LOWER SECONDARY CURRICULUM

Competency Based
Physics Learner's Work Book

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WRITTEN BY

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School name

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Student's name

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Stream:____________________ Year:_______________

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Preface

This Learner's workbook has been written in line with the revised Physics syllabus for the lower secondary curriculum. The activities of integration together with the research assignments embedded in each chapter will enable the learner to produce new knowledge, values and skills required in the present world of innovation and creativity.

This work book provides a range of class activities, activities of integration and research assignments which will enable the learner to interact and discuss with fellow learners, research and discover more through the internet and textbooks in order to understand the applicability of knowledge acquired at his or her respective school.

The learner is expected to be able to work as an individual, in pairs or groups according to the nature of the activities in order to be able to develop personal confidence and communication skills as they share learning experiences with their colleagues.

This Learner's workbook is one of the materials that are to be used to facilitate the teaching and learning process of the lower secondary curriculum.

KATO IVAN WUUNA

Physics and Mathematics tutor

Acknowledgements

I express my sincere appreciations to all those who worked tirelessly towards the production of this learner's workbook.

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To the Wuuna Family, my beloved granny; Nakisita Anasitanziya, my dearest wife; Mrs. Wuuna Naikesa Barbra, my beloved sons; Wuuna Simon Peter and Wuuna Simon Phililp, my brother; Wasswa Emmanuel Wuuna and my sister; Wuuna Mary Kevin thanks for constant support and advice.

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I welcome any suggestions for improvement to continue making my service delivery better. Please get to me through katoivans001@gmail.com or contact me on

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TOPIC COMPETENCES AND LEARNING OUTCOMES

TERM ONE

TOPIC 1: INTRODUUCTION TO PHYSICS.

Competency: The learner should be able to understand the importance of physics and safe laboratory practice.

Learning outcomes

a) understand the meaning of physics, its branches and why it is important to study Physics (u, v/a)
b) understand why it is important to follow the laboratory rules and regulations

TOPIC 2: MEASUREMENTS IN PHYSICS

Competency: The learner should be able to estimate and measure length, area, volume, mass, density, and time and express them using appropriate units.

Learning outcomes

The learner should be able to:

a) Understand how to estimate and measure physical quantities: length, area, volume, mass, and time (u, s, g, s)
b) Explain how they choose the right measuring instrument and units; explain how to use the instruments to ensure accuracy (u, s)
c) Appreciate that the accuracy of measurements may be improved by making several measurements and taking an average value (gs, v/a)
d) Identify potential sources of error in measurement and devise strategies to minimise them (u, s, v/a)
e) Understand the scientific method and explain the steps used in relation to the study of physics.
f) Know that practical investigations involve a 'fair test', analysis, prediction and justification of results, and observations, and apply learning in practice (k, s)
g) Record data in graphs and charts and look for trends (u, s)
h) Understand and be able to use scientific notation and significant figures (u, s)
i) Understand density and its application to floating and sinking (u)
j) Determine densities of substances and relate them to purity (u, s, g, s)
k) Understand the global nature of ocean currents and how they are driven by changes in water density and temperature

TERM TWO

TOPIC 3: STATES OF MATTER

Competency: The learner should be able to use the knowledge of the arrangement and motion of particles to explain the properties of solids, liquids, gases, and plasma.

Learning outcomes

The learner should be able to:

a) Understand the meaning of matter (u)
b) Understand that atoms are the building blocks from which all matter is made; appreciate that the states of matter have different properties (k, u)
c) Apply the particle theory to explain diffusion and Brownian motion and their applications (s)
d) Understand how the particle theory of matter explains the properties of solids, liquids and gases, changes of state, and diffusion (u)
e) Understand the meaning and importance of plasma in physics

TOPIC 4: THE EFFECTS OF FORCES

Competency: The learner should be able to explore the nature and types of force and describe how forces move or change the shape of objects, and understand some common applications of forces.

Learning outcomes

The learner should be able to:

a) Know that a force is a push or a pull and that the unit of force is the Newton (k)
b) Know the effects of balanced and unbalanced forces on objects (k, s)
c) Understand the existence of the force of gravity and distinguish between mass and weight (u)
d) Appreciate that the weight of a body depends on the size of the force of gravity acting upon it (k, u, v/a)
e) Understand the concept of friction in everyday life contexts (u)
f) Understand the meaning of adhesion and cohesion as forms of molecular forces (u)
g) Explain surface tension and capillarity in terms of adhesion and cohesion and their application (u, v/a)

TOPIC 5: TEMPERATURE MEASUREMENTS.

Competency: Appreciate that temperature change is a result of heat effects in a body and daily temperature changes have an effect on our lives.

Learning outcomes

The learner should be able to:

a) Understand the difference between heat and temperature (u)
b) Understand how temperature scales are established (u)
c) Calibrate a thermometer and use it to measure temperature (s, u)
d) Compare the qualities of thermometric liquids (u, s, v/a)
e) Describe the causes and effects of the daily variations in atmospheric temperature (u, v/a)

TERM THREE

TOPIC 6: HEAT TRASFER

Competency: The learner should be able to explain the modes of heat transfer and their applications to daily life.

Learning outcomes

The student should be able to:

a) Understand how heat energy is transferred and the rate at which transfer takes place (u, s)
b) Understand what is happening at particle level when conduction, convection, and radiation take place and their application (k, u, v/a)
c) Understand that greenhouse effect and global warming are aspects related to heat transfer on the earth surface (u, v/a)

TOPIC 7: EXPANSIN OF SOLIDS, LIQUIDS, AND GASES.

Competency: The learner should be able to explain the effect of heat on the expansion of solids, liquids, and gases and explore their applications.

Learning outcomes

The student should be able to:

a) Understand that substances expand on heating, and recognise some applications of expansion (u, s)
b) Understand the effect and consequences of changes in heat on volume and density of water (u, s)

c) Know about the anomalous expansion of water between 0°c and 4 °c and its implications (u, k, v/a)

TOPIC 8: NATURE OF LIGHT, REFLECTION AT PLANE SURFACES
Competency: The learner should investigate how some object emit light resulting in light and shade, while other objects, such as a mirror, simply reflect light, and understand the applications of light/shade and reflection.
Learning outcomes
The student should be able to:
a) Know illuminated and light source objects in everyday life (u, s)
b) Understand how shadows are formed and that eclipses are natural forms of shadows (u)
c) understand how the reflection of light from plane surfaces occurs and how we can make use of this (k, u, s, gs)

THEME 1:

INTRODUCTION TO PHYSICS

CHAPTER 1:

INTRODUTION TO PHYSICS

LEARNING OUTCOMES
1. Understanding the meaning of physics, its branches and why it's important to study physics.
2. Understanding why it's important to have laboratory rules and regulations and the need to follow them.

KEYWORDS
- Science
- Physics
- Matter
- Career
- Apparatus
- Laboratory
- Mechanics
- Optics
- Phenomena

INTRODUCTION
In primary, we learn science as one subject. In secondary school, science is divided into three subjects which are;
- Physics
- Biology
- Chemistry.

In this chapter, we will study the meaning of physics, its branches and why it's an important subject.
We shall also know that in physics, a lot of experiments are carried out in the physics laboratory and why it's important to observe safety in physics laboratory.

MEANING OF PHYSICS.
The word physics is derived from the Latin word "physica" which means "natural things" therefore physics is defined as the branch of science which deals with the study of matter and its relationship to energy.

Note:
> Matter is anything that occupies space and has weight.
> Energy is the ability to do work.

Why we study Physics

- To help students develop an experimental attitude by performing experiments and acquire skills such as observation, measuring, drawing logical conclusions.
- To understand scientific theories, principles and concepts
- To prepare students for further studies in Physics.
- To understand the applicability of Physics in other disciplines like security, medicine, engineering, e.t.c and improve the world's technology.

Activity (group work)

1. What are some of natural occurrences that can be explained by physics?

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BRANCHES OF PHYSICS.

Physics is wide and therefore for better understanding, it is divided into different branches as seen below.

1. Mechanics and properties of matter.

This deals with the study of bodies in motion (dynamics) and those at rest (statics)

2. Light.

This the study of form of energy that enables us to see. Stars, bulbs, our eyes, mirrors, lenses, periscopes, telescopes, microscopes, and many other optical instruments use light in their operations.

3. **Electricity**.

This is the study of charges at rest (electrostatics) and charges in motion (current electricity).

4. Magnetism.

This is the study of properties of metals that attract or repel other metals. Magnets are used in radios, electric bells, microscopes and loud speakers among others.

5. Heat and thermodynamics.

This deals with how energy is transferred between two points due to temperature difference between them.

6. **Modern physics.**

This deals with the study of the underlying processes of interaction of matter utilizing the tools of science and engineering. It consists of nuclear and atomic physics. Tools such as x-ray machines, cathode ray tubes and nuclear reactors use modern physics to operate.

7. Waves.
This deals with the study of periodic disturbances that carry energy from one point to another without permanent displacement of a medium. Electromagnetic waves, sound waves and light waves are the common examples of waves we use in our lives.
8. Earth and space physics.
This branch deals with the study of the solar system, the stars, moons galaxies, satellites, communication system and the universe in general.

Career opportunities in Physics:
A student who has done physics has the following career opportunities
i) Electrical engineering.
ii) Civil engineering.
iii) Architecture.
iv) Mechanical Engineering.
v) Geology.
vi) Chemical Engineering.
vii) Astronomy.
viii) Information technology.
ix) Telecom engineering.
x) Teaching physics.
xi) Agricultural engineering.
xii) Medicine.
xiii) Pharmacy.
xiv) Petroleum engineering

Discuss the career shown above, which one are interested in most?

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ROLES OF PHYSICS IN OUR SOCIETY.
Physics contributes to the technological development and provides trained personnel with advantage of scientific advances and discoveries.
Physics is an important element in the education of engineers, computer scientists, physics teachers among the others.

Activity
1. Reference to the library or internet, discuss and write notes about the roles of physics in our society.

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2. If technology is misused, it can be of great danger to our society. Discuss and write summary notes about the negative impacts of technology.

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THE PHYSICS LABORATORY.

The laboratory is a facility designed and equipped for conducting scientific research, experiments and measurements. Physics being a branch of science, it has a lot to do with testing, experimentation, demonstration, and research. Experiment prove that some statements, law and principle are true. A laboratory has apparatus used to do research almost on everything.

GENERAL LABORATORY RULES.

An average laboratory has electrical energy supply, water and gas piping systems, workbenches and cabinets for storage of equipment and chemicals. Some of the chemicals and equipment are particularly dangerous. An individual working in a typical laboratory will be exposed to a number of dangers including poisons, flammable materials, explosive materials, extreme temperature, moving machinery and high voltage electricity.

The following precautions must, therefore, be taken when working in the laboratory:

(i) Proper dressing must be put on. Shirts and blouses must be tucked in and long hair tied up. Closed shoes must be worn. This is to avoid loose clothing or body parts such as hair getting accidentally tangled up in moving machinery. In addition, safety glasses or face shields must be worn when working with hazardous or poisonous materials. Shorts and sandals must never be worn in the laboratory, and lab coats, if in use should always be buttoned.

(ii) The locations of electricity switches, fire-fighting equipment, First Aid kit, gas supply and water supply systems must be noted. These will be extremely useful in case of any emergency within the laboratory. Access to all these facilities must remain unobstructed, this includes emergency showers and eye washes, where these are available in the laboratory.

(iii) While working in the laboratory, windows and doors should be kept open. This is to prevent inhalation of dangerous materials or gases and also to allow for easy escape/evacuation in case of an emergency. Similarly, corridors or pathways within the laboratory should not be used as working or storage areas.

(iv) Any instructions given must be followed carefully. Never attempt anything while in doubt. In case of any doubt or queries, consult your teacher or the Laboratory assistant. Additionally, if any equipment fails to function, this should be reported immediately to the teacher or the laboratory technician. Never try to fix a problem on your own as this could cause a serious accident or damage to the equipment.

(v) Never taste, eat or drink anything in the laboratory. Food should also never be stored in the laboratory. This is to avoid the risk of consuming dangerous or poisonous materials or substances. Related to this, never pipette anything by mouth (a bulb should be used instead). Smelling of gases is also highly discouraged.

(vi) Ensure that all electrical switches, gas and water taps are turned off when not in use. This is to avoid wastage in addition to averting the risk of fire or other hazards.

(vii) When handling electrical apparatus, hands must be dry. Do not splash water where electrical sockets are located. Water to some extent is an electrical conductor and when in contact with exposed power cables, can cause severe electric shock.

(viii) Never plug foreign objects into electrical sockets. Apart from damaging the socket, this can also cause an electric shock.

(ix) Keep floors and working surfaces dry. Any spillage should be wiped off immediately. Liquid on the floor surface can cause skidding, resulting in serious injuries. Some corrosive liquids will damage the floor or working surfaces.

(x) All apparatus must be cleaned and returned to the correct location of storage after use. This facilitates easy re-use of the apparatus, apart from ensuring good order in the laboratory.

(xi) Laboratory equipment should not be taken out of the lab. This is to minimize the risk of damage to the equipment, or even loss.

(xii) Any waste after an experiment must be disposed of appropriately. This is because waste from certain experiments can be quite hazardous to the body and to the environment.
(xiii) Hands must be washed before leaving the laboratory.

Experiments should never be left unattended. Similarly, the Bunsen burner should be adjusted to give a luminous flame, or turned off, when not in use. Never should an open flame be left unattended. This is to minimize the risk of fire or other serious accidents.

Volatile and flammable compounds should only be used in the fume cupboard. The same applies to procedures that should result in hazardous fumes or any inhalable material.
One should never look directly down into the liquid being heated in a test- tube. The tube should also not be pointed towards anyone nearby.
Corrosive chemicals should be kept separately. This is to prevent damage to other laboratory appliances especially the metallic type.

FIRST AID MEASURES

Accidents or emergencies are prone to occur any time and it is, therefore, the user's responsibility to be conversant with the safety and fire alarm posters strategically positioned within the laboratory premises. These must be followed strictly during an emergency. The locations of vital emergency equipment such as fire extinguisher must be known and easily accessible to all, and users must be continually reminded of building evacuation procedures.
In case of injuries in the laboratory, the teacher in charge or the laboratory technician must be immediately informed and necessary action taken without delay. Common laboratory injuries include burns, cuts and bruises (sometimes resulting in bleeding), poisoning and foreign matter in the eyes. These cases should be handled in the following way. (Those offering first aid should ensure they are in the first place safe from the danger).

Cuts

These may result from poor handling of glass apparatus or cutting tools like razors and scalpels.
In case the cut results in bleeding, pressure or direct compression should be applied directly to the wound and proper dressing applied as medical assistance is sought.

Burns

Burns may result from naked flames or even splashes of concentrated acids and bases.
Burns should generally be treated by flushing cold water over the affected area. Acid burns could alternatively be treated with sodium hydrogen carbonate (baking soda), and base burns with boric acid or vinegar.

Poisoning

This may result from inhaling poisonous fumes or swallowing of poisonous chemicals or materials. In case this happens, the poisoning agent should be noted while urgent medical assistance is sought. For a poison ingested through the mouth, the recommended antidote should be given to the victim, and vomiting should not be induced unless recommended by a medical practitioner.
If the poison is in form of a gas, the first step should be to remove the victim from the area and take him/her to an area with fresher air. If the poison is corrosive to the skin, the victim's clothing should be removed from the affected area, and cold water run over the area for at least 30 minutes. If the poison gets to the eye, the same should be flushed with clean water for at least 15 minutes, and the patient advised not to rub the eyes.

Electric Shock

This may result from touching exposed wires or using faulty electrical appliances.
Without getting in contact with the victim, the first thing to do is to cut off the current causing the shock by:
(i) Turning off the current at the main switch, or,

(ii) Using a non-conducting object, such as wooden rod, to move the victim away from the conductor.
In the meantime, urgently seek medical assistance. If the victim has a pulse but is not breathing, offer mouth to mouth resuscitation as you awaits assistance.

If for some reason a laboratory user faints or loses consciousness, he/she should be promptly and gently moved to an area with fresh air and placed in a recovery position (with the head slightly lower than the rest of the body). If necessary, mouth to mouth resuscitation should be offered.
Make a poster that indicates all that one has to follow to be safe in the laboratory.

Activity

Visit a physics laboratory with a pen, note book and pencil.

a) Observe and identify the different equipment (apparatuses).

State the use of each apparatus.

Apparatus	use

b) Suggest the precautions you should observe for your safety and safety of the apparatus.

c) Using power point, prepare your findings and present to the class

Activity of Integration

Your school usually has careers day at the end of the first month of every first term of the academic year.

You have selected from your class to give a speech on that day about physics and the related careers.

Task,

Prepare a five minute speech that you will deliver on that day.

Make sure that your speech is attractive and attract many students to make up careers in physics field.

End of Chapter Assignment

1. List down any four benefits of studying physics.

2. Write down any five careers (occupation undertaken) in Physics.

3. State any four ways we can always commonly apply knowledge of physics while at home.

4. State any laboratory rules and guidelines you know and reasons why you should follow them while in a science laboratory.

THEME 2

MECHANICS AND PROPERTIES OF MATTER.

CHAPTER 2:

MEASUREMENTS IN PHYSICS

LEARNING OUTCOMES

- Understand how to measure and estimate physical quantities of length, area, mass and time.
- Explain how to choose and use the right measuring instruments and select the right units ensuring accuracy of measuring.
- Appreciate that the accuracy of measurements may be improved by making several measurements and taking an average value.
- Identify the potential sources of errors in measurement and devise strategies to minimize them.
- Understand the scientific method and explain the steps used in relation to the study of physics.
- Know that practical investigations involve a fair test, analysis, prediction and justification of results and observations and apply learning in practice.
- Record data in groups and charts and look for trends.
- Understand and be able to use scientific notation and significant figures.
- Understand density and its applications to floating and sinking.
- Determine densities of substances and relate them to purity.
- Understand the global nature of ocean current and how they are driven by changes in water density and temperature.

INTRODUCTION

Measurement is a very important feature in the study and application of physics. This is because it helps us to determine some of the properties of materials before we use them.

In this chapter we shall learn how to estimate and measure physical quantities in standard units, and the importance of making accurate measurement.

ESTIMATION AND MEASUREMENTS.

Measurement is a technique in which the properties of an object are determined by comparing them to a standard. Measurement requires tools and provide scientists with a quantity. Scientists use a system of measurement known as the "metric system" or international system of units abbreviated as **S.I.**

Estimate means using prior and a sound physical reasoning to state a rough idea of a quantity value. Estimation is a skill one should have.

Activity (Group work)

1. Mention situations where people use estimations in life.

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In your groups, discuss any two devices used for measurement of quantities and how they are used and in which units.

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SCIENTIFIC MEASUREMENTS.

PHYSICAL QUANTITIES.

Anything that can be measured is known as a **physical quantity**. Physical quantity is presented as a numerical value (magnitude) with a unit just like you have a surname and a first name. In general, a physical quantity is characterized by two features namely; size (magnitude) and the unit.

Physical quantities are of two types namely;

- Fundamental quantities
- Derived quantities

FUNDAMENTAL QUANTITIES.

The word fundamental means essential or most important. Fundamental quantities are also known as "**basic quantities** "

Fundamental quantities are physical quantities which are not expressed in terms of other physical quantities.

Examples of fundamental quantities are;

- Length
- Mass
- Time
- Temperature
- Current
- Amount of a substance
- Luminous intensity

DERIVED QUANTITIES.

These are physical quantities which can be expressed in terms of other physical quantities.

Derived quantities are obtained by multiplying or dividing two or more fundamental quantities.

Examples of derived quantities include;

- Area
- volume,
- power,
- density,
- weight,
- velocity,
- force
- Acceleration, among others.

Activity

In groups, discuss the various measurements of both derived and fundamental quantities. Use your findings to complete the table below.

Fundamental quantity	S.I unit	Symbol for unit
Derived quantity	S.I unit	Symbol of unit

MEASUREMENT OF LENGTH

Length is a measure of distance between two points. Breadth, width, height, radius, depth and diameter are all lengths. The S.I unit for length is meter (m). Other units of length include;

- Millimeters (mm)
- Centimeters (cm)
- decimeter (dm)
- Decameter (Dm)
- Kilometers (km)
- Acres
- Hectares among others.

There are special instruments for measuring different lengths. These include;

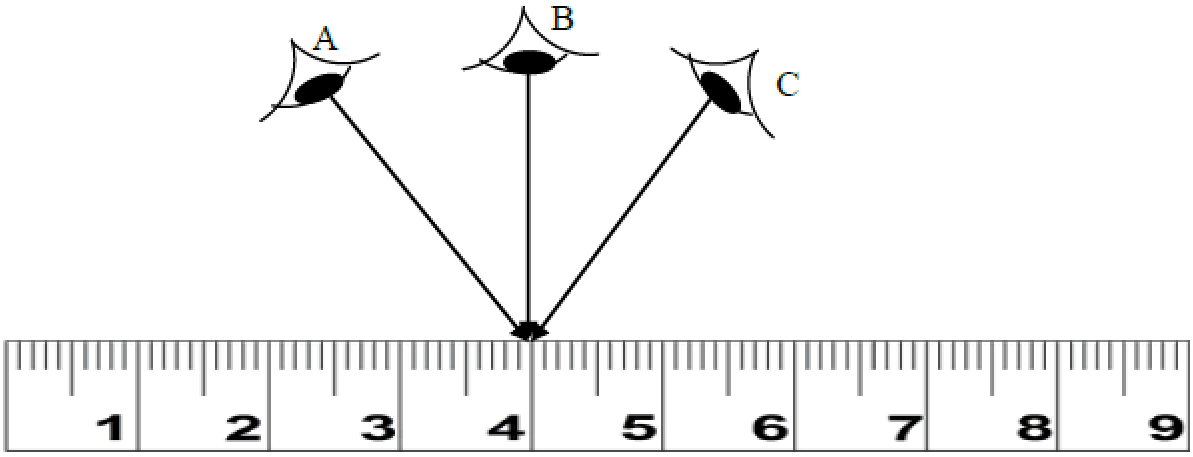
- Metre rule
- Tape measure
- Calipers
- Micrometer screw gauge
- Thread.

METRE RULE

A metre rule is used to measure length of a straight line. The tape measures are also used to measure the length. The choice of the actual instrument to be used for measuring depends very much on what is to be measured. For example, if the length of a football field is to be measured, a tape measure calibrated in metres and centimetres or millimetres may be used. If the width of a desk is to be measured the metre rule calibrated in cm and mm may be used. For smaller measurements of length a vernier calliper and a micrometer screw gauge is used.

When measuring length of an object using a metre rule the following should be noted:

1) Place the metre rule in contact with the object
2) Place the end of the object against the zero mark on the scale of the metre rule
3) Position your eye perpendicularly above the scale but not at an angle when reading the value



A – Wrong position

B – Correct position

C – Wrong position

Note; The accuracy and sensitivity of a reading obtained from any measuring instrument depends on the smallest scale division. For the metre rule the small scale division is one millimetre (1mm) or 0.1cm.

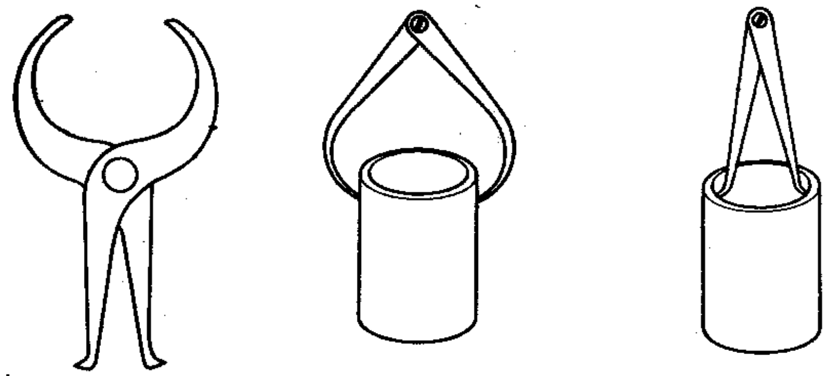
CALIPERS:

In the vernier callipers the vernier scale is designed to eliminate this guessing of the last digit. The instrument has two scales the main scale and the vernier scale. The main scale is divided into centimetres and millimetre. The vernier scale which slides over the main scale has a length of 9mm divided into ten equal divisions of $\frac{9}{10}$ =0.9mm each.

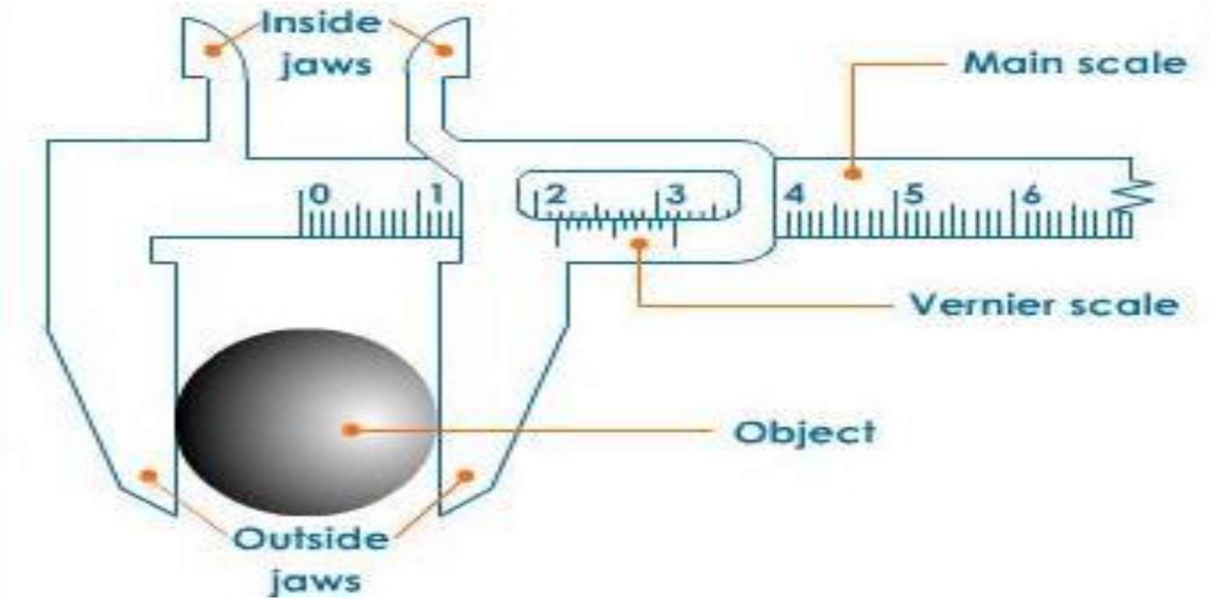
The difference between the main scale division and the vernier scale division is 0.1mm and this is the best accuracy or sensitivity of Vernier callipers measurements.

Calipers are of two types namely:
i) Engineer's calipers,
ii) Vernier calipers

ENGINEER'S CALIPERS



VERNIER CALIPERS



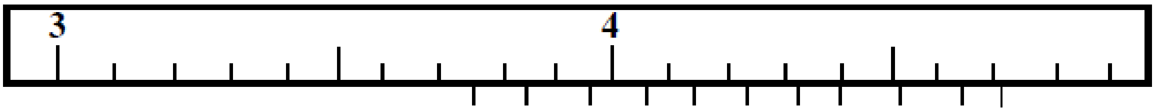
To measure any length using the vernier caliper the object is placed either between the outside jaws or the inside jaws, the sides or edges of the vernier scale slide over the main scale until the jaws grip the object.

How to use a vernier calliper

1. Close the jaws of the calliper and check if the zero of the main scale and the vernier scale coincide. If they differ, the amount by which they differ is known as a zero error
2. Open the jaws to touch appropriately the positions whose distance apart is to be measured. The inside or outside jaws should be used depending on what the measurement is, internal or external
3. You record the readings on the main scale immediately preceding a zero mark on the vernier scale
4. Record the number of graduations on the vernier scale. Which comes directly in line with the graduation on the main scale, this gives the second decimal place in centimetres
5. The final reading is the sum of the two readings in centimetres

Examples

1. What is the reading of the vernier caliper below?

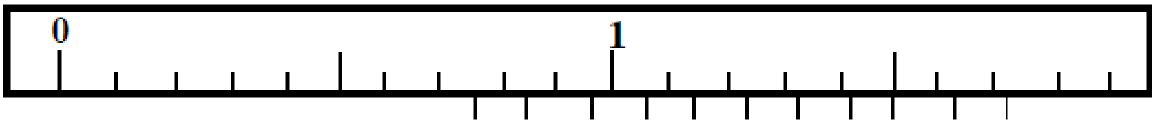


Main scale = 3.70cm

Vernier scale = 0.07cm

Vernier reading = 3.77cm

2. What is the reading of the vernier caliper below?

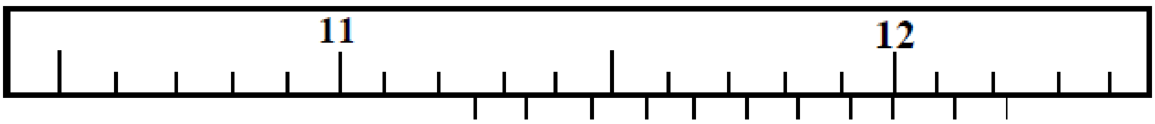


Main scale = 0.70cm

Vernier scale = 0.08cm

Vernier caliper reading = 0.78cm

2. What is the reading of the vernier caliper below?



Main scale = 11.20cm

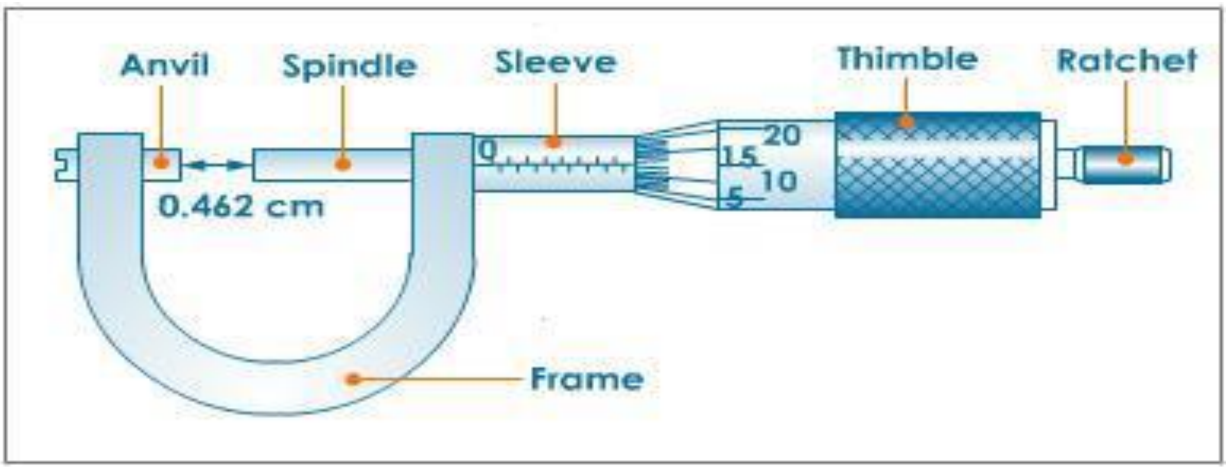
Vernier scale = 0.08cm

Vernier caliper reading = 11.28cm

MICROMETER SCREW GAUGE

The micrometer screw gauge accurately measures length less than 1centimetre (from 1*mm* to 25*mm*). Eg Diameter of wires, Diameter of ball beairings and pendulum bob, bicycle spoke pins, needles, etc.

The instrument measures up to 2 decimal places in mm. It consists of a spindle which can be screwed and it is fitted with a scaled thimble.



How to measure using a micrometer screw gauge

The object whose thickness is to be measured is placed between the jaws of the micrometer screw gauge. The ratchet is turned so that the jaws grip on the object. The ratchet starts to slip when the object is gripped tightly enough. To avoid errors, the anvil and spindle jaws should be wiped clean to remove any dirt and the (0) error of the micrometer screw gauge should be noted.

As in the vernier calliper, the reading in the micrometer screw gauge is taken in two parts.

Part1

The reading of the sleeve scale is read off at the edge of the thimble in mm and $\frac{1}{2}$ mm

Part 2

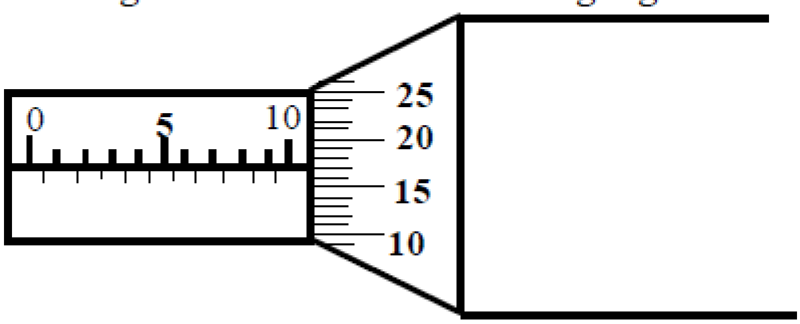
The reading on the thimble scale is the reading off opposite the centre line of the sleeve scale in hundredths of mm.

Precautions taken when using a micrometer screw gauge

- The faces of the anvil and the spindle must be cleaned to remove dust so as to get accurate readings.
- The reading must be checked.

Examples

1. What is the reading of the micrometer screw gauge below?



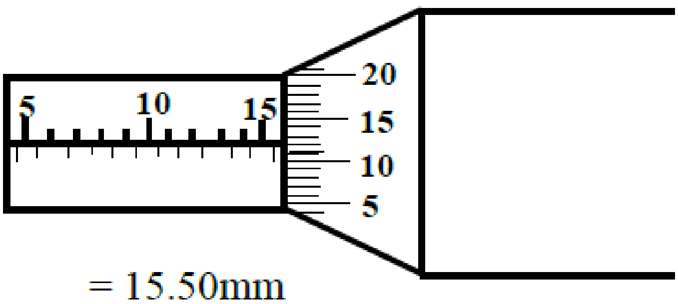
Sleeve scale = 10.00mm

Thimble scale = 00.17mm

Micrometer reading = 10.17mm

s

2. What is the reading of the micrometer screw gauge below?



Sleeve scale = 15.50mm

Thimble scale = 00.12mm

Micrometer reading = 15.62mm

Activity

1. James found that the perimeter of his farming plot was approximately 350 strides. His stride was 0.75m long. What was the perimeter of the plot in metres?

2. Measure the width of your desk, classroom window and the classroom using the ruler or any possible measuring instrument in S.I units.

3. Suggest the instrument you can use to measure the thickness and width of a metre rule.

CONVERSION OF UNITS.

The S.I unit for measuring length is metre (m). However, length can be measured in terms of other units which are also converted from one to the other as shown below.

Conversions

1m = 1000mm,

1m = 100cm,

1m = 10dm,

1km=1000m,

1km = 10000dm,

1km =100,000cm,

1km = 1,000,000mm

1mile = 1.61km,

1mile =1610m.

Examples

Convert the following measurements.

(a) 20mm to metres.

1m =1000mm

20mm = $\frac{20}{1000}$m

20mm = 0.02m

(b) 0.8m to centimeters

1m = 100cm;

0.8m = 0.8×100cm

0.8m = 80cm

Activity

Convert the following as instructed.

a) 2km to cm

b) 500cm to Hm

c) 0.02km to m

d) 150mm to m

MEASUREMENTS OF AREA.

Area is the quantity that expresses the extent of a given surface on a plane. It is a derived quantity of length. The SI unit of area is the square metre, written as m^2. It can also be measured in multiples and sub-multiples of m^2, for example, cm^2, dm^2, mm^2 and km^2.

Area is a measure of the extent of a two-dimensional surface or shape. It quantifies the amount of space enclosed within the boundaries of a flat object, such as a rectangle, circle, or triangle.

Area is an important concept in various fields, including mathematics, physics, engineering, and everyday life.

All objects occupy a particular two dimensional space called **area**.

Area is measured in square meters (m^2) .the other units of area are; square centimeters (cm^2), square millimeters (mm^2), square kilometers (km^2), square mile (ml^2) , among others.

IMPORTANCE AND APPLICATIONS OF AREA.

Architecture and Construction: Calculating the area is crucial for designing floor plans, determining the amount of materials needed (e.g., paint, flooring), and estimating costs.

Agriculture: Farmers need to know the area of their fields to manage planting, fertilization, and irrigation effectively.

Real Estate: The area of land and buildings is a fundamental factor in property valuation and transactions.

Clothing and Textiles: Manufacturers calculate the area of fabric needed to produce garments and other textile products.

Science and Engineering: In physics, area calculations are used in various contexts, such as determining the pressure exerted on surfaces (pressure = force/area) and in fluid dynamics.

Everyday Life: Understanding area helps in tasks like planning gardens, arranging furniture, and organizing spaces efficiently.

Visualization and Understanding:

Visualizing area often involves tiling a shape with unit squares. For instance, a rectangle with dimensions 3 meters by 4 meters can be covered by 12 unit squares of 1 square meter each, thus having an area of 12 square meters.

CONVERSION OF UNITS.

From 1m = 100cm

1m x 1m = 100cm x 100cm

$1m^2 = 10000cm^2$

From 1km = 1000m

1km x 1km = 1000m x 1000m

$1km^2 = 1000000m^2$

From 1cm = 10mm

1cm x 1cm = 10mm x 10mm

$1cm^2 = 100mm^2$

Examples

Convert the following to their S.I units

i) $1000mm^2$

1m = 1000mm

$1m^2 = 1000000mm^2$

$1000mm^2 = \frac{1}{1000000} \times 1000$

$= 0.001\ m^2$

ii) $90cm^2$.

1m = 100cm.

$1m^2 = 10000cm^2$.

$90cm^2 = \frac{1}{10000} \times 90$.

$= 0.009m^2$.

iii) $0.0045km^2$

1km = 1000m

$1km^2 = 1{,}000{,}000m^2$

$0.0045km^2 = 0.0045 \times 1{,}000{,}000$

$= 4500m^2$

iv) $7600cm^2$.

1m = 100cm.

$1m^2 = 10000cm^2$.

$7600cm^2 = \frac{1}{10000} \times 7600$.

$= 0.76m^2$.

Complete the table below.

(a)

SHAPE (DRAW)	FORMULA OF CROSS SECTIONAL AREA

(b)

REGULAR SHAPES(draw)	TOTAL SURFACE AREA
1.	
2.	
3.	
4.	

1. Mr. Wuuna brought an irregular shaped piece of land, explain how you would help him to determine its area.

MEASUREMENTS OF MASS.

Mass is the quantity of matter contained in a body. The **S.I** unit of mass is kilogram (kg). The other units of mass are; grams (g), tones, milligrams (mg), centigrams (cg), decigrams (dg), among others.

Mass is measured using a beam balance and the electronic mass meter among others.

Characteristics of Mass:

- Mass is a measure of inertia, which is the resistance of an object to changes in its state of motion. The more massive an object, the more force is required to accelerate it.
- Mass determines the strength of the gravitational force an object experiences in a gravitational field. The gravitational force between two objects is proportional to the product of their masses and inversely proportional to the square of the distance between them.
- Mass is conserved in isolated systems, meaning it cannot be created or destroyed. This principle is fundamental in classical mechanics and is extended in the form of mass-energy equivalence in relativity.

TYPES OF MASS:

Inertial Mass: A measure of an object's resistance to acceleration when a force is applied. It is defined by Newton's second law of motion, F=ma, where F is the force applied, m is the inertial mass, and a is the acceleration.

Gravitational Mass: A measure of the strength of an object's interaction with a gravitational field.

IMPORTANCE AND APPLICATIONS OF MASS:

Understanding mass is essential for analyzing forces, motion, and energy in physical systems. It plays a critical role in Newton's laws of motion, momentum, and kinetic energy.

Mass is a key parameter in studying celestial bodies, including their formation, dynamics, and interactions. It influences the structure and evolution of stars, galaxies, and the universe.

Accurate measurement and control of mass are crucial in designing and manufacturing products, from small electronic components to large structures like buildings and bridges.

Mass is commonly encountered in everyday activities, such as cooking (measuring ingredients), transportation (vehicle weight and fuel efficiency), and health (body weight).

Mass of the body is measured using the following instruments:

- Beam balance
- Lever – arm-balance
- Top-arm-balance

CONVERSION OF UNITS.

1kg = 1000g
1g = 100cg
1cg = 10 mg
1tonne = 1000kg

Activity

1. Apart from the beam balance and electronic balance, suggest any other devices used to measure mass.

2. Convert the following as instructed

a) 0.25 tonnes to kg

b) 200mg to g

c) 50g to kg

3. Briefly explain how you can determine the mass of milk in a plastic glass.

MASS AND WEIGHT.

As earlier discussed, **mass** is the amount of matter an object contains and **Weight** refers to the measurement of the pull of gravity on an object.

Mass becomes weight when an object being measured is suspended and acted upon by the force of gravity. **Force of gravity** is the force with which the earth pulls objects to itself. Weight is calculated from;

Weight = mass x acceleration due to gravity

W = m x g

Activity (Group)

In your groups, discuss the difference between mass and weight and share your finding with your class.

Weight	Mass

MEASUREMENTS OF VOLUME.

Volume is the space occupied by the object .The **S.I** unit of volume is cubic meters (m^3). The volume of the regular object can be determined if we know its dimensions. However, for irregular objects, we use the displacement method or the overflow can.

Importance and Applications:

1) Understanding volume is crucial in everyday activities like cooking (measuring ingredients), filling fuel tanks, and packing.
2) Volume calculations are essential in various scientific fields, including chemistry (stoichiometry and reactions involving gases), physics (density calculations), and engineering (designing containers, buildings, and other structures).
3) Dosage of liquid medications, blood transfusions, and intravenous fluids are often calculated based on volume.
4) Industries dealing with liquids (e.g., oil, beverages) and gases need to measure and control volumes accurately for production, storage, and distribution.

CONVERSION OF UNITS IN VOLUME.

Note that 1 litre = 1000cm^3

From 1m = 100cm

Therefore; $1m^3$ = 1000 litres

From 1km = 1000m

$1km^3$ = 1000, 000,000m^3

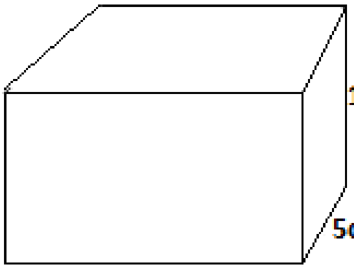
From 1cm = 10mm

$1cm^3$ = 10mm x 10mm x 10mm

$1cm^3$ = 1000mm^3

Examples

1. Use the rectangular box below to answer questions that follow.



Find the volume;

i) in cm^3

Volume = L x W x H

V= 8cm x 5cm x 10cm

V= **$400cm^3$**

(ii) In m^3

Volume in m^3

$1m^3$ = 1000, 000 cm3

$400cm^3$= **$0.0004m^3$**

2. A cuboid has dimensions 2cm by 10cm. Find its width in metre if it occupies a volume of $80cm^3$.

Solution

V = L x W x H

V = 2cm x W x 10cm = $80cm^3$

W = 4cm

Width in metres

4cm = m = **0.04m**

3(a) Find the volume of water in a cylinder of water radius 7cm if its height is 10cm.

Volume = $\pi r^2 h$

Volume = x 7cm x 7cm x10cm

Volume = **$1540cm^3$**

(b) The volume of the cylinder was $120m^3$.When a stone was lowered in the cylinder filled with water the volume increased to $15cm^3$.

Find the

(i) Height of the cylinder of radius 7cm.

Volume V = $\pi r^2 h$, 12 = 72xh

h = 0.078 cm

Assignment Activity

1. Convert the following as instructed

a) $200cm^3$to m^3

____

____

____

b) 50 liters to cm^3

c) $1200m^3$ to mm^3

d) $0.8m^3$ to litres.

2. Ivan has $30000cm^3$ of milk. He sells a liter at 750 Shs. Find how much will he earn from the milk.

VOLUME OF REGULAR SOLID

There are two types of objects namely;

- Regular objects
- Irregular objects

The volume of regular object is determined using a specific formula if the dimensions of the object are known.

Activity

Using the library or internet, make research and complete the table below.

OBJECT	SHAPE	FORMULA FOR VOLUME
Cuboid		

Cube		
Cylinder		
Sphere		
Rectangular Prism		

VOLUME OF AN IRREGULAR OBJECT.

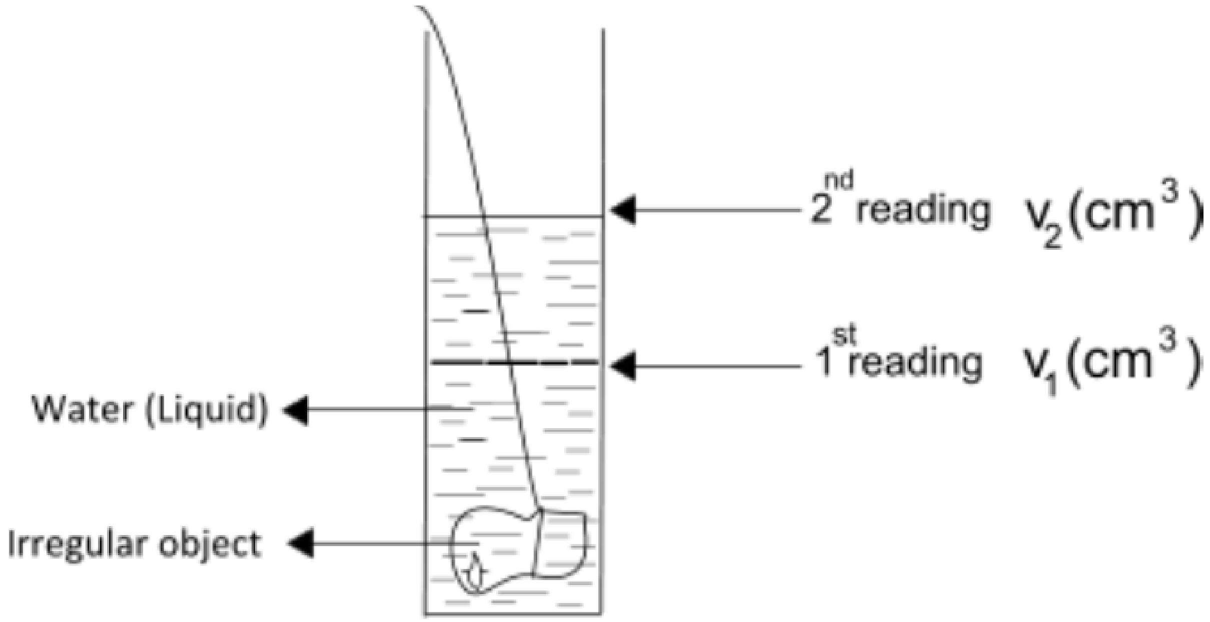
Irregular solids are those with undefined shapes for example a stone.
We use displacement method or eureka can to determine the volume of an irregular object.

Displacement method

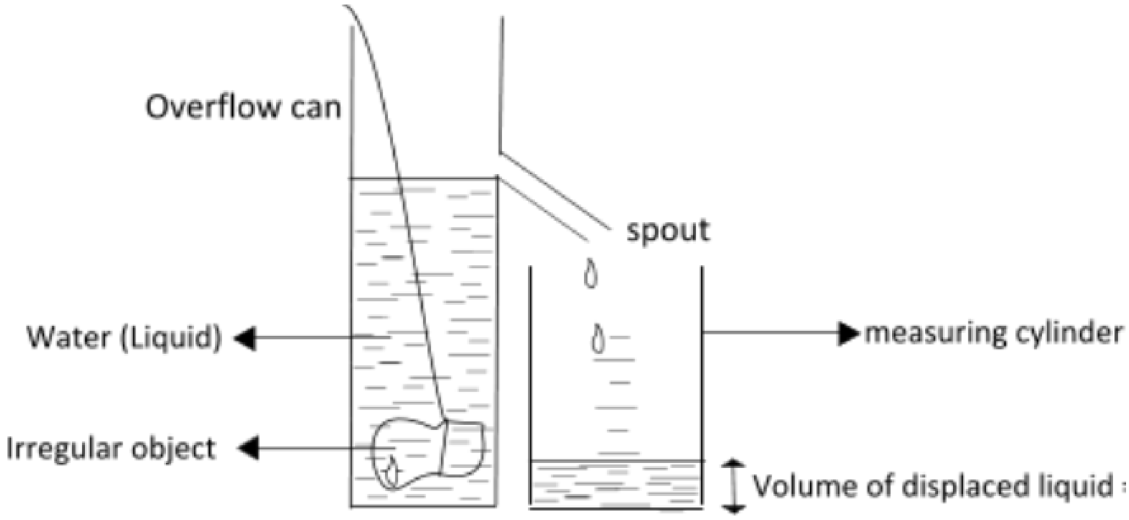
Procedure

a) Water is poured into a measuring cylinder and the volume noted on its scale.
b) A thread is tied around the irregular object.
c) The solid (object) is lowered into the water in the cylinder and the 2nd reading noted.
d) Volume of the solid is obtained from,
e) V= Volume of 2nd reading - Volume of 1st reading

Therefore, $\mathbf{V = V_2 - V_1}$



Overflow method



Procedure

a) An over flow can is filled with water
b) The irregular shaped object is tied onto a string and carefully lowered into the water in the overflow can. The water level is displaced.
c) The water flowing out of the can through the spout is collected using a measuring cylinder
d) The volume of the water collected is determined
e) The volume of the liquid displaced is equal to the volume of the irregular object (stone).

Volume of liquids

To measure fixed volumes, the following vessels are used:
Volumetric flask, measuring cylinder, beaker, pipettes etc
To measure varying volumes use a burette.

MEASURE OF TIME.

Time is the interval or duration between two events. The S.I unit of time is second (s). Other units of time include minute, hours, days, weeks, month, year, decades, among others.

Characteristics of Time:
Time is often perceived as moving in a linear fashion from the past to the present and into the future.
Time can be measured using various units and instruments, with seconds being the base unit in the International System of Units (SI).
In most everyday contexts and classical physics, time is perceived as unidirectional and irreversible, meaning events move forward and cannot be reversed.
Units of Time:
Time is measured in various units such as seconds (s), Minutes (min), Hours (h), Days, weeks, months, years, etc.
Conversion of unit of time
1minute = 60s
1hour = 60minutes
1h = 3600s
1day = 24hours
1 week = 7 days
1 months = 30 days
1 year = 365 days
Measurement of Time:
Clocks and Watches: Devices designed to measure and display time accurately. They range from mechanical clocks to electronic digital watches.
Atomic Clocks: Extremely precise timekeeping devices that use the vibrations of atoms (often cesium or rubidium) to measure time. These are used for scientific research and to maintain the accuracy of time standards.
Calendars: Systems for organizing days and larger units of time into a coherent structure. The Gregorian calendar is the most widely used today.

Importance and Applications of time
Time is essential for organizing daily activities, schedules, and routines. It helps in planning, coordinating, and managing tasks and events.
Accurate time measurement is crucial for experiments, observations, and the functioning of various technologies, including GPS, communication networks, and computer systems.
Time is a key variable in the laws of motion, thermodynamics, and quantum mechanics. It plays a crucial role in understanding the universe's structure and dynamics.
Time is a critical factor in financial markets, production schedules, project management, and service delivery.
Theories and Concepts:
Newtonian Time: In classical mechanics, time is considered absolute and universal, flowing at a constant rate regardless of the observer's state of motion.
Relativistic Time: According to Einstein's theory of relativity, time is relative and can vary depending on the observer's velocity and the presence of gravitational fields. Time dilates, or stretches, for objects moving at high speeds or in strong gravitational fields.
Arrow of Time: This concept describes the one-way direction or asymmetry of time, primarily observed through the increase of entropy as stated in the second law of thermodynamics, where systems evolve from order to disorder.

Practical Examples:
Daily Activities: Waking up at 7:00 AM, attending a meeting at 2:00 PM, or catching a flight scheduled for 6:00 PM.
Scientific Experiments: Measuring the reaction time in a chemical experiment or the half-life of a radioactive substance.
Technological Systems: Synchronizing data across global networks using Coordinated Universal Time (UTC).

Group work Assignment

1. Convert the following as instructed

a) 2.5 hours to seconds

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b) 640 hrs to days.

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c) A fortnight to minutes.

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MEANING OF DENSITY.

The density of a material is defined as its mass per unit volume. To determine the density of a substance, we need to know its mass and volume it occupies. The density is calculated from;

Density = $\frac{\text{Mass}}{\text{Volume}}$, D = $\frac{\boldsymbol{M}\ (\boldsymbol{kg})}{\boldsymbol{V}\ (\boldsymbol{m^3})}$

The S.I unit of density is kilograms per cubic metre (kgm^{-3}). Sometime density is measured in grams per cubic centimetre (gcm^{-3})

Characteristics of Density:

- Density is an intrinsic property of a substance, meaning it does not depend on the amount of substance present. It is a characteristic property that can be used to identify materials.
- The density of substances, especially gases, can change with temperature and pressure. For example, heating a substance typically decreases its density because the volume increases while the mass remains constant.

- Density is used in comparison of different materials. For example, lead is denser than aluminum, meaning a given volume of lead has more mass than the same volume of aluminum.

Applications of Density:

- Density is used to identify substances and verify their purity. For instance, gold's high density can help distinguish it from less dense metals.
- Objects with lower density than the fluid they are in will float, while those with higher density will sink. This principle is crucial in designing ships, submarines, and hot air balloons.
- Knowing the density of materials helps in calculating loads, stresses, and stability in construction projects.
- Density is used to estimate quantities and manage resources, such as determining the fuel efficiency of vehicles or the storage capacity for liquids.

Practical Examples:

- Water has a standard density of 1 g/cm^3 at 4°C. This property is often used as a reference point.
- The density of air at sea level is approximately 1.225 kg/m^3. This value is important in fields like meteorology and aviation.
- Gold has a high density of about 19.32 g/cm^3, which is why gold objects feel heavy for their size.
- Different types of wood have varying densities. For example, balsa wood is less dense and therefore lighter than oak wood.

CONVERSION OF UNITS.

$\frac{1\text{ kg}}{1\text{ m}^3} = \frac{1000\text{ g}}{1{,}000{,}000\text{ cm}^3}$, $1\text{ kgm}^{-3} = \frac{1}{1000}\text{gcm}^{-3}$

Multiplying through by 1000

$1000\text{ kgm}^{-3} = 1\text{ gcm}^{-3}$

Assessment activity

1. a) Calculate the density of the brick whose mass is 500g and dimensions are 30cm by 15cm by 10cm.

____
____
____
____
____
____

b) Calculate the mass of air of density 1.29 kgm^{-3} in a room of dimensions 7m by 6m by 4m.

____
____
____
____
____

3. convert the following as instructed

a) $15.2gcm^{-3}$to kgm^{-3}

b) $1250 kgm^{-3}$ to gcm^{-3}

2. The following results were obtained in an experiment to determine the density using a density bottle of $75 cm^3$.
Mass of an empty density bottle = 35g
Mass of the bottle full of liquid = 75g
Find the density of a liquid.

EXPERIMENT TO DETERMINE DENSITY OF REGULAR OBJECTS
The mass of the solid is obtained using a beam balance.
The volume of the object is obtained by measuring the dimensions length, width and height using a ruler or Vernier calipers or both, and then substitutes the dimensions into the known formula of determining the volume.

HOW TO DETERMINE DENSITY OF AN IRREGULAR OBJECT (e.g. a stone)
The mass, **m** of a solid is measured using a beam balance.
Its volume, **v** is obtained using displacement method.
The density is then obtained from, density = $\frac{\text{mass (m)}}{\text{volume (v)}}$

Density of liquids
i) The volume, **V** of the liquid is measured using a measuring cylinder.
ii) The liquid is poured into the beaker of known mass $\mathbf{M_0}$.
iii) The mass, $\mathbf{M_1}$ of the beaker containing the liquid is obtained using a beam balance.
iv) The density of the liquid will be

$$\text{Density} = \frac{M_1 - M_0}{V}$$

Density of Air

i) A round bottomed flask is weighed when full of air and its weighed again after removing air with a vacuum pump.

ii) The difference gives the mass of air.

iii) The volume of air is obtained by putting water in the same flask and measures its volume using a measuring cylinder.

iv) The volume of water will be equal to the volume of air

v) The density then calculated from;

$$\text{Density} = \frac{\text{mass of air}}{\text{volume of air}}$$

DENSITY OF MIXTURES

Suppose two substances are mixed as follows:

Substance	Mass	Volume	Density
X	M_X	V_X	$D_X = \frac{M_X}{V_X}$
Y	M_Y	V_Y	$D_Y = \frac{M_Y}{V_Y}$

$$\textbf{Density of mixture} = \frac{\textbf{mass of mixture}}{\textbf{Volume of mixture}}$$

$$\text{Density of mixture} = \frac{M_X + M_Y}{V_X + V_Y}$$

Example: 1

100cm^3 of fresh water of mass100g is mixed with 100 cm^3 of sea water of mass103g. Calculate the density of the mixture.

Solution

$$\text{Density of mixture} = \frac{\text{mass of mixture}}{\text{Volume of mixture}}$$

Density of mixture

$$= \frac{\text{mass of fresh water} + \text{mass of sea water}}{\text{Vol. of fresh water} + \text{Volume of sea water}}$$

$$\text{Density of mixture} = \frac{100 + 103}{100 + 100}$$

$$= \frac{203}{200}$$

Density of mixture = 1.015 gcm^{-3}

Example 2

Liquid Y of volume $0.40m^3$ and density $90.0kgm^{-3}$ is mixed with liquid X of volume$0.35m^3$ and density $800kgm^{-3}$. Calculate the density of the mixture.

Solution

$\text{mass of Y} = \text{Volume of Y} \times \text{Density of Y}$

$\text{mass of Y} = 0.40 \times 90.0$

$\text{mass of Y} = 360\text{kg}$

$\text{mass of X} = \text{Volume of X} \times \text{Density of X}$

$\text{mass of Y} = 0.35 \times 800$

$\text{mass of Y} = 280\text{kg}$

.Then:

$$\text{Density of mixture} = \frac{\text{mass of mixture}}{\text{Volume of mixture}}$$

$$\text{Density of mixture} = \frac{\text{mass of liquid Y} + \text{mass of liquid X}}{\text{Volume ofliquid Y} + \text{Volume of liquid X}}$$

$$\text{Density of mixture} = \frac{360 + 280}{0.40 + 0.35}$$

$$= \frac{640\text{kg}}{0.75m^3}$$

Density of mixture = $853.33kgm^{-3}$

RELATIVE DENSITY

Relative density, also known as **specific gravity**, is a dimensionless quantity that compares the density of a substance to the density of a reference substance, typically water for liquids and solids, and air for gases. It indicates whether a substance is more or less dense than the reference substance without requiring units.

Relative density is defined as the ratio of the density of a substance to the density of an equal volume of water.

$$\text{Relative Density} = \frac{\text{Density of substance}}{\text{Density of equal volume of water}}$$

Note: Density of pure water $=1\text{gcm}^{-3} = 1000\text{kgm}^{-3}$ since density = mass / Volume, Then:

$$\text{Relative Density} = \frac{\text{mass of substance}}{\text{mass of equal volume of water}}$$

$$\text{Relative Density} = \frac{\text{weight of substance}}{\text{weight of equal volume of water}}$$

Note: Relative density has no units.

Characteristics of relative density

Since relative density is a ratio of two densities, it has no units.

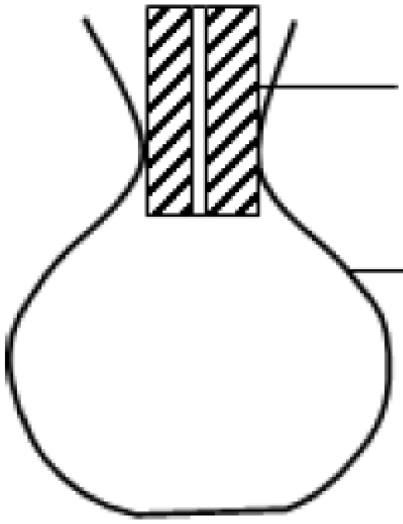
It allows for easy comparison of the density of a substance to the reference substance.

If R.D > 1, the substance is denser than the reference substance.

If R.D < 1, the substance is less dense than the reference substance.

When measuring relative density, it is important to specify the temperatures and pressures of both the substance and the reference substance, as density can change with these conditions.

Determining relative density of a liquid using density bottle



The bottle contains exactly the same volume when the liquid level is at the hole.

- mass of empty bottle M_0

A dry density bottle with a stopper is weighed when empty using a balance.

- Mass of bottle filled with the liquid M_2

A dry density bottle with a stopper is weighed when filled with the liquid using a balance.

- Mass of bottle filled with water M_1

After removing the liquid and rinsing out the density bottle with water, the density bottle is filled with water and weighed again.

- The measurements are recorded as below:

Mass of empty: $= m_0$

Mass of bottle full of water: $= m_1$

Mass of bottle full of liquid: $= m_2$

Mass of liquid: $= m_2 - m_0$

Mass of water: $= m_1 - m_0$

❖ Relative Density of a liquid $= \frac{m_2 - m_0}{m_1 - m_0}$

Note: The advantage of using a density bottle in measuring the relative density of a solid is that it is accurate compared to other methods.

Measurement of relative density of a solid

❖ This can be found by weighing the solid in air and when fully immersed in water.

❖ The solid immersed in water displaces an amount of water equal to its volume. The relative density is then calculated using;

❖ Relative density $= \frac{\text{Weight in air}}{\text{Weight in water}} = \frac{W_a}{W_a - W_w}$

Example 1

A density bottle was used to measure the density of mercury. The following measurements were taken:

- Mass of empty bottle = 20g
- Mass of bottle full of mercury = 360g
- Mass of bottle full of water = 45g

Calculate the;

a. Relative density of mercury

b. Density of mercury

Solution

(i)	(ii)
$R.D = \frac{m_2 - m_0}{m_1 - m_0}$ $R.D = \frac{360 - 20}{45 - 20}$ $R.D = \frac{340}{25}$ $\underline{R.D = 13.6}$	$R.D = \frac{\text{Density mercury}}{\text{Density of water}}$ $13.6 = \frac{\rho}{1000}$ $\rho = 13.6 \times 1000$ $\underline{\underline{\rho = 13600kgm^{-3}}}$

Applications of Relative Density:

a) Helps in identifying materials and verifying their purity. For example, the relative density of pure gold is about 19.3.

b) Used in industries like mining, oil, and chemicals to assess material properties.

c) Determines whether an object will float or sink in a fluid. An object with an Relative Density less than 1 will float in water.

d) Used in quality control processes to ensure consistency and standards in manufacturing.

Examples:

a) The relative density of water is 1, as it is the reference substance.

b) Ethanol has a relative density of about 0.79, meaning it is less dense than water and will float on it.

c) Mercury has a relative density of about 13.6, making it much denser than water. This high density allows mercury to be used in barometers and other instruments.

Importance of R.D in Different Fields:

a) Used to determine the concentration of solutions and the purity of substances.

b) Helps in studying the stratification of lakes and oceans where water density varies with temperature and salinity.

c) Essential in designing systems involving fluid flow, such as pipelines and hydraulics.

Ocean Currents and Water Density

Ocean currents are a critical component of Earth's climate system, influenced by various factors, including changes in water density. Ocean currents are large-scale movements of water within the oceans, driven by various forces such as wind, Earth's rotation (Coriolis Effect), temperature gradients, salinity differences, and tides.

Density-Driven Currents (Thermohaline Circulation):

Ocean water density is primarily influenced by temperature and salinity:

Temperature: Colder water is denser than warmer water.

Salinity: Water with higher salinity is denser than water with lower salinity.

Thermohaline circulation, also known as the "global conveyor belt," is a density-driven ocean circulation system. It plays a key role in distributing heat and regulating climate across the globe.

Cold, salty water in the Polar Regions sinks due to its higher density, driving deep ocean currents. As this water moves along the ocean floor, it eventually warms and rises, creating a global circulation pattern.

Role of Water Density in Ocean Currents:

In the Polar Regions, where water is cold and salty, the increased density causes the water to sink, initiating deep ocean currents that travel across the globe.

Changes in water density also affect surface currents. For instance, when surface water becomes denser, it can sink, driving vertical currents that impact surface water movement.

Upwelling occurs when deeper, colder, and nutrient-rich water rises to the surface, often driven by wind patterns and changes in water density. Downwelling occurs when surface water sinks due to increased density, often due to cooling or increased salinity.

Impact of Ocean Currents on the Warming of the North Atlantic Due to Climate Change:

Climate Change and the North Atlantic:

The North Atlantic region is particularly sensitive to changes in ocean currents, especially the Atlantic Meridional Overturning Circulation (AMOC), a key component of the global conveyor belt.

AMOC is responsible for transporting warm, salty water from the tropics northward, where it cools, sinks, and returns southward as a deep current.

Warming of the North Atlantic:

Climate change is causing accelerated melting of polar ice, particularly in Greenland. This influx of freshwater into the North Atlantic reduces the salinity of seawater, decreasing its density and potentially disrupting the sinking of water that drives the AMOC.

A reduction in the density of North Atlantic waters can weaken the AMOC, leading to a slowdown in the circulation. A weakened AMOC could reduce the transport of warm water to the North Atlantic, potentially leading to regional cooling in Europe and North America, despite global warming.

Ocean currents play a vital role in distributing heat across the planet. If the AMOC weakens, it could lead to significant changes in weather patterns, sea level rise, and more extreme weather events in the North Atlantic region.

Potential Impacts of a Weakened AMOC:

Paradoxically, while the planet warms, regions like Northern Europe and the eastern United States could experience cooler temperatures if the AMOC weakens and less warm water is transported northward.

A weakened AMOC could lead to a rise in sea levels along the North Atlantic coast due to changes in ocean circulation patterns.

Changes in ocean currents can alter atmospheric circulation, potentially leading to more intense storms and hurricanes in the North Atlantic region.

Changes in ocean currents and temperature can impact marine life, including fish populations and migratory patterns, affecting ecosystems and human activities like fishing.

As polar ice melts, it reduces the reflective surface area, causing more sunlight to be absorbed by the ocean, further increasing temperatures and accelerating ice melt. This feedback loop can further weaken ocean currents by altering water density.

Increased freshwater input from melting ice can further reduce the salinity and density of ocean water, amplifying the weakening of the AMOC and potentially leading to more pronounced climate impacts.

The monitoring of ocean salinity, temperature, and currents is crucial for predicting changes in the AMOC and understanding the potential impacts on the North Atlantic and global climate.

Advanced climate models are used to simulate the impact of changing ocean currents on global and regional climates. These models help predict potential scenarios and inform climate policy and adaptation strategies.

Coastal regions in the North Atlantic may need to implement adaptation strategies to cope with the potential impacts of a weakened AMOC, including sea level rise and changing weather patterns.

Reducing greenhouse gas emissions is critical to slowing the rate of climate change and its impact on ocean currents. Global efforts to limit temperature rise can help mitigate the risks associated with the disruption of ocean circulation patterns.
Ocean currents, driven by changes in water density, are integral to the global climate system. The potential weakening of the AMOC due to climate change could have profound effects on the North Atlantic region, including alterations in temperature, sea level, and weather patterns. Understanding these dynamics is crucial for developing strategies to address and mitigate the impacts of climate change on ocean currents and the broader environment.

DENSITY AND ITS APPLICATION IN SINKING AND FLOATING.

We normally witness objects floating or sinking in different media like water and air. The density of an object determines whether it will float or sink in another substance. An object will sink if it is denser than a liquid it is placed in.
Note; the density of water is $1gcm^{-3}$ or $1000kgm^{-3}$. Those substances with a density of less than that of water will float on water while those substances with density greater than that of water will sink.

Assessment activity

Why do you think large ships or ferries are able to float on water, even though they are made of steel which is denser than water?

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FLOATING AND SINKING IN AIR

It is not only liquids that can make things floating. Objects can float in air too

Research assignment

Research about how a hot air balloon works, discuss in your groups.

SCIENTIFIC NOTATION AND SIGNIFICANT FIGURES

A number is in scientific form, when it is written as a number between 1 and 9 which is multiplied by a power of 10.
Scientific notation is used for writing down very large and very small measurements.
Example:
(i) 598,000,000m = 5.98 x 10^8m
(ii) 0.00000087m = 8.7 x 10^{-7}m
(iii) 60220m = 6.022 x 10^4m

SIGNIFICANT FIGURES

Significant figures are the digits in a number that carry meaning contributing to its measurement accuracy. This includes all the non-zero digits, any zeros between them, and any trailing zeros in a decimal number.
Importance in Measurements
Significant figures reflect the precision of a measurement. When recording measurements, the number of significant figures indicates how accurate the measurement is.
The more significant figures in a number, the more precise the measurement is.

RULES FOR DETERMINING SIGNIFICANT FIGURES

Non-Zero Digits: Always significant.
Example: 123.45 has five significant figures.
Leading Zeros: Not significant; they only indicate the position of the decimal point.
Example: 0.0032 has two significant figures.
Captive (or trapped) Zeros: Zeros between non-zero digits are significant.
Example: 1002 has four significant figures.
Trailing Zeros:
With a Decimal Point: Significant.
Example: 2.300 has four significant figures.
Without a Decimal Point: Not significant unless explicitly indicated.
Example: 2300 has two significant figures, but if written as 2300. (With a decimal), it has four significant figures.

Addition and Subtraction:
The result should be reported with the same number of decimal places as the number with the fewest decimal places.
Example: 12.11 + 1.2 = 13.3 (one decimal place, matching the least precise term).
Multiplication and Division:
The result should have the same number of significant figures as the number with the fewest significant figures in the calculation.
Example: 2.5 × 3.42 = 8.6 (two significant figures).
Rounding Rules:
When rounding a number to a certain number of significant figures:
Look at the digit immediately after the last significant figure.
If it's 5 or greater, round up the last significant figure.
If it's less than 5, keep the last significant figure as it is.
Exact Numbers:
Numbers that are counted (e.g., 3 apples) or defined quantities (e.g., 1 inch = 2.54 cm) have an infinite number of significant figures and do not limit the precision of calculated results.
Use in Reporting Scientific Data:
In scientific publications and data reports, using the correct number of significant figures ensures that the data is not over-interpreted and reflects the actual precision of the measurement instruments.
Common Mistakes
Overestimating the precision by reporting too many significant figures.
Misinterpreting leading or trailing zeros.
Example:
If you measure a length as 0.00456 meters, the significant figures are 456, giving three significant figures. This indicates that the measurement instrument can measure to the nearest ten-thousandth of a meter.
Understanding significant figures is critical in maintaining the integrity of scientific calculations and reporting. It helps in avoiding the illusion of precision where there is none, ensuring the accuracy and reliability of scientific results.

Activity

1. Workout the following and write your answers to the correct number of decimal places and significant figures.

a) $\frac{92.15}{9.30}$ =

b) 30.15 + 2.12 - 18.5 =

c) $(\frac{0.36}{0.2} + 12.5 \text{ x } 0.15)$ =

2. Round off to stated decimal places

a) 2.062 to (2dp)

b) 4.586 (1dp)

c) 1.9705 (3dp)

d) 9.58 (0dp)

3. Write the following to stated significant figures.

a) 28.802 (2sf)

b) $\frac{2}{7}$ (2sf)

c) $4.035 \text{ x } 10^{-2}$ (3sf)

4. Convert each of these numbers to scientific notation.

a) 0.00102

b) 2.018

c) 150,000,000

d) 2004

5. Round off the following g digits and express them to 3 significant figures.

a) 245830

b) 3850

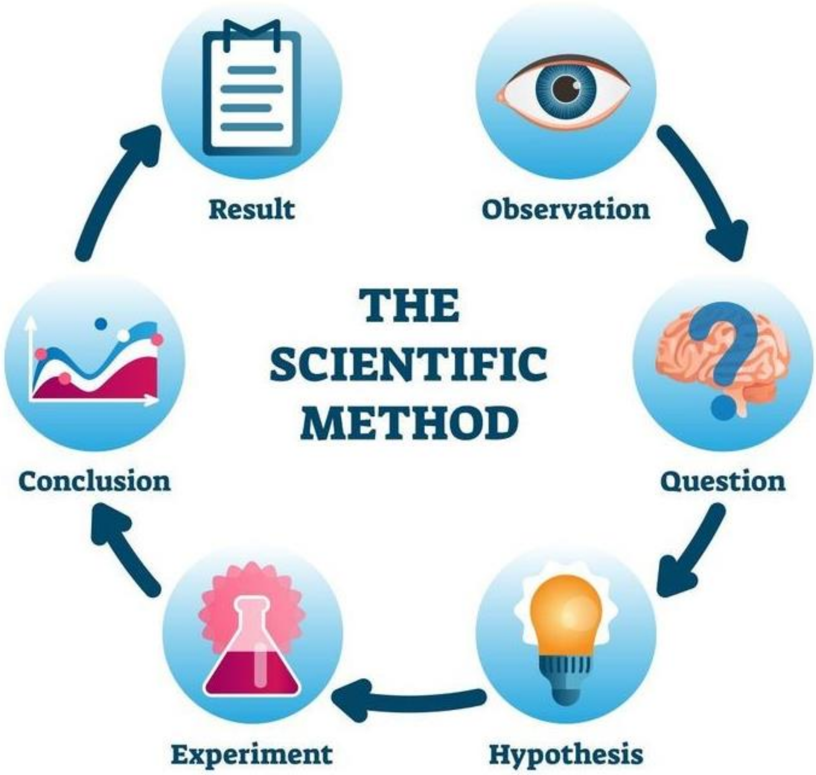
c) 0.08042

THE SCIENTIFIC METHOD IN STUDYING PHYSICS

The scientific method is a process of gathering and refining data, information and knowledge and explain why and how things occur.

Steps involved in a scientific method

There are many forms of the scientific method as there are scientists but general procedure is the same.



Assignment

1. Write short notes on each of the steps.

2. Present your work to rest of the class

Activity of Integration one

Your father finds a merchant selling what looks like pure gold stones. He buys a few and shows to the family because he is not sure whether it is real pure gold. The family assures him that is pure gold hence should buy more and sell to get money but he still doubts.

Prepare a demonstration to prove whether the stones are pure gold or not, help your father to clear the doubts.

Hint: density of pure gold is 19.3 $\boldsymbol{gcm^{-3}}$

Activity of Integration two

SCENARIO

Some bottles of colorless liquids were being labeled when the technicians accidentally mixed them up and lost track of their contents. $\mathbf{15.0\ ml}$ sample withdrawn from one bottle weighed **22.3 g**. The technicians knew that the liquid was either acetone, benzene, chloroform, or carbon tetrachloride. He however has challenges identifying the right chemical to label.

SUPPORT MATERIAL

LIQUID	Acetone	Benzene	Chloroform	water	Carbon-tetrachloride
DENSITY (g/cm^3)	0.792	0.899	1.489	1.000	1.595

TASK

a) What was the identity of the liquid? (Clearly show each step of your work out)

b) Name those liquids which can float on water and explain why they float on water.

a) Name those liquids on which water floats on top and explain why water floats on those liquids named.

END OF CHAPTER ASSIGNMENT

1. What do you understand by the term Measurement?

b) What do you understand by the term Estimation?

c) During class activity, the students were tasked to find the length of their classroom. Denis used his foot span and found out that the classroom length is 50-foot spans meanwhile Job went to the laboratory and got a tape measure to which he used and obtained 12 meters.

i) Why do you think there are differences between the values obtained by the two students?

ii) Which of the two values obtained is an estimated value?

iii) Which of the two values obtained is the actual value?

iv) Who obtained the actual value of the length of classroom?

v) How can we improve the reliability of an estimate?

(a) $\mathbf{m^2}$

(b) $\mathbf{cm^2}$

(c) $\mathbf{km^2}$

2. Fred sells water in a ***20 litre*** jerry can at UgShs.200 per jerry can. One day he was paid Ug. Shs. 15,000 by one of his customers who wanted to buy water.
(a) What physics term can be used to replace the sentence, "the space occupied by water in a jerry can?

(b) How much water should Fred sell to his customer?

(c)Name any other two common units used in measuring the amount of space occupied by an object.

(d) What is the relationship between those units in (c) and the unit used by Fred?

3. a) Calculate the relative density of the liquid from the following information.
Mass of empty relative density bottle $\mathbf{M_1}$= 24.5
Bottle with water mass $\mathbf{M_2}$ = 56.2g
Bottle with liquid $\mathbf{M_3}$ = 51.2g

b) If mass of solid is 84.2 g. Initial volume of water in a measuring cylinder is 36 ml. Final volume of water in measuring cylinder is 60 ml. Find the density of substance.

c) In an oil spill in the ocean, the oil rises to the top creating an oil slick on the surface of the ocean. State the reason why.

4. You turn a light switch on, and the bulb does not light. How could you use the scientific method to solve this problem? (Show step by step)

THEME:

MECHANICS AND PROPERTIES OF MATTER

CHAPTER 3:

STATE OF MATTER

LEARNING OUTCOMES

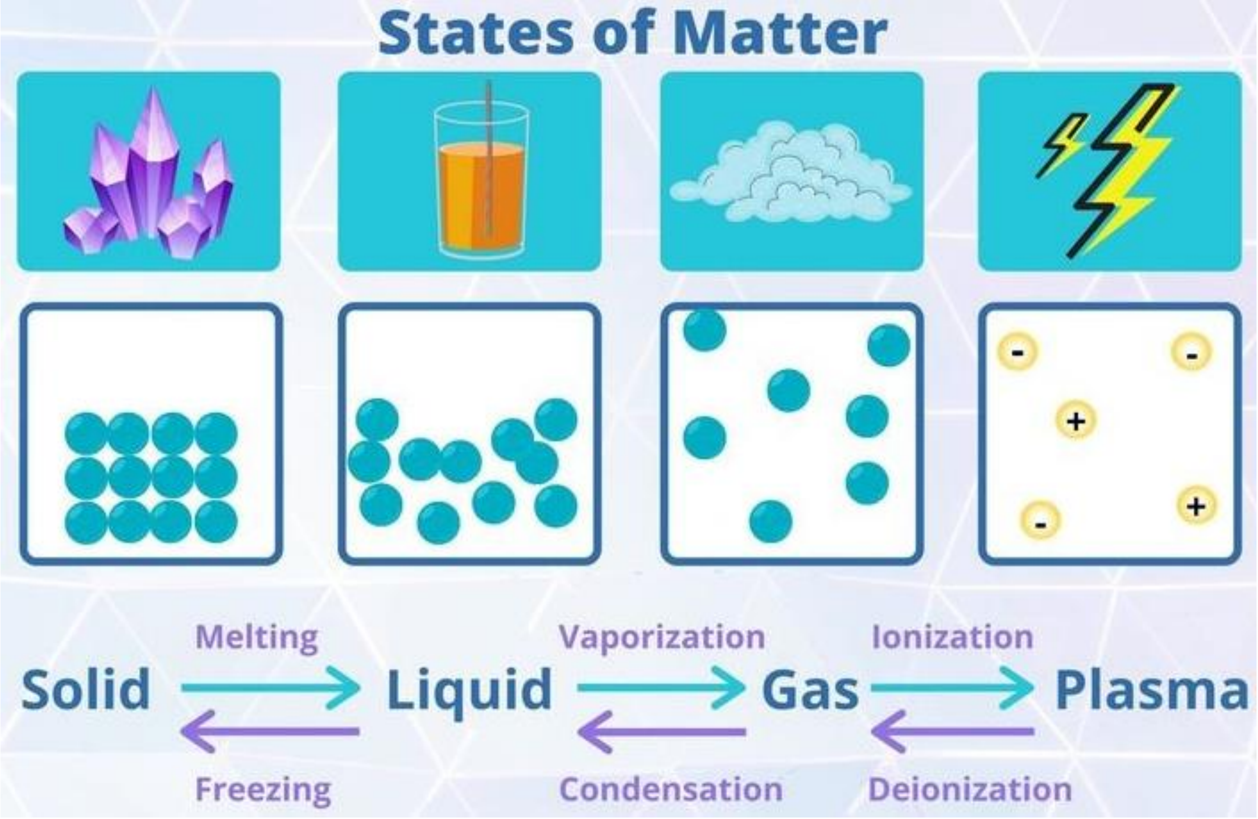
- ❖ Understand the meaning of matter.
- ❖ Understand that atoms are the building blocks from which all matter is made and appreciate that the state of matter have different properties.
- ❖ Apply the particle theory to explain diffusion and Brownian motion and their application.
- ❖ Understand how the particle theory of matter explains the properties of solids, liquids and gases, change of state and diffusion.
- ❖ Understand the meaning and importance of plasma in physics.

KEYWORDS

- ➢ Brownian Motion
- ➢ Change of state of matter
- ➢ Concentration
- ➢ Condensation
- ➢ Diffusion
- ➢ Evaporation
- ➢ Melting
- ➢ Particle theory of matter
- ➢ Plasma
- ➢ Sublimation
- ➢ Water theory

INTRODUCTION

There are four common state of matter that is solid, liquid, gas and plasma.



The difference of the substances in their states is observed in the property differences. In this chapter, you will learn more about matter and use the knowledge of the arrangement and motion of particles to explain the properties of solids, liquids, gases, and plasma.
Matter is the substance that constitutes the physical universe, encompassing everything that has mass and occupies space.
It forms the basis of all objects, living or non-living, and exists in various states: solid, liquid, gas, and plasma. Composed of tiny particles called atoms and molecules, matter interacts through physical and chemical processes, giving rise to the diverse materials and phenomena we observe in the world around us. Understanding the nature and properties of matter is fundamental to the study of physics and other sciences, as it helps explain the behavior of objects and the forces that govern them.
Matter is anything that occupies space and has weight. It exists in different forms/states of small items called atoms.

STRUCTURE OF MATTER
Matter is fundamentally defined as anything that occupies space and has mass. This definition encompasses all physical substances, from the smallest particles to the largest structures in the universe. Below are the key reasons why this definition holds:
Matter has a physical presence, meaning it takes up space in the universe. Whether it's a solid, liquid, gas, or plasma, matter displaces a volume in space, which is a key characteristic of its existence.
Mass is a measure of the amount of matter in an object. It is an intrinsic property of matter that does not change regardless of the object's location in the universe. Mass gives matter inertia, the resistance to changes in motion, and is directly related to the gravitational force an object experiences.

The Particle Theory of Matter
The particle theory of matter, also known as the kinetic theory of matter, is a scientific theory that explains the properties and behavior of matter in terms of small, discrete particles.
The key principles:
Whether an object is a solid, liquid, or gas, it is composed of tiny particles (atoms, molecules, or ions).
The particles of matter are always moving. The speed of their movement depends on the state of matter:
In solids, particles vibrate in fixed positions.
In liquids, particles move freely but stay close together.
In gases, particles move rapidly and are widely spaced.
The particles attract each other:
There are forces of attraction between particles that vary in strength depending on the state of matter: Strongest in solids, Weaker in liquids and Weakest in gases.
Energy and temperature affect particle movement: As temperature increases, the particles gain energy and move faster. This energy is known as kinetic energy.
How matter exists in different states and common examples
Matter can exist in several different states, primarily as solids, liquids, gases, and plasma. The state of matter is determined by the arrangement and energy of its particles.

Solids:
In solids, particles are closely packed together in a fixed arrangement. They vibrate but do not move freely. Solids have a definite shape and volume. Solids have a tightly packed and orderly arrangement of particles called **lattice**. Strong intermolecular forces hold the particles together.
Solids are formed through processes like cooling of liquids (solidification), deposition of gases, or directly from chemical reactions (e.g., precipitates formed during chemical reactions).
Metals (like iron, copper), minerals (like quartz, diamond), ice, wood, and plastics are common solids, and glass.
Solids find extensive use in construction (building materials), manufacturing (machinery parts), electronics (semiconductor materials), and daily objects (furniture, utensils).

Liquids:
In liquids, particles are close together but can move past each other. They have weaker intermolecular forces compared to solids. Liquids take the shape of their container. They have a fixed volume that remains constant. Liquids flow and can be poured. Liquids can be compressed slightly compared to gases.
Liquids are formed when solids melt or when gases condense. They can also be created through chemical reactions that produce liquid products.
Water, oil, milk, and alcohol are common liquids.
Liquids are crucial in industries such as food and beverage (processing and packaging), pharmaceuticals (drug formulations), automotive (engine lubricants), and cosmetics (lotions, creams).

Gases
Gas particles are widely spaced and move freely. They have weak intermolecular forces and no fixed arrangement. Gases take the shape of their container. They expand to fill the available space. Gases can be compressed significantly under pressure. Gases mix readily with each other. Gases are formed when substances vaporize (evaporate from liquids), sublimate (turn from solids directly into gases), or when gases are released during chemical reactions. Oxygen, nitrogen, hydrogen, and carbon dioxide are common gases.
Gases have diverse uses, including in energy production (natural gas, hydrogen fuel), healthcare (medical gases like oxygen), manufacturing (industrial gases for welding and cutting), and refrigeration (cooling gases like Freon).
In liquids, particles are closely packed but not in a fixed position, allowing them to move freely. Liquids take the shape of their container but have a definite volume.
Water, oil, milk, and alcohol are the common liquids.
In gases, particles are far apart and move rapidly in all directions. Gases do not have a definite shape or volume and expand to fill their container.
Examples: Oxygen, nitrogen, carbon dioxide, and steam.

Plasma:
Plasma consists of ionized particles positively charged ions and free electrons due to high energy levels. Plasma conducts electricity and responds to magnetic fields. The presence of ions and free electrons distinguishes plasma from gases. Plasma is often at high temperatures.

Plasma is formed when gases are heated to extremely high temperatures or subjected to strong electromagnetic fields, causing ionization of particles. Examples: Lightning, auroras, stars (like the sun), and fluorescent lights, neon signs, and plasma TVs are examples of natural and artificial plasmas.
Plasma finds applications in technologies like plasma cutting and welding, fluorescent lighting, plasma TVs, semiconductor manufacturing, and experimental fusion reactors.
Plasma is a state of matter similar to gas but with ionized particles, meaning the electrons are separated from atoms. This creates a mixture of positively charged ions and free electrons. Plasma is electrically conductive and responds to magnetic fields.

The nature of plasma and why it is described as the fourth state of matter

Plasma is often referred to as the fourth state of matter because it has distinct properties that set it apart from solids, liquids, and gases:
Plasma is created when a gas is energized to the point where electrons are stripped away from atoms, resulting in a soup of free electrons and positively charged ions. Unlike gases, plasma is a good conductor of electricity due to the presence of free-moving charged particles. Plasma can be influenced by magnetic fields, which can cause it to move or change shape. Plasma is the most common state of matter in the universe, found in stars, including our Sun, and interstellar space. Plasma has much higher energy levels than the other states of matter, which is why it requires significant energy input (such as heat or electrical discharge) to form.

KINETIC THEORY

The kinetic theory of matter is a fundamental concept in physics and chemistry that helps explain the behavior of gases, liquids, and solids based on the movement and interactions of their constituent particles.
According to the kinetic theory, all matter is made up of tiny particles (atoms, molecules, or ions) that are in constant motion. The particles in a substance are constantly moving and colliding with each other and the walls of their container.

Assumptions of the Kinetic Theory:

The kinetic theory makes several assumptions about the behavior of particles in matter:
Particles are in constant, random motion. Particles possess kinetic energy due to their motion. Collisions between particles are elastic, meaning energy is conserved during collisions. The average kinetic energy of particles is directly proportional to temperature (Kelvin scale).

Particle theory to explain states of matter

In gases, particles are widely spaced and move freely. They have high kinetic energy and are constantly moving in random directions. Gas particles collide with each other and the walls of the container, creating pressure.
In liquids, particles are closer together compared to gases. They have moderate kinetic energy and move past each other, allowing liquids to flow. Liquid particles also exhibit random motion but with less freedom compared to gases.
In solids, particles are tightly packed and vibrate in fixed positions. They have low kinetic energy and limited movement. However, solid particles still vibrate and can transmit vibrations (heat) through the substance.

Changes of State of Matter (Water and Ice)
When water and ice undergo changes in their state of matter due to heating and cooling, they demonstrate the fundamental principles of phase transitions. These processes include melting, boiling, condensing, and freezing. Understanding these transitions, helps explain the energy changes involved, specifically why heat is absorbed or released.

Melting: Ice to Water
Melting occurs when solid ice is heated, causing it to change into liquid water.

Molecular Explanation:
Ice is a solid where water molecules are arranged in a fixed, crystalline structure, held together by strong hydrogen bonds. As heat is added to ice, the energy causes the water molecules to vibrate more vigorously. When the temperature reaches 0°C (32°F), the vibrations are strong enough to break some of the hydrogen bonds, allowing the molecules to move more freely. This marks the transition from solid to liquid.

Energy Involvement:
Heat Absorption: During melting, ice absorbs heat from the surroundings. This energy is used to break the intermolecular bonds between water molecules, rather than increasing the temperature. This absorbed energy is known as the latent heat of fusion. The temperature of the substance remains constant at 0°C until all the ice has melted, after which the temperature of the liquid water begins to rise.

Boiling: Water to Steam
Boiling occurs when liquid water is heated to its boiling point, turning it into steam (water vapor).

Molecular Explanation:
In liquid water, molecules are close together but can move around each other freely. As heat is added, the molecules move faster, increasing the kinetic energy of the water. When the temperature reaches 100°C (212°F) at standard atmospheric pressure, the energy is sufficient to overcome the intermolecular forces completely, allowing the molecules to escape into the air as steam.

Energy Involvement:
Heat Absorption: During boiling, water absorbs a significant amount of heat, which is used to break the bonds that hold the molecules in the liquid state. This energy is known as the latent heat of vaporization. Like melting, the temperature remains constant at 100°C during the phase change until all the water has boiled off.

Condensation: Steam to Water
Condensation is the reverse of boiling, where steam (water vapor) cools down and changes back into liquid water.

Molecular Explanation:
As steam cools, the kinetic energy of the water molecules decreases. At a certain point, the molecules slow down enough that the intermolecular forces can pull them back together, forming liquid water. This occurs at the condensation point, which is the same temperature as the boiling point (100°C under standard conditions).

Energy Involvement:
During condensation, steam releases the latent heat of vaporization to the surroundings. This released energy is the same amount that was absorbed during boiling. The temperature remains constant during condensation until all the steam has converted back into liquid water.

Freezing: Water to Ice
Freezing occurs when liquid water is cooled and changes into solid ice.
Molecular Explanation:
As liquid water-cools, the molecules lose kinetic energy and move more slowly.
At 0°C, the water molecules begin to arrange themselves into a crystalline structure, forming ice. The hydrogen bonds that were partially broken during melting are reformed, holding the molecules in a fixed position.
Energy Involvement:
During freezing, water releases the latent heat of fusion, the same energy that was absorbed during melting. This energy is released into the surroundings as the water molecules settle into the solid structure. The temperature remains constant at 0°C during the phase change until all the water has frozen.

Why heat is taken in and given out during phase changes
Melting and Boiling (Heat Absorption):
Boiling: This is the process by which a liquid when heated changes to the gaseous state at a fixed temperature e.g. pure water at 100^0c changes to vapour by the process of boiling. There is no change in temperature at boiling point because the heat supplied is used to weaken cohesive forces of attraction of molecules and the rest is converted to kinetic form of energy. When a substance melts or boils, energy is required to break the intermolecular bonds that hold the particles in a solid or liquid state. This energy does not increase the temperature but is instead used to change the state of the substance. This is why heat is absorbed during melting and boiling.
Condensing and Freezing (Heat Release):
When a substance condenses or freezes, the intermolecular bonds are reformed. The energy that was absorbed during melting or boiling is now released back into the surroundings. This release of energy explains why heat is given out during condensation and freezing.

Importance of Changes of State in Everyday Life
Changes of state such as melting, freezing, condensation, and evaporation are essential in many everyday processes. They play crucial roles in maintaining life, influencing weather patterns, and supporting various practical activities.
Control of Body Temperature in Mammals (Sweating and Evaporation)
Mammals, including humans, rely on the evaporation of sweat to regulate body temperature. When the body overheats, sweat glands produce sweat, which is mostly water. As the sweat evaporates from the skin's surface, it absorbs heat from the body, cooling it down. This process is crucial for maintaining a stable internal temperature, especially in hot environments or during physical exertion.
Breathing and Heat Exchange*:*
Mammals also lose heat through the process of respiration. When air is exhaled, it often carries moisture from the lungs. The evaporation of this moisture helps cool the body. The balance between heat production (through metabolism) and heat loss (through evaporation and radiation) is vital for homeostasis.

Rain and the Water Cycle
Evaporation: The water cycle is driven by changes in the state of water. The sun's heat causes water from oceans, lakes, and rivers to evaporate, turning it into water vapor (gas) that rises into the atmosphere.

Condensation: As the water vapor rises and cools, it condenses into tiny droplets, forming clouds. This change of state from gas to liquid is crucial in cloud formation.
Precipitation: When the droplets in clouds combine and grow large enough, they fall to the Earth as precipitation (rain, snow, sleet, or hail). This process returns water to the surface, replenishing water bodies and supporting life on land.

Freezing and Melting in the Water Cycle:
In colder regions, precipitation can fall as snow or ice. This frozen water eventually melts during warmer periods, feeding rivers and lakes, contributing to the continuous cycle of water.
Cooling Drinks with Ice
Melting Ice: Adding ice to a drink cools it down through the process of melting. As the ice absorbs heat from the drink, it changes from a solid to a liquid, lowering the temperature of the drink. The melting process requires energy, known as the latent heat of fusion, which is absorbed from the drink, thus cooling it effectively.
Practical importance:
This is a practical application of phase change that people use daily, especially in warm weather, to keep beverages at a refreshing temperature.
Making Ice Cream
Freezing: The process of making ice cream involves freezing a mixture of cream, sugar, and flavorings. As the liquid mixture cools, it undergoes a phase change from liquid to solid. To achieve the right texture, ice cream is churned during freezing to prevent the formation of large ice crystals. This results in a smooth, creamy consistency.
Use of Salt in Ice Cream Making: Often, salt is added to ice surrounding the ice cream mixture to lower the freezing point of water. This allows the ice cream mixture to freeze at a lower temperature, speeding up the process and improving texture.
Importance: Understanding the freezing process is crucial in producing ice cream with the desired consistency and flavor, making it a popular treat worldwide.

Project Work (Making candles)

Required materials

- Candle wax
- Thick thread
- Manila paper
- Cutter
- Glue
- Heat source
- Aluminum pan
- Plastic cup
- Flat surface

What to do

(1) Cut the manila papers and fold them into small cylindrical molds using glue.
(2) Cut pieces of threads slightly longer than the length of the molds you have made.
(3) Place the candle wax in the aluminum pan and warm it until it melts.
(4) Hold a thread along the axis of the mold and carefully pour the molten wax up to about 2 cm below the brim of the wax molds.
(5) Allow the set up time to cool and solidify to make a candle.
(6) Repeat step 4 and 5 for the other remaining molds

Activity (Understanding importance of changes of states of matter)

(1) Apart from candle making and ice cream making. Explain any other activities that make use of changes of state of matter.

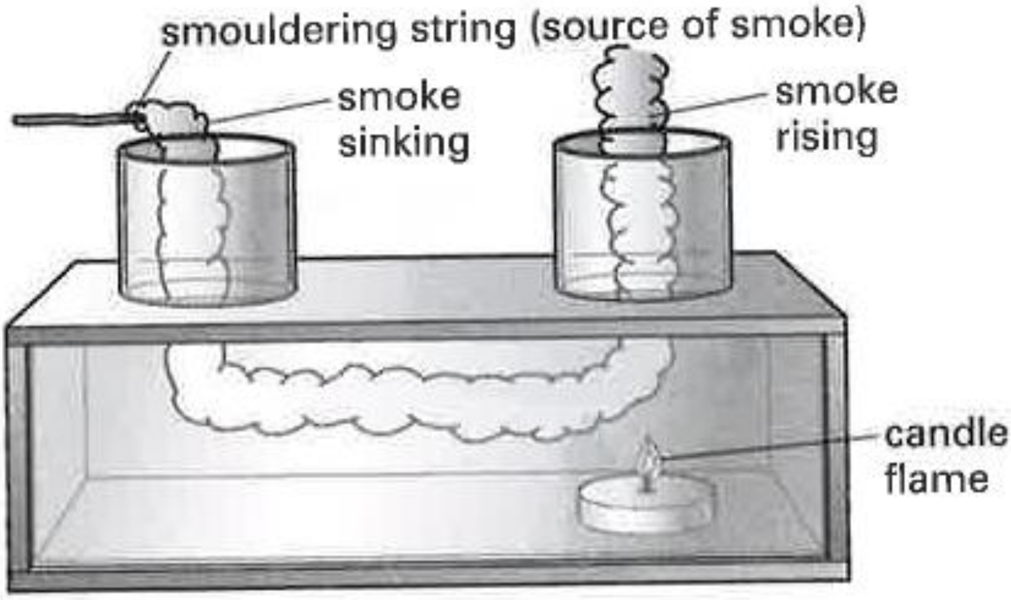
(2) Given clean water and a freezer, how can you make use of the changes of the states of matter on a hot day to earn some income?

Brownian motion

Brownian motion is the random movement of particles suspended in a fluid (liquid or gas) as they collide with the fast-moving molecules of the fluid. Brownian motion is commonly referred to as Brownian movement. This motion is a result of the collisions of the particles with other fast-moving particles in the fluid.

It is a direct observation of the kinetic theory of matter. The random motion is caused by the uneven and continuous bombardment of the suspended particles by the molecules of the surrounding fluid, which are in constant motion. Brownian motion provided evidence for the existence of atoms and molecules and supported the kinetic theory of matter, which states that matter is made up of small particles in constant motion.

Brownian motion experiment



When smoke particles are suspended in air and observed through a microscope. They seem to be in a state of continuous random motion. The smoke particles are seen as bright specks moving in continuous random motion. The bright specks are due to collision between smoke particles and gas molecules. The random motion is due to smoke particles colliding with air molecules, which were moving randomly. When the temperature of the glass cell is increased the random motion increases (smoke particles are seen to move faster), showing that increase in temperature increase the kinetic energy of molecules.
Brownian motion is fundamental to understanding processes such as diffusion, where particles spread from areas of higher concentration to lower concentration, and is used in various scientific fields to study particle dynamics and fluid behavior.

Causes of Brownian motion

The size of the particles is inversely proportional to the speed of the motion, i.e. Small particles exhibit faster movements. This is because the transfer of momentum is inversely proportional to the mass of the particles. Lighter particles obtain greater speeds from collisions. The speed of the Brownian motion is inversely proportional to the viscosity of the fluid. The lower the viscosity of the fluid, the faster the Brownian movement. Viscosity is a quantity that expresses the magnitude of the internal friction in a liquid. It is the measure of the fluid's resistance to flow.

Effects of Brownian motion

Brownian movement causes the particles in a fluid to be in constant motion.
This prevents particles from settling down, leading to the stability of colloidal solutions. A true solution can be distinguished from a colloid with the help of this motion. Albert Einstein's paper on Brownian motion was vital evidence on the existence of atoms and molecules. The kinetic theory of gases, which explains the pressure, temperature, and volume of gases, is based on the Brownian motion model of particles.

Diffusion

Diffusion is the process by which particles (such as molecules or ions) spread out from an area of high concentration to an area of low concentration. This movement occurs until the particles are evenly distributed, reaching a state of equilibrium.

Diffusion is a fundamental concept in chemistry, physics, and biology, describing how substances move within liquids, gases, and even across cell membranes.
Diffusion occurs down a concentration gradient, which means particles move from a region where they are more concentrated to a region where they are less concentrated. The steeper the concentration gradient (the greater the difference in concentration between the two areas), the faster the rate of diffusion.
Particles in liquids and gases are in constant, random motion due to their kinetic energy. This random movement is what drives diffusion, as particles naturally spread out to occupy all available space.
Diffusion continues until there is no net movement of particles, meaning the concentration of particles is the same throughout the space. At this point, dynamic equilibrium is achieved, where particles continue to move, but there is no overall change in concentration.
Diffusion in Gases: When you open a bottle of perfume, the scent molecules diffuse through the air. Initially, the concentration of perfume molecules is high near the bottle, but they gradually spread out and can be smelled throughout the room.
Diffusion in Liquids**:** If you drop a dye into a glass of water, the dye molecules will diffuse throughout the water until the color is evenly distributed. The dye moves from an area of high concentration (where it was dropped) to areas of lower concentration.
Biological Diffusion**:** In living organisms, diffusion is crucial for processes such as gas exchange in the lungs, where oxygen diffuses from the alveoli (where its concentration is high) into the blood (where its concentration is low), while carbon dioxide diffuses in the opposite direction.
Importance of Diffusion
Diffusion is vital for transporting substances within cells, including nutrients, gases, and waste products. Diffusion helps maintain homeostasis in organisms by ensuring that essential molecules like oxygen and glucose are evenly distributed where needed.
Diffusion is utilized in various industries, such as in the purification of gases, separation processes, and in creating concentration gradients for chemical reactions.
In summary, diffusion is a passive, natural process driven by the random motion of particles, allowing substances to move from areas of high concentration to areas of low concentration until they are evenly distributed. This process is essential in both natural and industrial systems, playing a key role in everything from cellular function to the distribution of scents in a room.
Demonstration of Diffusion in Gases;
Two Gas jars, one full of nitrogen dioxide / bromine and the other gas full of air.
When the gas cover is removed, and the gases mix up, the whole become filled with the brown gas (Nitrogen dioxide). The lighter gas diffuses faster than the heavier gas.

Activity (Investigating diffusion in gases)

Required materials
- Perfume
- Classroom
- Fellow class members

What to do
(1) Spray the perfume in one corner of the classroom and ask your classmates to smell it.
(2) What is their response and why is this so?

Demonstration of diffusion in liquids:
Activity (Investigating diffusion in liquids)
What you need
- Copper (II) sulphate crystal or potassium permanganate.
- 100 ml beaker
- Water

What to do.
(1) In groups, design a procedure you can follow to investigate diffusion in liquids.

(2) Following the procedure you have designed , carry out an experiment to investigate diffusion in liquids
(3) Record your observation and findings and present them to the class.

Factors that affect the rate of diffusion in fluids
Diffusion is the process by which particles spread from areas of high concentration to areas of low concentration, occurring in both liquids and gases. The rate of diffusion in fluids is influenced by several factors:
Temperature: Higher temperatures increase the kinetic energy of particles, causing them to move more rapidly. This increased movement accelerates the rate of diffusion. In contrast, at lower temperatures, particles move more slowly, and the rate of diffusion decreases.
Concentration Gradient: The concentration gradient is the difference in concentration between two regions. The greater the concentration difference, the faster the rate of diffusion. Diffusion occurs more rapidly when there is a steep concentration gradient, as particles move quickly to balance concentrations.

Molecular Size: Smaller molecules diffuse faster than larger molecules because they encounter less resistance and can move more easily through the fluid. Larger molecules move more slowly, reducing the rate of diffusion.
Medium of Diffusion: The rate of diffusion is also affected by whether the medium is a liquid or a gas. Gases typically allow faster diffusion due to the greater distance between particles, which leads to fewer collisions.
In liquids, particles are closer together, leading to more frequent collisions and slower diffusion.
Viscosity of the Fluid: Viscosity refers to the "thickness" or resistance to flow in a fluid. Higher viscosity fluids (e.g., honey) slow down the diffusion process because particles move more slowly through the dense medium. Lower viscosity fluids (e.g., water) allow for faster diffusion because particles can move more freely.
Nature of the Diffusing Substance: The chemical nature of the diffusing substance can also impact the rate of diffusion. For instance, substances that are more soluble in the fluid will diffuse faster. Polar substances may diffuse more slowly in non-polar solvents and vice versa.
Surface Area: The rate of diffusion increases with the surface area over which diffusion can occur. Larger surface areas provide more space for particles to move and spread out.

Comparison of Diffusion in Liquids and Gases
Speed of Diffusion:
Gases: Diffusion occurs much faster in gases than in liquids. This is because gas particles are further apart, with more kinetic energy and fewer collisions between particles, allowing them to spread quickly.
Liquids: In liquids, particles are closer together and move more slowly due to intermolecular forces, leading to slower diffusion rates.
Molecular Interaction:
Gases: In gases, the interaction between molecules is minimal because the particles are far apart, leading to a less frequent but faster spread of particles.
Liquids: In liquids, molecules interact more frequently due to closer proximity, which hinders the free movement of particles and slows down diffusion.
Density and Medium Resistance:
Gases: The lower density of gases means there is less resistance to the movement of particles, which facilitates faster diffusion.
Liquids: The higher density and viscosity of liquids create more resistance, slowing down the diffusion process.

Linking diffusion to biological processes: Transpiration and Osmosis
Transpiration:
Transpiration is the process by which water vapor diffuses from plant leaves into the atmosphere through stomata.
The rate of transpiration depends on factors similar to diffusion, such as temperature, humidity, and the concentration gradient between the inside of the leaf and the surrounding air.
In this process, water molecules move from areas of high concentration inside the leaf (where water is abundant) to low concentration outside the leaf (in the air), driven by diffusion.

Osmosis:
Osmosis is a special type of diffusion involving the movement of water molecules across a semi-permeable membrane from an area of lower solute concentration to an area of higher solute concentration.
In biological systems, osmosis is crucial for maintaining cell turgor pressure, nutrient absorption, and waste removal. For example, in plant roots, water diffuse into root cells via osmosis because the soil has a higher water potential (lower solute concentration) compared to the inside of the root cells (higher solute concentration).
Diffusion is a fundamental process that is faster in gases than in liquids due to differences in particle movement and density. Temperature, concentration gradients, molecular size, viscosity, and the nature of the diffusing substance all influence the rate of diffusion in fluids. In biological systems, diffusion plays a critical role in processes like transpiration in plants and osmosis in both plants and animals, which are vital for maintaining homeostasis and supporting life functions.
From the observations made in the above experiment, the movement of the colour from one region to another is what we call **diffusion**. Therefore diffusion is the movement of a substance from an area of high concentration to an area of low concentration.
Diffusion occurs in all states of matter. It is faster in gases than in liquids and least in solids.

Factors affecting the rate of diffusion

Activity (Investigating factors that affect diffusion)

Required materials

- Potassium permanganate crystals of different sizes
- Three glass beakers
- Water, Straw or tube
- Measuring cylinder
- Source of heat, Tripod stand and wire mesh

Precautions

- Be careful with fire to avoid burns
- Handle the apparatus with care to avoid damages.

What to do

(1) Label the three beakers as A, B and C.
(2) Pour equal volumes of water in each of the beakers. Allow the water to settle.
(3) In beaker A, drop some small-sized crystals of potassium permanganate to the bottom of the beaker using a straw or tube.
(4) In beaker B, drop the bigger-sized crystals of potassium permanganate.
(5) In beaker C, drop the small-sized crystals.
(6) Allow beaker A and B to stand for about 45 minutes without disturbance. During the 45 minutes, place beaker C and its contents on fire.
(7) Record the observations you make about all the three beakers. What conclusions can you draw from your observations?

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Research assignment (use library or internet)

Research and write a summary about the factors that affect the rate of diffusion and explain how they affect diffusion.

Activity of integration

As the Ugandan government priotises science education by increasing salaries for science teachers, a certain population feels the proposal unfair.

Your school science club has decided to write articles enlightening the society about the importance of science in the society, using your knowledge of states of matter, write an article educating the above group of people about the importance of science in society.

End of chapter assignment

1. Wet clothes are put on a washing line to dry. The water in the clothes turns into water vapour in the air as the clothes dry.

a) Name the change as water turns into water vapour.

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d) Rain forms from water vapour in the air. Name this change.

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e) The clothes dry much faster on a sunny day, explain why in terms of particles.

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f) Some substances can change directly from a solid to a gas, research the name of this process. Can you find an example of a substance that behaves like this?

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2. Isaac first filled one bowl with cold water, and another with boiled hot water. Then he just left them to settle for 5-10 minutes.
Then he added just a little food colouring in each bowl in a nice controlled way.
Perhaps by dipping a handle of a teaspoon into the food colouring and then just touch the surface of each bowl of water with it.

(a) State what was observed in the above experiment.

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(b) Explain your observation.

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(c) Name any two adjustments you can make so that the experiment takes place faster.

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REVISION SCENARIO QUESTIONS

1. During the visitation at your school, parents and guardians flooded the school compound and as part of school way of promoting the school to the outside community you are of the few students selected to show the parents around the school laboratory. Whereas in the laboratory many apparatuses were organized to be displayed to the parents and guardians who were eagerly waiting to see how well their learners have attained knowledge and skills while at school. You have been selected as one of the few students to guide parents and guardians through laboratory tour. Organize the speech you are going to present to parents about the physics laboratory and don't forget to inform them of the rules and regulations they must abide by as they enter the laboratory for the tour. As the second part of your presentation, you are required to organize ten different apparatuses found in physics laboratory, write down their name and briefly explain their real-life applications.

2. a) Your father, who knows nothing about measurements, intends to buy a piece of land to relocate the entire family. Musiime, his closest friend, informs him about a rectangular plot on sale. Musiime claims that the plot measures 150ft x 100ft. As a student of Physics, advise your father on the choice of the apparatus to measure the land. Write down the steps that your father would follow in order to accurately measure area of the land clearly highlighting the necessary precautions. Calculate the area of the land in m^2. Sketch the plot to scale.
HINT; 1ft = 30.5cm.

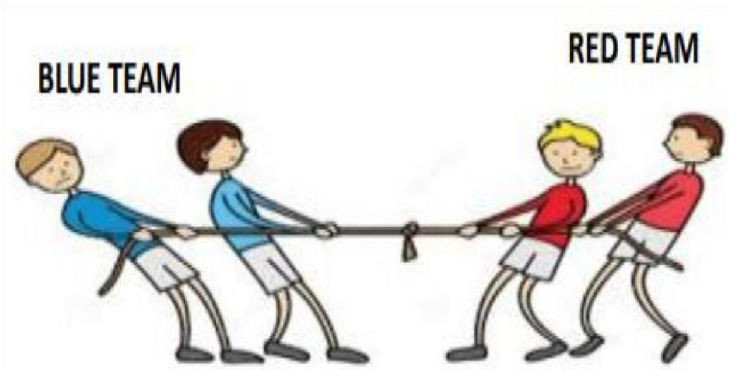
b) Bosco pours and sells water in a 20 litre jerrycan at UgShs.450 per jerrycan. One day he was paid UgShs.23400 by one of his customers who wanted to buy water. What physics term can be used to replace the sentence, "the space occupied by water in a jerry can? How much water in liters should Bosco sell to his customer? Name any other two common units used in measuring the amount of space occupied by an object, what is the relationship between mentioned units and the unit used by Bosco.

1. (a)(i) Explain the term weight and state its SI unit.
(ii) State the relationship between mass and weight.
(b) A minibus of mass 3,000 kg is authorized to carry 14 passengers, a driver and one conductor. If the average mass per person is 50 kg, determine;
(i) The weight of the minibus.
(ii) The total weight of its occupants.
(iii) The total weight of the minibus and its occupants.
(c) State three differences between mass and weight of an object.
(d) The mass of an object on earth with g =10 ms^{-2} is 250kg. If that same object is transferred to another place with g = 8.5 ms^{-2}. As a physics learner, find the change in its weight.

2. There has been an outbreak of malaria in your community and your friend is admitted in hospital. You have been delivering a warm meal; however, you are required to deliver a hot meal for her in the hospital.
Explain how you would ensure that the food you have prepared remains
Hot until you reach the hospital?

3. A certain family stays near the marram road and a school. Every day, the family receives dust raised by moving vehicles from the road and the bad smell from the school pit latrines. In the morning hours, the dust is not so much and the smell from the pit latrine is not so much either. These conditions worsen around midday on hot sunny days. The family is disgusted by these conditions. They do not know the cause of these conditions. As a Physics student, write a message to this family explaining what **causes** the above conditions and **possible ways** of solving the above problem.

4. You all have experienced a force in some way. Forces play a role in everything that we do. It may be kicking a ball, playing games and others. **BLUE** team and **RED** team are playing a tag of war. If each person in the blue team pulls the flag with a force of **200N** and each person in the red team pulls the flag with force of **100N**.

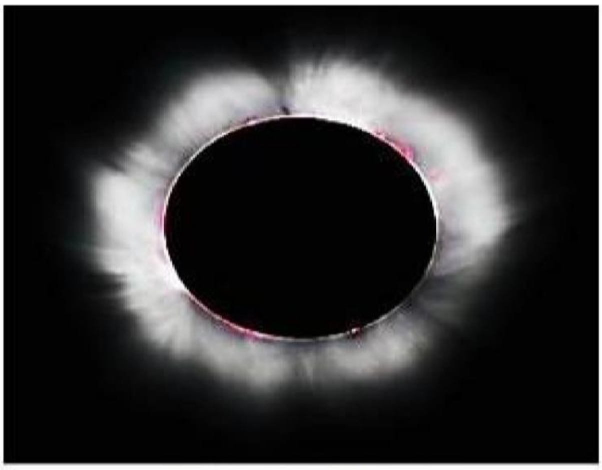


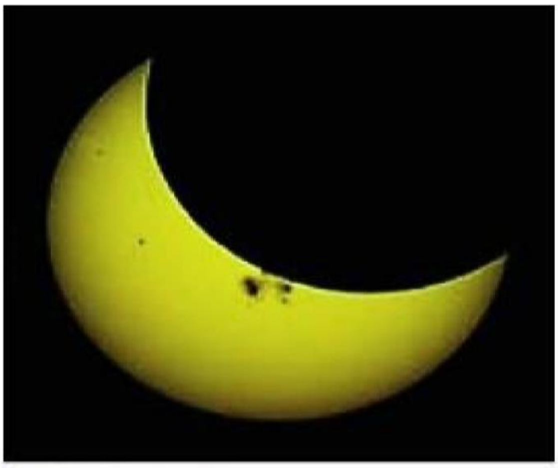
Task
By showing your working, which team do you think will win the game? In addition, how many people should be added to the losing team to match the strength of the winning team?

5. There has been an outbreak of malaria in your community and your friend is admitted in hospital. You have been delivering a warm meal; however, you are required to deliver a hot meal for her in the hospital.
Explain how you would ensure that the food you have prepared remains
Hot until you reach the hospital?

6. A certain family stays near the marram road and a school. Every day, the family receives dust raised by moving vehicles from the road and the bad smell from the school pit latrines. In the morning hours, the dust is not so much and the smell from the pit latrine is not so much either. These conditions worsen around midday on hot sunny days. The family is disgusted by these conditions. They do not know the cause of these conditions. As a Physics student, write a message to this family explaining what **causes** the above conditions and **possible ways** of solving the above problem.

7. A long time ago, solar eclipses were considered as a message from the gods since the people in that age dwelt so much in the spiritual realm than the scientific world. However, with the development of science and technology, eclipses can now easily be explained scientifically instead of spiritually. Whenever eclipses occur, many people gather out in open places to watch the beautiful view of the heavenly bodies as they align themselves in a beautiful display.

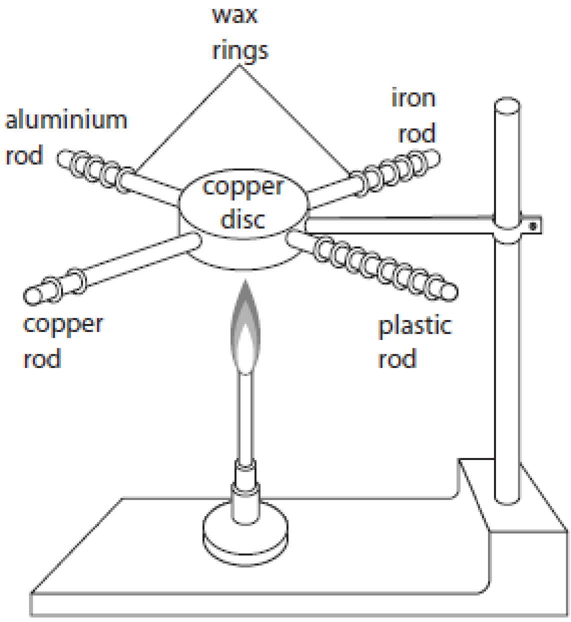

(a) Total eclipse


(b)Partial eclipse

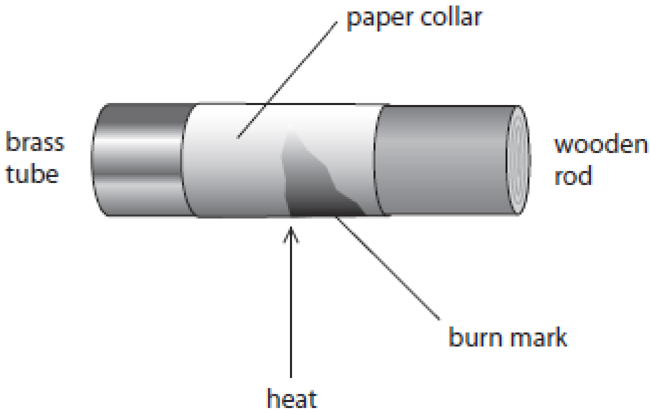
However, in most remote areas of Uganda some people still observe the eclipse directly using naked eyes not aware of the risk they are exposing their eyes to in the long run. The science club of your school has taken an initiative to always once in a while go out into the community and teach the community members about scientific facts. This year you are expected to go out during the day an eclipse is expected to occur to. You are expected to organize for the presentation about eclipses.

Task
As a student of physics and science club at the school, you are required to organize for the presentation about eclipses that you will use to address the community members on the day the eclipse is expected to occur. Conclude your presentation by recommending the best safe ways to watch an eclipse. (You may include ray diagram illustrations).

8. During a Physics lesson, a teacher performs three separate experiments to demonstrate conduction of thermal energy.
In the first experiment, he inserts four rods of different material into a copper disc and places 8 pieces of wax rings onto each rod. She then heats the copper disc with a Bunsen flame. The figure below shows the results of the experiment after the copper disc was heat for a few minutes.



In the second experiment, he places lumps of ice in a test tube, places a wire mesh on top of ice and fills the test tube with water. He then heats up the top of the test tube until the water boils.
In the third experiment, he inserts a wooden rod into the end of a brass tube and wraps the interface of the two materials with a paper collar which he then heats. The figure below shows the result of the experiment after a few minutes.



As a learner of Physics, help the students who did not attend the lesson that day to understand;
(a)What the first experiment tells us about conduction of thermal energy.
(b)The importance of the wire mesh and the observations made in the second experiment.
(c)Why the paper collar was burnt on the wooden rod but not on the brass tube.

9. A war erupted between two groups of soldiers who had camped on opposite sides of a certain hilly area surrounded by small water bodies. The soldiers communicated by throwing a stone in water to alert their colleagues of any danger ahead however the stone could alert their enemies too. One of the soldiers had **small sizable plane mirrors** and a **torn paper box** in his bag. Occasionally, the leader of one group of soldiers sent spies to peep behind the hills to see where the enemy troops were hiding but they could be captured and killed. One day as it was threatening to rain, bright colours of different kind spread out in the sky. This scared the soldiers and they took off and hid in a cave which is very dark inside as the rays from the sun couldn't reach there.

As a learner of Physics,

(a) Advise the leader of the soldiers on how they could be able to see where the enemy troops are hiding without having to climb up the hill.

(b) Help the soldiers understand the cause of the bright colours that spread out in the sky.

(c) Advise the soldiers on how they would solve the problem they faced inside the cave.

10. A mother preferred to cover her daughter using two thin blankets and one thick blanket of the same size.

Task

a) As a physics student, explain why two thin blankets are wormer than a single thick one.

b) Apart from covering her daughter with a blanket, what else can be done by another mother to keep her daughter in a worm condition and explain why it is necessary?

11. One morning, a boy woke up and observed that the dust particles in the path of light rays through a small hole in the roof of his room moved randomly. Later in the afternoon, he saw that the dust particles moved even faster. He became curious and asked his elder brother but who failed to give him a convincing explanation. He moved round the house and was amused to see that some substances had fixed volumes and shapes, others had fixed volumes but not shapes while others had neither fixed shape nor volume. Later at night as they were watching the television, his brother told him that inside the television is a state of matter called plasma.

As a learner of Physics, help the boy understand:

(a) Why the dust particles moved randomly.

(b) Why some substances have fixed shape and volume while others have fixed shape but not volume while others have neither a fixed shape nor fixed volume.

(c) What the plasma state of matter is. Your explanations may include some examples of plasma.

12. During a Physics lesson in a certain school, a teacher told the learners that when heat is supplied to matter, matter progressively changes from one state to another. Before explaining further, the bell for ending the lesson rung. The teacher couldn't explain how matter changes from one state to another but instead instructed the learners to make research. One of the learners approaches you for consultation. As a learner of Physics, help the student know how matter changes from one state to another. Your explanation should include the names of the changes, an illustrative diagram and the application of the different changes in states of matter.

13. Nelson a bright student of Countryside College mixed 200 cm^3 of a liquid of mass 80g with 100 cm^3 of another liquid of mass 160g. Assuming there was no loss of liquid during mixing and there was uniform mixing.

Task

As a physicist, help Nelson to;

i) Find the density of the mixture.

ii) Define the terms density, relative density and state their S.I units

14. In a remote village where medical facilities are distant, a child falls sick and is rushed to a nearby facility for medical attention. Unfortunately, the only thermometer available is worn out in that the scale readings are no longer visible and the thermometer appears unmarked to the medical assistant who attempts measure the temperature.

Task

As a physics learner, describe the steps you can undertake in order to make the unmarked thermometer suitable for measuring or monitoring the child's temperature.

15. Mr. Onyango and Mr. Oketcho had an argument over the width of the path that separates their land. Mr. Onyango claimed that the path is 12 feet wide. However, Mr. Oketcho claimed it was 10 feet. When the chairman intervened, he measured the path with a foot rule and found out that it was 8 feet, after that the three were in disagreement.

Task

a) Why did Mr. Onyango and Mr. Oketcho fail to agree on the width of their path?

b) Why do you think the chairman got a different measurement?

c) As a physics learner, how would you solve the disagreement?

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