a rope, belt or chain.

A. Wedge B. Pulley

C. Wheel and axle D. Inclined plane

9. A fork is an example of a __________.

A. wedge B. pulley

C. lever D. wheel and axle

10. A screwdriver can be used to open a can of paint. In this situation, the screwdriver is being used as a __________.

A. lever B. screw

C. inclined plane D. wheel and axle

Summary

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

- simple machines are tools that make work easier.
- there are six simple machines: the lever, pulley, screw, inclined plane, wedge and the wheel and axle.
- levers are simple machines used to lift weights.
- pulleys are extremely useful for lifting objects. Pulleys make work easier because it changes the direction of motion to work with gravity. Most machines used for lifting, such as cranes, have sets of pulleys that magnify the effort.
- the screw has threads that spiral down to its pointed end.
- the inclined plane works by helping you lift things more easily up to a higher level.
- a wedge is a double-inclined plane (both sides are inclined) that moves to exert a force along the lengths of the sides. The force is perpendicular to the inclined surfaces, so it pushes two objects apart.
- a wheel and axle is really two machines in one because you can use each part in different ways.
- wheels help you move an object across the ground because they cut down on the amount of friction between what you're trying to move and the surface you're pulling it against.

NOW DO PRACTICE EXERCISE 16 ON THE NEXT PAGE.

Practice Exercise 16

Answer the following questions:

1. Identify and describe the six types of simple machines.

    a. ______________________________

    b. ______________________________

    c. ______________________________

    d. ______________________________

    e. ______________________________

    f. ______________________________

2. List the uses of simple machines.

    a. ______________________________

    b. ______________________________

    c. ______________________________

    d. ______________________________

    e. ______________________________

    f. ______________________________

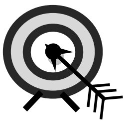
CHECK YOUR WORK. ANSWERS ARE AT THE END OF SUB STRAND 4.

Answers to Activity

1. **A**
2. **C**
3. **A**
4. **B**
5. **A**
6. **D**
7. **A**
8. **B**
9. **C**
10. **A**

Lesson 17: Measuring Force

Welcome to Lesson 17 of Strand 3. In the last lesson you learnt that simple machines are tools that make work easier. In this lesson you will learn about what a force is. Forces are acting everywhere in the universe at all times. The forces could be very big or very small. There are often many forces at work. If you were a ball sitting on a field and someone kicked you, a force would have acted on you. As a result, you would go bouncing down the field. These different forces have their own characteristics and can be measured.



Your Aims:

- define force
- name and describe the types of forces
- differentiate balanced and unbalanced forces
- calculate the force from a given situation

What Is A Force?

A **force** is a push or a 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 drink 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.

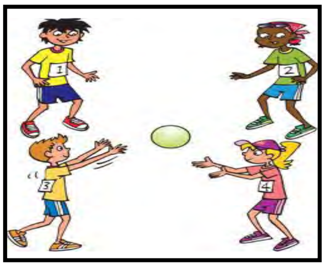
Types of Forces

Gravity is a force that pulls objects downwards towards the centre of the earth.

Let us look at these examples.

- What happens when you throw a ball up into the air?

  The ball goes up in the air and then falls down again.



- What happens when you jump up into the air?

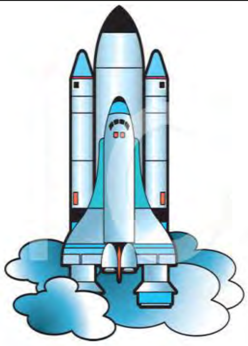
  You soon come down again to earth.

- What happens to ripe fruits such as mangoes that grow on trees?

  They will fall to the ground unless they are picked first.

Let us think about these questions.

- What keeps you on earth as it spins around?
- What does the space shuttle have to overcome to leave the earth?
- What keeps the water in the seas and the oceans?
- What keeps the air in the atmosphere?



All of these happen because of the force we call **gravity.**

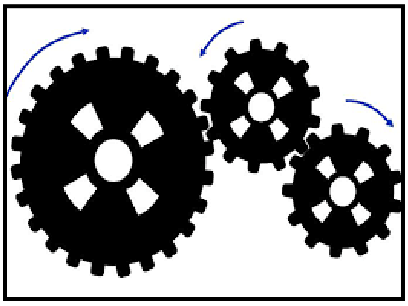
Friction

It is the resistance between two surfaces that are in contact with each other and a force that slows motion and reduces energy. No matter which direction something moves in, friction pulls it the other way. Move something left, friction pulls right. Move something up, friction pulls down. It appears as if nature has given us friction to stop us from moving anything. Friction is actually a force that appears whenever two things rub against each other. Although two objects might look smooth, when we look at them under a microscope, they are very rough and pointy.

Let us look at these examples.

There is a friction between a car tyre and the road with which it is in contact.

Blades of ice skates are sharp and able to slice through the surface of the ice, leaving a small water channel, so friction is lessened.



Friction can be reduced between two surfaces. Oil can be reduced friction between rotating cogs.

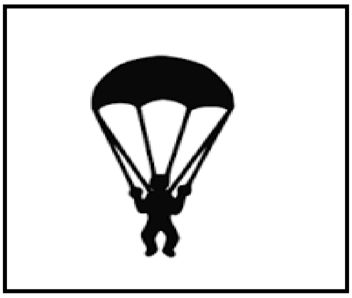
Sometimes we want to increase friction between two surfaces. When we want to slow a bicycle quickly, we need to have a lot of friction between the brake blocks and the wheels they touch.

Air Resistance

Air resistance pushes against things that are moving. Basically, it is friction between an object and the air. The particles in the air slow down an object by passing through it. You can feel this happening when you walk and run. When you walk, unless it is windy, you do not normally notice the air resistance because it is very low (collisions are not very hard). When you run, you can readily feel the air resistance on your face.

Let us look at these examples.

Air resistance pushes against a moving car and slows it down.



Air resistance pushes against falling objects and slows them down.

Upthrust

Upthrust is a force that pushes an object up and makes it seem to lose weight in a fluid. Remember that a fluid means a liquid or a gas.

Look at the examples below.

The upthrust or buoyancy keeps canoe afloat.

The upthrust or buoyancy keeps swimmers on top the water.

Turning forces

Turning forces are effects of **forces** allowing a body to rotate about a turning point or pivot. A force can cause many things to move or stop. When a force causes an object to turn, this turning effect is called moments.

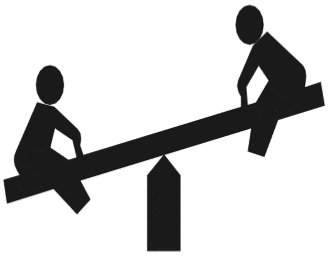
Look at the following examples.

What are balanced forces?

When things are not moving, the forces are balanced. Gravity pulls the table down, but the table is pushed up by the ground or floor it stands on, so the table does not move. The forces are **balanced.**	
The mug stands on a surface. It does not move because the force of gravity acting downwards is balanced by the force from the surface pushing back up.	
If the **upthrust** (or push up) of the air is equal to the force of gravity (pull down), then the balloon remains suspended in the air.	

What are unbalanced forces?

Unbalanced forces are needed to make things change movement and direction.

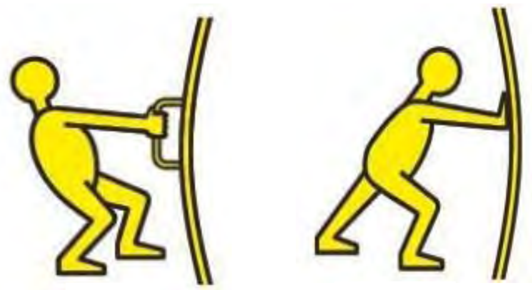


The see-saw is unbalanced because the forces are not equal.

The hurdle has lost contact with the ground and has moved upwards. The earth's pull is unbalanced. This makes her slow down and change direction, so he comes down to earth again.

Measurement of force

A force is a push or a pull. It is measured in **newtons** (N).

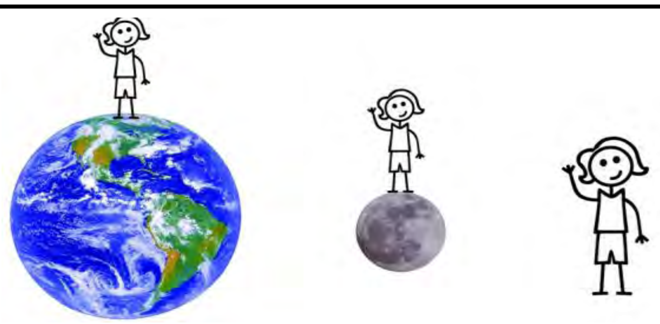


On Earth, every object has a downward force of gravity on it. This force is called its weight. Like other forces, it is measured in newtons (N).

For example, on earth

a mass	has this weight
1 kg	10 N
2 kg	20 N
3 kg	30 N

and so on…



My weight on Earth is around 560N.

My weight on the moon is around 90N.

My mass is always 56kg.

In other words, on Earth, things weigh 10N for each kilogram of mass. The earth's gravitational field strength is 10N/kg.

Force, mass and acceleration are linked like this

Force (N) = Mass (kg) x acceleration (m/s^2) (F = ma)

Let us look at the following examples.

Example 1
How much force is required to accelerate a 1,500 kg car at $6.00 m/s^2$?

$F = m \times a$

$F = 1500kg \times 6m/s^2$

$F = 9000N$

Example 2
A 17,250 kg rocket is pushed with a thrust of 3,14648N. What is the acceleration of the rocket?

$F = m \times a$

$a = \frac{F}{m}$

$a = \frac{314,648\ N}{17,250\ kg}$

$a = \mathbf{18.24 m/s^2}$

Example 3
If a force of 3,000N can move a crate at an acceleration of $0.4m/s^2$, what is the mass of the object?

$F = m \times a$

$m = \frac{F}{a}$

$m = \frac{3000N}{0.4\ m/s^2}$

$m = 7,500kg$

Example 4
A boy pushes on a box of mass 2kg and it moves at an acceleration of $0.4m/s^2$. With what force does the boy push on the box?

$F = m \times a$
$F = 2kg \times 0.4\ m/s^2$
$F = 0.8N$

Activity: Now test yourself by doing this activity.

Multiple Choice Questions. Circle the letter of the correct answer.

1. How are force, mass and acceleration related?

A. Force = mass / acceleration
B. Force = mass x acceleration
C. Force = acceleration / mass
D. Force = force x acceleration

2. When an object is not moving, what effect will balanced forces have on the object?

A. It will not move
B. It will speed up
C. It will slow down
D. It will start moving

3. A car of mass 1000kg can produce an acceleration of $8 m/s^2$. Calculate the force produced.

A. 8000 N
B. 18000 N
C. 10 000 N
D. 100 000 N

4. __________ forces will have no effect on the movement of an object.

A. Opposite
B. Identical
C. Balanced
D. Unbalanced

5. When two bodies push on each other the forces they exert on each other are __________ and __________.

A. friction and gravity
B. equal and opposite
C. balanced and identical
D. unbalanced and equal

6. A force of __________ acts when a solid surfaces slide across each other.

A. friction
B. weight
C. acceleration
D. deceleration

Summary

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

- a force is a push or pull.
- gravity is a force that pulls objects downwards towards the centre of the earth.
- friction is a force. It is a force that slows motion and reduces energy. No matter which direction something moves in, friction pulls it the other way.
- air resistance pushes against things that are moving. Basically, it is friction between an object and the air.
- upthrust is a force that pushes an object up and makes it seem to lose weight in a fluid.
- turning forces is an effect of a force allowing a body to rotate about a turning point or pivot.
- when things are not moving, the forces are balanced.
- unbalanced forces are needed to make things change movement and direction.
- a force is measured in newtons (N).
- force, mass and acceleration are linked like this:
  Force = Mass x acceleration (F = ma)
  (N) (kg) (m/s^2)

NOW DO PRACTICE EXERCISE 17 ON THE NEXT PAGE.

Practice Exercise 17

Answer the following questions:

1. What is force?

2. Name and describe the types of forces.

   a.

   b.

   c.

   d.

   e.

3. Describe the difference between balanced and unbalanced forces.

4. Calculate the force of the following.

   A. What force is required to accelerate an object having a mass of 3kg at 5 m/s^2?

   B. What is the mass of an object which is accelerated at $10m/s^2$ due to a force of 75N?

C. What would be the acceleration of an object with a mass of 20kg when hit with a force of 100N?

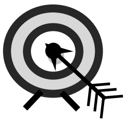
CHECK YOUR WORK. ANSWERS ARE AT THE END OF SUB STRAND 4.

Answers to Activity

1. **B**
2. **A**
3. **A**
4. **C**
5. **B**
6. **A**

Lesson 18: Measuring Work and Energy

Welcome to Lesson 18 of Strand 3. In the last lesson you learnt that a force is a push or a pull and can be measured. In this lesson you will learn about how to measure work and energy. We are greatly dependent upon energy. Energy can be said as the ability to do work. Work and energy seem much the same thing. However, while they are similar, they are not the same. Remember that work is an activity involving mental or physical effort done in order to achieve a result. Energy is the ability to do that work.



Your Aims:

- define work, energy, joules and Newton
- differentiate work from energy
- calculate work from a given example

What is Work?

The word work has several meanings to different people. Your parent or guardians go to work every day. Homework is work you do at home or something that a teacher assigns you to do at home in your own time. In science, work has a different meaning.

Work is the result of a force applied to an object to move another object through a given distance.

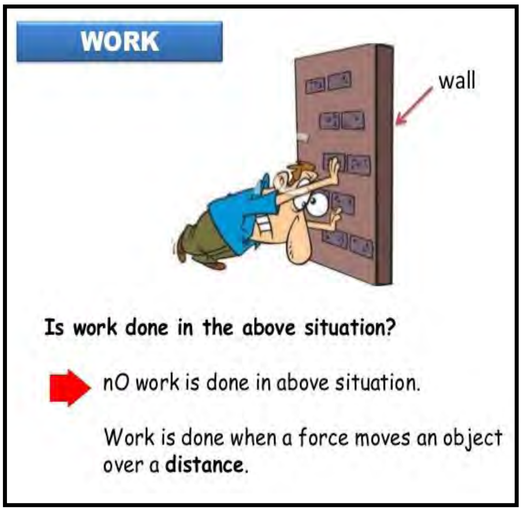
In mathematical terms,

Work = Force X Distance.

In this equation force is measured in Newtons (N) and distance is measured in meters (m). One Newton-meter is equal to one Joule (J). Joules therefore define the amount of work that has been done on an object. One joule (J) equals 0.2388 calories. Machines do work.

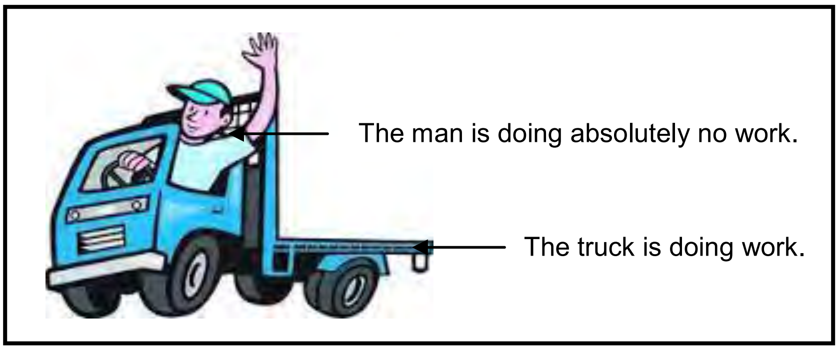
In order to say work is being done, a force must be applied. If you were to push on a brick wall all day as hard as you could, even though you may feel like you have done work, no work would have been done because the wall never moved.

Work is done when a force is applied to an object. You might head off to your job one day, sit at a computer, and type away at the keys. Is that work? Sitting and looking at a computer screen is not work. Tapping on the keyboard and making the keys move is work. Your fingers are applying a force and moving the keys and the result of your work is in the computer screen.



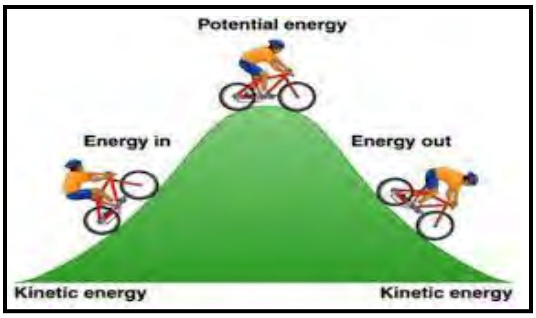
Driving to your job is not work because you just sit, but the energy your car engine uses to move the car does work. And the driver of the vehicle is working by moving the transmissions and moving the steering bar of the vehicle. You have to exert a force and move something to qualify as doing work.

Imagine that you are holding a block of brick above the ground. Your arm is straight out in front of you and it is pretty tough and hard to hold. Slowly, your arm gets tired, the block of brick feels heavier and heavier, and you finally stopped to let your arm rest. Even though you used your energy to hold up the block of brick for a while, you did not work. The block of brick did not move. No work was done if no movement happened. If you lifted the block of brick again after your arm had rested, that would be work.



What is energy?

It is the ability to do work. This applies to humans as well as to objects. If you have got a lot of energy, you can do many things like running, walking, jumping, swimming, climbing, pushing, riding and many more. If you have got no energy, you just feel like being very lazy and do not want to do anything.



Just as there are many forms of energy, there are different ways to measure these forms. The unit in which energy is measured is called a joule (J). One joule is the amount of energy it takes to lift an object that weighs one Newton at a one meter distance. A Newton is the unit of force. It is defined as the force required to cause a mass of one kilogram to accelerate at a rate of one metre per second squared in the absence of other force-producing effects (1kg at $1m/s^2$). Both work and energy are commonly measured in joules.

Work transfers energy from one object to another. Sometimes when energy is transferred, a force acts which moves something: lifting a book, cycling uphill, walking up stairs and kicking a football. We say that work is done on an object when a force moves that object. Take a look at this table of energy and compare the different amounts of energy produced.

Table of Energy

Description of Energy	joules
Energy to lift a book from the floor to the table	1
Energy of a bullet leaving a gun	1000
Average energy used by your body in a day	10^7
Energy provided by 1 gallon of petrol in a car	10^8
Energy from 1 ton of coal	10^{10}
Energy in a hurricane	10^{15}
Energy received on Earth from the sun each second	10^{17}
Energy of a severe earthquake	10^{18}
World energy consumption in a year	10^{20}
Energy received on Earth from the sun each day	10^{21}
Sound energy from a radio in 1 hour	10^8
Movement energy of a truck travelling along the road	10^6
Energy stored in a handful of peanuts	10^7
Energy from a fluorescent light in 5 minutes	10^9
Food energy stored in an egg	10^7

Activity: Now test yourself by doing this activity.

Part A. Complete the following work problems. The first one has been done as an example for you.

Remember: Work (J) = Force (N) X Distance (m).

1. 20J = 10N x 2m
2. 20J = force? x 2m (F = W / D)
3. Work? = 10N x 500m
4. 5000J = 500N x distance? (D = W / F)
5. Work? = 0.2N x 600m

Part B. Is the person doing work? Answer yes or no.

1. When pushing a 1000N car 20 metres ___________
2. When lifting a rock off the ground ___________
3. When holding a book in their hands ___________
4. When pushing hard against a brick wall ___________
5. When walking up the stairs ___________

Part C.

1. You push a 10N object 10 meters. How much work was done on the object?

   Work (J) = Force (N) X Distance (m).

2. You use 35J of energy to move a 7N object. How far did you move it?

   W = F x D
   D = W / F

3. If a small motor does 520 J of work to move a toy car 260 m, what force does it exert?

   W = F x D
   F = W / D

Summary

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

- work is the result of a force applied to an object and the measure of the distance that object has moved (W = F x D).
- energy is the ability to do work.
- when energy is used, work is done.
- one joule is the amount of energy it takes to lift an object that weighs one Newton at a one metre distance.
- a Newton is the unit of force. It is defined as the force required to cause a mass of one kilogram to accelerate at a rate of one metre per second squared in the absence of other force-producing effects (1 kg at 1 m/s^2).
- both work and energy are commonly measured in joules.

NOW DO PRACTICE EXERCISE 18 ON THE NEXT PAGE.

Practice Exercise 18

Answer the following questions:

1. Define the following terms.

   a. work

   ____
   ____

   b. energy

   ____
   ____

   c. joules

   ____
   ____

   d. Newton

   ____
   ____

2. Solve the following.

   a. How much work was done if you carry a 20 N bag of dog food up a 6 m flight of stairs?

   b. Calculate the work done by a 47 N force pushing a pencil 0.26 m.

   c. 6232J = 82N x Distance?

   d. 168100J = Force? x 205m

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

Answers to Activity

Part A

1. 20J = 10N x 2m

2. 20J = force? x 2m (F = W / D) Ans. 10N

3. Work? = 10N x 500m Ans. 5000J

4. 5000J = 500N x distance? (D = W / F) Ans. 10m

5. Work? = 0.2N x 600m Ans. 120J

Part B.

1. yes

2. yes

3. no

4. no

5. yes

Part C.

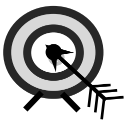
1. You push a 10 N object 10 meters. How much work was done on the object?
   Work (J) = Force (N) X Distance (m).
   W = 10N x 10m
   W = 100J

2. You use 35 J of energy to move a 7 N object. How far did you move it?
   W = F x D
   D = W / F
   D = 35J / 7N
   D = 5m

3. If a small motor does 520 J of work to move a toy car 260 m, what force does it exert?
   W = F x D
   F = W / D
   F = 520J / 260m
   F = 2N

Lesson 19: Mechanical Advantage of Simple Machines

Welcome to Lesson 19 of Strand 3. In Lesson 16, you studied about simple machine. You have learnt that simple machines are tools that make work easier. Simple machines are the elementary "building blocks" of which all more complicated machines (sometimes called "compound machines") are composed. For example, wheels, levers, and pulleys are all used in the mechanism of a bicycle.
The mechanical advantage of a compound machine is the product of the mechanical advantages of the simple machines of which it is composed. In this lesson, you will be studying about the mechanical advantages of simple machines.



Your Aims:

- explain a mechanical advantage
- calculate the mechanical advantage from a given example

Mechanical Advantage Of Simple Machines

Man started using machines to make work easier and faster. How much easier and faster a machine makes your work is the mechanical advantage of that machine. In science terms, the mechanical advantage is the number of times a machine multiplies your effort force.

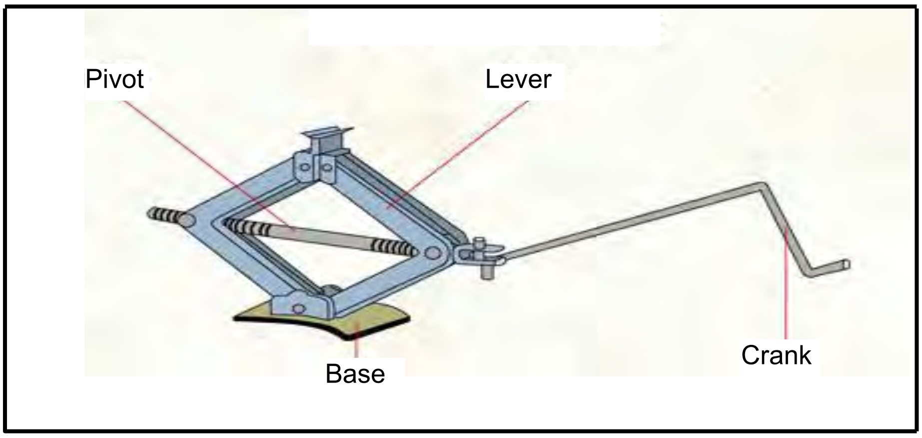
Mechanical advantage is the amount of times that a machine helps one does his or her work machine. The larger the mechanical advantage, the easier one's work is.
To find the MA of a machine, you can divide the load (output force) by the effort (input force). The load (output force) is the force applied by the machine, and the effort (input force) is the force applied to the machine by the human. Many common tools that are used in the home and in construction make use of this principle.

$$MA = \frac{\text{Load (output force)}}{\text{Effort (input force)}}$$

One of the best ways to understand the idea of mechanical advantage is to consider the simple action that takes place between a screwdriver and a screw. A screw is an inclined plane that turns round and round. Force is exerted on the screwdriver, causing the body of the tool to rotate while at the same time pressing the screw into some sort of surface, such as a wooden block. The combination of rotational force and forward movement make it possible for the screwdriver to use mechanical advantage to secure the screw into the medium.

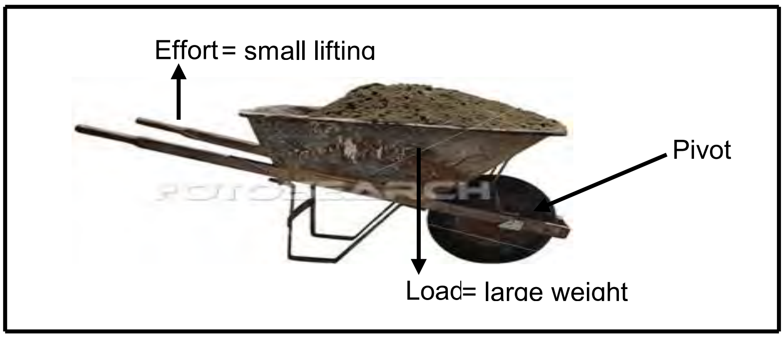
Turning a screw into wood with screw driver

Another example is the automobile jack. Automobile jack is a common device used to produce a mechanical advantage. The jack multiples the amount of force applied to the jack handle so that a small force (exerted by the operator) can be used to produce the larger force necessary to lift the automobile.



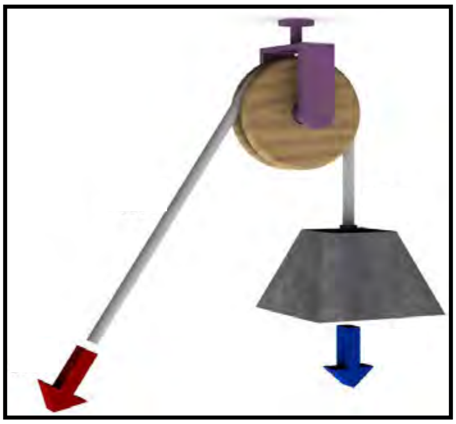
Automobile jack

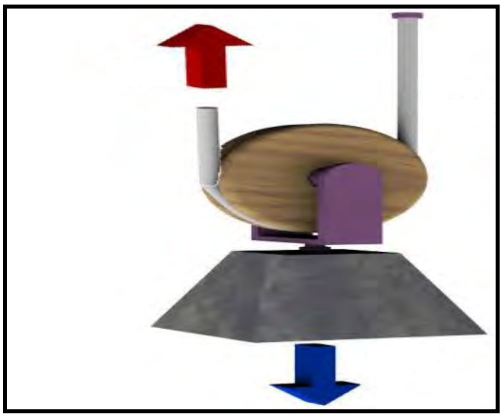
Other simple forms of mechanical advantage used in our daily lives include the lever. Examples of a lever are a crowbar, wheelbarrow and see-saw. Even the human arm can be used as a lever.
A wheelbarrow lets us lift a heavy load easily because only a small force is required. The easiest way to use a wheelbarrow is to have the load close to the pivot and to have your effort far from the pivot. When the effort is larger than the load then there is a force advantage. This means a small force is used to move a large load.



Wheelbarrow

Machines can also help you by changing the direction of a force. A single fixed pulley when attached to an unmovable objects e.g. a ceiling or wall, allow you to lift an object upwards by pulling downwards on a rope. The advantage of the fixed pulley is that you do not have to pull or push the pulley up and down. The disadvantage is that you have to apply more effort than the load. A tree branch can be used as a single fixed pulley.

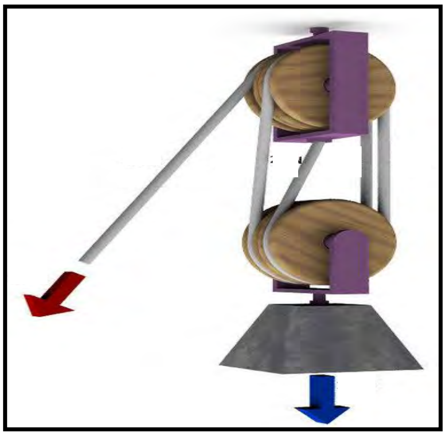




Single movable pulley

A movable pulley is a pulley that moves with the load. A single movable pulley can be used to give a force advantage. The movable pulley allows the effort to be less than the weight of the load. You need less force to lift the load with a pulley, but you need more rope. It does not change the direction of a force. As you pull upwards, the load also moves upwards. The main advantage of a movable pulley is that you use less effort to pull the load. The main disadvantage of a movable pulley is that you have to pull or push the pulley up or down.

A combined pulley makes life easier as the effort needed to lift the load is less than half the weight of the load. Pulley blocks with more than one pulley can be arranged to give a large mechanical advantage. The approximate mechanical advantage of a set of pulleys can be found by counting the numbers of strings supporting the load. The main advantage of this pulley is that the amount of effort is less than half of the load.
The main disadvantage is it travels a very long distance.

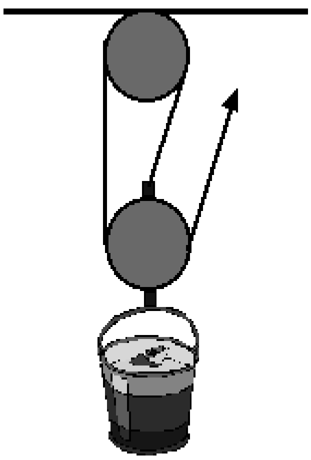


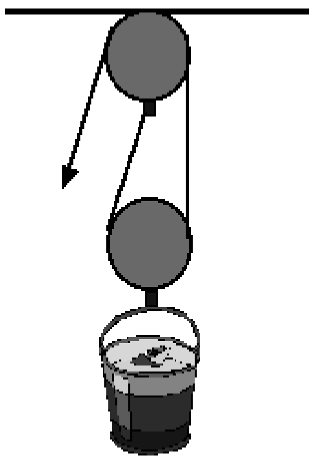
Combined pulley

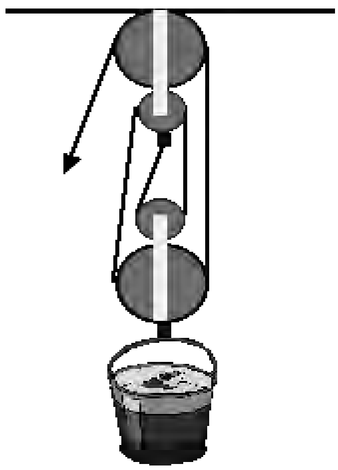
Activity: Now test yourself by doing this activity.

Part A. Interpret the diagrams to find the mechanical advantage of each pulley system.

(Note: The MA of a pulley is equal to the number of supporting ropes).







1. MA = __________ 2. MA = __________ 3. MA = __________

Part B. Work out the following problems.

1. A force of 200 newtons is applied to a machine in order to lift a 1,000-newton load. What is the mechanical advantage of the machine?

$$MA = \frac{\text{Load (output force)}}{\text{Effort (input force)}}$$

2. A machine is required to produce an output force of 600 newtons. If the machine has a mechanical advantage of 6, what input force must be applied to the machine?

$$MA = \frac{\text{Load (output force)}}{\text{Effort (input force)}}$$

$$\text{Effort (input force)} = \frac{\text{Load (output force)}}{MA}$$

Summary

You have come to the end of Lesson 19. In this lesson you have learnt that:

- mechanical advantage is the amount of times that a machine helps one does his or her work.
- to find the MA of a machine, you can divide the load (output force) by the effort (input force).
- the load (output force) is the force applied by the machine, and the effort (input force) is the force applied to the machine by the human.
- automobile jack is a common device used to produce a mechanical advantage.
- a wheelbarrow lets us lift a heavy load easily because only a small force is required. The easiest way to use a wheelbarrow is to have the load close to the pivot and to have your effort far from the pivot.
- turning a screw into wood with screwdriver produce a mechanical advantage. The combination of rotational force and forward movement make it possible for the screwdriver to use mechanical advantage to secure the screw into the medium.
- the advantage of the fixed pulley is that you do not have to pull or push the pulley up and down.

NOW DO PRACTICE EXERCISE 19 ON THE NEXT PAGE.

Practice Exercise 19

Answer the following questions:

1. Explain mechanical advantage.

2. Work out the following problems.

   a. A machine uses an input force of 200 newtons to produce an output force of 80 newtons. What is the mechanical advantage of this machine?

   b. A machine with a mechanical advantage of 10 is used to produce an output force of 250 newtons. What input force is applied to this machine?

   c. A machine is designed to lift an object with a weight of 12 newtons. If the input force for the machine is set at 4 newtons, what is the mechanical advantage of the machine?

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

Answers to Activity

Part A

1. MA = 2

2. MA = 2

3. MA = 4

Part B

1. $MA = \frac{\text{Load (output force)}}{\text{Effort (input force)}}$

$MA = \frac{1000N}{200N}$

MA = 5

2. $MA = \frac{\text{Load (output force)}}{\text{Effort (input force)}}$

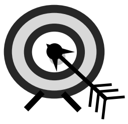
$\text{Effort (input force)} = \frac{\text{Load (output force)}}{MA}$

$\text{Effort} = \frac{600N}{6}$

Effort = 100N

Lesson 20 : Efficiency of Simple Machines

Welcome to Lesson 20 of Strand 3. In the last lesson, you have studied about the mechanical advantages of simple machines. You have enumerated the machines with mechanical advantages and explain the correct formula of it. You were also able to calculate the mechanical advantage of some simple machines from a given example.
For this lesson, you will be studying about the efficiency of simple machines.



Your Aims:

- revise the types of simple machines and their uses
- explain the efficiency of a machine

Simple Machines

These are simple because most have only one moving part. A machine is any device that makes work easier. When we say a machine makes it easier for us to do work, we mean that it requires less force to accomplish the same amount of work. Apart from allowing us to increase the distance over which we apply smaller force, machines may also allow us to change the direction of an applied force. Machines do not reduce the amount of work for us, but they can make it easier.

There are four types of simple machines which form the basis for all mechanical machines.

1. **Lever** – is an arm that pivots or turns against the fulcrum or a point.
Think of the claw end of a hammer that you use to pry nails loose, it is a lever. It is a curved arm that rests against a point on a surface. As you rotate the curved arm, it pries the nail loose from the surface. Any tool that pries something loose is a lever. There are three types of lever.

- **First Class Lever** – when the fulcrum lies between the force arm and the lever arm, the lever is described as a first class lever. It is a classic see-saw example.
- **Second Class Lever** – the load arm lies between the fulcrum and the force arm. A good example is a wheelbarrow.
- **Third Class Lever** – the force arm lies between the fulcrum and the load arm. Because of this arrangement, a relatively large force is required to move the load. This is offset by the fact that it is possible to produce movement of the load over a long distance with a relatively small movement of the force arm. Example is a fishing rod.

seesaw

2. Inclined Plane – is a flat surface. For example, a smooth surface board is a plane. Now, if the plane is lying flat on the ground, it is not likely to help you do work. However, when the plane is inclined or slanted, it can help you move objects across distances. And, that is work. A common inclined plane is a ramp. There are two kinds of inclined plane. These are the wedges and screws.

- Wedge – instead of using the smooth side of the inclined plane, you can also use the pointed edges to push things apart. Then the inclined plane is a wedge. Example is an axe blade.
- Screw – take an inclined plane and wrap it around a cylinder. Its sharp edge becomes another simple tool: the screw. Every turn of a metal screw helps you move a piece of metal through a wooden space.


Wedge


Screws

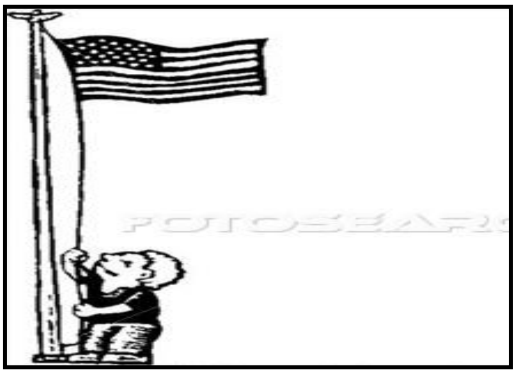
3. Wheel and Axle – a wheel is a circular disk attached to a central rod, called an axle. The steering wheel of a car is a wheel and axle. The section that we place our hands on and apply force is called the wheel, which turns the smaller axle. Screwdriver is another example of the wheel and axle.

Screwdriver

Wheel and axle of a wagon

4. **Pulley** – instead of an axle, the wheel could also rotate a rope or cord. This variation is called the pulley. In a pulley, a cord wraps around a wheel. As the wheel rotates, the cord moves in either direction. Attach a hook to the cord and you can use the wheel rotation to raise and lower objects. Example is a flag pole.


Block and tackle pulley


Flag pole

In the table below is the summary of simple machines and its uses.

Simple machines	What it is	How it helps us work?	Examples
Lever	A stiff bar that rests on a support called a fulcrum	Lifts or moves loads	Nail clipper, shovel, nutcracker, seesaw, crow-bar, tweezers, bottle opener
Inclined Plane	A slanting surface connecting a lower level to a higher level	Things move up or down it	Slide, stairs, ramp, escalator, slope
Wheel and Axle	A wheel with a rod, called an axle, through its centre: both parts move together	Lifts or moves loads	Doorknob, pencil sharpener, bike
Pulley	A grooved wheel with a rope or cable around it	Moves things up, down or across	Curtain rod, tow truck, mini blind, flag pole, crane

What do you mean by efficiency of a machine?
Efficiency is a measure of how much more work must be put into a machine than you get out of the machine. In the real world, the efficiency of a machine will always be less than 100%. This means that a machine will never do work for you. The best you can hope for in real life is that you do not have to put much more work into a machine than you get out. If there was no friction, the best you could hope for is an efficiency of 100% meaning work in = work out.

For example, a combustion engine produces a lot of energy but mostly in the form of heat and noise. About 25% of the energy trapped in the hydrocarbon bonds is converted from chemical to mechanical energy. Therefore, it has an efficiency of roughly 25%.

So efficiency of machines is the actual work they do in relation to the total amount of power they produce.

We can calculate efficiency by comparing work out to work in.

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

Here are some typical efficiency values.

For every 100 J of energy input →	Useful energy output	Efficiency
Petrol engine 	25 J	25%
Diesel engine 	35 J	35%
Fuel burning power station 	35 J	35%
Human engine 	15 J	15%

Activity: Now test yourself by doing this activity.

Multiple Choice Questions

Circle the letter of the correct answer.

1. The ratio of the work output to the work input of a machine is

   A. work
   B. power
   C. efficiency
   D. mechanical advantage

2. A screwdriver can be used to open a can of paint. In this situation, the screwdriver is being used as a

   A. lever
   B. screw
   C. inclined plane
   D. wheel and axle

3. What is a simple machine that uses grooved wheels and a rope to raise, lower or move a load?

   A. Lever
   B. Pulley
   C. Inclined plane
   D. Wheel and axle

4. What simple machine uses a slanted surface that connects a lower level to a higher level?

   A. Lever
   B. Screw
   C. Wedge
   D. Inclined plane

5. What type of simple machine is a seesaw on a playground?

   A. Lever
   B. Pulley
   C. Wedge
   D. Inclined plane

6. A fork would be an example of what type of simple machine?

   A. Lever
   B. Screw
   C. Pulley
   D. Wedge

7. Which of the following would you use a pulley for?

   A. To cut food
   B. To hold pieces of plastics together
   C. To help guide a sail on a sailboat
   D. To push an object to a higher level

Summary

You have come to the end of Lesson 20. In this lesson you have learnt that:

- Simple machines are devices we use to make work easier.
  1. Lever - A stiff bar that rests on a support called a fulcrum. It lifts or moves loads. Examples are nail clipper, shovel, nutcracker, seesaw, crow-bar, tweezers and bottle opener.
  2. Inclined Plane - A slanting surface connecting a lower level to a higher level. It moves up or down things. Examples are slide, stairs, ramp, escalator and slope.
  3. Wheel and Axle - A wheel with a rod, called an axle, through its centre: both parts move together. It lifts or moves loads. Examples are doorknob, pencil sharpener and bike.
  4. Pulley - A grooved wheel with a rope or cable around it. Moves things up, down or across. Examples are curtain rod, tow truck, mini blind, flag pole and crane.
- Efficiency is a measure of how much more work must be put into a machine than you get out of the machine.
- The efficiency of a machine will always be less than 100%. This means that a machine will never do work for you.
- Efficiency of machines is the actual work they do in relation to the total amount of power they produce.
- We can calculate efficiency by comparing work out to work in and multiply it with 100 to get the percentage.

NOW DO PRACTICE EXERCISE 20 ON THE NEXT PAGE.

Practice Exercise 20

Answer the following questions:

1. What is simple machine?

 ____

2. Match Column A with Column B. Write the correct letters beside column A.

	Column A
	Simple machines
	Wheel and axle
	Inclined plane
	Ramp
	Lever
	Fulcrum
	Nail puller
	Bottle cap opener
	Fishing pole
	First class lever
	Machines
	Second class lever

	Column B
A	a wedge or a screw
B	a bar used to put force at one end and lift an object at the other
C	an object placed under a lever to take part of the weight of an object from the lever
D	a type of third class lever
E	a machine that has a few moving parts that makes work easier
F	an inclined plane used to push an object to a higher level with less effort
G	the fulcrum is between the load and the force
H	a simple machine used in cars
I	a type of second class lever
J	a type of first class lever
K	the load is between the fulcrum and the force
L	make man's work easier

3. Explain efficiency of a machine.

____
____
____
____
____

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

Answers to Activity

1. **C**
2. **A**
3. **B**
4. **D**
5. **A**
6. **D**
7. **C**

REVIEW OF SUB STRAND 4: SIMPLE MACHINES

Revise all the Lessons in this Sub Strand and then do **ASSIGNMENT 3.**
Here are the main points to help you revise.

Lesson 16: Simple Machines

- Simple machines are tools that make work easier.
- There are six simple machines: the lever, pulley, screw, inclined plane, wedge and the wheel and axle.
- Levers are simple machines used to lift weights. Baseball bats, wheelbarrows, see saw and crowbars are types of levers.
- Pulleys are extremely useful for lifting objects. Pulleys make work easier because it changes the direction of motion to work with gravity. Most machines used for lifting, such as cranes, have sets of pulleys that magnify the effort.
- The screw is really an inclined plane in the round with a wedge at the tip. Screws are used in many different places to hold things together.
- The inclined plane is the simplest of simple machines because to make it work, nothing moves.
- A wedge is a double-inclined plane (both sides are inclined) that moves to exert a force along the lengths of the sides. The force is perpendicular to the inclined surfaces, so it pushes two objects apart.
- A wheel and axle is really two machines in one because you can use each part in different ways.

Lesson 17: Measuring Force

- A force is a push or pull.
- Gravity is a force that pulls objects downwards towards the centre of the earth.
- Friction is a force. It is a force that slows motion and dampens energy. No matter which direction something moves in, friction pulls it the other way.
- Air resistance pushes against things that are moving. Basically, it is friction between an object and the air.
- Upthrust is a force that pushes an object up and makes it seem to lose weight in a fluid.
- Turning forces is an effect of a force allowing a body to rotate about a turning point or pivot.
- When things are not moving, the forces are balanced.
- Unbalanced forces are needed to make things change movement and direction.
- A force is measured in newtons (N).
- Force, mass and acceleration are linked like this

Force	=	Mass	x	acceleration	(F = ma)
in N		in kg		in m/s^2	

Lesson 18: Measuring Work and Energy

- Work is the result of a force applied to an object and the measure of the distance that objects has moved (W = F x D).
- Energy is the ability to do work.
- When energy is used, work is done.
- One joule is the amount of energy it takes to lift an object that weighs one Newton at a one metre distance.
- A Newton is the SI unit of force. It is define as the force required to cause a mass of one kilogram to accelerate at a rate of one metre per second squared in the absence of other force-producing effects (1 kg at 1 m/s^2).
- Both work and energy are commonly measured in joules.

Lesson 19: Mechanical Advantages of Simple Machines

- Mechanical advantage is the amount of times that a machine helps one does his or her work.
- To find the MA of a machine, you can divide the load (output force) by the effort (input force).
- The load (output force) is the force applied by the machine, and the effort (input force) is the force applied to the machine by the human.
- A wheelbarrow lets us lift a heavy load easily because only a small force is required. The easiest way to use a wheelbarrow is to have the load close to the pivot and to have your effort far from the pivot.
- Turning a screw into wood with screwdriver produce a mechanical advantage.
- The advantage of the fixed pulley is that you do not have to pull or push the pulley up and down.
- The main advantage of a movable pulley is that you use less effort to pull the load.
- A combined pulley makes life easier as the effort needed to lift the load is less than half the weight of the load
-

Lesson 20: Efficiency of Simple Machines

- Simple machines are devices we use to make work easier.
- Lever - A stiff bar that rests on a support called a fulcrum. It lifts or moves loads. Examples are nail clipper, shovel, nutcracker, seesaw, crow-bar, tweezers and bottle opener
- Inclined Plane - A slanting surface connecting a lower level to a higher level. It moves up or down things. Examples are slide, stairs, ramp, escalator and slope.
- Wheel and Axle - A wheel with a rod, called an axle, through its centre: both parts move together. It lifts or moves loads. Examples are Doorknob, pencil sharpener and bike.
- Pulley - A grooved wheel with a rope or cable around it. Moves things up, down or across. Examples are curtain rod, tow truck, mini blind, flag pole and crane.
- Efficiency is a measure of how much more work must be put into a machine than you get out of the machine.
- The efficiency of a machine will always be less than 100%. This means that a machine will never do work for you.

- Efficiency of machines is the actual work they do in relation to the total amount of power they produce.
- We can calculate efficiency by comparing work out to work in and multiply it with 100 to get the percentage.

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

Answers to Practice Exercises 16- 20

Practice Exercise 16

1. a. **Levers** are simple machines used to lift weights. Baseball bats, wheelbarrows, see-saw and crowbars are types of levers.

   b. **Pulleys** make work easier because it changes the direction of motion to work with gravity. Most machines used for lifting, such as cranes, have sets of pulleys that magnify the effort.

   c. **The screw** is really an inclined plane in the round with a wedge at the tip.

   d. **The inclined plane** is the simplest of simple machines because to make it work, nothing moves. Another name for an inclined plane is a ramp.

   e. **A wedge** is a double-inclined plane (both sides are inclined) that moves to exert a force along the lengths of the sides.

   f. **A wheel and axle** is really two machines in one because you can use each part in different ways. The axle is the object that attaches the wheel to the object it's moving.

2.
   a. **A pulley** is a simple machine that uses grooved wheels and rope to raise, lower or move a load. Pulleys are extremely useful for lifting objects.

   b. **A lever** is a stiff bar that rests on a support called a fulcrum which lifts or moves loads.

   c. **A wedge** is an object with at least slanting side ending in a sharp edge which cuts materials apart.

   d. **A wheel** with a rod called **an axle** through its center lifts or moves loads.

   e. **An inclined plane** is a slanting surface connecting a lower level to a higher level.

   f. **A screw** is an inclined plane wrapped around a pole which holds things together or lifts materials.

Practice Exercise 17

1. Force is a push or a pull.

2. A. Gravity is a force that pulls objects downwards towards the centre of the earth.
   B. Friction is a force. It is a force that slows motion and dampens energy. No matter which direction something moves in, friction pulls it the other way.
   C. Air resistance pushes against things that are moving. Basically, it is friction between an object and the air.
   D. Upthrust is a force that pushes an object up and makes it seem to lose weight in a fluid.
   E. Turning forces is an effect of a force allowing a body to rotate about a turning point or pivot.

3. Balanced forces are forces when things are not moving while unbalanced forces are forces needed to make things change movement and direction.

4.
   A.

$$F = m \times a$$

$$F = 3kg \times 5m/s^2$$

$$\mathbf{F = 15N}$$

   B.

$$F = m \times a$$

$$m = \frac{F}{a}$$

$$m = \frac{75\ N}{10\ m/s^2}$$

$$\mathbf{m = 7.5kg}$$

   C.

$$F = m \times a$$

$$a = \frac{F}{m}$$

$$a = \frac{100N}{20kg}$$

$$a = \mathbf{5m/s^2}$$

Practice Exercise 18

1.

a. Work is the result of a force applied to an object and the measure of the distance that objects has moved.

b. Energy is the ability to do work.

c. A joule is the amount of energy it takes to lift an object that weighs one Newton a one metre distance.

d. Newton is define as the force required to cause a mass of one kilogram to accelerate at a rate of one metre per second squared in the absence of other force-producing effects.

2.

a. How much work was done if you carry a 20N bag of dog food up a 6m flight of stairs?

W = F x D
W = 20N x 6m
W = 120J

b. Calculate the work done by a 47N force pushing a pencil 0.26m.

W = F x D
W = 47N x 0.26m
W = 12.22J

c. 6232J = 82N x Distance?

D = W / F
D = 6232J / 82N
D = 76m

d. 168100J = Force? x 205m

F = W / D
F = 168100J / 205m
F = 820N

Practice Exercise 19

1. Machines that help people contain a mechanical advantage. Mechanical advantage is the amount of times that a machine helps one does his or her work. The larger the mechanical advantage, the easier one's work is. In science terms, the mechanical advantage is the number of times a machine multiplies your effort force. To find the MA of a machine, you can divide the load (output force) by the effort force (input force). The load (output force) is the force applied by the machine, and the effort (input force) is the force applied to the machine by the human.

$$MA = \frac{\text{Load (output force)}}{\text{Effort (input force)}}$$

2.
   a. A machine uses an input force of 200 newtons to produce an output force of 80 newtons. What is the mechanical advantage of this machine?

$$MA = \frac{\text{Load (output force)}}{\text{Effort (input force)}}$$

$$MA = \frac{80N}{200N}$$
$$MA = 0.4$$

   b. A machine with a mechanical advantage of 10 is used to produce an output force of 250 newtons. What input force is applied to this machine?

$$MA = \frac{\text{Load (output force)}}{\text{Effort (input force)}}$$
$$Effort = \frac{Load}{MA}$$

$$Effort = \frac{250N}{10}$$
$$Effort = 25$$

   c. A machine is designed to lift an object with a weight of 12 newtons. If the input force for the machine is set at 4 newtons, what is the mechanical advantage of the machine?

$$MA = \frac{\text{Load (output force)}}{\text{Effort (input force)}}$$

$$MA = \frac{12N}{4N}$$
$$MA = 3$$

Practice Exercise 20

1. Simple machines are devices we use to make work easier.

2.

	Column A
E	Simple machines
H	Wheel and axle
A	Inclined plane
F	Ramp
B	Lever
C	Fulcrum
J	Nail puller
I	Bottle cap opener
D	Fishing pole
G	First class lever
L	Machines
K	Second class lever

	Column B
A	a wedge or a screw
B	a bar used to put force at one end and lift an object at the other
C	an object placed under a lever to take part of the weight of an object from the lever
D	a type of third class lever
E	a machine that has a few moving parts that makes work easier
F	an inclined plane used to push an object to a higher level with less effort
G	the fulcrum is between the load and the force
H	a simple machine used in cars
I	a type of second class lever
J	a type of first class lever
K	the load is between the fulcrum and the force
L	make man's work easier

3. Efficiency is a measure of how much more work must be put into a machine than you get out of the machine. The efficiency of a machine will always be less than 100%. This means that a machine will never do work for you. Efficiency of machines is the actual work they do in relation to the total amount of power they produce.

GLOSSARY

Acids	Chemicals which will turn blue litmus paper red.
Alkalis	Bases which are soluble in water.
Base	Substance which forms hydroxide (**OH^-**) ions in a solution. It turns red litmus paper blue.
Boric acid	Weak acidic substance that is sometimes used to wash the eyes. It is also used as fire retardant.
Circuit	Path that electricity follows, from a source through a connection to an output device.
Conduction	Main way by which heat moves through a solid. The heat gradually spreads out through the solid from a hot part to a cold part.
Density	A measure of the amount of matter in a given volume.
Efficiency	A measure of how much more work must be put into a machine than you get out of the machine.
Electrical Circuit	An electrical device that provides a path for electrical current to flow.
Electricity	A form of energy produced by the movement of electrons.
Electrolysis	A process of passing an electric current through a liquid which causes chemical changes.
Electromagnet	An iron bar inside the coil of wire and only works while the current is flowing.
Energy	The ability to do work.
Evaporation	The process of conversion of a liquid into its vapours at room temperature.
Force	A push or pull.
Fossil fuel	Material that can be burned and that comes from the fossil remains of animals and plants.
Friction	A force that slows motion and dampens energy.
Gravity	A force that pulls objects downwards towards the centre of the earth.
Heat Energy	The type of energy that moves from places of higher temperature to those of lower temperature.
Helium	A light gas and used in balloons to help them float.
Hydroelectric Energy	Energy produced when water falls from a high place to a low place.
Indicator	Dye that will change colour when mixed with an acid or a base.
Mass	The amount of matter in an object.
Mechanical Advantage	The amount of times that a machine helps one does his or her work.
Neutralisation	The reaction between an acid and an alkali producing heat energy and salt.
Nitric Acid	Industrial acid used in the manufacture of fertilizers, plastics, photographic film, and dyes.
Parallel Circuit	More than one path for current flow. In the event of an open in the circuit in one of the branches, current will continue to flow through the remaining other branches.
pH scale	A scale of numbers from 0 to 14 that is used to measure the strength of an acid or a base.

Physical properties	The characteristics that are used in describing objects that can be seen without changing how the object looks.
Series circuit	The simplest circuit. The conductors, control and protection devices, loads, and power source are connected with only one path to ground for current flow.
Simple Machines	Tools that make work easier.
Solar Cells	Special cells that convert sunlight directly into electrical energy.
Sonorous	Property of metals that make a ringing sound when they are struck.
Temperature	A measure of the degree of hotness or coldness of something.
Turning forces	An effect of a force allowing a body to rotate about a turning point or pivot.
Universal indicator	A mixture of different indicators.
Upthrust	A force that pushes an object up and makes it seem to lose weight in a fluid.
Weight	A measure of the pull of gravity on an object.
Work	The result of a force applied to an object and the measure of the distance that objects has moved.
Volume	The amount of space that an object takes up.

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5. Watson, Christine. Heinemann Interactive Science 1. Port Melbourne: Reed International Books Australia Pty Ltd. 1998

6. Watson, Geoff. Science Works 2. New York: Oxford University Press, 2001.

FODE PROVINCIAL CENTRES CONTACTS

PC NO.	FODE PROVINCIAL CENTRE	ADDRESS	PHONE/FAX	CUG PHONE (COORDINATOR)	CUG PHONE (SENIOR CLERK)
1	ALOTAU	P. O. Box 822, Alotau	6411343/6419195	72228130	72229051
2	BUKA	P. O. Box 154, Buka	9739838	72228108	72229073
3	CENTRAL	C/- FODE HQ	3419228	72228110	72229050
4	DARU	P. O. Box 68, Daru	6459033	72228146	72229047
5	GOROKA	P. O. Box 990, Goroka	5322085/5322321	72228116	72229054
6	HELA	P. O. Box 63, Tari	73197115	72228141	72229083
7	JIWAKA	c/- FODE Hagen		72228143	72229085
8	KAVIENG	P. O. Box 284, Kavieng	9842183	72228136	72229069
9	KEREMA	P. O. Box 86, Kerema	6481303	72228124	72229049
10	KIMBE	P. O. Box 328, Kimbe	9835110	72228150	72229065
11	KUNDIAWA	P. O. Box 95, Kundiawa	5351612	72228144	72229056
12	LAE	P. O. Box 4969, Lae	4725508/4721162	72228132	72229064
13	MADANG	P. O. Box 2071, Madang	4222418	72228126	72229063
14	MANUS	P. O. Box 41, Lorengau	9709251	72228128	72229080
15	MENDI	P. O. Box 237, Mendi	5491264/72895095	72228142	72229053
16	MT HAGEN	P. O. Box 418, Mt. Hagen	5421194/5423332	72228148	72229057
17	NCD	C/- FODE HQ	3230299 ext 26	72228134	72229081
18	POPONDETTA	P. O. Box 71, Popondetta	6297160/6297678	72228138	72229052
19	RABAUL	P. O. Box 83, Kokopo	9400314	72228118	72229067
20	VANIMO	P. O. Box 38, Vanimo	4571175/4571438	72228140	72229060
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.