FORM ONE PHYSCIS UPDATED NOTES

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For F1-F4 All Subjects Notes

INTRODUCTION TO PHYSICS

The primary school science syllabus covers topics such as matter and its properties, energy in its various forms for example heat, light, sound and their corresponding sources, machines and the way they make work easier, balancing and weighing of various shapes of objects, electricity and magnetism.These topics and more are covered in physics.

MEANING OF PHYSICS

Physics is the study of **matter** and its relation to energy. **Matter** is anything that occupies space and has weight.

The study of physics allows one to understand and enjoy other subjects
As a subject, the study of physics involves measurement of quantities and collection of data. Through experimentation and observation, hypotheses are drawn, test and laws and principles established.

Physics explain the how and why behind the following phenomena;

- Formation of rainbow.
- Occurrence eclipse.
- The falling of the objects towards the earth's surface.
- The seasonal occurrence of ocean and sea tides
- The crackling sound heard when nylon cloth is removed from the body.
- Formation of shadow and many more.

Physics gives scientific, systematic and consistent explanation based on the concepts of physics.

BRANCHES OF PHYSICS

Physics may be split into the following key areas;

- ✓ **Mechanics-** is a branch of physics that deals with the study of the motion of the bodies under the influence of forces. It is divided into two key areas namely; **kinematics** and **dynamics**. Kinematics is *the study of the motion of the bodies disregarding the forces acting on it while dynamics is the study of the motion of bodies with regard to forces acting on the body*. Under this branch, we look into details the aspects of linear, circular and oscillatory motions as well as motion of fluids.
- ✓ **Electricity and magnetism-** this branch looks at the interaction between electric fields and magnetic fields and the applications of such interactions e.g. electric motors, microphones, electric speakers etc.
- ✓ **Thermodynamics-** This branch looks at how heat as a form of energy is transformed to/from other forms of energy.
- ✓ **Geometrical optics-** This branch takes a keen look at the behavior of light in various media e.g. optic fibre, microscopes, and lenses e.t.c.
- ✓ **Waves-** It deals with the study of the propagation of energy through space. It involves properties of waves such as refraction, reflection, diffraction and polarization
- ✓ **Atomic physics-** This area of study is targeted at the behavior of particles of the nucleus and the accompanying energy changes. It involves radioactivity, nuclear fission and fusion. It is the basis of the production of nuclear energy.

RELATIONSHIP BETWEEN PHYSICS AND OTHER SUBJECTS

Physics does not only relate the remaining two science subjects but also enjoys a relationship with other subjects as well. For instance, it is the foundation of **technological development** in any country.

- Physics and history- Carbon dating is an application of radioactivity which serves as a crucial tool to history in establishing fossil age and hence past pattern of life.
- Physics and Geography- Establishment of weather patterns rely on accurate use of instruments like thermometer, wind vane and hygrometer .Heat transfer by convection explains the formation of conventional rainfall and pressure variation that determine wind patterns. All these are physics concepts.
- Physics and Home Science
- Physics and religion- Systems in the universe reveal great orderliness which can be traced back to the creator. Study of physics has come up with findings which are in total agreement with orderliness. Matter can be reduced to nothing scientifically the reverse is true which confirms that matter was created from nothing by God.
- Physics and Biology- Knowledge of lenses in physics are used in making microscope used in study of cells in biology. Physics formulae are used in calculation of magnification by microscopes.
- Physics and Chemistry- Physics has helped in explaining forces within atoms and therefore atomic structure. It is this structure of the atom that then determines the reactivity of the atom as explained in chemistry
- Physics and Mathematics- Many physics concepts are expressed mathematically. Many physics formulae are expressed mathematically.
- Physics and Technology- some areas of technology that requires knowledge of physics are:

a) Medicine; in medicine, x-rays, lasers, scanners which are applications of physics are used in diagnosis and treatment of diseases.

b) Communication; satellite communication, internet, fibre optics are applications of internet which requires strong foundation in physics.

c) Industrial application; in the area of defense, physics has many applications e.g. war planes, LGB (laser-guided bombs) which has high level accuracy.

In entrainment industry, knowledge of physics has use in mixing various colours to bring out the desirable stage effects. Is application of science to solve problems in everyday situation most forms of technology are due to Physics e.g. Information and Technology, Computer Science, Mobile Phones, building technology, automotive technology.

CAREER OPPORTUNITIES IN PHYSICS

The study of Physics can open up many avenues of professions including engineering, degree, diploma or certificate courses.

A physics student will have the following opportunities in the following areas;

- Bachelor of Architecture.
- Bachelor of pharmacy.
- Bachelor of medicine.
- Bachelor of dental surgery.
- Bachelor of science(nursing)
- Bachelor of education science(physics)
- Bachelor of science(Electrical and electronic Engineering)

❖ Bachelor of Veterinary Medicine.

At college level, some of the courses are offered.
❖ Diploma in building and construction.
❖ Diploma in mechanical Engineering.
❖ Diploma in physiotherapy.
❖ Diploma in electrical Engineering.
❖ Diploma in computer science.

BASIC LABORATORY RULES

LABORATORY- This is a room containing facilities, apparatus and equipment that aid the investigative study of physics

BASIC LABORATORY RULES

1) Proper dressing
2) Note the location of electricity switches, fire-fighting equipments, First aid kit, gas supply and water supply taps.
3) When in the laboratory open doors and windows to let in fresh air.
4) Follow instructions given carefully.
5) No eating or drinking in the laboratory.
6) Turn off electrical switches, gas and water taps when not in use.
7) When handling electrical apparatus hands must be dry.
8) Do not plug foreign objects into electrical sockets.
9) Keep floors and working surfaces dry.
10) Clean and return all apparatus used in their correct location.
11) All equipments should not be taken out of the laboratory.
12) Wash your hands before leaving the laboratory.
13) All instructions given must be followed strictly. Never attempt anything while in doubt.
14) Windows and doors should be kept open while working in the laboratory
15) Any wastes after experiments must be disposed appropriately after use

FIRST AID MEASURES

- **CUTS** -These may result from poor handling of glass apparatus or cutting tools like razors and scalpels. In case of cuts, assistance should be sought to stop bleeding and for immediate depressing up of the wound.
- **BURNS** - Burns may result from naked flames or even splashes of concentrated acids and bases. In case of burns caused by acids or bases, quickly run cold water over the affected part as you seek help for further treatment.
- **POISONING** - This may result from inhaling poisonous fumes or actual swallowing of poisonous chemicals. Assistance should be sought immediately.
- **EYE DAMAGE** -Eyes must be safeguarded from dangerous chemicals and bits of solids. In case an irritating chemical lands in the eye, it should be washed off immediately with a lot of cold water
- **ELECTRIC SHOCK** -This may result from touching exposed wires or using faulty electrical appliances. When such an accident occurs, first put off the main switch before treating for the shock.

TOPIC 2: MEASUREMENT

Scientists from various parts of the world were giving measurements in different units and languages. Some used pounds, inches and seconds while others were using grams, centimetres and seconds. This was undesirable, especially when a comparison of results was necessary.
This made it impossible for them to compare discoveries. Consequently, scientists agreed on one international system of units to be used, the Systeme International d'Unites (International System of Units), shortened to SI units, in all languages. This system has seven basic physical quantities and units on one Universal System of units called **system international d' unites** (International system of units) **SI units** which assigned seven basic quantities as shown below.

UNIT	**Symbol of quantity**	S.I UNIT	SYMBOL OF UNIT
Length	L	metres	m
Mass	m	kilogram	kg
Time	t	seconds	s
Electric Current	I	ampere	A
Thermodynamic temperature	T	kelvin	K
Luminous Intensity		Candela	Cd
Amount of Substance		mole	mol

These quantities above cannot be obtained from any other physical quantities. Measurements are made by comparing the magnitude of a quantity with that of a given unit of that quantity. A physical quantity is a measurable aspect of matter.

Basic Physical Quantity -These are quantities that cannot be obtained by any other quantity e.g. mass, time, length.

Derived Quantity-These are quantities obtained by multiplication or division of basic physical quantities e.g. Area, Volume, Density.

LENGTH

This is the distance between two fixed points. **It is the measure of distance between two points in space.** The SI unit for length is the **metre (m).**

Other units of length include;

unit	symbol	Equivalence in metres
Kilometre	Km	1000
Hectometre	Hm	100
Decametre	Dm	10
Decimetre	dm	0.1
Centimetre	Cm	0.01
Millimetre	mm	0.001
Micrometre	μm	0.000001

MEASUREMENT OF LENGTH

Length can be estimated or measured accurately using appropriate measuring instrument. The type of instrument to be used at any time depends on two factors:

- The size of the object to be measured
- The desired accuracy

The methods used include;

a) Approximation/ Estimation
b) Accurate measuring using standard instruments

a) Estimation

This method involves comparing the object to be measured with another of standard measure. For example, the height of a tall flag post can be compared with that of a wooden rod whose length is known. Thus at any given time;

$$\frac{\textbf{Height of flag post}}{\textbf{Height of rod}} = \frac{\textbf{Length of shadow of post}}{\textbf{Length of shadow of rod}}$$

From this expression, the height of the flag post can be estimated.

Example;

Suppose the height of the rod= 1m, length of shadow of rod= 120cm and length of shadow of post= 480cm, then the height of the flag post is given by;

$$\frac{\text{Height of post, } H_p}{100\text{cm}} = \frac{480\text{cm}}{120\text{cm}}$$

$$\text{Height of post, } H_p = 100 \times 4$$
$$= 400\text{cm}$$

Also, the thickness of a sheet of paper may be estimated by taking several sheets of the paper and measuring their thickness then dividing by the number of sheets of paper;

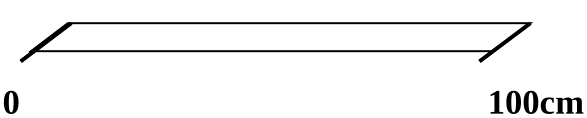
$$\text{Thickness of a sheet of paper} = \frac{\text{Thickness of n papers}}{\text{Number of papers, n}}$$

b) Using a standard measure(instruments)

This involves the use of standard measure or instruments. To measure length accurately, the instruments used are metre rules, half metre rules, tape measure, vernier calipers and micrometer screw gauges

a) Metre rule

A metre rule is marked in centimetres. It is marked 0 and 100cm at its extreme ends.

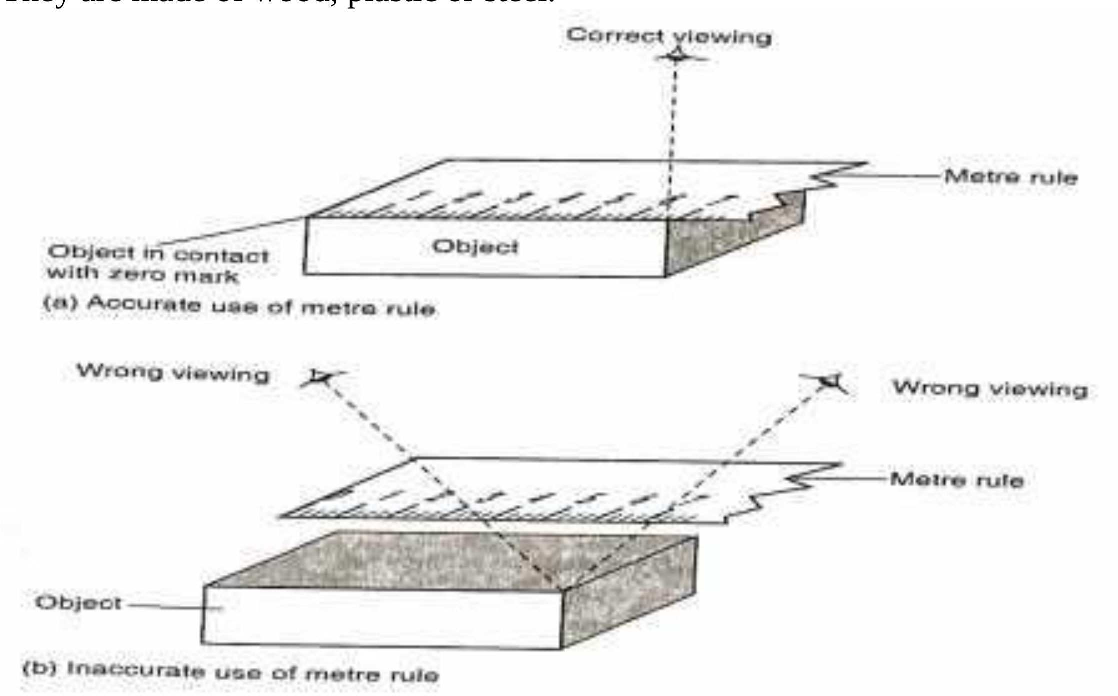


(a) a metre rule

The smallest scale division of a metre rule is 0.1cm (1mm). The smallest scale division of any instrument is known as its accuracy. Thus the accuracy of a metre rule is 0.1cm.
When using a metre, one must ensure the following:

- That the object to be measured is in contact with the metre rule.
- That one end of the object is at 0cm mark i.e. zero (0) mark to coincide with the start of the object to be measured.
- That the eye is perpendicular to the scale so as to avoid parallax error. This ensures that accurate reading is obtained.

Metre rules and half metre rules used are graduated in centimetres and millimetre.
They are made of wood, plastic or steel.

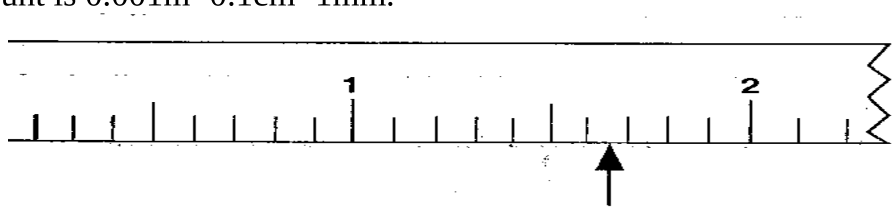


When using a ruler the following precautions should be taken;

- Never drop a metre rule
- Never use it as a walking stick
- Never use it as a cane
- Keep it in a dry place away from corrosive substances

EXAMPLE 1

The reading should be taken in terms of the least count of the metre rule. For a metre rule the least count is 0.001m=0.1cm=1mm.



The reading shown above is 0.0165m=1.65cm=16.5mm.The metre rule cannot read 4th, 2nd or 1st decimal places of metre, centimeters or millimeters respectively. This is only approximated.

EXAMPLE 2

Figure below shows a fencing post whose length is being measured using a strip of a measuring tape.

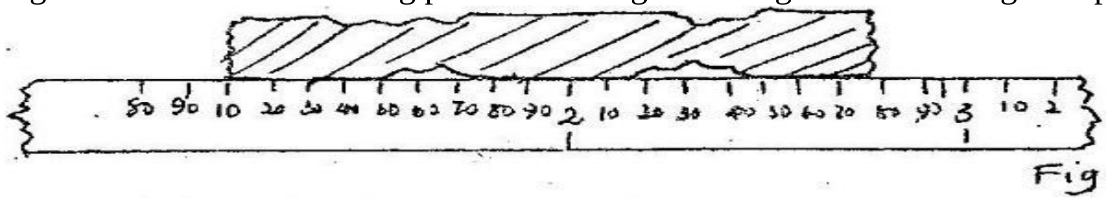


Fig. 1

(a) State the accuracy of the tape:

(b)What is the length of the post?

SOLN

(a)Accuracy of measuring tape is 10mm or o.1 cm + 5cm or o.o5m.

(b)Length of post is 1.5 m

b) Tape measure

It is graduated in millimetre (mm) or centimetre (cm)

They are three types;

i) Tailor's tape measure
ii) Carpenter's tape measure
iii) Surveyor's tape measure

NOTE: The choice of a tape measure depends on accuracy required and the size of object to measure. A tape measure can be made up of cloth, steel or flexible plastic. Always ensure that the tape measure is taut when measuring.

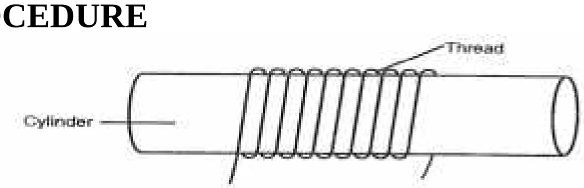
MEASUREMENT OF CURVED LENGTH

Curved length can be measured using a thread. The thread is placed along the required length and the length is found by placing the thread on a scale.

EXPERIMENT: Measuring the circumference of a cylinder using a thread.

APPARATUS: A cylinder, a thread and a metre rule

PROCEDURE



i) Wrap a thin thread say 10 times around the cylinder
ii) Mark with ink the beginning and end of turns as shown
iii) The circumference of the cylinder will be given by;

Circumference $= \frac{[\text{length of thread}]}{10}$

But; Circumference $= \pi d$ or $2\pi r$ (where r is the radius of the cylinder)

ESTIMATION OF LENGTH

EXPERIMENT: To estimate the height of a tree
APPARATUS: A metre rule, tape measure
PROCEDURE

i) Measure the length of the metre rule when upright using a tape measure followed by measuring its shadow.
ii) Measure the shadow of the tree in the school compound.

RESULTS

Height of metre rule = ...Cm
Height of shadow of metre rule=...........Cm
Height of shadow of the tree =..............Cm
Estimation of the height of the tree is given by the formula provided above.

AREA

Area is defined as the measure of surface enclosed by the boundaries of the body. Its SI Unit is the square metre (m^2). Since it is measured in metre-square (m^2), this means it's a derived quantity. Other multiples and sub-multiples of area are; cm^2, mm^2, km^2, hectares etc.
Area can also be estimated or calculated accurately.

CONVERTING

a) mm^2 to m2

$1m^2 = 1000 \times 1000$
$= 1000000\ mm^2$
$1mm^2 = \{1 \div 1000000\}$ m2 **(Divide by 1million)**
$= 0.000001\ m^2$

b) m^2 to mm^2

$1m^2 = 1000000\ mm^2$ **{multiply by 1 million}**

c) cm^2 to m^2

$1cm = 0.01m$
$1cm^2 = 0.01m \times 0.01m$
$= 0.0001m^2$ **{multiply by 0.0001}**

d) m2 to cm^2

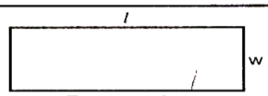
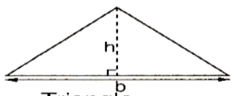
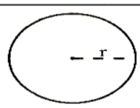
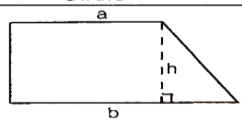
$1m = 100cm$
1m2 $= 100cm \times 100cm$
$= 10000cm^2$ **{multiply by 10000}**

EXERCISE

1) Convert 7.5m^2 to cm^2
2) Convert 940mm^2 to cm^2
3) Convert 12000mm^2 to m^2

Measurement of area (Accurate Measurement)

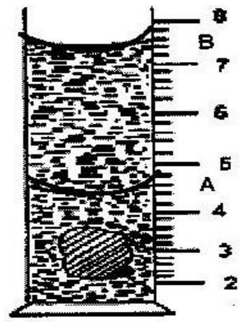
The area of regularly shaped objects can be found by applying an appropriate formula shown below;

Shape	*Area*
 Rectangle	$A = \text{length} \times \text{width}$ $= l \times w$ $= lw$
 Triangle	$A = \frac{1}{2}(\text{base} \times \text{height})$ $= \frac{1}{2} b \times h = \frac{1}{2} bh$
 Circle	$A = \pi r^2$
 Trapezium	$A = \frac{1}{2}(\text{sum of parallel sides}) \times \text{height}$ $= \frac{1}{2}(a + b)\,h$

QUESTIONS ON THE TOPIC

1. State two factors that should be controlled in manufacturing a cylindrical container of uniform thickness, which should normally be in a standing position.

2. The figure shows a measuring cylinder which contains water initially at level A. A solid mass 11g is immersed in the water, the level rises to B.

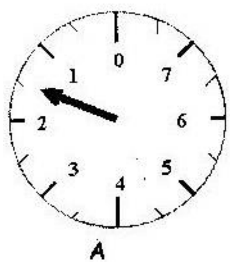


Determine the density of the solid. (Give your answer to 1 decimal point)

A butcher has a beam balance and masses 0.5 kg and 2 kg. How would he measure 1.5 kg of meat on the balance at once?

3. Determine the density in kg/m^3 of a solid whose mass is 40g and whose dimensions in cm are 30 x 4 x 3

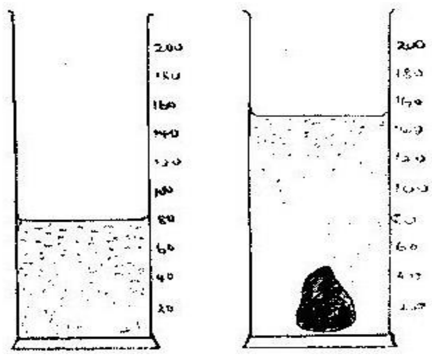
4. Record as accurately as possible the masses indicated by the pointer in figures A.



5. Figure 1 shows the reading on a burette after 55 drops of a liquid have been used.

If the initial reading was at 0cm mark, determine the volume of one drop

6. Fig. 1 shows the change in volume of water in a measuring cylinder when an irregular solid is immersed in it.



Given that the mass of the solid is 567g, determine the density of the solid in gcm^{-3}. (Give your answer correct to 2 decimal places.

7. A thin wire was wound 30 times closely over a boiling tube. The total length of the windings was found to be 9.3 mm. Calculate the radius of the wire.

8. (a) Given that a kilogram of copper contains about 10^{25} atoms and that density of copper is about $9000kg/m^3$, estimate the diameter of the copper atom?
(b) State the assumption made in (9a) above.

9. The density of concentrated Sulphuric acid is $1.8gcm^{-3}$. Calculate the volume of 3.6kg of the acid.

10. 1600 cm^3 of fresh water of density l g/cm^3 are mixed with $1400cm^3$ of seawater of density $1.25g/cm^3$. Determine the density of the mixture.

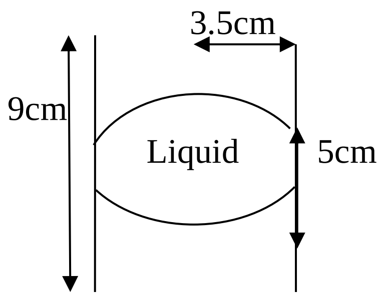
11. With the aid of a diagram, illustrate the meaning of the parallax error

12. Describe how you can measure the density of a rock which has no definite shape.

13. A shopkeeper has a scale balance and masses of 250g and 2kg. How would he measure 1.75kg of flour on this scale at once

14. A pebble of mass 50g is placed in a measuring cylinder containing some water. The reading of the water level increased from $75cm^3$ to $95cm^3$. Calculate the density of the pebble

15. The container shown below is filled to a depth of 5cm with a liquid.



(i) Using pie as 22/7, determine the volume of the liquid.

(ii) If the mass of the liquid in the container is 2.554kg, estimate the density of mercury in g/cm^3.

(iii) Calculate the mass of water that would be needed to completely fill the remaining space in the container above the liquid. (Density of water is $1g/cm^3$)

(iv) A pebble of density $9g/cm^3$ is gently dropped into the container full of water and the liquid. Describe and explain what is observed.

SOLUTIONS

1. height, base area
2. Volume of one molecule = 18/ $(6x10^{23})$ = 3x 10^{-23}cm
   X^3 = 3x 10^{-23} cm^3
   X = 3.11 x 10^{-8} cm^3
3. d= m/v=40g/ 30 x 4 x $3cm^3$ = 0.1111 g/cm^3
4. 1.5 kg
5. D= m/r $= {}^{567}/_{(150-80)}$ $= {}^{576-80}/_{70g/cm3}$
6. 2000 cm^3
7. $1.12g/cm^3$

TOPIC 3: FORCE

Force is a pull or a push or that which changes a body way of motion and distort it
Its SI unit is newtons (N)

EFFECTS OF FORCE

- It can increase the speed of a moving object or make a stationary object start moving.
- Slow down or stop a moving object.
- Change the direction of a moving object.
- Distort (change) the shape of an object.

Force is that which changes a body's state of motion or shape. Some forces are small and others are large.
Force is represented by a line with an arrow showing the direction it acts. i.e.

$$\xrightarrow[F]{\hspace{3cm}}$$

Force can be categorized in two ways. These are:

- As either a push or a pull
- As either contact or non-contact force

Contact forces are those forces between bodies which are in contact e.g. action and reaction, viscous drag, friction etc. Non-contact forces act between bodies at a distance e.g. gravitational force, magnetic force, electrostatic force etc.

TYPES OF FORCES

i) Gravitational force
ii) Tensional force
iii) Upthrust
iv) Frictional force
v) Magnetic force
vi) Centripetal force
vii) Cohesive and adhesive force
viii) Molecular force
ix) Electric force
x) Nuclear force
xi) Electrostatic force

- **GRAVITATIONAL FORCE**

This is a force of attraction between two bodies of given mass. Objects thrown from the earth's surface always falls back to the surface of the earth. This force which pulls the body towards the centre of the earth is called **Gravitational force.**

Moon and other planets also have their gravitational force to objects.

The pull of gravity on the body towards the centre is called **weight**. The weight of an object varies on different planets because of different gravitational pull.

- **TENSION FORCE**

Tension force is as a result of two opposing forces applied. The pull or compression of a string or spring at both of its ends is called **Tension**.
Compressed or stretched object will tend to regain its original shape, when the stretching or compressing force is removed .Materials that can be extended without breaking are called **elastic materials.** Such materials can be used to make a spring balance an instrument used to measure force. Other examples include; bows and catapults.

- **UPTHRUST FORCE**

The upward force acting on an object immersed in a fluid (liquid or gas) is called **upthrust force.**
An object in a vacuum will not experience upthrust.

EXAMPLE 1
An object weighs 80N in air and 60N when immersed in water. Calculate force acting on the object.

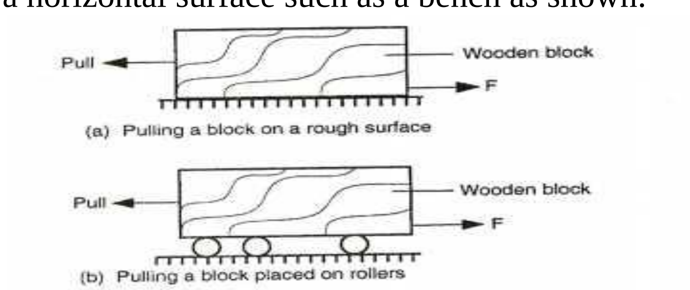
Solution
Upthrust force = weight of object in air –weight of object in the liquid
= 80 - 60
= 20N

Exercise
a) **An o**bject weighs 100N in air and 26N when immersed in water. Calculate the apparent loss weight of the object. Calculate also the mass of object in water. (1Kg=10N).
b) **2kg** blue band weighs 20N when placed in air .The apparent loss in water is 2N .Calculate the mass of blue band in water.

- **FRICTIONAL FORCE**

Frictional force is a force that opposes relative motion between two surfaces in contact.
The opposing force involving a fluid is called **viscous drag** (viscosity).This viscous drag limits the speed with which a body can move in a liquid.
Friction can be applied during walking.

EXPERIMENT: To investigate frictional force.
Apparatus: wooden block, rollers.
Procedure:
1. Put a block of wood on a horizontal surface such as a bench as shown.



2. Pull the block gradually, increasing the force.
3. Repeat the experiment, this time resting on rollers as shown above

Conclusion

The wooden block starts to move when the applied force is just greater than frictional force between the block and the surface of the bench.
Frictional force can be reduced by using rollers, oiling and smoothening.

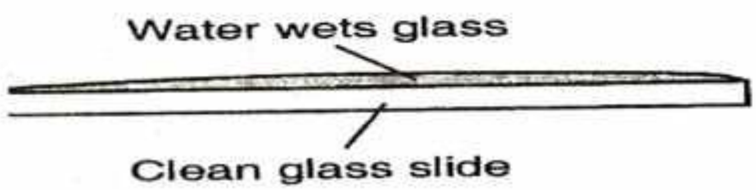
- **MAGNETIC FORCE**

Magnetic force is the force of attraction or repulsion between a magnetic material and a magnet.
A magnet has two types of poles, a north pole and a south pole. Like poles repel while unlike poles attract. Some materials are attracted by a magnet while others are not .Those that are attracted are called **magnetic materials** e.g. iron ,steel ,nickel and cobalt while those that are not attracted are called **non-magnetic materials** e.g. wood and aluminium.

- **COHESIVE AND ADHESIVE FORCES**

The force of attraction between molecules of the same kind is known as **cohesive force** e.g. A water molecule and another water molecule. The attraction between molecules of different kinds is known as **adhesive force** e.g. between water molecules and molecules of the container in which the liquid is put.

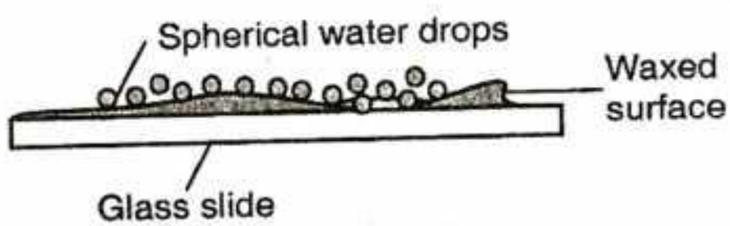
EXPERIMENT: To see the behaviour of water on different surfaces.
a. Water wets glass



Observation

Water on the glass slide spreads

b. Water forms spherical water drops on waxed surface



OBSERVATION

Small spherical balls was observed on a waxed glass

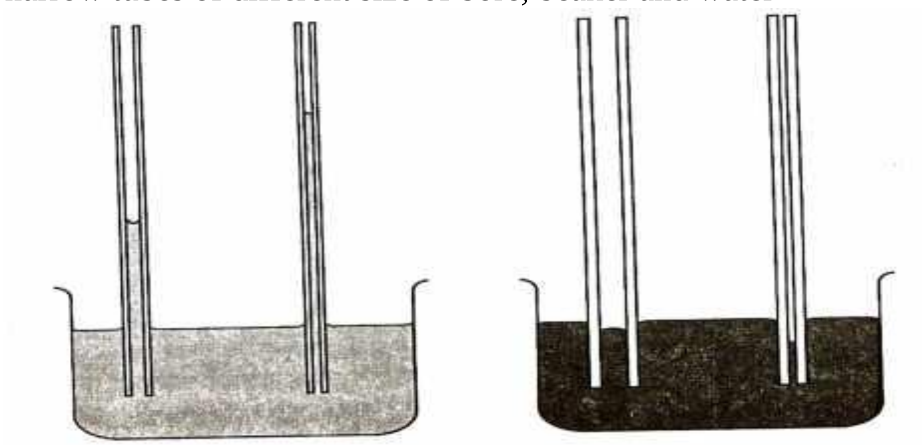
EXPLANATION

Water wets the glass surface because the adhesive forces between the water molecules and the glass molecules are greater than the cohesive forces between water molecules.

Water does not wet the waxed glass surface because the cohesive force is greater than the adhesive.
If mercury was used in the experiment it could be observed that small drops on a clean glass dish collect into spherical ball as shown below
This is due stronger cohesive forces between mercury molecules which forms small spherical drops. The adhesive force between mercury and glass makes mercury not wet glass.

N/B: Mercury is poisonous and should not be handled in ordinary laboratory.

EXPERIMENT: To demonstrate cohesive and adhesive forces of liquids on narrow tubes
APPARATUS: narrow tubes of different size of bore, beaker and water



a) Glass tubes dipped in water b) Glass tubes dipped in mercury

OBSERVATION

The level of the water inside the tubes is higher than outside the tubes. A meniscus is formed at the top of the water level and it curves upwards (concave).
The rise in the tube with a smaller bore is higher than in the tube with a larger bore.
Different liquids rise by different heights depending on the diameter of the glass tube.
When mercury is used, the level of mercury inside the tubes goes lower than that outside the tubes. The surface of the mercury will curve downwards (convex).

EXPLANATION

Adhesive forces between the water and glass is greater than cohesive forces between the water molecules, the water rises up the tube so that more water molecules can be in contact with the glass. This wets the glass. Liquids such as glycerol, kerosene and methylated spirit rise in tubes.

On the other hand, the force of cohesion with the mercury is greater than the force of adhesion between glass and mercury. The mercury sinks to enable mercury molecules to keep together.

- **SURFACE TENSION**

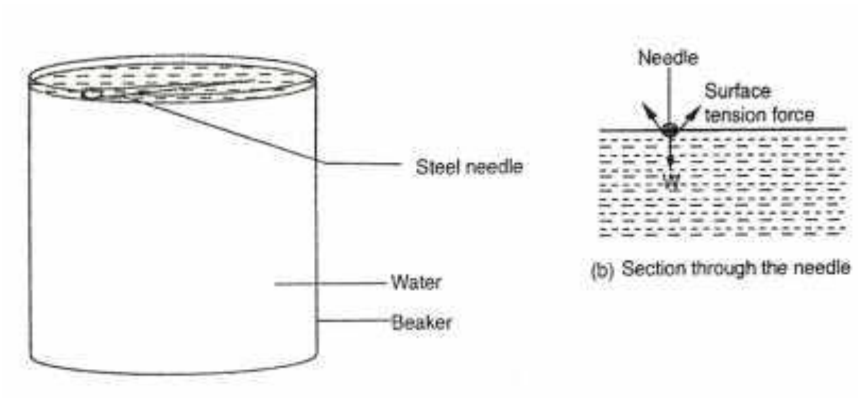
This is a force that causes the surface of a liquid to behave like a stretched plastic skin.
The force is due to the force of attraction between individual molecules in a liquid. Its due to this force that liquids form drops, water wets the surface but runs off others, some insects like pond skaters manage to rest on the surface of water without sinking, water rises up in narrow glass tubes but

mercury is pushed down to a lower level in the same tube and steel needle or razor blade floats on water even though steel is denser than water

EXPERIMENT: To investigate the behaviour of a liquid surface
APPARATUS: Beaker, water, soup solution, razor blade or steel needle.

PROCEDURE:

- Fill the beaker with clean water to the brim as shown



(a) Steel needle floating on water
(b) Section through the needle

- Place a dry steel needle or razor blade at the edge of the beaker and carefully introduce it on the surface of water. Take care not to break the surface of water. Observe what happens.

- Put a few drops of soap solution and observe what happens.
- Depress the tip of the needle into the water and observe what happens.

QUESTIONS ON THE TOPIC

1. A student was heard saying "the mass of a ball on the moon is one sixth its mass on earth". Give a reason why this statement is wrong.
2. In the study of a free fall, it is assumed that the force f acting on a given body of mass m is gravitational, given by F= mg. State two other forces that act on the same body.
3. State how a lubricant reduces friction in the bearings of moving part of a machine.
4. Distinguish between mass and weight of a body stating the units for each.
5. State with reason the purpose of the oil that circulates in a motorcar engine.
6. Name two types of forces which can act between objects without contact.
7. A house in which a cylinder containing cooking gas is kept unfortunately catches fire. The cylinder explodes. Give a reason for the explosion.
8. Give a reason why the weight of a body varies from place to place
9. State why a pin floating on water sinks when a detergent is added.
10. Fig 8 shows water drops on two surfaces. In 8 (a), the glass surface is smeared with wax while in 8 (b) the glass surface is clean.

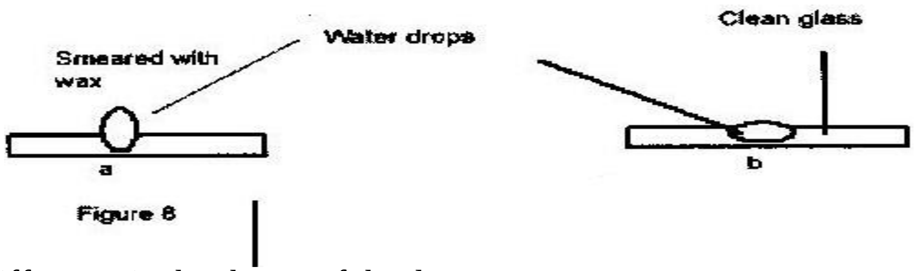
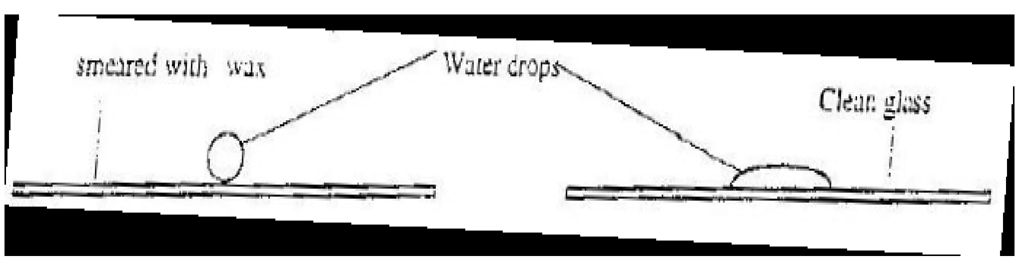


Figure 8

Explain the difference in the shapes of the drops.

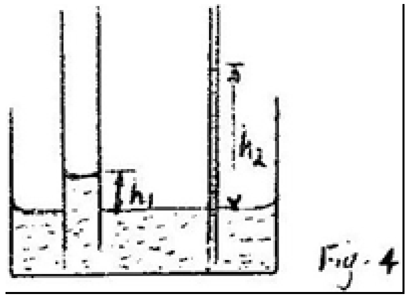
11. An astronaut is on the moon. He drops a hammer from a height of 3.2m and it takes 2.0s to hit the lunar landscape. What is the acceleration due to gravity of the moon?
12. An unloaded spring has a length of 15cm and when under a load of 24N it has a length of 12cm. What will be the load on the spring when length is 10cm?
13. Give a reason why the weight of the body varies from place to place
14. A metal pin was observed to float on the surface of pure water. However the pin sank when a few drops of soap solution were carefully added to the water. Explain his observation.
15. A bag of sugar is found to have the same weight on planet earth as an identical bag of dry sawdust on planet Jupiter. Explain why the masses of the two bags must be different.
16. Fig 4 shows water drops on two surfaces. In (a) the glass surface is smeared with wax while in (b) the glass surface is clean.

17.



Explain the difference in the shapes of the drops.

18. The diagram in figure 5 shows two glass tubes of different diameters dipped in water. Explain why h2 is greater than h1



19. Name two forces that determine the shape of liquid drop on the solid surface.

SOLUTIONS

1. The mass of the body is constant as the number of particles in a body remains constant. Mass is constant everywhere
2. Up thrust and frictional force
3. By going between two moving parts so that the parts slid on oil instead of each other.
4. - Weight is a vector quantity while mass is a scalar quantity.
   - Weight varies from place to place while mass is constant.
   - Weight is measured using a spring balance while mass is measured using beam balance.
5. To lubricate the engine/ reduce frictional force
6. Magnetic, electrostatic and gravitational.
7. Kinetic energies of molecules increase hence the pressure increases.
8. Because gravitational force varies with distance from the centre of the earth. Since weight depends on the gravitational pull, then it also varies.
9. The soap reduces the surface tension and hence the weight of pin becomes greater the surface tension.

TOPIC 4: PRESSURE

Pressure is the force acting normally (perpendicularly) per unit area. The SI unit of pressure is N/m^2 or Nm^{-2}, which is also called Pascal (Pa).
Pressure in solids depends on two main factors i.e. force and area

EXAMPLE 1

A force of 100N is applied to an area 100mm2. What is the pressure exerted on the area in Nm^{-2}.

Solution

Area; $100mm^2 = 0.0000001m^2$ and Force = 100N

Pressure = F/A
= 100 ÷ 0.0000001
= $1.0 \times 10^9 Nm^{-2}$

A man whose mass is 90kg stands on a floor.

a) If the area of contact between his feet and the floor is $0.0368m^2$, determine how much pressure he able to exert on the floor.

Pressure, P = F/A
= $900N/0.0368m^2$
= $24,456.5217N/m^2$.

b) What pressure will he exert on the floor if now he stands on one foot?

Pressure, P = 900N/ (0.0368/2)
= $48,913.0435N/m^2$

MAXIMUM AND MINIMUM PRESSURE

Maximum pressure = $\frac{\text{Force}}{\text{Minimum area}}$

Maximum Pressure P_{max} = $\frac{F}{A_{min}}$

Minimum pressure = $\frac{\text{Force}}{\text{Maximum area}}$

Minimum pressure P_{min} = F/A_{max}.

EXAMPLE 2

A block of wood measures 2cm by 3cm by 4cm and has a mass of 6 kg.

Calculate its pressure when; a) Area is minimum (maximum pressure) b) Area is maximum (minimum pressure).

Area -2 x 3 =6cm2

-2 x 4 =8cm2

-3 x 4 =12cm2

1. A min =6cm2 =0.006m2 and F =60N

P max =60/0.006 =100,000Nm^{-2}

2. A max =12cm2=0.0012m2 and f = 60 N

P_{min} = 60/0.0012 =50,000Nm^{-2}

EXERCISE

1. A block of wood measures 3m by 6m by 2m and mass 3kg. Calculate;
i) Maximum pressure
ii) Minimum pressure
2. A brick 20cm by 10cm by 5cm has a mass of 500g. Find maximum and minimum pressure. (take g = 10N/kg)
3. How much force must be applied on a blade of length 4cm and thickness 0.1mm to exert pressure of 5,000,000 Pa.?

Exercise 4.1 (no 1, 2, 3, 4, 5) KLB

PRESSURE IN LIQUIDS

Pressure in liquids depends on the following;

- Depth of the liquid
- Density of the liquid

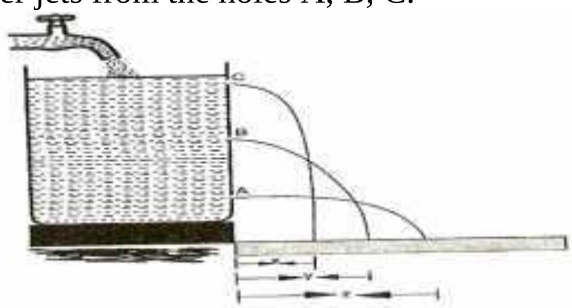
Pressure in liquids increases with depth and density.

EXPERIMENT: To show variation of pressure in liquids

APPARATUS: A tall tin, nail and water

PROCEDURE

- Using the nail, make 3 holes A, B, C of the same diameter on a vertical line of one side of the tin
- Fill the tin with water as shown below.
- Observe water jets from the holes A, B, C.



OBSERVATION

The lower hole, A, throws water farthest, followed by B and lastly by c

EXPLANATION

The pressure of water at A is greatest than pressure at B and pressure at B is greater than pressure at C. Hence, pressure increases with depth.

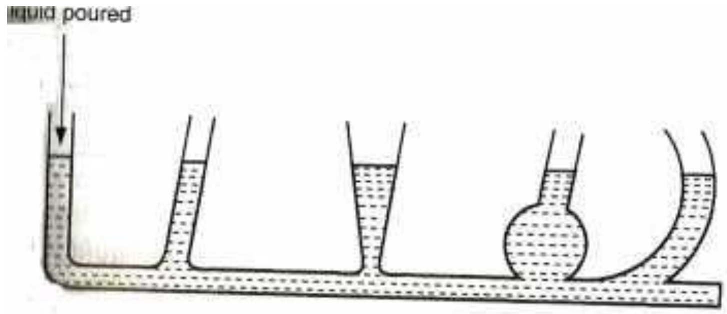
QUESTION

Explain why a diver at the bottom of the dam experiences greatest pressure

At the bottom of the dam depth is greatest and therefore the diver experiences greatest pressure due to the weight above him.

LIQUID LEVELS

When a liquid is poured into a set of connected tubes with different shapes, it flows until the level are the same in all tubes as shown

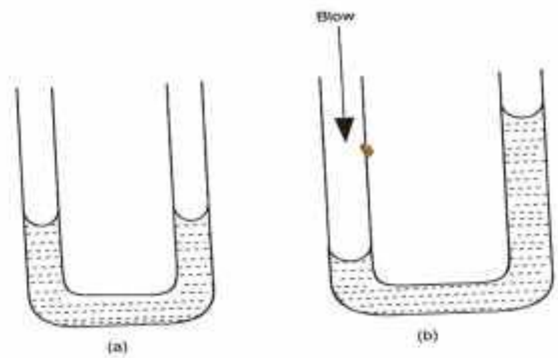


This shows that the liquid flows to find its own level.

LIQUID LEVELS IN A U-TUBE

When water is poured into a u-tube, it will flow into other arm. Water will settle in the tube with the levels on both arms being the same.

When one arm is blown into with the mouth, the level moves downwards, while on the other arm it rises. This is caused by pressure difference between the two arms as shown,



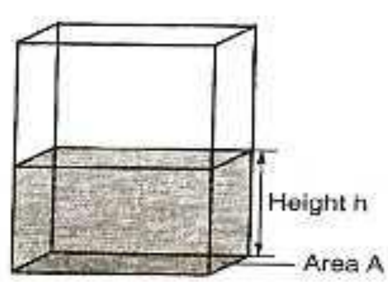
Pressure in liquids increases with depth below its surface

Pressure in a liquid at a particular depth is same in all directions.

Pressure in a liquid increases with density of the liquid.

FLUID PRESSURE FORMULA

Consider a container containing a liquid as shown below;



If A is the cross-section area of the column, h the height of the column and ρ the density of the liquid then;

Volume of the liquid = cross-section area x density

= Ah

Mass of the liquid = volume of the liquid x density

= A h ρ

Therefore, Weight of the liquid = mass x gravitational force

= A h ρ g

From definition of pressure P = force/area

$$\text{Pressure} = \frac{A\,h\,\rho\,g}{A}$$

$$= h\,\rho\,g$$

From the formula (p = h ρ g) pressure is directly proportional to;

- Height of the column
- The density of the liquid
-

NOTE: Pressure in liquids does not depend on the cross-section area of the container.

The formula is also used to determine pressure due to a gas column.

EXAMPLE 3

A diver is 10m below the surface of water in a dam. If the density of water is 1000kg/m3, determine the pressure due to the water on the diver. (Take g=10N/Kg)

Solution

Pressure = h ρ g

= (10 x 1000 x 10)

= 100,000 N/m2

EXAMPLE 4

The density of mercury is 13600Kg/m3. Determine the liquid pressure at a point 76cm below mercury level.

Solution

Pressure = hρg

= 0.76 x 13600 x 10

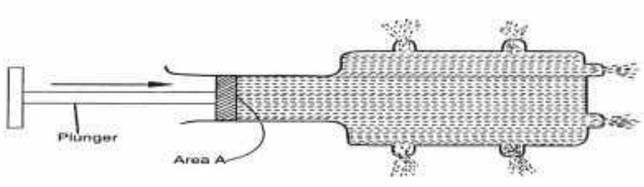
= 103,360 N/m^2

EXAMPLE 5

Calculate the pressure due to water experienced by a diver working 15m below the surface. (Take g = 10N/kg and density of sea water = 1.03g/cm^3)

TRANSMISSION OF PRESSURE IN LIQUIDS

Pressure applied at one part in a liquid is transmitted equally to all other parts of the enclosed liquid. (**Plunger)**



This is the principle of transmission of pressure in liquids called **Pascal's principle** which states that pressure applied at a given point of the liquid is transmitted uniformly or equally to all other parts of the enclosed liquid or gas.

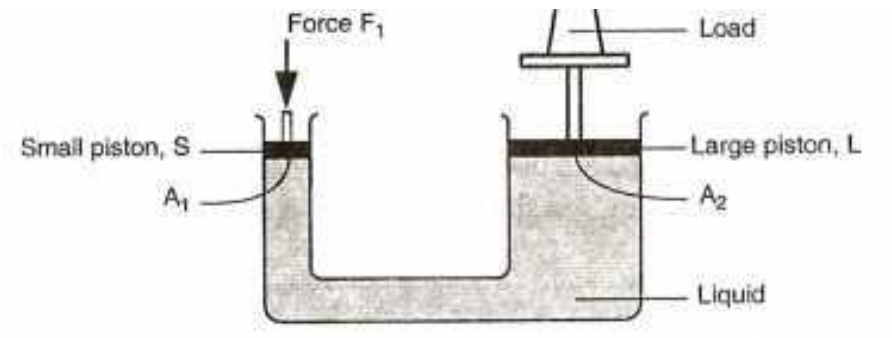
Gases may transmit pressure in a similar way when they are confined and incompressible.

HYDRAULIC MACHINES

The principle of transmission of pressure in liquids is made use in hydraulic machines where a small force applied at one point of a liquid produces a much larger force at some other point of the liquid.

a) HYDRAULIC LIFT

The hydraulic lift consists of a small piston S of cross-section A1 and a large piston L of cross-section area A_2. When a force is applied on piston S, the pressure exerted by the force is transmitted throughout the liquid to piston L.



At the smaller piston S the force applied F_1 cause a pressure P_1 at the cross section area A_1.

Therefore, Pressure $P_1 = \frac{F_1}{A_1}$

The pressure is equally transmitted throughout the liquid to the larger piston.

Thus at small piston pressure is equal to the pressure at the large piston

$$\mathbf{F_2 = P_1 \times A_2}$$

But, $P_1 = \frac{F_1}{A_1}$

$$F_2 = \frac{F_1 \times A_2}{A_1}$$

$$\frac{F_2}{F_1} = \frac{A_2}{A_1}$$

NOTE; Equation applies if pistons are at the same level

EXAMPLE 6

Find F_2 if $A_1 = 0.52m^2$, $A_2 = 10m^2$ and $F_1 = 100N$

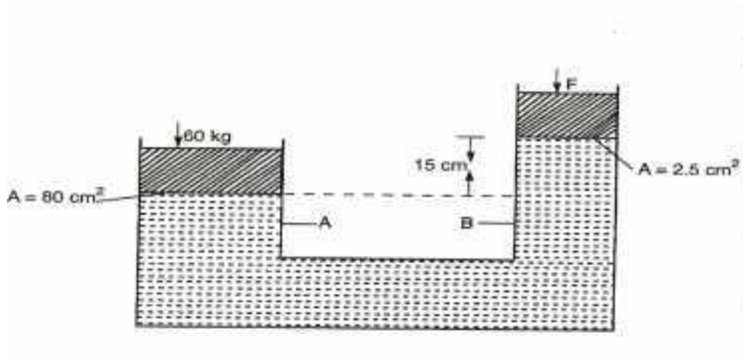
$$\mathbf{\frac{F_2}{100} = \frac{10}{0.25}}$$

$$\mathbf{F_2 = \frac{(100 \times 10)}{0.25}}$$

$$\mathbf{= 4000N}$$

EXAMPLE 7

Determine f2 in the figure below. Density of the liquid =800kg/m3 and g=10N/kg



Pressure at A, P_A = Pressure at B, P_B

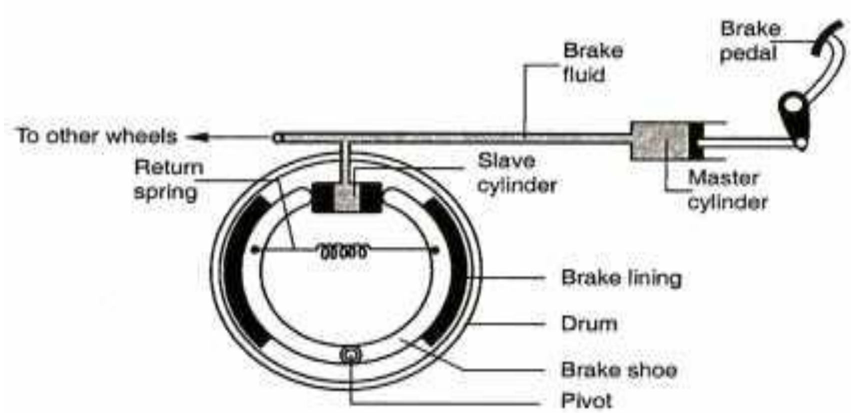
$$\frac{60 \times 10}{0.008} = \frac{F_2}{0.00025} + (0.15 \times 800 \times 10)$$

$$0.00025(7500 - 1200) = F_2$$

$$F_2 = 18.45N$$

Exercise 4.2 no.7

b) <u>HYDRAULIC BRAKE SYSTEM</u>



The force applied on the foot pedal exerts pressure on the master cylinder. The pressure is transmitted by the brake fluid to the slave cylinder. This causes the pistons of the slave cylinder to open the brake shoe and hence the brake lining presses the drum.

The rotation of the wheel is thus resisted. When the force on the foot pedal is withdrawn the return spring pulls back the brake shoe which then pushes the slave cylinder piston back.

Advantage of this system is that the pressure exerted in master cylinder is transmitted equally to all four wheel cylinders.

The liquid to be used as a brake fluid should have the following properties;

- Be compressible, to ensure that pressure exerted at one point is transmitted equally to all other parts in the liquid
- Have low freezing point and high boiling point.
- Should not corrode the parts of the brake system.

ASSIGNMENT (exercise 4.2 no 1, 2, 3,4,5,6 & 8) KLB

ATMOSPHERIC PRESSURE

Atmosphere means the air surrounding the earth. The air is bound round the earth by the earth's gravity. The atmosphere thins outwards indicating the density of air decreases with the distance from the surface of the earth

The pressure exerted on the surface of the earth by the weight of the air column is called **air pressure**

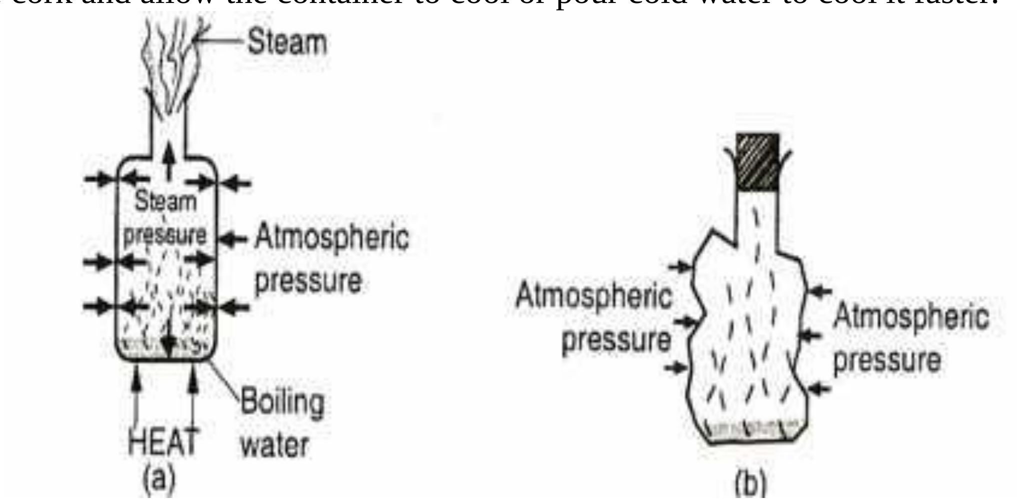
Atmospheric pressure can be demonstrated by **crushing can experiment.**

EXPERIMENT: To demonstrate the existence of the atmospheric pressure

APPARATUS: Tin container with a tight-fitting cork, water, tripod stand, Bunsen burner.

PROCEDURE

- Remove the cork from the container and pour in some little water.
- Boil the water for several minutes.
- Replace the cork and allow the container to cool or pour cold water to cool it faster.



OBSERVATION

During cooling, the container crushes in.

EXPLANATION

Steam from boiling water drives out most of the air inside the container. When heating, the steam pressure inside the container balances with atmospheric pressure outside.

On cooling the steam condenses. A partial vacuum is therefore created inside the container. Since pressure inside the container is less than the atmospheric pressure outside, the container crushes in.

NOTE: Steam inside the container condenses lowering the pressure. The outside atmospheric pressure exceeds the pressure inside the container thereby crushing it.

SOLUTIONS

1. Because of its low density

2. Atmospheric pressure is the pressure exerted on the surface of the surface of the earth by the weight of the air column

3. $h_w \varrho_w g = h_w \varrho_w g$

$\therefore h_w \varrho_w = h_a \varrho_a$

Density of alcohol $= \frac{16 \text{ cm} \times 1 \text{g/cm}^3}{20 \text{ cm}} \times 1000$

$= 800 \text{ kgm}^{-3}$

4. $P = h \varrho g$

$= \frac{90 \text{ m} \times 13600 \text{kgm}^{-3} \times 10 \text{Nkg}^{-1}}{1000}$

$= 12\ 240 \text{ Nm}^{-2}$

5. $\frac{(76 - 74)}{100} \times 13600 \times 10 = h \times 1.25 \times 10$

$H = \frac{2}{100} \times \frac{13600}{1.25}$

$= 217.6 \text{ m}$

6. Pressure due to kerosene = h kg

$= 800 \times 0.1 \times 10 = 800 \text{p.a}\surd 1$

Pressure due to water = w h w g

$= 1000 \times 0.2 \times 10 = 2000 \text{p.a}\surd 1$

Atmospheric pressure = 103,000p.a

Total pressure $= 800 + 2000 + 103000$

$= 105800 \text{ Pa}$

7. Pressure applied at one pat in a liquid is transmitted equally to all other parts of the enclosed liquid.

8. Pressure on Solid at c $= L\ f\ g$

$= (0.02 \times 1000 \times 10) + (0.04 \times 800 \times 10)$;

$= 200 + 320$

$= 520\ N/m^2$

9. Difference in the level of water should be 20cm

10. Pressure of the gas $=$ Atmospheric pressure + ehg;

$$= 1.0 \times 10^5 + \frac{20 \times 1000}{100} \times 10$$

$= 1.0 \times 105 + 2.0 \times 103Nm^{-2}$

$= 1.02 \times 105Pa$;

11. - Rubber is elastic; and when a nail is pushed through it stretches and grips firmly the nail without allowing air leakage; or – Valve effect pressure from inside causes tyre rubber to press firmly on the nail;

12. (a) – Increasing the force (weight)

(b) Slanting sides increase the area supporting the weight of the liquid, hence its effect on the bottom of the container

13. Max pressure = $^{Force}/_{Min\ Area}$ √ 1

$= {}^{3N}/\ 0.1 \times {}_{0.05}$√1

$= 600N/m^2$ √ 1

14. (a) – Incompressible

– Not corrosive

– Has low freezing point and high boiling point (any one)

15. $h_1p_1g = h_2p_2g$

$$h_2 = \frac{h_1p_1}{p_2}$$

$$= \frac{0.7 \times 13600Kg/m^3}{1000kgm^{-3}}$$

$= 9.52m$

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

$$= \frac{2500}{4 \times 0.025}$$

$= 250,000Pa$

17. a)i) Atmospheric pressure $1.05 \times 10^5N/M^2$

ii) Any water vapour available is near its condensing point. Intermolecular forces are therefore appreciable √, so it does not behave like an ideal gas

iii) - Fix a millimeter scale to read the length (L) of air column B √ and the difference in height (h) between the levels A and C√

- Adjust the level of C by adding more mercury a little at a time and record the corresponding values of L and h each time √

- A graph of L against h represents Boyle's law √

(b) i) Increase in temperature causes gas molecules to move faster(increases in kinetic energy), √ hence they generate greater/ higher impulsive force on impact √

iii) With increase in volume gas molecules are sparsely spaced √ so the rate of collision is reduced/ lowered

MORE QUESTIONS

1. The total weight of a car with passengers is 25000N. The area of contact of each of the FOUR tyres with the ground is $0.025m^2$.
   Determine the minimum car tyre pressure.

I Write an expression for pressure on a liquid in hydraulic jack

II While using a jack, a mechanic applied a force of 100N on the effort piston while raising the rear part of a car.

i) Determine the maximum load that can be raised

ii) Give a reason why gas is not suitable for use in place of the liquid in a jack.

2. The lift pump is effective for pumping water as long as the well is less than 10m deep. Explain.
3. The reading on a mercury barometer at Mombasa is 760mm. Calculate the pressure at Mombasa (density of mercury = 1.36×10^4 Kgm^{-3})
4. State one property of a barometer liquid and explain its effects.
   Figure 1 below shows a liquid being siphoned from one beaker to another. Refer to this diagram where answering questions 5, 6 and 7

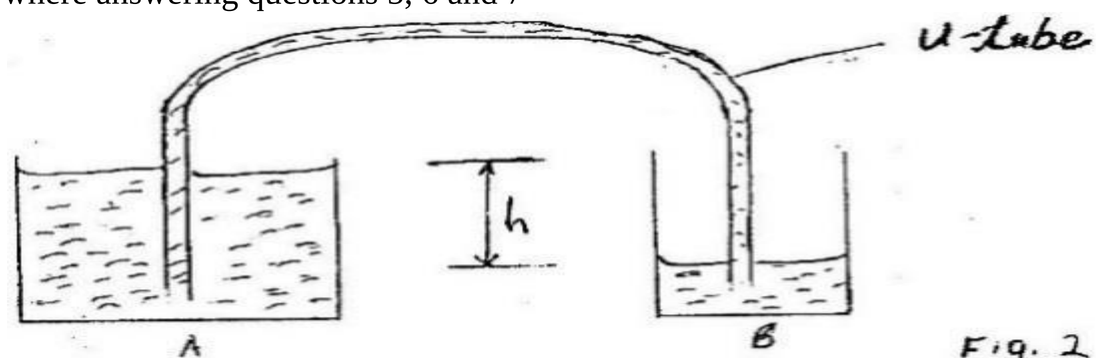


Fig. 2

5. Indicate on the diagram the direction of flow of the liquid
6. Show that the force driving the liquid through the U – tube is proportional to the height, h
7. State what would happen to the flow if the system in figure 2 were put in vacuum.

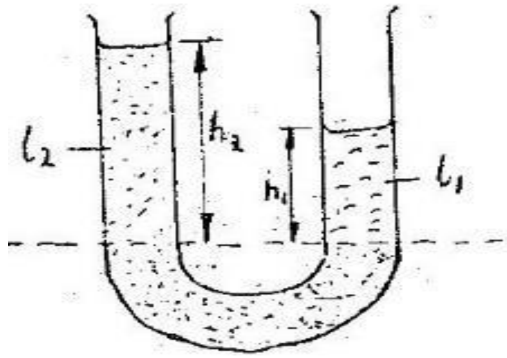


Fig. 2

8. Figure above shows a U tube containing two liquids L1 and L2 of densities 0.8 g cm^{-3} and 1.8 cm^{-3} respectively in equilibrium. Given that h2 = 8 cm determine the value of h1

9. A small nail may pierce an inflated car tyre and remain there without pressure reduction in the tyre. Explain this observation

10. The height of the mercury column in a barometer at a place is 64cm. What would be the height of a column of paraffin in barometer at the same place? (Density of paraffin = 8.0 x 102 kgm^{-3})

11. 7. A vacuum pump was used to pump out air from the glass tube immersed in liquids as shown in figure 3.

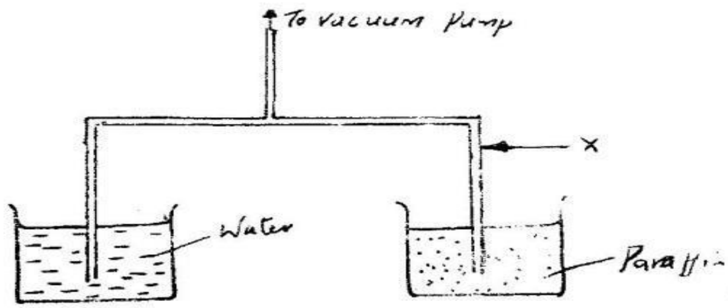


Fig. 3

After sometime the level of paraffin rose to position X. Mark the corresponding position for the water level. Give a reason for your answer.

12. A hole of area 2.0 cm^2 at the bottom of a tank 2.0m deep is closed with a cork. Determine the force on the cork when the tank is filled with water. (Density of water is 1000kg/m^3 and acceleration due to gravity is 10m/s^2).

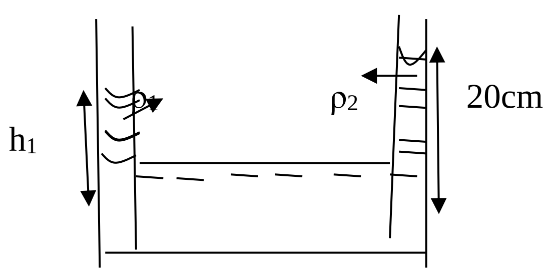
13. The reading on a mercury barometer at a place in 700mm. What is the pressure at the place Nm^{-2} (Density of mercury is 1.36 x 104 kgm^{-3})

14. In an experiment to demonstrate atmospheric pressure, a plastic bottle is partially filled with hot water and the bottle is then tightly corked. After some time the bottle starts to get deformed
(a) State the purpose of the hot water.
(b) State the reason why the bottle gets deformed. Explain your answer.

15. Figure 4 shows a lift pump.
(a)Explain why, when the piston is;
i) Pulled upwards, valve A opens while valve B closes.

ii) Pushed downwards, valve A closes while valve B opens.
c) After several strokes, water rises above the piston as shown in Figure 5.

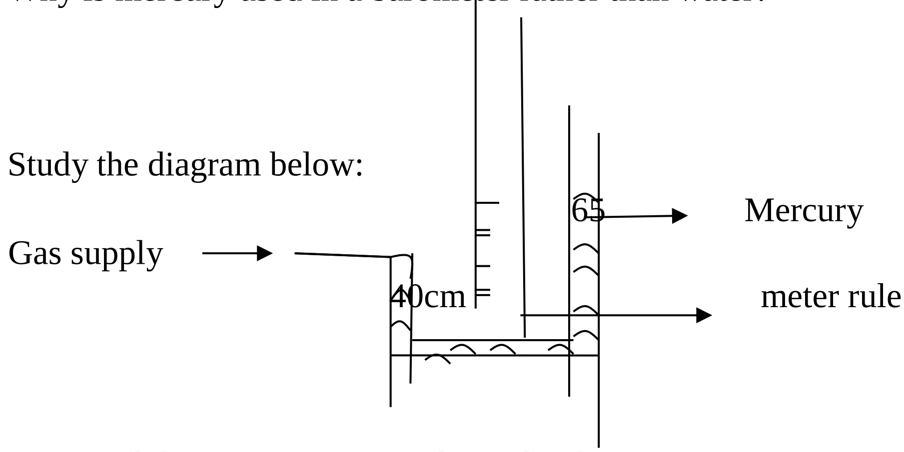
16. State how water is removed from the cylinder through the spout.
   c) A lift pump can lift water to a maximum height of 10m.
   Determine the maximum height to which the pump can raise paraffin. (Take density of paraffin as $800kgm^{-3}$ and density of water as $1000kgm^{-3}$).
   d) State one factor that determines the height to which a force pump can lift water.
17. Explain why a dam is thicker at its base than at the top.
18. The pressure exerted by the atmosphere on a table is 100,000Pa. What does this mean?
19. On a dining table of area $1m^2$, air pushes down with force of 101,000N (atmospheric pressure = 101,000Pa). Explain why the table does not collapse or break.
20. Explain why the level of mercury in a mercury barometer varies from day to day.
21. If atmospheric pressure is 101,000 N/m^2, what force is exerted on a wall of area $12m^2$?
22. Explain why you can fill a bucket from a downstairs tap quicker than from an upstairs tap
23. Explain why a giraffe must have a stronger large heart compared to a human being.
24. State why a barometer will show a greater reading when taken down a 200m pit.
25. A hydraulic press has the small piston of area $5cm^2$ and a force of 40N is applied to it.
26. (i) Calculate the pressure transmitted throughout the liquid.
   (ii) If the larger piston has an area of $20cm^2$, what is the force exerted on it?
27. Explain why a sharp knife cuts well than a blunt one.
28. State Pascal's principle of pressure.
29. Explain why the atmospheric pressure decreases with increasing the height or altitude.
30. Explain why we do not feel the great air pressure around us.
31. Why do deep sea divers wear diving suits?
32. Why are planes pressurized?
33. Explain how a drinking straw operates when in use.
34. Explain how a syringe operates when being used.
35. Describe the working of a hydraulic press
36. Study the diagram below:



If ρ_1= $2000kg/m^3$ and ρ_2 = $1500kg/m^3$, calculate h_1.
37. Explain why walking on a murrum road in bare feet is more painful than walking on sand.
38. A pressure of 2000Pa acts on an area of $0.05m^2$. What force is produced?
39. At sea level, what is the approximate value of atmospheric pressure in
   (a) Pa
   (b) MmHg
   (c) Atmospheres

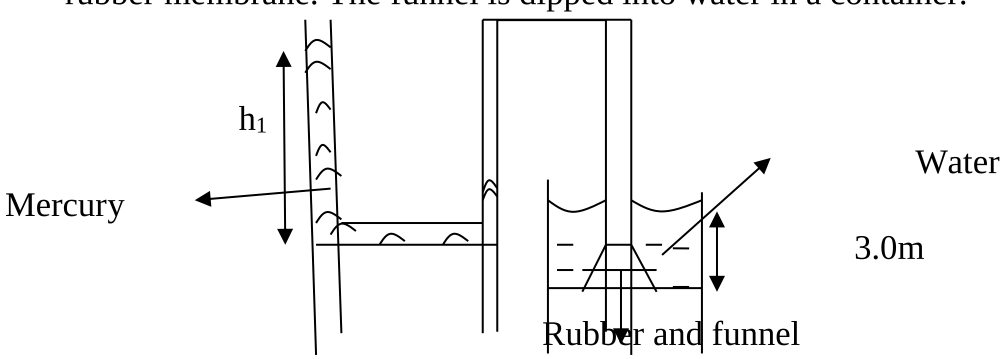
40. Why is mercury used in a barometer rather than water?

41. Study the diagram below:



(a) Record the excess pressure shown by the meter in mmHg
(b) If the atmospheric pressure is 760mmHg, what is the pressure of the gas supply?

42. State one advantage of fitting wide tyres on a vehicle that moves on earth roads.
43. A small nail may piece an inflated car tyre and remain there without pressure reduction in the tyre. Explain this observation.
44. The height of the mercury column in a barometer at a place is 74cm. What would be the height of a column of a water barometer at the same place? (Density of mercury is 13.2g/cm^3 and water 1g/cm^3.)
45. Explain why it may not be possible to suck a liquid into your mouth using a drinking straw on the moon surface
46. Derive the formula P=h ρ g where P = pressure, h = height or depth, ρ = density of liquid and g = gravity.
47. The figure below shows a manometer connected to a small funnel whose mouth is covered by a rubber membrane. The funnel is dipped into water in a container.



(a) Given that the density of mercury is 13.6g/cm^3 and that of water is 1g/cm^3, determine the pressure indicated by the manometer.
(b) Determine the height h$_1$.
48. The diagram below shows a liquid being siphoned from one beaker to another. Use this information to answer the questions that follow:
(a) Indicate on the diagram the direction of flow of the liquid
(b) Show that the force driving the liquid through the pipe is proportional to the height h.
49. State and explain what would happen to the flow in question 2 above if the system in the diagram were put in a vacuum.

50. Give a reason why water is not a suitable liquid for a barometer.

51. A rectangular block measures 10cn x 5cm x 4cm and has a mass of 2.2kg.

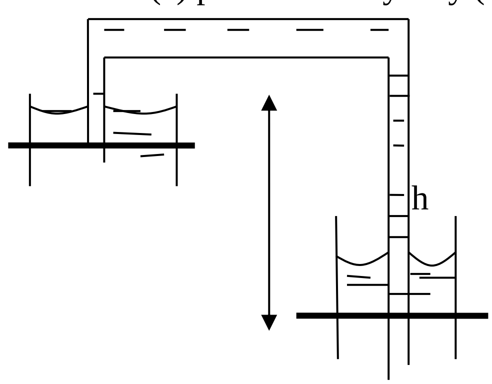
52. a) (i) If the gravitational field intensity is 10N/kg, what is the weight of the block?
(ii) What is the area of the smallest face of the block?
(iii) What pressure will the block exert when it is resting on a table on its smallest face?
(iv) What is the least pressure the block exerts on the table?
(b) Calculate the volume of the block.
(c) Determine the density of the material from which the block is made.

53. A diving bell is pressurized inside to a pressure of 1,000,000Pa above atmospheric pressure. This diving bell is made for use at 100m below the sea surface for oil exploration. The pressure outside the diving bell must be equal to the pressure inside for its door to open. (Opens from inside.)

i. Calculate the pressure at 100m depth in water.
ii. Explain what would happen to the diving bell when the door opens at :
i. 10m below the surface.
ii. 200m below the surface.
iii. When the diving bell is under the sea, how is the pressure on top of it different from that underneath it?

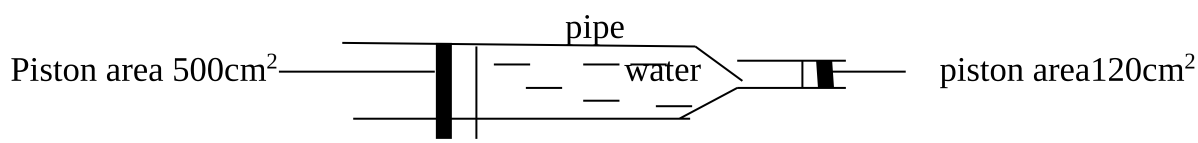
iv. Explain why the pressure difference in (c) produces buoyancy (upthrust).

54. Study the figure below:

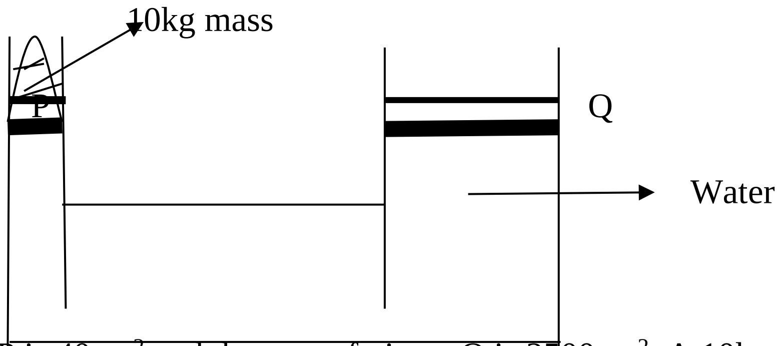


The piston can be pushed in and out but no water can escape. If the larger piston is pushed into the pipe by a force of 200N,

i) Calculate the pressure applied to the water.
ii) Determine the force exerted on the smaller piston.



55. (a) The figure below shows two cylinders connected by a pipe. in each cylinder there is a piston and the space below each piston is full of water.



The area of piston P is $40cm^2$ and the area of piston Q is $2500cm^2$. A 10kg mass is placed on piston P.

i) Calculate the weight of the 10kg mass.
ii) What is the downward force on piston P.
iii) Determine the pressure on the water
iv) State the pressure on the water at Q.
v) Calculate the upward force on Q.

(b) Kamau suggested that the above device could be used as a car jack.

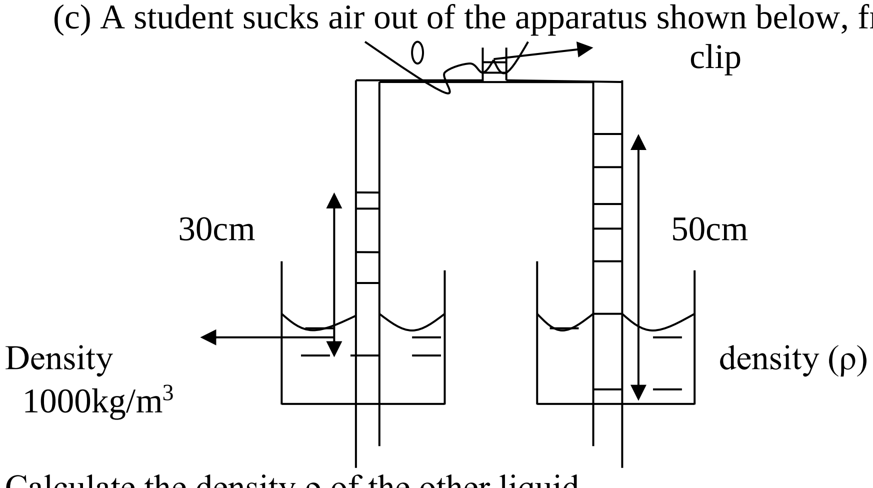
i) Which piston (A, or B) would you use to support the car? Explain your answer.
ii) Name the above device.

56. (a) If a lorry weighs 100,000N and has 4 tyres.

(i) Calculate the force exerted on the road by each tyre
(ii) What assumption have you made in the calculation above
(iii) If each tyre has an area of $0.2m^2$ in contact with the road, calculate the pressure exerted.

(b) Using a diagram, explain how a bicycle pump operates when filling a tyre with air.

(c) A student sucks air out of the apparatus shown below, from the top.



Calculate the density ρ of the other liquid.

57. (a) A car containing six adults and their luggage weighs 20500N. The area of contact of each tyre with the ground is $0.025m^2$.

(i) Calculate the pressure exerted by each tyre on the ground.
(ii) State any two assumptions made.

(iii) The car has to be driven off the road and cross a patch of soft damp sand. The driver thinks that the tyres will sink into the sand and stop the car moving. One of the passengers suggests that the sinking can be prevented by letting some air out of the tyres.

I What effect would this have on the shape of the tyres?

II How would letting air out of the tyres stop the wheels from sinking.

III What other change could be made to stop the tyres sinking into the sand.

(b) The air pressure near the ground is about 101KPa. Some aircrafts fly at height of about 20km where the air pressure is only 27KPa.

i. State two reasons why the outside air pressure is less at 20km than at the ground.

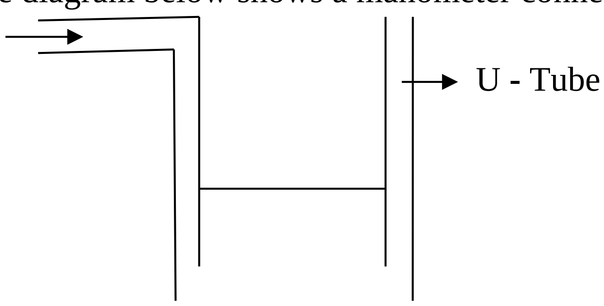
ii. If the air inside the aircraft is 101KPa, what is the difference in air pressure between the inside of the aircraft when fling at a height of 20km?

iii. How does this difference in air pressure influence the choice of material used in the construction of the aircraft.

iv. The door of the aircraft is designed to fit into the door frame from inside the aircraft. Explain why the door is designed to fit in this way.

v. If the fuselage of the aircraft has an area of 4000m^2, determine the force acting on the fuselage due to the difference in air pressure between the inside and outside of the aircraft at a height of 20km.

58. (a) The diagram below shows a manometer connected to a gas supply.



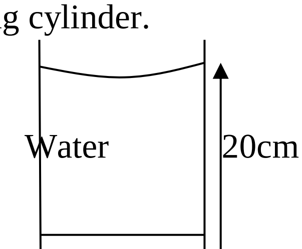
The pressure of the gas supply above atmospheric pressure is equivalent to 20cm column of water.

i) Complete the diagram by marking the position of the levels of the water in the manometer when the gas supply is connected.

ii) If the gas supply had only been partly turned on, what effect, if any, would this have had on the levels of the water in the manometer? Explain your answer.

iii) Calculate the pressure of the gas supply above atmospheric pressure in Pascal's. (ρ_w=1000kg/m^3)

(b) The diagram shows water standing to a depth of 20cm in a measuring cylinder. There are 500cm^3 of water in the measuring cylinder.



I If the density of water is 1g/cm^3, calculate the mass and weight of the water in the measuring cylinder

II Using the weight in part (i), calculate the pressure exerted by the water on the bottom of the measuring cylinder.

III Mark with a letter P on the diagram above a position where the pressure exerted by the water is a quarter of the pressure calculated in part (ii)

59. a) A newspaper article claimed that a woman wearing shoes with heels which had a small area exerted more pressure on the ground than a n elephant.
   (i) Explain in terms of the area how this is possible.
   (ii) The article claims that the pressure exerted on the ground by a woman weighing 600N wearing shoes with heels each having an area of $0.9cm^2$ was $666.7N/m^2$. What assumption was made about the way the woman was standing? Explain your answer.
   (iii) A typical elephant weighs 30,000N. If each of the elephant feet has an area of $600cm^2$, calculate the pressure exerted by the elephant on the ground.

(b) A water storage tank is 20m above a tap. Given the density of water as $1g/cm^3$,
   i) Calculate the pressure of the water at the tap in N/m^2.
   ii) The area at the end of the tap is $2.0x10^{-4}m^2$; calculate the force needed to stop the water leaving the tap.
   iii) When a shower is directly connected to another water storage tank, it is found that water will only flow when the shower head is lowered and not when it is raised. Why is this so? In which way can this problem be overcome?

60. (a) Describe a laboratory experiment to show that the pressure in a liquid increases with depth.
   (b) The experiment in (a) is repeated with a liquid of lower density. What effect, if any, does this have on the pressure at different depths? Explain your answer.

(c) How is the fact that pressure increases with depth
   i) Taken into account when constructing the wall of a dam.
   ii) Used in the measurement with a manometer of the excess pressure of the gas supply.

(b) The diagram below shows the inner details of a device called bourdon gauge which can be used to measure air pressure.

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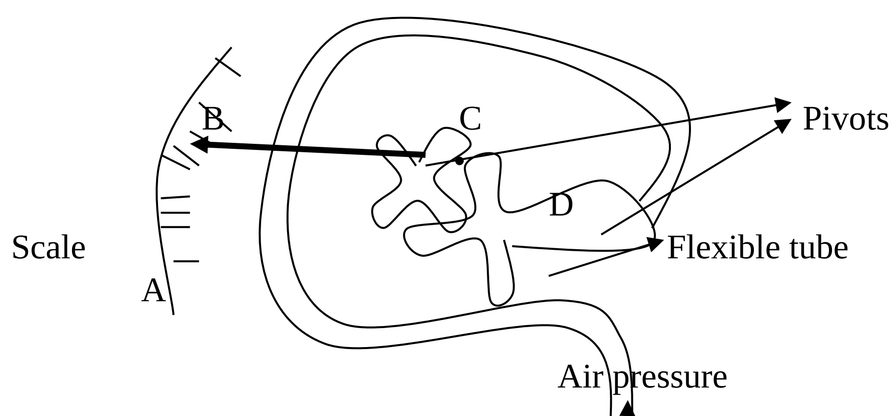
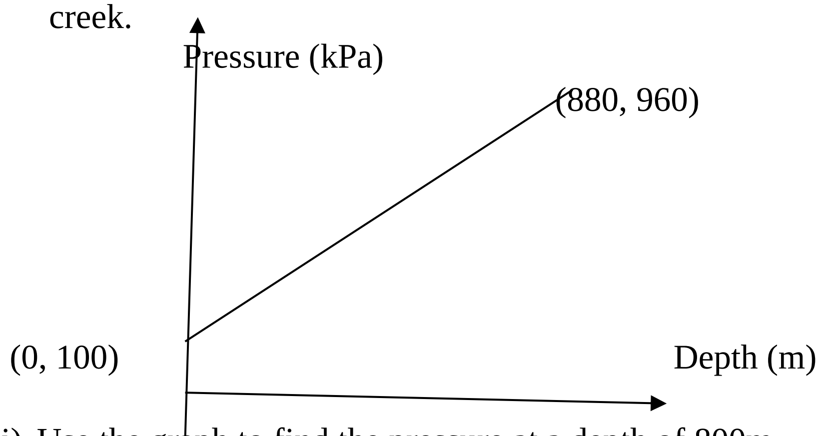


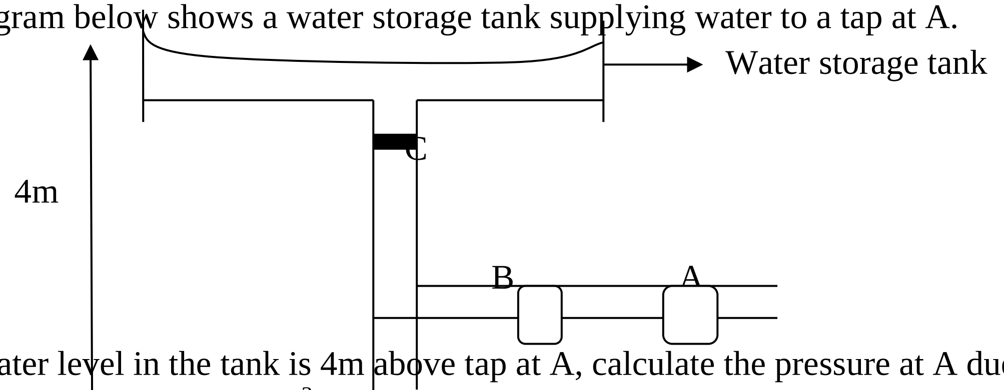
As the air pressure increases the flexible tube straightens out. Explain why the pointer moves towards B when the air pressure increases.

61. The graph below shows how the pressure in water changes with depth below the water surface of a creek.



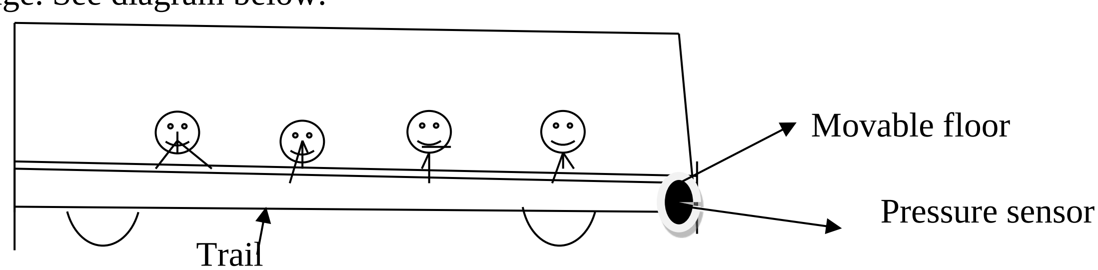
i) Use the graph to find the pressure at a depth of 800m.
ii) Calculate the force exerted by the water on 2.0m^2 of the outside surface of a submarine at a depth of 800m.
iii) State why the pressure is not zero at the surface of the water.
iv) The part of the submarine containing the crew contains air at normal atmospheric pressure. Explain why the outside walls of this part of the submarine are usually made from very thick steel.
v) Explain why at a depth of 100m the pressure in sea water is different from lake water.

62. The diagram below shows a water storage tank supplying water to a tap at A.



i) If the water level in the tank is 4m above tap at A, calculate the pressure at A due to this water. (density of water = 1000kg/m^3)
ii) The tap is moved from A to B. Explain why the water pressure at the tap is unchanged.
iii) The diagram is drawn to scale. An object becomes stuck in the pipe at C and the water is unable to flow to the tap. Calculate the pressure at C due to the water and explain your calculation.
iv) If the cross section area of the pipe is 1.2x10^{-3}m^2, what force is acting on the object at C due to the water above it?

63. A pressure sensor attached to an airbag can be used to determine the weight of passengers in a train carriage. See diagram below.

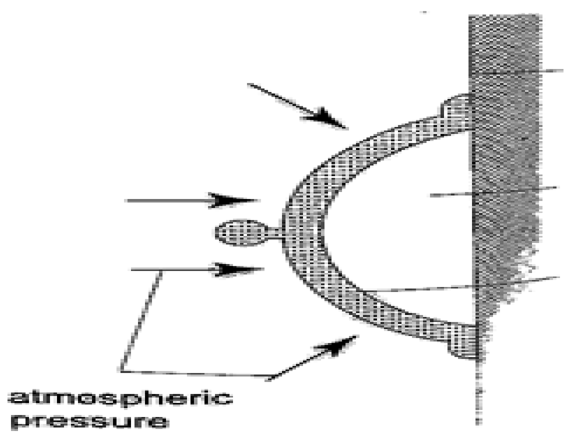


In a trial using different number of passengers in a carriage the following results were obtained.

Numbers of passengers in a carriage	20	40	60	80	100	120
Pressure in MPa	8.8	11.2	12.2	14.0	15.0	16.8

i) Plot a graph of pressure (y-axis) against the number of passengers in the carriage.
ii) What is the pressure when we have 55 passengers in the carriage?
iii) Explain why
   a. The graph does not pass through the point (0,0)
   b. The points do not lie on a straight line
   c. Similar readings would have been obtained if the pressure sensor had been placed at the other end of the airbag.

Rubber sucker– this is a shallow rubber cap. Before use it is moistened to get a good seal then pressed firmly on a smooth surface so that the air inside is pushed out. The atmospheric pressure will then hold it firmly against the surface as shown below. They are used by printing machines to lift papers, lifting glass panes, heavy metal sheets



-Drinking straw– when a liquid is drawn using a straw air is sucked through the straw to the lungs. This leaves the space in the straw partially evacuated. The atmospheric pressure pushing down the liquid in the container becomes greater than the pressure inside the straw and this forces the liquid into your mouth.
-The syringe– they work in the principle as the straw. They are used by the doctors in hospitals for giving injections.

64. State **two** reasons why mercury is preferred as a barometric liquid and not water
65. The diagram in figure 5 below shows hydraulic brake system.

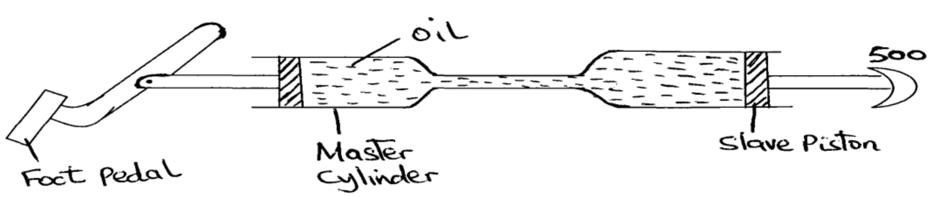


Fig. 5

A force of 20N is applied on the foot pedal to a piston of area 50cm^2 and this causes a stopping force of 5000N.

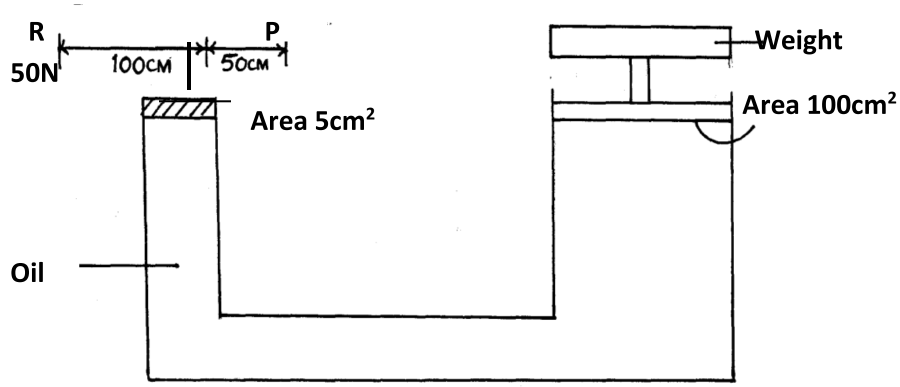
Determine;

(i) Pressure in the master cylinder.

(ii) Area of the slave piston.

66. The height of mercury column in a barometer density 13600kg/ m^{-3}, at a place is 64cm. What would be the height of a column of paraffin in barometer at the same place?
(Density of paraffin = 8.0 x 10^2 kg /m^3).

67. The figure 3 shows hydraulic press system using a lever of negligible mass, on the ride of the small piston pivoted at a point P. A force of 50N is applied at R.



Calculate

(i) Force exerted by small piston on the liquid.

(ii) Pressure of liquid below the small piston.

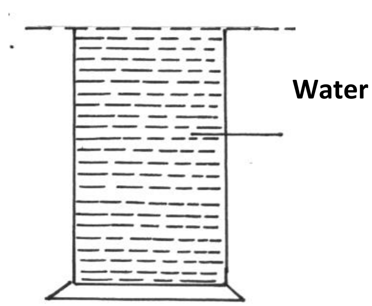
(iii) The weight of object supported on the larger piston

68. Water tanks in houses are erected as high as possible. Explain.

- Water will flow at high pressure√¹

Or- for water to have high potential energy √

69. The figure below is a gas jar completely filled with water and covered with a wire gauze.



a) State the observation when the set-up is suddenly inverted.

b) Explain the observation made in (a) above.

TOPIC 5: PARTICULATE NATURE OF MATTER

Matter is anything that occupies space and has mass. Matter commonly exists in three states i.e. solid, liquid and Gas

The process of sub-dividing matter into smaller units and smaller units continues indefinitely, suggesting that matter is not continuous, but is made up of even smaller parts e.g. A piece of paper can be cut endlessly until a stage when the small pieces cannot be cut into pieces. This suggests that the sheet of paper is made up of tiny particles

DEMONSTRATION OF DILUTION

APPARATUS: Beaker and potassium permanganate crystals

PROCEDURE

- Pour water into the beaker to half full.
- Dissolve the potassium permanganate crystals until the solution is purple.
- Transfer half of the solution to another beaker and add water
- Continue the process with other beakers, comparing the colour to each other.

OBSERVATION

The process of dilution can continue until the solution appears colourless. This suggests that the particles of potassium permanganate are spread evenly on water.

As water particles increase, the particles of potassium permanganate are spread further, making the purple colourless and less until it appears colourless.

CONCLUSION

Potassium permanganate is made up of tiny particles.

DISSOLVING A SOLID IN A SOLVENT

- ✓ 100g of salt is put into the flask and water added carefully using a pipette without shaking the salt until it is full.
- ✓ The stopper is then inserted to the mouth of the flask and shaken to dissolve the salt.

OBSERVATION

The volume of the solution of salt is less.

CONCLUSION

Particles of salt are able to occupy some spaces between the water particles.

This suggests that the particles of salt differ in size.

The particles of the solution pack more closely in the available space, thus reducing the volume. This further suggests that particles of salt are broken down to fit into spaces between water particles.

BROWNIAN MOTION

This is the random movement of particles of a substance in fluids. A fluid is anything that is capable of flowing, e.g. a gas or a liquid.

The particles in a fluid are in a constant random motion.

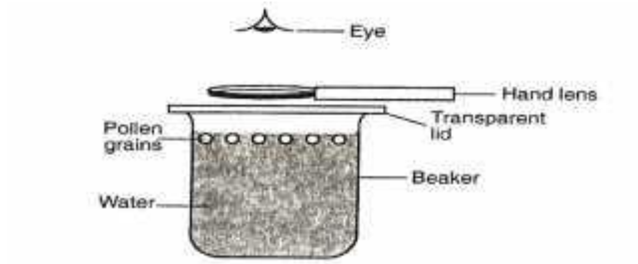
BROWNIAN MOTION IN LIQUIDS

DEMONSTRATION OF THE BROWNIAN MOTION

Apparatus: Beaker, hand lens, chalk dust, transparent lid.

PROCEDURE

- Pour water into the beaker about full as shown



- Sprinkle pollen grains or chalk dust on the surface of water (particles should be small in size, light and sprinkled evenly).
- Cover the beaker with a transparent lid and with the help of a hand lens observes what happens to pollen grains or chalk dust.

OBSERVATION

The pollen grains or chalk dust is in constant random motion.

CONCLUSION

The particles are hit continually by the movement of small invisible particles of water. The movement is random, suggesting that the particles of water are in constant random movement. This kind of movement is called **Brownian motion** a tribute to a scientist **Robert Brown** who first observed the effect.

BROWNIAN MOTION IN GASES

THE SMOKE CELL EXPERIMENT

DEMONSTRATION OF THE BROWNIAN MOTION IN AIR

Apparatus: Drinking straw, smoke cell, microscope and a bright light source

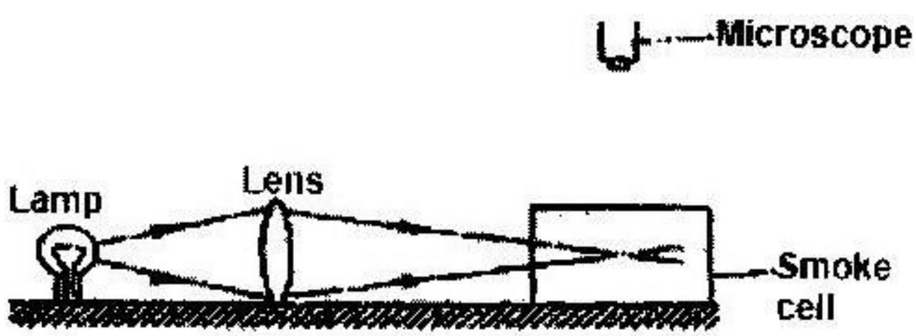


Figure 9

In this case, one end of the straw is burnt and let the smoke from the other end of the straw into the smoke cell as shown above. The smoke is then covered using a transparent glass lid. The smoke cell is covered to seal the content of the smoke cell. This ensures that the smoke molecules do not escape from the smoke cell. The lid is transparent to allow for easy visible of the smoke cell. The cell is illuminate with bright light. Therefore, the work of lamp in this case is to provide light which illuminates the content of the smoke cell. A hand lens is used to focus the light on the smoke particles in the smoke cell. The microscope is adjusted until bright specks are seen against the grey background. The work of the microscope is therefore to enlarge/magnify the smoke particles in the smoke cell for easy visibility.

OBSERVATION

In this experiment, the smoke particles (which are seen as bright specks) are seen moving in continuous random motion.

EXPLANATION

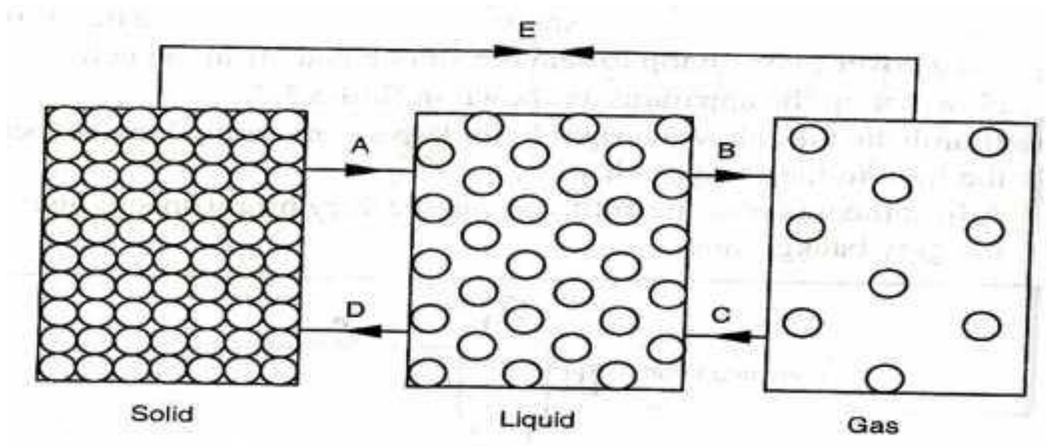
The smoke particles appear as bright specks since they scatter the light shining on them and appear as bright points. They move about in a continuous random movement because of uneven bombardment by the invisible particles or molecules in air. This suggests that air is made up of small particles which are in constant motion.

When this experiment is repeated at a higher temperature, the smoke particles move faster in a continuous random manner. This is due to increased kinetic energies of the molecules. The opposite is true when the temperature of the content is reduced.

CONCLUSION

From the experiments above, matter is made up of very small particles which are in constant random motion. This is called **kinetic theory of matter.**

ARRANGEMENT OF PARTICLES IN THE STATES OF MATTER



a. <u>SOLID</u>

- The particles of solids are closely packed together in an organised way.
- The closely knit structure is due strong attractive forces (cohesive forces) between the particles.
- In their fixed positions, they vibrate to and from so that increasing the temperature of the solid increases this vibratory motion.
- At a certain temperature the solid breaks away from this knit structure and the solid is said to have melted.

b. <u>LIQUIDS</u>

- The particles are further apart. They are not fixed as in solids but move about in Brownian motion.
- Liquids can break a solute put in it. It's easier to dissolve a solute in hot water because the particles have increased energy.
- The cohesive forces between the particles in liquids are weaker compared to those in solids. Due to this liquids can flow and take up the shape of the container in which they are put.
- When a liquid is heated molecules gain kinetic energy, they vibrate about and expand. The space between them widens further apart and the liquid changes into gaseous state by a process called **vaporization.**
-

c. <u>GASES</u>

- The particles are further apart and have increased random motion compared to those in the liquid state.
- The cohesive force between the particles is extremely small and as the particles move they collide with each other and with the walls of the container in which they are trapped. This produces gas pressure.
- □Gases are easier to compress indicates that there exists a large intermolecular distance in gas than in liquids. Gas molecules or particles can lose some of their energy and fall back into the liquid state by a process known as **condensation.**

  NOTE: Solids which when heated change directly into gas undergo the process called **sublimation.**

<u>DIFFUSION</u>

□□This is the process by which particles spread from regions of high concentration to those of low concentration. Diffusion takes place in solids, liquids and gases.

□□In solids, diffusion is exceedingly slow but occurs when two metals are placed in contact with each other e.g. lead and gold, metal block vibrating atoms breaks away from the substances to which they belong and enter the other substance to be trapped by its attractive forces. This process is speeded up by high temperature.

□□Diffusion in liquids occurs at a faster rate than in solids.

□□Diffusion in gases is faster due to their low density, high kinetic energy and weak cohesive forces.

<u>DIFFUSION IN LIQUIDS</u>

To investigate diffusion in liquids

Apparatus: Funnel, beaker, copper (II) sulphate solution.

PROCEDURE

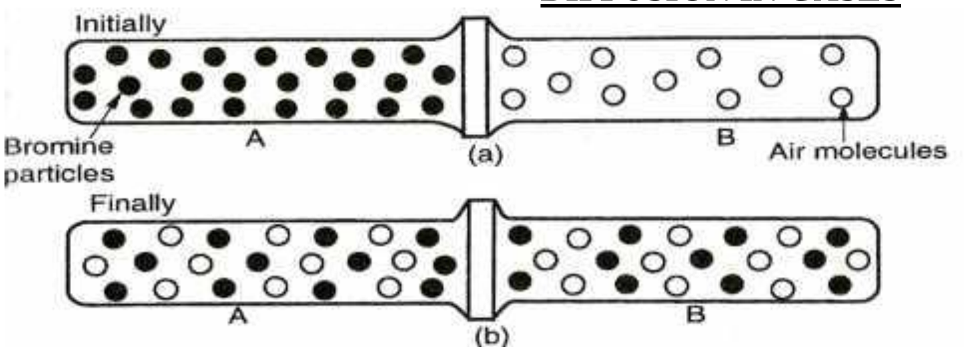
- Pour water into the beaker until it is half full.
- Pour saturated copper (II) sulphate solution down the funnel slowly and notice how the two liquids settle.
- Remove the funnel carefully so that the liquids are not disturbed.
- Repeat the same steps for another set of apparatus but using warm liquids. Make observation.
-

OBSERVATION AND EXPLANATION

□□Initially, the water layer floats on top of the saturated copper (II) sulphate because it is less dense. After sometime, the boundary disappears and the liquids form a homogeneous pale blue mixture.

- Formation of the mixture is faster with hot liquids than because the movement of particles is faster due to increased energy. There is greater movement of water particles (molecules) from the water layer into copper (II) sulphate layer because it has greater concentration of water molecules than copper (II) sulphate particles.
- Similarly, there is a greater movement of particles from copper (II) sulphate layer into the water layer because of greater concentration of copper (II) sulphate particles than water molecules.

<u>DIFFUSION IN GASES</u>



OBSERVATION AND EXPLANATION

- The bromine gas spreads into the gas jar B at a greater speed than it returns to gas jar A because of high concentration of bromine particles.

- Likewise, air spreads in gas jar A at a greater rate than it returns to gas jar B because of high concentration of air particles in B.

TOPIC 6: THERMAL EXPANSION

TEMPERATURE

This is the degree of hotness or coldness of a body. Temperature of a body is measured by an instrument called **a thermometer.**

Temperature is a basic physical quantity and is measured in degrees celcious (^{0}C) or Kelvin (K).

The S.I unit of temperature is Kelvin (K) which is a scalar quantity.

MEASURING TEMPERATURE

A thermometer is an instrument used for measuring temperature. There are various types of thermometers in use. A thermometer is designed according to the purpose for which it is required. The following are some of the commonly used thermometers:

a) Liquid-in-glass thermometer.
b) Clinical thermometer
c) Six's maximum and minimum thermometer

(a) LIQUID-IN-GLASS THERMOMETER

A liquid-in-glass thermometer commonly in use is **mercury or coloured alcohol** as the thermometric substance.

The volume of the liquid changes uniformly with the change in temperature

The characteristics of the liquid in the bulb include;

i) Be easily seen (visible).
ii) Expand or contract uniformly and by a large amount over a small range of temperature.
iii) Not stick to the inside of the tube. (Should not wet the inside of the tube)
iv) Have a wide range of temperature.

THERMOMETRIC LIQUIDS

The most common in use is mercury and alcohol.

Mercury freezes at -39^{o}C and boils at 357^{o}C while alcohol freezes at -115^{o}C and boils at 78^{o}C. Alcohol is therefore suitable for measuring temperatures below - 39^{o}C.

PROPERTIES OF THE TWO THERMOMETRIC LIQUIDS

ALCOHOL	MERCURY
- Low boiling point, 78oC	- High boiling point, 357oC
- Low melting point, -115oC	- Relatively higher melting point, -39oC
- Poor thermal conductor	- Good thermal conductor
- Expansion slightly irregular	- Expands regularly
- Wets glass	- Does not wet glass
- Coloured to make it visible	- Opaque and silvery

NB

Water is not used as a thermometric liquid because it undergoes anomalous expansion.

TEMPERATURE SCALE

The scale of a thermometer is obtained by selecting two temperatures called fixed points; the lower fixed point and the upper fixed point. The lower fixed point is the temperature of pure melting ice. It is taken to be 0^0C. The upper fixed point is the temperature of steam above pure boiling water at normal atmospheric pressure. It is taken to be 100^0C.

The temperature of steam is used since impurities do not affect its temperature but will raise the boiling point of water. The temperature of boiling water itself is not used because any impurities in water would raise its boiling point. The temperature of steam is not affected by impurities in water.
The range between these two points is then divided into equal divisions. Each division is called **degree.**

FEATURES OF A COMMON THERMOMETER

The basic features of a common laboratory are as shown below.

- **Bulb-** Carries the liquid in the thermometer. It has a thin glass wall for effective heat transmission between the liquid and body whose temperature is taken.
- **Capillary bore –** Liquid expands and contracts along the capillary tube. It is narrow for high degree of accuracy.
- **Glass stem –** this is a thick wall surrounding the capillary bore. It also serves as a magnifying glass for easy reading of scale.

CELCIOUS AND KELVIN SCALE

They are the commonly used temperature scale. The celcious scale has the fixed points at 0^oC and 100^oC. In Kelvin scale, the temperature of pure melting ice is 273K while that of pure boiling water at normal atmospheric pressure is 373K.
The lowest temperature in the Kelvin scale (0K) is referred as **absolute zero.**
This is the temperature at which the energy of the particles in material is zero.

To change ^oC to Kelvin

T = (ɵ – 273) K where ɵ is the temperature in ^oC

EXAMPLE 1

Convert 25^oC in Kelvin
SOLN
T = (25 + 273)
= 298 K

To change Kelvin to ^oC

ϴ = (T- 273) ^{0}C where T is the temperature in Kelvin

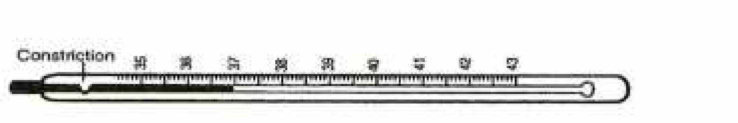
EXAMPLE 2
Convert 1 K
SOLN
ϴ = 1-273
= -272ºC

ASSIGNMENT
1. Convert the following into Kelvin:
a) 35^0C b) -111^0C c) $-273\ ^0$C
2. Convert the following into ^{0}C:
a) 123 K b) 323 K

NOTE: Temperature in Kelvin scale cannot have a negative value because the absolute zero, (0K), is the lowest temperature attainable.

(b) CLINICAL THERMOMETER

A clinical thermometer is an instrument used to measure the temperature of a human body.
It uses mercury as its thermometric substance and has a narrow constriction in the tube just above the bulb.
The diagram below shows the main features of a clinical thermometer.

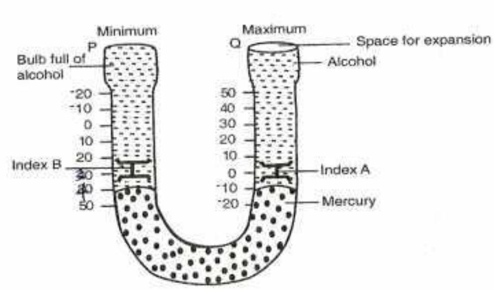


The **constriction** prevents the mercury level from falling down when it contacts with the human body. The clinical thermometer has a short scale of temperature from 35ºC to 43ºC spread over its entire level. This is because the human body temperature falls slightly above or below 37ºC which is the temperature of a normal and healthy person. Methylated spirit is used to sterilize the clinical thermometer.

Boiling water is not used because its temperature is quite far away from the maximum temperature of the clinical thermometer. This can destroy the thermometer. The thermometer can be reset by a simple flick.

(c) SIX'S MAXIMUM AND MINIMUM THERMOMETER

This thermometer is used to record the maximum and minimum temperature of a place during a day. The thermometer consists of a U-tube connected to two bulbs. The U-tube contains mercury. The two bulbs contain alcohol.
The figure below shows the main features of a six's maximum and minimum thermometer.



Working of the Thermometer
When temperature raises alcohol occupying volume of bulb A expand and forces mercury in the U-tube to rise on the right hand side.
The mercury in turn pushes the steel index A upwards. The maximum temperature can be noted from the lower end of the steel index A.

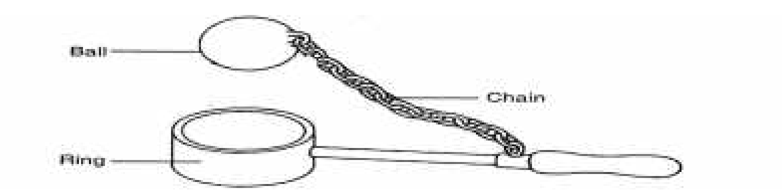
On the other hand when the temperature falls, alcohol in the bulb A contracts and the mercury is pulled back rising u the left hand side of the U-tube. The index B is then pushed up. During contraction of the alcohol, index A is left behind (in the alcohol) by the falling mercury.
The minimum temperature is then read from the lower end of index B.

NOTE: To reset the thermometer, a magnet is used to return the steel indices to the mercury surfaces.

(d) THE BIMETALLIC THERMOMETER
It is made up of a coiled bimetallic strip whose one end is fixed and the other end connected to a pointer. Commonly used metals are brass and invar. When the temperature rises brass expands more than invar. The strip thus curls forcing the pointer to move over a calibrated scale.

THERMAL EXPANSION AND CONTRACTION OF SOLIDS, LIQUIDS AND GASES
All substances increase in size when heated. This increase in size of a substance is called **expansion.** On the other hand when a substance is cooled it decreases in size. This decrease in size is called **contraction.**

EXPANSION IN SOLIDS
Thermal expansion and contraction in solids can be demonstrated using a ball and ring experiment. Set the apparatus as shown below.



NOTE: The ball should pass through the ring when both are at room temperature
- Heat the ball and try to pass it through the ring. Observe what happens.
- Leave it for sometime

OBSERVATION
- When both the ball and the ring are at the same room temperature**,** the ball just passes through the ring.
- When the ball is heated; it does not go through the ring but when left there for sometime, it goes through.

EXPLANATION

- When heated, the ball **expands** so that it cannot go through the ring.
  When left on the ring for some time, the temperature of the ball decreases and it **contracts.**
- At the same time, the temperature of the ring increases and it expands so that the ball goes through.

WHY SOLIDS EXPANDS ON HEATING

The molecules of a solid are closely packed together and are continuously vibrating in their fixed positions When a solid is heated the molecules gain more kinetic energy and therefore make larger vibrations about their fixed positions. This increase in vibration means that the molecules collide with each other with larger forces and the molecules increases and so the solid expand.

LINEAR EXPANSIVITY

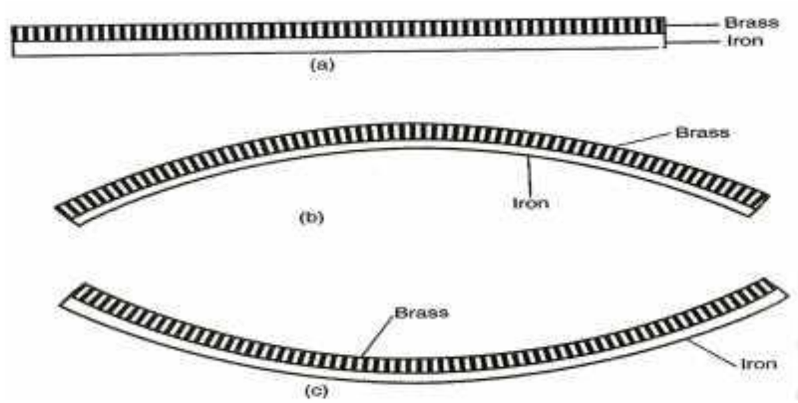
The measure of the tendency of a particular material to expand is called its **expansivity** e.g. aluminium expands more than iron thus aluminium has higher expansivity than iron.
The knowledge of linear expansivity values is applied in the designing of materials to ensure that they are able to operate well under varying thermal conditions.

Ordinary glass expands at a higher rate than Pyrex glass. When hot water is poured into a tumbler made of glass it breaks but does break in Pyrex glass.
Concrete and steel are reinforced together because they are of the same linear expansivity. Hence cannot crack under varying thermal conditions.

THE BIMETALLIC STRIP

When two metals of different linear expansivity are riveted together they form a bimetallic strip.
Brass and iron are used to make the bimetallic strip.
On heating the bimetallic strip, brass expands more than iron.

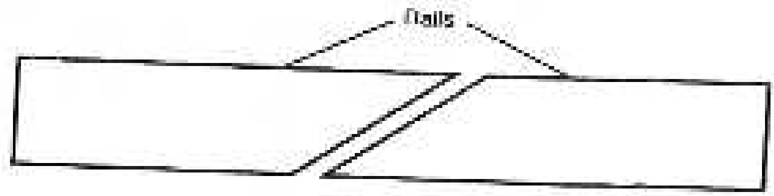
The brass thus becomes longer than the iron for the same temperature range. Hence, the bimetallic strip bends with brass on the outside of the curve as shown in (b) below
On cooling, the brass contracts more than iron. It therefore becomes shorter than the iron and thus ends up being on the inner side of the curve as shown in (c) above



APPLICATIONS OF EXPANSION AND CONTRACTION IN SOLIDS

(a) RAILWAY LINES

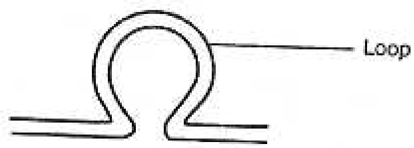
Gaps are left between the rails. Expansion for the rail is provided by overlapping the plane ends using overlapping joints as shown in the figure below



If these gaps for the expansion are not provided then during hot weather, they rails may buckle out, bend and cause derailment of the train leading to destruction and accidents.

(b) STEAM PIPES

Pipes carrying steam from boilers are fitted with loops or expansion joints to allow pipes to expand and contract easily when steam passes through and when it cools down.



(c) TELEPHONE WIRES

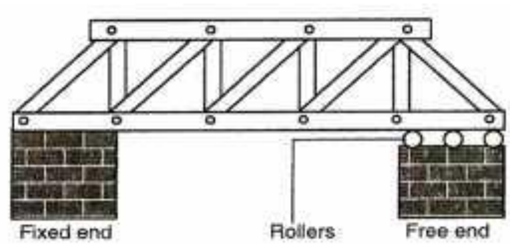
They are loosely fixed to allow for contraction and expansion. During cold weather, they contract and when it is warm they expand.

Telephone or electricity wires appear to be shorter and taut in the morning.

However in hot afternoons, the wires appear longer and slackened.

(d) STEEL BRIDGES

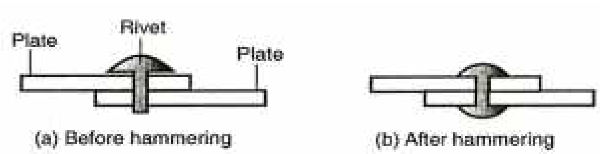
In bridges made of steel girders, one end is fixed and the other end placed on rollers to allow for expansion as shown



(e) RIVETS

Thick metal plates, sheets and girders in ships are joined together by means of rivets.

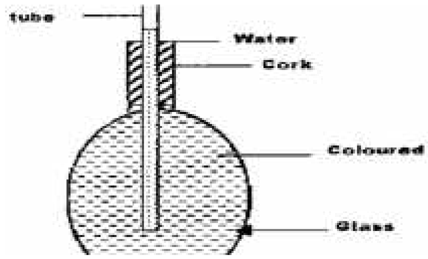
The rivet is fitted when hot and then hammered flat. On cooling, it contracts, pulling the two firmly together as shown



(f)<u>ELECTRIC THERMOSTAT</u>
A thermostat is used to maintain a steady temperature in some devices such as electric iron box, refrigerators, fire alarm and flashing unit for indicator lamp in motor cars.

<u>EXPANSION AND CONTRACTION IN LIQUIDS</u>

The experimental set up below can be used to demonstrate expansion of a liquid.



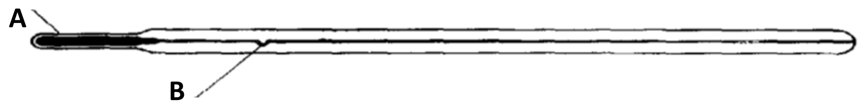
A glass flask is filled with coloured water and heated as shown above
OBSERVATION
Immediately the level of coloured water on the tube drops slightly at first and then starts rising.

EXPLANATION
The initial fall of the level of the water is due to the expansion of the glass flask which gets heated first. The water starts expanding when heat finally reaches it and it rises up the tube.
NOTE: The water expands faster than the glass.

QUESTION
Explain why there is a drop in the level of the water initially followed by a steady rise in the level of water.

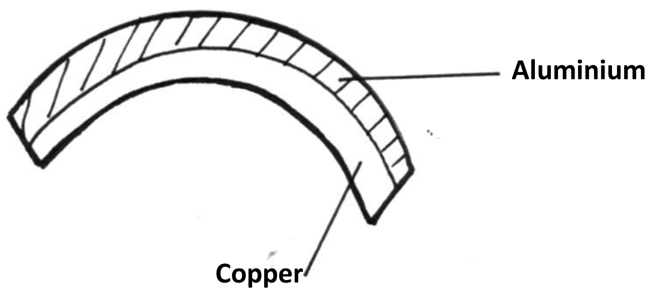
MORE QUESTIONS

1. Figure 5 shows a clinical thermometer which is not graduated.



a) Name the parts indicated with letters: **A** and **B.**
b) Mark the appropriate scale range in degrees Celsius

2. A bimetallic strip is made from aluminium and copper. When heated, it bends as shown below.



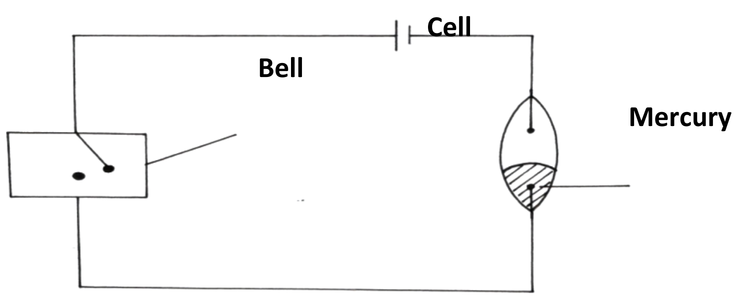
   Sketch a diagram showing the strip when cooled below room temperature.

3. Explain why fish can survive under water when the surface is already frozen.

4. Explain the purpose of the constriction in a clinical thermometer.

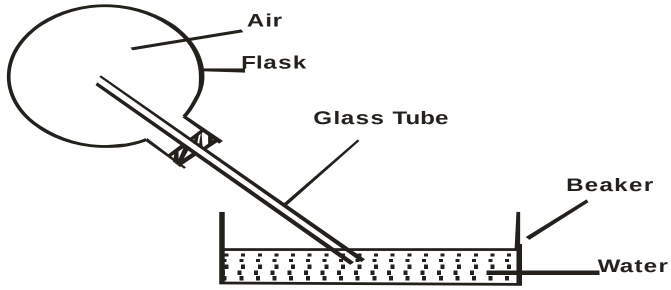
5. It is not advisable to fix electrical cables tightly during the day. Give a reason for this.

6. The diagram below shows circuit of a fire alarm. When fire breaks it rings the bell to alert people that there is fire. Name two properties of mercury that makes it suitable to be used.



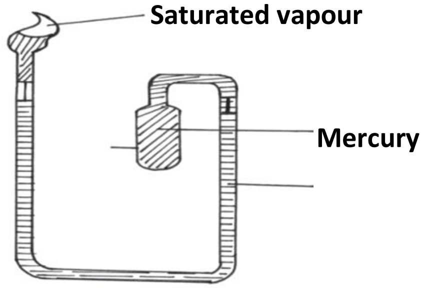
7. In an attempt to prepare a cup of tea, a student placed boiling water into a glass tumbler. The glass tumbler broke into pieces. Explain this observation.

8. Figure 5 shows a flask fitted with a tube dipped into a beaker containing water at room temperature. The cork fixing the glass tube is tight.



State with reason what would be observed if cold water is poured on to the flask

9. Explain why steel is selected for use to reinforce a concreter beam
10. State **two** properties of mercury that make it a suitable thermometric liquid.
11. The diagram below shows a six's maximum and minimum thermometer.



i) What is the thermometric liquid in the thermometer?
ii) Why is it necessary for the vapour in bulb B to be saturated?
iii) Explain how the thermometer indicates maximum and minimum temperature.
iv) Indicate on the figure the two points where the reading of the temperature shown by the thermometer can be made.

12. Explain why a lemon juice bottle always has space between the top of the liquid and the cap.

13. Explain the difference between heat and temperature.
14. Convert 450^0C to Kelvin.

15. The figure below shows a bimetallic strip.

This strip is at room temperature. Sketch the bimetallic strip after being cooled several degrees below room temperature. Explain your answer.

16. A metallic disc is thin and has a hole passing through its centre. Describe what happens to the size of the hole when the disc is heated uniformly.

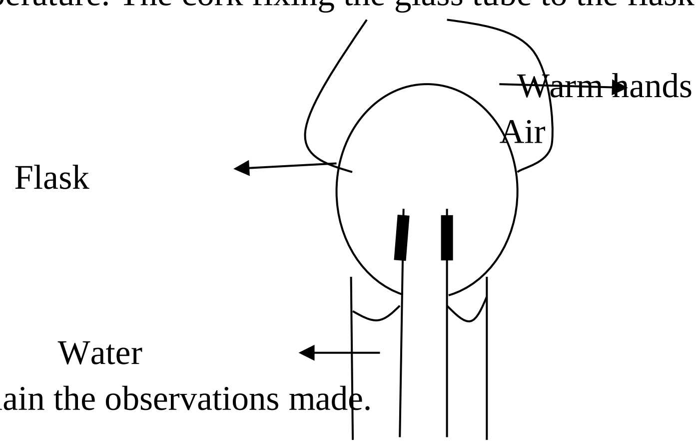
17. Give a reason why a concrete beam reinforced with steel does not crack when subjected to changes in temperature.

18. Describe the thermal expansion of a solid using kinetic theory of matter.

19. Explain the application of expansion in telephone and electric overhead cables.
20. Describe how a bimetallic thermometer works.
21. Explain why aquatic animals are able to survive under water when the surface is already frozen.
22. When a mercury thermometer is used to measure the temperature of hot water, it is observed that the mercury level first drops before beginning to rise. Explain this observation.

23. The coefficient of linear expansion of lead is 2.7 x10^{-5}per ^{0}C. Explain this statement.

24. Compare the expansion of brass and iron.
25. Air in a bulb may be used as a thermometric substance. State:
(i) One property of air that would enable the temperature to be measured.
(ii) One limitation of such a thermometer.
26. What is meant by absolute zero temperature?
27. Explain why a thick glass container is more likely to crack than a thin one when boiling water is suddenly poured in.
28. One property of a liquid that is considered while constructing a liquid in glass thermometer is that the liquid must expand more than the glass for the same temperature range. State any other two properties of the liquid that are considered.
29. Describe and explain the features of a thermometer which will make it: (a) sensitive (b) Quick acting.
30. Why would you crawl close to the flow in a smoke filled room when trying to move out?
31. State three properties of a liquid for it to be considered in constructing a glass thermometer.
32. Sketch a volume against temperature graph for water that cools from 10^{0}C to - 4^{0}C
33. The figure below shows a flask fitted with a glass tube dipped into a beaker containing water at room temperature. The cork fixing the glass tube to the flask is air tight. The flask is warmed with the hands.



State and explain the observations made.

34. (a) Explain why in warm coastal regions, a cool breeze often blows from the sea to the land during the day time.
(b) Describe and explain what happens at night in question (a).
(c) Careful measurements are made on the density of pure water as shown in the table below.

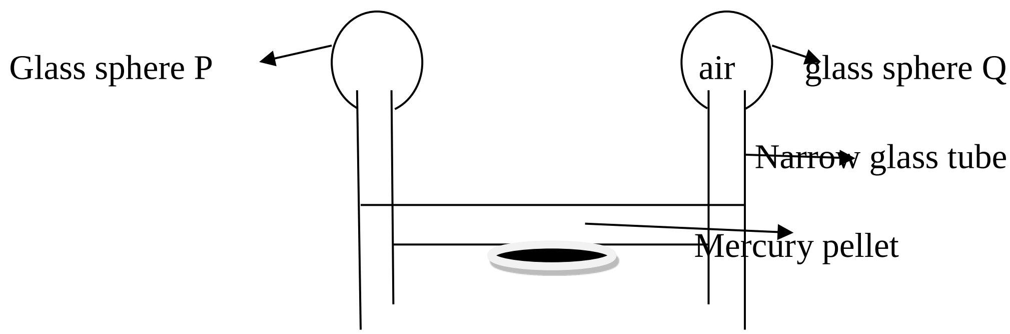
State	Temperature ^0C	Density (kg/m^3)
Liquid	8.0	999.85
Liquid	6.0	999.94
Liquid	4.0	999.97
Liquid	2.0	999.94
Liquid	0.0	999.84
Solid	0.0	916.59

(i) Use the density data above to describe how the volume of the liquid changes as it cools from 8^0C to 0^0C.

(ii) Describe the change in volume of water as it changes from liquid to solid.

(iii) Describe what happens to a sealed glass bottle full of water if it were placed in the freezing compartment of a refrigerator.

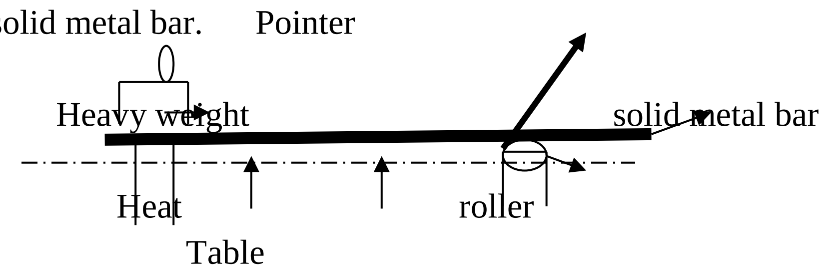
35. (a) Two glass spheres contain equal volumes of air at the same temperature and pressure. The spheres are connected by a narrow glass tube containing a mercury pellet as shown below.



(i) Describe how the air molecules exert a pressure on the walls of the glass spheres.

(ii) Describe and explain using the ideas of molecules what happens to the mercury pellet when sphere Q is gently heated while sphere P is kept at its original temperature.

(b) The diagram below shows an experiment which can be used to demonstrate the thermal expansion of a solid metal bar.

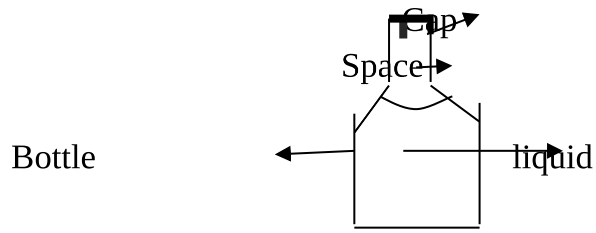


i. Describe what happens when the bar is heated.

ii. Explain what happens in (i) using kinetic theory of matter.

iii. Give an example of an everyday situation where allowance must be made for the expansion of a solid. Explain how this allowance is made for the expansion.

36. (a) When liquids are stored in a sealed bottle, they are not completely filled out, but a space is left between the cap and the surface of the liquid as shown below.



(i) Describe what happens to the contents of the bottle when the temperature is increased slowly and uniformly.

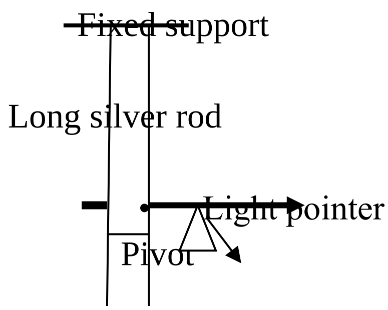
(ii) Explain what happens in (i) in terms of the expansion of liquids and solids.

(iii) Give a use of the above effect.

(iv) Describe and explain what happens to the gas in the space above the liquid using kinetic theory.

(c) A cylindrical copper rod is heated. State and explain what happens to the density of copper as the rod is being heated.

37. a) The diagram below shows a long silver rod, a light pointer and a pivot.



(i) Describe how this apparatus can be used to measure the expansion of the silver rod as its temperature increases.

(ii) State a problem of repeating the above experiment using a polythene rod of the same shape and size as the silver rod.

(iii) State two extra pieces of apparatus that would be needed

38. (a) Place in ticks in the table below to show which liquid is better in each case.

racteristic	**rcury**	**hol**
ands more evenly		
ands more		
etter conductor of heat		
ful at higher temperatures		
ful at lower temperatures		

(b) In terms of the forces of attraction between the particles, the particle spacing and their motion describe and explain the change in volume that occurs on boiling.

TOPIC 7: HEAT TRANSFER

HEAT AND TEMPERATURE

Heat is a form of energy which passes from a body at high temperature to a body at a lower temperature. When a body receives heat energy its temperature increases whereas the temperature of a body that gives away energy decreases.

Thermal equilibrium- Condition when if two bodies at the same temperature are in contact, there is no net flow from one body to the other.
The SI unit of heat is joules.
Heat cannot be measured directly by an instrument as temperature is measured by a thermometer.

MODES OF HEAT TRANSFER

Heat can travel through a medium as well as in a vacuum. There are three (3) modes of heat transfer namely;

i) Conduction – takes place in solids.
ii) Convection – takes place in fluids (liquids and gases).
iii) Radiation – takes place in gases (vacuum)

1. CONDUCTION

In stirring a hot tea the handle of a spoon becomes warm. The mechanism to this is explained below,

- Heat energy entering the spoon from the hot end increases vibrations of the atoms at this ends. These atoms in turn collide with neighbouring atoms, increasing their vibrations and hence passing the heat energy along.
- Metals have free electrons which travel throughout the body of the metal. Heat energy injected at the hot end of the metal spoon increases the vibration of the particles at the end. The free electrons in that region gain more kinetic energy and because they are free to move, they spread heat energy to the other parts of the spoon.

THERMAL CONDUCTIVITIES OF VARIOUS CONDUCTORS

Different materials have different thermal conductivities. Metals are generally good conductors of heat. Non-metals are poor conductors of heat (insulator).
Solids that are good conductors of heat use both atom vibration and free electrons to conduct heat.

Solids that are poor conductors of heat like glass, wood, rubber make use of atom vibration as a mechanism to conduct heat because they have no free or mobile electrons.

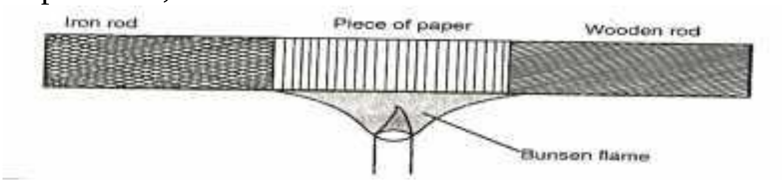
The table below shows some of the good and poor conductors in decreasing order of thermal conductivity.

Good conductors	Poor conductors
Silver	Concrete
Copper	Glass
Aluminium	Brick
Brass	Asbestos paper
Zinc	Rubber

NOTE: During thermal condition, heat flows through the materials without the material shifting or flowing. Conduction is therefore transfer of heat as a result of vibration of particles.

CONDUCTIVITY OF WOOD AND IRON RODS

The following set up is used;



Observation and explanation

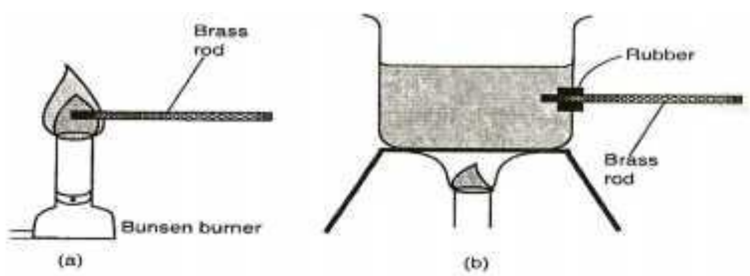
The paper gets charred (blackened) on the region covering the wooden rod. This is because the wood does not conduct heat from the paper. Wood is said to be a bad conductor of heat while iron is a good conductor.

FACTORS AFFECTING THERMAL CONDUCTIVITY

Thermal conductivity in materials depends on the following factors;
(a) Temperature difference (Θ) between the ends of the conductor.
(b) The length of the conductor.
(c) The cross-sectional area (A) of the conductor.
(d) The nature of the material (K)

(a) Temperature difference

To demonstrate how temperature difference (Θ) affects thermal conductivity, the following set up is used.



Observation

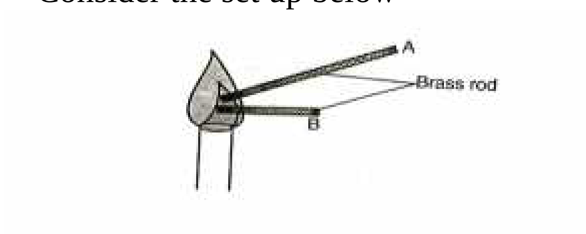
It will be observed that the rod placed in the flame becomes too hot faster than the one placed in the boiling water.

Explanation

The rate of heat flow (thermal conduction) increases with increase in temperature.
Thermal conduction in metals is by two mechanisms i.e. vibration of atoms and by free electrons.
A high temperature difference between the ends of the conductors sets the atoms into vibrations more vigorously and the vibrations are passed more quickly to the cooler end. The electrons on the other hand gain a lot of kinetic energy causing them to spread the heat energy to cooler parts of the metal within a short time.

(b) <u>Length of the conductor</u>

Consider the set up below



Observation

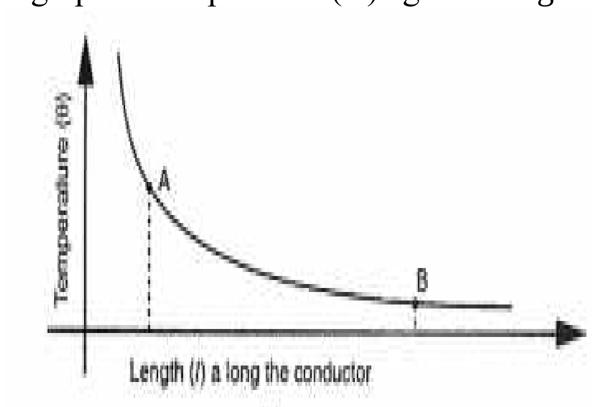
It will be observed that the end of metal B held in hand becomes too hot earlier than metal A. Thermal conductivity increases with decrease in length.

Explanation

Heat travels within a conductor along imaginary lines called **lines of heat flow.**

These lines diverge from the hot end as shown

The graph of temperature (Θ) against length (l) is as shown.



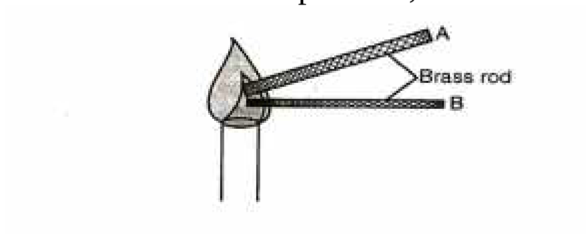
When the heat energy gets to the surface of the metal it is easily lost to the surroundings.

The lines of heat are more divergent near the hot end than they are far away (position A and B).

The slope of the graph in the above figure is steeper at A (near the hot end) than at B further away. This indicates that the shorter the length of the material, the higher the rate of heat flow.

(c) <u>The cross-sectional area of the conductor</u>

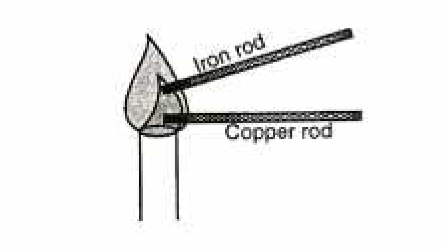
Consider the set up below,



Observation
The end of metal A held in the hand becomes too hot earlier than metal B.
Thermal conductivity increases with increase in area of cross-section of the conducting material.

Explanation
The number of free electrons per unit length of the thicker length A is more than those in the thin metal rod B.

(d) <u>The nature of the material K</u>
To demonstrate how the type of the material K affects thermal conductivity, consider the diagram below,

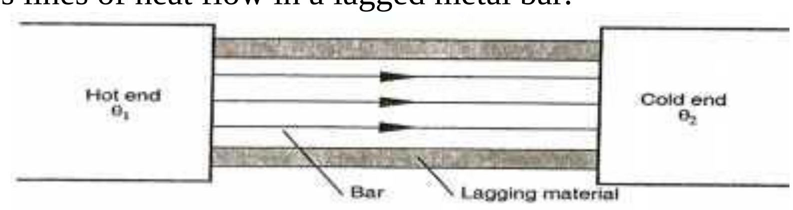


Observation
In this case, it is observed that end of copper rod held in the hand becomes too hot earlier than iron rod. This shows that thermal conductivity depends on the nature of the material.

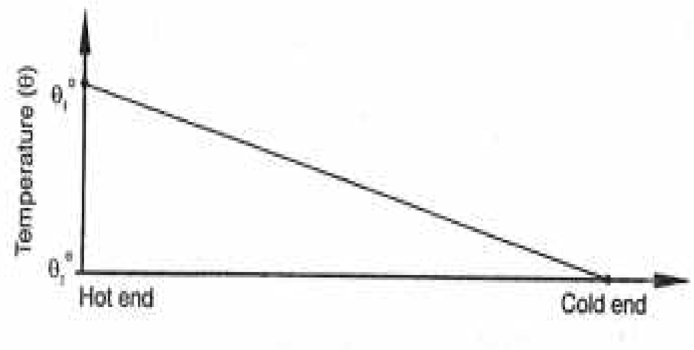
Explanation
Different materials have different strength of force bonding the atoms within the material. The number of free electrons also differs from one material to another material.
Materials with many free electrons are better conductors of heat e.g. copper has more free electrons than iron.

$$\textbf{Rate of heat flow} = \frac{\textbf{thermal conductivity x cross-sectional area x temperature difference}}{\textbf{Length L}}$$

<u>LAGGING</u>
This is the covering of good conductors of heat with insulators to reduce heat loss through surface effects. For example, iron pipes carrying hot water from boilers are covered with thick asbestos material.
The figure below shows lines of heat flow in a lagged metal bar.

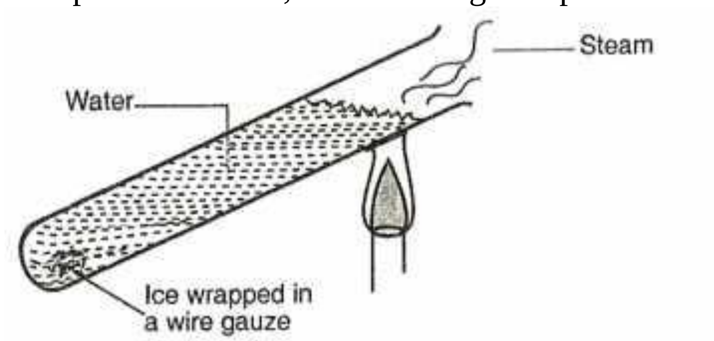


A graph of temperature (ɵ) against the position along the lagged conductor is as shown below.



THERMAL CONDUCTIVITY IN LIQUIDS

To demonstrate that water is a poor conductor, the following set up considered,



Observation and explanation

It will be noted that water at the top of the boiling tube boils while ice remains unmelted. This shows that water is a poor conductor.

NOTE: The boiling tube is made of glass (poor conductor of heat) which limits possible conduction of heat down the tube.

The ice is wrapped in wire gauze to ensure it does not float. The fact that the wire gauze is a good conductor of heat and yet ice remained unmelted shows that there is very little heat conduction in water, unable to melt the ice.

Water is heated at the top to eliminate possibility of heat transfer to the ice by convection.

Although liquids are in generally poor conductors of heat, some liquids are better heat conductors than others e.g. mercury is a better conductor of heat than water.

Why Liquids Are Poor Conductors of Heat

Pure liquids have molecules further apart from each other. Although molecules move about within the liquid, they are slow to pass heat to other regions compared to the free electrons in metals. This is because there are large intermolecular distances between liquid molecules. There are also fewer and rare collisions between the molecules.

Electrolytes e.g. salt solution, are better conductors of heat than pure liquids because of increased compactness of the particles.

Mercury is a metal existing as a liquid at room temperature. Bromine, the only non-metal existing as a liquid at room temperature, is a poor conductor.

THERMAL CONDUCTIVITY IN GASES

Since thermal conductivity is by means of vibration of atoms and presence of free electrons, gases are worse conductors of heat because of large intermolecular distance.

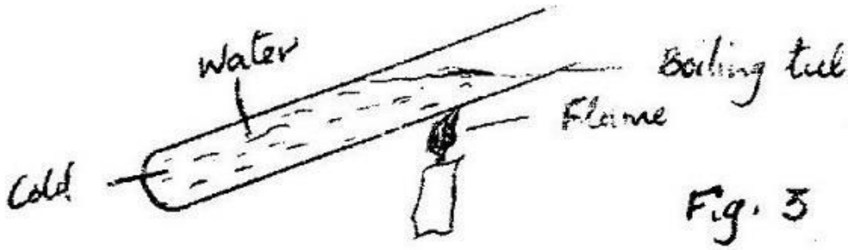
A match stick held within the unburnt gas region of a flame cannot be ignited by the heat from the hot part of the flame. This is because gas is a poor conductor of heat.

APPLICATIONS OF GOOD AND POOR CONDUCTORS

- Cooking utensils, soldering irons and boilers are made of metals which conduct heat rapidly. For cooking utensils, the handles are made of insulators such as wood or plastic. Metal pipes carrying hot water from boilers are lagged with cloth soaked in a plaster of Paris to prevent heat losses.
- Overheating of integrated circuits (ICs) and transistors in electronic devices can drastically affect their performance such components are fixed to a heat sink (a metal plate with fins) to conduct away undesired heat. The fins increase the surface area of heat sink and conduct more heat away to the surrounding.
- Fire fighters put on suits made of asbestos material to keep them safe while putting out fire.
- Birds flap their wings after getting wet as a means of introducing air pockets in their feathers. Air being a poor conductor reduces heat loss from their bodies.
- In modern buildings where desired inside temperatures is to be stabilised, double walls are constructed. Materials that are good insulators of heat and can trap air put between the walls. Examples of such materials that are glass, wool (fibre glass) and foam plastic Air on its own may not effectively give the desired insulation because it undergoes convection. Double glazed windows used for the same purpose have air trapped between two glass sheets.
- In experiment involving heating water or liquid, the beaker is placed on the wire gauze. The gauze is heated and spreads the heat to a large area of the beaker. If the gauze is not used, heat from the Bunsen burner may concentrate on a small area and may make the beaker crack.

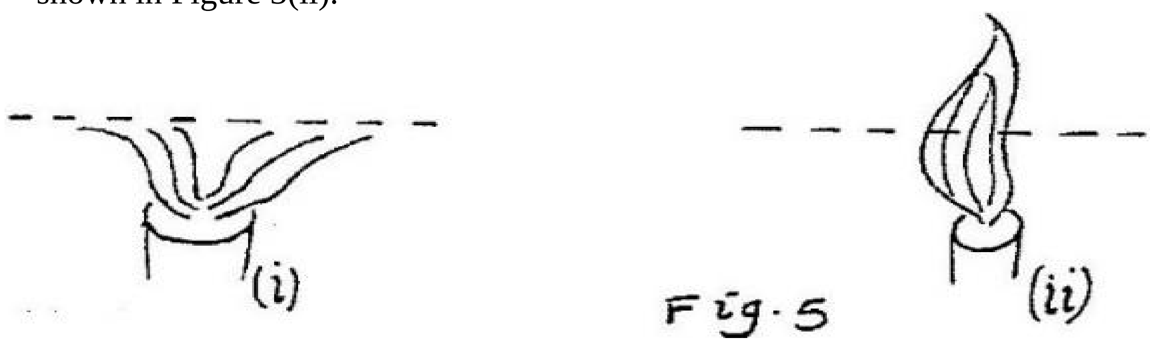
QUESTIONS

1. In the set up shown in figure 1, water near the top of the boiling tube boils while at the bottom it remains cold.



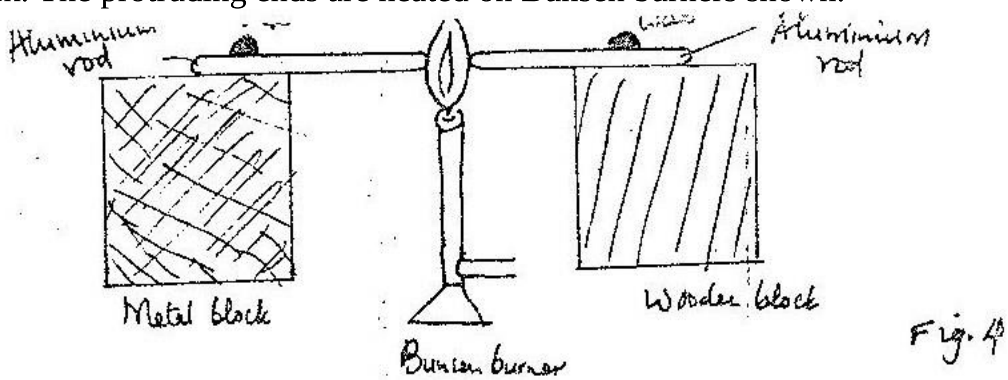
Give a reason for the observation

2. When a Bunsen burner is lit below wire gauze, it is noted that the flame initially burns below the gauze as shown in Figure 2 (i).After sometime, the flame burns below as well as above the gauze as shown in Figure 3(ii).



Explain this observation

3. Two identical aluminum rods as shown in figure 3. One rests on metal block the other on the wooden block. The protruding ends are heated on Bunsen burners shown.



State with reason on which bar the wax is likely to melt

4. Fig. 4 shows a hot water bath with metal rods inserted through one of its sides. Some wax is fixed at the end of each rod. Use this information to answer questions below

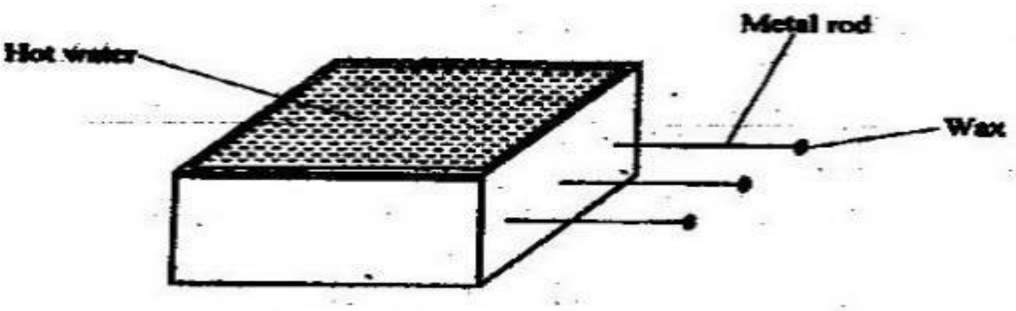
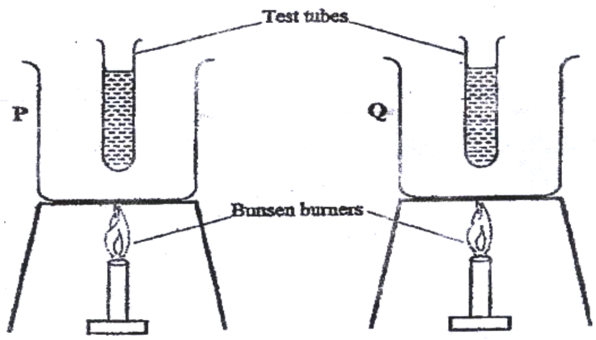


Figure 3

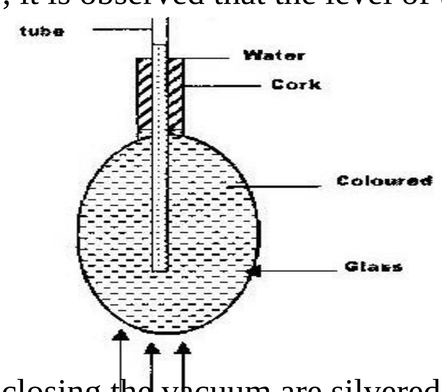
What property of metals could be tested using this set-up?

5. Two identical empty metal containers P and Q are placed over identical Bunsen burners and the burners lit. P is dull black while Q is shiny bright. After each container attains a temperature of 100^0C the burners are turned off. Identical test tubes containing water are suspended in each container without touching the sides as shown



(i) Explain why the container Q may become hot faster than P.
(ii) Explain why the water in test- tube in P becomes hot faster than in Q

6. In a vacuum flask the walls enclosing the vacuum are silvered on the inside. State the reason for this.
7. Give a reason why heat transfer by radiation is faster than heat transfer by conduction.
8. A wooden bench and a metal bench are both left in the sun for along time. Explain why the metal bench feels hotter to touch.
9. An electric heater is placed at equal distances from two similar cans A and B filled with water at room temperature. The outer surface of can A is shiny while that of can B is dull black. State with reasons, which of the cans will be at higher temperature after the heater is switched on for some time.
10. In the set up shown in figure 4, it is observed that the level of the water initially drops before starting to rise.



Explain this observation.
11. In a vacuum flask the walls enclosing the vacuum are silvered on the inside. State the reason for this

Figure 4 shows two identical balloons A and B. The balloons were filled with equal amounts of the same type of gas. The balloons are suspended at distances X_1 and X_2 from a metal cube filled with boiling water and placed on an insulating material. Use this information to answers questions 12 and 13 below:

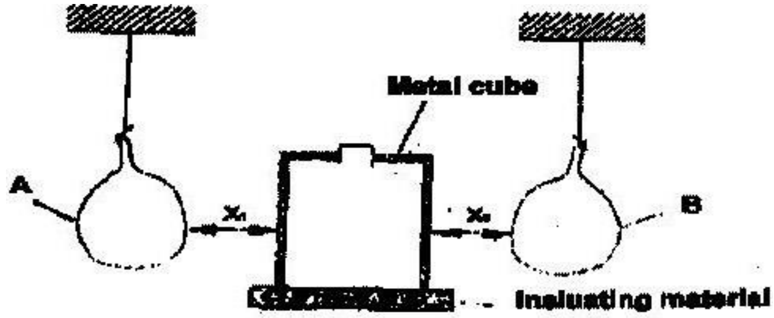


Figure 4

12. State the mode by which heat travels from the cube to the balloons

13. The face of the cube towards A is bright and shiny and the face towards B is dull black. State with reason the adjustments that should be made on the distances X_1 and X_2 so that the rate of change of temperature in both balloons is the same.

14. Temperature scale in clinical thermometer ranges from 35^0c to 43^0c. Explain.

15. State one application of expansion in gases

16. Why is it that boiling is not used for sterilization of clinical thermometer?

17. Describe ONE advantage and ONE Disadvantage of anomalous behavior of water.

18. (a) Draw a well labeled diagram of a vacuum flask

(b) Stating the specific parts in the flask explain how heat loss is reduced through:

(i) Conduction

(ii) Convection

(iii) Radiation

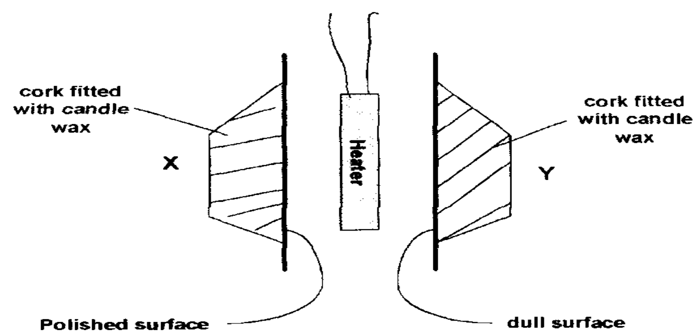
SOLUTIONS

1. Water/ or glass are poor conductor of heat
2. Initially the wire gauze conducts heat away so that the gas above does not reach the ignition temp/point. Finally the wire gauze becomes hot raising the temp of the gas above ignition point.
3. Wooden Block; Wooden block is a poor conductor of heat all the heat goes in melting the wax.
4. Heat conductivity/ rates of conduction/ thermal conductivity
5. Dull surface radiate faster than bright surface P- Looses more of the heat supplied by burner than Q or Q shinny surface is a poorer radiator/ emitter of heat thus retains more heat absorbed Or P- Dull surface is a better radiator/ emitter i.e. retains less of the heat absorbed. Heat travels from container to test tube by radiation so the dull surface P, gives more heat to the test tube.
6. Reduce/ minimize the transfer of heat by radiation OR Reduce the loss of heat OR gain of heat by radiation.
7. Radiation is at the electromagnetic waves Φ infrared while conduction involves particles, which move at lower speed
8. This is because metal is a good conductor, so that heat is conducted from outer parts to the point touched; while wood is a poor conductor
9. Can B is a good absorber of radiation/better absorber of radiation or heat.
10. Glass flask expands first (creating more volume for water) Water then expands using the tube.
11. To reflect heat outwards or inwards hence reduce heat loss by radiation.

12. - x^2 is made larger than X_1
13. - Since B receives radiation at a higher rate, it must be moved further from source for rates to be equal.
14. Since the quantity of water in A is smaller, heat produces greater change of temperature in A; a decrease in density causing the cork to sink further.

MORE QUESTIONS

1. Figure below shows two corks **X** and **Y** fixed on a polished plate and a dark plate with candle wax



   Explain the observation, when the heater is switched on for a short time.
2. What feature of a vacuum flask minimizes heat loss by radiation? Explain how this is achieved.
3. Explain why fuel carrying tankers are painted white or silvery.
4. When a thermometer is immersed in ice cold water, the mercury thread is observed to rise before dropping steadily in the capillary tube. Explain.

TOPIC 8:
RECTILINEAR PROPAGATION AND REFLECTION AT PLANE SURFACES

Light is a form of energy. It enables us to see the surrounding objects. Light itself is not visible but its effect is felt by the eye.
Light is also very essential as a source of energy for the process by which plants their own food (photosynthesis).

SOURCES OF LIGHT

Luminous (incandescent) source – these are objects that produce their own light e.g. sun, stars, burning candles, wood or charcoal, electric bulbs, television screens, glow worms e.t.c.

Non-luminous source – these are objects which do not produce light of their own. They are seen when light falling on them from luminous sources is reflected (bounces off their surfaces) e.g. the moon, planets, plants, people, books, walls, clothes e.t.c.

RAYS AND BEAMS OF LIGHT

A source of light produces pulses of energy which spread out in all directions.

The path along which light energy travels is referred to as **a ray of light.** Rays are represented by lines with arrows on them to show the direction of travel.

A stream of light energy is called **a beam.** It is also considered to be a bundle of rays of light. Beams of light can be seen;

- In the morning as the sunlight breaks through the clouds or leaves.
- When a spotlight is shown in a smoky room or a car driven along a dusty road at night with its headlamps on.
- When sunlight streams into a smoky dark room through a small opening

TYPES OF BEAMS OF LIGHT

a) Diverging beam
b) Converging beam
c) Parallel beam

Diverging beam – These are beams of light that appear to spread out (diverging) e.g. light from a spotlight.

Converging beams – these are beams which appear to collect (converge) to a point.

Parallel beam – are those beams which appear to be perfectly parallel to each other e.g. a beam of light from the sun reaching the earth's surface.

OPAQUE, TRANSLUCENT AND TRANSPARENT OBJECTS

OPAQUE – these are objects that do not allow light to pass through them at all e.g. brick walls, metals, wood, stones e.t.c.

TRANSLUCENT – these are objects that allow light to pass through but we cannot see through e.g. glass panes used in toilets and bathroom window and greased paper.

TRANSPARENT – these are objects which allow light to pass through and we see clearly through them e.g. car wind screen and ordinary window panes.

RECTILINEAR PROPAGATION OF LIGHT

Light does not need a material medium to carry it. In a vacuum, the speed of light is 3.0×10^8m/s. Light from the sun reaches the earth having travelled mostly through a vacuum.

When light falls on an opaque object, it casts a shadow of the object with sharp edges on a screen behind it. This suggests that light travels in a straight line.

TO INVESTIGATE HOW LIGHT TRAVELS

Apparatus: three cardboards, source of light.

Arrange the apparatus as shown

The cardboards are arranged such that holes are exactly in line.

OBSERVATION

When the holes in the three cardboards are in line, the eye can see the lamp.

However when the middle cardboard is displaced, the eye can no longer see the lamp.

EXPLANATION

When the holes in the cardboards are in a straight line, light travels through the holes and the lamp is seen from the other side. When one of the cardboards is displaced, the beam of light is cut off and since light cannot bend to follow the displaced hole, the lamp cannot be seen.

CONCLUSION

Light travels in a straight line. This property is known as **rectilinear propagation of light.**

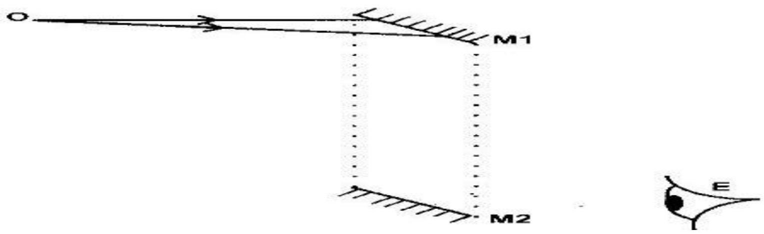
SHADOWS

Shadows are formed when an opaque object is on the path of light. The type of shadow formed depends on;

i. The size of source of light.
ii. The size of opaque object.
iii. The distance between the object and the source of light.

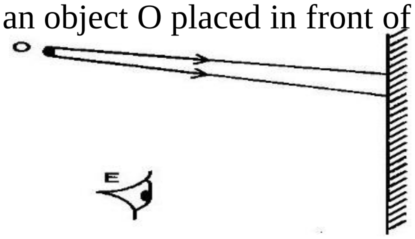
QUESTIONS

1. What is meant by a virtual image?
2. The figure below shows an object O being viewed using two inclined mirrors M_1 and M_2.



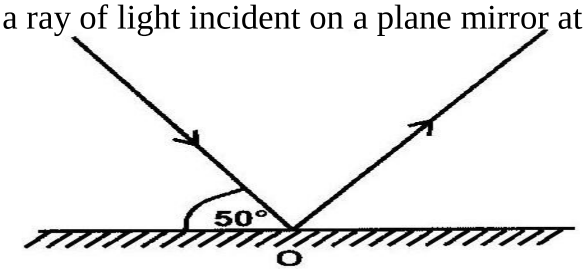
Complete the diagram by sketching rays to show the position of the image as seen by the eye E

3. The figure below shows an object O placed in front of a plane mirror



On the same diagram, draw rays to locate the position of the image 1 as seen from the eye E.

4. The diagram shows a ray of light incident on a plane mirror at point O.

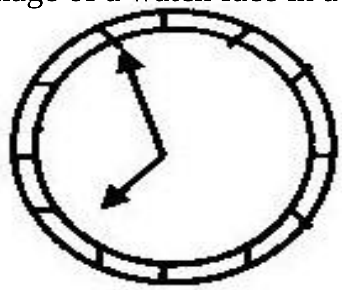


The mirror is rotated clockwise through an angle of 30^0 about an axis perpendicular to the paper. Determine the angle through which the reflected ray rotated.

5. A luminous point object took 3 s to move from P to Q in front of a pinhole camera as shown below.

What is speed in cm/s of the image on the screen?

6. The diagram shows the image of a watch face in a plane mirror



What is the time shown on the watch face?

7. (a) Give two main reasons why concave mirrors are unsuitable as driving mirrors

   (b) State one disadvantage of a convex mirror as a driving mirror

8. Explain why a concave mirror is suitable for use as a make up mirror.

9. In the space provided below, sketch a labeled diagram to show how a pinhole camera forms an image of a vertical object placed in front of the pinhole

10. A building standing 100m from a pinhole camera produces on the screen of the camera an image 5 cm high 10 cm behind the pinhole. Determine the actual height of the building.

11. What property of light is suggested by the formation of shadows?

12. State the reason why when a ray of light strikes a mirror at 90o, the reflected ray travels along the same path as the incident ray.

13. Figure 1 shows two point objects A, and B, placed in front of a mirror M

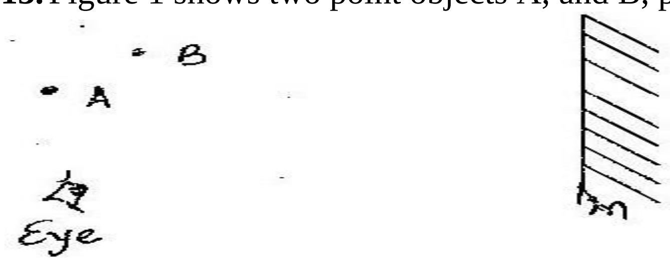


Fig. 4

Sketch a ray diagram to show the positions of their images as seen by the eye.

14. What is meant by virtual image?

15. Figure 2 shows a ray of light incident on plane mirror at point O.

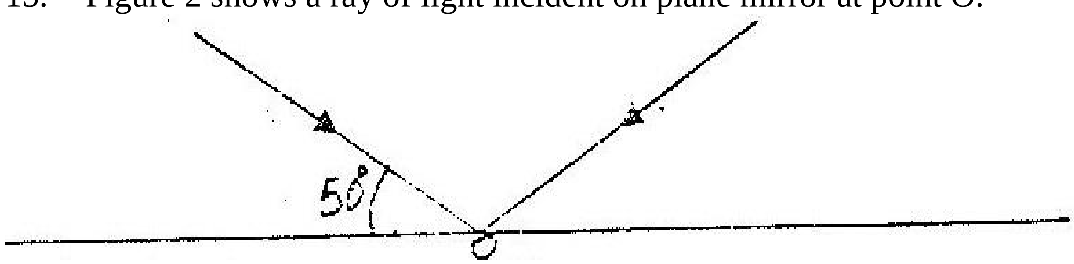


Fig. 6

The mirror is rotated clockwise through an angle 300 about an axis perpendicular to the paper. Determine the angle through which the reflected ray rotated.

16. Fig. 3 shows an object O being viewed using tow inclined mirrors M1 and M2.
Complete the diagram by sketching rays to show the position of the image as seen by the eye.

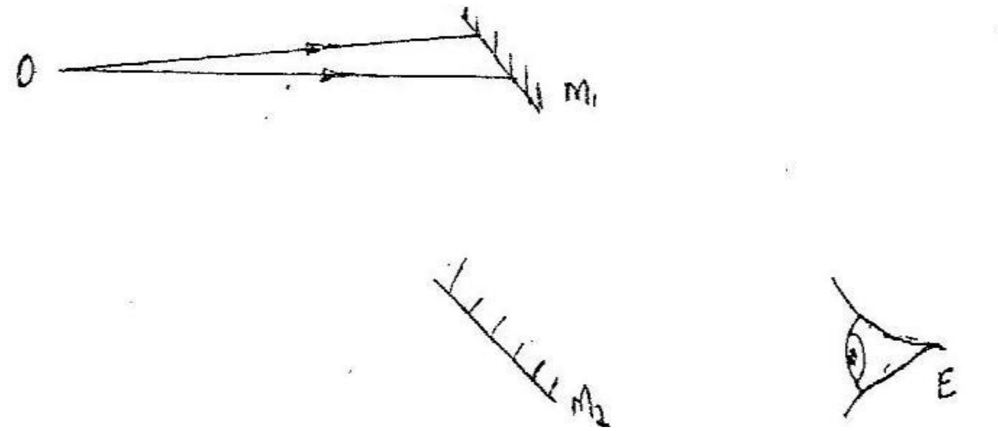


Fig. 6

Sketch the same diagram, the path of the ray until it leaves the two mirrors. Indicate the angles at each reflection

17. In a certain pinhole camera, the screen is 10cm from the pinhole. When the camera is placed 6m away from a tree, a sharp image of the tree 16cm high is formed on the screen. Determine the height of the tree

18. Figure 4 shows three point sources of light with an opaque object placed between them and the screen.

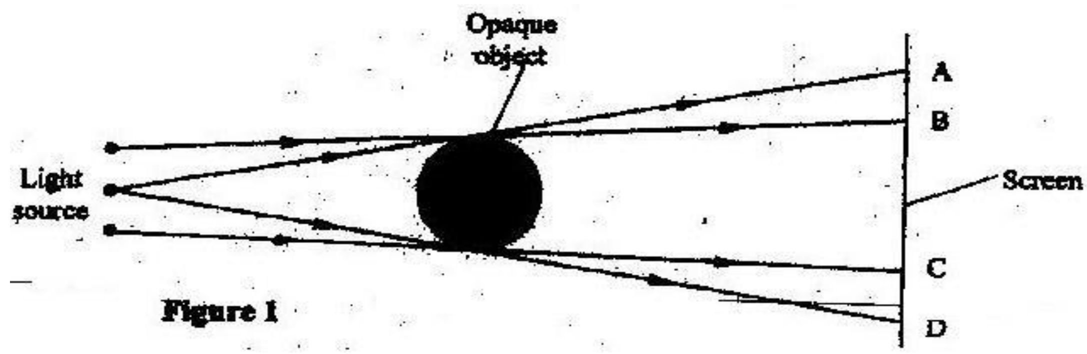


Figure 1

Explain the nature of the shadow formed along B and C.

19. State the number of images formed when an object is between two plane mirrors placed in parallel.

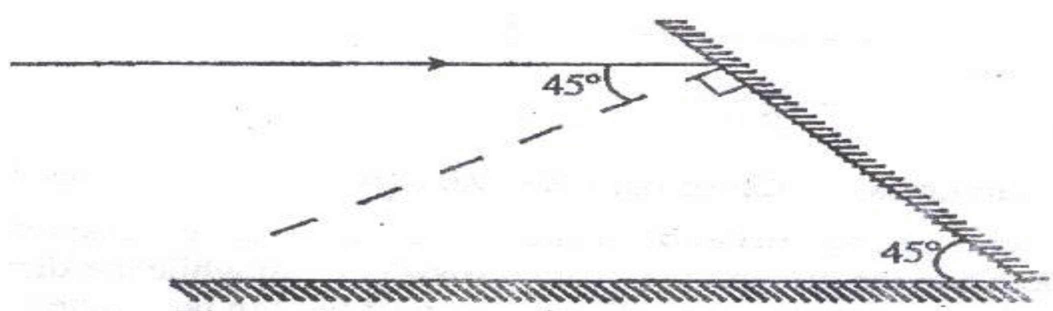


Figure 1

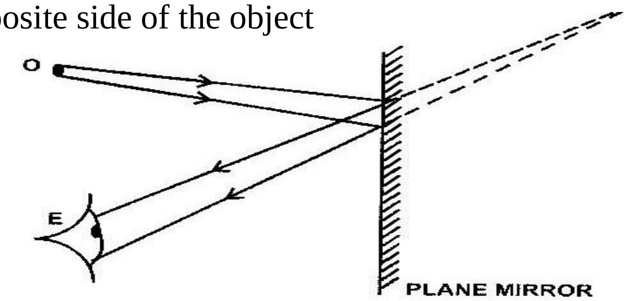
20. Figure 5 shows a ray of light incident on a mirror at an angle of 450. Another mirror is placed at an angle of 450 to the first one as shown .Sketch the path of the ray until it emerges

SOLUTION

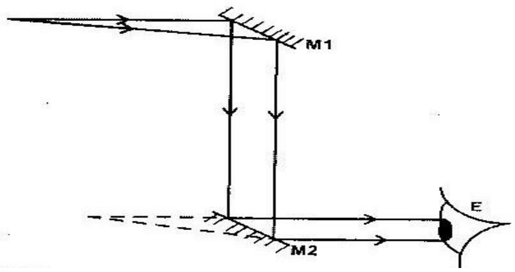
(a) - Image that cannot be formed on screen.

- Always on the opposite side of the object

(b)



(c)



(d) Angle of rotation of reflected ray = 2(angle of rotation of mirrors)

$= 2x\ 30^0$

$=60^0$

TOPIC 9: ELECTROSTATICS 1

This is the study of static charges. There are two types of charges i.e. **negative charge** and **positive charge.**

When a plastic ruler is brought near to small pieces of paper, it will be noted that it cannot be able to attract the small pieces of paper. This is because the ruler is electrically neutral.

When the ruler is rubbed against fur or hair the static charges becomes active. In this case, between the ruler and fur or hair they interchange charges whereby one becomes positively charged and the other negatively charged. Because of this the ruler is able to attract the small pieces of paper.

The SI unit of charge is coulomb (C). Millicoulombs and micro-coulombs are also used.
1000 millicoulombs = 1 coulomb
1000000 micro-coulomb = 1 coulomb

Origin of Charge

Matter is made up of atoms. An atom has particles known as protons, electrons and neutrons. Protons are **positively** charged, electrons are **negatively** charged and neutrons are neutral.

Protons and neutrons are found at the centre and nucleus of the atom while electrons are found moving around the energy levels.

The nucleus has positive charge due to the charges on the protons. Electrons in the outermost orbit are weakly held by the nucleus and can be transfer easily from one material to another by rubbing.

The material that gains electrons becomes **negatively** charged and that which loses electrons becomes **positively** charged. A negatively or positively charged atom is called **an ion.**

Materials like polythene and plastic they acquire electrons when they are rubbed hence they become **negatively charged** while materials like acetate, Perspex and glass have their electrons removed from their surface when rubbed and they become **positively charged.**

In general origin of charge is based on the atom of any given substance; each atom contains protons, electrons and neutrons.

Basic Law of Charges

This law is based on the relationship between charges when they are brought near to each other. It states that **unlike charges attract while like charges repel.**

CHARGING MATERIALS

Materials can be charged by the following methods;

a. Induction
b. Contact
c. Separation

a) INDUCTION

This is the ability in which a body which is charged finds to influence another adjacent to acquire an opposite.

A positively charged material, when it is brought near to another uncharged material, it will influence another body to acquire some charge.

The positive charges in B which has been repelled are removed by the process of **earthing.**

Earthing is the process through which electrons are made to the ground or from the ground through a conductor.
In the above case when a conductor is connected to B, electrons will flow from the ground to neutralise the positive charges.
After the positive charges have been neutralised, the conductor in B is removed fast while the two bodies are maintained adjacent to one another.

This is to enable the electrons in B to remain within that body but if you remove body A while the conductor is connected with B, those electrons in B will escape to the ground.
When body A and B are separated as far as possible the negative charges will distribute uniformly.

b) CHARGING BY CONTACT
In this method two bodies are brought directly into contact, because of this some charges are able to cross over between their surfaces.
In this method, one of the bodies must be charged. That charge will influence the other body to acquire some charge.
NOTE: When a body is charged by contact method, it acquires charges that are similar to the ones on the charging rod.

In the diagram above body A was charged positively and because of this charge when it is in contact to body B it attracts negative charges and repel with positive charge.

When the two are made to be in contact the negative charge in body B crosses to body A to neutralise part of its positive charge.
If this process continues with time the number of positive charges in A will reduce and the number of the positive charges in B will increase.
Finally when the two bodies are separated the positive charges in B will distribute uniformly.

c) CHARGING BY SEPARATION
In this case two uncharged bodies are brought near to charged material. By the process of induction the two bodies will acquire an opposite charge because of attraction and repulsion.

The positive charge in A influence negative charges in X because of attraction while it influences positive charges in Y because of repulsion.
NOTE: In order to sustain the two opposite charge in X and Y in the two bodies, they are first separated while the position in body A is maintained. Finally when they are separated the two bodies will distribute uniformly as shown.

THE ELECTROSCOPE
This is an instrument which works on the principle of electrostatic charges. It is also used for investigating the effects of electric charges.
The gold-leaf electroscope consists of a thin gold or aluminium leaf of plate connected to a metal rod that has a brass cap at the top as shown,
The cap acquires the charges through induction or contact and spreads it through the rod to the plate and leaf.

The cap is circular to ensure uniform distribution of charges.
Both the leaf and the plate show the presence of charges by repelling each other, making the leaf to diverge. The absence of charges is also shown when leaf divergence decreases.

Metal casing is for protecting the leaf from the effects of draught. The casing has a glass window through which observations are made.
The rod is supported by passing it through a plug of good insulating material such as rubber. The insulator stops charge given to the cap from spreading onto the case and leaking away. The casing may be a terminal connected to the earth.
When the electroscope is touched by a finger or connected to the earth by a wire, electrons either flow to the earth, depending on the charge on the electroscope.
The process of losing to or gaining charges from the earth through a conductor is called **earthing.**

- **<u>Charging an Electroscope by Contact Method</u>**

In this method, a charged body is brought into contact with the cap of the electroscope as shown in the figure below,

Because the positive charge on the rod are in contact with the negative charge at the cap, the two charges neutralise i.e. negative charges move to the rod and positive charge move to the cap.
It will be observed that at the leaf, the leaf diverges because of like charges at the point (positive charges).

The more positive charges at the leaf will make the leaf to diverge at a greater angle. If the process is continued, the electroscope will charge to a maximum point in which the leaf cannot diverge any further.
NOTE: The charged material coming into contact with the cap of the electroscope is an insulator. Only charges on the rod's surface coming into contact with the cap are used in neutralizing the charges induced on the cap.

- **<u>Charging Through Induction</u>**

In this method a charged body is brought near to the cap of the electroscope and because of attraction the cap is going to have opposite charge while at the leaf is going to have same charge because of repulsion as shown,

The positive charges at rod attract the negative charge at the cap and repel positive charge at the leaf. The positive charges at the leaf repel one another thus making the leaf to diverge through an angle.
In order to eliminate the charges at the leaf, one is required to earth the cap by the use of a finger or a wire while maintaining the position of the charging rod as shown;

Through earthing electrons are going to flow from the ground through the cap down the leaf to neutralise the positive charge hence making the leaf to fall.

These electrons when they are passing through the cap, they are not affected by the negative charge at the cap. This is because the negative charge at the cap and the positive charge on the rod are strongly attached because of attraction.

While maintaining the position of the rod removes the finger or the earth wire first in order to avoid the negative charge at the cap not to escape down to the ground.
Finally remove the positive charged rod away from the cap. Because of like charges at the cap they will repel one another in order to distribute uniformly on the cap and the leaf.
The negative charges which move to the leaf diverge once more indicating electroscope has been charged.

ASSIGNMENT
Use a negatively charged rod to explain how to charge an electroscope using induction method.

USES OF THE ELECTROSCOPE

(a) To detect the presence of charge on a body

-The material to be tested is placed on or close to the cap of the electroscope. If it is not charged, the leaf does not diverge.

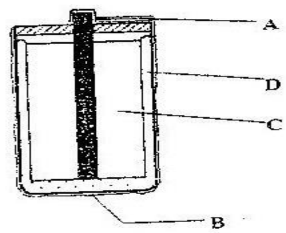
(b) To test the sign of charge on a charged body

-Charge an electroscope negatively by contact method. Slowly bring a negative rod to be tested close to the cap of the electroscope. The leaf **diverges more.** It does so because the negative charges on the rod repel more charges from the cap to the plate and the leaf. Similar charges in the plate and the leaf are repelled more.

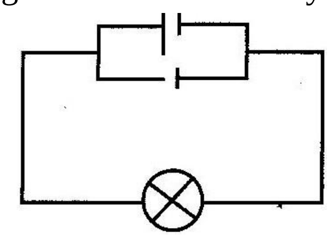
-When a strong positively charged rod is brought from high position towards a negatively charged electroscope, the leaf divergence first decreases then increases as the rod approaches the cap. The leaf divergence reduces slightly first because the positive on the rod attract negative charges on the leaf and plate, making the electroscope neutral.

QUESTIONS

1. In a simple cell, the zinc plate gets negatively charged and the copper plate gets positively charged.
a) Name the electrolyte in the cell.
b) Explain how :(ii) Zinc gets negatively charged. (ii)Copper gets positively charged.
c) State what constitutes the current when a wire is used to connect the zinc and the copper plate externally?
2. A student wishes to investigate the relationship between current and voltage for certain device X. In the space provided, draw a circuit diagram including two cells, rheostat, ammeter, voltmeter ad the device X that would be suitable in obtaining the desired results.
3. In large current circuits large resistors in parallel are preferred to low resistors in series explain
4. Fig 1shows the features of a dry cell



a) State the polarities of the parts labeled A and B. Page 110 of 162
b) chemical substance in the parts labeled C and D
5. State one advantage of an alkaline cell over a lead – acid cell.
6. A car battery requires topping up with distilled water occasionally. Explain why this is necessary and why distilled water is used.
7. A current of 0.5A flows in a circuit. Determine the quantity of charge that crosses a point in 4 minutes.
8. State the reason why a voltmeter of high resistance is more accurate in measuring potential differences, that one of low resistance.
9. A student learnt that a battery of eight dry cells each 1.5V has a total e.m.f of 12V the same as a car battery. He connected in series eight new dry batteries to his car but found that they could not start the engine. Give a reason for this observation
10. Distinguish between a primary cell and a secondary cell.
11. What current will a 500Ω resistor connected to a source of 240V draw?
12. A current of 0.08A passes in a circuit for 2.5 minutes. How much charge passes through a point in the circuit?
13. In large circuits, large resistors in parallel are preferred to low resistors in series. Explain.
14. State two advantages of an alkaline battery over a lead acid battery.
15. A current of 0.5A flows in a circuit. Determine the quantity of charge that crosses a point in 4 minutes.
16. State the purpose of manganese dioxide in a dry cell. (1 mark)



17. A student wishes to investigate the relationship between current and voltage for a certain device X. In the space provided, draw a circuit diagram including two cells, rheostat, ammeter, voltmeter and the device X that would be suitable in obtaining the desired results.
18. State one advantage of an alkaline cell over a lead acid cell
19. Explain clearly the precautionary measures you would take to maintain the efficiency of an accumulator?
20. State the advantage of Nickel-cadmium battery over the lead -acid type
21. Draw a well labeled diagram of a dry cell
22. When ammeter is connected between the two plates of a simple cell, the pointer deflects along the scale. Explain

<u>SOLUTIONS</u>

1. Dry cells have a very high internal resistance hence give very little current that start a vehicle.
2. Secondary cells are rechargeable while primary are not.
3. Q = it =0.08 x 2.5 x 60 =12c.
4. When connected in parallel, the total effective resistance is much less. The heating effect is reduced.
5. Large amounts of current can be drawn from them without damaging them while in lead acid batteries.
6. Q = It
   = 0.5 x 4x60