Ministry of Education and Sports

THE REPUBLIC OF UGANDA

HOME-STUDY LEARNING

SENIOR **2**

PHYSICS

August 2020

NCDC
NATIONAL CURRICULUM DEVELOPMENT CENTRE

FOREWORD

Following the outbreak of the COVID-19 pandemic, government of Uganda closed all schools and other educational institutions to minimize the spread of the coronavirus. This has affected more than 36,314 primary schools, 3129 secondary schools, 430,778 teachers and 12,777,390 learners.

The COVID-19 outbreak and subsequent closure of all has had drastically impacted on learning especially curriculum coverage, loss of interest in education and learner readiness in case schools open. This could result in massive rates of learner dropouts due to unwanted pregnancies and lack of school fees among others.

To mitigate the impact of the pandemic on the education system in Uganda, the Ministry of Education and Sports (MoES) constituted a Sector Response Taskforce (SRT) to strengthen the sector's preparedness and response measures. The SRT and National Curriculum Development Centre developed print home-study materials, radio and television scripts for some selected subjects for all learners from Pre-Primary to Advanced Level. The materials will enhance continued learning and learning for progression during this period of the lockdown, and will still be relevant when schools resume.

The materials focused on critical competences in all subjects in the curricula to enable the learners to achieve without the teachers' guidance. Therefore effort should be made for all learners to access and use these materials during the lockdown. Similarly, teachers are advised to get these materials in order to plan appropriately for further learning when schools resume, while parents/guardians need to ensure that their children access copies of these materials and use them appropriately.
I recognise the effort of National Curriculum Development Centre in responding to this emergency through appropriate guidance and the timely development of these home study materials. I recommend them for use by all learners during the lockdown.

Alex Kakooza
Permanent Secretary
Ministry of Education and Sports

ACKNOWLEDGEMENTS

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Director,
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ABOUT THIS BOOKLET

Dear learner, you are welcome to this home-study package. This content focuses on critical competences in the syllabus.

The content is organised into lesson units. Each unit has lesson activities, summary notes and assessment activities. Some lessons have projects that you need to carry out at home during this period. You are free to use other reference materials to get more information for specific topics.

Seek guidance from people at home who are knowledgeable to clarify in case of a challenge. The knowledge you can acquire from this content can be supplemented with other learning options that may be offered on radio, television, newspaper learning programmes. More learning materials can also be accessed by visiting our website at www.ncdc.go.ug or ncdc-go-ug.digital/. You can access the website using an internet enabled computer or mobile phone.

We encourage you to present your work to your class teacher when schools resume so that your teacher is able to know what you learned during the time you have been away from school. This will form part of your assessment. Your teacher will also assess the assignments you will have done and do corrections where you might not have done it right.

The content has been developed with full awareness of the home learning environment without direct supervision of the teacher. The methods, examples and activities used in the materials have been carefully selected to facilitate continuity of learning.

You are therefore in charge of your own learning. You need to give yourself favourable time for learning. This material can as well be used beyond the home-study situation. Keep it for reference anytime.

Develop your learning timetable to ca ter for continuity of learning and other responsibilities given to you at home.

Enjoy learning

NCDC PHYSICS SELF-STUDY FOR S2 TERM 2 AND TERM 3 2020

These self-study materials have been developed to help you continue with learning despite the closure of schools that was necessitated by the COVID-19 pandemic. They are a continuation of the first self-study materials that were previously developed. They will help you understand the major concepts in different topics in Physics for your level.

A variety of activities and exercises have been provided. Please fry out all the activities and exercises to improve your understanding of the topics. Where possible, consult with other learners in your area. You can also consult from other sources like textbooks and use internet to further your knowledge. However, ensure that you are following the standard operating procedures (SOPs) so as to avoid Covid-19. You should ensure that you regularly wash your hand with soap and water and avoid crowded places. In case you are to be in public, always put on your mask.

All the best as you continue to study using these materials.

CHAPTER: PRESSURE IN SOLIDS AND FLUIDS

By the end of this chapter, you will be able to;

i) define pressure and state its SI units.
ii) state the formula for pressure due to solids.
iii) state the factors on which pressure due to solids depends.
iv) derive the formula for pressure in fluids.
v) describe experiments to show what pressure in fluids depends on.
vi) describe real life situations where knowledge of pressure is applied.
vii) work out numerical computations concerning pressure.

LESSON 1: PRESSURE IN SOLIDS

Competences

In this lesson, you will:

i) define pressure and state its SI units.
ii) investigate the factors that affect pressure due to solids.
iii) explain some happenings using your knowledge of pressure.

iv) solve related mathematical problems.

Materials you need

Pin, nail, pencil, pen, banana leaf stalk

Introduction

In ordinary language the word pressure is commonly used when someone has so many challenges. In science language pressure is a measure of how force is distributed over an area.

Activity 1: Factors that affect pressure due to solids.

In this activity you will find out the factors that affect pressure due to solids.

i. Look at your pin, nail, pencil and pen. Arrange them starting with the one having the biggest tip. …………………………., …………………………., …………………………., ………………………….

ii. Try to push each of them into the banana leaf stalk and list them in order of which one enters most easily…………………………., …………………………., …………………………., ………………………….

iii. Try to complete these sentences using what you have observed in the activity

a. The smaller the area of contact, the ………….. (more/less) force needed to push the object into the stalk.

b. The bigger the area of contact, the …………… (more/less) force needed to push the object into the stalk.

iv.   Imagine how it would feel if you were using your hand instead of the banana leaf stalk. That feeling is caused by the pressure acting on your hand. We say the object is **exerting** pressure on the stalk or on your hand.
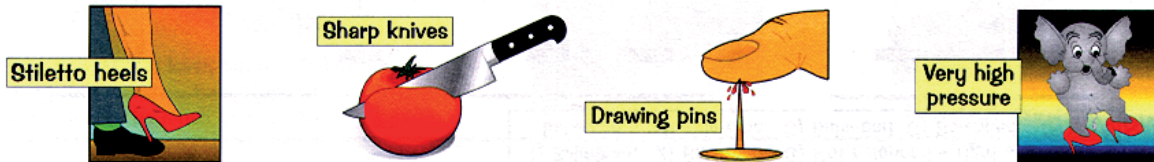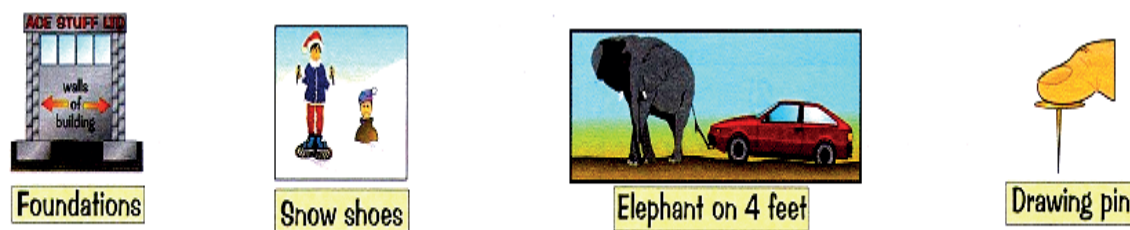
Now think about the following situations and try to explain them using your knowledge of pressure

a.   On a rainy day, small car gets stuck in a muddy road but heavier tractors pass through without getting stuck.

b.   Hippos can walk well along the banks of a river but antelopes get stuck and avoid river banks.

c.   Women wear flat soled shoes on rainy days and pointed heel shoes on dry days.

d.   When carrying a load like a pot on the head, a cushion is put between the load and the head.

e. Bags have wide pads along their handles.

Important information

Pressure is defined as the force acting normally per unit contact area. The formula for pressure is

$$Pressure = \frac{Force}{Area}$$

$P = \frac{F}{A}$ Where

P is pressure
F is force acting at 90° to the surface
A is the area of the surface.

The SI units of pressure are N/m², Nm^{-2} or Pascals (Pa). 1Pa = 1Nm^{-2} = 1N/m²

SUMMARY of Pressure due to Solids

From the activity 1 above you should have noticed that **area of contact** and **force acting perpendicularly** are the factors that affect pressure exerted.

✗ For the same perpendicular or normal force, *the less the area, the more the pressure and the more the area the less the pressure.*

✗ For the same area of contact, *the more the force, the more the pressure and the less the force, the less the pressure.*

✗ *Pressure in solids acts only in the direction of the force.*

Exercise 1

Try out the following questions.

1. Calculate the pressure exerted on the floor by a jerrycan full of water having a weight of 100N while resting

   a) On its bottom of area 0.04m²

   b) On its side of area 0.2m²

2. If the same jerrycan is carried by a boy on his head, what is the pressure exerted on his head given that

   a) He uses a circular banana leaf cushion of area 0.314m²?

   b) He puts the jerrycan directly on his head and the area of contact is 0.0033m²?

3. A hawker carries his bag of mass 40kg. What pressure does it exert on his shoulder if he uses:

a) a small handle that makes 10cm² area of contact with the shoulder?

b) a padded handle with 50cm² contact area?

Answers to exercise 5.1

1.	a.	P = 2,500Pa	2.	a.	P = 318.47Pa	3.	a.	P = 400,000Pa
	b.	P = 500Pa		b.	P = 30,303Pa		b.	P = 80,000Pa

LESSON 2: PRESSURE IN FLUIDS

Competences

In this lesson, you will:

    i)   investigate the factors affecting pressure in fluids.

    ii)   derive the expression **P = hρg.**

    iii)   apply **P = hpg** to solve simple numerical problems.

You will need the following items — Foot ruler, 1 two litre plastic soda bottle, Polyethene bag, 3 mineral water bottles of different sizes and shapes, Water, Cooking oil

Introduction

When we open a tap, water flows out because it is under pressure. Have you ever thought about why water flows downwards or why water tanks are put high above the taps? Does a jerrycan full of water weigh the same as a similar jerrycan full of cooking oil or paint? In this lesson you are going to find out the factors that affect pressure in fluids. Remember that a fluid is a liquid or a gas.

Activity 1: Investigating the effect of <u>height</u> on fluid pressure.

   i. Make holes of the same size along the same vertical line at the top, middle and bottom of a big plastic soda bottle.

  ii. Make the bottle to stand on a bench or any other raised surface.

 iii. Quickly pour water in the bottle until it is full. Continue pouring to keep the bottle full.

 iv. Let the water to flow out through the holes.

  v. Measure how far from the bottle the water hits the ground for each hole.

 vi. What can you say about height and pressure?

Hole	Distance(cm)
Top	
Middle	
Bottom	
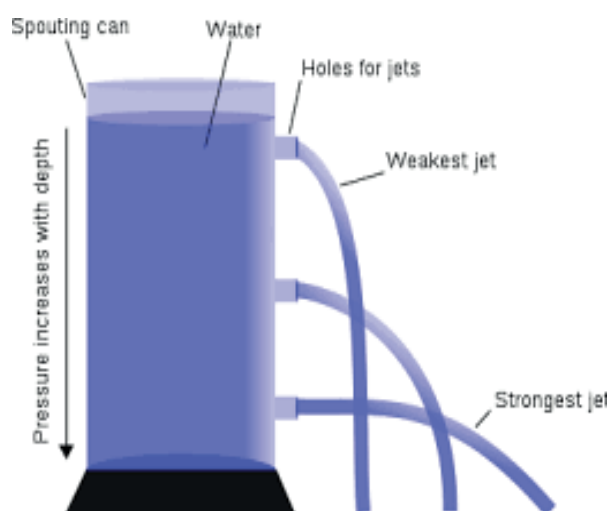
Activity 2: Investigating the effect of <u>density</u> on fluid pressure.

    i. Repeat the above activity 5.2.1 but use **cooking oil** instead of water.

    ii. Compare the distance from the bottle to the point where the cooking oil hits the ground with the distance where the water hit the ground for each hole.

	Distance (cm)	
Hole	Water	Cooking oil
Top		
Middle		
Bottom		

    iii. What can you say about density of a fluid and fluid pressure? (density of water is 1000kg/m³and density of cooking oil is ≃920kg/m³)

From the activity 1 above you should have realised that

• When height increases, pressure also increases and when height reduces, pressure also reduces. We say that ***pressure is directly proportional to height.***

And from activity 2 you see that

• ***Pressure is directly proportional to density***.

Activity 3: Relationship between pressure and <u>direction</u> at the same depth.

i. Make several holes of the same size at the same level in different directions in the big plastic soda bottle.

ii. Fill the soda bottle with water and let the water flow out through the various holes. Continue pouring to keep the bottle full.

iii. Measure and record the distance from the bottle where the water hits the ground.

iv. What can you say about the effect of direction on pressure at a given depth?
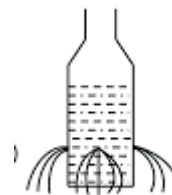
From this Activity 3 you should see that *at the same depth, pressure is the same in all directions.*

Activity 4: Investigating the effect of <u>shape</u> of the container on fluid pressure.

i. Remove the covers and cut off the bottoms of the mineral water bottles of different shapes.

ii. Cut holes in the side of a big soda bottle so that the mineral water bottles can fit **tightly** in those holes.

iii. Place the big soda bottle on a table horizontally and fix the mineral water bottles with the cut ends facing up.

iv. With the soda bottle cover tightly screwed, pour water through one of the mineral water bottles until the water reaches halfway the mineral water bottle.

v. Measure the height of the water level in each mineral water bottle.

vi. What can you say about the shape of a container and fluid pressure?

Pressure at depth h:
$$P = \rho g h$$
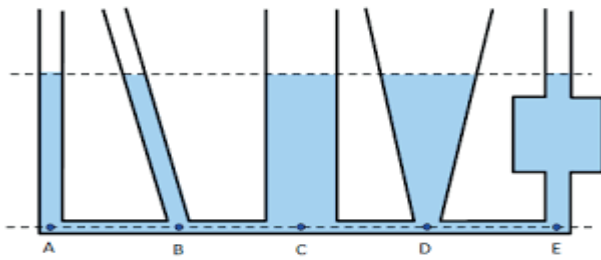
The results of activity 5.2.3 show that **pressure in open and connected containers DOES NOT depend on the shape of the container but only on the vertical height.**

Activity 5: Deriving the formula P = hpg

i) Think of a liquid column with cross sectional area A, vertical height h, and density p

ii) The volume of this liquid column,

V= cross sectional area x height

V = Ah

iii) The mass of this column is volume x density

m = Ah x p = Ahp

iv) The force due to gravity of the column is its weight = mass x acceleration due to gravity

W = mg

W = Ahp x g

W = Ahpg

v) Pressure exerted by the liquid column,

$$P = \frac{Force}{Area}$$

$$= \frac{Ahpg}{A} = hpg$$
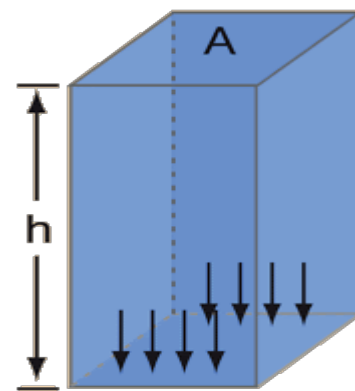
P = hpg

Summary of lesson 2: Pressure in Fluids

- *Pressure in fluids is directly proportional to height.*
- *Pressure in fluids is directly proportional to density.*
- *At the same depth, pressure is the same in all directions.*
- *Pressure in open and connected containers DOES NOT depend on the shape of the container. It depends only on the vertical height.*
- **P = hpg**

LESSON 3: PASCAL'S PRINCIPLE OF TRANSMISSION OF PRESSURE IN FLUIDS

Competences

In this lesson, you will:

i) describe experiments to demonstrate the principle of transmission of pressure.

ii) apply the principle of transmission of pressure to solve some problems.

Materials you need

- Orange peelings
- Old Bic pen

Introduction

Do you remember playing with polyethene bags filled with water? When you make some holes with a sharp object and then squeeze the bag, the jets that come out of each hole are of equal size and speed. This fun activity is a simple way of showing Pascal's principle of transmission of pressure in fluids.

Activity 1: Investigating how pressure is transmitted in enclosed fluids

i) Remove the plastic tube and covers from the Bic pen to remain with the glass casing only.

ii) Press the bigger end of the glass casing into an orange peeling until a pellet enters the casing.

iii) Push the pellet using the plastic tube, past the middle hole on the side, until it reaches the narrow end of the glass casing

iv) Press the bigger end of the glass casing again on the orange peeling to get a second pellet into the glass casing.

v) Now push the pellet from the wider end towards the middle side hole. Does the first pellet move? ....
Why? ....

vi) Push the pellet more until it passes the middle side hole. Does the first pellet move?
Why? ....

vii) Repeat the above steps and have some fun with a toy air powered gun☺

Explanation

In **step v.** *the first pellet does not move. This is because of the middle side hole in the glass casing which allows the air to escape.*

In **step vi**. *the first pellet moves. This is because when the second pellet moves past the middle side hole, air is trapped between the two pellets. Pushing on the second pellet applies pressure on the trapped air. The trapped air transmits this pressure to the first pellet and makes it to move until it pops out.*

This principle is used in the following:

1. Car braking systems
2. Hydraulic jack
3. Hydraulic press or ram
4. Hydraulic arm used on earth movers

$$\frac{F_2}{F_1} = \frac{A_2}{A_1}$$
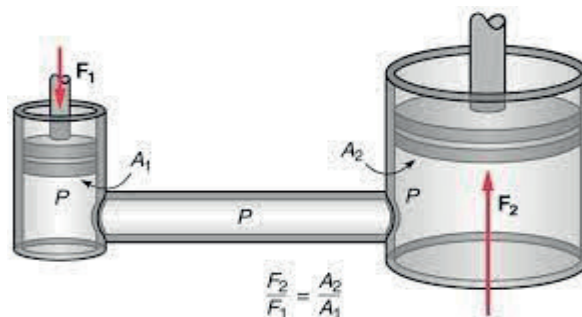
LESSON 4: ATMOSPHERIC PRESSURE

Competences

In this lesson, you will:

i) describe an experiment to show that atmospheric pressure exists.

ii) explain the dependence of atmospheric pressure on altitude

iii) solve numerical problems.

iv) describe application of atmospheric pressure e.g.

- o common lift pump,
- o force pump,
- o siphon

Materials you need:

- Plastic mineral water bottle with a cover
- Heat source (to be used under adult supervision)
- Water
- Two sauce pans
- Straw
- Cup
- Gum tree leaf or birthday party toy

Introduction

The earth's atmosphere is the air that surrounds the earth. This air has weight and this weight acts on the earth and everything on earth or above earth but within the atmosphere.

> "*When pressure is applied at one point of an enclosed incompressible fluid, the pressure is transmitted equally throughout the entire fluid.*"
>
> This is called Pascal's principle of transmission of pressure in fluids

The weight of this atmospheric air per unit area is the atmospheric pressure.

Activity 1: Drinking with a straw

i. Pour some water in a cup

ii. Place a straw in the cup

iii. Suck on the upper end of the straw until the water reaches your mouth.

iv. What makes the water to reach your mouth?

....

v. Quickly put the straw out of your mouth and place a finger on the straw and pull the straw out of the cup.

a.Does the water flow out of the straw? ……………………

b. Why? ………

vi. Now remove your finger from the straw.

   a. What happens?

   ………..

   b. Can you explain why that happens?

   ………..

Explanation

In **Step iv.** *sucking on the top part of the straw makes the pressure inside the straw less than the pressure acting on the water. Rising of the water to the mouth shows that the water in the cup has a greater pressure acting on it due to the air on the surface.* **This air pressure is called atmospheric pressure.**

*When you put your finger on the straw in **step v.** the water DOES NOT flow out of the straw. There is a greater pressure acting at the bottom of the straw that the pressure due to the column of water in the straw. This is more evidence of air pressure or atmospheric pressure. The water flows out in **step vi.** This is because air pressure acts on top of the straw and combines with the pressure due to the water column to overcome the air pressure acting at the bottom of the straw.*

Activity 2: The crushing bottle experiment to show that air exerts pressure (Please take care and avoid being burnt by steam)

i. Prepare a saucepan full of very hot water and another one full of cold water

ii. Pour a small amount of water, about one bottle cover full, into the mineral water bottle.

iii. Place the mineral water bottle into the saucepan of hot water without covering the bottle

iv. The little water in the bottle will start to evaporate. When most of it has evaporated, cover the bottle tightly.

v. Quickly transfer this bottle to the saucepan of cold water. What do you observe?

   ………

What is the explanation for your observation?

....

Explanation

In step iv. *the water evaporates and pushes out the air from the bottle. When the bottle is covered, it mostly contains water vapour.*

In step v., *the bottle collapses as if it has been crushed.*

Putting the bottle in cold water cools down the vapour and it condenses back to water. This leaves an almost empty space in the bottle. This is called a <u>partial vacuum.</u> *This makes the pressure inside the bottle to be very small. Crushing of the bottle shows that there is a much greater pressure due to air being exerted outside the bottle. This outside air pressure is called the* **atmospheric pressure.**

Read about how atmospheric pressure is used in other situations such as

a. Lifting using suckers
b. Siphon
c. Breathing
d. Jar covers
e. Common lift pump
f. Force pump

Important information
- A mercury barometer at sea level reads 76cm = 760mm.
- The atmospheric pressure at sea level is said to be 76cm of mercury or 760 millimeters of mercury.
- This is written as H = 76cmHg or 760mmHg.
- Other pressures may also be expressed in terms of cmHg or mmHg
- The value of atmospheric pressure at sea level in pascals or Nm^{-2} is

    $H = hpg = 0.76 \times 13600 \times 10 = 103,360 Pa.$
- As altitude increases, the height of the air column from the top of the atmosphere to the earth <u>reduces</u>. **This causes the atmospheric pressure to reduce as altitude increases.**

Worked example

The difference in pressure at the peak of the mountain and the foot of the mountain is

5.0 x 10^3 Nm^{-2}. Given that the density of air is 1.3 kgm^{-3}, calculate the height of the mountain.

Solution

Difference in pressure = pressure exerted by air column from bottom to top of mountain

$$\Delta P = h\rho g$$

5.0x 10^3 = h x 1.3 x 10

$$h = \frac{5.0\ X10^4}{1.3X10}$$

h = 3846 m

h = 3.85 km

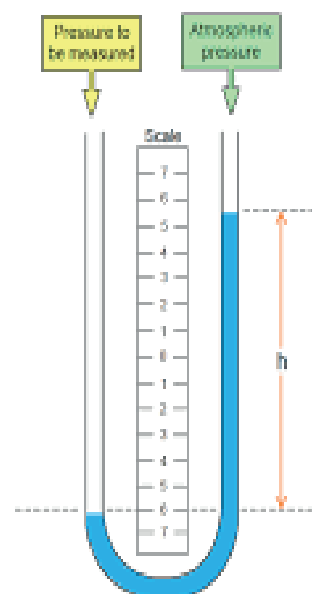## LESSON 5: MEASURING GAS PRESSURE USING A MANOMETER.

Competences

In this lesson, you will:

i)   describe an experiment to measure gas pressure using a manometer.

ii)   solve related mathematical problems.

Materials you need:

- Any transparent plastic tube e.g. Builders' water level (they are sold at hardware shops).
- Water.
- Foot ruler

Introduction

As seen in the previous lesson, the air in the atmosphere exerts a pressure. This pressure acts on everything that is exposed to atmospheric air. In this lesson you will learn how to measure gas pressure using a manometer. A manometer is a u-(shaped) tube or a j-(shaped) tube containing a dense liquid. It is used for measuring gas pressure.

Activity 5.5.1: Measuring gas pressure using a manometer.

i) Get a piece of transparent plastic pipe of length 20cm.

ii) Bend it to form a u-shape. This becomes a u-tube.

iii) Pour water into one arm of the u-tube you have formed.

iv) Make sure that both arms are open to the air and compare the water level in each arm. What do you notice?

   ………..

v) What is the explanation for your observation above?

   ………..

vi) Now blow air into one arm of the u-tube. What happens to the water level in the

   a. Arm where you are blowing?

      ……..

   b. Opposite arm?

      ……..

vii) Measure the difference in height of the two water levels and record it as h_e = ……..cm.

viii) What can you say about your blowing ability in pascals?

   ………..

ix) By how much does the pressure of the gas you have blown exceed atmospheric pressure? (This is called excess pressure)

   ………..

Explanation

In **step iv.** the water is at the same level in each arm. This is because each arm is open to the atmospheric air and atmospheric pressure is acting equally on the water in each arm. This

makes the levels equal since they are both being acted upon by the same atmospheric pressure.

Blowing air from the mouth in one arm in
step vi. *increases the pressure acting on the water in that arm. The level in that arm goes down and the level in the opposite arm rises.*

> Important information
> A water manometer needs very long limbs to measure high values of pressure. This is because the density of water is low.
> When Mercury is used, shorter limbs are needed because mercury has a high density.

Step viii. *Wants you to calculate the pressure of the gas you have blown. This has been called your blowing capacity. This is equal to the pressure of the water column in the opposite limb plus the atmospheric pressure. You may need a longer tube to get your maximum blowing capacity.*

The excess pressure in **step ix** *is given by the pressure due to the water column in the opposite limb only.*

Worked Example

1.(a)   In the figure above, a fixed mass of dry air is trapped in bulb A. If the atmospheric pressure is 76cm of mercury, calculate the total pressure of the air in A, in:

(i)   mmHg

(ii) Pa   (atm. pressure = 101325 Pa,

ρ of mercury = 1.36×10^4 kg m^{-3}, g = 10 ms^{-2})

Solution:

Atmospheric Pressure = 76 cmHg= 76 x 10 = 760 mmHg

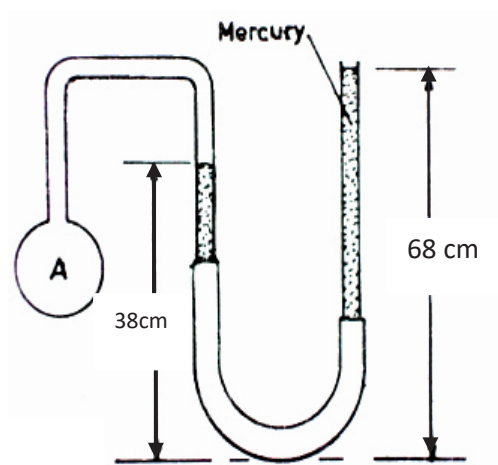h_1 = 38 cm = 38 x 10 = 380 mm,

h_2 = 68 cm = 68 x 10 = 680 mm

(i)Pressure due to mercury column,

$$h = h_2 - h_1$$

$$= 680 - 380 = 300 \text{ mmHg}$$

Gas pressure   = P_A + Pressure due to liquid column

= 760 + 300**= 1060 mmHg**

    (ii)   Pressure, P, due to mercury column   = $h\rho g$

= 0.3 x 13600 x 10

= 40,800 Pa

Gas pressure   = P_A + Pressure due to liquid column

= 101,325 + 40,800

= 142,125 Pa

CHAPTER: MOLECULAR PROPERTIES OF MATTER

By the end of this chapter, you should be able to;

    i)   state the kinetic theory of matter.
    ii)   use the kinetic theory of matter to explain diffusion.
    iii)   describe intermolecular forces.
    iv)   perform experiments to show capillarity.
    v)   describe applications and problems associated with capillarity.
    vi)   perform experiments to demonstrate surface tension and identify its uses.
    vii)   estimate the size of a molecule.

LESSON 1: KINETIC THEORY OF MATTER

Competences

In this lesson, you will:

    i)   state the kinetic theory of matter.
    ii)   describe experiment to demonstrate random motion of particles.
    iii)   identify instances in which kinetic theory of particles is observed.

Materials you need

- Dust
- Morning sunshine
- Flower with Pollen grains

- Water
- Sauce pan
- Heat source

Introduction

In Senior One, you learnt that matter is anything that occupies space and has weight. So matter is made up of a wide range of things, some are so big and others are so tiny that we cannot see them. The small particles of matter are called **atoms** and **molecules.**

According to the kinetic theory of matter, these particles are always in constant random motion and this motion increases with increase in temperature.

The smoke cell experiment is one of the ways by which the kinetic theory can be demonstrated.

This is done by confining smoke in a smoke (glass) cell, illuminating the cell with a powerful source of light and then observing the smoke particles under a powerful microscope as shown in Figure 1. The smoke particles are seen to move in all directions. Raising the temperature of the cell increases the speed of the random motion of the smoke particles.
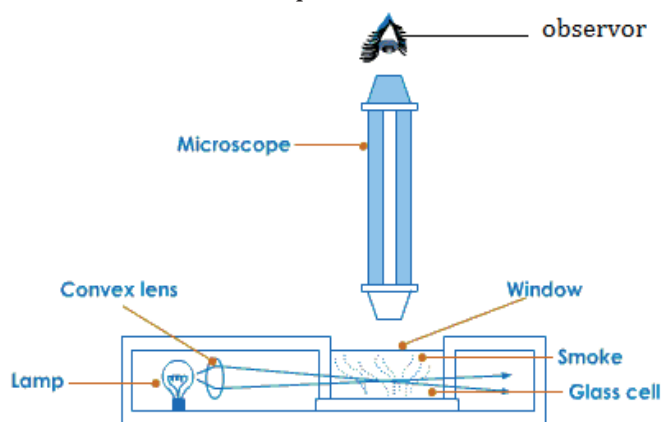

Figure 1: Smoke cell experiment

> **Important Information**
>
> Brownian motion is ***the random, erratic or haphazard motion of small particles in a liquid or a gas due to collision with the particles of the liquid or gas.***
> It was named after Robert Brown. He was a Scottish scientist who did much research about the nature of matter.

While sweeping the house in the morning, you may see some small particles moving in a zigzag way when you look at the air. When you rub two pieces of chalk or dry cassava together, their dust does not fall straight to the ground. They move in a haphazard way as they fall down. This non-uniform motion is also called Brownian Motion.
The random motion in the smoke cell experiment and the one of dust particles is due to collision between the particles and the invisible air molecules.

Activity 1: experiment to demonstrate the existence of Brownian motion

i. Pour some water into a sauce pan and allow the water to settle.
ii. Shake a flower over the water so that the pollen grains fall on the still water.
iii. What do you notice about the pollen grains? You may use your clear bottle full of water to magnify the pollen grains.
    ....
iv. Carefully place the saucepan on the heat source. What happens to the floating pollen grains as the water warms up? ....
v. Why do the pollen grains behave that way?
    ....

    Explanation

*In **step iii.** of activity 1 above, the pollen grains are seen moving in a zigzag way on the surface of the water. This zigzag motion of the pollen grains and the dust particles mentioned in the introduction is called Brownian motion. As the pollen or dust particles try to move in a straight line, they are hit by the invisible water or air molecules that are moving randomly. This is evidence of the kinetic theory of matter.*

*In **step iv.** the particles are seen to move faster as the water gets warmer. This is also because of another assumption of the kinetic theory of matter; the higher the temperature, the greater the random motion of the particles. So when the water is warmed, the invisible particles of water move faster. They collide with the pollen grains with more speed and more frequently. This makes the pollen grains to also move with greater speed.*

LESSON 2: DIFFUSION

Competences

In this lesson, you will:

    i)   demonstrate diffusion in fluids.

    ii)   investigate factors which affect the rates of diffusion.

    iii)   describe local examples involving diffusion.

Materials you need

    ❖   One cup full of milk, One cup full of millet or maize porridge, Three Small saucepans, Water, Heat, source, Table spoon

Introduction

When a neighbour is cooking delicious food, we are able to know even if there is a fence between the homes. The sense of smell helps us to get the scent of things which may be far or even unseen.

In this lesson we are going to learn how scents move from their area sources to our noses. It is a process called diffusion. We are also going to find out why some smells spread faster than others. These are the factors that affect the rate of diffusion.

Important information

Diffusion is the spread of particles from a region of high concentration to a region of low concentration in a liquid or gas medium. Diffusion can also take place in solids.
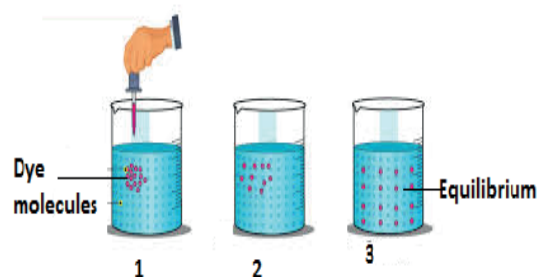
Do the activities 1, 2 and 3. Use the table below to record your observations and measurements.

Activity	Conditions	Equilibrium time(minutes)	Conclusion
1	Milk in cool water		
2	Milk in warm water		
3	Porridge in cool water		

Activity 1: Diffusion in liquids.

i. Pour some clean water into a small saucepan until it is almost full.

ii. Pour one table spoon full of milk in the middle of the water in the saucepan.

iii. What do you notice?..

iv. How long does it take for the colour to change in all parts the water? …………………………

When there is no more colour change, we say that there is _equilibrium_.

Activity 2: Diffusion and temperature.

i. Pour some clean water into the second small saucepan until it is almost full.

ii. Put the saucepan on the heat source.

iii. After 15 minutes of heating, pour one table spoon full of milk in the middle of the water in the saucepan.

iv. What do you notice? ....

v. How long does it take for the colour to change in all parts the water? …………………………

vi. Compare the time it takes for all the water to change colour in the cool water with the time taken in the warm water. In which water does it take a shorter time? ………………….....

vii. What can you say about diffusion and temperature?

…………………………………………………………………………..

Activity 3: Diffusion and density.

    i.Pour some clean water into the third small saucepan until it is almost full.

    ii.Pour one table spoon full of <u>porridge</u> in the middle of the water in the saucepan.

    iii.What do you notice? ....

    iv. How long does it take for the colour to change in all parts the water? ....

    v.Compare the time it takes for all the water to change colour when using milk with the time taken when using porridge. Which is the shorter time? ....

    vi. What can you say about diffusion and density?

    ....

Explanation

In activity 1, **step iii.** *the clear water slowly becomes cloudy after the milk has been poured in the middle of the saucepan. It takes a fairly long time for all the clear water to change colour to cloudy water in* **step iv.** *The spoonful of milk is an example of concentrated substance. When this spoonful of milk is poured in the middle of the water in the saucepan, the milk* **spreads form where it is most concentrated until it is evenly distributed throughout all the water**. *This is a* demonstration of diffusion.

Activity 2 investigates the relationship between diffusion and temperature. In **step iii.** *you should have seen that the milk spreads to all parts of the clear water just as in activity 6.4.1. however in* **parts iv. and v.** *you must have seen that it takes a much shorter time for all the clear water to turn cloudy. This shows that* **increase in temperature increases the rate of diffusion.**

Activity 3 studies the relationship between diffusion and density. Porridge is used because it is denser than milk. In **step iii.** *you should have seen that the porridge also spreads to all parts of the clear water but it takes a very long time and the particles may settle at the bottom. This shows that* **increasing density reduces the rate of diffusion.**

Wind or liquid currents can also increase the rate of diffusion in the direction they are flowing. If they are flowing in the opposite direction, they can reduce the rate of diffusion. Agitating or stirring

the liquid or gas also increases the rate of diffusion. This is what happens when we stir sauce and tea or when we fan the air to diffuse a bad smell!

Lesson summary

♦ Diffusion is the spreading of molecules from a region of high concentration to a region of low concentration in another medium.

♦ Diffusion commonly takes place in gases and liquids but it also happens in solids.

♦ The factors that affect diffusion include:

♦ Temperature: the higher the temperature, the more the rate of diffusion.

♦ Density: the higher the density, the less the rate of diffusion.

♦ Currents; the rate of diffusion is higher in the direction of the current and lower in the opposite direction.

♦ Stirring, swirling, agitation or fanning also increase the rate of diffusion.

LESSON 3: INTERMOLECULAR FORCES AND CAPILLARITY

Competences

In this lesson, you will:

i) describe the forces between molecules of the same substances and different substances.

ii) demonstrate capillarity.

iii) carry out experiments to show the behaviour of liquids in tubes of narrow bore.

iv) mention situations where capillarity is useful, a problem.


Fig .1

Materials you need

- 15cm strip of old towel or rug, Water, Cup, Plate, brick
- Porridge, cup, Bic or Nice clear pen.

Introduction

One of the properties of matter is that there are forces of attraction or repulsion between the particles of matter.

The repulsion makes solids and liquids to have fixed volumes. The volume of gases can change but in reality, each gas has a minimum volume because of repulsion of the gas molecules.

Fig .2

The forces of attraction may be between molecules of the same kind or between molecules of different substances. The attraction between molecules of the same kind is called **cohesion.** Attraction between molecules of different substances is called **adhesion.** These forces between molecules are called **intermolecular forces.** Many happenings in real life are caused by intermolecular forces. One of them is capillarity.

Plants use capillary action to draw water from the ground.

Fig .3
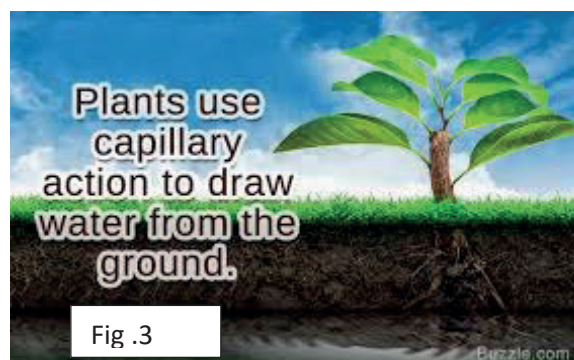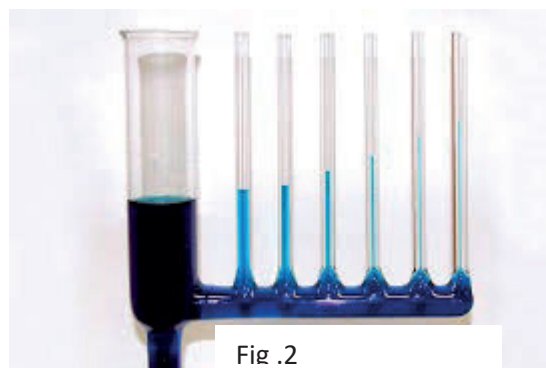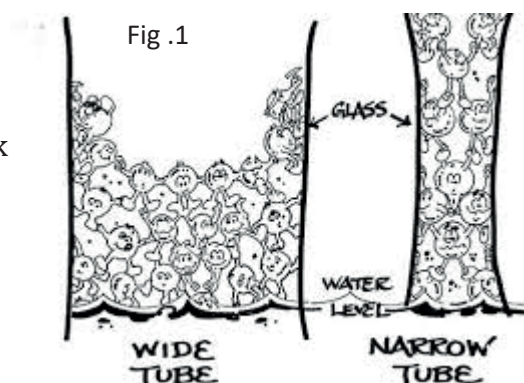
Activity 1: Capillary rise

i) Obtain a corner in the house or the kitchen which is not exposed to direct sunlight or wind.

ii) Pour some water into the cup and put the cup on the floor in the corner.

iii) Put a plate on a brick near and higher than the cup full of water.

iv) Dip one end of the old towel strip in the water in the cup and put the other end on the plate. You must start with a dry plate!

v) What do you notice about the old towel strip after a few minutes?

....

vi) Leave the arrangement to stay undisturbed for five hours. What do you see in the plate after five hours? ....

vii) How can you explain your observation? ....

Observations and Explanations

*In **step v)** of **Activity 1**, the strip of towel is seen to get wet and the wetness increases upwards. After five hours, in **step vi)**, some water is seen in the plate yet the plate was dry at the beginning. The old towel in activity 6.5.1 is made up of many small threads and each thread is also made up of two or more smaller threads. These have tiny spaces between them. These spaces act like very tiny tubes called **capillary tubes**. The adhesion force between the threads and the water molecules is greater than the cohesive force between water and water molecules. This causes the water molecules to rise along the gaps between the threads. This is called **capillary action** or **capillarity** in general. When the water rises, it is called **capillary rise**. It happens whenever a narrow tube or capillary tube is placed in a liquid like water as shown in **Figure 1**.*

*For some liquids there is **capillary depression.** This is when the liquid level in the tube is lowered below the level of the rest of the liquid outside the tube. This happens with very few liquids like mercury. In such liquids, the cohesive forces between the mercury-mercury molecules are stronger than the adhesive forces between the mercury-glass molecules. We avoid using mercury because it is poisonous, expensive and rare.*

*The smaller the diameter of the capillary tube, the greater will be the capillary rise as shown in **Figure 2**.*

Capillary action in real life

Benefits due to capillary action	Problems due to capillary action
Wick sucking fuel from the reservoir to the burner in lamps.	Dampness of floors and walls
Trees sucking water from the soil to the leaves in figure 3	Formation of wet patches on clothes after visiting the toilet
Mopping using rugs or tissue paper	Formation of wet patches on beddings of bedwetters.
Some desert lizards can also suck water through their scales from morning dew to their mouths	

Summary of Important information

- Cohesion is the force of attraction between molecules of the same type.
- Adhesion is the force of attraction between molecules of different types.
- Capillary rise is when the liquid level in a narrow tube rises higher than the level of the surrounding liquid.
- Capillary depression is when the liquid level in a narrow tube goes lower than the level of the surrounding liquid.
- When adhesive forces are greater than cohesive forces, there is capillary rise and the meniscus is curved upwards.
- When cohesive forces are greater than adhesive forces, there is capillary depression and the meniscus is curved downwards.
- The narrower the diameter of the capillary tube, the greater the capillary rise or depression.
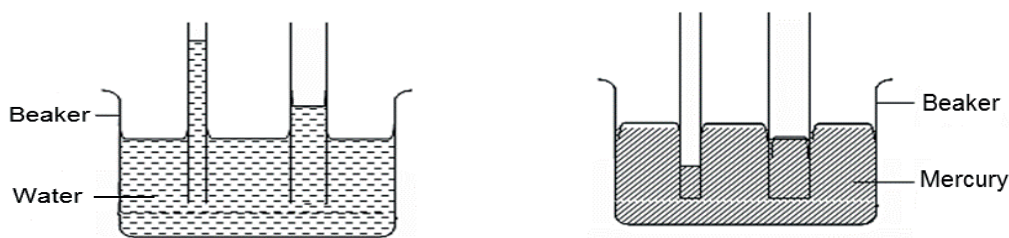

Figure 4: Capillary rise and fall in water and mercury

LESSON 4: SURFACE TENSION

Fig 1

Fig .2

Fig 3

Competences

In this lesson, you will:

i)   demonstrate the existence of surface tension.
ii) mention some phenomena to show the existence of surface tension.
iii) perform activities to investigate the factors that affect surface tension.
iv) describe applications of surface tension knowledge.

Materials you need

- Razor blade/small pin, water, saucepan/basin/bucket, tissue paper, liquid soap, heat source

Introduction

Look at Figures 1, 2 and 3 above. What is happening in each figure? What causes the phenomenon in each figure?

To answer these questions, you need knowledge about the concept of surface tension. You can demonstrate the existence of surface tension using activity 1 below.

Activity1: Evidence of surface tension by floating a razor blade/pin on water.

i.   Pour some water in a saucepan to make it half way full.

ii. Put a razorblade/pin on the tissue paper and carefully place the tissue paper on the surface of the water.

iii. What do you notice after a few minutes?

....

iv. Explain your observation

....
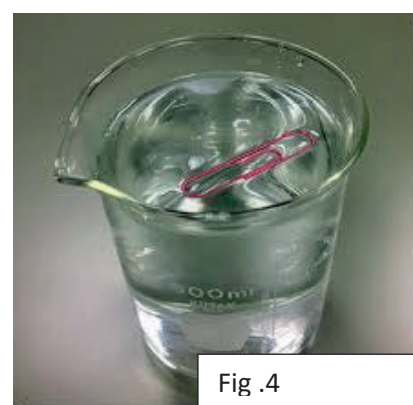

Fig .4

Activity 2: Effect of soap on surface tension

    i. Repeat activity 1

    ii. Pour a drop of liquid soap near one side of the floating razor blade/pin

    iii.What happens to the razorblade/pin?

    ………………………………………………………………...

    iv. Pour more liquid soap all around the razorblade.

    v. What happens to the razorblade/pin?

    ………………………………………………………………..

Fig 5

Observations and explanation

A razorblade/pin is made of steel which is denser than water. So we would expect a razorblade/pin to sink in water. However, in **step iii** *of activity 6.6.1, the tissue paper sinks after getting wet but the razorblade/pin is seen to float on the water. This is a sign that there is a force supporting the weight of the razorblade/pin. This force is called* **surface tension***.*

In **step iii** *of activity 2, the razorblade/pin may move in the direction opposite to the side where the liquid soap is dropped. This is because the soap reduces the surface tension where it is dropped and the surface tension on the opposite side pulls the razorblade/pin. When the liquid soap is poured all around the razorblade/pin, the razor blade/pin sinks in the water. This is because surface tension is reduced all around the razor blade/pin and it can no longer support the weight of the razorblade/pin.*

Activity 3: Effect of temperature on surface tension

    i)   Heat up the water for a few minutes

    ii) Put a razor blade/pin on the tissue of paper and carefully place the tissue paper on the surface of water

    iii)   What do you notice after a few minutes?

    iv)   What happens to the razor blade/pin?

*In activity 3 **step iv** the razorblade sinks as soon as the tissue paper gets wet. This is because increasing the temperature of the water reduces the surface tension of the water.*

___

Meaning of surface tension

Surface tension is the force per unit length in the surface of a liquid which makes the liquid surface to behave like a stretched elastic skin.

___

The following happenings are due to surface tension:

- Insects walking on water as shown in Fig 1.
- Formation of droplets as seen in Fig 2.
- Formation of bubbles which is seen in Fig 3.
- Filling containers slightly beyond their brims without them overflowing as shown in Fig 5.
- Failure of water to remove dirt from clothes and fats from dishes.

**Below are applications of surface tension knowledge:**

- Soap or detergent is used in washing. This reduces the surface tension of the water and enables it to dissolve the dirt particles.
- Hot water is used to wash very dirty or very fatty items. This also reduces the surface tension even more and helps the water to dissolve the fats.

LESSON 5: THICKNESS OF AN OIL MOLECULE

Competences

In this lesson, you will:

i) describe an experiment to estimate the thickness of an oil molecule.

ii) state the assumptions made in the oil film experim

iii) solve related numerical problems.

Fig 1
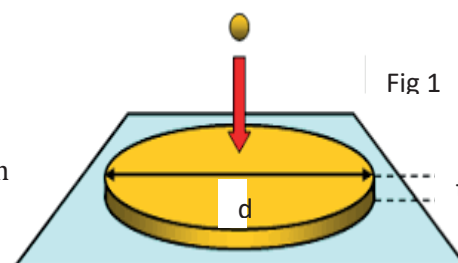
Materials you need

Introduction

- Cooking oil
- Water
- Large container
- Foot ruler
- Cough syrup cup or teaspoon

When oil is poured on water, it first spreads until it has covered the entire surface of the water before it can rise. This **patch is in form of a cylinder and it is assumed to have a thickness of one molecule.**

Activity: Estimating the thickness of a molecule.

i) Pour some water in the large container until it is about 3cm deep.

ii) Measure a volume V = 5cm³ of cooking oil using a teaspoon or cough syrup cup

iii) Pour the measured volume, V, of cooking oil on the water in the large container.

iv) Allow the cooking oil to spread until it forms a circular patch.

v) Measure the diameter, d, of the oil patch using your foot ruler.

vi) Calculate the thickness, t in cm, of the oil molecule by substituting for d and V in the formula below: $t = \frac{4V}{\pi d^2}$

Important information

volume of the oil = volume of the oil patch = V

V = volume of cylindrical patch

V = cross sectional area x thickness

V = At, where A is cross sectional area and t is thickness

$V = \pi r^2 t$, since the cross section is circular (i.e A=πr²)

$V = \pi \left(\frac{d}{2}\right)^2 t$, because r = d/2

$V = \pi \frac{d^2}{4} t$

$4V = \pi d^2 t$, multiplying both sides by 4

$t = \frac{4V}{\pi d^2}$, after dividing both sides by πd^2

Note: During the above experiment, it is also normal to spray lycopodium powder on the surface of the water before the oil is sprayed. This is to make the patch of oil more visible.

The above calculation is based on the following observations:

- The oil layer is a monolayer i.e. there is no molecule on top of the other or the layer is one molecule thick
- The oil molecules are cylindrical

Exercise 6.7: Thickness of an oil molecule

1. An oil drop of volume 10^{-3} cm³ forms a patch of an area of 0.795 cm² on water surface during an experiment to estimate size of a molecule. If the film is 1 molecule thick, what is the size of the molecule?

A. 4.06×10^{-3} cm   B. 7.95×10^{-3}cm   C. 1.26×10^{-3}cm   D. 5.03×10^{-3}cm

2. In an experiment to estimate the size of a molecule of olive oil, 12 mm³ of the solution was dropped on a clean water surface in a trough. The oil spreads to form a circular patch with a diameter of 2.0×10^2 mm. Estimate the size of a molecule of olive oil.

Answers to exercise 6.7

1. C

2. $t = 3.82 \times 10^{-4} m$

CHAPTER: WAVES

By the end of this chapter, you should be able to;

    i)   explain the basic terms used in relation to waves.

    ii)   explain how waves are produced, how they travel in various media and how they interact with obstacles in their paths.

    iii)   distinguish between different types/forms of waves.

    iv)   describe the behaviour of electromagnetic waves.

LESSON 1: NATURE OF WAVES

Competences

In this lesson, you will:

    i)   explain how a wave is produced.

    ii)   distinguish between transverse and longitudinal waves.

    iii)   state examples of transverse and longitudinal waves.

    iv)   define progressive wave

    v)   state examples of progressive waves.

    vi)   use the wave equation to solve numerical problems

Materials you need

- Rope

- Beaker of water

Introduction

When you drop a stone in a pond of water some ripples are formed. These are an example of waves. When a rope is shaken up and down, different parts of the rope go up and others go down. The up and down movements move from the side being held by the person to the other end of the rope. This is another example of a wave. In this chapter we are going to see different types of waves and learn about how they behave.

Activity 1: Characteristics of a Wave

i) Tie one end of a rope to a pole or small tree and shake the free end up and down as shown below. What (small) letters of the alphabet does the rope make while you shake it?
………………..., ……………., ……………, ……………...

ii) Stop shaking the rope and hold it in one position while pulling it to full length. This is called the rest position or the mean position. What shape does the rope make when it is not being shaken? ………………………………………………………………..

iii) Shake the rope again and try to find the maximum distance any part of the rope moves from its rest or mean position. …………….. This is called the amplitude of the wave.

iv) What shape does the rope form when it is at maximum distance above the rest position? …………………………. This is called a crest.

v) What shape does the rope form when it is at maximum distance below the rest position? …………………………. This is called a trough.

vi) What happens to this maximum distance in iii. when you shake the rope a long way up and a long way down? ………………………………………………………………………….

vii) Can you find some points along the rope which are moving in the same direction and having the same distance from their rest position? These points are said to be in **phase**. On Figure 1 below, points **a** and **c** are in phase while points **b** and **d** are also in phase.

viii) Shake the rope more quickly. What happens to the number of crests and troughs? ………………………………………………...

ix) Shake the rope slowly. What happens to the number of crests and troughs?

Fig 1

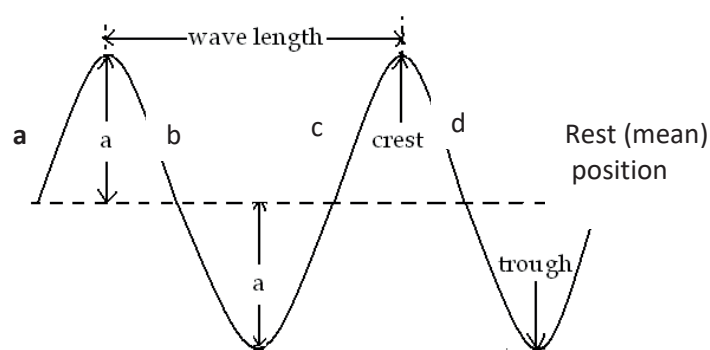………………………...……………………………………...……………………………………...

Explanations

In **step i***. of activity 7.1.1, you may see the letters* <u>m, w, n, or v</u>

The rope forms a <u>straight line</u> *when you are not shaking it but pulling it to full length on one side in* **step ii***.*

The rope forms <u>letter n</u> *when part of it is at maximum displacement above the mean position. This is called a* **crest.** *When part of the rope is at maximum displacement below the mean position,* <u>letter v</u> *is formed and this part is called a* **trough.**

In **step vi.** <u>the amplitude increases</u> *when the rope is shaken a long way up and a long way down. When the rope is shaken more quickly in* **step viii***,* <u>there are more crests and troughs</u>*. This means that the rate at which crests and troughs are forming has increased. We say that the* **frequency of the wave has increased.** *In* **step ix** <u>there are fewer crests and troughs</u> *and we say that the* **frequency has reduced.**

Important information

A wave is a repeated disturbance by which energy travels through a medium without a net movement of the particles of the medium.

A single disturbance is called a **pulse.**

The direction of travel of the energy is called the **direction of the wave.**

When the particles of the medium vibrate parallel to the direction of the wave, such a wave is called a **longitudinal wave.** An example of longitudinal waves is sound.

If the particles of the medium vibrate perpendicular to the direction of the wave, such a wave is called a **transverse wave.** Examples of transverse waves are water waves, light, waves on a string, etc

There are waves which can only move through material media. These are called **mechanical waves.** Water waves, sound waves, waves from a stretched string are all mechanical waves.

Electromagnetic waves can travel through matter as well as through empty space or vacuum.

When a wave transfers energy from one point to another, it is called a **progressive wave.** Examples of progressive waves are waves formed by;

    Shaking a rope

    Dropping a stone in water

Wind blowing water on the lake

Sound

Light, etc

When a progressive wave is reflected in such a way that the crests and troughs of the reflected wave are in the same position but different direction as the incident wave, a **standing wave** or **stationary wave** is formed.

A **Wave front** is any line or section taken through an advancing wave in which all the particles are in the same phase.

The wave equation

This equation gives the speed, v, of a wave

Speed = $\frac{distance}{time}$

Distance covered in one oscillation is one wavelength, λ

Time for one complete oscillation is the period, T

$$v = \frac{\lambda}{T}$$

$$v = \frac{1}{T} \times \lambda$$

But $\qquad f = \frac{1}{T}$

So $\qquad \boldsymbol{v = f\lambda}$

Example

1. What is the speed of a wave which has a frequency of 10Hz and a wavelength of 91.3m?

Solution

f = 10Hz, $\lambda = 91.3m$

$$v = f\lambda$$

v = 10 x 91.3

v = 913ms^{-1}

Summary

A **Wave** is a disturbance that makes energy to travel through a medium without a net movement of particles of the medium.

Wavelength λ, is the distance between two successive particles in phase.

Wavelength can also be described as the distance between two successive crests or troughs.

Frequency, f, is the number of complete cycles/oscillations per second.

Period, T, is the time taken for one complete oscillation to be made.

$$T = \frac{1}{f}$$

$$f = \frac{1}{T}$$

**Speed, v,** is the distance moved by a trough or any part of a wave in one second.

Phase is a condition where two or more particles are in the same state of disturbance.

Exercise 7.1: Nature of waves

Circle the correct alternative

1. Figure above shows a wave produced in a string. If the frequency is 2Hz, at what speed do the waves travel along the string?
   A. 0.5ms^{-1} B. 1.0ms^{-1} C. 2.0ms^{-1} D. 4.0ms^{-1}

Fig 7.1.2
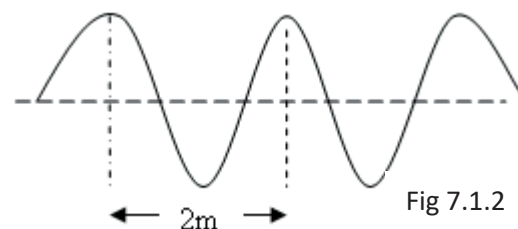
2. A longitudinal wave is one in which the
   A. Direction of propagation is parallel to that of the vibration producing it.
   B. Particles of the medium through which it travels move opposite to the direction of propagation.
   C. Direction of propagation is perpendicular to that of the vibration producing it.
   D. Particles of the medium through which it travels move together with it.

3. The number of complete oscillations made per second is referred to as
   A. Periodic time   B. amplitude   C. Wave length   D. frequency

4. A source producing waves which travel a distance of 140cm in 0.08 s. If the distance between successive crests is 20cm, find the frequency of the source in Hz.
   A. 0.875   B. 8.750   C. 87.500   D. 8750

Answers to exercise 7.1

1. D   2. A   3. D   4. C

LESSON 2: REFLECTION OF WAVES

Competences

In this lesson, you will:

i) demonstrate the relationship between rays and wave fronts.
ii) carry out experiments on reflection of waves.
iii) draw the reflected wave fronts.
iv) use the reflection of waves to determine the speed of sound in air

Materials you need

- Large basin or saucepan
- Set ruler (ruler from mathematical set)
- Foot ruler
- Direct sunlight
- Plastic plate

Introduction

In the previous lesson we saw that in a progressive wave, energy travels form one point to another in form of a wave. When the wave meets a barrier or an obstacle, the wave is bounced back. This is called reflection. In this lesson we are going to learn how waves are reflected at various shapes of barriers.

Activity 1: Reflection of a Plane Wave on a Plane Barrier (This activity is best done outside the house when there is no wind)

i. Pour some water into a large saucepan or basin to a depth of about 2cm.
ii. Put the saucepan on the ground under bright sunlight. Midday sunshine is recommended.
iii. Put the foot ruler in the saucepan such that one scale touches the bottom and the two ends of the ruler touch the rim of the sauce pan. ***The foot ruler acts as a straight reflecting surface.***
iv. With the set ruler parallel to the foot ruler, touch the water <u>once</u>, as far as possible from the foot ruler. What do you notice?………………………………………..
v. Touch the water with the set ruler again and repeat this four times at equal intervals. What do you see at the bottom of the saucepan? ………………………………
vi. Lift the set ruler up and turn it to make an angle with the foot ruler.
vii. Touch the water several times, at equal intervals, at the far end, with the set ruler to make an incident straight wave.
viii. Draw the pattern of the incident and reflected waves from the straight edge.

Explanation

*In **step iv** of activity 1, you should have seen a single disturbance moving from the point where the set ruler touches the water. This is a wave front.*

*Touching the water repeatedly in **step v.** produces multiple wave fronts which will be seen at the bottom of the saucepan. These wave fronts make up the wave.*

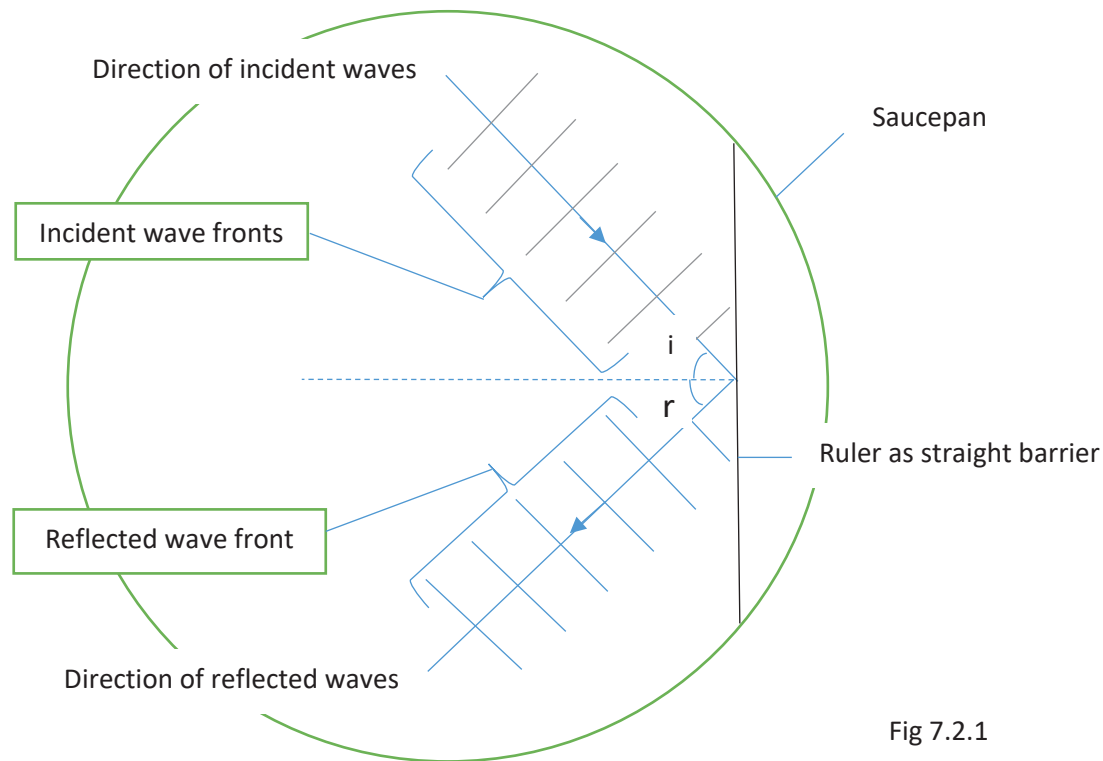*Fig 1 below is an illustration of what the pattern in **step viii** should look like.*

Fig 7.2.1

The angles of incidence equal the angle of reflection (r = i)

Activity 2: Reflection of a <u>Plane Wave</u> on a <u>Concave Barrier</u>

i. Remove the foot ruler form the saucepan such that the ***concave rim of the sauce pan acts as the reflecting surface.***

ii. With the set ruler parallel to the foot ruler, touch the water with the set ruler and repeat this six times at equal intervals. What do you see at the bottom of the saucepan?
   ....

iii. Draw the pattern of the incident and reflected waves from the concave edge.

Explanation

Reflected waves

Concave rim of the saucepan

Fig 2
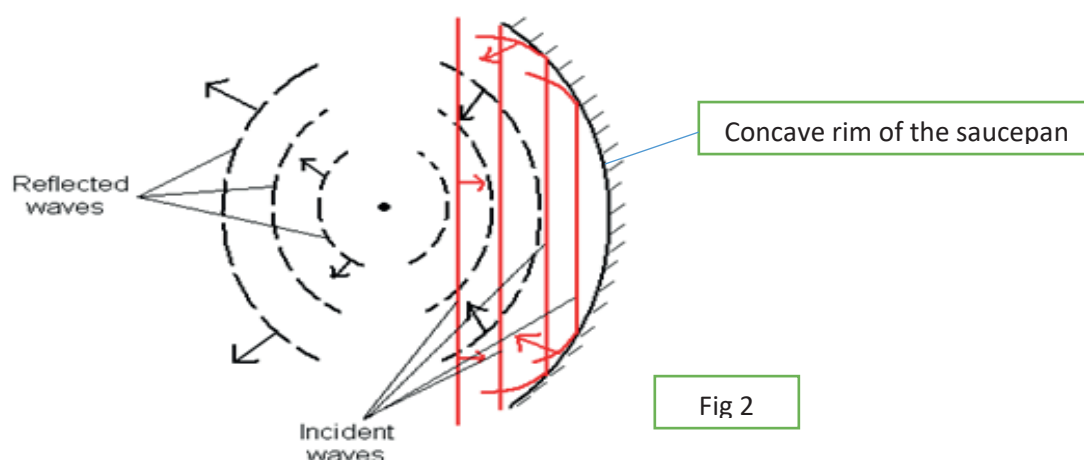
Incident waves

The straight incident waves will be <u>reflected as circular waves</u> converging at the focal point of the concave surface and then spreading out after passing that point

Activity 3: Reflection of a <u>Plane Wave</u> on a <u>Convex Barrier</u>

i)   Put a plastic plate upside down in the saucepan near the rim of the saucepan such that the ***convex rim of the plate acts as the reflecting surface.***

ii)   With the set ruler parallel to the foot ruler, touch the water with the set ruler and repeat this six times at equal intervals. What do you see at the bottom of the saucepan?

………

iii) Draw the pattern of the incident and reflected waves from the convex surface.
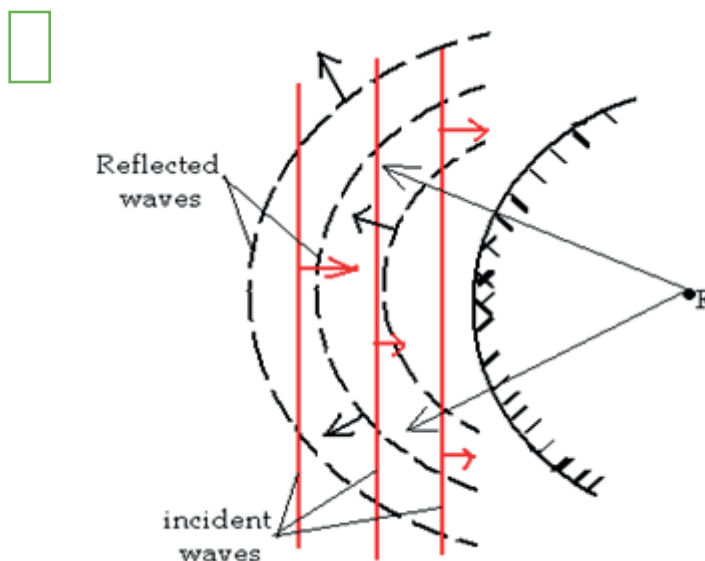

Reflected waves

incident waves

F

Fig 3

The straight incident waves will be <u>reflected as circular waves</u> with their centre as the focal point of the convex surface.

Exercise 2: Reflection of circular waves on various barriers

Use your index finger instead of the set ruler and repeat each of the activities above to study the reflection circular of waves at various surfaces.

Note:

For sound waves, reflected waves are called **echoes**. Echoes are applied in different ways e.g

    (i) Determining the speed of sound in air

    (ii) In sonometer to determine the depth of the sea

    (iii) In ultrasound in imaging

Let us consider a situation where echo sounding is used to determine the speed of sound in air. When a person standing at a distance from a barrier makes a loud sound such as clapping two blocks of wood and an echo is heard by the same person, the sound will have travelled the distance between the barrier and the person twice.

Suppose the distance between the person and the barrier is d and the time taken for the echo to be heard is t, speed v, of sound can be obtained from the expression

$$speed, v = \frac{distance}{time}$$

$$v = \frac{2d}{t}$$

Now try out this:

A person standing at some distance from a cliff makes a loud sound. If the person hears an echo 0.5 seconds later, calculate the distance between the person and the cliff (speed of sound in air is 320 m/s)

LESSON 3: REFRACTION OF WAVES

Competences

In this lesson, you will:

    i)   perform activities on refraction of waves.

    ii)   draw the reflected wave fronts.

    iii)   use the relationship between rays and wave fronts, and the laws of refraction to predict the shape and direction of the refracted wave fronts.

Materials you need

- Large basin or saucepan
- Set ruler
- Direct sunlight
- Clay or glass plate
- Clay brick or block of wood

Introduction

In the previous lesson we saw how waves are reflected at barriers of different shapes. In this lesson we are going to see what happens when the speed of a wave is changed while maintaining the frequency. This is called refraction. Waves can be refracted by placing barriers of different shapes to change the depth and speed of the wave.

Activity1: Refraction of a Plane Wave on a Plane interface.

i.   Pour more water into the sauce pan until it is about 20cm deep.

ii.   Put a brick in the middle of the saucepan so that it lies on its widest face and it is fully covered by the water.

iii. Position the set ruler at an angle to the brick and tap the water surface at regular intervals.

iv. Carefully observe the waves before they reach the brick and after they have passed the vertical brick face. Draw the incident and refracted wave fronts.

fast
Deep water
shallow water
i
r
plate
slow
saucepan
Fig 1
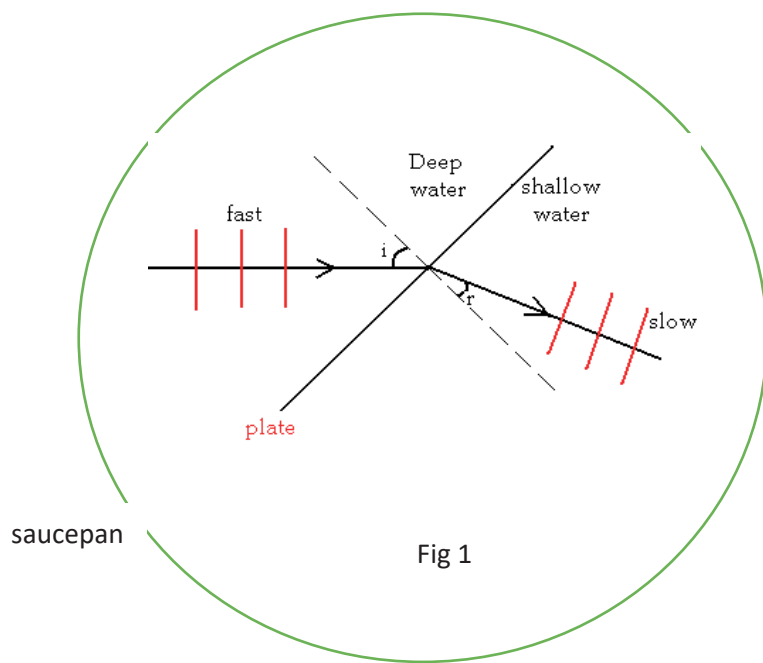
Explanation

Tapping the water repeatedly with the set ruler produces straight wave fronts. When each wave front reaches the face of the brick, its direction is seen to change and the spacing between the wave fronts is smaller after the brick face as shown in fig 1. The reduction in spacing is a reduction in **wavelength.** *This causes a reduction in* **speed** *of the wave. All this combine to cause a change in direction of the wave as it moves from a deeper to a shallower medium. This is called refraction. In general, whenever a wave moves from a less dense to a denser medium, it is refracted towards the normal.*

Exercise 7.3: Refraction of Waves

i. Use the set ruler for straight waves or your finger for circular waves and other shapes to change the depth of the water.

ii. Carefully observe the wave forms and draw a diagram for each of them.

LESSON 4: INTERFERENCE OF WAVES

Competences

In this lesson, you will:

  i)   observe interference in a water trough
  ii)   learn when interference is useful
  iii) learn when interference is a nuisance

Materials you need

  • Large basin or saucepan
  • Set ruler
  • Direct sunlight

  • Pair of dividers
 • Pair of small and round fruits like young guava fruits, tomatoes

Introduction

When one wave meets another, they are said to **interfere**. This interference depends on how the parts of the waves meet. If a trough meets a trough or a crest meets a crest, a bigger trough or crest is formed. This is called **constructive interference**. When a trough meets a crest, the two cancel each other out and it is called **destructive interference.**

Activity 1: interference of circular waves

  i)   Use a pair of dividers to prick two small round fruits
  ii)   Adjust the dividers to get a good distance between the fruits
  iii)   Pour water into the saucepan until it is 20cm deep.
  iv)   Put the saucepan under direct sunlight.
  v)   Use the divider to dip the fruits into the water at regular intervals.
  vi)   Carefully observe the patterns formed and draw them in your book.

There are many instances in which interference can be observed, especially for sound waves. For example, if two loud speakers producing sound of the same frequency are positioned at a reasonable distance between them and turned on, a person moving between them will hear loud sound at some points and less sound at some other points. Points of loud sound are due to constructive interference. This is illustrated in the figure below.
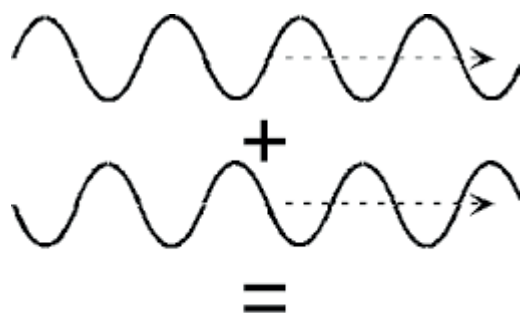
Destructive interference

Fig 7.4.2
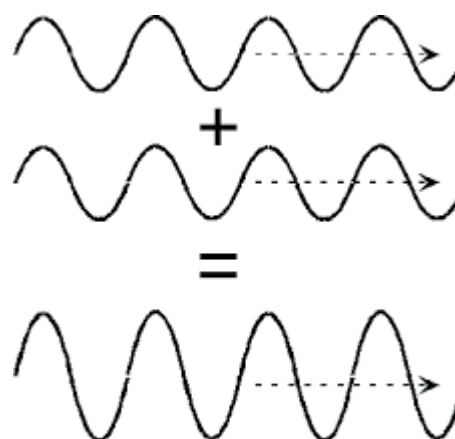
Constructive interference

Fig 7.4.3

LESSON 5: ELECTROMAGNETIC WAVES

Competences

In this lesson, you will:

    i)   identify the different electromagnetic waves.

    ii)   identify the properties and applications of electromagnetic waves.

Introduction

Electromagnetic waves are transverse waves that can move through matter and in a vacuum. They consist of both electric and magnetic fields oscillating at right angles from the source. They originate from a variety of man-made sources, though some originate from the sun. They have the following characteristics:

- They are transverse in nature.
- They consist of oscillating electric and magnetic field vectors at right angles to each other
- They can travel through a vacuum.
- They travel at the **speed of light** in vacuum, i.e. 3×10^8 m/s.
- They have different wavelengths and different frequencies
- They carry no electric charge

The table below summarises the components of the electromagnetic spectrum, their sources, their uses and possible danger of overexposure.

Electromagnetic wave	Source	Applications	Danger of overexposure
Radio waves	Electronic circuits	Communication in radios and television	Burning if concentrated
Microwaves	Electronic circuits	Communication in satellites, telephony, heating water and food	Burning if concentrated
Infra red	Electronic devices, warm objects, the sun	Remote control e.g. TV, detector in security lighting	Burning if concentrated
Visible light	Electronic devices (LED), the sun	Seeing, photography, communication e.g. optical fibre, laser surgery	Blindness if concentrated
Ultraviolet	Sun, gas discharge lamps	Making vitamin D, killing bacteria in water treatment	Sunburn, skin cancer, retinal damage
X-rays	Fast moving electrons decelerated by hitting metal surface	Imaging, detecting defects in bones and other medical uses	Cell destruction, mutations, cancer
Gamma rays	Radioactive nuclei decaying	Medical tracer, killing cancer cells, sterilizing medical equipment	Cell destruction, mutations, cancer

Note: Electromagnetic waves undergo reflection, refraction and diffraction like any other waves. They also obey the general wave equation i.e. $v = f\lambda$

Now try out this:

''A local radio station broadcasts at 90.0 MHz''.

    (i) What is the meaning of this statement?

    (ii) Calculate the wavelength of the waves from this station.

CHAPTER: MAGNETISM

By the end of this chapter, you should be able to:

i) demonstrate the existence of magnetic field around a current carrying conductor.
ii) describe the operation of electromagnets.
iii) describe the applications of electromagnets in electric bell and other devices.

LESSON 1: MAGNETIC EFFECT OF AN ELECTRIC CURRENT

Competences

In this lesson, you will:

i) demonstrate the existence of a magnetic field around a current carrying conductor.
ii) use Fleming's right hand grip (cork-screw) rule to determine the direction of magnetic flux.
iii) wire an electromagnet and explain how it works.
iv) describe and explain some applications of electromagnets.

Materials you need

• Iron filings, a pair of dry cells, connecting wire, Iron nail, piece of paper, old plastic cup, cardboard, cello tape.

Introduction

Electricity and magnetism usually go hand in hand. In this lesson we shall look at one of the relationships between electric current and magnetic fields.

Activity 1: Magnetic field due to a current carrying conductor

Fig 1

i. Make a small hole through the middle of the old cup and the cardboard.

ii. Peel off the insulation from 30 cm of connecting wire.

iii. Pass the connecting wire through the hole in the middle of the plastic cup and the cardboard.

iv. Place the cup upside down so that the wire is vertical.

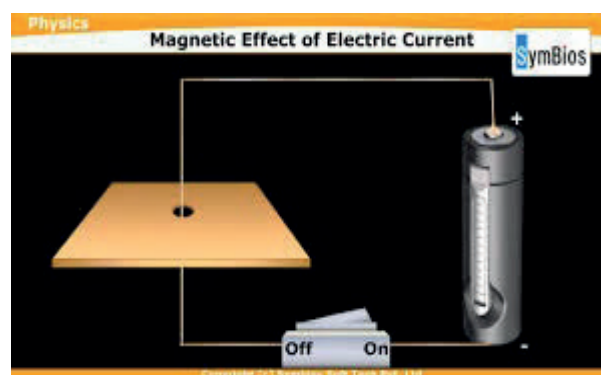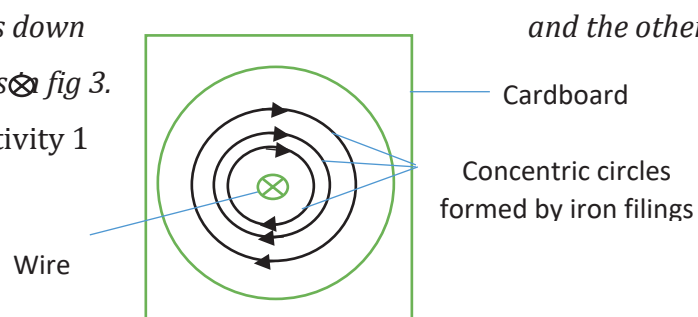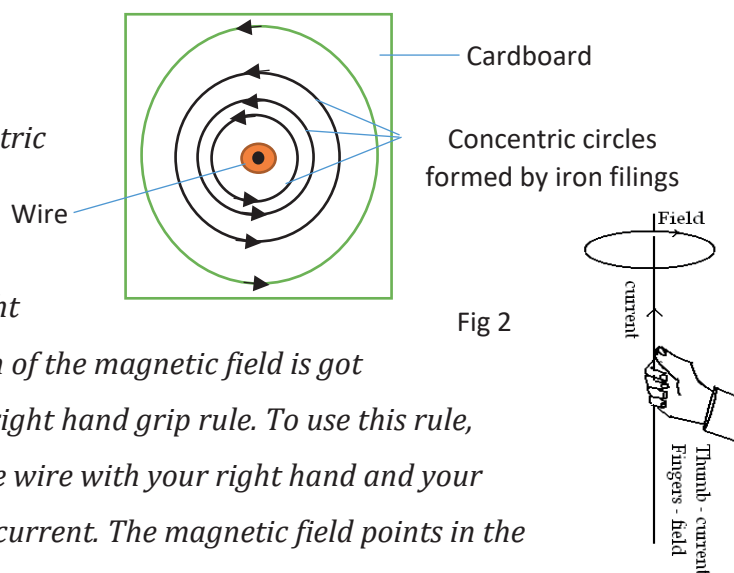v. Connect the wire to the dry cells in series as shown in Fig. 1 but do not complete the circuit.

vi. Sprinkle some iron filings on the cardboard around the wire.

vii. Complete the circuit by connecting the wires that were not in contact.

viii. Tap the cardboard slightly.

ix. Draw the pattern that you see formed by the iron filings on the cardboard.

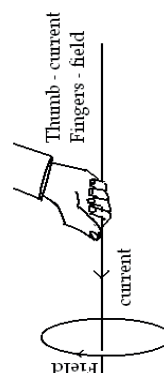x. Change the terminals of the batteries and draw the pattern formed by the iron filings on the cardboard.

Explanations

*In **step ix** and **step x** of activity 1 the concentric circles, with the wire as their centre, will be observed as shown in fig 2. This is the pattern of the magnetic field due to a straight conductor carrying a current. The direction of the magnetic field is got using a plotting campus or using Fleming's right hand grip rule. To use this rule, imagine that you are gripping or holding the wire with your right hand and your thumb is pointing in the direction of flow of current. The magnetic field points in the direction of the other fingers. In fig 2 current is flowing out of the cup's base. This is shown by a small dot. The thumb faces up and the other fingers point in the anticlockwise direction as shown by the arrows. When the terminals are changed, current is reversed. This is represented by an encircled x. The thumb faces down and the other fingers point clockwise as shown by the arrows in fig 3.*

Cardboard

Concentric circles formed by iron filings

Wire

Fig 2

Field

current

Thumb - current
Fingers - field

Try forming a coil using a wire and repeat activity 1 to see the magnetic field pattern of a current carrying coil.

Cardboard

Concentric circles formed by iron filings

Wire

Fig 3

Thumb - current
Fingers - field

current

Field

Activity 2: Operation of an Electromagnet

i) Wrap a piece of paper around an iron nail.

ii) Wrap the connecting copper wire around the paper on the nail. Make sure there is some space between neighbouring turns of wire and they don't touch each other. Use cellotape to keep the wire paper and nail together.

iii) Connect the ends of the wire to the terminals of the dry cells to complete the circuit.

iv) Bring the iron filings near the arrangement. What happens? ……………………………....

v) Break (Disconnect) the circuit and record what happens?...

vi) Remove the nail from inside the paper and repeat steps iv. and v. What happens?

………

Explanation

Steps i) to iii) in activity 2 above describe how an electromagnet is made. An electromagnet is a magnet that can be switched on by passing current through a solenoid. A solenoid is a cylindrical coil. When current is switched off, the solenoid loses its magnetism.
*In **step iv**. the iron filings are attracted to the solenoid because it becomes magnetized.*
*When current is switched off by breaking the circuit in **step v**, the iron filings fall because the solenoid loses its magnetism.*
*When the iron nail is removed from the solenoid in **step vi.** and the circuit is completed, the solenoid attracts only a few filings. This shows that when a magnetic material like a nail is put inside the solenoid of an electromagnet, more magnetic force is produced when current passes through the solenoid.*

> **Important information**
> Electromagnets are used in Electric bells, tape recorders, loudspeakers, telephone mouth pieces, relay switches, etc. The knowledge that a current carrying conductor has a magnetic field is used to make motors.

Exercise

Do some research and explain how an electric bell works.

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