FOCUS ON

Combined Science

Learner's Book

Form 2

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Focus on Combined Science Learner's Book Form 2

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Section 1

Biology

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Topic 1 Variation

Learning objectives	Activities
• State differences between living organisms	• Look at differences in leaves and seeds in pods
• Compare continuous and discontinuous variation	• Comparing height, mass, shoe size, skin/coat colour, sex, right or left handedness, tongue rolling
• Draw bar graphs to show variations in organisms	• Drawing bar graphs to show variations

When you look at all the different kinds of living organisms, you will see that there are not only differences between organisms of different types but also differences between the organisms of the same type. No two organisms of the same type are exactly the same. Studying the other children in your class will demonstrate this. You do not all look the same.

In Agriculture Form 1, you will have seen variations in livestock and crop plants.

In Form 1 you learnt about the nucleus in a cell. The nucleus contains the hereditary/genetic material.

In Form 1 you learnt how to present data in the form of tallies, tables and bar graphs.

Differences among living organisms

The differences in characteristics among individuals of the same kind is called **variation**.

Variation in organisms of the same type may occur as a result of **inherited** characteristics. Some characteristics of organisms can be passed on from one **generation** to the next. For example, tallness may be passed from father to son. These characteristics are genetically determined.

Variation can also be the result of the influence of the **environment** in which organisms live. For example, maize plants grown in poor soil have yellow leaves compared to maize plants grown in fertile soil (Figure 1.1). The fertility of the soil influences how the maize plant looks. Variation resulting from only environmental factors cannot be passed on from one generation to the next.

Word help

generation: parents are a generation and the offspring are the next generation.
variation: small differences in characteristics among individual organisms of the same kind.
environment: surroundings.
inherited: passed on from parents.

Figure 1.1 Maize plants show variation if they are grown in fertile soil and poor soil

Sometimes environmental factors can influence human characteristics. For example, the characteristic such as height of a human is inherited, but it is also influenced by environmental factors such as diet. A person may suffer from malnutrition because of a lack of nutrients as required by a balanced diet. The individual will not grow as he or she could have grown if a balanced diet had been followed. The person could be thinner or shorter.

Figure 1.2 shows a class of school children of the same age. You can see that there are small differences in the characteristics between the individual children in the group. The class of children will show differences in height, mass, shoe size, sex or gender, right or left handedness and being able to roll their tongues.

Figure 1.2 A group of children all have different characteristics

Types of variation

There are two types of variation: continuous and discontinuous variation.

Continuous variation

In **continuous variation** there is a range of measurements in a group of individuals of the same kind. For example, the height of learners in the class will show continuous variation. There is a range of heights for your age group. Other examples of continuous variation include mass and shoe size.

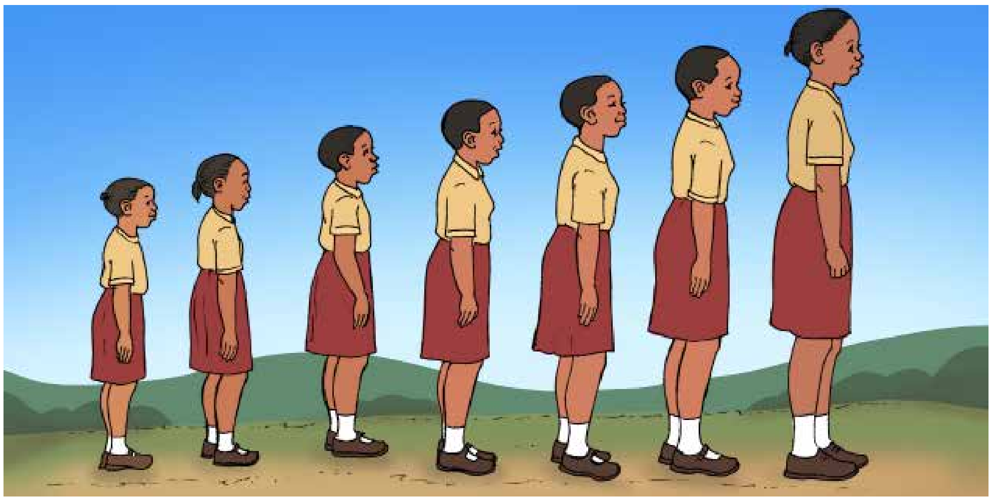
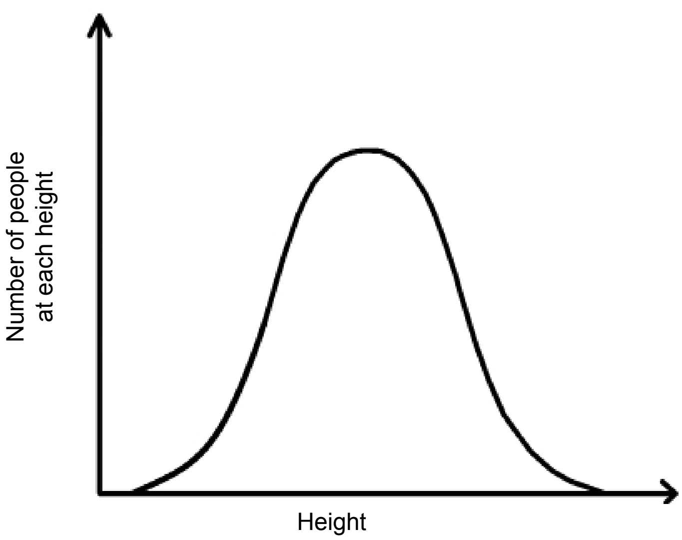


Figure 1.3 Height is an example of continuous variation

Continuous variation is the result of inherited characteristics and environmental factors.

If you plotted a graph to show the range of heights of learners in your class, you would get a bell-shaped curve. See Figure 1.4. This is called a **normal distribution curve**. The curve shows that the majority of the learners are of more-or-less the same height and then a few are shorter and a few are taller. The normal distribution curve is the same shape for all examples of continuous variation.



x-axis Height; y-axis Number of learners at each height

Figure 1.4 A bell-shaped curve shows continuous variation

Word help

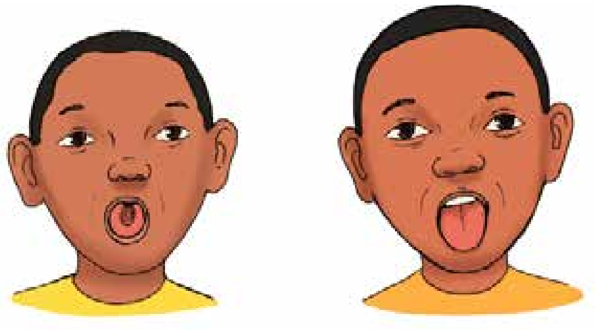
continuous variation: characteristics that show a range within a group of organisms.
normal distribution curve: a bell shaped curve that shows the range of measurements taken for a characteristic that shows continuous variation.

Discontinuous variation

In **discontinuous variation** the individuals in a group can be put into distinct groups or categories. The individual either has the characteristic or it does not have it. There are no in-betweens. Examples of characteristics that show discontinuous variation are right or left handedness, tongue rolling and **gender**.

Discontinuous variation is the result of inherited characteristics only and the environment has no influence.

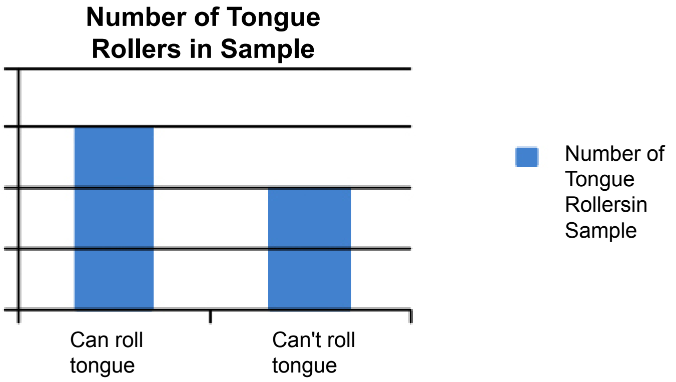
Tongue rolling



Roller Non-roller

Figure 1.5 Tongue rolling is an example of discontinuous variation

Discontinuous variation amongst a group can be represented by a bar graph. See Figure 1.6. This graph shows the number of learners that can roll their tongues and the number that cannot. A bar is drawn for the number of learners that are tongue rollers and a bar for number of learners that are not.



x-axis tongue rolling, y-axis number of learners

Figure 1.6 Bar graph to show variation in tongue rolling in a class of children

Word help

discontinuous variation: characteristics that individuals either have or have not male or female sex.
gender: male or female sex.

Something interesting

Straight thumbs, free ear lobes, two wrist cords and tongue-rollers are the common characteristics found in human populations. Curved thumbs, attached ear lobes, three or more wrist cords and non tongue-rollers are less frequently found variations. Even identical twins show small variations in certain features and so are not absolutely identical.

Activity 1.1 Practical

Work in pairs

Observing variation in the length of leaves of a tree

Aim: To observe variation in the length of leaves of a tree

You will need:

leaves from a tree

measuring tape or ruler

Method

Follow the instructions.

1. Pick ten mature, fully grown leaves from different parts of a tree and from different trees of the same kind.
2. Measure each leaf accurately from the tip to the base of the leaf where the leaf stalk starts. Measure to the nearest mm.
3. Record the results.

Observations and results

Arrange the leaves from longest to shortest.

Describe what you notice about the length of leaves from the same tree.

Describe what you notice about the length of leaves from different trees.

Conclusion

Write a conclusion about the type of variation shown by tree leaves.

Activity 1.2 Practical

Work in pairs

Investigating variation in the mass of peas OR the number of seeds (peas) in a pod

Aim: To investigate variation in the mass of peas or the number of seeds (peas) in a pod

You will need:

- 10 fresh peas OR
- 10 pods with seeds (peas) in
- electronic balance

Method
Follow the instructions.
1. Use the electronic balance to find the mass of each of the ten peas. Record these in a table.
2. Count the number of peas in each pod. Record these in a table.

Observations and results
Record the mass of the peas OR the number of seeds (peas) in a pod in a table.

Sample number	1	2	3	4	5	6	7	8	9	10
Mass of peas (grams)										
Number of peas in a pod										

1. Describe what you notice about the mass of the different peas.
2. Draw a bar chart to show the variation in the mass of the peas. Plot the masses on the *x*-axis and the number of peas of each mass on the *y*-axis.
2. Draw a bar chart to show the variation in the number of peas in a pod. Plot the number of peas on the *x*-axis and the number of pods with the same number of peas on the *y*-axis.

Conclusion
Write a conclusion to state what type of variation is shown in the mass of the peas. Explain how you reached your conclusion from the results of the investigation.

Activity 1.3 Practical

Work as a group and a class
Investigating variation of characteristics in the class

Aim: To investigate variation of characteristics in the class

You will need:
- measuring tape

Method
Follow the instructions.
1. Divide the class into five groups. Each group investigates one characteristic. The characteristics to be investigated are: height, shoe size, sex, right or left handedness, tongue rolling.
2. For each characteristic collect data for the whole class.
3. Each group to collate the information for the characteristic they are investigating. For example the group investigating height needs to measure the height of all the learners in the class; the group measuring shoe size needs to record all the shoe sizes of all the learners in the class.

Observations and results

Record the results in tables.

Height in cm					
Number of learners					

Shoe size					
Number of learners					

	Left handed	Right handed
Number of learners		

Sex	Male	Female
Number of learners		

Tongue rolling	Yes	No
Number of learners		

1. Decide what type of graph would be most suitable to represent each set of data.
2. Use the data collected to draw suitable graphs to represent each set of data.

Conclusion

Write a conclusion based on which of the characteristics investigated show continuous variation and which show discontinuous variation.

Summary

- Variation refers to differences that occur between individual organisms of the same kind.
- Variation occurs as a result of inherited factors and environmental factors.
- There are two types of variation; continuous and discontinuous variation.
- In continuous variation there is a range of measurements in organisms of the same kind, for example height.

- When measurements of characteristics showing continuous variation are plotted, a bell shaped curve called a normal distribution curve is obtained.
- In discontinuous variation, individuals either have the characteristics or they do not, for example tongue rolling.
- A bar graph can be used to show the results of an investigation into discontinuous variation.

Topic Assessment

Answer the questions.

1. Study the graph of seeds in pods in Figure 1.7.

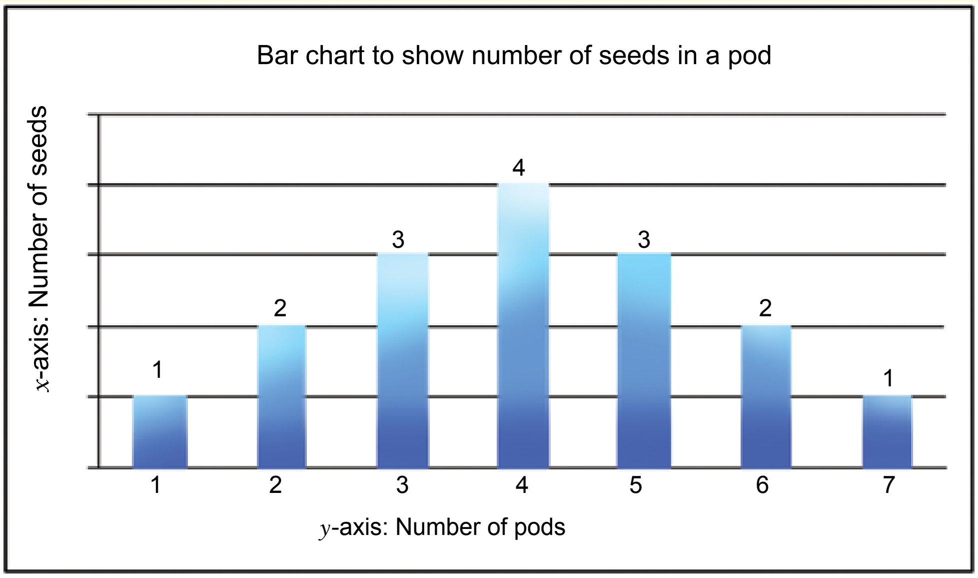


Figure 1.7 Bar chart to show number of seeds in different pods

   a) How many pods had their seeds counted? (2)
   b) What is the most common number of seeds in the pods in this group? (2)
   c) How many pods had three seeds each? (2)
   d) What is the biggest number of seeds in pods in this group? (2)
   e) What type of variation is shown by seeds in pods? Explain your answer. (4)
2. Explain the main difference between continuous and discontinuous variation. (4)
3. Give two examples of characteristics that show:
   a) continuous variation (2)
   b) discontinuous variation. (2)

[Total marks = 20]

Topic 2 Nutrition in plants

Learning objectives	Activities
• Explain the importance of plants as producers	• Discuss the conversion of solar energy to chemical energy by plants
• State the word equation for photosynthesis	

All living organisms need food for energy for life processes such as breathing, growth, reproduction and movement. Living organisms need different nutrients to stay healthy.

In Form 1 you learnt about the composition of air and identified the respiratory gases: oxygen and carbon dioxide.

Plants as producers

Green plants can make their own food and are therefore called **producers**. Plants use sunlight energy from the Sun to make food. Animals cannot make their own food so they eat plants or other animals to get food. Animals are referred to as **consumers**.

In the absence of plants all animals and humans on earth and in the seas will die because they cannot produce food on their own. All life rely on plants as a main source of food.

Plant also produce oxygen as a by-product of photosynthesis this is essential for humans and animals as they need oxygen for biological systems such as respiration and digestion to occur.

Photosynthesis

Green plants make their own food through a process called **photosynthesis**.

Something interesting

Photo means 'light' and *synthesis* means 'making'.

Photosynthesis is a series of chemical reactions that mainly take place inside the cells of green leaves. During photosynthesis the plants use water from the soil and carbon dioxide from the air and energy from sunlight to make food (glucose) and release oxygen into the air. The green pigment **chlorophyll** is required for photosynthesis. Chlorophyll is found in the organelles called chloroplasts of plant cells.

Word help

producers: plants that are able to produce food by photosynthesis; they are the start of all food chains.
consumers: living organisms that eat other organisms.
photosynthesis: a process whereby plants make their own food using sunlight energy, water and oxygen.
chlorophyll: a green pigment found in the chloroplasts in plant cells.

The process of photosynthesis is represented by the following word equation:

$$\text{carbon dioxide + water} \xrightarrow[\text{sunlight}]{\text{chlorophyll}} \text{glucose + oxygen}$$

The process of photosynthesis is summarised in Figure 2.1

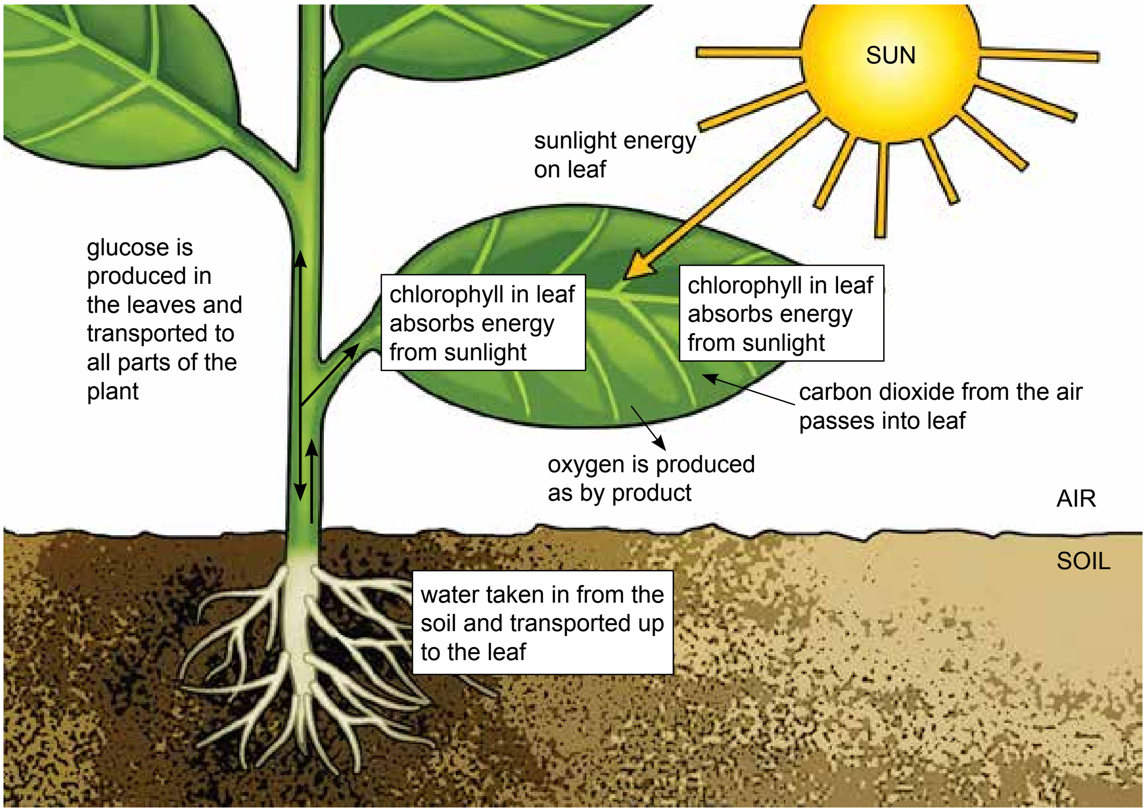


Figure 2.1 Summary of photosynthesis

Activity 2.1 Role play

Work in groups

A life without plants

Learners in groups of 4 simulate a life without plants.

They present either a play, poem, debate or skit of a life without plant.

Safety box

(Practical tasks)

Be careful when using sharp instruments like scalpels.

Activity 2.2 Practical

Work in pairs

Observe leaf structure
Aim: To examine the structure of a leaf

You will need:
- scalpel
- leaf
- hand lens.

Method
1. Carefully observe the leaf using the hand lens.

Observations and results
Make a labelled drawing to show the external structure of a leaf.

Questions
Answer the questions.
1. a) Which surface of the leaf is a darker green colour?
   b) Suggest a reason for your answer in a).
2. Explain why it is an advantage for a leaf to have a large surface area?
3. The leaf is thin from upper to lower surface. Suggest how this assists in photosynthesis?
4. Which structures support the leaf and prevent it from folding up?

Activity 2.3

Work on your own

Answer the questions.
1. List the:
   a) requirements for photosynthesis
   b) products of photosynthesis.
2. What energy conversion takes place during photosynthesis?

Summary

- All organisms need food for energy.
- Producers are green plants that can make their own food by the process of photosynthesis.
- Consumers are animals that cannot make their own food so they eat plants and other animals.

- Photosynthesis is a series of chemical reactions that take place in plants to produce chemical energy in the form of glucose.
- The requirements for photosynthesis are carbon dioxide, water, chlorophyll and sunlight energy.
- The products of photosynthesis are glucose and oxygen.
- Oxygen is released into the air.

Topic assessment

Answer the questions.

1. Explain why plants are called producers. (2)
2. Write down a word equation for the reaction of photosynthesis. (6)
3. Explain the function of chlorophyll? (2)
4. a) List the requirements for photosynthesis. (4)
   b) List the products of photosynthesis. (2)
5. What energy conversion takes place during photosynthesis? (2)
5. Explain why animals are called consumers. (2)

[Total marks = 20]

Something interesting

The largest leaves in the Plant Kingdom are those of the *Raphia* palm at 19 metres in length. The palms are native to islands in the Indian Ocean but Zimbabwe has an isolated colony at the north end of the Great Dyke. It is a botanical reserve and the palms, with their magnificent leaves, are protected.

Topic 3 Nutrition in humans

Learning objectives	Activities
• Draw and label the digestive system of humans	• Observe a model of the alimentary canal
• Outline the route followed by food in the human digestive system	

In Form 1 You learnt about nutrition and the components of a balanced diet as being carbohydrates, proteins, fats, vitamins, mineral ions, fibre and water.

In Topic 2 Nutrition in plants you learnt that plants can make their own food through photosynthesis and are called producers. Animals cannot make their own food and are called consumers.

The digestive system in humans

Humans are consumers and eat food to get energy for life processes and the nutrients necessary to keep the body healthy. To get the nutrients from the food consumed the food needs to be digested and broken down into smaller pieces that could be absorbed by the body and used. The digestive system breaks down the food into usable pieces. A system is a group of related organs which work together to bring about a life function, for example nutrition.

The digestive system is a long tube that extends from the mouth to the anus. There are some organs that are also part of the digestive system. These are the liver, pancreas and gall bladder. The long tube is also called the alimentary canal or gut. The digestive system functions to breaks down food so that it can be absorbed into the body.

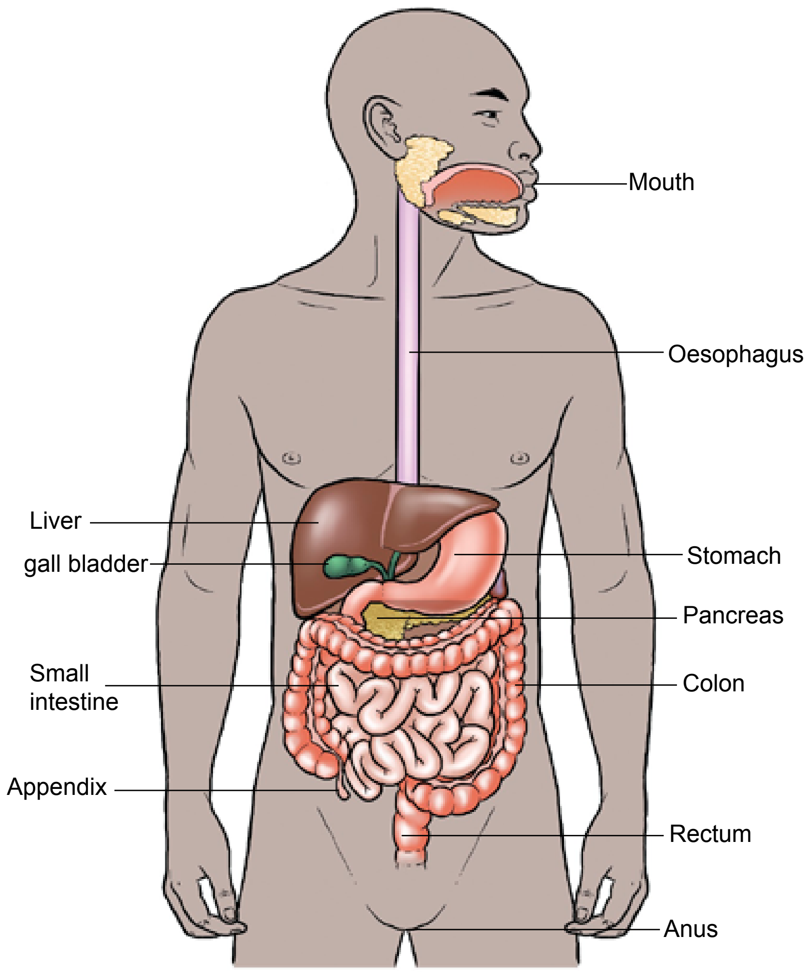


Figure 3.1 Alimentary canal of a human

Parts of the digestive system

The digestive system consists of different parts and each part has a specific function in the digestion of food. You will learn more about the functions of each part in Form 3.
Figure 3.1 shows the human digestive system. The digestive system consists of the following parts: mouth, teeth and tongue: The mouth is the opening to the digestive system. Food enters the digestive system through the mouth. Digestion starts in the mouth. Teeth grind food mixing it with saliva through the help of the tongue.

Oesophagus: The food moves from the mouth to the oesophagus. The opening to the oesophagus is at the back of the mouth.

Stomach: The food moves from the oesophagus to the stomach which is positioned under the diaphragm. The stomach is a muscular bag that churns the food. Certain chemicals called enzymes are realised into the stomach to assist in digestion.

Small intestine: The food moves from the stomach to the small intestine. The small intestine is very long and has folds in its walls.

Large intestine: The food moves from the small intestine to the large intestine. It is a wider tube compared to the small intestine and is positioned around three sides of the abdomen.

Rectum: The undigested waste moves from the large intestine to the rectum. The rectum is a short section of the alimentary canal.

Anus: The anus is an opening at the end of the alimentary canal. Undigested waste leaves the body through the anus.

Activity 3.1

Work in pairs
Identify the parts of the alimentary canal of humans
1. Look at a chart or model of the human digestive system or use Figure 3.1. Identify the parts of the digestive system.
2. Draw the human digestive system and label all the parts.

Activity 3.2 Individual work

Answer the question.
1. List the parts of the alimentary canal to outline the route food follows.

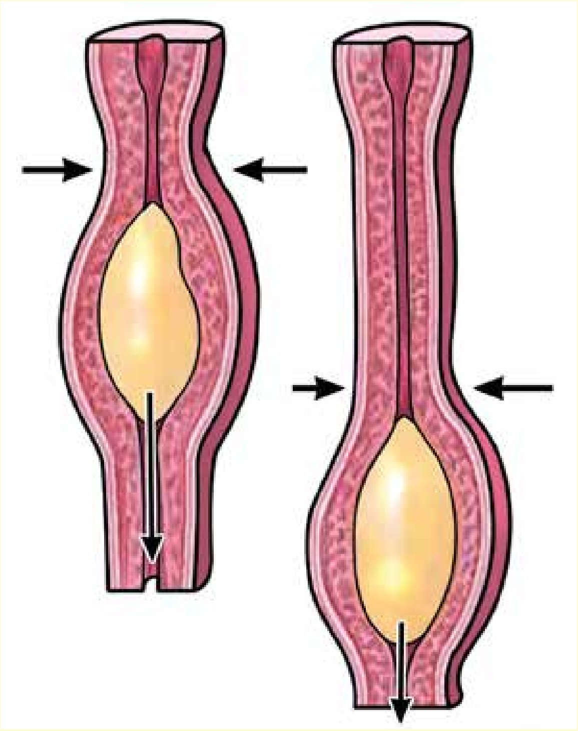
Summary box

- Animals are consumers which means that they eat plants or other animals.
- Food passes along the alimentary canal where it is broken down into smaller food particles and then absorbed by the body.
- The route followed by food along the alimentary canal is the mouth, oesophagus, stomach, small intestine, large intestine, rectum and anus.

Topic assessment

Answer the questions.

1. Explain why animals and humans need a digestive system? (1)
2. A diagram of the human digestive system.



   Label the parts 1 to 7 of the alimentary canal. (7)

3. Describe the route followed by food in the human digestive system. (7)

[Total marks = 15]

Something interesting

The adult human alimentary canal is 8 to 9 metres in length (many times the height of an adult). It fits into the abdomen by being in coiled back and forth.

Topic 4 Respiratory system

Learning objectives	Activities
• State the word equation for respiration	• Carrying out experiments to show that energy is released during burning of food (during respiration)
• Label parts of the respiratory system	

In Form 1 you learnt about the respiratory gases, oxygen and carbon dioxide. In Topic 3 Nutrition in humans you learnt about the need for food to be digested and the parts of the human alimentary canal.

The process of respiration

All living organisms require energy for life processes such as breathing, growth, reproduction and movement. This energy comes from food.

When we take in food, the food is digested in the digestive system. During digestion, large food substances are broken down into smaller substances that can be absorbed by the body and into cells. When we eat carbohydrates, the end product of carbohydrate digestion is glucose. Glucose is a type of sugar that is an important source of energy in living organisms.
The energy stored in glucose is released through the process of **respiration**. This energy is used in the body for all **metabolic reactions** needed to live and grow.

Respiration is the chemical breakdown of food molecules, like glucose, in the cells of organisms to release energy. Oxygen is needed for the reactions to take place. Carbon dioxide and water vapour are formed as waste products during the reactions. Respiration is an oxidation (combustion) reaction. You will learn more about combustion reactions in chemistry Topic 5 Oxidation and reduction.

The chemical reactions of respiration can be summarised in a word equation:

$$\text{glucose} + \text{oxygen} \longrightarrow \text{carbon dioxide} + \text{water} + \text{Energy}$$

During the process of respiration glucose reacts with oxygen to form carbon dioxide, water and energy

Word help

respiration: the process by which energy is released from food in a series of chemical reactions.
metabolic reactions: all the reactions that occur in an organism for life processes.

Activity 4.1 Practical

Work in pairs

Experiment to show that energy is released during respiration

Aim: To show that energy is released during the burning of food (during respiration) for example a ground nut

You will need:

- retort stand
- clamp
- large test tube
- thermometer
- measuring cylinder
- balance
- Bunsen burner or spirit burner
- mounted needle or sharpened piece of wire pushed into a cork
- shelled raw ground nuts or peanuts

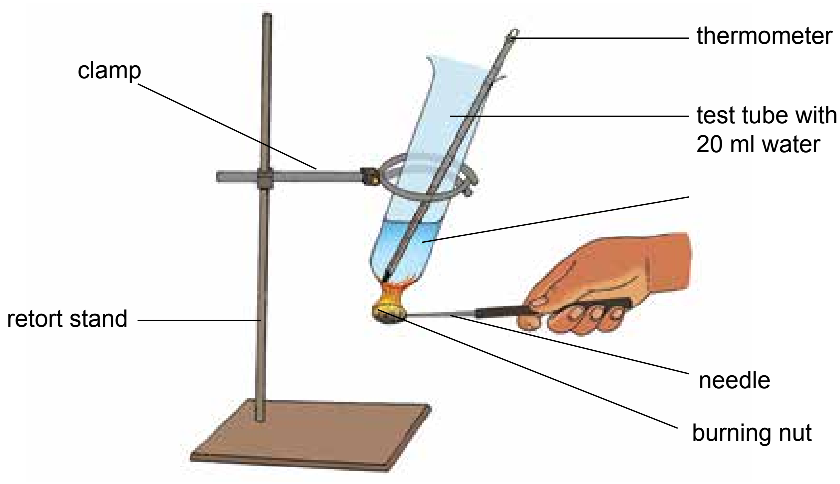


Figure 4.1 Experimental set up to show that ground nuts have energy

Method

Follow the instructions.

1. Using the measuring cylinder, measure exactly 20 ml of water and pour it into the test tube.
2. Clamp the test tube diagonally (at about 45 degrees) on to the retort stand.
3. Place the thermometer in the water in the tube. Let it adjust and then read and record the water temperature.
4. Light the burner then pierce the nut with the needle.

Safety box

Turn off the Bunsen burner as soon as the nut is alight. The burner will remain hot for some time. Do not touch it until it is cool.

5. Hold the nut in the burner flame until it catches alight.
6. Immediately hold the burning nut under the base of the test tube of water and keep it there until it ceases to burn.
7. Record the temperature of the water again using a thermometer.

Observations and results

Record your results in a table.

Initial water temperature (°C)	Final water temperature (°C)	Final temperature – initial temperature (°C)

Conclusion

Write a conclusion based on the aim of the experiment and your results. Remember to state the origin of the energy that caused the rise in water temperature.

Questions

Answer the questions.

1. Explain what caused the change in the temperature of the water.
2. Energy has been released from the burning nut.
   a) What type of energy is this?
   b) What was the energy conversion in the nut?
3. State two ways in which energy might have been lost in this experiment.

The respiratory system

For the reactions of respiration to take place, oxygen is needed. Carbon dioxide is produced during the reactions and is a waste product that must be removed from the body. Oxygen and carbon dioxide are called respiratory gases as these gases are involved in respiration.

The respiratory system is responsible for supplying oxygen to the body and for removing carbon dioxide from the body. Figure 4.2 shows the human respiratory system.

Word help

bronchus: (plural - bronchi): air passage leading to a lung.
bronchioles: small branching air passages leading to air sacs.
cavity: an empty space within something.
air sacs: small hollow ball-like structures at the end of air passages.

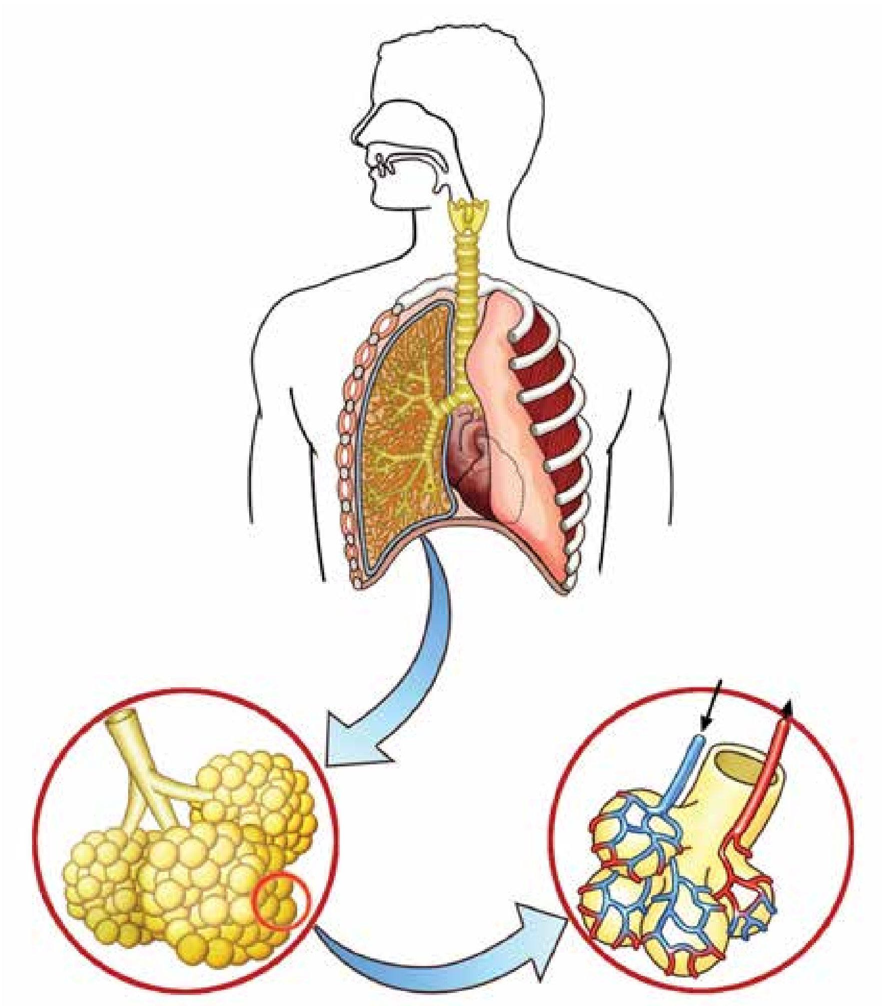


Figure 4.2 The human respiratory system

Parts of the respiratory system

The respiratory system consists of air passages and the lungs through which air moves. Muscles including the diaphragm are also part of the respiratory system.

The respiratory system consists of different parts and each part has a specific function in the respiration process.

The respiratory system consists of the following parts:
Nose and mouth: Air passes through the nose or mouth into the respiratory system.
Trachea and bronchi: Air passes down the windpipe or trachea into the lungs, through tubes and many air passages called **bronchi** and **bronchioles**.
Lungs: The lungs are sponge-like sacs that lie inside the chest **cavity** or **thorax**. They are made of millions of tiny **air sacs**. As air passes into the lungs, the air sacs fill up with air. Each air sac is surrounded by lots of small blood vessels or capillaries.

Activity 4.2 Practical

Work in pairs

Identify the parts of the respiratory system of humans

1. Look at a chart or model of the human respiratory system or use Figure 4.2. Identify the parts of the respiratory system.
2. Draw the human respiratory system and label all the parts.

Activity 4.2

Answer the questions.
Study Figure 4.1.

1. State the position of the opening to the air passages.
2. a) What name is given to the air passage that extends into the chest cavity?
   b) Inside the chest cavity or thorax, the main air passage branches into two tubes leading to right and left lungs. Name these tubes.
   c) Inside the lungs the tubes branch into smaller and smaller tubes. Name these tubes.
   d) The tiny tubes of the air passages enter into little bubble-looking structures. What are these structures called?

Breathing

Breathing is a process during which air enters and leaves the lungs. When we breathe in, or **inhale**, air containing oxygen passes into the air passages until it reaches the air sacs in the lungs.

When we breathe out or **exhale** carbon dioxide produced by the cells through respiration is removed from the body.

As the air passes through the nose and trachea it is filtered to remove dust and other particles so that they do not reach the air sacs in the lungs. The air is also warmed and moistened so that the air passages are not dried out.

The breathing mechanism

The process of breathing (**ventilation**) brings air to the air sacs. When breathing, air rich in oxygen is inhaled, and air with a high carbon dioxide content is exhaled. Breathing works by changing the air pressure in lungs when the volume of the chest or thoracic cavity increases or decreases. Figure 4.3 shows the breathing **mechanism**.

Word help

inhale: breathe in.
exhale: breathe out.
ventilate: Breathing; the exchange of air between lungs and outside air. The inhalation and exhalation of air.
mechanism: a process by which something works.

Breathing in/inhalation

- Muscles between ribs contract lifting the ribs up and out.
- **Diaphragm** muscles contract and the diaphragm becomes flatter from its curved position.
- These movements increase the volume of the **thorax**.
- The increased volume decreases the air pressure in the thorax so air flows into the lungs along the air passages.

Breathing out/exhalation

- Muscles between the ribs relax and the ribs move down and inwards.
- Diaphragm muscles relax and the diaphragm curves upwards.
- These movements decrease the volume of the thorax.
- The decreased volume increases the air pressure in the thorax so air from the lungs flows out along the air passages and is breathed out.

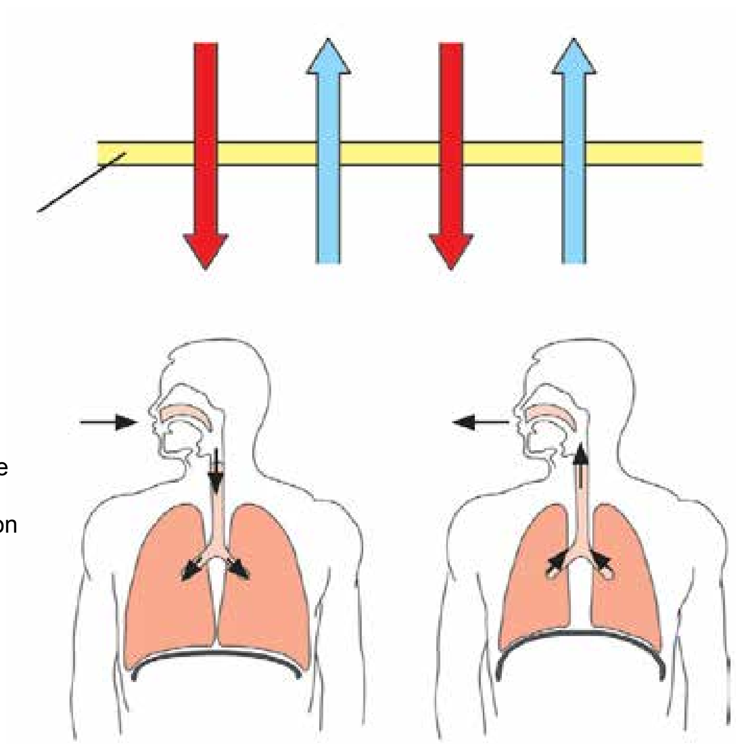


Figure 4.3 The breathing mechanism a) inhalation and b) exhalation

Word help

respiratory gases: gases that are involved in respiration; oxygen and carbon dioxide.
thorax: chest.
trachea: the main air passage.
diaphragm: a muscular membrane separating the chest from the abdomen.
resuscitate: revive.

Activity 4.3 Practical

Work in groups

Make a model to demonstrate the breathing mechanism

Aim: To show the mechanism of inhalation and exhalation during breathing

You will need:
- a two-litre plastic bottle
- plastic drinking straw
- balloon
- rubber sheet or plastic bag
- elastic band
- putty or plasticine (modelling clay)
- masking tape
- piece of string
- pair of scissors
- sharp nail.

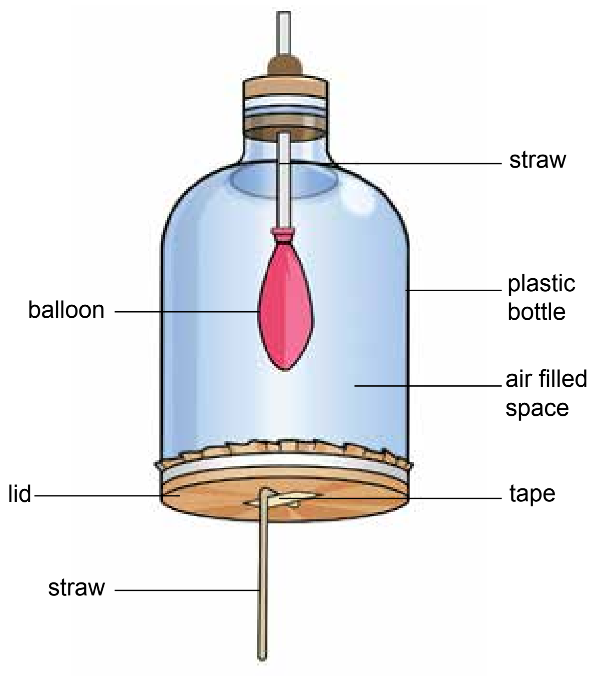


Figure 4.5 Model to demonstrate the breathing mechanism

Method

Follow the instructions.

1. Use a pair of scissors to cut off the base of the cold drink bottle.
2. Use the nail to make a hole in the lid just large enough for the plastic straw to fit through. Make sure that the lid is screwed tightly onto the bottle.
3. Use an elastic band to tie the balloon to one end of the straw. Push the other end of the straw through the hole in the lid. Press modelling clay around the straw on top of the lid to make an airtight seal.
4. Cut the plastic bag in a circular shape large enough to cover the bottom of the bottle. Stretch the plastic sheet tightly across the bottom of the bottle. Tape the plastic sheet to the side of the bottle to hold it securely and make the bottle airtight. Tape a piece of string to the centre of the plastic sheet, allowing a short piece to hang downwards.
5. Use the string to pull the sheet of plastic downwards. Then push the sheet of plastic upwards into the bottle. Notice what happens to the balloon in each case.

Observations and results

Write down what happened to the balloons inside the bottle when you pushed the balloon covering the base of the bottle up or pulled it down.

Conclusion

Write a conclusion based on your observations and the aim of the experiment.

Questions

Answer the questions.

1. What part of the respiratory system does each part of the model represent?
   a) the straw
   b) the plastic bottle
   c) the rubber or plastic sheet at the base of the bottle
   d) the balloon attached to the straw inside the bottle?
2. Explain why the balloon inflated and deflated when you pushed the rubber or plastic sheet at the base of the bottle, up or down. Use the terms 'pressure' and 'volume' in your answer.

Summary

- Respiration is a series of chemical reactions in cells that release energy from food.
- The word equation for respiration is:

glucose + oxygen ⟶ water + carbon dioxide + energy

- The respiratory system consists of the nose and mouth, the trachea, bronchi, bronchioles, air sacs, lungs and blood.
- Breathing is to bring in air containing with oxygen into the lungs (inhalation) and removing air containing carbon dioxide (exhalation).
- The breathing mechanism involves contraction and relaxation of the diaphragm and muscles between the ribs.

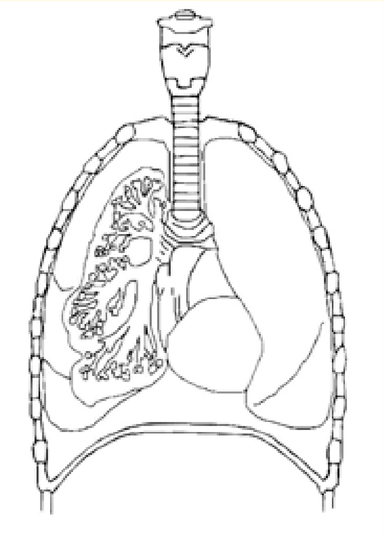
Topic assessment

Answer the questions.

1. The food substance that takes part in the reactions of respiration is usually:
   A. fibre B. glucose C. water D. vitamins E. minerals (1)
2. The gases involved in respiration are:
   A. nitrogen and oxygen
   B. nitrogen and carbon dioxide
   C. water vapour and rare gases
   D. oxygen and carbon dioxide
   E. carbon dioxide and water vapour (1)
3. Respiration occurs in:
   A. all cells B. lungs C. bronchi D. trachea E. bronchioles (1)

4. a) What is the purpose of respiration in the body? (1)
   b) Write the word equation for respiration. (5)

5. a) Give a caption to the diagram in Figure 4.6. (1)
   b) Provide labels for the parts 1 to 6 in Figure 4.6. (6)



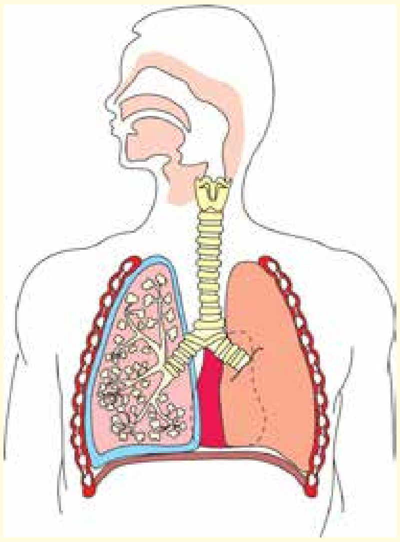


Figure 4.6

6. Choose the correct word:
   a) to breathe in, the volume of the thorax must increase/decrease. (1)
   b) to breathe out, the air pressure in the thorax must increase/decrease. (1)

7. Suggest reasons why it is important that air is filtered, warmed and moistened as it passes along the respiratory tract. (2)

[Total marks = 20]

Something interesting

Lungs have a very large surface area for respiratory gas exchange. If all the air sacs of one adult human's lungs were opened and placed side by side, they would cover the area of a tennis court.

Indigenous knowledge

Many people in Zimbabwe smoke tobacco. Although this is often part of their culture, smoking tobacco is linked to lung cancer.

[a/w 4.7] Photo of woman smoking *ndomabonda* smoking pipe

Figure 4.7 The BaTonga people traditionally smoke ndomabonda smoking pipe

Topic 5 Transport systems in plants

Learning objectives	Activities
• Outline the internal structures of a root and stem	• Discussing the internal structures of a root and stem
	• Viewing prepared slides of roots and stems
• Describe water and ion uptake in plants	• Carrying out an experiment using dye to show arrangement of vascular tissue

In Form 1 you learnt about the structure of a typical plant cell. However, there are several different types of plant cells and internal structures that make up the plant. In this topic you will learn more about the different cells and internal structures found in the plant.

In Form 1 you learnt about osmosis as a process by which water moves in a plant. You also learnt about the process of diffusion whereby gases and dissolved solid substances move in plants.

Transport in plants

Large **multicellular** organisms need a transport system to supply oxygen and nutrient to all parts of the organism and to remove waste products. In plants the roots and stems contain structures that make up the transport system.

In Topic 2 Nutrition in plants you learnt about the process of photosynthesis that takes place in the green leaves of plants. For photosynthesis to take place water and minerals from the soil need to be transported from the roots to the leaves. Glucose, a product of photosynthesis, needs to be transported to the rest of the plant. There are internal structures in the root and the stem of the plant that transport glucose, water and minerals through the plant.

Internal structure of a root and stem

If you cut a cross section of a root and stem and view the section with a microscope or using bio-viewer slides, it is possible to see different layers and structures inside the root and stem. Figure 5.1(a) and Figure 5.2 (a)) show these layers. These diagrams show only the arrangement of the internal layers of cells not individual cells. These diagrams are called **plan diagrams**.

Word help

multicellular: consisting of many cells.
plan diagrams: show boundaries of layers of different cells, but no individual cells.

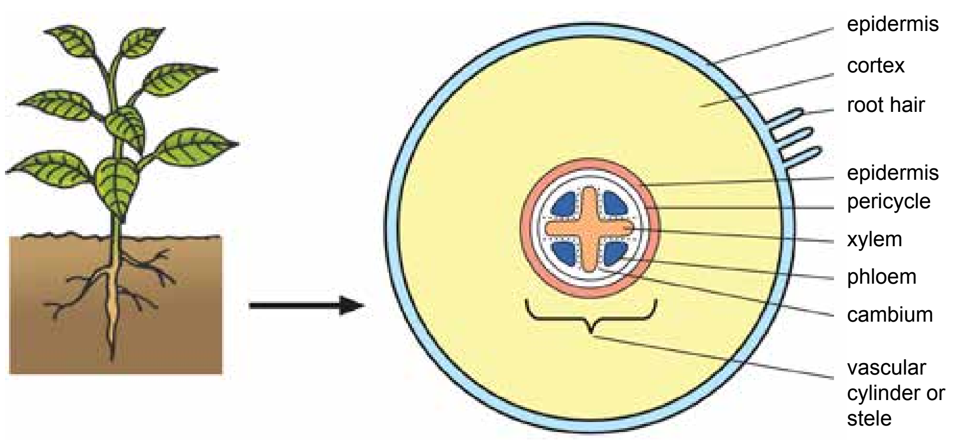


Figure 5.1 Plan diagram showing cross section of a root

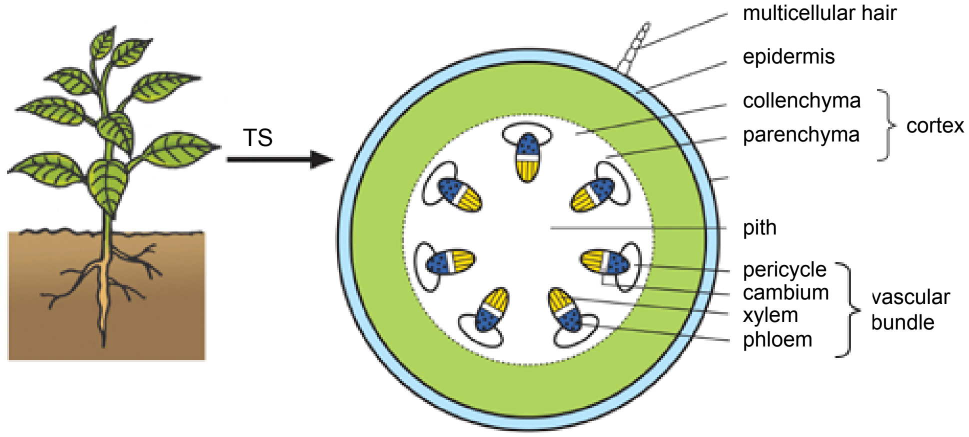


Figure 5.2 Plan diagram showing cross section of a dicot (bean) stem

Root and stem structures

In a cross-section the root and stem consist of different layers and structures: epidermis, cortex and the vascular bundles consisting of the phloem, cambium and xylem.

Epidermis: The epidermis is single layer of cells on the outside of the root and stem. It forms a protective outer covering layer of the root and stem. The root epidermis has root hairs that are important for uptake of water and minerals.

Cortex: The cortex is the largest region in a root and stem. It consists of **packing** cells.

Vascular bundle: The phloem, xylem and cambium are arranged together in a vascular bundle. The vascular bundle is responsible for transporting substances in the plant root and stem.

Phloem: is made up of tube-like cells that transport glucose from the leaves where it is made by photosynthesis to the roots where it is stored.

Xylem: is made up of long hollow tube-like structures called **xylem vessels**. Xylem transports water and minerals from the roots to leaves. It also helps to support the plant.

Cambium: forms new phloem and xylem tissue, as the plant grows.

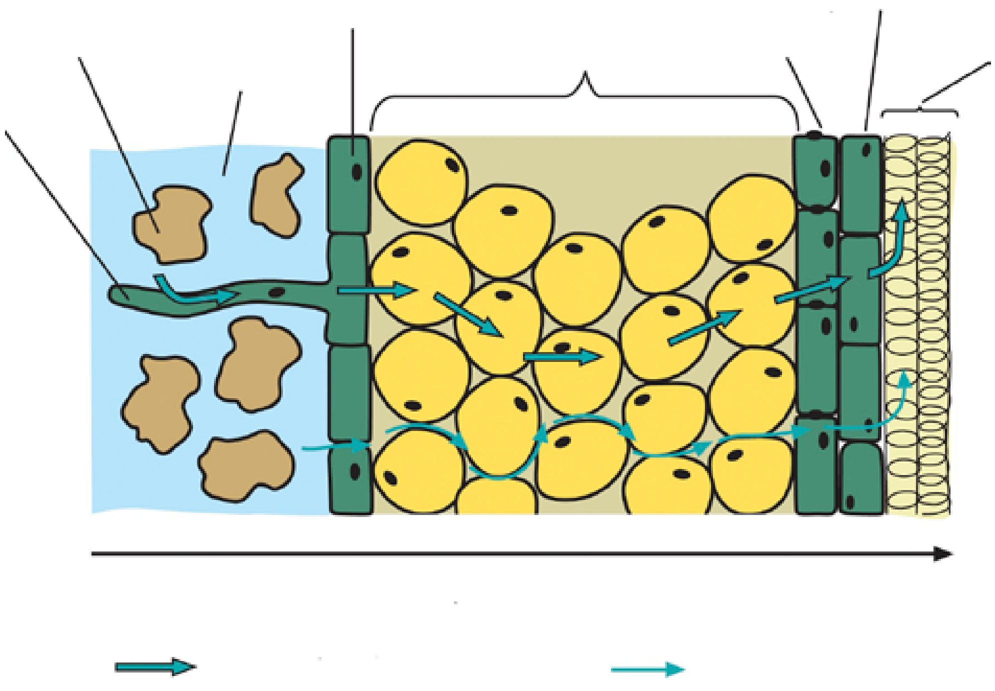
Activity 5.1 Practical task

Work in pairs

Observation of the internal structure of the plant root and stem
Aim: To investigate the internal structure of plant roots and stems

You will need:
- bio-viewer
- bio-viewer slides of the cross-section of a bean root and bean stem.

If the cross section of a root or stem is viewed at higher magnification, details of the cells can be seen. A **photomicrograph** is a photograph of these sections taken at higher magnification. Figure 5.3 (a) and 5.3 (b) are photomicrographs of cross sections of a dicot (bean) root and stem.



Photomicrograph of cross-section of a dicot (bean) a) root and b) stem

Method
Follow the instructions.
1. Examine the slide of a cross section of a root using a bio-viewer.
   a) Compare what you see with Figure 5.3 a).
   b) Identify the different layers.
   c) Identify the structures responsible for transport in the root.

Word help

photomicrograph: a photograph taken through a microscope.

2. Examine the slide of a cross section of a stem.
   a) Compare what you see with Figure 5.3 b).
   b) Identify the different layers.
   c) Identify the structures responsible for transport in the stem.

Observations and results

a) Using a bio-viewer slide, draw a plan diagram of a cross section of root. Draw what you see. Label your diagram.
b) Using a bio-viewer slide, draw a plan diagram of a cross section of a stem. Draw what you see. Label your diagram.

Conclusion

Write a conclusion about the transport structures in plants.

Questions

Answer the questions.
Rewrite the following sentences and complete them by filling in the missing words.

1. Vascular bundles consist of ________ and ____________.
2. The vascular bundles in a root are positioned in the _________ of the root.
3. In the root, xylem forms a star shape with ____________ tissue between the points of the star.
4. Stems have separate vascular bundles arranged in a circle near the __________of the stem.
5. In each vascular bundle in a stem there is _________ tissue on the inner side and ____________ on the outer side with a layer of ________ cells in between.
6. ___________ is a protective layer of cells found on the outside of stems and roots.

Activity 5.2 Practical

Work with a partner

Aim: To investigate the arrangement of vascular bundles in plants

You will need:

- plants such as black jacks or celery stems
- jar or beaker
- blade or scalpel
- hand lens or magnifying lens
- methylene blue or ink

Safety box

(Practical tasks)
Be careful not to cut yourself with the sharp scalpel or blade.

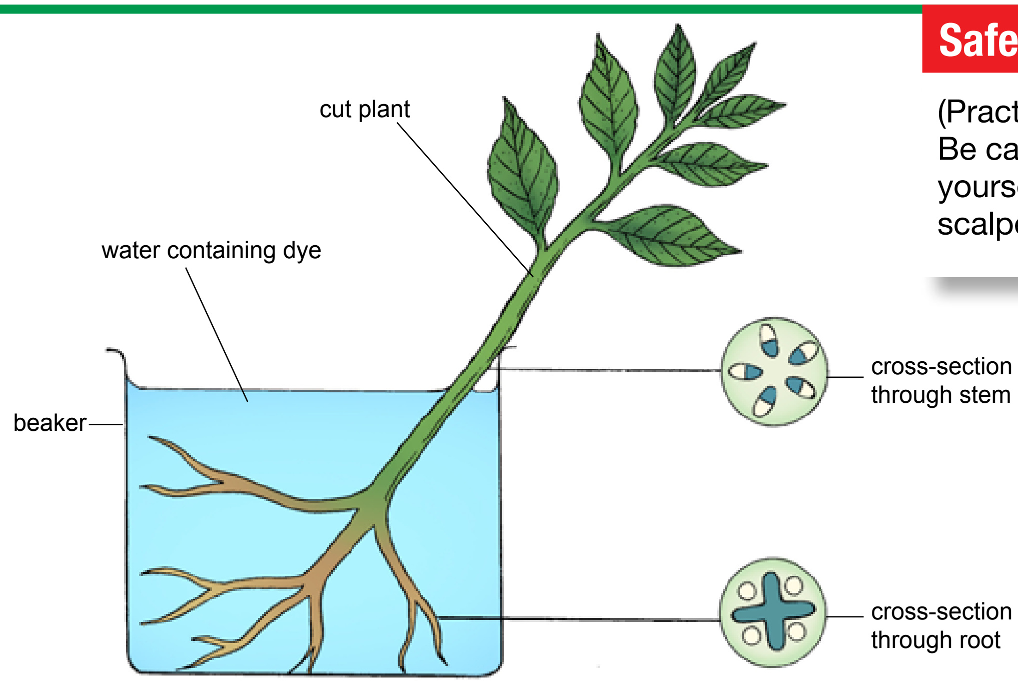


Figure 5.4 A cut stem into a beaker of water containing dye

Method:

Follow the instructions.

1. Add a few drops of methylene blue or ink to 100 ml of water in a beaker.
2. Place the celery or black jack stems in the beaker containing methylene blue or ink and leave them overnight.
3. Cut the stems into a few cross sections and examine the cut ends with a hand lens.

Observations

Draw a plan diagram of the cross section showing what you see.

Conclusion

Write a conclusion about which part of the vascular bundle has been stained by the dye.

Questions

1. What is the name of the tissue that has been stained by the dye?
2. Suggest a reason why the whole vascular bundle has not been stained by the dye.
3. Name the two types of tissue in the vascular bundle that are not stained by the dye.

Water and ion uptake by plants

Plants need water to make their food through the process of photosynthesis. Plants also need minerals for growth. The water and minerals are taken up from the soil through the root hairs and transported to the leaves. The process whereby water is taken up from the soil is called **osmosis**. Minerals in the form of **ions** are taken up into the plant through a process called **active uptake**.

Water uptake by plants

Water is taken up into plant roots by osmosis. Osmosis is the movement of water along a **water concentration gradient**, from where there is a high concentration of water particles to where there is a lower concentration of water particles (molecules) through a **selectively permeable membrane**. The process of osmosis does not require energy; it happens **passively**.

Water in the soil enters the root hair cells and a water concentration gradient is set up in the plant. This means that, as water moves into a cell, the water concentration increases and it becomes higher than the next cell and so water will move into the next cell where there is a lower water concentration. Water moves in this way from cell to cell across the cortex by osmosis until it reaches the xylem. In the hollow xylem vessels, water moves up to the leaves. See Figure 5.5.

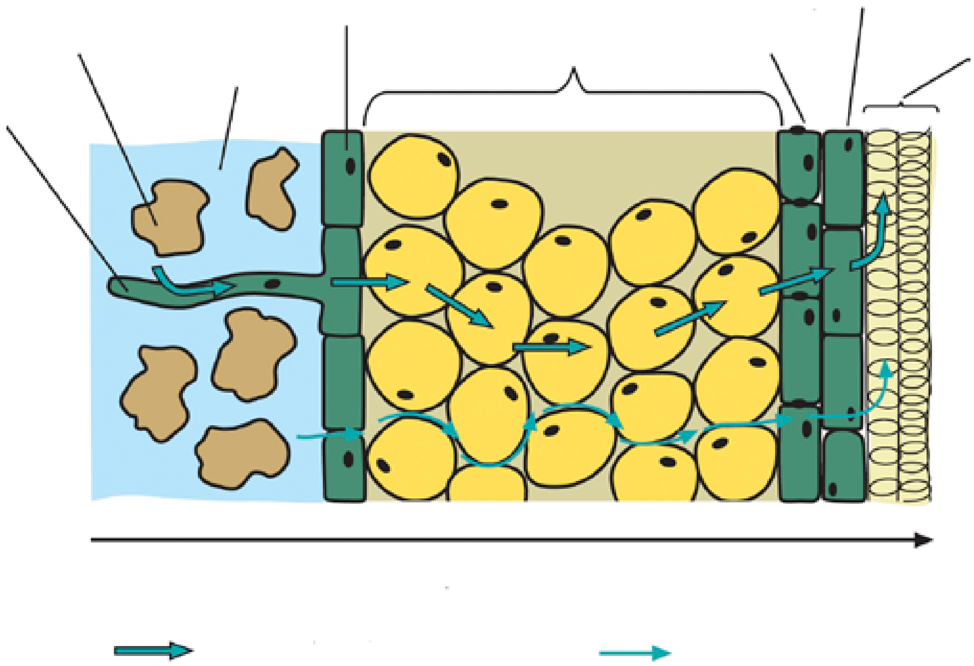


Figure 5.5 Pathway of water through a root

Word help

osmosis: the process whereby water moves from a the movement of water from where there is a high concentration of water particles to where there is a lower concentration of water particles through a selectively permeable membrane.
ions: the form of minerals when dissolved in water.
active transport: the process during which ions are absorbed against a concentration gradient; from a low ion concentration to a higher concentration with the use of energy.
passively: without using energy.
water concentration gradient: the difference in the concentration of water particles between areas.
selectively permeable membrane: a membrane that allows only substances through it.

Mineral uptake by plants

Plants can only absorb **soluble** minerals. This means that the minerals need to be dissolved in water in the soil. When minerals are dissolved in water, they are referred to as ions. The concentration of ions in the soil water is low. The ions cannot move by osmosis as this process involves movement of water particles only. They cannot be absorbed by diffusion as the ions are in a low concentration outside the root. In Form 1 you learnt that diffusion is the movement of particles from a high concentration to a lower concentration. Therefore another mechanism of transport is required by plants to take up ions from the soil into the root.

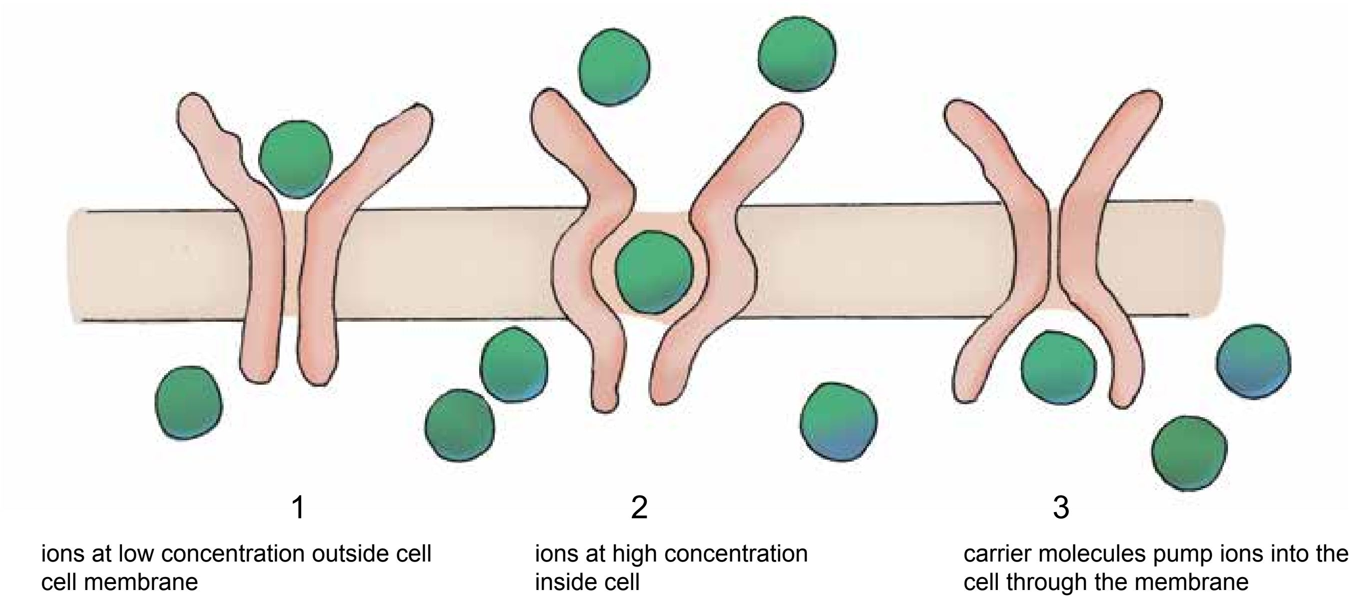


Figure 5.6 Active uptake through the cell membrane

Ions are taken up into plant roots by a process called active uptake. They are absorbed *against* a concentration gradient; from a low ion concentration to a higher concentration. In the cell membrane there are particles called **carriers** that take the ions through the cell membrane into the cell against the concentration gradient. Energy is needed for active transport.

Word help

soluble: able to be dissolved in a liquid like water.
carriers: substances in the cell membrane that help move particles across it into the cell.

Activity 5.3 Simulation

Work in groups.

Simulation of osmosis and active transport
Aim: To demonstrate the movement of particles by osmosis and active transport

You will need:
- jelly beans in two different colours
- a piece of paper with holes cut in it.

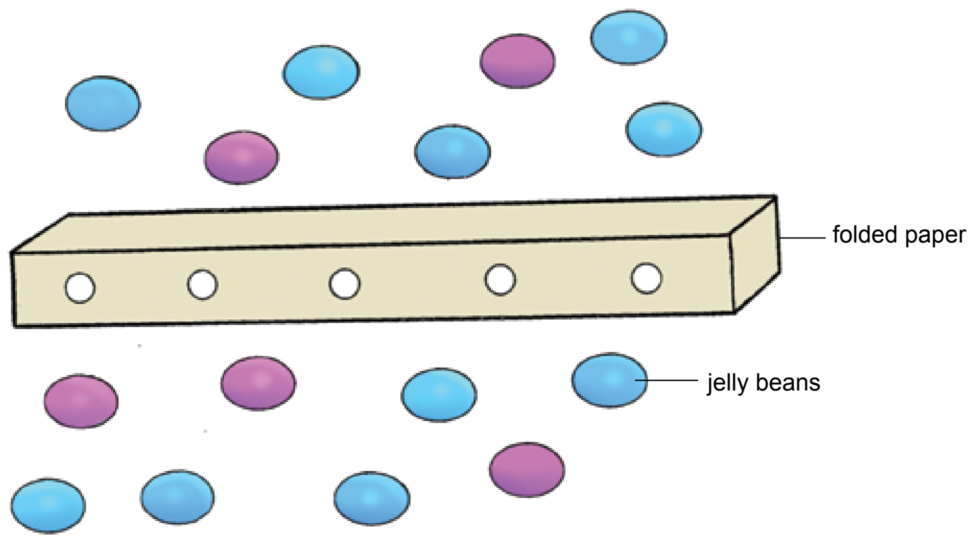


Figure 5.7 Arrange the jelly beans on either side of the folded paper

Method:
Follow the instructions.
1. Sort ten jelly beans of each colour; red and blue.
2. Fold a piece of paper and make holes in it as shown in Figure 5.7. This represents a selectively permeable membrane.
3. Blue jelly beans represent water particles and red jelly beans represent mineral particles (ions).
4. Arrange the blue jelly beans on either side of the paper to show how water particles moves by osmosis.
5. Show a solution of ions in water.
6. Now show how ions move through the membrane.

Questions
Answer the questions.
1. Explain how you used the jelly beans to show the different concentration of water particles on either side of the membrane when osmosis takes place.
2. How did you show a solution of ions in water?

3. a) By what process do ions move through the membrane?
   b) Explain how you showed the difference in the ion concentration on either side of the membrane.
4. What is missing from the representation of ion transport?

Activity 5.4

Answer the question.
Explain the difference between osmosis and active uptake.

Summary

- Plant roots and stems consist of different tissues that perform different function; epidermis, cortex, xylem and phloem and cambium.
- The vascular bundle of a stem or root consists of xylem and phloem tissues.
- In a root, the xylem tissue is arranged in a central 'star' with phloem between the points of the star.
- In a stem the xylem and phloem are in vascular bundles close to the outside of the stem.
- Water and minerals move into the root through the root hairs.
- Water is taken up into the roots by osmosis when there is more water particles outside the root cell that inside the root; a water concentration gradient has been set up.
- Minerals in solution are called ions.
- Ions are taken up by roots against a concentration gradient by active transport using energy.
- Water and ions are transported by xylem vessels to the leaves.
- Glucose, made by photosynthesis is transported from the leaves to the root by phloem tissue.

Topic assessment

Answer the questions.

1. a) Name the transport structures in a plant. (1)
   a) What is transported by xylem tissue? (1)
   c) What other function apart from transport does xylem tissue have? (1)
2. What is transported by phloem tissue? (1)
3. Draw plan diagrams to show the internal structure of;
   a) a root
   b) a stem.
   Label the following on your diagrams:
   xylem, phloem, cambium, cortex, vascular bundle, epidermis (12)

4. a) Define osmosis. (3)
   b) What substance moves by osmosis? (1)

5. Name the process by which minerals are taken up by plants. (1)

6. Explain the difference between osmosis and active uptake. (4)

[Total marks = 25]

Something interesting

A four month old rye plant was estimated to have a total length of 620 km of roots. To achieve this, the plant must have produced almost 5 km of new roots and more than 100 million new root hairs each day.

Topic 6 Transport system in humans

Learning objectives	Activities
• Draw and label the structure of the human heart	• Examine a model of the circulatory system • Draw and label heart structure
• Name the main blood vessels to and from the heart	• Identify the vessels to and from the heart
• State the functions of the heart	• Simulations on the action of the heart

In Form 1 you learnt about the components of blood. Blood consists of a liquid medium called plasma in which red blood cells, white blood cells and platelets (cell fragments) are suspended.

In Topic 4 The respiratory system you learnt that all cells need oxygen and nutrients to produce energy. Carbon dioxide, a product of respiration, needs to be removed from the body. In this topic you will find about the transport system in humans that fulfills this role.

Parts of the circulatory system in humans

Humans are large multicellular organisms and therefore need a transport system to supply oxygen and nutrients to all cells and remove carbon dioxide and waste products from the cells. The transport system in humans is the circulatory system that consists a liquid medium (blood), pipes (the blood vessels) through which the blood flows and a pump (the heart).

Types of blood vessels

There are three types of blood vessels:

Arteries which carry blood away from the heart and divide into tiny vessels called capillaries.

Capillaries are blood vessels with a very small diameter. They carry blood to the cells to supply them with oxygen and nutrients, and remove waste.

Veins are formed when capillaries join up. They carry blood to the heart.

The main blood vessels are the aorta, which takes blood from the heart to the body, the pulmonary arteries and veins which take blood to and from the lungs and the vena cavae which take blood from the body to the heart. Figure 6.1 shows the circulatory system in humans.

Word help

arteries: blood vessels that transport blood towards the heart.
capillaries: tiny blood vessels that take blood to and from the cells.
veins: blood vessels that transport blood away from the heart.

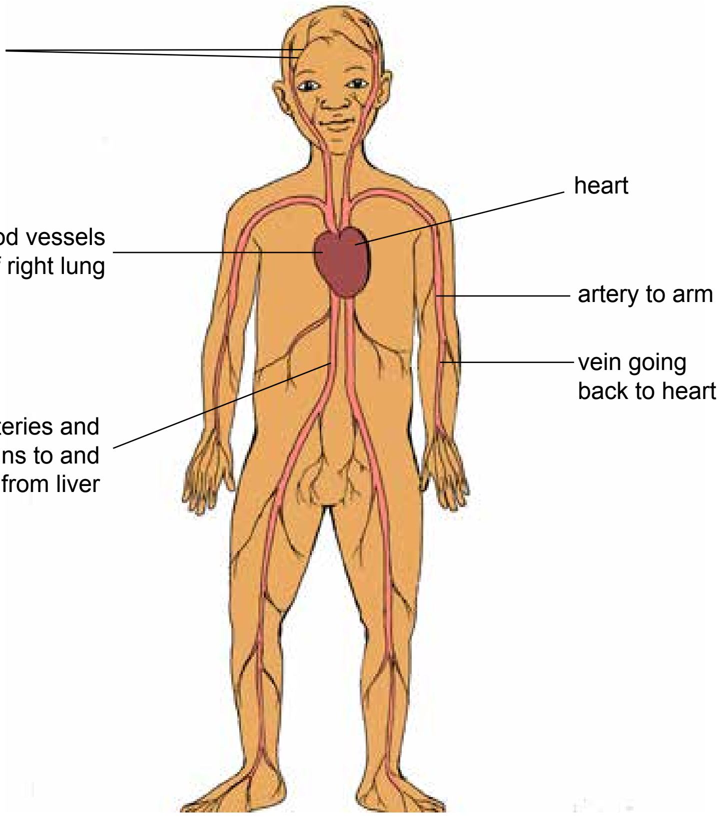


Figure 6.1 The human circulatory system

Structure and function of the heart

The heart acts as a pump to push blood around the body and receive blood from the body.

External structure of the heart

The heart is a muscular organ, about the size of your fist that is situated in the thorax or chest cavity in a space between the lungs. The heart muscle is able to contract and relax. It pumps blood through blood vessels that supply the heart muscle with oxygen and nutrients and remove waste products. These vessels are called **coronary blood vessels**. There are also several arteries and veins that transport blood to and from the heart (Figure 6.2).

Word help

coronary blood vessels: blood vessels that provide the heart muscle with oxygen and nutrients and remove waste products.

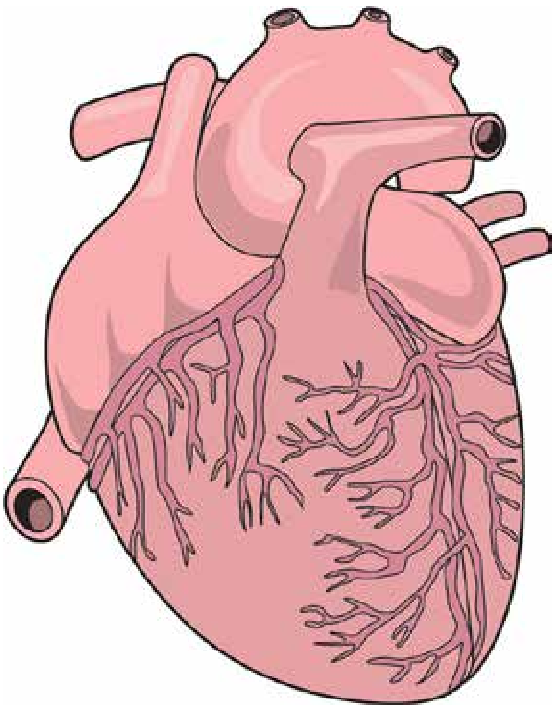


Figure 6.2 Diagram to show the external structure of the heart

Internal structure of the heart

The heart is divided into two parts by a muscular plate called the **septum**. Each side of the heart has two chambers. The upper chambers are called **atria** (singular – atrium) and the lower chambers are called **ventricles**. There are two thin-walled atria and two thick walled ventricles. Figure 6.3 shows a **longitudinal** section of the heart that shows the internal structure of the heart. The arrows show the direction the blood flows through the heart.

Blood flow in the heart

The right atrium receives blood from the body that is low in oxygen via the inferior and superior vena cava. This blood is referred to as **deoxygenated** blood. The heart pumps deoxygenated blood into the right ventricle. The right ventricle pumps this blood to the pulmonary arteries, which transport it to the lungs. In the lungs the blood gets oxygen and is then referred to as **oxygenated** blood.

The left atrium receives oxygenated blood from the lungs through the pulmonary veins. When the left atrium contracts blood flows into the left ventricle. When the left ventricle contracts it pumps the blood into the **aorta**, which transports it to the body.

The walls of the right and left atria are thin because they only have to pump the blood over a short distance into the ventricles. The ventricles have much thicker walls as they need more muscle to pump the blood much further. The wall of the left ventricle is much thicker than the wall of the right ventricle as it has to pump blood to all the organs of the body, whereas the right ventricle has to pump blood only to the nearby lungs.

The **bicuspid** valve is situated between left ventricle and left atrium and the **tricuspid** valve between the right atrium and ventricles. These valves ensure one way flow of blood into the ventricles from the atria. **Semi-lunar valves** in the aorta and pulmonary artery stop backflow of blood into ventricles when the heart relaxes after each contraction.

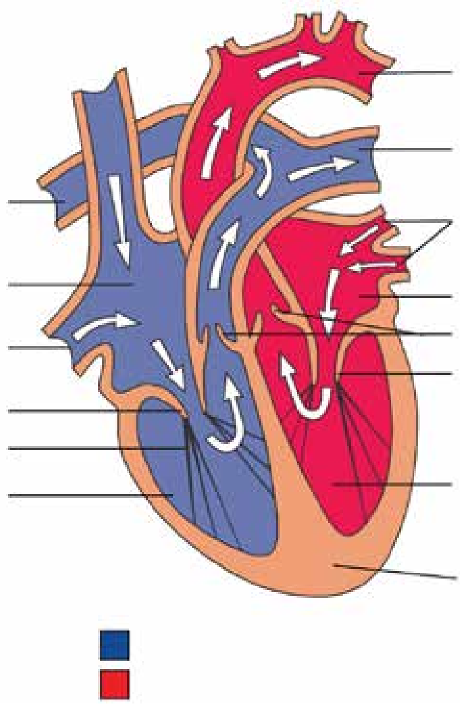


Figure 6.3 Longitudinal section through human heart to show the internal structure
The table summarises the main blood vessels to and from the heart.

Table 6.1 Blood vessels of the heart

Vessels that take blood TO the heart	contain	**Vessels that take blood AWAY from the heart**	contain
venae cavae	blood low in oxygen and high in carbon dioxide from the body	**aorta**	blood high in oxygen and low in carbon dioxide to the body
pulmonary vein	blood high in oxygen and low in carbon dioxide from the lungs	**pulmonary artery**	Blood low in oxygen and high in carbon dioxide to the lungs

Activity 6.1

Work on your own

Answer the questions.

1. Which blood vessels:
   a) take blood from the heart to the body
   b) receive blood from the body
   c) take blood to the lungs
   d) receive blood from the lungs
   e) supply the heart muscle with blood?
2. What is the difference in the composition of blood on the left and right sides of the heart?
3. Describe the function of the septum.
4. List the blood vessels and parts of the heart through which blood:
   a) flows when it returns from the body
   b) flows when it leaves the heart to go to the body.

Activity 6.2

Work in pairs

Identify the parts of the human heart

Look at a chart or model of the human heart or use Figure 6.2 and 6.3.

Identify the main blood vessels to and from the heart.

Identify the parts of the heart.

2. Draw the human heart and label all the parts.

Activity 6.3

Work on your own

Answer the questions.

1. How many chambers are in the heart?
2. Name the chambers that receive blood.
3. Name the chambers that pump blood out of the heart.
4. Name the valves between the atria and ventricles. Explain their function.
5. Name the thin walled blood vessels of the heart.
6. Choose the correct word:
   a) Veins take blood to / from the heart.
   b) Arteries take blood to / from the heart.
7. Explain why there are valves in the aorta and pulmonary artery.

Simulation of heart actions

Use the Internet to find videos showing the pumping action of the heart. These simulations will help you answer the questions.

1. List the sequence of movements involved in contraction of the heart starting with blood flowing into the atria.
2. How often does the heart beat per minute in a person at rest?
3. What makes the heart sounds of 'lub dub'?

Summary

- The transport system in humans is called the circulatory system.
- The circulatory system is made up of blood, blood vessels and the heart.
- There are three types of blood vessels; arteries, veins and capillaries.
- Arteries take blood away from the heart, veins take blood to the heart and capillaries take blood to and from the cells.
- The heart is a muscular pump that pumps blood around the body.
- The heart itself is supplied with blood vessels called coronary arteries and veins.
- The heart consists of four chambers; two thin-walled atria and two thick-walled ventricles.
- The wall of the left ventricle is the thickest as it has to pump blood all the way around the body.
- Valves in the heart ensure one-way flow of blood through the heart and prevent it flowing back.
- Blood with a high oxygen content is called oxygenated blood and blood with a low oxygen content is called deoxygenated blood.
- The venae cavae carry deoxygenated blood from the body to the heart.
- The aorta takes oxygenated blood away from the heart to the body.
- The pulmonary artery takes deoxygenated blood to the lungs where it becomes oxygenated.
- The pulmonary veins take oxygenated blood from the lungs to the body.

Topic assessment

Answer the questions.

1. Describe the function of the bicuspid and tricuspid valves. (4)
2. Give the meaning of the following terms:
   a) oxygenated blood
   b) deoxygenated blood
   c) atria
   d) septum. (4 x 2 = 8)
3. a) Which side of the heart contains deoxygenated blood? (1)
   b) Which side of the heart contains oxygenated? (2)
3. Rewrite the following sentences. Choose the correct word in each sentence.
   a) Veins carry blood to / from the heart? (1)
   b) Arteries carry blood to / from the heart. (1)

4. a) Describe the position of the semilunar valves in the heart. (1)
   b) What is the function of these valves? (2)
5. Rewrite and complete the sentences by filling in the missing words.
   a) Blood enters the right atrium through the ____________ (1)
   b) Blood enters the left atrium through the _____________ (1)
   c) Blood leaves the left ventricle through the ____________. (1)
   d) Blood leaves the right ventricle through the _____________ (1)
6. Which part of the heart receives blood from
   a) the body
   b) the lungs? (2)
7. Explain why the atria have thinner walls than the ventricles? (2)
8. Explain why the left ventricle has a thicker wall than the right ventricle? (1)
9. The four chambered square in Figure 6.4 represents the heart. Copy the squares and label the chambers. Use arrows to show the direction of blood flow into and through the heart for one complete heart beat (that includes pumping blood to the lungs and the body and back to the heart). (6)

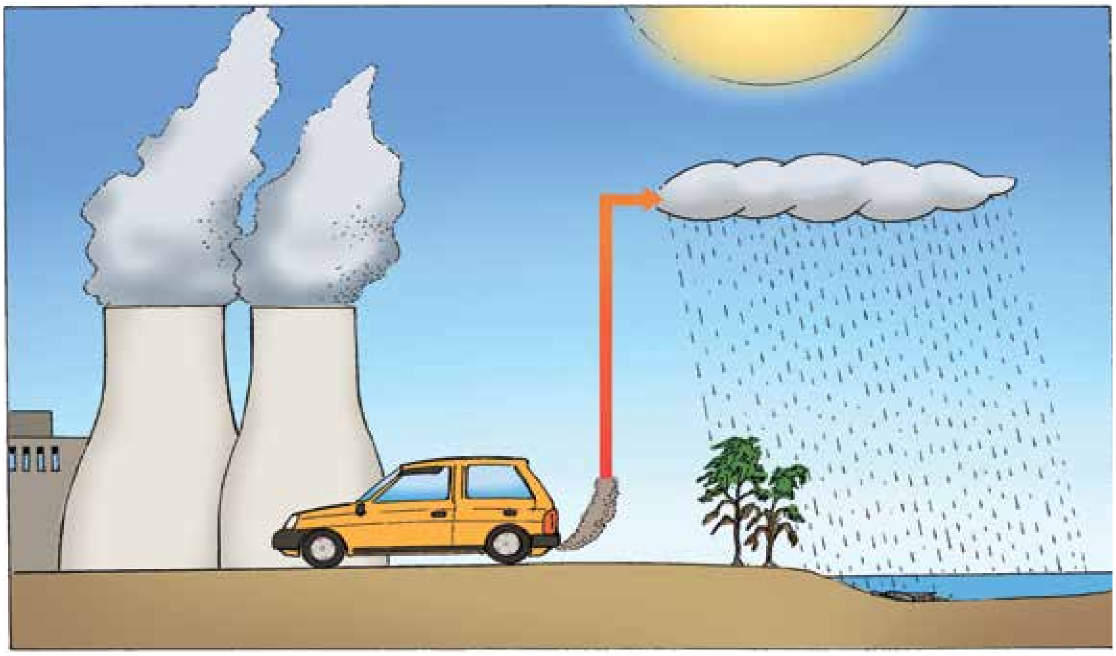
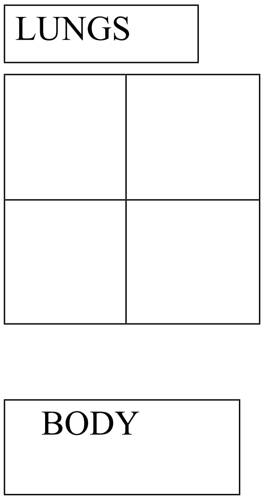


Figure 6.4



[Total marks = 35]

Something interesting

During the lifetime of a person who lives to seventy years, the heart will contract and relax rhythmically over two and a half billion times.

Topic 7 Reproductive systems in plants

Learning objectives	Activities
• Distinguish between monocotyledonous and dicotyledonous plant seeds	• Comparing internal and external features of monocotyledonous and dicotyledonous plant seeds
• Describe the functions of the cotyledon and endosperm	

In Form 1 you learnt that the reproductive structures of a plant are the flowers. You also learnt about the processes of pollination and fertilisation that lead to seed and fruit formation.

Monocotyledonous and dicotyledonous plant seeds

Flowering plants have flowers as their reproductive structures. Flowering plants are classified into two groups based on the structure of their seeds. The two groups are: monocotyledonous and dicotyledonous plants.

Structure of plant seeds

All seeds contain three main parts; an embryo, a seed coat and a supply of food for the developing embryo.

Embryo

The embryo develops inside the seed after fertilisation has taken place. After some time, a part of the embryo called the **plumule** forms leaves. At the opposite end of the embryo, a region called the radicle develops into roots.

Seed coat

All seeds are enclosed by a protective seed coat that is called the **testa**. There is a small scar on the seed coat called the **hilum**. This is where the seed was attached to the ovary. A small pore called the **micropyle** can be seen next to the hilum. The micropyle is used for the absorption of oxygen and water when the seed germinates.

Food supply

The developing embryo inside the seed needs food to grow. Food is provided by a region of the embryo called the **endosperm**. In some seeds such as wheat and maize, the endosperm remains as a food store. Additional food storage structures called **cotyledons** also develop to supply the embryo with food. Monocotyledonous plants have one cotyledon (*mono* =one) whereas dicotyledonous plants have two cotyledons (*di* = two). Figure 7.2 shows the internal and external features of a dicotyledonous seed for example a bean seed and of a monocotyledonous seed for example a maize seed.

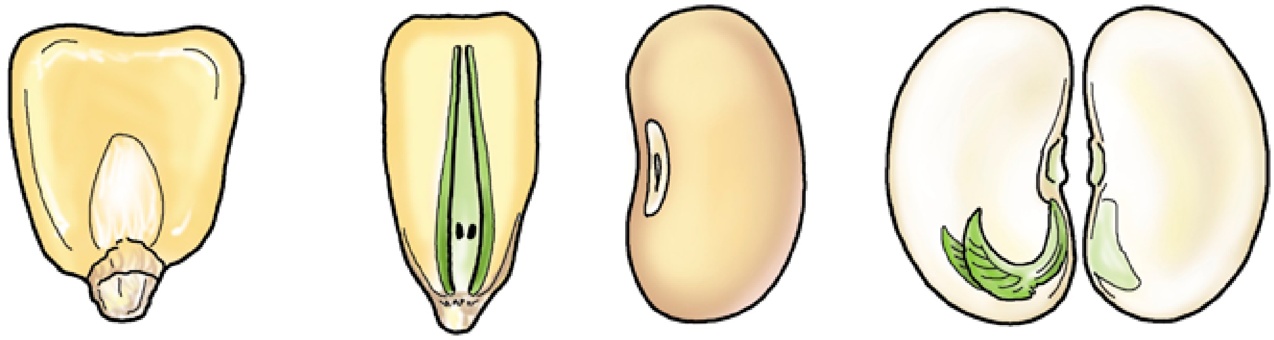


Figure 7.2 (a) External structure of i) a dicotyledonous seed (bean) and a monocotyledonous seed (maize) (b) (i) Internal structure of a dicotyledonous (bean) and ii) a monocotyledonous seed (maize)

Word help

embryo: the part of a seed that will develop into a new plant.
plumule: embryo shoot in a seed.
testa: seed coat.
hilum: a small scar on the seed coat.
micropyle: a small opening in the seed coat through which water and oxygen are absorbed.
endosperm: additional food storage structure in some seeds.
cotyledons: food storage organ in a seed.
angiosperms: flowering plants.
dispersed: spread over an area.
germinate: when a seed grows into a new plant.
radicle: embryo root in a seed.

Activity 7.1 Practical task

Work on your own.
Examining the structure of dicotyledonous and monocotyledonous seeds

Aim: To investigate the structure of bean and maize seeds

You will need:
- a bean seed and a maize seed that have been soaked in warm water overnight
- hand lens
- scalpel or blade.

Safety

A scalpel blade is sharp so you should use it with care.

Method

Follow the instructions.

1. Examine the bean seed and find the swelling where the radicle or first root is.
2. Use the hand lens to look for the tiny pore at the tip of the radicle swelling that allows water into the seed to start germination.
3. Draw the external view of the bean seed. Label the seed coat or testa, radicle swelling, pore and the scar where the seed was attached in the ovary which became a bean pod or fruit.
4. Carefully peel off the testa and open the seed into two parts. Each half is a cotyledon.
5. Between the two cotyledons observe the tiny first shoot or plumule and first root or radicle.
6. Draw the internal view of the bean seed.
7. Now observe the maize seed and notice the position of the single cotyledon and the scar on the base where the seed was attached to the cob.
8. Draw the maize seed externally to show these structures.
9. Carefully cut the maize seed longitudinally through the middle of the single cotyledon and use the hand lens to examine the cut surface to see the plumule and radicle, each inside its protective sheath in the cotyledon. All the tissue around the cotyledon is the endosperm. Around the outside is the testa fused with the ovary/fruit wall.
10. Draw the cut surface of the seed and label radicle, plumule, cotyledon and endosperm and testa.

Questions

Answer the questions.

1. State the name given to the tough protective coat around a seed.
2. What is the function of the tiny pore in the seed coat?
3. The seed contains an embryo plant. What does it consist of?
4. Which structures in dicotyledonous seed and a monocotyledonous seed store food?
6. List the similarities of the bean and maize seeds.
7. State the main difference between a dicotyledonous bean seed and a monocotyledonous maize seed.

Activity 7.2 Research

Answer the questions.

The major food crops grown in Zimbabwe are maize, soya and wheat while small holder farmers grow tomatoes, paprika and onions.

Use internet or the library to find out whether these crop seeds are monocotyledonous or dicotyledonous seeds.

Draw a table with two columns Monocotyledonous seeds and Dicotyledonous seeds. Record your findings in the table.

Summary

- Flowering plants are called angiosperms and there are two groups called monocotyledonous and dicotyledonous plants.

- After fertilisation inside the ovule of a flower, seeds are formed.
- A seed contains an embryo plant.
- Seeds consist of a seed coat called the testa, the embryo and food stores called the endosperm and cotyledons.
- Monocotyledonous plants have one cotyledon and dicotyledonous plants have two cotyledons.
- Food stores supply the embryo with food for its growth.
- The embryo consists of shoots called the plumule, roots called the radicle and later, the hypocotyl which will grow to form the plant stem.

Topic assessment

Answer the questions.

1. Describe the differences between a monocotyledonous maize seed and a dicotyledonous bean seed. Give an example of each. (4)
2. Matching columns. Match the term in column I with the description in column II.

Column I	Column II
a) radicle	a) outer protective covering of a seed
b) cotyledon	b) develops into the plant root
c) plumule	c) develops into the first leaves
d) testa	d) food store

(4)

3. Why do seeds need a food store? (1)
4. Humans use seeds as a major source of food. Name the seeds used to make flour for bread. State whether these seeds are monocotyledonous or dicotyledonous. (2)
5. Provide labels for 1 to 4 in Figure 7.3. (4)

[a/w 7.3] Unlabelled diagram of section through dicot (bean) seed
labels 1 to 4]

Figure 7.3

[Total marks = 15]

Something interesting

In Chibaka in north west Zimbabwe, communities have stored seeds of indigenous vegetables such as *tsunga, regusha, mutsine* and *nyevhe.* They also save seeds from traditional crops such as cowpeas, *madhumbe* and bambara nuts. Every second year they hold a seed fair to show other communities their indigenous seed varieties. [http://www.sundaymail.co.zw/indigenous-foods-fight-back/]

Topic 8 Reproductive systems in humans

Learning objectives	Activities
• State the functions of the female and male reproductive systems	• Discuss the functions of male and female reproductive systems

In Grade 6 you identified the human reproductive parts. You recognised the stage of puberty and the impact of early pregnancy on young people. You also explained the **gestation** period in humans.

In Form 1 you learnt about the signs of puberty and the changes that take place in the body of boys and girls.

In this topic you will learn about the structure and functions of the organs of the male and female reproductive systems.

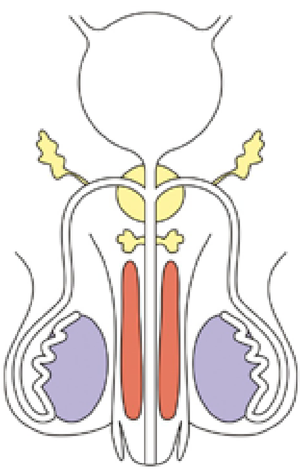
The male and female reproductive systems

Humans are born with reproductive organs but these organs only **mature** at puberty. This means that humans can only reproduce after puberty is complete. Reproduction ensures that organisms can produce **offspring** for continuation of their **species**.

The male reproductive system

The male reproductive system consists of several organs that are specialised to produce the male sex cells called sperm and deliver them to the female during **intercourse**.

The human male reproductive system consists of the penis, testes, sperm duct, urethra and prostate glands. Figure 8.1 shows the structure of the male reproductive system.



[a/w 8.1] Drawing to show male reproductive organs
[start labels]
testis; sperm duct; urethra; prostate gland; penis; scrotum

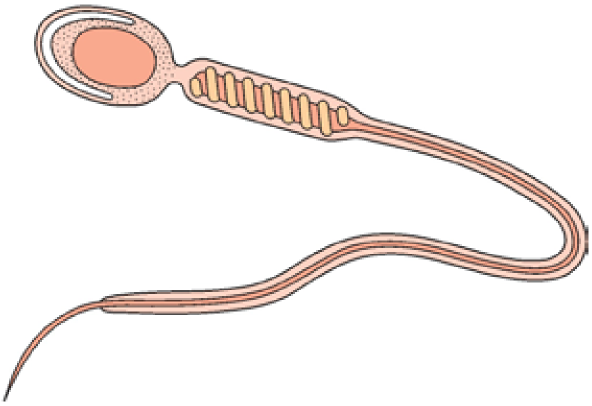
penis
testes
sperm duct
urethra
prostate gland
[end labels]

Figure 8.1 Front view of male reproductive system

Word help

gestation: pregnancy.
mature: fully developed.
offspring: the young of an animal.
species: a group of similar organisms.
intercourse: the sexual act of placing the male's penis into the female's vagina.

The **testes** (singular – testis) produce male sex cells or sperm. Sperm are small cells that are able to swim using a tail called the **flagellum** (Figure 8.2). The testes consist of many tiny tubes in which millions of sperm are produced at a rapid rate. Sperm are stored in a **coiled** tubular structure **adjacent** to the testes. The testes are enclosed in a sac called the **scrotum**.



[a/w 8.2 Drawing of a sperm cell]
[labels]
head
neck
mid-piece
tail

Figure 8.2 Male sex cells is a sperm

The testes also make a **hormone** called **testosterone**. Hormones are chemical substances in the body that bring about changes. Testosterone is a male sex hormone that is important during puberty for the development of the male reproductive organs and male characteristics as well as for the production of sperm. Table 8.1 Summarises the function of the different parts of the male reproductive system.

Table 8.1 Functions of parts of the male reproductive system

Structure	Function
Penis	When erect and firm it deposits sperm in the vagina of the female
Testes	Produce sperm continuously Produce hormone called testosterone which controls development of male features
Sperm duct	Transports sperm by muscular contractions to the urethra

Word help

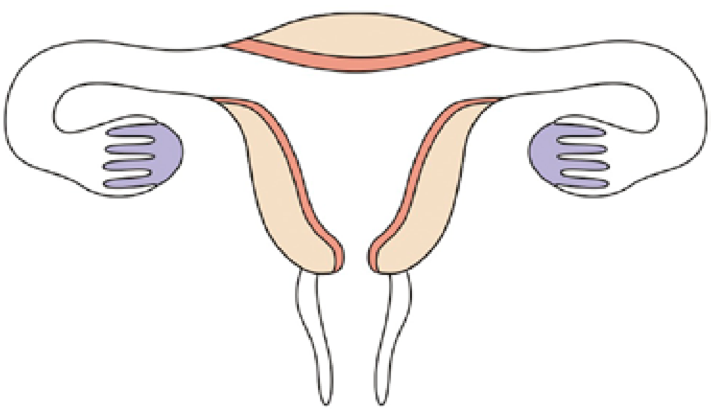
testes (singular – testis): male organs which produce sperm and testosterone.
flagellum: a tail-like structure that enables sperm to swim.
coiled: series of twisted loops, like a spring.
adjacent: next to.
scrotum: skin sac containing testes.

Prostate gland	Produces a fluid which makes up semen **Semen** consists of sperm cells in fluid that keeps them alive and enables them to swim
Urethra	Tube that carries sperm from sperm ducts through the penis to pass out of body It also carries urine from bladder through the penis to pass out of body

The female reproductive system

The female reproductive system is designed to produce female sex cells, and to house and protect the growing **embryo** during pregnancy.

The female reproductive system consists of the vagina, ovary, oviduct, uterus and cervix. Figure 8.3 shows the structure of the female reproductive system.



[a/w 8.3] Front view of female reproductive system]
[start labels]
ovary; oviduct; uterus; cervix; vagina; endometrium
[end labels]
[caption]

Figure 8.3 Front view of female reproductive system

Word help

hormone: a chemical substance produced in an organism that brings about changes in the body.
testosterone: male hormone**.**
sperm: small male swimming sex cell.
prostate gland: a small gland that adds fluid to sperm.
penis: a male organ used to introduce sperm into female vagina during intercourse.
semen: a fluid that contains sperm and substances that help them to stay alive.
urethra: a tube leading from bladder which carries both urine and sperm in males.

The **ovaries** produce female sex cells called **ova** (singular - ovum) (Figure 8.3). They also produce the female sex hormones, oestrogen and progesterone. Note that unlike the male, in the female the bladder and urethra are completely separate from the reproductive system.

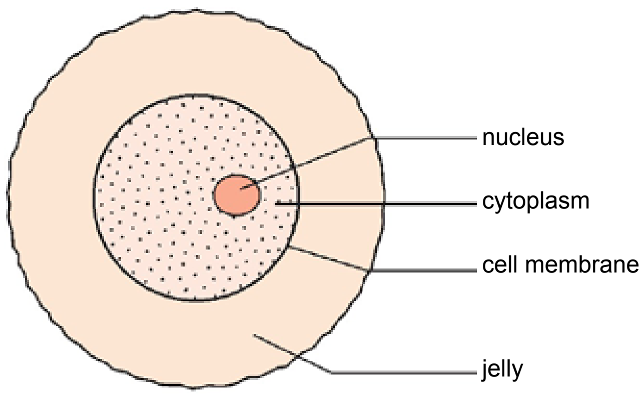


Figure 8.4 The female sex cell is an ovum

Table 8.2 summarises the functions of the different parts of the female reproductive system.

Table 8.2 Functions of parts of female reproductive system

Structure	Function
Ovaries	Produce the female sex cells called ova Produce female sex hormones oestrogen and progesterone
Oviduct	Passage for ovum to reach uterus Fertilisation of ovum by a sperm takes place here
Muscular wall of uterus	Protects developing embryo Contracts strongly to push baby out during child birth

Word help

embryo: a baby in the early stages of its development.
ova (singular - ovum): female egg cells.
ovary: the female organ which produces ova and hormones.
oviduct: a tube that carries an ovum from the ovary to the uterus; fertilisation takes place in it.
cervix: a narrow opening between uterus and vagina.
uterus: a muscular organ in females where a developing baby grows.
endometrium: the lining of the uterus which is shed during menstruation.
vagina: a female tube that receives male penis during intercourse; also called the birth canal.

Lining of uterus	Called the **endometrium** It is shed during **menstruation** Provides nutrition for developing baby.
Cervix	Ring of muscle around a narrow opening into uterus Directs sperm deposited by male penis into the uterus
Vagina	Receives the penis during intercourse Also called the birth canal as during child birth the baby passes through it

Activity 8.1 Practical

Work in a pairs

Examining the structure of the male and female reproductive systems

1. Look at charts or models of the male reproductive system or use Figure 8.1. Identify the parts of the male reproductive system.
2. Draw and label a diagram of male reproductive system. Give your drawing a heading. Write down the function of each part next to the label.
3. Look at charts or models of the female reproductive systems or use Figure 8.3. Identify the parts of the digestive system.
4. Draw and label a diagram of female reproductive system. Give your drawing a heading. Write down the function of each part next to the label.

Questions

Answer the questions.

1. Draw a two-column table with the headings 'Male' and 'Female'. Complete the table correctly using terms from the following list:
   ovary, sperm, cervix, vagina, penis, sperm duct, uterus, testes
2. Name the hormone produced by the testes.
3. What are the functions of the ovaries?
4. What is the function of the prostate gland?
5. Which structure in the female reproductive system opens to the outside of the body?

Summary

- Reproduction in organisms ensure the continuation of species by the production of offspring
- The male reproductive system is designed to produce the male sex cells and transfer them into the female's body.
- The male sex organs are the penis, testes, sperm duct, urethra and prostate glands.
- The penis provides a passage for sperm to the outside of the body.

- The testes produce male sex cells called sperm and the hormone testosterone.
- The sperm pass from the testes along sperm ducts and into the urethra where fluid from the prostate gland is added.
- The female reproductive system is designed to produce the female sex cells called ova, receive sperm from the male and to house and protect the developing embryo during pregnancy.
- The ovaries produce ova and also the female sex hormones called oestrogen and progesterone.
- The ovum passes along the oviduct to the uterus.
- Sperm are deposited by the male penis into the vagina during intercourse.
- Fertilisation can take place in the oviducts when an ovum fuses with a male sperm cell.
- A developing embryo grows, and is protected, in the uterus during pregnancy.
- The uterus muscles contract during child birth to push the baby through the cervix and the vagina.
- The lining of the uterus is shed during menstruation.

Topic assessment

Answer the questions.

1. List, in the correct order, the structures that sperm would pass through from the site of their production until they leave the male's body. (5)
2. a) Describe the position of the prostate gland in a male. (1)
   b) What is its function? (1)
3. Name the tube along which an ovum passes to the uterus. (1)
4. What is the name of the narrow opening between vagina and uterus? (1)
5. Name the female hormones produced by the ovaries. (2)
6. What is the function of the penis? (1)
7. Name the part where:
   a) fertilisation usually take places
   b) sperm are deposited during intercourse
   c) the male hormone testosterone is produced.

[Total marks = 15]

Something interesting

Human sperm travel at about 4 mm per minute. Their journey to the oviduct can take up to three days.

Topic 9 Health and diseases

Learning objectives	Activities
• State causes of diseases	
• Describe the causes of bilharzia	• Discuss transmission of bilharzia parasite
• Describe the life cycle of the bilharzia parasite	• Methods of preventing spread of bilharzia

In Grade 4 you learnt about parasitic diseases, their prevention and control. In Grade 5 you found out about harmful gut worms and in Grade 6 you discussed HIV/AIDS. In Grade 7 you explored epidemic diseases like Ebola and influenza. You also discussed ways to prevent and manage **chronic** diseases such as cancer, hypertension and diabetes. In Form 1 you learnt about the methods of **transmission** of diseases such as cholera, Ebola, malaria and bilharzia. The method of transmission means how the disease is spread from one person to the next. Diseases can be transmitted by water, food, contact and by **vectors** such as the mosquito or snail. In Form 1 you also learnt that the organisms that cause disease are **micro-organisms** including viruses, bacteria, parasitic protozoa, fungi and some worms.

In this topic you will learn more about the causes of diseases and in particular the parasite that causes the disease bilharzia.

Causes of diseases

Some diseases are caused by poor eating, smoking and stress. These are called lifestyle diseases. Examples include diabetes, high blood pressure and heart disease. Other diseases are caused by micro-organisms such as viruses, bacteria, fungi, parasitic **protozoa** and worms when they **contaminate** water, food or air. This means that these organisms get into water or food that is then drunk or eaten by humans. Humans can also breathe in microorganisms. Disease-causing micro-organisms are called **pathogenic**.

Examples of diseases caused by pathogenic micro-organisms include malaria. This is a disease caused by a micro-organism that is spread from one person to another by a mosquito. Tuberculosis is caused by a type of bacterium that is breathed in and cholera is caused by a type of bacterium that contaminates water.

Word help

chronic: an illness that lasts for a long time.
vectors: organisms that transmit a disease.
micro-organisms: organisms that can only be seen with a microscope.
transmission: spread or passing on.
contaminate: pollute.
protozoa: single celled animals.
pathogenic: disease-causing organism.

In this topic you are going to learn more about a disease called bilharzia.

Bilharzia

Bilharzia is a disease that affects many people in Zimbabwe.

Causes of bilharzia

Bilharzia is caused by several different types of **parasitic** bilharzia worms. These worms occur in many rivers and dams in Zimbabwe. Some worms cause a type of bilharzia that affects the gut and some bilharzia worms affect the bladder.

[a/w 9.1] Photo of black
children swimming in river

Figure 9.1 People can get bilharzia when they swim in contaminated rivers

Lifecycle of the bilharzia parasite

Bilharzia worms are parasites that have two **hosts**. A host is an organism in which the parasite lives and feeds. The bilharzia parasite has humans and snails as hosts.

Word help

parasitic: a way of life in which an organism, the parasite, lives and feeds off another organism.
host: an organism that is infected by a parasite.

Figure 9.2 shows the life cycle of the bilharzia worm. A person infected with bilharzia urinates or defecates into water. Eggs from the bilharzia worm passes into the water in this way. A type of larva hatches from the eggs. The **larvae** enter certain types of snail hosts where they multiply and develop. When mature, the larvae leave the snails, usually during the hottest time of the day, and swim to the water surface where people bathe and collect water.

A person gets bilharzia when he or she comes into contact with water that is contaminated with the **larvae** of bilharzia worms. The larvae burrow through the person's skin into their blood vessels. They travel in the blood for about six weeks. In the blood vessels the larvae develop into adult worms. The worms settle in veins of the walls of the gut or bladder where they lay thousands of eggs. A person's body reacts to the eggs and they experience the symptoms of bilharzia.

The life cycle continues when the infected person urinates or defecates in water and the eggs pass out of their body.

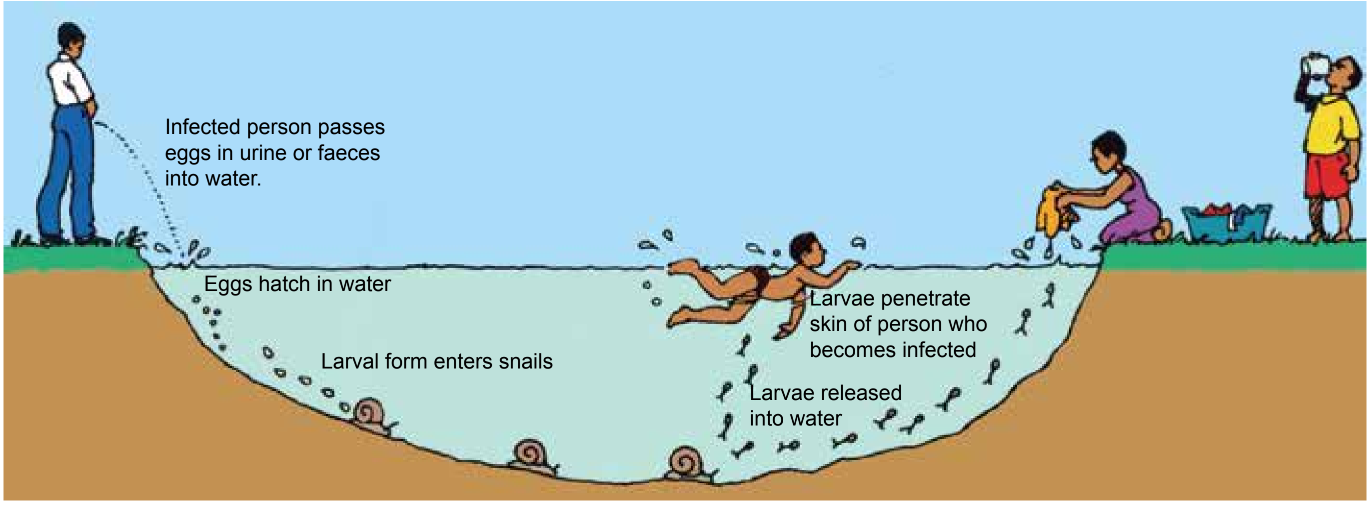


Figure 9.2 Life cycle of bilharzia parasite

Transmission and prevention of bilharzia

The life cycle (Figure 9.2) shows that transmission of bilharzia is via contact with contaminated water. Education of people to prevent urination and defecation in or near water bodies would prevent eggs reaching water and so stop the transmission of bilharzia.

Methods of prevention of the spread of bilharzia

Methods of preventing bilharzia include:

- Educating people to build Blair toilets (Figure 9.3) to prevent eggs reaching water.
- Treatment of water, collected for household use, with chlorine.
- Treating water bodies with chemicals to kill snails or putting ducks on the water to eat snails.
- Supplying all communities with clean piped water.
- Treating infected people to prevent transmission.
- Collection of water to be done early in the morning when fewer larvae are released from the snails.

Something interesting

A Blair toilet was designed at the Blair Research Institute in Harare in the 1970s. This institute is now called the National Institute of Health Research.

[a/w 9.3 A Blair toilet]

Figure 9.3 A Blair toilet

Activity 9.1

Answer the questions.

1. a) List three ways that diseases can be transmitted.
   b) Which of these ways cause the transmission of bilharzia?
2. Write down the meaning of the following terms:
   a) contaminated
   b) parasitic
   c) host
   d) pathogenic.
3. Give the names of the two hosts involved in the bilharzia life cycle.
4. a) Where do bilharzia eggs hatch?
   b) What causes the symptoms of bilharzia?

Activity 9.2 Practical task

Work in a group

Methods of preventing the spread of bilharzia
Aim: Make a poster to show methods of prevention of the spread of bilharzia parasite

You will need:
A sheet of large poster paper, coloured pencils

Method
Follow the instructions.

1. Study the life cycle diagram in Figure 9.2 as well as the information about ways to prevent the transmission of bilharzia. Discuss all possible methods of prevention of bilharzia transmission.
2. Make a list of all prevention methods you have discussed.
3. Plan the poster to include pictures or drawings to show all these methods.
4. Make your poster bold and colourful so that it can be displayed.

Case study

Students in Grade 7 at Chingwaru School in Murewa were asked to write an essay about bilharzia. The title of the essay was "Bilharzia is an enemy to my health and education". Read the essay then answer the questions.
[adapted from Pig.bio.ed.ac.uk/outreach/essays]

I was a fit and clever boy. I came top in my class and I was also good at athletics, volleyball and soccer.

One day I started to feel weak and very sleepy. I had tummy pains and I felt hungry not long after I had eaten. Eventually my parents took me to a health centre. My urine and blood was tested. My parents were told that I had bilharzia. A health worker measured my height and weight so that he would know how many tablets I would need to take. I was given the tablets and within a week I was feeling better.

The health workers told me that I must not visit the toilet without wearing shoes and I must not swim in rivers or drink untreated water.

Written by Tinashe Muyambo
Grade 7

Questions

1. Describe three of Tinashe's symptoms.
2. When Tinashe went to clinic what tests were done?
3. He was diagnosed with bilharzia. What treatment was he given?
4. How quickly did he get back to normal at school?
5. What prevention methods did the health workers tell him?
6. What measurements did the health professionals take of all the children before they treated them for bilharzia?
7. Why is it important that every rural home has a Blair toilet?

Summary

- Diseases may be caused when water, air or food is contaminated by viruses, bacteria, fungi, protozoa and worms.
- Some diseases such as diabetes and heart disease are caused by poor lifestyle.
- Bilharzia is caused by parasitic worms that have two hosts; humans and snails.
- When a person, infected with bilharzia worms, urinates or defecates into water, eggs pass into the water.
- The eggs enter snails where larvae form.
- The bilharzia larvae leave the worm and swim in the water until they find a human host.
- The larvae burrow into the human's skin and move into the blood vessels where they mature into adult bilharzia worms.
- The worms settle in the gut or bladder and lay eggs which pass out when the person urinates or defecates.
- The transmission of bilharzia may be stopped by education, water treatment, treated infected people and collecting water early in the day.

Topic assessment

Answer the questions.

1. Match the disease in Column I with the factor that causes it in Column II.

Column I	Column II
i. diabetes	A. bacteria
ii. bilharzia	B. poor diet
iii. TB	C. parasitic worm

(3)

2. Use words and arrows to draw the life cycle of the bilharzia parasite. (6)
3. Describe how a person may become infected with bilharzia parasites. (2)
4. Describe two methods of controlling the spread of bilharzia. (2)
5. Name two places where the bilharzia worms live in an infected person. (2)

[Total marks = 15]

Something interesting

The larvae multiply in the snail hosts and each infected snail can release 10 000 larvae into the water.
60% of children in Zimbabwe have the urinary form of bilharzia.
200 million people in 76 countries around the world are infected with bilharzia.

Indigenous knowledge

The torchwood trees, *Balanites aegyptiaca* and *B. maughamii,* produce fruits which local people know to be lethal to bilharzia larvae as well as to snails. A single fruit from one of these trees dropped into 30 litres of water will immediately kill all bilharzia larvae making it safe for household use.

Section 2

Chemistry

Topic number	Topic	Learning objectives
1	Separation	• State the applications of filtration, winnowing magnetism and evaporation
2	Matter	• Determine the concentrations by colour intensities of dissolved substances • Determine the concentration of a substance by varying the amount of solute in a given solvent
3	Acids, bases and salts	• Describe an acid–base reaction
4	Industrial processes	• Outline the manufacture of soap
5	Oxidation and reduction	• Write simple word equations • Define oxidation and reduction in terms of oxygen • Distinguish between physical and chemical changes
6	Organic chemistry	• Define complete and incomplete combustion of fuels • List the products of complete and incomplete combustion of fuels • Describe the effects of burning fuels

Topic 1 Separation

Learning objectives	Activities
• State the applications of filtration, winnowing, magnetism and evaporation	• Experiments on salting of peanuts • Field trips to a grinding mill, water filtering plant, ammonium nitrate manufacturing plant

In Form 1, you learnt about separating mixtures using filtration, magnetism, winnowing, decanting, evaporation. You did several experiments to illustrate these different methods.

Application of separation methods

These separating techniques have been around for hundreds of years and are still in use. The different substances in mixtures are usually easily separated from one another. The method you use depends on the type of mixture you have.

Filtration

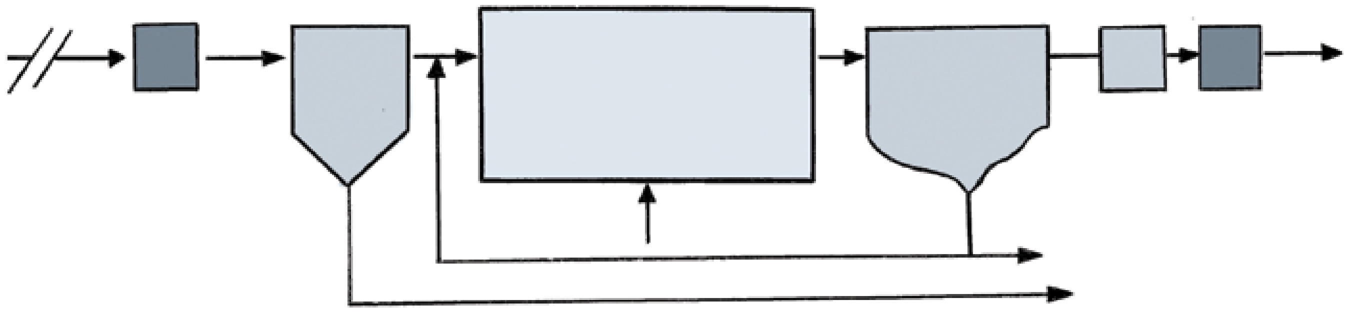
You will remember from Form 1 that **filtration** is when you use any of various means to separate solids from liquids by adding a medium through which only the fluid can pass. An example could be a tea strainer, which catches the tea leaves, but allows for the liquid to pass through.

This is why filtration is good for separating an insoluble solid from a liquid. This occurs, for example, at a sewage treatment plant, which is where water used in households or businesses goes for treatment.

Every time you flush the toilet, have a shower, wash the dishes or clothes, and even your teeth, the water washes away into an underground sewerage system. It contains suspended solids such as bacteria, grit, human waste and dirt as well as some large items like rags and sticks. It also contains many dissolved substances. Filtration is used at two steps in the treatment of sewerage.
When the sewage arrives at the sewage treatment plant for primary treatment, it passes through a screen (a wire mesh filter) that removes the larger items.

Word help

filtration: when you use any of various means to separate solids from liquids by adding a medium through which only the fluid can pass.
sediment: matter that settles to the bottom of a liquid.



[a/w 1.1] Diagram to illustrate a sewerage treatment works

[start labels]
grid
waste water
solids removal
pre-treatment
aeration zone
air
settler
sand filtration
disinfection
effluent
sludge
[end labels]

Figure 1.1 An overview of sewerage treatment works

The sewage then flows into settling tanks in which suspended solids settle to form a **sediment**, and floatables such as oil and plastic collect on top of the sewage and are removed.

The watery part of the sewage flows from the settling tank into secondary treatment. This waste water still contains dissolved substances and bacteria. Secondary treatment takes place by filtering the water though sand, soil or grass. In the secondary treatment, the bacteria in the waste water break down the dissolved substances to purify the water further.

Winnowing

Winnowing is a process by which one can separate any heavy material from a lighter one with the use of wind. It is a relevant method of separation in case of solid-solid mixtures having components of different weights. For example the wheat grains from the field still have dried husk and chaff, which have to be separated and thrown away before the wheat can be used. The husk is blown away as it is much lighter than the grain. So, when the grains land back in the winnowing implement, the husk blows away.

Word help

winnowing: process by which one can separate any heavy material from a lighter one with the use of wind.

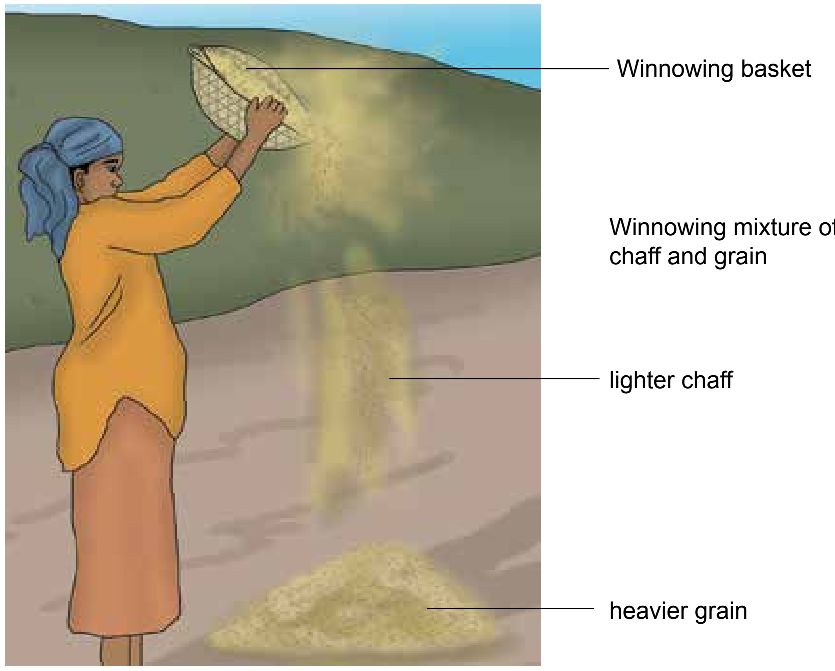


Figure 1.2 Winnowing being used to separate the wheat grain from the husks and chaff

Magnetism

You will remember from Form 1 that magnetism is a property of certain substances which pull closer or repel (push away) other objects. A magnet can be used to separate a mixture of a magnetic substance and a non-magnetic substance. For example, magnetism can be used to separate metallic objects from grain before grinding.

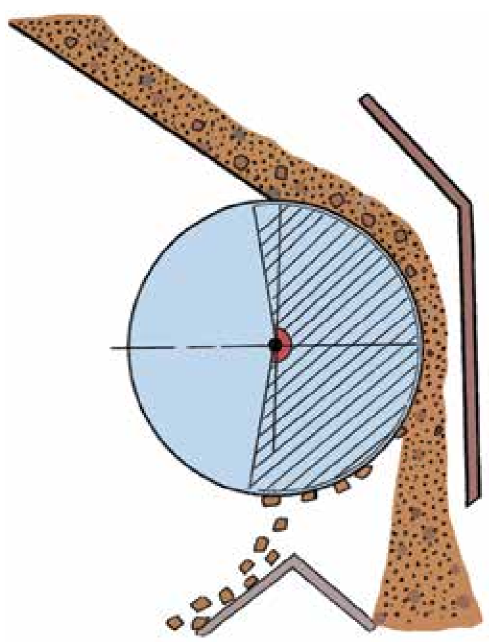


Figure 1.3 Magnetism can be used to remove pieces of metal from grain before it is ground

Another example where magnetism can be used is in the separation of metallic waste for recycling.

Steel cans are separated from other containers using a magnet. The steel is collected in a separate container, ready to be sent to steel manufacturers. Material that is not attracted to a magnet continues along the conveyor belt.

Figure 1.4 Magnetism can be used to remove steel cans from other general recycling

Evaporation

Evaporation is when a substance in a liquid state changes to a gaseous state due to an increase in temperature and/or pressure. This process is used to separate a mixture containing a non-volatile, soluble solid from its **volatile**, liquid solvent. (A volatile solvent is a liquid that vaporises at room temperature, and a non-volatile solute, is a substance one that does not readily evaporate into a gas under existing conditions.)

We can separate sugar from its solution by evaporating the water from the solution. This can also be done for ammonium nitrate crystals. Remember it is the water that evaporates away, not the solution.

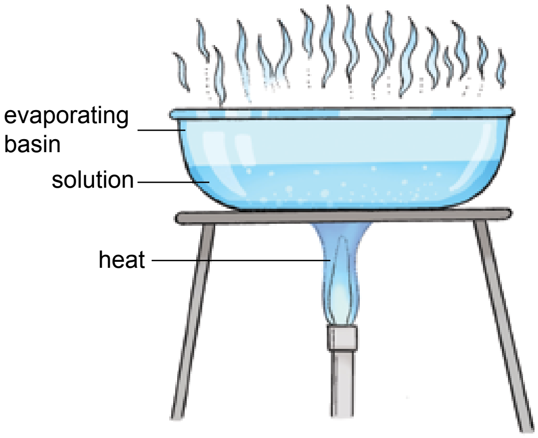


Figure 1.5 Evaporation of a solution to leave crystals

Word help

evaporation: when a substance in a liquid state changes to a gaseous state due to an increase in temperature and/or pressure.
volatile: easily evaporated.

Activity 1.1

Work in a group

Experiment to salt peanuts
Aim: To salt shelled peanuts

You will need:
- Bunsen burner
- pressure cooker
- oven
- a handful of shelled peanuts
- brine (saltwater) solution

Method
Follow the instructions.
Place the peanuts and brine in the pressure cooker.
Heat under pressure, for 15 minutes.
Drain off the excess brine solution.
Lay the peanuts on a roasting tray, and roast in the oven until they are dry.

Observations and results
Did the peanuts taste salty once roasted?

Conclusion
The pressure of the pressure cooker forces the salt into the peanut shell. Excess liquid is then removed by the process of _______________ leaving salt behind on the peanuts.

Questions
Answer the questions.
1. What is evaporating off during roasting?
2. What is left behind after evaporation?

Safety

Other safety symbol, followed by description
Heat - be careful not to burn yourself during this experiment. Use heat-resistant gloves where possible.
NEVER eat or taste anything from your experiments unless a responsible adult has instructed you to do so.

Activity 1.2 Field trip

Work as a class

Visit a grinding mill, water filtering plant, ammonium nitrate manufacturing plant.
1. At each site, think about what separation technique is being used.
2. Write a short report on each visit.
3. Draw a basic flow chart with each report to show the steps in the separation processes.

Activity 1.3

Work on your own

What is the best technique to get salt from salty water, like sea water?
Filtration works when two substances have different:
a) melting points
b) colours
c) densities
d) solubilities.

Blue-green algae has grown in a lake. It forms a fine, green suspension in the water. The local council wants to make the water clear again so that fish and other living organisms can safely inhabit the lake. Propose a method that you would use to solve the local council's problem. Remember that your method should not harm the fish already in the lake.

Summary

- When separating mixtures there are different methods that can be used such as filtration, winnowing, magnetism and evaporation.
- Filtration method allows separation of solids and liquids. Liquid passes through leaving the solid particles behind.
- Separation of lighter material from the heavy ones is done by winnowing.
- When two mixtures of metalic and non-metalic substance is separated this can be done by magnetism. Metalic material which is magnetic will be pulled out leaving the non-magnetic.
- Evaporation will separate a solution. The liquid will evaporate to leave a crystal behind.

Topic assessment

Answer the questions.

1. From these techniques, filtration, winnowing, magnetism and evaporation, choose the best for separating the following mixtures:
   a) copper sulfate solution to give copper sulfate crystals
   b) a muddy solution of sand and water
   c) a steel earring in the dust of a vacuum cleaner
   d) stones and tiny feathers [4]
2. State whether the following statements are true or false?
   a) A mixture of milk and water can be separated by filtration.
   b) A mixture of powdered salt and sugar can be separated by process of winnowing.
   c) Separation of sugar from tea can be done with filtration.
   d) Grain and husk can be separated with the process of evaporation. [4]

3. Complete the following table to show what you know of the four separation techniques listed. [8]

Technique	Description of how it works	Example of how it can be used at home or in industry
Filtration		
Evaporation		
Magnetism		
Winnowing		

4. During an experiment, a teacher accidentally drops some steel drawing pins into a bowl of sugar. Suggest a method that could be used to remove the drawing pins from the sugar.
   a) Briefly explain the method. [3]
   b) Imagine you dropped nails in the sawdust in woodwork class. Suggest two reliable ways of separating the nails from the sawdust. [2]
5. You have been asked to analyse some salt-contaminated soil and to propose a method for separating the salt from the soil. Outline the method that you would use to obtain pure dry salt and pure dry soil. [4]

Total [25]

Something interesting

Salt has always been important. Over centuries, civilisations have used salt to cure hides, make cheese, preserve food and as a flavouring in cooking. Salt was even used as a form of currency instead of money.
It is also an essential element in the diet of humans and animals, and some plants also need salt to survive.

Many civilisations grew rich on their knowledge and practice of salt extraction from seawater. These communities would pour seawater into shallow pools and allow the water to evaporate, leaving behind the salt. Sometimes they would heat the seawater in pots over fires until only the salt remained. This salt was then bought or traded.

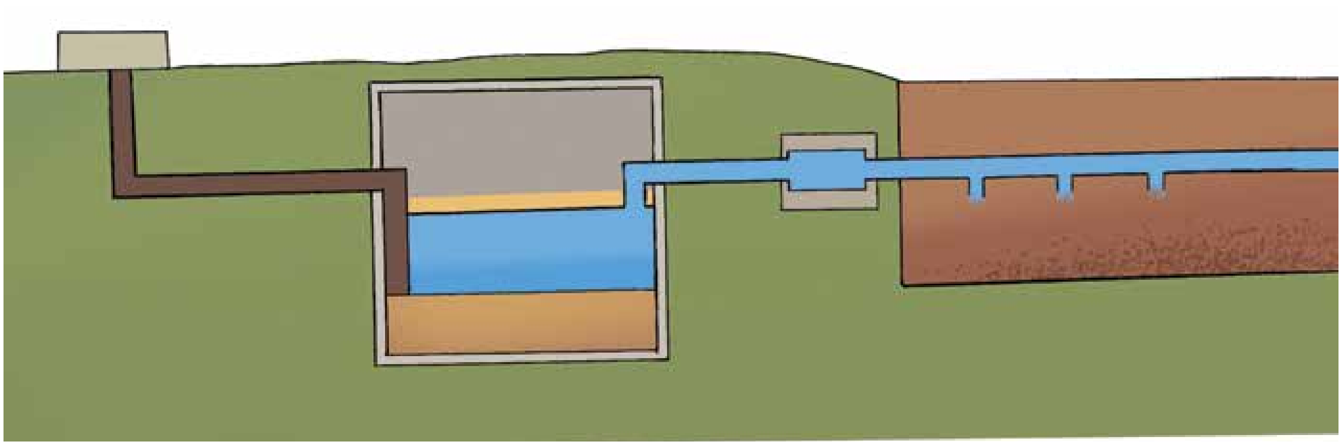
Indigenous knowledge

Septic tanks buried in the back garden are common in Zimbabwe. They collect a household's personal sewage and waste water. A septic tank contains bacteria that break down the sewage. A thick, smelly sludge is formed.

Word help

floatable: in this chapter, items in the sewage that float.
magnetism: the property of certain substances which pull closer or repel (push away) other objects.
non-volatile solute: a substance that does not readily evaporate into a gas under existing conditions.
sewage: the waste matter carried off by drains and pipes.
sewerage: the physical facilities (e.g., pipes, lift stations, and treatment and disposal facilities) through which sewage flows.
suspended solids: small solid particles that float in water.
volatile solvent: a liquid that vaporises at room temperature.

The sludge sinks to the bottom of the tank and clear water flows out into the surrounding area. The sludge needs to be removed from time to time.



[start labels]
house sewer
water level
scum
clear zone
septic tank
inlet
outlet
access point
[end labels]

Figure 1.6 A typical septic tank system

Career

A process engineering role often involves the separation of solids and liquids using some of the methods discussed in this chapter. Farmers use winnowing for their grains. People who want to work in recycling will also have to apply the theories of magnetism to sort the waste that is collected for resale, especially when tin cans and other items made from valuable magnetic metals arrive at the depot.

Learning objectives	Activities
• Determine the concentrations by colour intensities of dissolved substances	• Carrying out experiments on dissolving coloured substances (differing amounts to be dissolved)
• Determine the concentration of a substance by varying the amount of solute in a given solvent	• Carrying out experiments on dissolving known masses of solute in known volumes of solvent

In Form 1 you learnt about the three states of matter as well as the arrangement of particles in solids, liquids and gases, also called kinetic theory. You also investigated elements, mixtures and compounds, the factors that affect solubility, and the properties of metals and non-metals.

Concentration of solutions

When more solute is dissolved in a solvent, the solution is said to be more **concentrated**. For example, by adding more and more sugar to a cup of hot water, you are making the solution more and more concentrated. Eventually the solution gets so concentrated that no more sugar will dissolve in it. When no more solute can be dissolved in a solvent, the solution is **saturated**.

You could make a solution of sugar and water less concentrated by adding more water. This process, where more solvent is added, is called **dilution**. When you add water to bottled cordial you are diluting it. The more diluted the cordial, the lighter the colour.

Figure 2.1 Coloured glasses of cordial at increasing concentrations

Word help

concentrated: a solution that has more solute particles in it compared with another.
dilution: the spreading out of particles by adding water.
saturated: a solution that will dissolve no more solids, there is very little water in a saturated solution.

Activity 2.1 Practical task

Work in a group

Adding different amounts of coloured solute to a solvent
Aim: To investigate the effect of adding different amounts of coloured solute to a solvent

You will need:
- 9 jam jars
- stirring rod
- water
- potassium permanganate crystals
- ammonium dichromate crystals
- copper sulfate

Safety

Heat - be careful not to burn yourself during this experiment. Use heat-resistant gloves where possible.
NEVER eat or taste anything from your experiments unless a responsible adult has instructed you to do so.

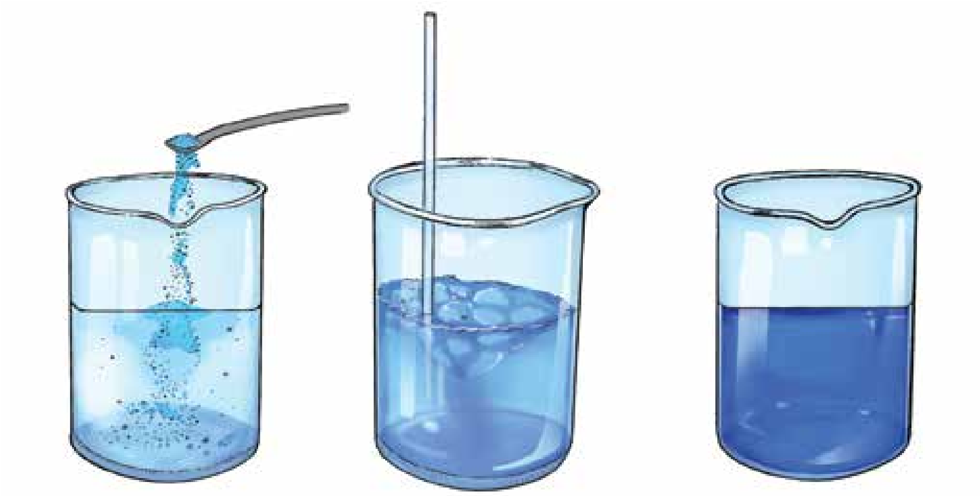


Figure 2.2 Dissolving different concentrations of copper sulfate (solute) in water (solvent)

Method
Follow the instructions.
1. Add 20 ml water to each of the 9 jam jars.
2. Add one pinch, two pinches, three pinches, respectively to each of the potassium permanganate jars.
3. Do the same for the ammonium dichromate jars and copper sulfate jars.
4. Mix well with a stirring rod – wash the stirring rod between mixing different chemicals.

Observations and results
1. Have a look at the three jam jars containing potassium permanganate. Which of the jars has the darkest/lightest liquid?
2. Make a note of your observations.
3. Do the same for the other two chemicals, first for the ammonium dichromate and then for the copper sulfate.

Conclusion
The more coloured solute added, the ___________ the solution becomes. The solution is becoming more ______________. The solution with the least solute in it is the most _________________.

Questions
Answer the questions.
1. The most dilute solution is the palest in colour. Why is this?
2. Which of the three jars in each set has the greatest concentration of solute?
3. What substance could be added to a solution to make it more dilute?

Concentration of solutions expressed as mass of solute dissolved per given amount of solvent

You can calculate the concentration of a solution by using this equation:
Concentration in **g/dm³** = amount in g ÷ volume in dm^3
If the volume remains the same, but more solute is added, the solution becomes more concentrated.

Amount of solute added (g)	Volume of solvent (dm^3)	Concentration of solution (g/dm^3)
10	1	$10 g/dm^3$
20	1	$20 g/dm^3$
30	1	$30 g/dm^3$
40	1	$40 g/dm^3$

Example 1:
If 1g of salt is added to $1 dm^3$ of water, a very dilute brine will result with a concentration of $1 g/dm^3$.

Example 2:
If 1g of salt is added to 0.5 dm^3 of water, the concentration will be $2 g/dm^3$.

Word help

dm^3: decimetre cubed = 1 litre = 1000 ml

Activity 2.2 Practical

Work in a group

Dissolving solutes in solvents
Aim: To investigate dissolving known masses of solute in known volumes of solvent

You will need:
- 2 jam jars
- stirring rod
- brown sugar
- ammonium nitrate/salt
- water

Safety

Potassium permanganate is caustic, and concentrated solutions can burn skin.
Ammonium dichromate can cause severe skin burns and eye damage, so safety glasses and care are advised.
Copper sulfate can cause severe eye irritation, so protect your eyes with safety glasses. It may also burn your skin or respiratory tract, so be careful at all times.

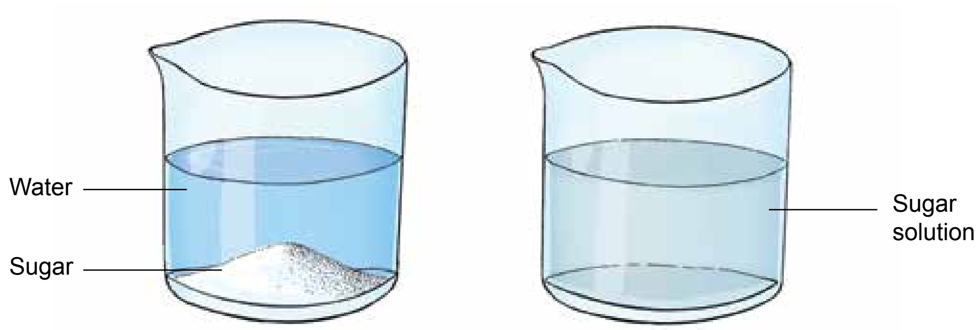


Figure 2.3 Dissolving brown sugar in water

Method

Follow the instructions.

1. Add 20 ml water to each jam jar.
2. Weigh out 5 g of brown sugar and add to the one jar. Stir until dissolved.
3. Add another 5 g of sugar and stir until dissolved.
4. Continue this until no more sugar will dissolve in the water.
5. Do the same for the ammonium nitrate/salt.

Observations and results

Remembering that 20 ml water = 0.020 dm^3, calculate the concentration of the solutions at each step.

Amount of solute added (g)	Volume of water (dm^3)	Concentration of solution (g/dm^3)

Conclusion

The more solute that is added, the more _________________ the solution becomes until no more solute can dissolve – the solution is ______________.

Questions

Answer the questions.

1. Calculate the concentration of a solution in the following:
   a) 5 g potassium permanganate in 30 ml water
   b) 2.5 g powder colddrink mix in 250 ml water
   c) 50 g salt in 2 dm^3 water
   d) 100 g calcium chloride in 1000 ml water.
2. Explain what a saturated solution is.
3. If you tasted two salt solutions of concentration 5 g/dm^3 and 10g/dm^3, which would taste saltier?

Activity 2.3

Work with a partner

Use the word search to find 13 relevant words. The words can be horizontally, vertically or diagonally. Write down the word.

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

3. A salt solution is tasted and found to be too salty. It is said to be a _______________ solution and needs to be _______________.

Summary

- A concentrated solution is one which has more solute particles in it. The more the solute is added it becomes more concentrated until it become saturated.
- A saturated solution is one that can not dissolve solids in it because there is very little water in it.

Topic assessment

Answer the questions.

1. A salt solution is made by mixing salt and water. The salt is known as the
   a) filtrate
   b) solution
   c) solute
   d) solvent [1]
2. When more solute is dissolved in a solvent, the solution is said to be more ____________. [1]
3. 5 g of solute is dissolved in 500 ml water. Calculate the concentration of the solution in g/dm^3. [2]
4. What is the concentration of a solution containing 9.478 g of rubidium chloride in enough water to make 1 litre of solution? [2]
5. What is the concentration of a solution containing 72.06 g of barium chloride in enough water to make 800 ml of solution? [2]
6. What is the concentration of a solution containing 11.522 g of potassium hydroxide in enough water to make 350 ml of solution? [2]

[10]

Word help

solution: is a mixture composed of two or more substances, where one substance is dissolved.
solute: a substance dissolved in another substance, known as a solvent.
solvent: a substance in which another substance, the solute, is dissolved.

Indigenous knowledge

Any Zimbabwean will feel at home with a glass of Mazoe Orange Crush, a juice concentrate. The more concentrate with water, the sweeter it will be. This fruit drink is often voted among Zimbabwe's top brands.

Career

Solvents are among the most commonly used chemicals in workplaces. Workers in different jobs regularly use solvents for removing grease, cleaning metal, adhesion (sticking) and as paint thinners or lubricants.

Jobs most frequently using solvents include: cleaning, dry cleaning, chemical manufacturing, spray painting, manufacturing footwear or plastics and printing. All these careers may require personal protective equipment (PPE) and engineering solutions where the handling of solvents may be isolated or done mechanically. Water-based solvents cause less damage to one's health than organic solvents.

Topic 3 Acids, bases and salts

Learning objectives	Activities
• Describe an acid-base reaction	• Carrying out experiments to demonstrate acid-base reactions

In Form 1 you learnt that acids have a sour taste and turn litmus paper red. You also learnt that bases feel soapy and turn litmus paper blue. You leant how to identify an acid and a base using litmus paper.

Acids-base reactions

If one day you are putting pool acid in the swimming pool and you spill some on yourself, you can use a strong base to stop the acid from burning you. The acid has been neutralised.

When an acid is mixed with a base, a salt is formed. The other product is water.

acid + base ⟶ salt + water

A salt is always the product of a neutralisation reaction.

For example:

acid		base		salt		
hydrochloric acid	+	sodium hydroxide	⟶	sodium chloride	+	water

NEUTRALISATION

Salt + Water

Figure 3.1 Neutralisation

Word help

acid: a solution which turns litmus paper red.
base: a solution which turns litmus paper blue.
neutralisation: a reaction in which an acid reacts with a base to give a salt and water.

Activity 3.1 Practical

Work in a group

To demonstrate acid-base reactions
Aim: To investigate the effect of adding a base to an acid

You will need:
- 2 plastic beakers
- measuring cylinder
- stirring rod
- plastic pipette
- litmus paper
- dilute hydrochloric acid
- sulfuric acid
- sodium hydroxide

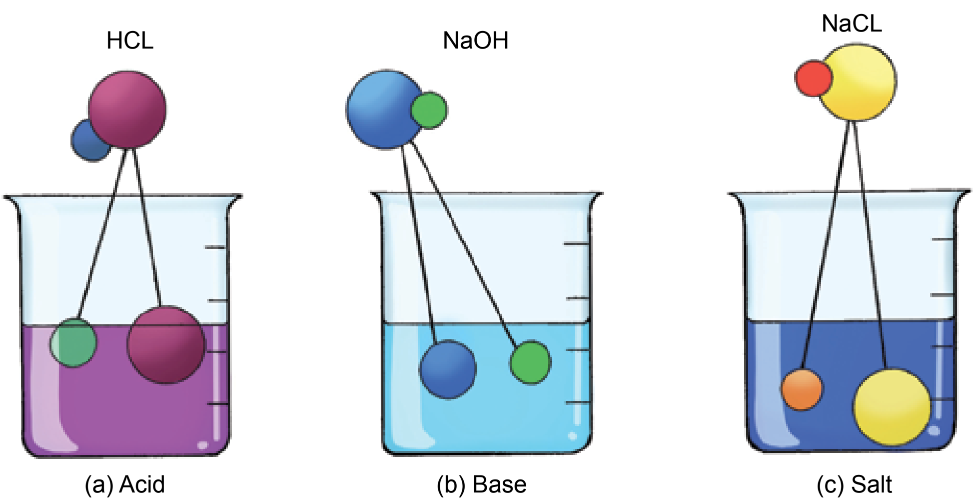


Figure 3.2 Neutralisation in action

Method
Follow the instructions.
1. Using the measuring cylinder, pour 5 ml of dilute hydrochloric acid into one of the beakers.
2. Using the stirring rod, put a drop of the acid onto the litmus paper. Note the colour change of the litmus paper.
3. Add five drops of sodium hydroxide to the acid and stir with the rod.
4. Again put a drop onto the litmus paper and observe the colour.
5. Repeat this until no further colour change is noted.
6. Repeat this using the sulfuric acid in place of the hydrochloric acid.

Observations and results

Note how the colour of the litmus paper changed as the base was added.

Conclusion

An acid added to a __________ results in __________ and _________ being formed. Initially, the acid turned litmus paper ______. As more base was added to the acid, the solution turned litmus paper __________ until no more colour change was noted and the solution was said to be ___________________.

Questions

Answer the questions.

1. Was a salt produced in these reactions? Explain your answer.
2. The salt formed in a neutralisation reaction depends on the acid and base used. Name the salt formed in the following reactions:
   a) hydrochloric acid + sodium hydroxide
   b) sulfuric acid + sodium hydroxide
   c) hydrochloric acid + sodium carbonate

Activity 3.2

Work on your own

1. a) An acid turns litmus paper ______________.
   b) A base turns litmus paper ______________.
   c) How do you know when there is no more acid left in the reaction, that is, it is neutralised?
2. A ___________ and _____________ are always the products of a neutralisation reaction.

Summary

- Solutions could be acid or base.
- An acid solution has a burning effect and turns litmus paper red.
- A base will turn litmus paper blue and can be used to neutralise an acid solution giving a salt and water.

Topic assessment

Answer the questions.

1. You suffer from severe acid reflux. You can choose between vinegar (acetic acid) and baking soda (sodium bicarbonate) to neutralise it. Which do you choose? Explain your answer. [3]
2. Often in an acid-base reaction, we know a salt is formed but we can't see it. Why is this? [2]
3. Why do lemons taste sour? [1]

[6]

Something interesting

Our stomachs use strong hydrochloric acid to help us digest our food.

Something interesting

Burning coal releases sulfur dioxide gas, which mixes with water vapour to make sulfuric acid. This comes down to earth as acid rain and causes a lot of destruction.

Something interesting

Though chemical engineering or pharmaceutical jobs are obvious careers that use bases, there are many others. People can work in water purification or manufacturing. Cookery is also an option. This is because acids and bases are the foundation of many chemical reactions that occur when food is prepared. They can enhance flavour, tenderise seafood and meat, make baked goods rise properly and even put out a kitchen fire.

Topic 4 Industrial processes

Learning objectives	Activities
• Outline the manufacture of soap	• Making soap • Visiting soap-manufacturing companies

In Form 1 in industrial processes you learnt how to make peanut butter. You also learnt about how to identify acids and bases using litmus paper as well as the general properties of acids and bases. This is particularly relevant in this chapter as you will see that bases are a key component of soap.

Figure 4.1 Examples of different kinds of soaps

Production of soap (saponification)

Soap is made from reacting a fat (from plants or animals) or oil (or a mixture) with a strong base (a solution that turns litmus paper blue). **Strong bases**, for example sodium hydroxide (**lye** or caustic soda) or potassium hydroxide (caustic potash), are those bases that completely dissociate in water into the cation (positively charged ion) and OH^-(hydroxide ion).

The soap-making reaction is called **saponification**, and after reacting, the mixture is said to be saponified. Saponification involves reacting the fat or oil with a strong base, usually sodium hydroxide, or potassium hydroxide and salt. The saponification reaction is **exothermic**, this means that heat is liberated during the process. The addition of salt causes the soap to form a solid that excludes impurities, such as the sodium hydroxide. This soap is suitable not just for washing clothes or pots, but also for use on skin.

Word help

exothermic: heat is released during the chemical process.
saponification: the process of making soap.
leach: to remove certain soluble substances from something else by filtering water through it.
lye: sodium hydroxide or caustic soda.
glycerin: a sweet, syrupy liquid obtained from animal fats and oils or by the fermentation of glucose.
strong base: a bases that completely dissociates in water into the cation (positively charged ion) and OH^-(hydroxide ion).

This reaction breaks the fat or oil into one-third glycerin and two-thirds soap molecules. The glycerin is then often removed and sold to other companies to make explosives or fertiliser. However, if you refine the solid soap, add sugar and alcohol, and skim off the impurities, you get glycerin soap. Glycerine keeps the soap moist.

The reactions during the saponification process are:

Sodium hydroxide + oil/fats ⟶ heat + soap + glycerin
(hard soap)

Potassium hydroxide + oil/fats ⟶ heat + soap + glycerin
(soft soap)

Activity 4.1 Practical

Work in a group

Making soap
Aim: To make soap

You will need:
- 100 cm^3 beaker
- water bath
- glass stirring rod
- 2 test tubes
- spatula
- funnel
- filter paper
- 10 ml sodium hydroxide solution
- 5 ml ethanol
- 10 g sodium chloride (salt)
- small block plant/animal fat
- litmus paper
- water

Safety

Sodium hydroxide is extremely dangerous. It can cause skin damage, blindness (with eye contact) and death (if eaten). Do wear goggles, rubber gloves, long-sleeved shirts and trousers when using it. Any spills on your skin and eyes should be flushed with water for 30 minutes.

Figure 4.2 Making soap with sodium hydroxide (lye)

Method

Follow the instructions.

1. Place the fat (2 cm^3) and 5 ml ethanol into a beaker. Stir with a glass rod to mix.
2. Put a drop of this mixture onto the litmus paper.
3. Add 10 ml sodium hydroxide solution.
4. Put the beaker into the prepared water bath and stir for 5 minutes.
5. Put a drop of this mixture onto the litmus paper.
6. In a separate test tube, make a saturated solution of sodium chloride in water, that is, add sodium chloride until it no longer dissolves.
7. After 5 minutes, add the saturated sodium chloride solution to the small beaker and stir.
8. Cool the mixture by changing to a cold-water bath (or an ice bath if available).
9. Soft, white lumps of the soap will gradually form in the mixture. Leave for a few minutes to improve the yield. During this time the soap may rise to the surface and form a soft crust on cooling.
10. Using the funnel and filter paper, filter off the soap, breaking up the crust with a glass rod if necessary.
11. Allow the soap to drain on a paper towel – do not touch it with your fingers, as it may still contain sodium hydroxide.
12. Use a spatula to transfer a little of the soap to a test tube, and add a few ml of water. Shake well.

Observations and results

1. What colour is the litmus paper at Point 2?
2. What colour is the litmus paper at Point 5?
3. How much sodium chloride did you need to add to the water before the solution was saturated?
4. Where do you think the heat is coming from?
5. Why should you be careful with sodium hydroxide?
6. Record any other observations you think may be important.

Conclusion

The white suspension formed is made up of soap and glycerin. The process of formation of soap is called ____________.

The final solution turned litmus paper __________ showing that soap suspension is ___________ in nature.

Question

Answer the question.

1. What happened when you shook the test tube of soap and water?

Activity 4.2 Field trip

Whole class activity

Visit to a soap-making company

Follow the instructions.

1. Bring a notebook and write careful notes of ingredients used in the soap.
2. Take note of any explanations of the chemical processes taking place.
3. What equipment do you see being used?
4. How do staff members working at the company protect themselves from strong chemicals?
5. What other facts do you think are important?
6. In groups of three or four, prepare a report on what you have seen or learnt.
7. Use hand sketches or photos if you have these to illustrate your points.

Summary

- When producing soap one has to use strong bases.
- When soap is produced it is saponified using fat or oil and a strong base.
- Heat is released during the chemical process

Topic assessment

Answer the questions.

1. Give two examples each of an animal fat and a plant fat which could be used in soap making. [4]
2. Give a brief outline of the process of making soap. [3]
3. There is a step in saponification called "salting out." Can you suggest which step this would be? [1]
4. What is lye? [1]
5. What does saponification produce other than soap? [1]

[10]

Something interesting

Traditionally, soaps were made from animal fat and lye (NaOH). (Lye was traditionally made by pouring water through wood ashes.)

Something interesting

Sodium hydroxide is a good example of a strong base. Sodium hydroxide is also called lye. The traditional way to make lye is to leach ashes with water. **Leaching** means to remove certain soluble substances (in this case the sodium hydroxide) from something else (the ashes) by filtering water through it. The sodium hydroxide, which dissolves in the water, forms a solution of sodium hydroxide (lye water).

Indigenous knowledge

The plant Ruredzo/Inkunzane (commonly known as Devil Thorn) has in the past been used in Zimbabwe as soap and shampoo. These days it is promoted in health stores as a healthier soap/shampoo to use.

[a/w 4.3]Photo of the ruredzo plant

Figure 4.3 Ruredzo is the vine like plant that grows on the ground and has purple flowers

Careers

A career in soap making is a great option if you'd like to work from home. These can be produced to supply hotels, guesthouses or individuals. Soap making has great scope for creativity with the introduction of different scents, oils and other ingredients.

Topic 5 Oxidation and reduction

Learning objectives	Activities
• Write simple word equations	
• Define oxidation and reduction in terms of oxygen	• Burning magnesium ribbon
• Distinguish between physical and chemical changes	• Melting ice, burning sugar/mealie meal

In Form 1, you learnt that rusting is a chemical process that occurs when iron is exposed to oxygen and water.

Chemical reactions

In this chapter, we will explore rusting further and describe some examples of oxidation and reduction reactions. **Oxidation** is a reaction in which oxygen is added to a substance. **Reduction**, on the other hand is when oxygen is removed from a substance.

When two substances are reacted together and their original properties change, a **chemical reaction (change)** is said to have taken place. An example of a chemical change is when you heat iron filings and sulfur powder. A solid mixture is formed, which is not at all the same as the original mixture. It looks very different and its properties are different. Whereas iron filings in the original mixture are attracted to a magnet, this new substance is not. Therefore a chemical reaction has taken place.

A chemical reaction results in a new substance being produced. The new substance in the example above is a **compound** called iron sulfide. You will recall from Form 1 – Matter that a compound contains atoms of different chemical elements joined together.

Word help

chemical change: usually involves a change in appearance (e.g. colour) or a detectable energy change (e.g. involving heat, light or sound); **all** chemical reactions involve the formation of **one or more new substances.**
compound: a substance formed when two or more chemical elements are chemically bonded together.
oxidation: a reaction in which oxygen is added to a substance.
oxidising agent: a substance that adds oxygen to, or removes hydrogen from another substance.
reduction: the removal of oxygen from a substance.
reducing agent: a substance that removes oxygen from a substance.

This chemical reaction that has taken place can be expressed in the following word equation:

iron + sulfur ⟶ iron sulfide

The compound formed does not have any of the properties of iron and sulfur.

Another example of a chemical reaction is the one seen when magnesium burns in air (containing oxygen) to form magnesium oxide. This reaction can be expressed in the following word equation:

magnesium + oxygen ⟶ magnesium oxide

When carbon is burnt in air, carbon dioxide is formed:

carbon + oxygen ⟶ carbon dioxide

When sulfur is burnt in air, sulfur dioxide is formed:

sulfur + oxygen ⟶ sulfur dioxide

These are three examples of a chemical reaction called **oxidation**, which you will remember is a change in which oxygen is added to the element.

In each case oxygen is added to the element. The element is oxidised during combustion. Oxygen is the oxidising agent.

The opposite happens when a metal oxide reacts with hydrogen. Here, hydrogen is the reducing agent. A reducing agent removes oxygen. Copper oxide is reduced.

copper oxide + hydrogen ⟶ copper + water

Oxidation and reduction reactions are summarised in Table 5.1.

Table 5.1 Defining oxidation and reduction in terms of oxygen

Oxidation	**Reduction**
Addition of oxygen	Removal of oxygen
Oxidising agent	**Reducing agent**
Adds oxygen	Removes oxygen

Physical and chemical change

As mentioned above, a chemical change results in the formation of a new compound with different properties from the original elements. Chemical changes are not easily reversible. For example, burning magnesium ribbon in air, burning a piece of paper in the fire and rusting. These are all oxidation reactions.

In everyday life chemical changes are also visible. For example, burning sugar involves a chemical change. Fire (through the process of combustion) activates a chemical reaction between the sugar and the oxygen. The oxygen in the air reacts with the sugar and the chemical bonds are broken. The same would apply if mealie meal was burnt.

In contrast, a **physical change** does not result in a new substance being formed and these reactions are easily reversed. For example, mixing sugar in water. The sugar and water still keep their properties (the sugar is still sweet and the water still turns cobalt chloride paper pink). The mixing can easily be reversed since the sugar and water can be separated. Another example of a physical change is mixing iron filings with sand. No new substance is formed, and the two substances can be easily separated using a magnet. Changes of state are also an example of a physical change. (Remember kinetic theory from Form 1 – Matter?) For example ice forming or melting. No new substance is formed, and the change of state can be easily reversed.

Figure 5.1 A mixture of sand and iron filings can be separated by using a magnet.

Activity 5.1 Practical

Work in a group

An experiment to demonstrate a physical change
Aim: To investigate the changes that occur when ice melts and then freezes

Word help

physical change: does not result in a new substance being made; easily reversible.

- **You will need:**
- Bunsen burner
- beaker
- freezer
- ice blocks

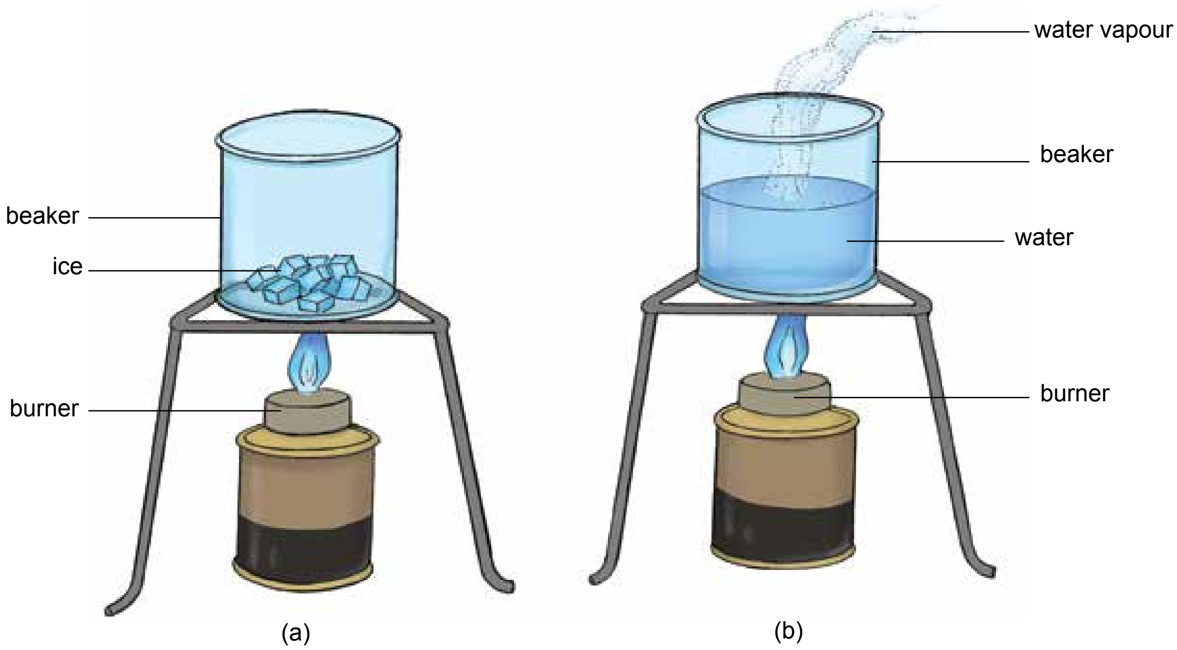


Figure 5.2a Ice melts to form water; b) water evaporates to form water vapour

Method

Follow the instructions.

1. Place three blocks of ice in the beaker and place over a gentle flame.
2. Continue heating until the ice has melted.
3. Turn up the flame and continue heating until you see steam.
4. Remove from the heat and allow to cool.
5. Pour the water in the beaker into an ice tray and place in the freezer for a few hours.

Observations and results

1. What happens when heat is added to the ice blocks?
2. What happens to the water?
3. What happens when the water is placed back in the freezer?

Conclusion

When the ice cube is melted, a __________ change occurs. If we freeze it, it becomes ice again (the change is _____________), with the same properties it had when it was previously a solid. Finally if the liquid is heated more, the particles can move around freely as they become ___________. They are the same particles but they have changed the way they move.

Questions
Answer the questions.
1. Melting ice is an example of a physical change. Explain why.
2. Give another example of a physical change.
3. Is freezing water to make ice a physical or a chemical change? Explain your answer.
   Look at the word equation below for this reaction:

   ice ↔ water ↔ steam

What do you think the reverse arrows mean?

Activity 5.2 Practical

Work in a group

An experiment to demonstrate a chemical change
Aim: To investigate the changes that occur when a magnesium ribbon and sugar are burnt

You will need:
- tongs
- Bunsen burner
- sandpaper
- magnesium ribbon
- teaspoon of sugar

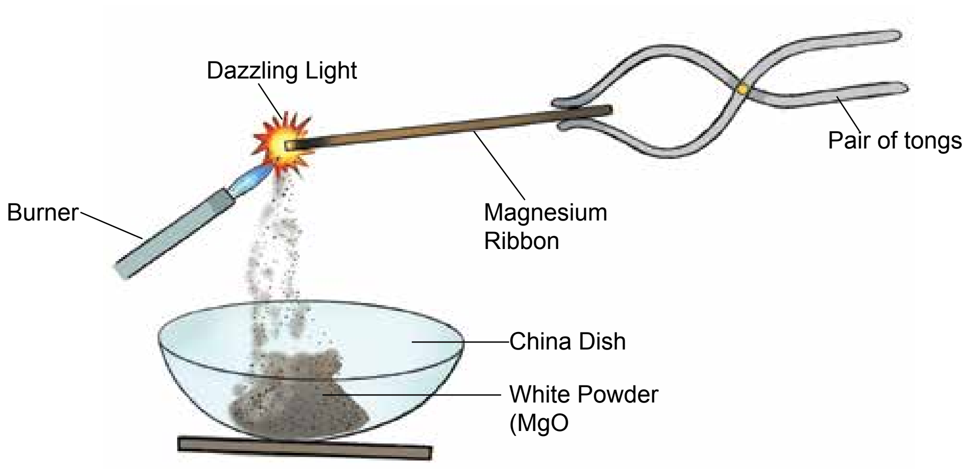


Figure 5.3 The burning of magnesium in air is an example of a chemical reaction

Method
Follow the instructions.
1. Clean a piece of magnesium ribbon with sandpaper.

2. Examine the magnesium and describe the physical properties of the element.
3. Hold the magnesium ribbon with the tongs and heat it in the flame until it ignites.
4. Do not look directly at the burning magnesium.
5. Remove the magnesium from the flame. It will continue burning for a while.
6. When the magnesium has finished burning, examine the new compound.
7. Now repeat the same process by burning a teaspoon of sugar.

Observations and results

1. How does the magnesium ribbon look before it is burnt?
2. What happens when the magnesium burns?
3. Describe the appearance of the new compound.
4. How does the sugar look before it is burnt?
5. What happens when sugar burns?
6. Describe the appearance of the new compound.

Conclusion

The new compound formed when magnesium is burnt is called ___________ ___________. When sugar is burnt, it forms a new ___________. These are examples of ___________ reactions.

Questions

Answer the questions.

1. Write the word equation for the reaction.
2. What acts as the oxidising agent?
3. Is this a chemical or a physical change? Explain your answer.
4. Is the magnesium oxidised or reduced? Explain your answer.

Activity 5.3

Work on your own

1. During an oxidation reaction, the oxidising agent is _____________.
2. During a reduction reaction, the reducing agent is _____________.
3. When an element is oxidised, it _____________ oxygen.
4. When a metal oxide is reduced, it _____________ an oxygen.
5. Explain the difference between a chemical change and a physical change.

Summary

- When oxygen is added in a reaction it is called oxidation.
- The reverse of oxidation is reduction. This is when oxygen is removed from a substance during reaction.
- A new compound with different proporties is formed when a chemical change happens.
- No new substance is formed when physical change takes place and those can be easily separated.

Topic assessment

1. Here is the word equation for the reaction between copper oxide and hydrogen:
   copper oxide + hydrogen ⟶ copper + water
   a) What has happened to the oxygen in the copper oxide?
   b) Which substance has been reduced?
   c) Which substance has been oxidised?
   d) Is this a chemical or a physical change? [4]
2. The oxidation of iron is called rusting.
   a) What is the chemical name for rust?
   b) Write a word equation to show rusting
   c) Name the oxidising agent.
   d) Is this a chemical or physical change? [4]
3. Give two different examples of reduction reactions. [2]
4. Give 2 different examples of oxidation reactions. [2]
5. A piece of bread is toasted. Is this a chemical or a physical change? [1]
6. In which reaction is the underlined substance oxidised?
   copper oxide + <u>hydrogen</u> ⟶ copper + water
   <u>iron oxide</u> + carbon monoxide ⟶ iron + carbon dioxide
   magnesium + oxygen ⟶ <u>magnesium oxide</u>
   <u>nitrogen</u> + hydrogen ⟶ ammonia [4]

[17]

Something interesting

Explosives are single chemical substances that contain strong oxidising agents and strong reducing agents in the same molecule, or they are mixtures of a strong oxidising agent and a strong reducing agent.

Indigenous knowledge

Zimbabwe has many rock art sites, some better preserved than others. The oldest Zimbabwe paintings (Matobo) are estimated to be around 7000 years' old. The paint used in these early African cave paintings consisted mostly of earth pigments. Many relied on oxides. For example yellows, orange and reds came from ochre (a natural pigment containing hydrated iron oxide) and white from zinc oxide.

Figure 5.5 Matobo rock art using oxides

Learning objectives	Activities
• Define complete and incomplete combustion of fuels	• Lighting burners (methylated spirits) with long and short wicks/paraffin stove
• List the products of complete and incomplete combustion of fuels	• Lighting Bunsen burner sleeve wide/ narrow
• Describe the effects of burning fuels	• Carrying out environmental campaigns

In Form 1 you learnt about the different types of fuels. In Topic 5, you learnt that **combustion** requires oxygen and is therefore an oxidation reaction.

Complete and incomplete combustion

In this chapter we will explore complete and incomplete combustion and their effects on our environment. When a fuel combusts, it does so in the presence of oxygen. When a fuel burns in plentiful oxygen supply, it produces carbon dioxide and water. This is **complete combustion**. For example when petrol burns, it can be represented by the following word equation:

$$\text{petrol} + \text{oxygen} \longrightarrow \text{carbon dioxide} + \text{water}$$

This is an example of complete combustion.

When there is insufficient air (oxygen), there is **incomplete combustion** and **carbon monoxide** and **soot** may be produced. Carbon monoxide is a poisonous gas and it is never recommended to make a fire indoors when all the windows are shut. Soot is the black substance that comes from fires and the exhausts of buses and lorries. It pollutes the air and causes **smog** over cities. An example of incomplete combustion is shown in the following word equation:

Word help

combustion: the burning of a substance, an oxidation process.
complete combustion: the burning of a substance in plentiful oxygen; carbon dioxide and water are the products.
incomplete combustion: the burning of a substance in insufficient oxygen; carbon, carbon monoxide, water.
carbon monoxide: a colourless, odourless toxic flammable gas formed by incomplete combustion of carbon.
soot: a black powdery or flaky substance consisting of carbon, produced by the incomplete burning of organic matter.
smog: fog or haze combined with smoke and other atmospheric pollutants.

petrol + oxygen $\longrightarrow$ carbon monoxide + carbon + water

When the fuel in the carbon is oxidised to carbon dioxide, more energy is released than when the carbon is only partially oxidised to carbon monoxide. Incomplete combustion is therefore wasteful.

[a/w 6.1]Photo of smog
over a large city

Figure 6.1 Smog over a large city

Activity 6.1 Practical

Work in a group

Investigating the efficiency of a methylated spirit burner
Aim: To compare the efficiency of a methylated spirit burner with a long and short wick.

You will need:
2 methylated spirit burners, one with a short wick and the other with a long wick
matches

Method
Follow the instructions.
Light both burners and allow to burn for five minutes.

Observations and results
1. Observe the size and colour of both flames.

2. Did one of the burners produce more smoke and soot?
3. How did the flame from the other burner seem?

Conclusion

The ____________wick resulted in a clean flame and very little smoke and soot. This is because the combustion was ______________. The products of this were _____________ and _______________.

The ______________ wick resulted in a less clean flame and produced black smoke (soot). This is because the combustion was ________________.

Question

Answer the question.

1. Explain your observations in terms of length of wick and complete/incomplete combustion.

Activity Practical 6.2

Work in a group

Investigating the efficiency of a Bunsen burner flame

Aim: To compare the efficiency of a Bunsen burner flame with the air-hole open and the air-hole closed

You will need:

- Bunsen burner
- beaker
- thermometer
- clock
- water

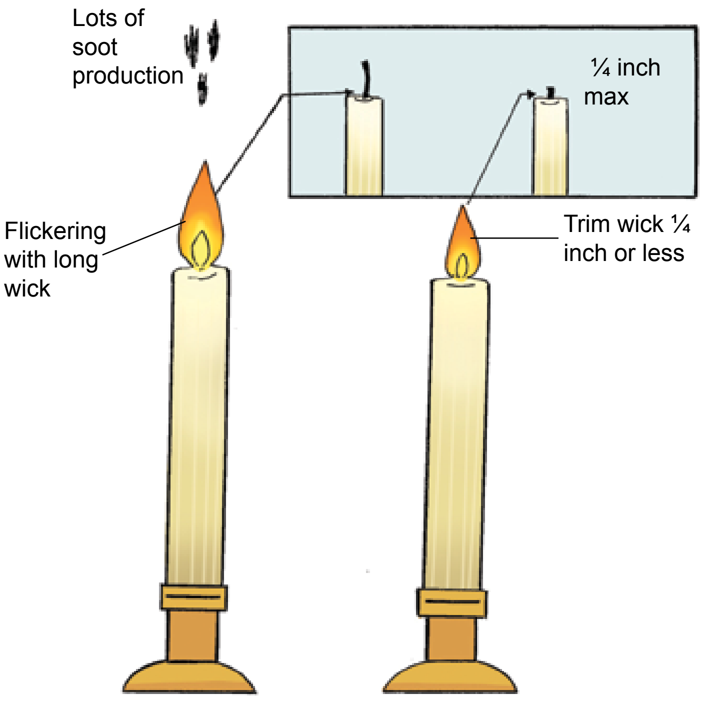


Figure 6.2 Long wick versus short wick for complete combustion

Method

Follow the instructions.

1. With the air-hole on the Bunsen burner closed, record the time taken for the temperature of 100 cm^3 of water to rise by 10 °C.
2. Repeat the experiment with the same volume of water and the air-hole open.

Observations and results

1. Which flame heats the water more rapidly?
2. Describe how each flame looks. You can do this using a drawing if necessary.

Conclusion

When the air-hole is closed, _______ cannot mix with the gas before it burns. This results in ________________ combustion and a sooty flame is given off. This flame is not very efficient and does not give off as much _________ energy as the flame from the Bunsen with its air-hole open.

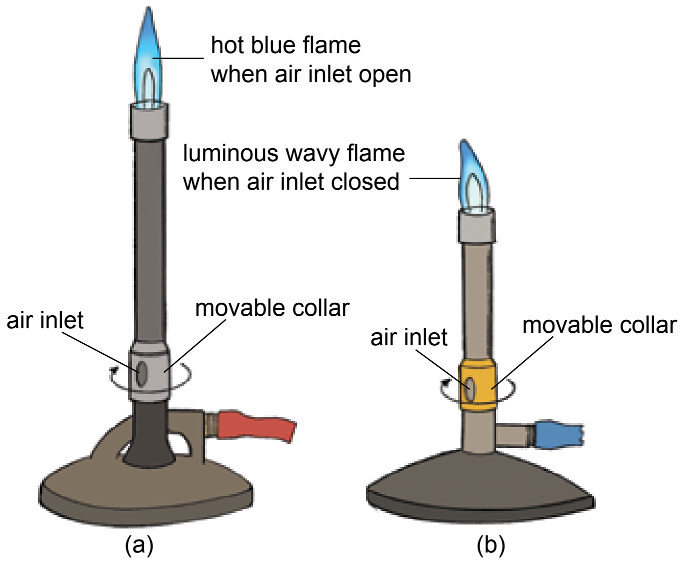


Figure 6.3 Air-hole of the Bunsen burner open and closed

Questions

Answer the questions.

1. Combustion is either complete or incomplete.
   a) Which type of combustion releases more heat energy?
   b) Which is more efficient?
   c) Name the products of both types of combustion.
   d) Is combustion an oxidation reaction or a reduction reaction?
2. Would soot more likely be produced when the air-hole is open or closed? Explain your answer.
3. The amount of air entering a car's engine is controlled by the choke. On a cold winter morning, to make starting the car easier, would you open or close the choke (that is, let more or less air in).

Effects of burning fuels

The combustion of fuels has caused enormous environmental problems. Valuable resources are being used up and pollution of the land, sea and air is increasing.

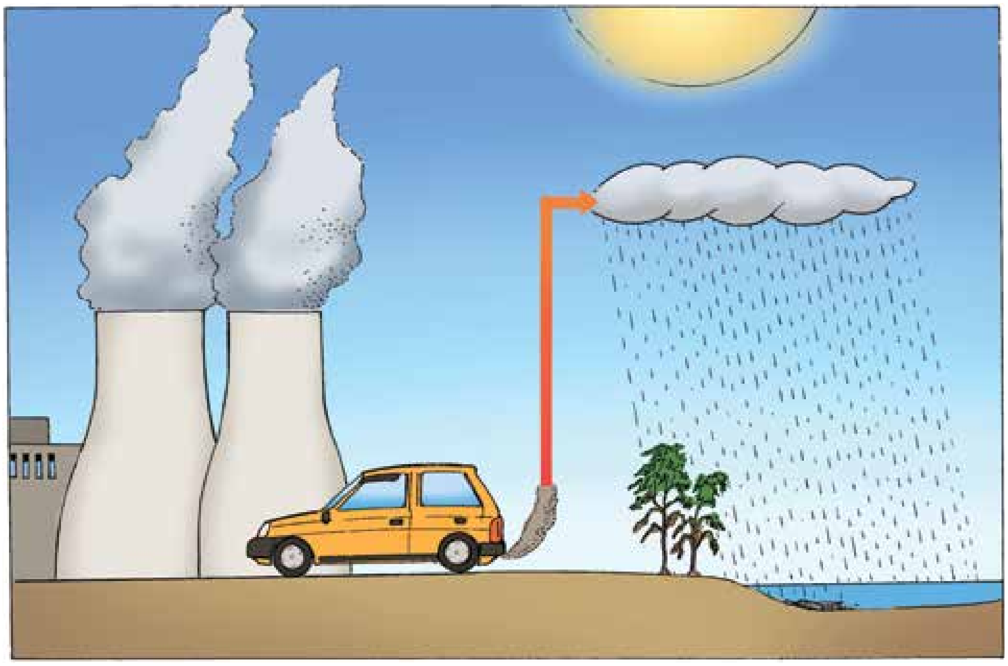


Figure 6.4 The effects of burning fuels on the environment.

Oil spills during the transport of this fuel are a serious problem associated with ruining sea shores and killing birds, fish and other marine life.

A car's engine does not burn petrol very efficiently as there is limited air. Therefore carbon (soot particles) and carbon monoxide are released from the exhaust into the air. Petrol additives, like lead compounds, are put in petrol to prevent sharp sounds caused by early combustion of part of the air-fuel mixture in the car. These additives do not burn, but vaporise and are present in high concentrations in the air of big cities. Lead compounds can cause brain damage.

When coal is burnt, the fuel releases waste gases, including carbon dioxide into the atmosphere causing pollution. The phosphorous and sulfur content in coal is oxidised producing acidic byproducts that make acid rain. Plants are damaged by acid rain and fish in lakes and rivers cannot tolerate acidic conditions.

Wood also gives off carbon and other toxic substances such as nitrogen oxides and sulfur dioxide when it is burnt.

Deforestation

Not only is the burning of wood causing pollution, but also large areas of Africa and other parts of the world are having their trees cut down for fuel. Trees are slow-growing plants and **reforestation** projects cannot keep up with the destruction (that is, we cannot plant and grow tress as fast as they are being chopped down). Plant and animal habitats are destroyed so that the land cannot support its normal animal population. **Deforestation** (loss of trees) on sloping ground often results in the loss of top-soil. Acid rain is also restricting the growth of trees.

Global warming

Burning any fuel has the undesirable effect of carbon dioxide produced being released into the atmosphere and trapping the sun's heat. Scientists have shown this has caused global temperatures to rise and ice caps to melt in an effect known as the **greenhouse effect**. Greenhouse gases such as water vapour, methane and carbon dioxide stop heat escaping from the earth into space. An increased greenhouse effect can lead to global warming and climate change.

Figure 6.5 The greenhouse effect

It is not just the release of carbon dioxide and methane that can contribute to global warming. Dust produced from factories can also go into the atmosphere and reflects radiation back to the earth. This also causes warming.

Word help

Chlorofluorocarbons (CFCs): nontoxic, nonflammable chemicals containing atoms of carbon, chlorine, and fluorine, often found in aerosol sprays.
deforestation: the clearing of trees.
global warming: heating of the earth and its environment due to radiation of the sun trapped by carbon dioxide and water vapours in the atmosphere.
greenhouse effect: when heat energy from the sun is trapped in the earth's atmosphere, much in the same way as a greenhouse, which traps heat with its glass.
reforestation: process of planting an area with trees.

However, it is not just human activities that can affect weather patterns and climate. Ash and gases released by volcanic eruptions also go into the atmosphere. They reflect radiation from the sun back into space, causing cooling. This, and other effects, can make it difficult for scientists to study the atmosphere and global warming.

Activity 6.3 Practical

Work in a group

Carrying out environmental awareness campaigns

1. Make a list of the issues around burning fuels. Together discuss solutions.
2. Split up and form a new pair. Discuss your findings from Step 1.
3. Now as a class, design a poster together with the conclusions from steps 1 and 2. Use crayons, newspaper or magazine clippings to put the poster together. Hang this poster outside your classroom for school mates to read.
4. When you go home today, speak to your family about what you have learnt. How much do they know about the greenhouse effect and global warming?

Summary

- Complete combustion occurs when there is plenty of oxygen during burning.
- Incomplete combustion occurs when oxygen is not sufficient hence carbon monoxide and soot is produced.
- Combustion of fuels causes pollution.
- When pollution is caused carbon dioxide in the atmosphere traps the sun's heat causing global warming.

Topic assessment

Answer the questions.

1. What is the name of the process that takes place when a hydrocarbon burns in air? [1]
2. What substance in air is reacting with the hydrocarbon when it burns? [1]
3. Give the word equation for the burning of petrol in plentiful air. [2]
4. Give the word equation for the burning of petrol in insufficient air. [2]
5. When fuels burn, it is known as a/an __________ reaction. Why is this? [2]
6. The reactions in human beings and in a car's engine that result in the release of energy can be written:

In humans:
sugar + oxygen $\longrightarrow$ carbon dioxide + water + energy

In a car's engine:

petrol + oxygen ⟶ carbon monoxide + carbon dioxide + water + energy

a) How do these equations suggest that human being are more efficient machines than a car's engine?

b) How could you attempt to prove whether sugar or petrol contained the greater amount of stored energy? [3]

[11]

Word help

carbon monoxide: a colourless, odourless toxic flammable gas formed by incomplete combustion of carbon.
Chlorofluorocarbons (CFCs): nontoxic, nonflammable chemicals containing atoms of carbon, chlorine, and fluorine, often found in aerosol sprays.
combustion: the burning of a substance, an oxidation process.
complete combustion: the burning of a substance in plentiful oxygen; carbon dioxide and water are the products.
deforestation: the clearing of trees.
global warming: heating of the earth and its environment due to radiation of the sun trapped by carbon dioxide and water vapours in the atmosphere.
greenhouse effect: when heat energy from the sun is trapped in the earth's atmosphere, much in the same way as a greenhouse, which traps heat with its glass.
incomplete combustion: the burning of a substance in insufficient oxygen; carbon, carbon monoxide, water.
reforestation: process of planting an area with trees.
soot: a black powdery or flaky substance consisting of carbon, produced by the incomplete burning of organic matter.
smog: fog or haze combined with smoke and other atmospheric pollutants.

Something interesting

Polar bears have become a symbol of global warming, because the Arctic landscape is one of the first to absorb the impact of rising temperatures. Warming temperatures melt polar ice and force animals like the polar bear to move farther south in search of food and other resources.

Indigenous knowledge

In Topic 5 Oxidation and reduction, you learnt about the rock paintings in Zimbabwe and the pigments used to make red, yellow and orange (ochre pigments containing hydrated iron oxide) and also white from zinc oxide. In this chapter we can add to this knowledge that black in these paintings was created from soot, which as you know from this topic is produced by the incomplete burning of organic matter (incomplete combustion).

Career

Working toward protecting the environment is a very important way of contributing to the future of the planet. Environmental science includes various fields, including information science, ecology, physics, zoology, geology, soil sciences, oceanology and even atmospheric science. Areas of study that are related are environmental engineering and materials engineering, where products are reengineered or recycled.

Section 3

Physics

Topic number	Topic	Learning objectives
1	Data presentation	• Construct a straight line graph from appropri-ate data • Interpret straight line graphs
2	Measurements	• Convert units • Measure mass of a liquid • Measure the volume of an irregular object • Determine the thickness, volume and mass of small objects • Calculate density
3	Forces	• Calculate the resultant of a pair of inline forces • Define moment of a force • Calculate moment of a force • State the principle of moments • Apply the principle of moments in simple cal-culations • Define friction • Measure friction • State the applications of frictional force • Define a machine • Construct a simple machine
4	Energy	• State the law of conservation of energy • Define work and energy • State the S.I unit of work and energy • Calculate the work done or energy used by forces • List sources of light energy • Show that light travels in a straight line • State the production and transmission of sound • Demonstrate the need for a medium in the transmission of sound

5	Magnetism	• Describe properties of magnets • State the law of magnetism • Draw magnetic fields
6	Electricity	• Define current and voltage • State the S.I units of current and voltage • Measure current and voltage • Determine electrical power

Topic 1 Data presentation

Learning objectives	Activities
• Construct a straight line graph from appropriate data	• Drawing a straight line graph from given data
• Interpret straight line graphs	

In Form 1 you learnt how to collect and represent data in the form of tallies, tables and bar graphs. You also learnt how to interpret data represented by tallies, tables and bar graphs. In this topic, you will learn how to construct and present data in the form of a straight line graph.

A straight line graph

A straight line graph is **constructed** by connecting data points with a straight line. The straight line passes through the **centre** of a **series** of points. The points are **plotted** on a system of axes, the *x*-axis and the *y*-axis. The *x*-axis is **horizontal**. The *y*-axis is **vertical**.

Point	Coordinate	
	x-value	*y*-value
A	1	1
B	3	3
C	5	5

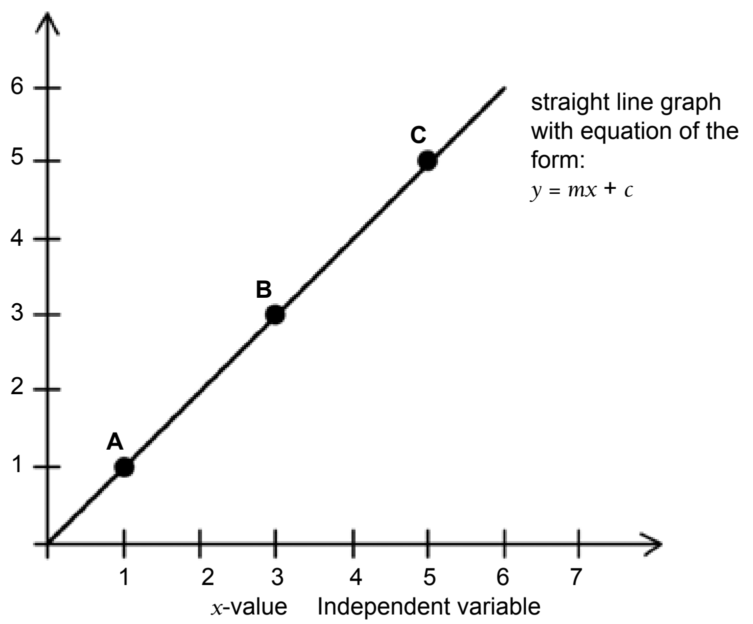


Figure 1.1A straight line graph passes the centre of all the data points

Word help

construct: draw a shape according to a set of instructions.
centre: the middle of a shape or object.
series: a number of things that are arranged one after the other.
plot: draw points on a graph with a system of axes.
horizontal: moving from right to left or left to right.
vertical: moving up and down.

Each point is a **coordinate**. Each coordinate has a *x*-value and a *y*-value. The first number of the coordinate is the *x*-value (**independent variable**). The *x*-value is read from the horizontal *x*-axis. The second number of the coordinate is the *y*-value (**dependent variable**). The *y*-value is read from the vertical *y*-axis. The *x*-value and *y*-value of the coordinate tells you where the point is positioned on the graph.

Constructing a straight line graph

Straight line graphs are constructed from a given data set. For example, table 1 shows the distance travelled by a car and the time taken to travel that distance.

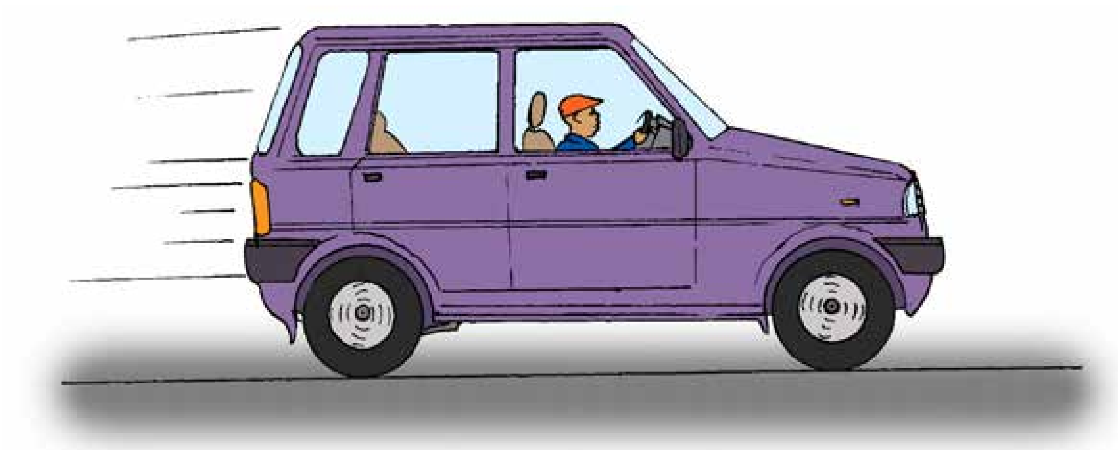


Figure 1.2 A moving car travels a distance in a certain time

Table 1 Data of distance travelled by a car and the time taken to travel the distance

Distance travelled (m)	0	10	20	30	40	50
Time (s)	0	5	10	15	20	25

Word help

coordinate: a set of values that show the exact position of a data point on a graph.
independent variable: the variable that changes by itself. For example: time is usually an independent variable because as far as we know the flow of time is independent of any physical cause.
dependent variable: the variable that changes as a direct result of the independent variable.

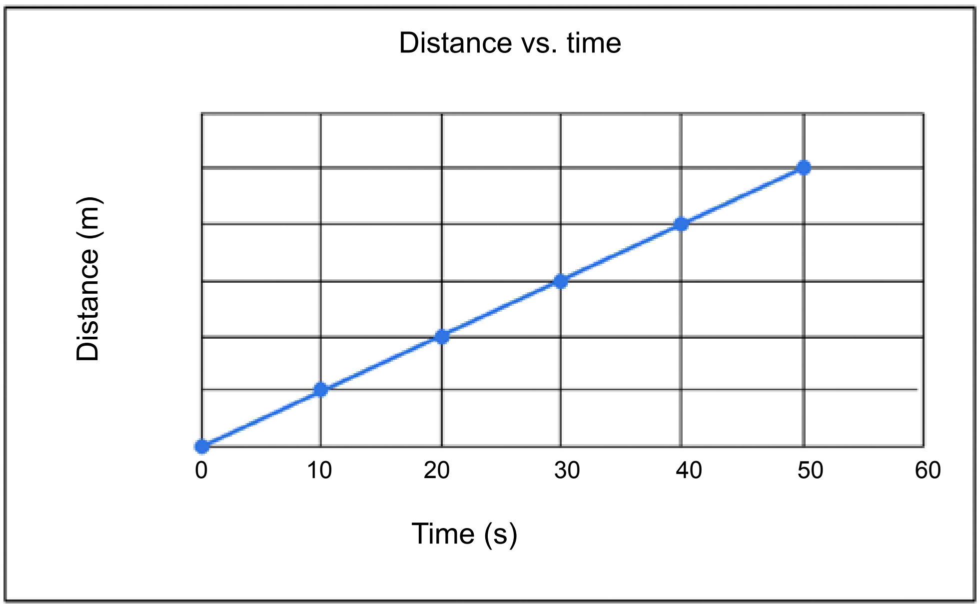


Figure 1.2 A straight line graph of distance vs. time travelled by a car

In figure 1.2, each coordinate is plotted on the graph as a point. A straight line is drawn through the centre of each point. Time is the independent variable and distance is the dependent variable.

The straight line graph shows us that the distance travelled by the car is **directly proportional** to the time taken. After 10 seconds, the car travels 5 metres.

What distance does the car travel after 20 seconds?

$$\frac{20\ seconds}{10\ seconds} = 2$$

Since distance is directly proportional to time, we can use this ratio to calculate the distance the car has travelled after 20 seconds.

$$\frac{x}{5\ meters} = 2$$

$x = 2 \text{ x } 5$
$x = 10m$

After 20 seconds, the car travels 10 metres.

Interpreting a straight line graph

We can determine the equation of the straight line graph in Figure 1.2.
The equation of a straight line is:

$$y = mx + c$$

Where:
x is the x -value of a coordinate
y is the y -value of a coordinate
m is the gradient of the straight line
c is the value on the y-axis where the straight line **intersects** the y-axis

We first need to find the gradient (m) of the line.
The gradient tells us the **rate** at which the distance changes with time.

To find the gradient of a straight line:
a) choose two points on the straight line.
b) construct a right-angled triangle with the straight line graph as the **hypotenuse**.
c) use the scale on each axis to find the triangle's:
   i. vertical length
   ii. horizontal length

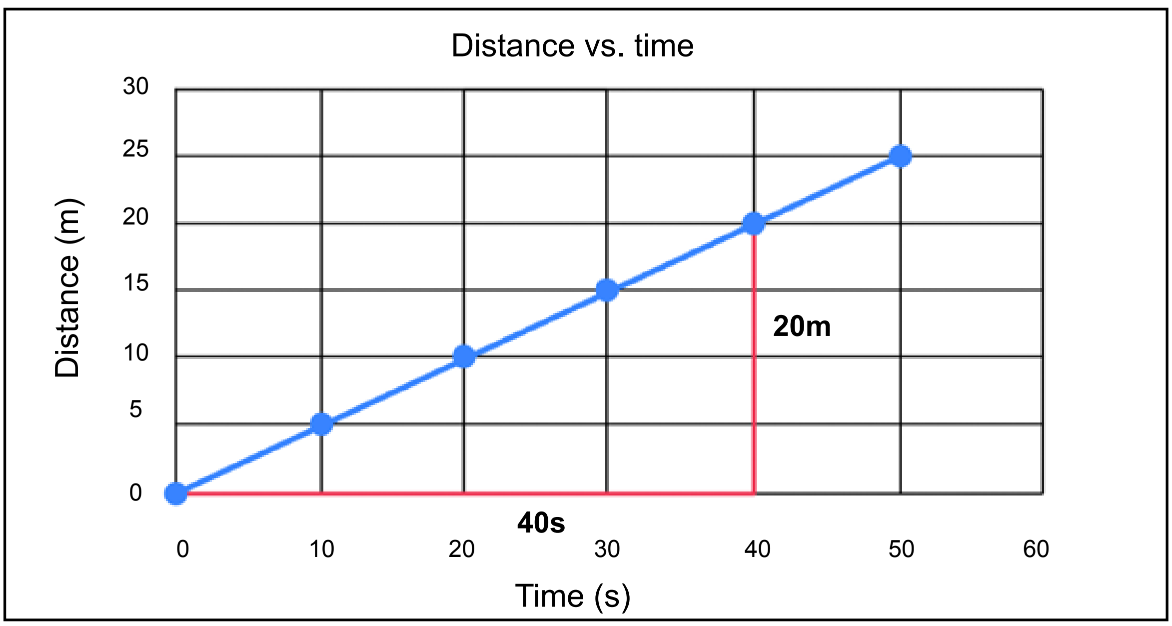


Figure 1.3 Determining the gradient of the straight line graph using a right-angled triangle.

Word help

directly proportional: as one amount increases, the other amount increases at the same rate.
intersect: meet at one point.
hypotenuse: the longest side of any right-angle triangle.
rate: a ratio that compares two quantities that have different units of measure.

To find the gradient:

$$m = \frac{\textit{vertical length}}{\textit{horizontal length}} \quad \text{or} \quad m = \frac{\textit{change in distance}}{\textit{change in time}}$$

$$m = \frac{20}{40}$$

$$m = \frac{1}{2}$$

The gradient of the graph is $\frac{1}{2}$. The gradient is also the speed that the car is traveling in metres per second (m/s).

The equation of the straight line is:

$$y = \frac{1}{2}x + c$$

We need to determine the value of c.
The straight line intersects the -axis at $y = 0$. Therefore, $c = 0$.

The equation of the straight line is:

$$y = \frac{1}{2}x + 0$$

$$y = \frac{1}{2}x$$

Why is this equation important?
We can use this equation to **predict** the distance the car has travelled after a certain time, if it continues to move at the same speed.

Example 1: Use the equation to determine the distance the car has travelled after 100 seconds.

$$y = \frac{1}{2}x$$

Time is on the -axis, therefore seconds.

$$y = \frac{1}{2}(100)$$

$$y = 50m$$

The car has travelled 50 metres after 100 seconds.

We can also use the equation of the line to predict the time the car would have taken to travel a certain distance.

Example 2: Use the equation to determine the time taken for the car to travel 60 metres.

$$y = \frac{1}{2}x$$

Distance is on the -axis, therefore metres.

$$60 = \frac{1}{2}x$$

$$x = 60 \times 2$$
$$x = 120s$$

The car has travelled 60 metres in 120 seconds.

Activity 1.1

Work on your own

Draw and interpret a straight line graph

1. Given the data in Table 1.2, construct a straight line graph.
   a) Give the graph a suitable heading.
   b) Label the -axis: Day.
   c) Label the -axis: Height (mm).
   d) Find the equation of the straight line graph.
   e) Use the equation to calculate the height of the bean plant on day 20.

Table 1.2: Data for the height of a bean plant in the first two weeks of growth.

Day	0	2	4	6	8	10	12	14
Height (mm)	40	60	80	100	120	140	160	180

Figure 1.5 A germinating bean plant

Activity 1.2

Draw and Interpret a Straight line graph using Microsoft Excel

- Input the data given in table 1.2 into Microsoft Excel.
- Plot a graph using the Insert Chart tool.
- Use Excel to find the equation of the line.
- Check if this equation is the same as the equation you calculated in Activity 1.1.

Summary

- A straight line graph is constructed by connecting data points with a straight line.
- The equation of a straight line is: $y = \frac{1}{2}x + c$.
- We can use the equation of a straight line to make predictions that are not shown on the straight line graph.

Topic assessment

Answer the questions.

1. Define a straight line graph. [1]
2. The data in table 1.3 forms a straight line graph. Determine the gradient of the straight line.

x-value	y-value
2	1
4	2

[2]

3. Karabo is filling his water storage container with water from the tap. His water tank can hold a maximum of 42 litres of water. He records the total volume of water in the tank after every minute. Karabo presented his results as straight line graph.

Figure 1.6 Filling a water storage container with water from a tap

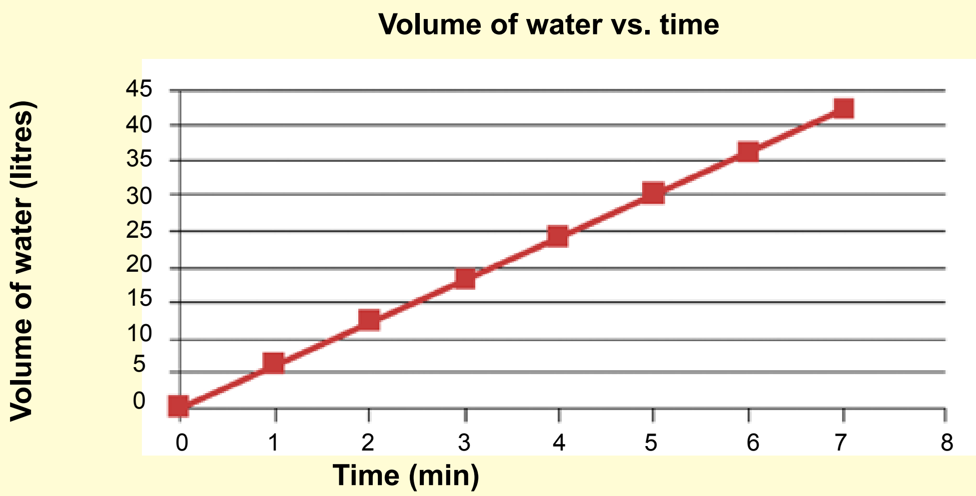


Figure 1.4 Straight line graph of volume of water vs. time

Use the graph to answer the following questions.

a) How long did it take Karabo to fill his water tank [1]

b) What was the volume of water in the tank at 4 minutes? [1]

c) If Karabo had a larger tank, what volume of water would he have after 10 minutes? [5]

[Total: 10 Marks]

Topic 2 Measurements

Learning objectives	Activities
• Convert units	• Converting metre to centemetre, millimetre, kilogram to gram, hour to minutes, minutes to seconds
• Measure mass of a liquid	• Carrying out experiments on measurement by differences of mass
• Measure volume of an irregular object	• Carrying out experiments on measurements of irregular objects
• Determine thickness, volume and mass of small objects	• Carrying out experiments on measurements of volume, thickness and mass
• Calculate density	• Carry out experiments to find mass and volume

In Form 1 you learnt how to measure physical quantities, for example length, time, temperature, and mass of a solid.

You also learnt about estimations, measuring instruments and how to measure accurately. In this topic, you will learn how to estimate and determine the thickness, volume, mass and density of a liquid and small objects.

Measurements of physical quantities

For scientists to understand the world, they need to be able to estimate and measure physical quantities accurately with appropriate measuring instruments. We read the scale on a measuring instrument to get the measure/size of a physical quantity.

A physical quantity is a **property** of an object or substance that can be measured using an appropriate measuring instrument. Examples of physical quantities are length, time, mass and temperature. Measuring instruments have specific scales that are marked according to the internationally recognised system of SI units.

Word help

property: a quality a material or object has.

Table 2.1 Some physical quantities and their SI units

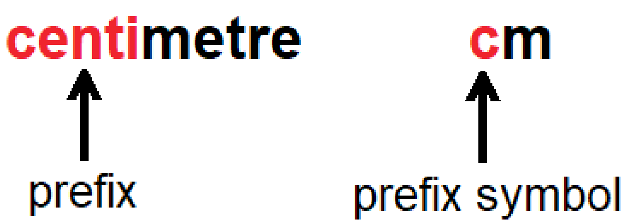
Physical quantity	SI unit	Symbol
length	metre	m
mass	kilogram	kg
time	second	s
temperature	Kelvin	K

Something interesting

The international system of units (SI) was first adopted by France in 1799. It is now the most widely used form of measurement throughout the world.

Convert units

SI **prefixes** are used to **convert** units. We may want to convert units to avoid very large or very small numeric values. The prefix is attached in front of the name of a unit. The prefix symbol is attached in front of the symbol for a unit.



Conversions between units of length

In order to convert between different units we need to use a multiplication factor.
The SI unit for length is the metre (m).

Word help

prefix: group of letters placed in front of the root of a word.

metres to centimetres (cm)		
Conversion	**Multiplication factor**	**Example**
metres to centimetres	100	
centimetres to metres	100	

metres to millimetres (mm)		
Conversion	**Multiplication factor**	**Example**
metres to millimetres	1 000	
milliimetres to metres	1 000	

Conversions between units of mass

The SI unit for mass is kilogram (kg)

kilograms to grams (g)		
Conversion	**Multiplication factor**	**Example**
kilograms to grams	1 000	
grams to kilograms	1 000	

Conversions between units of time

The SI unit for time is seconds (s)

hours (hrs) to minutes (min)		
Conversion	**Multiplication factor**	**Example**
hours to minutes	60	
minutes to hours	60	

minutes (min) to seconds (s)		
Conversion	**Multiplication factor**	**Example**
minutes to seconds	60	
seconds to minutes	60	

Activity 2.1 Online task

Work on your own

Using the internet to convert between units of measure
Aim: To explore conversions between different length units.

You will need:
A computer or smartphone that is connected to the Internet
- Visit the Internet site: http://www.onlineconversion.com/length_common.html
- Choose the unit you want to convert from.
- Type the value of the unit you wish to convert.
- Select, in the right hand column, the units you wish to convert *to*.
- Click on "Convert" to see the answer.
- Calculate the multiplication factor.

Measurement of mass

Mass is the amount of matter in an object. Anything that takes up space is matter. An object that has more matter, will have a larger mass. The mass of an object can be measured with a balance. Mass is measured in kilograms.

Measurement of mass of a liquid

In Form 1 you learnt how to use a balance scale to measure the mass of solid objects. You will now learn how to measure the mass of a liquid.

Something interesting

The mass of water depends on the temperature of the water. Water has the largest mass at 4°C.

In order to measure the mass of a liquid we need to use:
- a container to keep the liquid in
- the liquid
- a balance

The container the liquid is poured into, has a mass. We need to subtract the mass of the container from the measured mass to determine the mass of the water.

Activity 2.2 Practical

Work in a group

Determining the mass of a liquid
Aim: To measure the mass of water in a beaker.

You will need:
- 250 ml beaker
- balance scale
- water

Method
Follow the instructions.
1. Place the empty beaker on the balance scale. Make sure the beaker does not fall and break.
2. Measure the mass of the empty beaker.
3. Pour 50 mℓ of water into the beaker.
4. Measure the mass of the beaker and the 50 mℓ of water.
5. Continue adding 50 mℓ of water until the volume of the water in the beaker is 200 mℓ. Measure the mass of the beaker each time.
6. Copy and complete table 2.2. Record your measurements in the second column of the table.
7. Subtract the mass of the beaker when you are calculating the mass of the water.

Table 2.2

Volume of water (ml)	Measured mass (g)	Mass of water (g)
0		
50		
100		
150		
200		

Questions
Answer the questions.
1. Why did you subtract the mass of the beaker to determine the mass of the water?
2. What is the relationship between the volume of water to the mass of water in grams?

Measurement of the volume of an irregular object

An **irregular** object does not have a specific shape. It is difficult to calculate the volume of an irregular shape by measuring the sides. You will not be able to measure the sides **accurately**. For example, a stone has an irregular shape because it is not a perfect sphere, cube, pyramid or even a hexagon! Therefore, we need to find another way of determining the volume of irregular objects.

We can **submerge** an object in water (or another liquid) in order to determine its volume accurately. When the object is placed in a container filled with water, the water level in the container will increase.

Thembi wants to determine the volume of her front door key. She tries to use a ruler, but the shape of the key is irregular. She decides to use a measuring cylinder filled with water to measure the volume of the key.

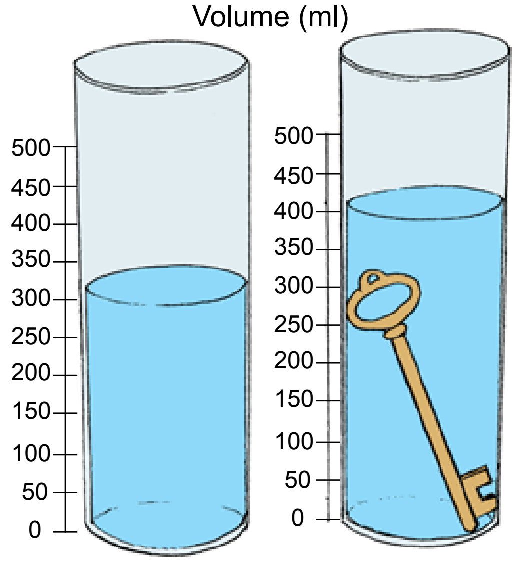


Figure 2.2 Thembi's key displaces the water and the water level rises

In Figure 2.2, Thembi fills a measuring cylinder with 350 mℓ of water. When she drops the key in the water, the volume of the water increases to 450 mℓ.

Word help

irregular: not following a usual pattern or shape.
accurate: without any errors.
submerge: place under water.

Thembi calculated the volume of the key:

key volume = 450ml – 350ml
= 100ml

100ml = 100cm3
Therefore, the key has a volume of 100 cm^3.

When we place an irregular object in a liquid, the object will **displace** the water. The volume of water that the object displaces is equal to the volume of the object. So if you measure the volume displaced, you measure the volume of the object.

Activity 2.3 Practical

Work in a group

Determining the volume of irregular objects
Aim: Determine the volume of irregular objects.

You will need:
- measuring cylinder or beaker
- overflow can
- 3 stones of different shapes and sizes. Make sure the stones can fit in the measuring cylinder.

Method
Follow the instructions.
1. Fill the overflow can up with water until the water pours out the spout.
2. When the water has stopped pouring out the spout, place the beaker under the spout.
3. Tie a piece of string to the stone.
4. Place the first stone in the overflow can. The displaced water will pour into the beaker.
5. Use the string to remove the stone from the overflow can.
6. Measure the volume of water from the beaker.
7. Repeat steps 1 to 5 for the other two stones.

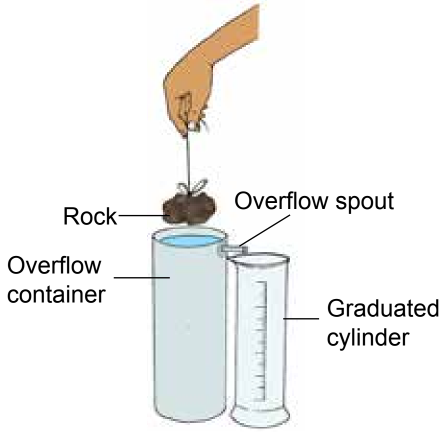


Figure 2.3 Measuring the volume of irregular objects

Questions
1. Would this method work for other irregular objects?
2. Why do we first fill the Overflow can up with water until the water comes out the spout?

Determining thickness, volume and mass of small objects

Sometimes we need to measure the length/size of very small objects, for example the thickness of one page of a book. The smallest **division** on a metre rule is one millimeter. The thickness of a page is less than one millimeter. We would need to read in between the divisions of a metre rule. The thickness of the page is so small that it cannot be measured accurately with a metre rule.

To determine the thickness of one page of a book, we can measure the thickness of all the pages in the book together. We can then determine the thickness of a single page by calculating the **average** thickness of a page.

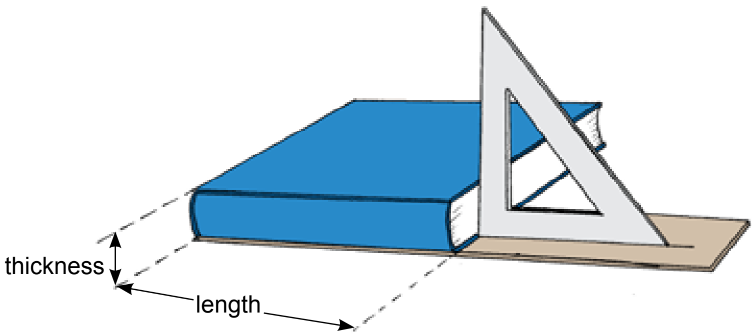


Figure 2.4 Calculating the average thickness of a page of a book

We can also calculate the mass of small objects in a similar way. We cannot use a balance scale to measure the mass of one pin. The mass of one pin is small and we need a special electronic scale that is very sensitive. To calculate the mass of a single pin, we must measure the mass of many pins together. We count the number of pins and divide the mass of all the pins by the number of pins. This gives us the average mass of one pin.

Figure 2.5 Calculating the average mass of a pin

Word help

division: split into equal parts or groups.
average: number calculated by adding quantities together and then dividing by the number of objects.

You can determine the volume of small objects in a similar way. In this unit we learnt how to measure the volume of an irregular object through displacement. A seed is a small object with an irregular shape. If we try to measure the volume of one seed by submerging it in water (displacement), we will not get an accurate reading. The displacement of the water will be too small to measure accurately.

To calculate the volume of a single seed, we must measure the volume of water displaced by many seeds. We count the number of seeds and divide the volume of the water displaced by the number of seeds. This gives us the average volume of one seed.

Activity 2.4 Practical task

Work in a group

Volume, mass and thickness of small objects
Investigation
Aim: Determine the volume, mass and thickness of small objects

You will need:
- meter rule
- book
- pins
- seeds
- measuring cylinder
- balance scale

Method
Follow the instructions.
1. Count the number of pages in the book. Do not count the cover pages of the book.
2. Measure the thickness of all the pages of the book. Do not include the cover pages of the book.
3. Calculate the average thickness of one page.
4. Count the number of pins.
5. Use the balance scale to measure the mass of all the pins together.
6. Calculate the average mass of one pin.
7. Count the number of seeds.
8. Half fill the measuring cylinder.
9. Place the seeds in the measuring cylinder.
10. Measure the volume of water displaced.
11. Calculate the average volume of one seed.

Conclusion
Compare your results with the results obtained by other groups. Were your results the same? Why or why not?

Density

Density is a physical quantity that describes the amount of matter an object contains in a particular volume. The derived S.I unit for density is $\frac{kg}{m^3}$.

Look at Figure 2.6. All four containers are the same size and have the same volume. The first container has the least number of **particles**. The last container has the most number of particles. The last container will have a greater mass than the first container because it has more particles in the same volume. The last container will have the highest density and the smallest spaces between the particles. The first container will have the lowest density and the largest spaces between the particles.

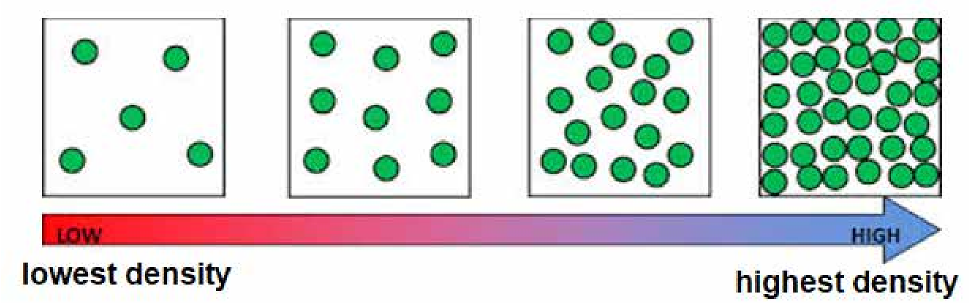


Figure 2.6 The density of a material increases as the number of particles in a given volume increase.

Fresh water at 25 °C has a density of 1 000 kg/m^3. This means that 1 cubic metre of water has a mass of 1 000 kg.

Table 2.3 shows some densities of common materials.

Table 2.3 Some densities of common materials.

Material	**Density (kg/m^3)**
Granite	2 750
Glass	2 400
Iron	7 874
Mercury (liquid)	13 560
Gold	19 320

Word help

particle: the smallest unit that makes up a material.

To calculate the density of an object we divide the mass of the object by its volume. Now we can see why it was important to be able to determine the volume of irregular objects. Without that method, we cannot determine the density of the irregular object.

For example, we can calculate the density of a piece of plastic to determine what kind of plastic it is. The mass and volume of the plastic are recorded in table 2.4.

Table 2.4 Some physical quantities and their SI units

Mass (kg)	Volume (m^3)	Density (kg/m^3)
0.092	0.0001	$\frac{0.092}{0.0001} = 920$

When we look up this density in a table of plastics of known densities, we see that the plastic was a type of plastic called Low Density Polyethylene. This type of plastic is used for plastic bags and bottles.

Activity 2.5 Practical

Work in a group

Density of different materials
Aim: Measuring the density of various materials

You will need:
- rectangular brick
- rock
- a closed glass bottle
- vegetable oil
- measuring cylinder
- overflow can
- mass balance
- metre rule

Method
Follow the instructions.
1. Measure the mass of all the solid objects (rock, brick and glass bottle).
2. Pour 200 ml of vegetable oil into the measuring cylinder and measure the mass of the oil and measuring cylinder together.
3. Using the equation:

   Volume of a rectangle
   = *length* × *breadth* × *height*

   calculate the volume of the brick.

4. Determine the volume of the rock and glass bottle using the overflow can.
5. Record your results in the second and third column of the table:

Object	Mass (g)	Volume (cm^3)	Density (g/cm^3)
Vegetable oil			
Brick			
Rock			
Glass bottle			

Use the mass and volume of each object to calculate the density of the object in the last column.

Questions

Answer the questions.

1. Which material has the highest density?
2. Which material has the lowest density?
3. Which material would float on water and why?

Summary

- In order to convert between different units we need to use a multiplication factor.
  1 *m* = 100 *cm*
  1 *m* = 1 000 *mm*
  1 *kg* = 1 000 *g*
  1 *hr* = 60 *min*
  1 *min* = 60 *s*
- Submerge an irregular shaped object in water in order to determine its volume.
- The volume of water that the object displaces is equal to the volume of the object.
- We must use a number of small objects to determine the average thickness, volume and mass of small objects.
- Density is a physical quantity that describes the amount of matter an object contains in a particular volume.

Topic assessment

Answer the questions.

1. Convert the following to metres: [5]
   a) 256 mm
   b) 105 cm
   c) 3 091 mm
   d) 23 cm
   e) 23 mm

2. The average thickness of one page of a book is 0.1 mm. If there are 215 pages in that book, what is the total thickness of all the pages together? [2]
3. The mass of a piece of copper is 12 kg and its density is 8 960 $\frac{kg}{m^3}$, what is the volume? [2]
4. Describe the method you would use to find the volume of a bolt which is an irregular solid? [3]
5. The volume of the bolt in Question 4 is 2 cm^3 and the mass is 15 g. What is the density of the bolt? Give your answer in $\frac{kg}{m^3}$. [3]

[Total] 15 Marks

Topic 3 Forces

Learning objectives	Activities
• calculate the resultant of a pair of inline forces	• Carry out experiments to demonstrate equal and unequal forces
• define moment of a force	
• calculate moment of a force	• Demonstrating moment forces
• state the principle of moments	• Applying the principle of moments
• apply the principle of moments in simple calculations	
• define friction	
• measure friction	• Carry out experiments to investigate frictional forces
• state the applications of frictional force	
• define a machine	• Lifting a load using a crowbar
• construct a simple machine	• Constructing a simple machine

A force is a push or a pull on an object resulting from an object's interaction with another object. In Form 1 you learnt about the effects of forces. You learnt that forces can cause an object to change its shape, position or speed. You learnt about contact forces and non-contact forces. An example of a contact force is friction. Examples of non-contact forces are gravitational, electrostatic and magnetic force. You also learnt how to measure force using a force meter or spring balance. Force is measured in newtons.

Inline forces

Force is a **vector quantity**. This means that force has **magnitude** and direction. We represent vectors with arrows. We need to know the magnitude and the direction of the force to measure the force. When a large enough force acts on an object, the object will move in the direction of the force.

It is possible that at any one time, more than one force acts on a single object. Forces that act in a straight line (i.e. at either 0° or 180° to each other) are inline forces. We can replace the inline forces with one force, called the resultant force.

Word help

vector quantity: unit of measure that has both magnitude and direction.
magnitude: the size of something.

Resultant force

The **sum** of two or more inline forces acting on a body is called the resultant force. This is also known as the **net force**. We need to consider the direction that the forces are acting in when determining the resultant force.

Forces that act in the same direction (at 0° relative to each other) are additive forces.

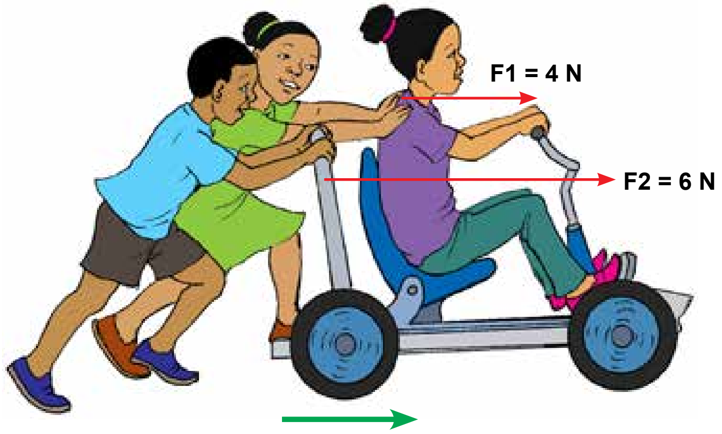


Figure 3.1 Two forces that are acting in the same direction are added.

In Figure 3.1, force F1 is pushing to the right (forward). Force F2 is also pushing to the right. The forces are in the same direction. We add the forces to calculate the resultant force. The direction of the resultant force is in the same direction as forces F1 and F2. Therefore the resultant force is 10 N to the right (forward).

Forces that act in opposite directions (at 180° relative to each other) are subtractive or **opposing** forces.

We have a zero net force when forces have equal magnitude and are acting in opposite directions. The forces cancel each other out. The resultant force is 0 newtons and the forces are **balanced**. See Figure 3.2. Two teams of learners are in a tug-of-war. The team on the left is pulling with a force of 100 N to the left (backwards) and the team on the right is pulling with a force of 100 N to the right (backwards). The forces are equal and in opposite directions. Therefore there is no resultant force. The forces are balanced, therefore the two teams will not move and stay in one position.

Word help

net force: the sum of all the forces acting on an object.
oppose: against or in the other direction.
non-zero: having a value other than zero.
unbalanced force: net force is greater than zero.

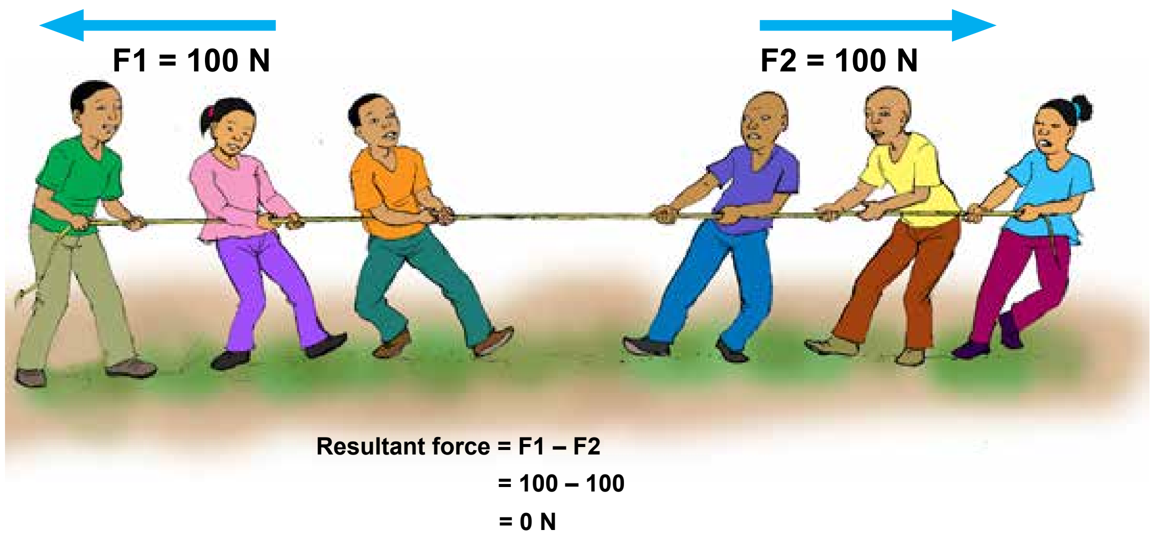


Figure 3.2 Balanced (equal) forces have a resultant force that is equal to zero

In Figure 3.3 two learners are pulling a learner in opposite directions. Force F1 is pulling at 15 N to the left. Force F2 is pulling at 5 N to the right. The forces are in the opposite directions. We subtract the smaller force from the larger force to calculate the resultant force. The direction of the resultant force is in the same direction as the larger force (F1).The resultant force is **non-zero**. The forces are **unbalanced**. Therefore the learner in the learner in the middle would move in the direction of the larger force i.e to the left with a force of 10 N.

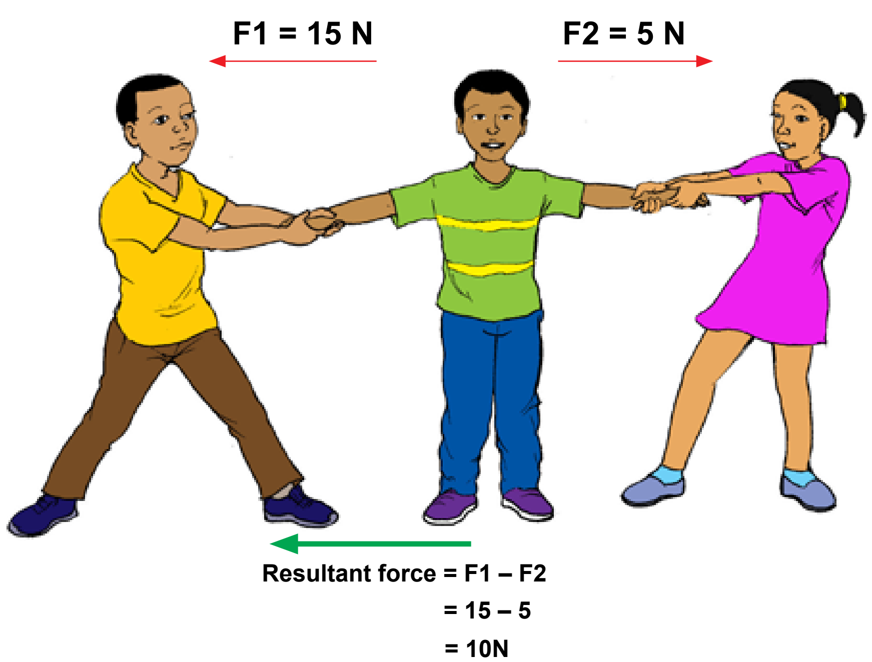


Figure 3.3 Unbalanced (unequal) forces have a resultant force in the direction of the bigger force

Word help

balanced force: net force is equal to zero.

Activity 3.1 Practical

Work in a group

Equal (balanced) and unequal (unbalanced) forces
Aim: Investigate balanced and unbalanced forces.

You will need:

- force meter
- 2 buckets of equal size
- 1 rope or thick string
- 2 rollers or smooth bars (wood or iron)

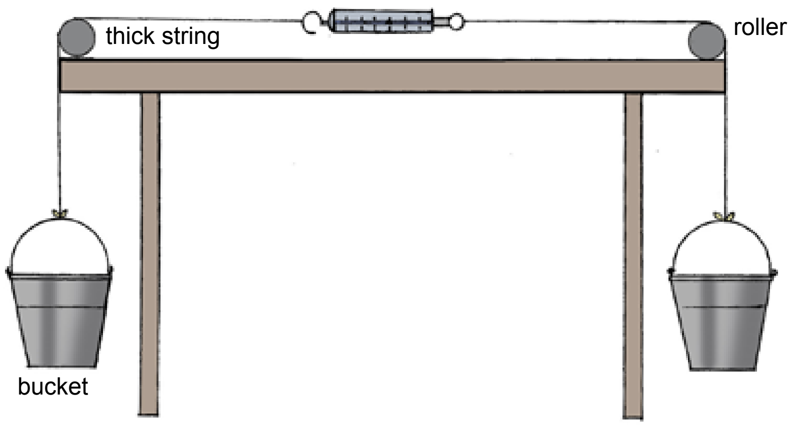


Figure 3.4 Experimental set up

Method
Follow the instructions.

1. Set up the experiment as shown in Figure 3.4.
2. Record the reading on the force meter when both buckets are empty.
3. Fill both buckets up with water until they are a quarter full.
4. Record the reading on the force meter.
5. Fill one bucket up with water until it is half. Record the reading on the force meter.
6. Fill both buckets up with water until they are half full.
   Record the reading on the spring balance.
7. Fill one bucket up with water until it is full. Record the reading on the force meter.
8. Fill both buckets completely with water.
   Record the reading on the force meter.

Questions
Answer the questions.

1. When is the force at its maximum value on the force meter?
2. What is causing the force?
3. One bucket is full and the other bucket is empty. What do you think the reading on the force meter will be?

Moment of force

The moment of a force is the turning strength of the force. This is caused when a force is applied on an object which is fixed by a pivot at a distance perpendicular to the applied force.

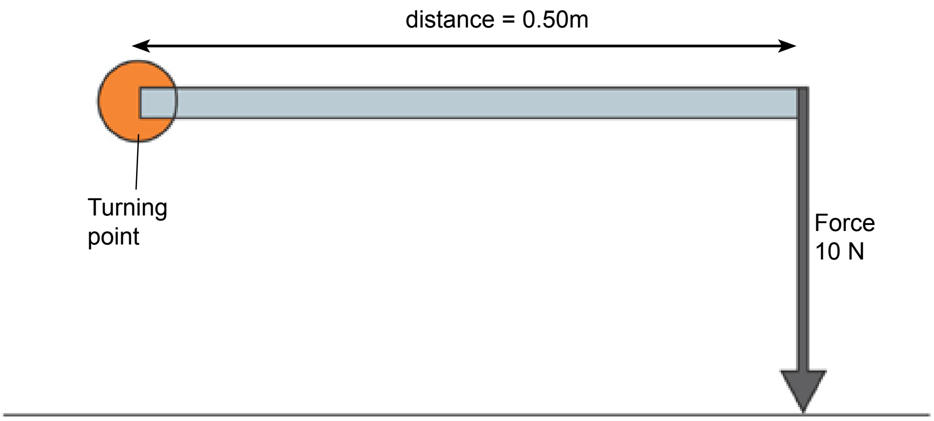
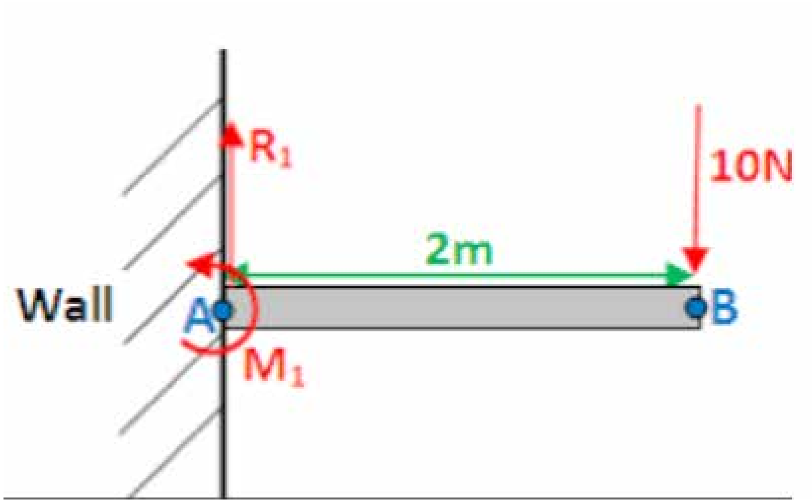


Figure 3.5 A moment is applied onto the bolt by the spanner.



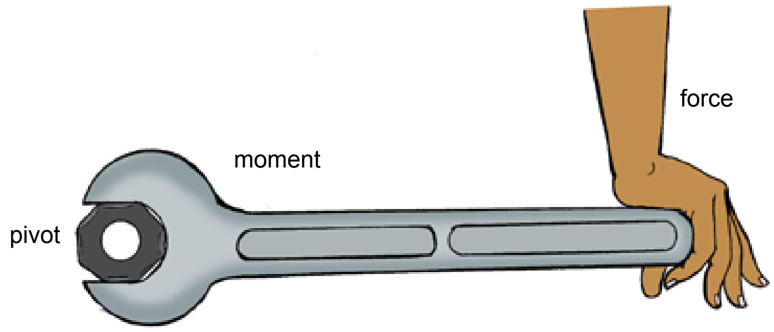


Figure 3.5 A moment is applied onto the bolt by the spanner.

The moment of a force is calculated using the following equation:
moment of force about a point

= *forced applied*

× *perpendicular distance from point*

The moment of a force is measured in *N. m*.

Look at **beams** A – D in Figure 3.6. Each beam has a force of 5 N applied at the end of the beam. Each beam is **fixed** into a wall at the other end. The end that is fixed into the wall acts as a pivot. The length of beams A, B and C are all different. Beam A has the largest distance between the applied force and the pivot. This means that beam A has the largest moment of force. Beam C has the shortest distance between the applied force and the pivot. This means that beam C has the smallest moment of force.

The force is applied at a distance of 1 m from the pivot for beams C and D. However, the force of 5 N is not applied in the same direction. In beam C, the force is applied upwards. In beam D, the force is applied downwards. This means that the moment force of beams C and D will not be in the same direction. The direction of the applied force determines the direction of the moment force. We use the terms clockwise and anticlockwise to describe the direction of the moment.

The moments of beams A, B and C are all clockwise. The moment of beam D is anticlockwise.

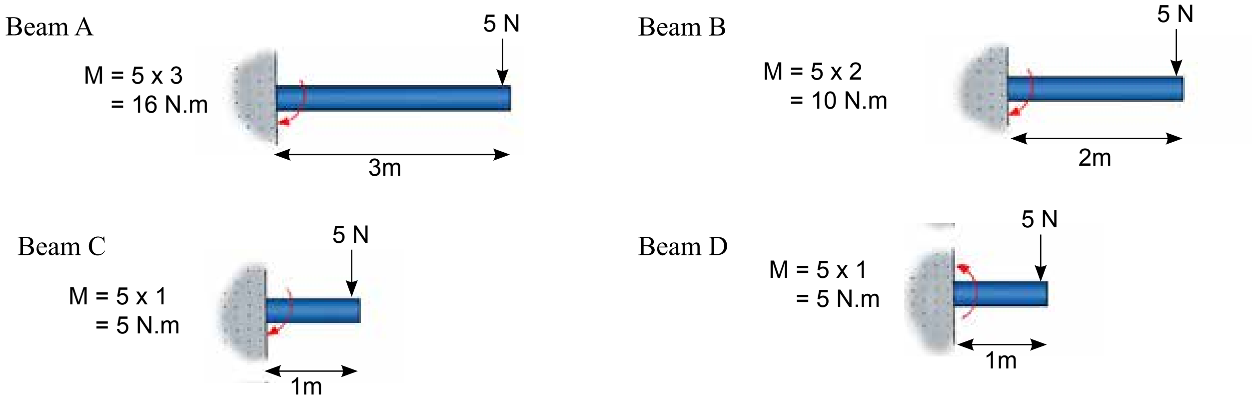


Figure 3.6 The magnitude of the moment is larger when the applied force is further from the pivot.

Word help

beam: a long piece of wood or metal.
fixed: does not have freedom to move.

The principle of moments

We can move the position of the pivot so it is not at the end of the beam. The pivot can be somewhere along the beam. For example, in the middle of the beam.

When a force is applied on one end, the beam **rotates** about the pivot. Think of a **see-saw**. Now we can apply more than one force on either side of the pivot – think of a see saw with two people at either end.

The principle of moments states that if moments of the forces acting on either side of the pivot are equal, the beam is in **equilibrium** and will not **accelerate** or move. Remember: it is the moments of the forces that must be balanced, not the forces themselves. The principle of moments can be summarised as:

At equilibrium:
clockwise moments = anti-clockwise moments

Look at Figure 3.7. The moments produced at the pivot from both sides of the see-saw are equal. This means that the see-saw will not move up or down, but will be balanced. We say the beam is in equilibrium.

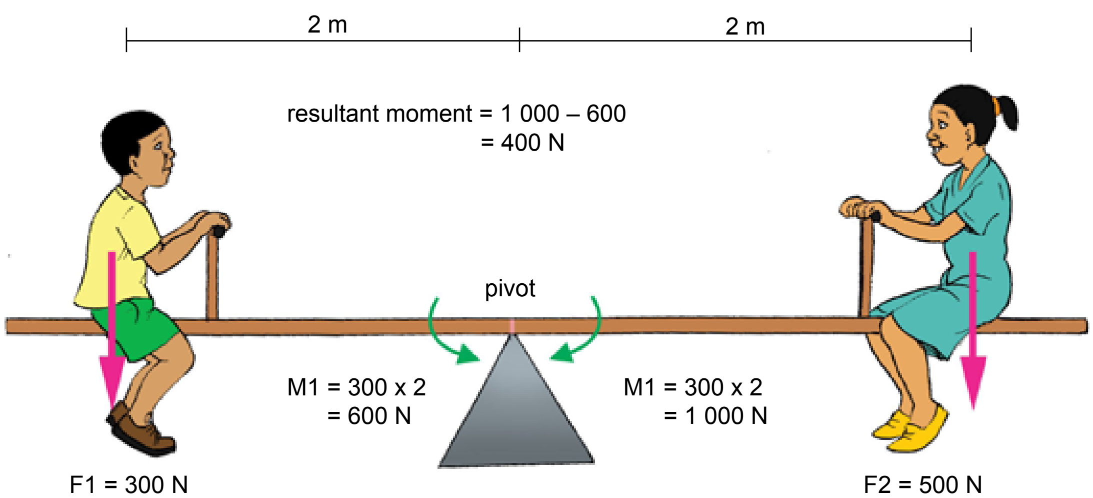


Figure 3.7 The moments of the forces acting on both sides of the pivot are equal. The beam is in equilibrium.

Word help

rotate: turn in a circular manner about a point.
see-saw: a plank that is balanced in the middle. When the one end of the plank goes up, the other goes down.
accelerate: increase in speed.
equilibrium: balance of opposing forces.

When the moments are not equal, the see-saw will accelerate (move) in the direction of the resultant moment. The beam is not in equilibrium. We need to add and/or subtract all the moments acting at the pivot to calculate the resultant moment. In Figure 3.8 the resultant moment is in the clockwise direction.

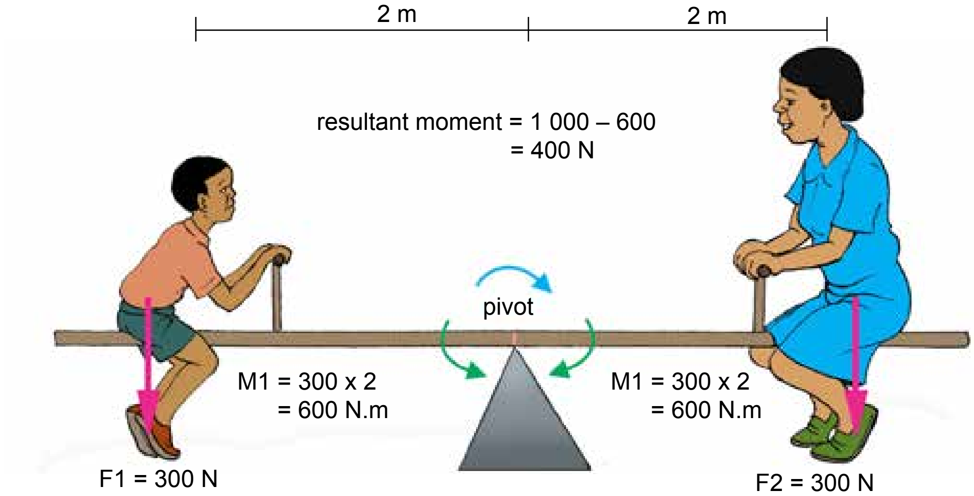


Figure 3.8 The moments of the forces acting on both sides of the pivot are not equal. The beam is not in equilibrium.

Something interesting

Archimedes, who is credited with inventing the lever, supposedly said "Give me somewhere to stand and I can move the World!" In a very simple way, this is true. A beam long enough, and a pivot secure enough could create moment of force large enough to move any weight, even that of the world.

Activity 3.2 Practical

Work in a group.

Moments of force and principles of moments
Aim: To demonstrate moments of force and apply principles of moments

You will need:
- a ruler
- 10 coins with different masses
- a pivot (e.g. a triangular block)

Method
Follow the instructions.
1. Place the pivot underneath the ruler. The pivot must be midway along the ruler.
2. Get the ruler to balance on the pivot.
3. Place a coin at on the left hand side of the ruler, 5 cm away from the pivot.

4. Place a coin of a different mass on the right hand side of the ruler.
5. Move the pivot along the length of the ruler and find the point where the anti-clockwise and clockwise moments balance each other and the beam is in equilibrium.
6. Repeat steps 1 to 5 with coins of different masses.

Questions

Answer the questions.

1. What was the distance from the pivot required on the right hand side to balance the coin?
2. Why is the distance from the coin on the left to the pivot different from the distance from the coin on the right to the pivot?
3. Assume the left hand coin is 5 grams. Calculate the weight of the coin.
4. Calculate the moment of the force on the left hand side of the ruler in N.m.
5. Calculate the weight of the right hand coin that is needed for the ruler to be in equilibrium. *Hint: the anticlockwise moment must equal the clockwise moment for a beam in equilibrium.*
6. Calculate the mass of the right hand coin.

Frictional forces

Friction is the **resistance** of movement when one object **rubs** against another object. In Form 1 you leant that a frictional force always acts in the direction opposing motion. For example if a car is moving forward, friction acts backwards. If the car is **reversing**, then friction acts in the forwards direction.

The effect of the nature of the surface of friction

The nature of the surface on which an object moves determines the magnitude of the frictional force applied onto the object. For example, **rough** surfaces result in large frictional forces. **Smooth** surfaces result in smaller frictional forces. Think about when riding a bicycle. Do you go faster if you are cycling on thick grass or on smooth tar? Smooth tar, right? This is because smooth tar offers less resistance to forward motion than long grass resulting in less friction.

Word help

resistance: frictional force exerted by an object.
rub: moving to two surfaces against each other.
reverse: move in the opposite direction (e.g.backwards).
rough: uneven, bumpy surface.
smooth: even surface.

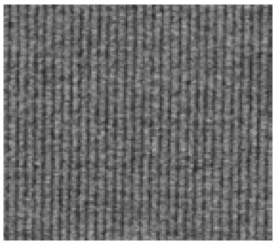
Most rough → Least rough		
grass	carpet	tar
		

Figure 3.9 Surfaces with different roughness

Measurement of Friction

We can measure friction by pulling an object at a **constant** speed across a surface. We place a spring balance between our hand and the object that will be pulled. As we pull the object hooked to the spring balance, we can take readings from the spring balance. The spring balance measures the frictional force between the object and the surface. Look at Figure 3.10.

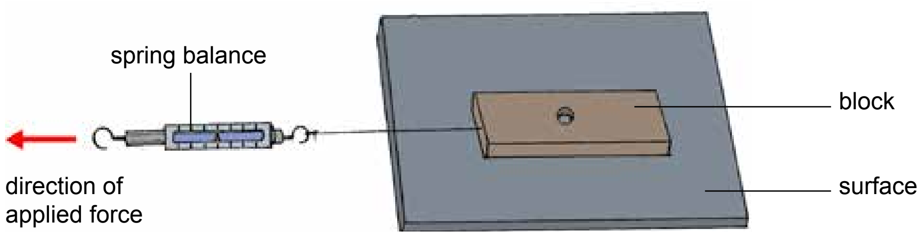


Figure 3.10 Measuring frictional force

If the block is moving at a constant speed, the only **horizontal** forces acting on the block are frictional force and the applied force. If we can remove friction completely, we would not have to apply any force to keep the object moving at a constant speed!

Word help

constant: not changing.
horizontal: moving from left to right or right to left.

Activity 3.3 Practical

Work in a group

Frictional force of different surfaces
Aim: To investigate frictional forces of different kinds of surfaces

You will need:

- a ball
- corrugated cardboard
- smooth cardboard
- aluminium foil
- wooden plyboard or planks
- something to create a slope or incline (a pile of text books or a pile of bricks)

Method

Follow the instructions.

1. Make three slopes that are 2 m in length. Use the wooden plyboard or planks. Each slope should have the same incline (same steepness). It should be a very shallow incline so that the ball slowly begins to roll when placed on the top.
2. Cover each surface in a different material, e.g. smooth cardboard, corrugated cardboard or aluminium foil. Make sure the material is firmly stuck or pinned down to the surface of the slope.
3. Place the ball at the top of each slope.
4. Allow the ball to slide down the slope.
5. Measure and record how far the ball slides down on each surface.

Observations and results

1. Which surface allowed the ball to travel the greatest distance?
2. On which surface does the ball travel the shortest distance?
3. Which surface causes the highest amount of frictional force?

Conclusion

Write a conclusion for the investigation based on the aim and the results.

Applications of frictional forces

It is important for us to look at the effects of friction, especially in some machines. Friction can result in loss of power in some machines. That is why we put oil on gears and in engines. Oil is a **liquid lubricant** and reduces friction. Other lubricants include the solid lubricant, graphite. In our bodies, our **joints** have a fluid that acts as a lubricant. As we become older, this fluid reduces and our joints **creak**.

Word help

lubricant: a substance that causes something to be slippery and slide easily.
joint: the point where two bones in your body meet.
cartilage: flexible tissue that protects your bones from rubbing against one another.
creak: grating noise.

Here are some other examples where frictional forces apply:

- Car brakes are designed to maximise friction at the control of the driver. A driver can use the braking device to increase friction around the rotating tire. This friction causes the car to slow down.
- Car tyres are designed to increase friction at the point where the tire meets the road. See Figure 3.11. The tire **tread** is specially designed so that the wheel does not slip. Instead it rolls in a controlled fashion. When the tread of a tyre is worn the tyre will not experience the necessary friction and will slip.

Figure 3.11 The tread of the tyre increases the friction between the tyre and the road surface

- Soles of shoes are designed to increase the friction between the shoe and the ground. This prevents our feet from slipping on the ground surface. The frictional force helps us push off the ground before a slip.
- Roads are made of tar. This is a flat, hard material which allows tires to roll over it with less friction than, for example, grass or dirt (unpaved) roads.
- When there is too much water on the road, cars can **hydroplane** when they are moving too fast. A layer of water lies between the tires and the road. Water exerts a much smaller frictional force than the tar. The car tyres can slide on the almost frictionless surface of the water and spin out of control. That is why one needs to drive slower on a wet surface. The tread also lets the water squirt out between the tyre and the road surface so that there is not a film of water on the road surface that could cause the wheel to slip.

Machines

A machine makes work easier. A machine is a device that uses mechanical parts to change or **transmit** energy into a more useful form.

Word help

tread: the part of a car tire that makes contact with the ground surface.
transmit: send.
sum: addition.

A simple machine: Lever

A lever is an example of a simple machine. A lever transmits the force applied at one point to a second point. At the second point, the force is increased due to the Principle of moments.

Levers are particularly useful for lifting heavy objects. We can lift heavy loads with less effort. A lever magnifies the force applied at one end of a beam in order to apply a much higher force at the other end. The higher force on the other end lifts a heavy load. Figure 3.12 shows how a simple lever.

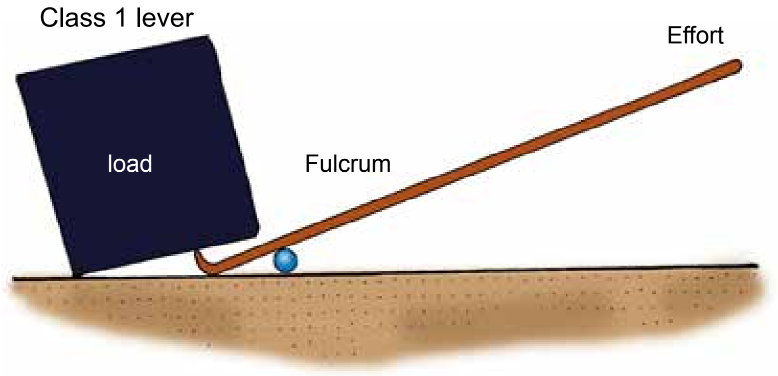


Figure 3.12 A simple machine: Lever

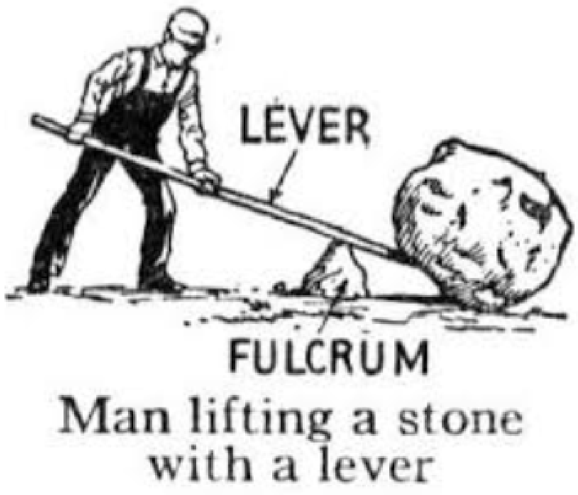
Activity 3.4 Practical

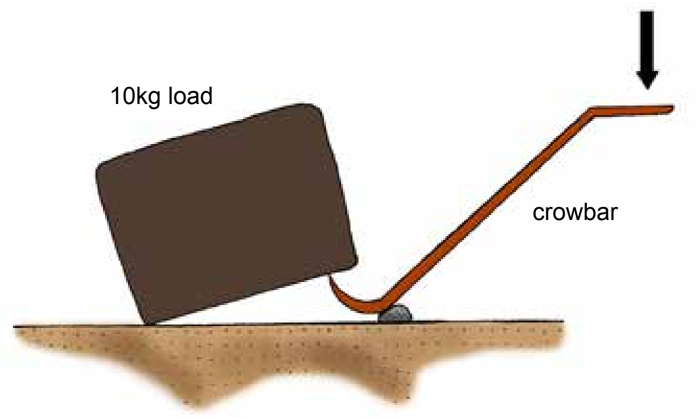
Work in a group

Lift a heavy object using a lever
Aim: To use a crow bar to lift a load

You will need:

- crowbar
- pivot point (rock)
- masses (1 – 10 kg)





A lever makes the lifting of a heavy load easier

Method

Follow the instructions.

1. Place a rock on the floor. This is the pivot.
2. Rest the crowbar on the pivot. The pivot must be at the length of the crowbar.
3. At the shorter end of the crowbar, place the 10 kg mass. The long end of the crowbar should now stick up in the air.
4. Hang the 1 kg mass from the long end of the crowbar. Does it lift the 10 kg mass at the other end?
5. If not, add a second 1 kg mass. Continue adding mass pieces until the 10 kg mass is lifted.

Summary

- Forces that act in a straight line are inline forces.
- The sum of two or more inline forces acting on a body is called the resultant force.
- Forces that act in the same direction are additive forces.
- Forces that act in opposite directions are subtractive or opposing forces.
- We have a zero net force when forces have equal magnitudes and are acting in opposite directions.
- The moment of a force is the turning strength of the force.
- The direction of a moment of a force is clockwise or anti-clockwise.
- The principle of moments states that if moments of the forces acting on either side of the pivot are equal, the beam is in equilibrium and will not accelerate or move.
- Friction is the resistance of movement when one object rubs against another object.

Topic assessment

Work on your own

Answer the questions.

1. A beam is 1.5 m long and a force of 3 N is applied at the one end. Calculate the turning moment at the far end of the beam. [1]
2. A skier is racing downhill on a steep slope. As he gets to the bottom, he begins to slow down and eventually stops.

Figure 3.14

   a) Explain why can the skier move down the slope quite easily? [1]
   b) Which force causes the skier to stop? [1]
   c) In which direction does this force act? [1]

3. A box with a mass of 30 kg rests on a beam. The pivot point is 0.25 m from the box. Karabo can apply a maximum force of 100 N at the other end of the beam. Karabo wants to use her force to lift the box.

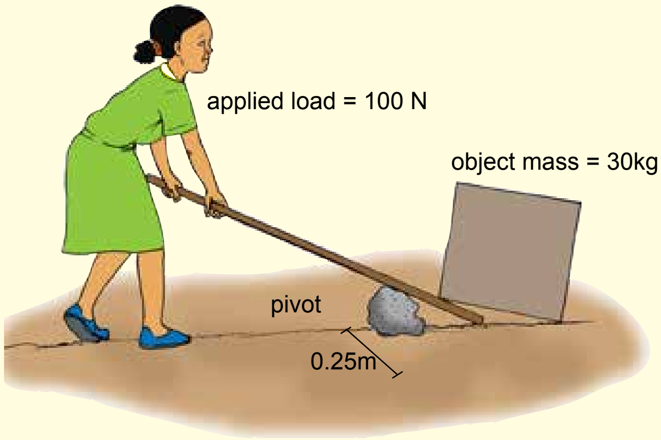


Figure 3.15

4. Calculate the minimum distance from the pivot point at which Karabo must apply the force to lift the box. [3]
5. The mass of the box is increased to 40 kg. Does Karabo need to apply less or more force to lift the box? [1]
6. The distance between the pivot and the box is increased. Does Karabo need to apply less or more force to lift the box? [1]
7. Calculate the applied force that is needed to exert a moment force of 12 N over a distance of 3 m along a beam. [3]

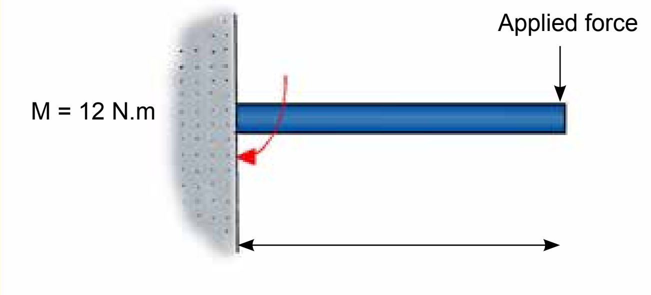


Figure 3.16

8. Which direction will the see-saw rotate? State clockwise or anti-clockwise. Show all your calculations. [4]

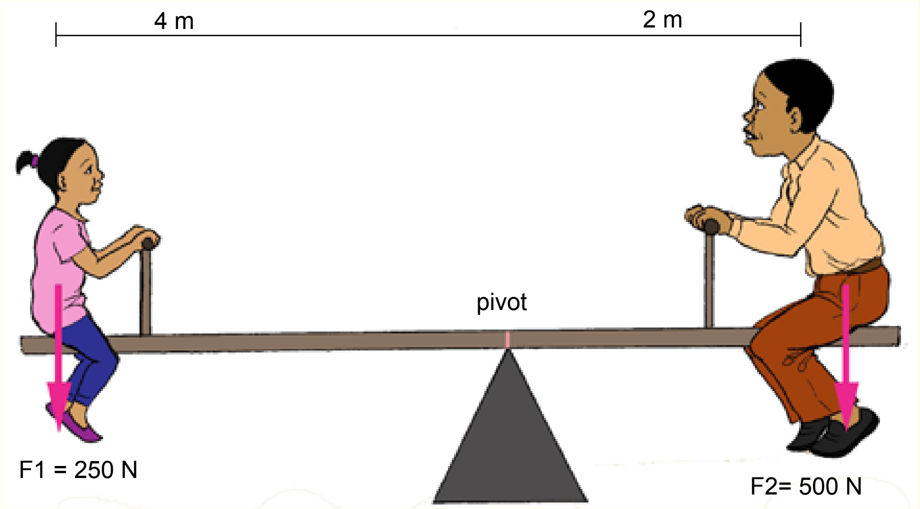


Figure 3.17

9. If the force exerted by the young boy increased to 300 N, which direction will the see-saw rotate? State clockwise or anti-clockwise. Show all your calculations. [4]

[20 Marks]

Topic 4 Energy

Learning objectives	Activities
• State the law of conservation of energy	
• Define work and energy	• Carrying out experiments to demonstrate Work done = Energy used
• State the S.I unit of work and energy	
• Calculate the work done or energy used by forces	• Solving problems on work done and energy used
• List sources of light energy	• Observing sources of light
• Show that light travels in a straight line	• Carrying out experiments to demonstrate that light travels in a straight line (production of shadows)
• State the production and transmission of sound	• Producing sound using musical instruments
• Demonstrate the need for a medium in the transmission of sound	• Conducting a bell jar experiment to show that sound requires a medium

We cannot see energy, but we can see, feel and hear the effects of energy. In Form 1 you learnt about the effects of energy and that there are different forms of energy such as kinetic, potential, light, heat, electrical and sound energy. You also learnt that energy can be converted from one type to another.

Law of conservation of energy

Energy is the 'ability to do work'. Energy is a measure of the **potential** for a change to occur in the **universe**. Energy is how things in the universe change and move. Energy is found in different forms and is all around us.

In Form 1, you learnt that when energy conserved can be converted from one form to another. The total energy in the universe stays the same. The energy is only converted (transformed) from one form to another.

The Law of Conversation of energy states:
Energy cannot be created or destroyed.

Word help

potential: having the ability to do something.
universe: everything that can be touched, sensed, felt and measured or detected. The space that is all around us and everything in it.
capacity: the total amount that something can hold.

Work and energy

Energy is the **capacity** to do work. Work is done on an object when we transfer energy to that object. Work is done when a force is applied to an object and moves that object over a certain distance.

Work is measured in joules (J)
Force is measured in newtons (N)
Distance is measured in metres (m)

Note that:

work done = energy transferred

Activity 4.1 Practical

Work in a group.

Work done on an object
Aim: Demonstrate and calculate the work done on an object that is pulled across a surface.

You will need:

- force meter
- object (2 bricks)
- plastic bag
- ruler

Method
Follow the instructions.

1. Place the brick in the plastic bag.
2. Place the plastic bag and the brick on the floor.
3. Hook the force meter onto the handles of the plastic bag.
4. Use your hands to apply a constant force by dragging the brick across the floor.
5. While moving the brick, measure the force applied with the force meter.
6. Measure the distance that the brick moves.
7. Use the equation: to calculate the work done.
8. Repeat steps 1 to 8 using two bricks in the plastic bag.

Questions
Answer the following questions.

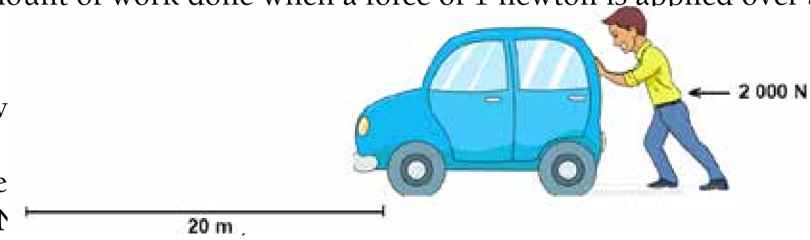
1. Copy the sentence and choose the correct word in brackets to make the sentences true.
   a) We need to apply (more/less/the same) force to move two bricks.
   b) The amount of work done (increased/decreased/stayed the same) when the second brick was added.
   c) (More/Less/The same amount of) energy is needed to move two bricks.

The S.I. unit of work and energy

Energy is a physical quantity that can be measured. The S.I. unit for energy is the joule (J). 1 Joule is defined as the amount of work done when a force of 1 newton is applied over a distance of 1 metre.

Example 1

A car is pushed w



e is:

Work = Force

2 000 N

In this example it does not matter how much the car weighs or how fast the car is moving, the work done is constant.

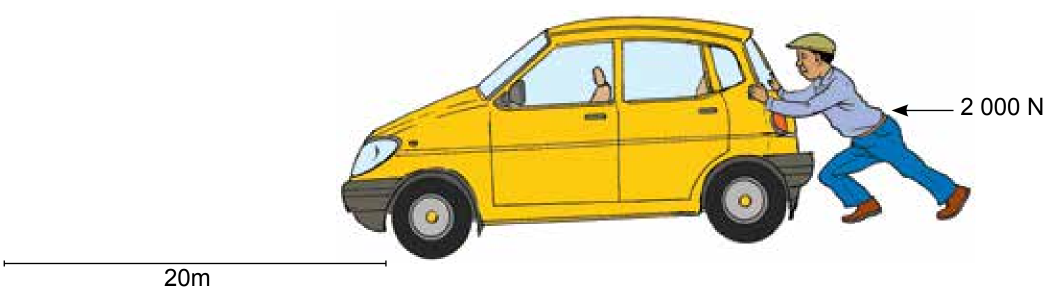


Figure 4.1 The man does work when pushing the car over a distance

Example 2

Calculate the work done when a bucket of 5.6 kg is carried up a 3 m high ladder.
We first need to calculate the applied force. The force we need to apply onto the bucket to lift the bucket, is equal to the weight of the bucket.

Figure 4.2 Work is done when carrying a bucket up a ladder over a distance

$F = mg$

$F = 5.6 \times 10$

$F = 56\ N$

The minimum force needed to lift the bucket upwards is 56 N. Now we can calculate the work done.

$$\begin{aligned} \textit{work done} &= \textit{Force} \times \textit{distance} \\ &= 56\ N\ \ 3\ m \\ &= 168\ J \end{aligned}$$

The work done to carry the bucket is equal to the energy needed to lift the bucket.

work done = energy used

This is only true for systems that are 100% efficient. Later, you will learn about systems which are *not* 100% efficient. Some of the energy is lost to the surrounding environment as heat, sound or light and so:

work done = energy used

Activity 4.2

Work with a partner

Answer the following questions.

1. Calculate how much work is done when a wooden block is pushed with a force of 30 *N* for 30 *m*.
2. Explain what equipment you need to calculate the work done to push a wooden block from one end of the table to the other end.
3. A brick layer pushes 50 bricks at a time using a wheel barrow from point A to point B. The mass of the wheel barrow with the bricks is 170 kg. He applies a force of 50 N to push the wheel barrow. The total energy used to move the wheel barrow and the bricks from point A to point B is 500 *J*. Calculate the distance from point A to point B.

Figure 4.3 Work is done when pushing a wheelbarrow over a distance

Light energy

In Form 1 you learnt about light as a form of energy. Light energy is energy that we can see. Light is a type of energy called radiant energy. Light waves do not require a medium and can travel through a **vacuum**.

Sources of light

The main source of natural light energy comes from the Sun. Light energy from the Sun is necessary for all life on earth. Light can also be made **artificially**. Fire is an example of artificial light. Fire gives off heat and light energy. The electric bulb is a device that uses electrical energy to produce light. The tungsten filament electric bulb (the bulb with a wire in it that glows white) is not energy **efficient** and most of the electrical energy is converted into heat instead of light. LED light bulbs produce less heat energy and are more energy efficient.

Figure 4.4 Sources of light can be natural or artificial.

Activity 4.3 [Online games]

Work on your own.

Light online activity.
Aim: Use internet sources to learn more about light.

Go to the website and follow the instructions.
http://www.sciencekids.co.nz/gamesactivities/lightdark.html

Word help

artificial: not natural.
efficient: avoid wastage materials, time or energy.
vacuum: a space that has no matter. Even air has been removed.

Activity 4.4 Practical

Work in a group

Sources of light
Aim: To observe different sources of light

You will need:
- light bulb
- torch
- candle
- matches and match box or a lighter

Figure 4.5 A torch shines light

Method
Follow the instructions.
1. Find the light switch in the classroom.
2. Switch the light on and off. Notice the light produced by the light bulb.
3. Use a torch to produce light in a dark corner in your classroom. Notice the light produced by the torch.
4. Use a match to light a candle.
5. Observe the light produced by the flame of the candle. Be careful not to burn yourself or anything else.
6. Look through the window to see the light emitted by the sun. Do not look at the sun directly! Looking at the sun directly can damage your eyes!

Light travels in a straight line

Light travels very fast in a straight line. What this means is that light takes the shortest route between two points. The straight path of light is called a **light ray**. Sunlight, starlight, torchlight or candlelight all travel in straight lines from the point of origin to the point where the light is detected or seen.

Word help

light ray: a line of light that radiates from an object.

Something Interesting

Light travels at about 299 792 458 meters per second. The Sun is about 150 million kilometres from the earth. It would take a car about 177 years to drive from the Earth to the Sun. It takes light about 8 minutes to travel from the sun to the earth.

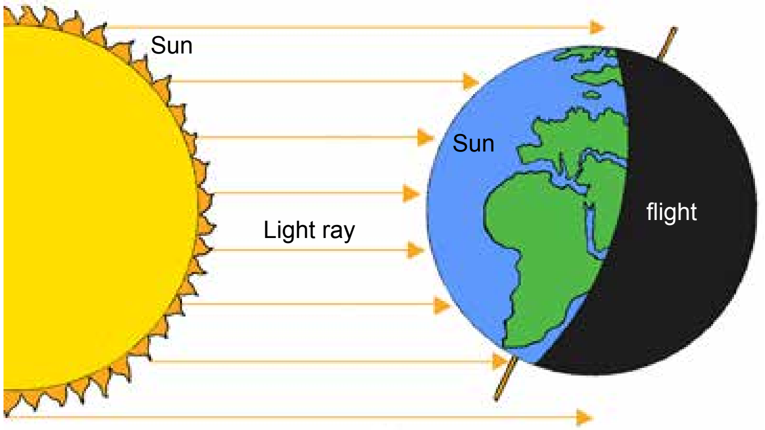


Figure 4.6 Sunlight travels as light rays, in a straight line from the Sun to the Earth

Activity 4.5 Practical

Work in a group

Light travels in a straight line
Aim: To demonstrate that light travels in a straight line

You will need:
- light source (candle or torch)
- card with 2 mm slits screen
- ball
- white screen or white cardboard

Method
Follow the instructions.
1. Place the light source behind the card with the slits screen.
2. Place the white screen or white cardboard 30-40 cm in front of the slit screen.
3. Place in the ball between the slits screen and the white screen.
4. Turn on the light source and observe the screen.

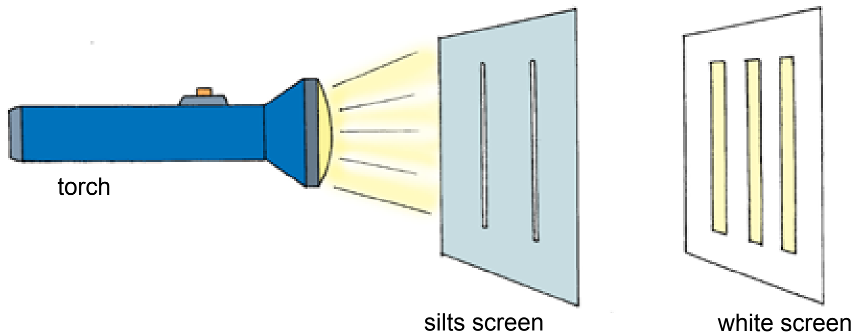


Figure 4.7 Light travels as light rays from the torch, in a straight line.

Questions

Answer the following questions.

1. Describe what you see on the white screen.
2. Move the ball. What do you observe on the white screen?
3. What conclusion can you make about the direction that light travels in?

Activity 4.6

Work on your own.

Answer the following questions.

1. Where does the Earth get almost all of its energy from?
2. Which do you think produces the most amount of light energy per second – torch, Sun or candle?
3. If energy cannot be created or destroyed, as stated by the Law of Conservation of Energy, where does a torch get the energy from to emit light energy?
4. And a candle?
5. And the sun?

Sound energy

Sound energy is produced when an object or substance **vibrates**. Sound energy is a type of energy that travels through most materials such the air, wood or water. It cannot travel through a vacuum. Sound energy travels as sound waves. The purpose of our ears is to detect those sound waves.

Word help

vibrate: moving backwards and forwards or side to side very quickly.

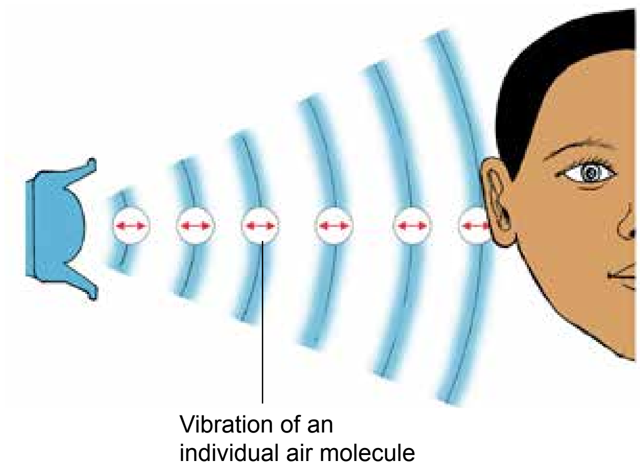


Figure 4.8 Sound energy travels through the air when the air particles vibrate

Production of sound

Musical instruments produce sound by vibrating parts that they are made of. Musical instruments can also make the air inside them vibrate in order to produce sound. In order to produce a sound wave, an object needs to vibrate. Striking the skin of a drum with your hand produces the "boom" sound of the drum. Running a string across a violin causes the strings of the violin to vibrate and make sound. Air passes over your vocal chords and vibrates the chords, forming a noise which is your voice.

Activity 4.7 Practical

Work in a group

Producing sound in musical instruments
Aim: To produce sound using musical instruments.

You will need:
- drum
- guitar
- mbira
- flute or whistle
- any other musical instruments

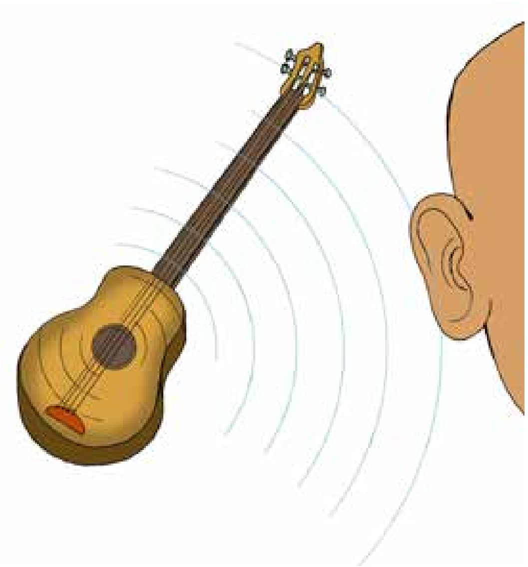


Figure 4.9 The strings of a guitar vibrate and make sound

Method
Follow the instructions.
1. Hit the skin of the drum with your hand.
2. Listen to the sound produced while watching the instrument.
3. Strum the strings of the guitar with your hand.
4. Listen to the sound produced while watching the instrument.
5. Pluck the mbira with your finger
6. Listen to the sound produced while watching the instrument.
7. Blow into the flute.
8. Listen to the sound produced.
9. Do this with any other musical instruments you have.

Questions
Answer the following questions.
1. For each instrument, what part of the instrument was vibrated in order to make a sound?
2. For each instrument, what would you change in order to make the sound louder?
3. If you made the sound louder, do you think you are putting more or less energy into the sound waves?

Sound transmission

When a disturbance is caused in a material, the **particles** in the material begin to vibrate. These vibrating particles cause the surrounding particles to also vibrate. The vibration spreads from particle to particle, producing a sound wave. Without the vibrating particles, sound will not travel. Sound must travel through **matter** in order to be **transmitted**. The matter that transmits sound is called the **medium**. The air around us is made up of particles. The particles in the air vibrate and allow sound to travel. In outer space, there is a vacuum with no particles. This means sound cannot be transmitted because there is no medium for sound to travel through. Sound waves are **longitudinal waves** made by compressions and rarefactions of the medium they are traveling through. Figure 4.10 shows the longitudinal waves produced by a tuning fork. As the arms of the tuning fork move back and forth, they push the surrounding air particles. This backwards and forwards movement causes areas where particles in the air are pushed closer together (compressions). The movement also causes particles to be spaced further apart (rarefactions). The compressions are areas of high **pressure**. Rarefactions are mediums of low pressure.

Word help

particle: basic unit of matter. The smallest amount of something.
matter: anything around you that has mass and takes up space.
transmit: send.
medium: a substance that has matter and allows energy to be transferred from one location to another.
longitudinal wave: a wave where the particles that make up the medium move in the direction of the wave.
pressure: force that acts over an area.

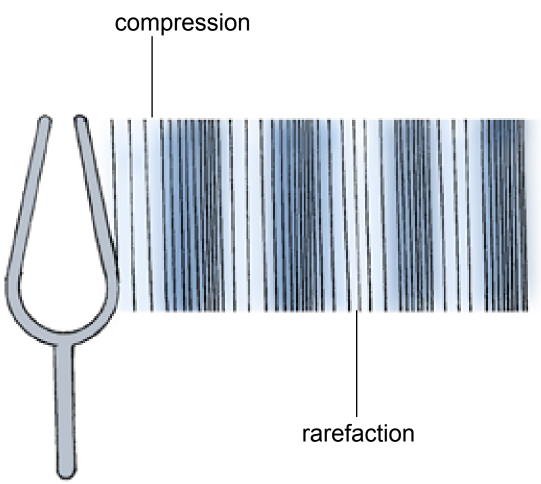


Figure 4.10 Sound waves are longitudinal waves

The medium that sound is transmitted through affects the speed with which sound will travel. Sound will travel faster in water than in air. Water has a higher **density** than air. In water, the particles are closer together. They can transmit the sound from one particle to another faster than in air. Air is less dense than water and the particles have larger spaces between them. It will take longer for the particles to transmit sound from one particle to another. The more dense a material (medium) is, the faster it can transmit sound. Look at Figure 4.11. Sound will travel faster along a string than through the air because the string has a higher density than air.

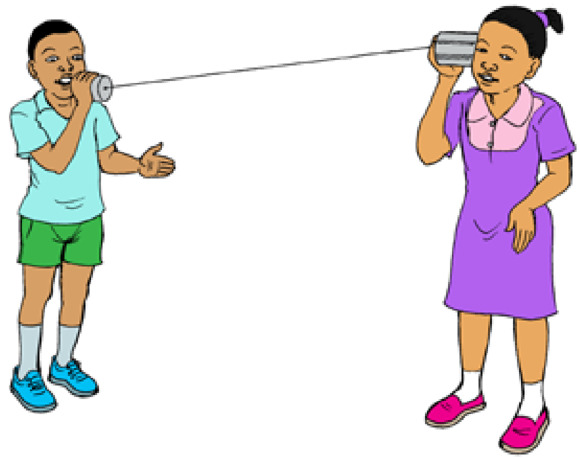


Figure 4.11 Sound travels faster along a string than through the air

Steel is a strong metal used in construction. Steel has a density that is eight times greater than the density of water. Sound will travel even faster through steel because the particles are closer together.

Word help

density: a measure of how close the molecules of a substance are. A substance has a higher density when the molecules are closer together.

Something Interesting

Elephants can warn other elephants when predators are approaching by stomping their feet and trumpeting. The sound travels through the ground to other elephants. Elephants have special receptors on their feet that allow them to hear the sound that travels through the ground. The elephants hear the sound through the ground faster than through the air because the ground has a higher density than air.

Activity 4.8 Practical

Work in a group

Sound requires a material medium for transmission
Aim: To show that sound can only be transmitted through a medium

You will need:
- bell jar
- vacuum pump
- electric bell

Method
Follow the instructions.
1. Place a ringing electric bell in the bell jar.
2. Listen to the sound made by the electric bell.
3. Use the vacuum pump to remove the air in the bell jar.
4. As the air is removed, listen to the sound produced by the electric bell.

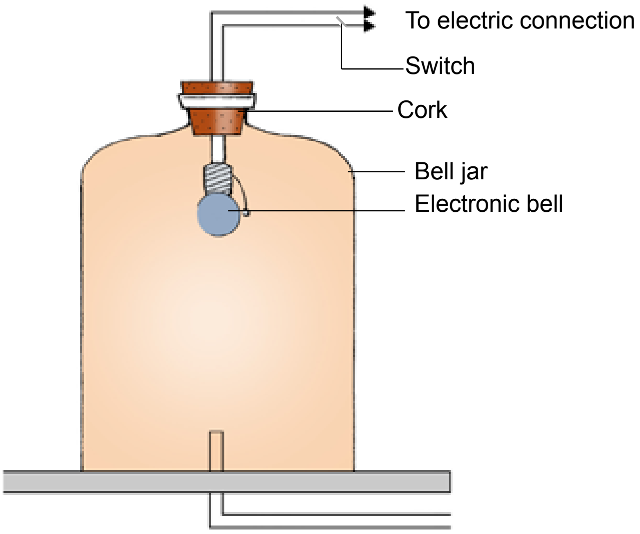


Figure 4.12 Experimental set up

Questions

Answer the following questions.

1. Could you hear the electric bell before the air was pumped out of the bell jar? Explain why?
2. What happened to the sound produced by the electric bell as the air was pumped out? Why did this happen?
3. Could you hear the electric bell after the air was pumped out of the bell jar? Why?

Questions

What conclusion can you make about the transmission of sound?

Summary

- Energy is the 'ability to do work'.
- Energy can be converted from one type to another.
- Energy is the capacity to do work.
- Work is done when a force is applied to an object and moves that object over a certain distance.
- *Work = Force × Distance*
- *Work done = Energy transferred*
- The S.I. unit for energy is the joule (J).
- Light energy is energy that we can see.
- Light travels fast in a straight line.
- Sound energy is produced when an object or substance vibrates.
- Sound energy travels as sound waves.
- Sound must travel through matter in order to be transmitted.
- The matter that transmits sound is called the medium.
- The medium that sound is transmitted through affects the speed with which sound will travel.

Topic assessment

Answer the following questions.

1. Define energy. [1]
2. Describe when work is done on an object. [2]
3. State the law of conservation of energy. [2]
4. A donkey pulls a cart with a mass of 60 kg, on a flat road, with a force of 3 000 N. The donkey travels a total distance of 300 m.

Figure 4.13

a) Calculate the work done by the donkey. [3]

b) The mass of the cart is now doubled. Calculate the work done by the donkey. [2]

c) The distance the donkey travels is increased to 600 m. Calculate the work done by the donkey. [2]

5. A 40 kg box is dropped 10 m. How much work was done on the box? (*Take gravitational acceleration to be 10* $\frac{m}{s^2}$). [4]
6. A box is dropped 12 m. The amount of work done on the box is 200 J. What is the mass of the box? (*Take gravitational acceleration to be 10*$\frac{m}{s^2}$). [4]
7. Why does sound need a medium to travel? [3]
8. Why does it take longer for sound to travel through air than through rock? [2]

[25 Marks]

Topic 5 Magnetism

Learning objectives	Activities
• Describe properties of magnets	• Illustrating properties of magnets
• State the law of magnetism	• Carrying out experiments using magnets
• Draw magnetic fields	• Demonstrate magnetic fields

In Form 1 you learnt that a magnetic force is a non-contact force and that it acts over a distance.

In Form 1 you learnt that materials can be magnetic or non-magnetic. You learnt that a magnet has a north pole and a south pole. There are different types (shapes) of magnets: bar magnet, horseshoe magnet, C-magnet and an E-magnet.

In this topic you will learn about the properties of magnets and magnetic fields.

Properties of magnets

Magnets can attract or repel. Similar poles repel and opposite poles attract. They attract materials such as iron, cobalt and nickel.

Magnetic field

All magnets have a north and a south pole. Magnets can exert a magnetic force on magnetic objects. Magnetic objects experience a force in a magnetic field and are attracted by a magnet. This force exerted on magnetic objects is called a magnetic force and it acts over a distance. It is a non-contact force. Objects that experience a magnetic force are called magnetic. Objects that do not experience a magnetic force from a magnet are called non-magnetic. All magnetic materials are **metals**. Not all metals are magnetic. Metals that contain iron, nickel or cobalt are magnetic.

All magnets have a magnetic field. Any magnetic object that lies in the magnetic field of a magnet, will experience a magnetic force. Figure 5.1 shows the magnetic force exerted on iron filings in the magnetic field of a bar magnet and of a horse shoe magnet. In Activity 5.2 you will investigate magnetic fields using iron filings.

We can see the magnetic field lines of a magnet with **iron filings**. The magnet is placed underneath a paper. The iron filings are placed on top of the paper. The magnetic field form the magnet will exert a force on the iron fillings. The iron filings will align themselves with the magnetic field lines, forming visible lines.

Word help

metal: a substance with a shiny appearance and is a good conductor of heat and electricity
iron filings: very small pieces of iron.

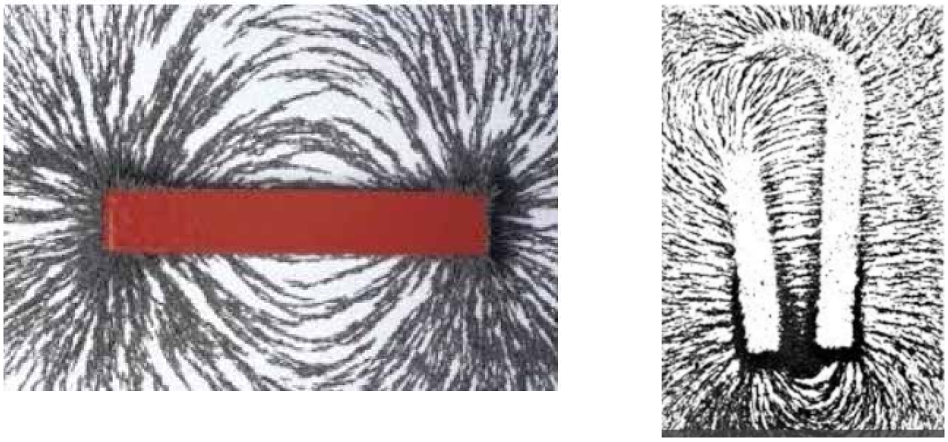


Figure 5.1 All magnets are surrounded by a magnetic field

The stronger the magnet, the stronger the magnetic field. A stronger magnetic field will exert a stronger force on magnetic objects.

Polarity

All magnets have two poles: a north pole and a south pole. The poles are at opposite ends of the magnet to each other. You cannot find a magnet with one pole. You also cannot find a magnet with two poles of the same kind. The magnet will always have two different poles: one north pole and one south pole.

Something interesting

Speakers use a magnet to convert electrical energy into mechanical energy. This moves a part in the speaker which then creates sound.

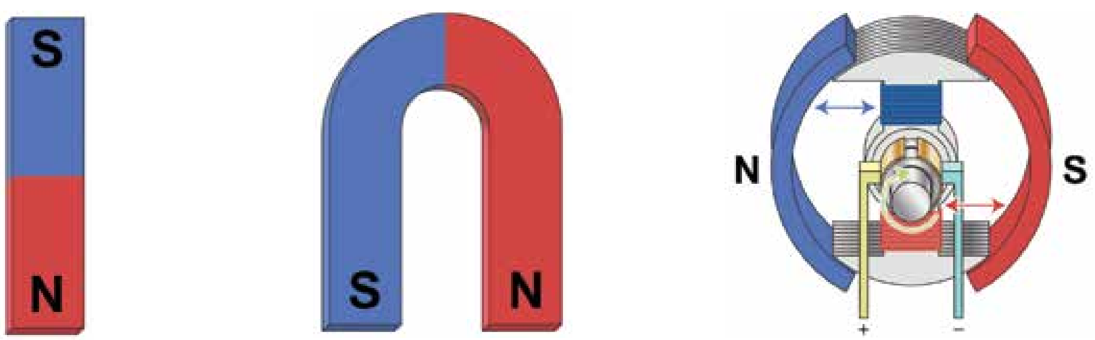


Figure 5.2 All magnets have a north and south pole

The Law of Magnetism

The Law of Magnetism states that:
Opposite (unlike) magnetic poles **attract** each other while the same (like) magnetic poles **repel** each other.

Word help

attract: pull or draw towards.
repel: push further away.

If you bring two opposite (unlike) poles (a north pole and a south pole) close together, the magnets will attract each other. There is a force of attraction between the two magnets.

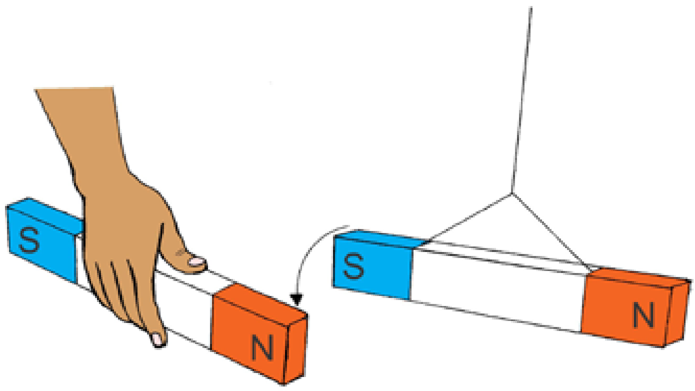


Figure 5.3 Unlike poles repel each other.

If you bring two like poles (a north pole and a north pole or a south pole and a south pole) close together, the magnets will repel each other. There is a force of repulsion between the two magnets.

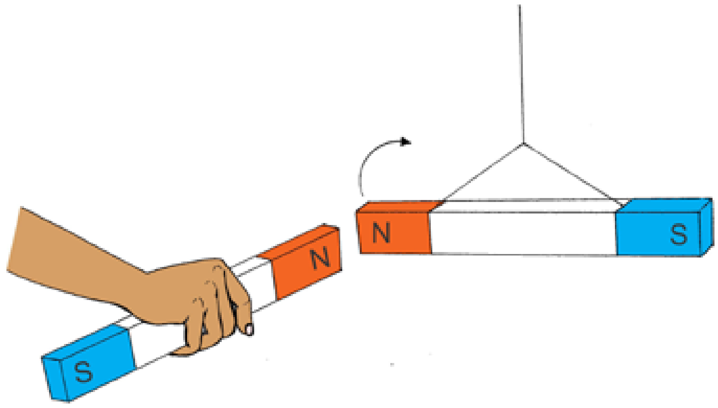


Figure 5.4 Like poles repel each other

Activity 5.1 Practical

Work in pairs

Forces of attraction and repulsion between magnets
Aim: To demonstrate the forces exerted between unlike poles and like poles of magnets

You will need:

- two bar magnets

Follow the Instructions

1. Place a magnet on the table.

2. Place a second magnet on the table. The north pole of the first magnet must face the north pole of the second magnet.
3. Bring the magnets together.
4. Describe what you experience.
5. Rotate the first magnet so that the south pole of the first magnet is facing the north pole of the second magnet.
6. Bring the magnets together again.
7. Describe what you experience.

Questions

Answer the following questions.

Copy the sentence and choose the correct word in brackets to make the statement true.

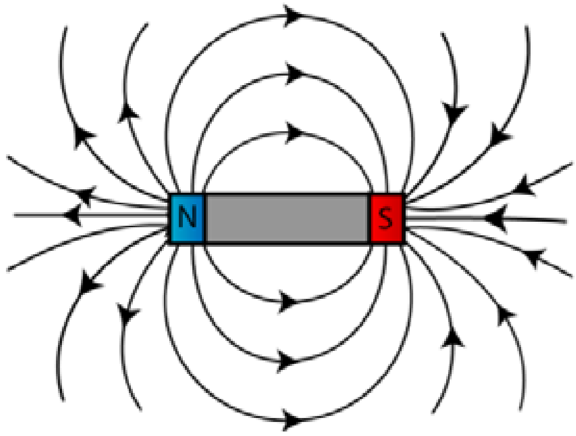
1. When two like poles of magnets are brought together, there is a (attractive/repulsive) force between the magnets.
2. When two unlike poles of magnets are brought together, there is a (attractive/repulsive) force between the magnets.

Magnetic field, field direction and strength

A magnetic field is a region of space in which another magnetic material will experience a force. Magnetic fields can be illustrated using magnetic field lines. On Figure 5.1 the iron filings line up according to the magnetic field lines.

Magnetic field lines indicate areas where the magnetic force is experienced. The closer the magnetic field lines are together the stronger the magnetic field.

The direction of the magnetic field lines on the outside of a magnet is always from the north pole of a magnet, to the south pole. Inside the magnet the direction of the magnetic field lines is from the south pole to the north pole. Figure 5.5 shows the direction of magnetic field lines.



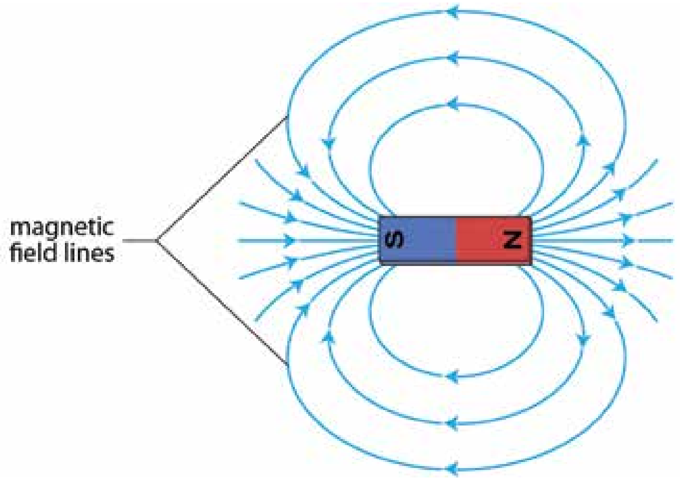


Figure 5.5 The magnetic field around a bar magnet

When we bring the north and south poles of any two magnets near each other, the magnets experience a force of attraction. Figure 5.6 shows the magnetic field lines between unlike poles that experience a force of attraction. The direction of the magnetic field lines is in the same direction and the two poles are pulled towards each other.

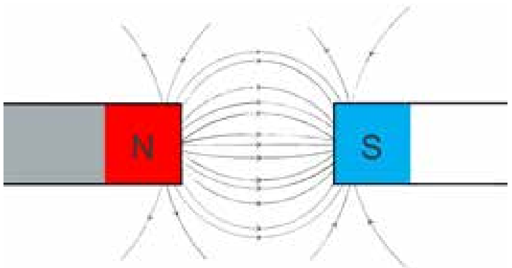


Figure 5.6 Unlike poles attract each other.

When we bring the like poles (north and north or south and south) of any two magnets near each other, the magnets experience a force of repulsion. Figure 5.7 shows the magnetic field lines between unlike poles that experience a force of repulsion. The direction of the magnetic field lines is in the opposite direction and the two poles repel each other.

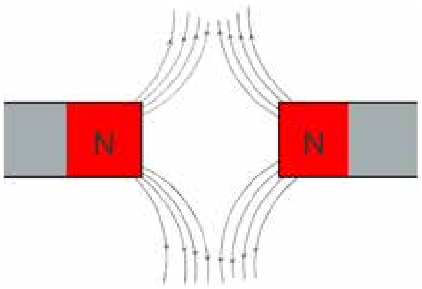


Figure 5.7 Like poles attract each other.

The magnitude of the force of attraction or repulsion between two magnets tells us how strong a magnet is. The magnetic field lines also tell us how strong the force is around the magnet. Areas where magnetic field lines are close together will have a stronger force. Areas where the magnetic field lines are further apart will have a weaker force. The magnetic field lines are closest at the poles of the magnet. The magnetic fields lines are further apart at the centre of the magnet. Object A will experience a stronger magnetic force than object B.

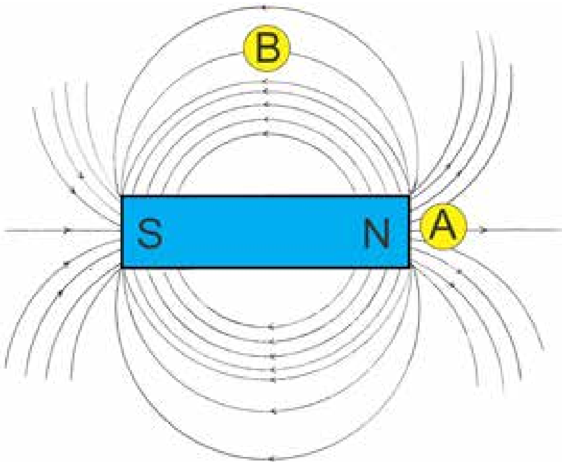


Figure 5.8 The magnetic field is stronger where the magnetic field lines are closer together.

Activity 5.2 Practical

Work in a group.

Magnetic field lines
Aim: To illustrate the magnetic field lines around a bar magnet

You will need:
- bar magnets
- paper
- iron fillings

Method
Follow the Instructions.
1. Place the bar magnet under the plain paper.
2. Sprinkle iron filings over the paper so that there is a fine layer of filings over an area of the paper.
3. Draw a diagram of what you observe. Label the north and south pole and indicate the direction of the magnetic field lines.
4. Move the magnet around a few centimeters in either direction.
5. Describe what you observe now.

Summary

- All magnets have a north and a south pole.
- Objects that experience a magnetic force are called magnetic.
- A magnetic field is a region of space in which another magnetic material will experience a force.
- The direction of the magnetic field lines is always from the north pole of a magnet, to the south pole.
- Any magnetic object that lies in the magnetic field of a magnet, will experience a magnetic force.
- A stronger magnetic field will exert a stronger force on magnetic objects.
- Areas where magnetic field lines are close together will have a stronger force.
- Areas where the magnetic field lines are further apart will have a weaker force.
- The Law of Magnetism states that: Opposite magnetic poles attract each other while like magnetic poles repel each other.

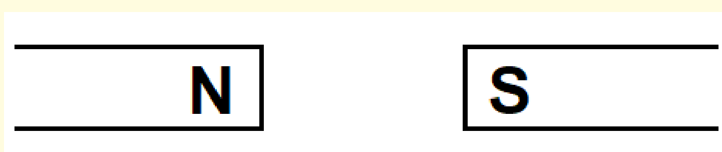
Topic assessment

Work on your own

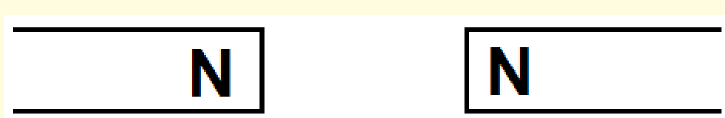
Answer the following questions.

1. State the Law of Magnetism. [2]
2. Draw a bar magnet and label the poles and magnetic field lines. [6]
3. Indicate the direction of the magnetic field lines. [1]
4. Copy each of the following cases. Draw the magnetic field lines given each of the following cases. Remember to indicate the direction of the magnetic field lines. [6]

a)



b)



c)

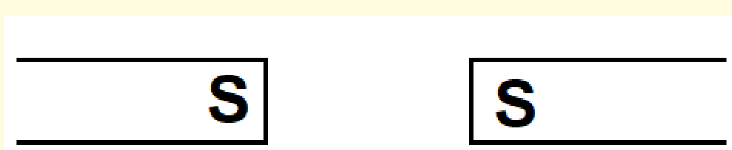


Figure 5.11

5. Use the word box to fill in the missing words. [5]

Word box

magnetic
stronger
weaker
poles
centre

a) Magnets exert a magnetic force onto magnetic objects.
b) Areas where magnetic field lines are close together will have a __________force.
c) Areas where the magnetic field lines are further apart will have a ___________force.
d) The magnetic field lines are closest at the __________ of the magnet.
e) The magnetic fields lines are further apart at the ____________ of the magnet.

[20 Marks]

Topic 6 Electricity

Learning objectives	Activities
• Define current and voltage	• Discussing the meaning of current and voltage
• State the S.I units of current and voltage	
• Measure current and voltage	• Carrying out experiments to measure current and voltage
• Determine electrical power	• Calculate electrical power

In Form 1 you learnt about charge. You also learnt that there are two different types of electricity. Static electricity and current electricity. Current electricity is the flow of negative charge.

Current electricity

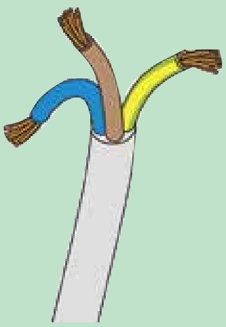
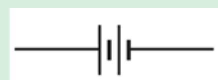
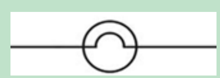
When **electrons** move, they carry electrical energy from one place to another. Current electricity is the flow of electric charge. Electrons flow as electric charge through a conductor. An electric **conductor** is a material that allows electrons to flow through it. Examples of good conductors of electricity are metals such as: copper, iron and steel. Materials that do not allow electrons to flow are called **insulators**. Examples of insulators are plastic, rubber, wood and glass.

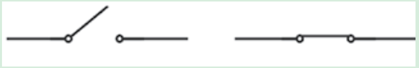
A path must be created for electric charge to move from one object to another object. This path is called a **circuit**. A circuit is a closed loop. It is made by **linking circuit components** together with connecting wires. In Form 1 you learnt about some of the circuit components of an electric circuit and their **symbols**.

Word help

electron: a small particle that has a negative charge.
conductor: material that allows electric current to flow.
insulator: material that does not allow electric current to flow.
circuit: pathway that electrons can flow through made up of wires and circuit components
link: connect to.
circuit component: basic parts that make up an electric circuit.
symbol: a sign that is used to represent something else.

Table 6.1
Some circuit components and their circuit symbols

Circuit component	Function	Symbol
Connecting wires 	Provide a path for electric current.	
Cell or battery 	A supply of electrical charge. The longer line is the positive terminal and the shorter line is the negative terminal.	
Light bulb 	Converts electrical energy into light and heat energy. A resistor.	

A switch 	Breaks or closes a circuit, stopping or starting the current to flow.	Closed switch  Open switch
Resistor 	Restricts the flow of current in a circuit.	

Voltage

When a circuit is complete, charge can move through the circuit. Something needs to **force** the charge to move. The battery in the circuit provides the force. Voltage (potential difference) is an electrical force that makes electric current move through a circuit. Voltage is a measure of the difference of electrical potential energy between two points in a circuit.

Voltage is **directly proportional** to current. This means that more current will flow through a circuit that has a battery with a higher voltage.

In Figure 6.1 the battery of circuit A provides the circuit with 1.5 volts. The battery of circuit B provides the circuit with 3 volts. The voltage of the battery of circuit B is higher than the voltage of the battery in circuit A. Circuit B will have greater current than circuit A. This means that the light bulb in circuit B will be brighter.

Word help

force: a push or a pull on an object.
directly proportional: one amount increases at the same rate as another amount.

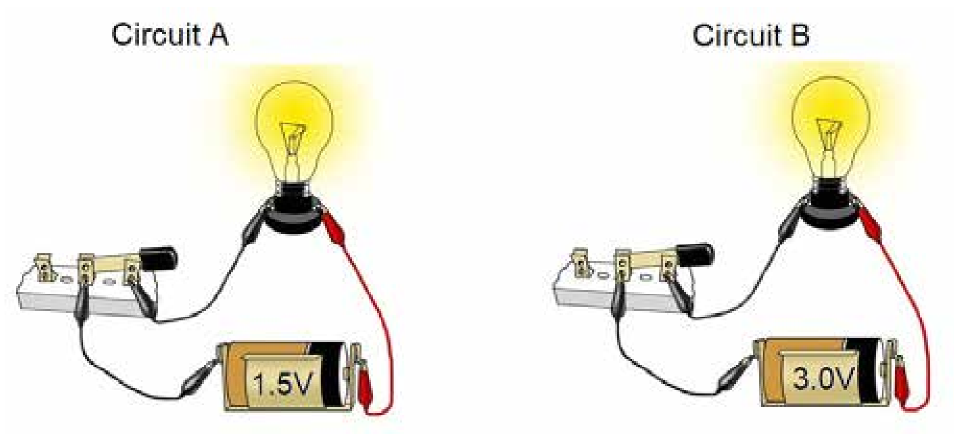


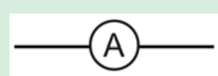
Figure 6.1 Circuit B (b) will have a stronger current than circuit A (a) because circuit B has a higher voltage than circuit A

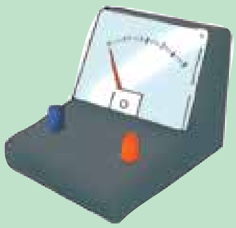
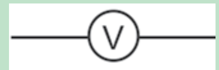
Measuring current and voltage

Current is the flow of charge in an electric circuit and the SI unit for current is the ampere (A). An ammeter is an instrument used to measure the strength of electric current.

The SI unit for voltage is the volt (V). A voltmeter is a measuring instrument that measures the voltage between two points in an electric circuit.

Table 6.2
Circuit symbols of an ammeter and a voltmeter.

Circuit component	Function	Symbol
Ammeter 	Measures the size (strength) of the current	

Voltmeter 	Measures the electrical energy (potential difference) in a circuit	

The ammeter

An ammeter is an electronic device that measures the total current flowing through an electric circuit. In order for an ammeter to measure the current, the current must flow through the ammeter. Therefore, an ammeter is connected in **series** so that all the charge flows through it.

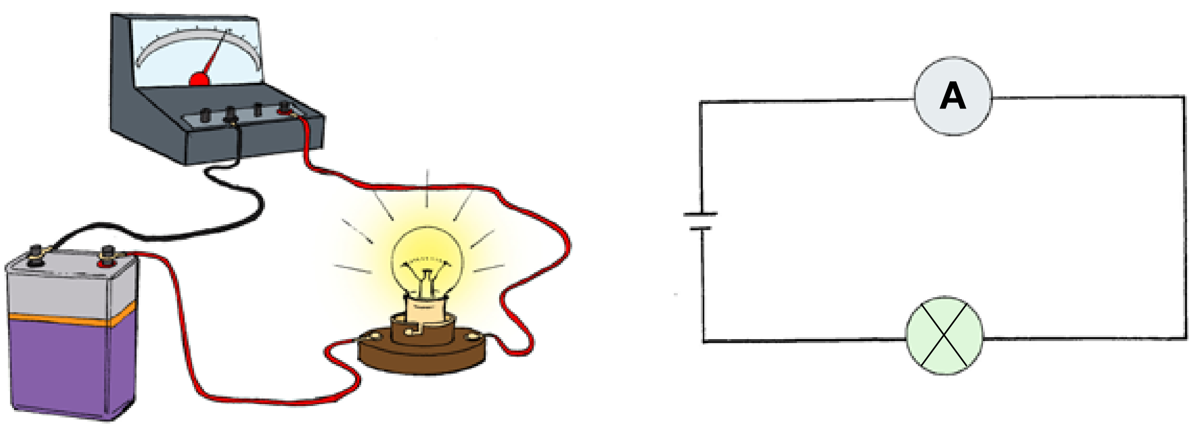


Figure 6.9 Ammeter is connected in series

An ammeter has a low **resistance** so that it does not affect the total resistance in the circuit.

When we connect an ammeter to a circuit, we connect the negative **terminal** of the battery to the black connector. We connect the positive terminal of the battery to the red connector.

Word help

series: circuit that only has one pathway for electricity to flow.
resistance: force opposing the flow of electrons through a circuit.
terminal: the point on a battery where electric current enters or leaves.

Look at the red connectors on the ammeter in Figure 6.10. There are three different ampere ranges. Each range has a different scale on the ammeter. Select the range that suits the current that flows through the circuit. Use the correct scale to record the electric current reading.

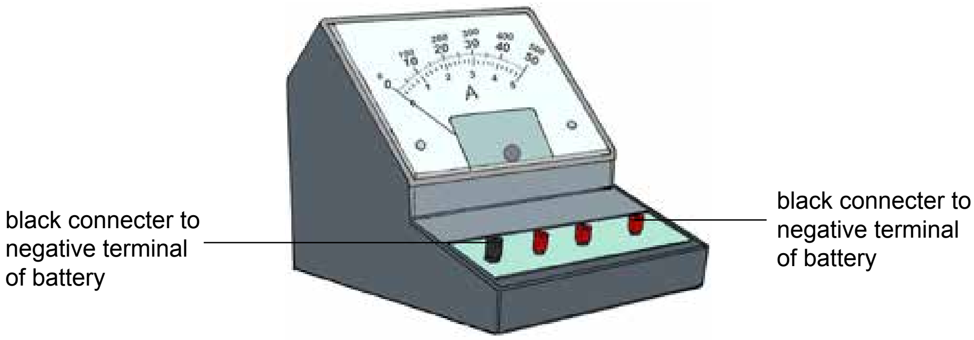


Figure 6.10 An ammeter has one negative connector and a range of positive connectors.

Look at Figure 6.11. The red connector is in the 5A range. We use the scale that has a maximum value of 5. The current reading from the ammeter is 3.5V.

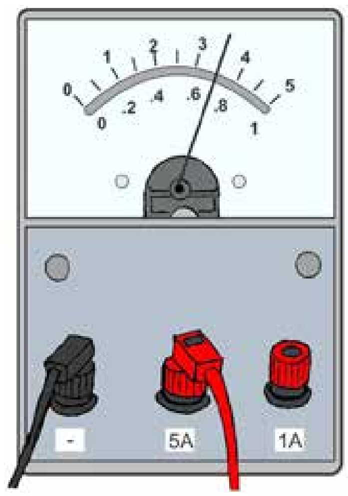


Figure 6.11 The connecting wire is plugged into the 5A connector. Use the scale that has a maximum value of 5.

The voltmeter

A voltmeter is a device that measures the potential difference between two points in an electric circuit. The current does not flow through a voltmeter. A voltmeter has a high resistance and is always connected in **parallel**.

Word help

parallel: circuit where there is more than one pathway for current to flow.

Look at Figure 6.12. In circuit A, the voltmeter is connected in parallel across the light bulb. The voltmeter is measuring the electrical potential difference in volts between the two ends of the light bulb.
In circuit B, the voltmeter is connected in parallel across the battery. The voltmeter is measuring the electrical potential difference in volts between the two ends of the battery. This shows the total energy available in the battery.

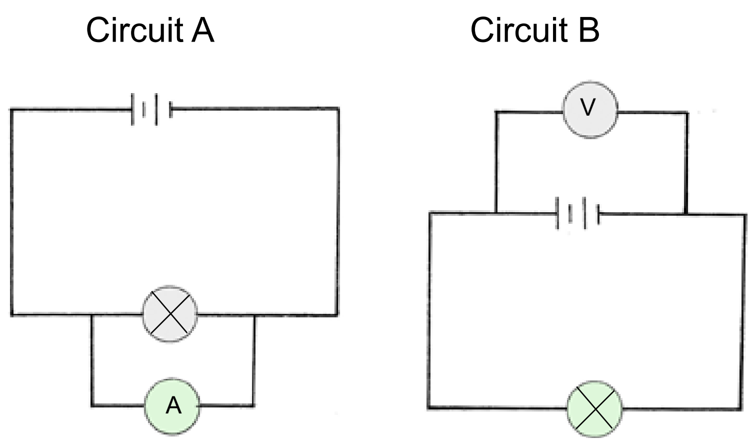


Figure 6.12 The voltmeter is connected in parallel across the circuit components.

A voltmeter has a high resistance and is always connected in parallel across a circuit component. It is connected in parallel so that it does not affect the total resistance in the circuit.

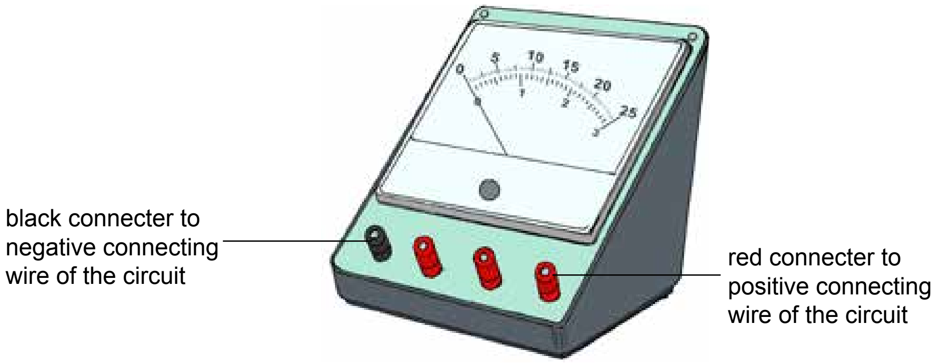


Figure 6.13 A voltmeter has one negative connector and a range of positive connectors.

When we connect a voltmeter to a circuit, we connect the black connector to the connecting wire that leads to the negative terminal of the battery. We connect the red connector to the connecting wire that leads to the positive terminal of the battery.

There are three different voltage ranges. Each range has a different scale on the voltmeter. Select the range that suits the voltage of the battery in the circuit and use the correct scale to record the voltage reading.

Look at Figure 6.14. The red connector is in the 10V range. We use the scale that has a maximum value of 10. The voltage reading from the voltmeter is 5V.

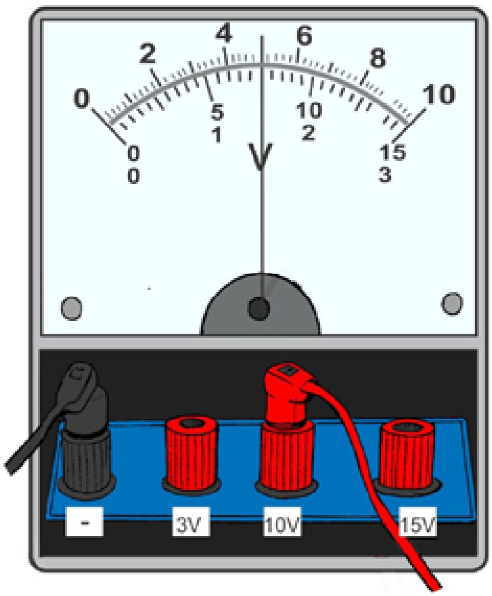
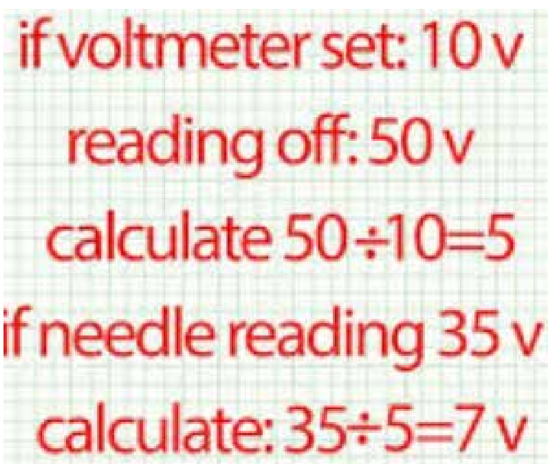


Figure 6.14 The connecting wire is plugged into the 10V connector. Use the scale that has a maximum value of 10.



Something interesting

An electric eel is a fish that can produce electric shocks of 500 volts.

Activity 6.1

Work on your own

Answer the questions.

1. Write down the reading indicated by the ammeter or voltmeter.

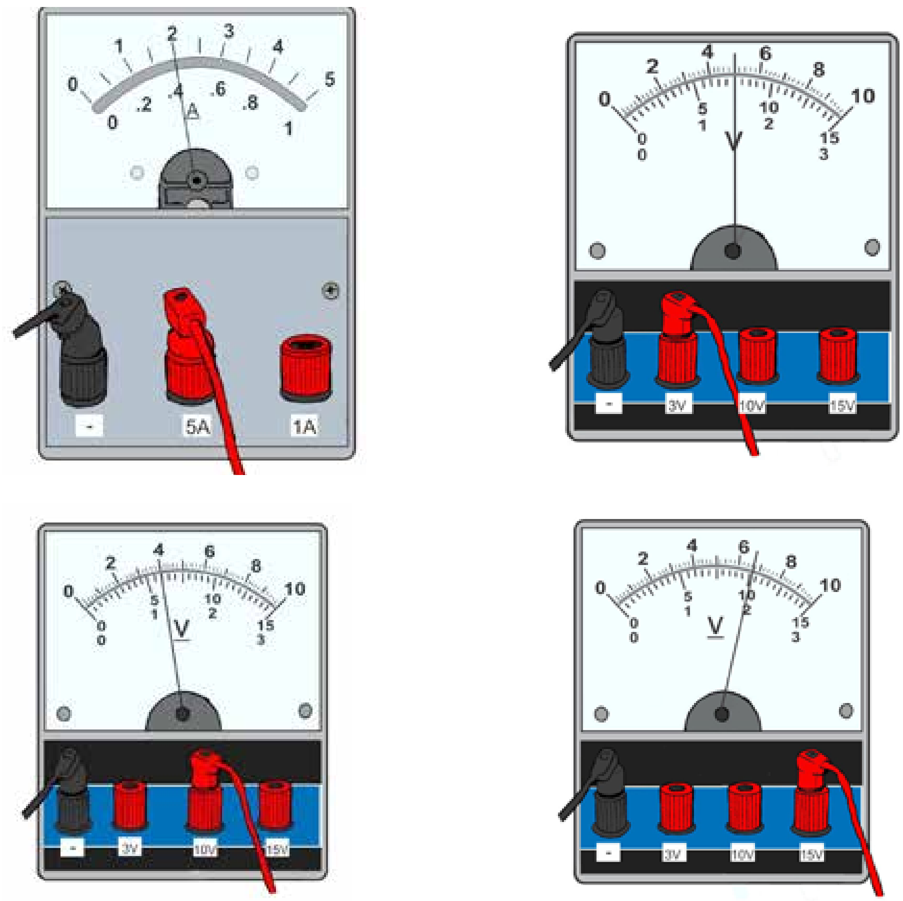


Figure 6.15

Activity 6.2 Practical

Work in a group

Measuring current and voltage
Aim: To measure the current and voltage in a simple circuit.

You will need:

- ammeter
- voltmeter
- connecting wires
- light bulb
- circuit board
- cells (3 × 1.5V)

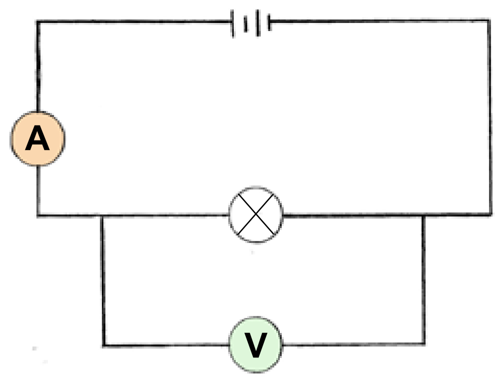


Figure 6.16 An electrical circuit diagram with voltmeter across the light bulb

The voltmeter must be connected across the cell.

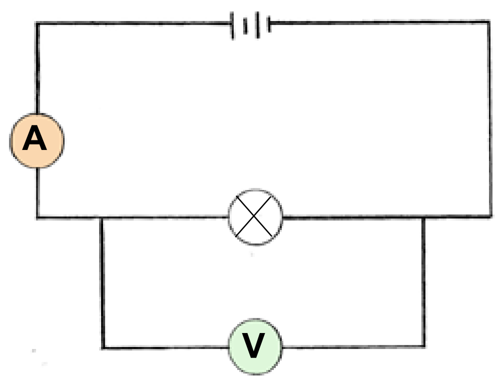


Figure 6.17 An electrical circuit diagram with voltmeter across the cell

Method

Follow the Instructions.

1. Set up an electric circuit as shown in Figure 6.16. Start with one 1,5 volt cell. The voltmeter must be connected across the light bulb.

2. Record the readings on the ammeter and voltmeter.
3. Repeat steps 1 and 2 with two cells (3 volts).
4. Repeat steps 1 and 2 with three cells (4,5 volts). Record your reading in a table:

Number of cells	Current (A)	Voltage (V)
1		
2		
3		

5. Set up an electric circuit as shown in Figure 6.17. Start with one 1,5 volt cell. The voltmeter must be connected across the cell.
6. Record the readings on the ammeter and voltmeter.
7. Repeat steps 1 and 2 with two cells (3 volts).
8. Repeat steps 1 and 2 with three cells (4,5 volts).
   Record your readings in a table:

Number of cells	Current (A)	Voltage (V)
1		
2		
3		

Questions

1. What happened to the ammeter readings when more cells were added to the circuit?
2. What happened to the voltage readings when more cells were added to the circuit?
3. Were the voltage readings across the light bulb different to the voltage readings across the battery? Explain why.

Electrical power

Electrical power is the **rate** at which electrical energy is **transferred** in a circuit. The SI unit if power is the watt (W). One watt is equal to one **joule** of energy per second.
A watt is a relatively small unit of measure of electrical power. It is more common for us to use the kilowatt (kW).

1 000 w =1 kW

The electric power of a circuit is equal to the product of the voltage and the current in the circuit. We use this equation to calculate electrical power:

$$Power = Current \times Voltage$$

A circuit that has a high voltage and a strong current will have more electrical power.
Example

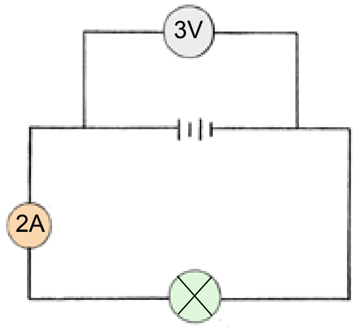


Figure 6.18 A circuit diagram

Word help

rate: a ratio that compares two quantities that have different units of measure.

The circuit in Figure 6.18 has a current of 2A and a battery with a voltage of 3V. The electrical power is:

$$\begin{aligned} Power &= Current \times Voltage \\ &= 2 \times 3 \\ &= 6W \end{aligned}$$

Activity 6.3

Work in with a partner

Answer the questions.

Refer to Activity 6.2. Determine the electrical power for each circuit. Use a table like this to calculate the power:

Number of cells	Current (A)	Voltage (V)	Power (W)
1			
2			
3			

2. Describe what happened to the electrical power when the voltage in the circuit was increased.

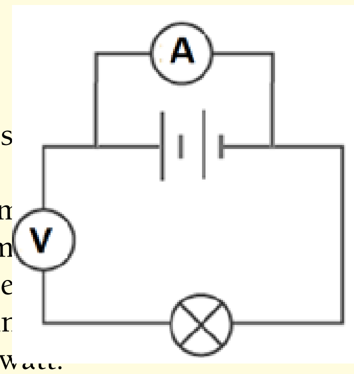
Summary

- Current electricity is the flow of electric charge.
- The SI unit for current is the ampere (A).
- An ammeter is an instrument used to measure the strength of electric current.
- Voltage is a measure of the difference of electrical potential energy between two points in a circuit.
- An ammeter is connected in series.
- The SI unit for voltage is the volt (V).
- A voltmeter is a measuring instrument that measures the voltage between two points in an electric circuit.
- A voltmeter is connected in parallel.
- Electrical power is the rate at which electrical energy is transferred in a circuit.
- The S.I unit of power is the watt (W).
- The electric power of a circuit is equal to the product of the voltage and the current in the circuit.

Topic assessment

Answer the questions.

1. Define current. [1]
2. Define voltage. [1]
3. Define electrical power. [1]



4. Each of the following statements are false. Rewrite the s word in each statement to make it true. [6]
   a) An ammeter is an electronic device that is used to m a circuit.
   b) A voltmeter is an electronic device that is used to m a circuit.
   c) A voltmeter has a low resistance and must be conne
   d) An ammeter has a high resistance and must be conn
   e) The SI unit used to quantify electric current is the watt.
   f) The SI unit used to quantify voltage is the ampere.
   g) The SI unit used to quantify electric power is the volt.

5. Look at the circuit. Discuss why the readings from the voltmeter and ammeter will not be accurate.

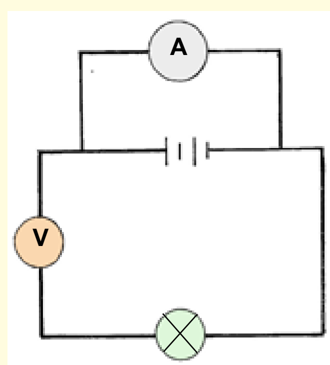


Figure 6.19

6. Write the reading from each device. Make sure you include the correct units for each measurement. [4]
   a)

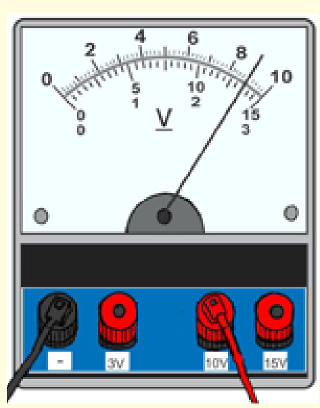


Figure 6.20

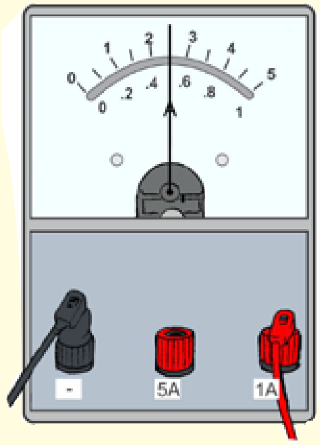


Figure 6.21

7. The current through a circuit was measured to be 5 A. The voltage of the battery in the circuit is 15 volts. Determine the power in the circuit. [3]
8. The electric power through a circuit was calculated to be 10 watts. The voltage of the battery in the circuit is 15 volts. Determine the electric current in the circuit. [3]
9. The electric power through a circuit was calculated to be 15 watts. The electric current through the circuit is 5A.
   a) Determine the voltage of the battery in the circuit. [3]
   b) If the battery consists of 3 identical cells, what is the voltage of each cell? [1]
   c) How many cells would you need if you wanted a voltage of 5V? [1]
   d) Does the power increase or decrease when the voltage in the circuit is increased? [1]

[Total]:25 Marks